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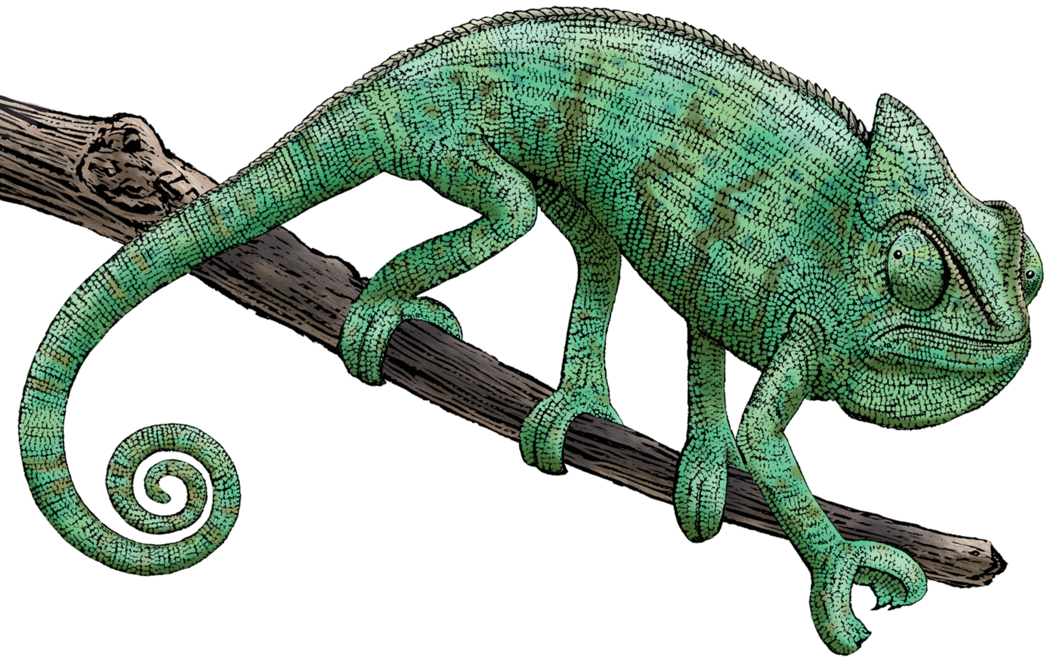
Fourth Edition

SQL in a Nutshell

A Desktop Quick Reference



Kevin Kline,
Regina O. Obe
& Leo S. Hsu

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SQL in a Nutshell

Written for developers, analysts, and database administrators, this Nutshell guide is the essential reference for the SQL language used in today's most popular database products. The updated fourth edition clearly documents SQL commands according to the latest ANSI/ISO standard and details how those commands are implemented in various relational databases.

You'll also get a concise overview of the relational database management system (RDBMS) model and a clear-cut explanation of foundational RDBMS concepts—all packed into a succinct, comprehensive, and easy-to-use format.

Sections include:

- **Background on the relational database model, including current and previous SQL standards**
- **Fundamental concepts for understanding relational databases and SQL commands**
- **A comprehensive command reference of SQL statements according to the SQL 2019 standard**
- **Implementation of each command using MariaDB 10.5, MySQL 8, Oracle 19c, PostgreSQL 14, SQL Server 2019**
- **Platform-specific functions unique to each implementation**

"Developers who have to write queries for several different relational systems will find this book very useful."

—**Bruce Momjian**
cofounder and core team member of the PostgreSQL Global Development Group

Kevin Kline is a renowned database expert and software industry veteran. He was a founder and former president of the Professional Association for SQL Server.

Regina O. Obe is on the development team of PostGIS, a spatial extension for PostgreSQL, and is a coauthor of several PostgreSQL-related books.

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A DESKTOP QUICK REFERENCE

Kevin Kline, Regine O. Obe, and Leo S. Hsu

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SQL in a Nutshell
by Kevin Kline, Regina O. Obe, and Leo S. Hsu

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Table of Contents

Preface

Since its first incarnation in the 1970s, the Structured Query Language (SQL) has evolved hand-in-hand with the information boom. As a result, it is the most widely used language to administer and query relational databases. Many software companies and developers, including those in the open source and NoSQL movements, have developed their own SQL dialects in response to specific needs. All the while, standards bodies have codified a growing list of features.

SQL in a Nutshell, 4th edition, describes the latest SQL standard—SQL:2016—version of many SQL commands, then details how different platforms implement that particular command. (Although the standards bodies have released SQL:2019, the new specifications mostly lie in the area of multidimensional arrays, which have not been implemented by the major vendors. You can read more about how SQL can be used in conjunction with these arrays on the ISO website). In this book, you will find a brief overview of the relational database model, which undergirds all relational database management systems (RDBMSs), followed by a more thorough treatment of frequently used SQL syntax and commands. New in the fourth edition are expanded explanations of programming concepts used in each vendor's offerings, such as stored procedures and user-defined functions. And, of course, we have added popular commands that have arrived since the publication of the third edition.

SQL in a Nutshell, 4th edition, provides a concise guide to the two most commonly installed commercial database packages on the market, Oracle and Microsoft SQL Server, and to the three most commonly installed open source databases: MySQL, PostgreSQL, and MariaDB (a fork of MySQL).

The language and database versions covered in this book include:

- SQL:2016 standard syntax
- MySQL 8 and MariaDB 10.5

- Oracle Database 19c
- PostgreSQL 14
- Microsoft SQL Server 2019

Why This Book?

The primary and definitive source of information for any given relational database package is the official documentation, along with help files, tutorials, advisories, and other tidbits provided by the vendors themselves. But while each vendor's documentation should be the resource that developers and database administrators turn to first, official documentation has a number of limitations:

- It describes the vendor's implementation of SQL without providing an indication of how well that implementation meets the SQL standard.
- It covers only the vendor's specific product, without discussing potential translation, migration, or integration issues across different vendors.
- It covers individual commands in often unrelenting detail, thereby obscuring the most common use cases.
- It typically describes programming methods in an overwhelming number of disconnected articles or help files.

A vendor's official documentation can be expected to provide an exhaustive explanation of every aspect of their offering. It will describe every command, including each obscure variant, along with some implementation guidance. Subjective commentaries are off-limits. However, if you move between data platforms and need to be productive quickly, you will rarely need this level of detail on all the obscure command variations. Instead, you're looking for the most applicable usage found in real-life situations.

This book begins where the vendor documentation ends by distilling the experiences of professional database administrators and developers who have used these SQL products to support complex enterprise applications. It offers you the benefit of their decades of experience in a compact and easily usable format. Whether you're new to SQL or you have been using SQL since its earliest days, there are always new tips and techniques to learn. And when you're moving between different data platforms, it's always important to uncover compatibility issues before they bite you.

Who Should Read This Book?

SQL in a Nutshell, 4th edition, targets several groups of users. It will be useful for developers who require a concise and handy SQL reference tool; for developers who need to migrate from one SQL dialect to another; and for database administrators (DBAs) who need to both execute a myriad of SQL statements to keep their enterprise databases up and running, and to create and manage objects such as tables, indexes, and views.

This book is a reference work, not a tutorial. The writing is not expository. For example, we won't explain the concept of an elementary nested loop algorithm. Instead, we will explain the workings of the cursor as implemented in the standards, then special capabilities of cursors on each database platform. We include advice, based on experience, on how to avoid and circumvent pitfalls when using cursors.

While we don't intend this book to serve as a tutorial on SQL or a handbook for the database architect, we do provide some coverage of introductory design topics. Chapters 1 and 2 provide a concise introduction to the language itself, covering essential structures, basic usage, and some history. If you're new to SQL, these two chapters will help you get going.

How This Book Is Organized

The book is divided into 10 chapters and an appendix:

Chapter 1, "SQL History and Implementations"
: Discusses the relational database model, describes the current and previous SQL standards, and introduces the SQL implementations covered in this book.

Chapter 2, "Foundational Concepts"
: Describes the fundamental concepts necessary for understanding relational databases and SQL commands, including different syntax elements, data types, and constraints.

Chapter 3, "Structuring Your Data"
: Provides the command reference for SQL statements that `CREATE`, `ALTER`, and `DROP` the various objects you might find in a relational database, such as tables, views, and schemas. The commands described here for defining data structures are collectively referred to as *Data Definition Language* (DDL) statements.

Chapter 4, "Reading Your Data"
: Discusses the glorious `SELECT` statement and all of the optional clauses and keywords relevant to reading data. From subqueries and joins to cursors and common table expressions (CTEs), this chapter goes deep into the single most frequently used SQL statement.

Chapter 5, "Manipulating Your Data"
: Provides details on SQL statements used to manipulate data within a given database. These are collectively referred to as *Data Manipulation Language* (DML) statements; they include `INSERT`, `UPDATE`, `DELETE`, `MERGE`, and `TRUNCATE` as well as `SELECT` (discussed in Chapter 4).

Chapter 6, "Securing Your Data"
: Details the ways to control access to and provide security for data using the *Data Control Language* (DCL) statements of the SQL standard: `GRANT`, `REVOKE`, `SET`, and a few others.

Chapter 7, "SQL Built-in Functions"
: Covers the full scope of built-in functions, both those detailed in the SQL standard and those provided by the database platforms covered in the book. From data-handling functions to data type conversion functions to string manipulation functions, they're all here.

Chapter 8, "SQL Built-in Aggregate and Window Functions"
: Details the use and handling of two of the most important and powerful components of SQL code. Aggregate functions provide the capability to sum, average, find minimum and maximum values, and more. Window functions are functions that use values from one or more records, returning a value for each row, and are characterized by the use of the `OVER` clause. This is in contrast to aggregate functions, which return a single value for multiple rows.

Chapter 9, "Storing Logic in the Database"
: Gives an overview of important aspects of SQL code used to write stored procedures, triggers, and user-defined functions. In this chapter you will find details on conditional control, variable handling, subroutines, and other aspects of developing database-dependent code.

Chapter 10, "Flexible and Schemaless"
: Offers a quick introduction to handling JSON and XML data in relational databases.

Appendix
: Provides a comprehensive list of keywords declared by the SQL standard and by the various database platforms covered in this book. You can use this as a reference to look for words that you should not use for object or variable names.

How to Use This Book

SQL in a Nutshell, 4th edition, is primarily a command reference. As a consequence, you'll probably use it to look up a variety of SQL commands and functions. However, with documentation for the SQL standard itself plus four database platforms, the description for each command has the potential to get very large.

In an attempt to reduce redundant verbiage describing each command and its variants across the various database platforms, the book compares each platform's implementation to the SQL standard that is current at the time of writing. If the platform supports a clause as described in the SQL discussion, we won't repeat that clause again in the section(s) describing the vendor implementations of the SQL standard.

Generic and transportable examples are provided for each SQL statement. Platform-specific examples are given only in the event that at least one RDBMS discussed in the book supports the command, which is not always the case as the SQL standard usually precedes implementation by database platforms. Examples that highlight unique extensions and enhancements of the different platforms, of which there are many, are provided.

We recognize that our approach may necessitate jumping from a description of a platform's implementation of a command back to the description of the SQL standard syntax and implementation details. However, we felt that this was preferable to bulking up the book with hundreds of pages of redundant content.

Resources

This book strives to deliver an up-to-date and comprehensive discussion of the SQL standard and its implementation by the leading database platforms. This, however, is a big task, and it's a lot like shooting at a moving target. While the book contains decades' worth of useful information, you may wish to check with a specific database platform vendor for the latest details. The following websites provide additional information about the various platforms covered in this book:

MySQL and MariaDB
: The MySQL website and MySQL 8.0 Reference Manual are both good resources, as is the MariaDB documentation.

PostgreSQL
: The PostgreSQL website makes a great deal of useful information available for download, and also maintains mailing lists for PostgreSQL users. The documentation for the latest major stable release of PostgreSQL and the documentation for the upcoming release are both good resources.

Oracle
: Oracle's website has a great resource for hardcore Oracle users, as well as all the Oracle documentation.

SQL Server
: The official Microsoft SQL Server website and the SQL Server documentation includes full documentation for SQL Server and its cloud counterpart, Azure SQL.

Changes in the Fourth Edition

One of the biggest reasons to release a new edition of a technology book is because the technology has progressed. Since the third edition of this book was published, three new versions of the ANSI/ISO standard have been published, and the database platforms it covers have each delivered at least two major releases. Consequently, our readers want fresh content on the latest versions of SQL in the marketplace today.

Here are some additional details about changes in this fourth edition:

Improved navigation
: Previous editions of this book grouped all SQL commands into a single chapter. As the book grew over the years, the chapter covering SQL commands became difficult to navigate. As a result, this latest edition now features multiple chapters broken out by traditional categories of the SQL standard to make navigation easier.

Programming basics
: While previous editions showed you how to program a stored procedure, trigger, or other SQL module, the fourth edition includes a full chapter dedicated to writing structured procedural code on Oracle, SQL Server, MySQL, MariaDB, and PostgreSQL. The syntax for keywords like `IF` statements and `WHILE` loops is not actually part of the SQL standard, but these are part of the everyday life of DBAs and developers. Therefore, it made sense to give readers a good overview of how to perform this aspect of SQL coding.

Greater breadth
: SQL is the lingua franca of data and databases. In some ways, it is analogous to the way in which the English language is the most popular *second* language in the world. Across the globe, English is often the first language a person learns after their native tongue. In the same way, there are a multitude of popular programming languages that allow developers to do great work, yet they all embed SQL code within to communicate with the database backend.

More examples
: It's impossible to have too many examples. We've added to our already large set of basic examples, including more sample code that highlights the unique and powerful capabilities of the SQL standard and the extensions offered by each database platform. In addition, this version includes examples that showcase the functionality introduced in the newer SQL standards, such as JSON support.

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic
: Used to introduce new terms, for emphasis, for filenames and file extensions, and for user/group/role names; used to indicate programming elements such as commands, functions, data types, variables, and values; and used to display the names of database objects such as tables, columns, and schemas.

`UPPERCASE CONSTANT WIDTH`
: Used to indicate SQL keywords when they appear in the text.

`Constant width`
: Used to indicate programming syntax, code fragments, and examples.

`Constant width italic`
: Used to indicate variables in code that should be replaced with user-supplied values.

`Constant width bold`
: Used in code sections to highlight portions of the code and in examples to distinguish input from results.

This element signifies a tip or suggestion.

This element signifies a general note.

This element indicates a warning or caution.

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Kevin E. Kline's Acknowledgments

Many people helped deliver the big, thick book you hold in your hands. This note expresses my appreciation to those who helped make this book a reality.

First of all, a big thanks to my two awesome coauthors, Regina and Leo. It has been such a pleasure to work with you on this massive project. Your expertise, tenacity,

and professionalism have made this entire endeavor possible. I am grateful for you and appreciate you so much!

Here's a dedication to my beloved—Rachel. From a small seed planted so many years ago, our tree of love and joy has grown taller and broader than I could have ever expected. More precious than jewels and more valuable than rubies, your love restores my heart and my faith daily.

Regina Obe and Leo Hsu's Acknowledgments

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A tremendous thanks to Evelyn Nunez, who painstakingly reviewed some of the new chapters, correcting our numerous mistakes and adding in missing information.

We thank our own Caitlin O'Nan, who has been our employee for countless years. She reviewed the manuscript, bringing her SQL and programming expertise to the book. If anyone can catch our flaws, Caitlin is the one.

Finally, we thank Kevin for inviting us to coauthor with him. The quote "We stood on the shoulders of a giant" comes to mind. Needless to say, this fourth edition would not have been possible without his work on the prior three editions.

1

SQL History and Implementations

In the early 1970s, the seminal work of IBM research fellow Dr. E. F. Codd led to the development of a relational data model product called SEQUEL, or *Structured English Query Language*. SEQUEL ultimately became SQL, the *Structured Query Language*. Ironically, the SQL standard treats "SQL" as the name of this language and not as an acronym. Jim Melton, longtime editor of the SQL standard, claims that if SQL is an acronym, it stands for "SQL Query Language."

IBM, along with other relational database vendors, wanted a standardized method for accessing and manipulating data in a relational database. Although IBM was the first to develop relational database theory, Oracle was first to market the technology. Over time, SQL proved popular enough in the marketplace to attract the attention of the American National Standards Institute (ANSI) in cooperation with the International Standards Organization (ISO), which released standards for SQL in 1986, 1989, 1992, 1999, 2003, 2008, 2011, 2016, and 2019.

Since 1986, various competing languages have allowed developers to access and manipulate relational data. However, few were as easy to learn or as universally accepted as SQL. Developers and administrators now have the benefit of being able to learn a single language that, with minor adjustments, is applicable to a wide variety of database platforms, applications, and products.

SQL in a Nutshell, 4th edition, provides the syntax for five common implementations of SQL:

- The ANSI/ISO SQL standard (SQL:2016)
- MySQL 8 and MariaDB 10.5
- Oracle Database 19c

- PostgreSQL 14
- Microsoft SQL Server 2019

The Relational Model and ANSI SQL

Relational database management systems (RDBMSs) such as those covered in this book are the primary engines of information systems worldwide, and particularly of web applications and distributed client/server computing systems. They enable a multitude of users to quickly and simultaneously access, create, edit, and manipulate data without impacting other users. They also allow developers to write useful applications to access their resources and provide administrators with the capabilities they need to maintain, secure, and optimize organizational data resources.

An RDBMS is defined as a system whose users view data as a collection of tables related to each other through common data values. Data is stored in tables, which are composed of rows and columns. Tables of independent data can be linked (or *related*) to one another if they each have unique, identifying columns of data (called *keys*) that represent data values held in common. E. F. Codd first described relational database theory in his landmark paper “A Relational Model of Data for Large Shared Data Banks,” published in the *Communications of the ACM* (Association for Computing Machinery) in June 1970. Under Codd’s new relational data model, data was *structured* (into tables of rows and columns); *manageable* using operations such as selections, projections, and joins; and *consistent* as the result of integrity rules such as keys and referential integrity. These terms and their definitions were based upon earlier mathematical concepts—in particular, relational algebra—and as such are fully provable theorems. Codd also articulated rules that governed how a relational database should be designed. The process for applying these rules is now known as *normalization*.

Codd’s Rules for Relational Database Systems

Codd applied rigorous mathematical theories (primarily relational algebra and set theory) to the management of data, from which he compiled a list of criteria a database must meet to be considered relational. Cobb, at least in part, set forth his 12 principles to constrain the overenthusiastic marketing verbiage of the many vendors of every remotely DBMS-like product who wanted to claim to be “relational.” In fact, Cobb was so emphatic about these principles of relational databases as a mechanism of anti-hype that he further laid out an important foundational principle he called Rule 0:

> Rule 0: For any system that is advertised as, or claimed to be, a relational database management system, that system must be able to manage databases entirely through its relational capabilities.

At its core, the relational database concept centers around storing data in tables. This concept is now so common as to seem trivial; however, it's only since the 1980s that the idea of designing a system capable of sustaining the relational model has not been considered a long shot with limited usefulness.

Following are Codd's *Twelve Principles of Relational Databases*:

1. Information is represented logically in tables.
2. Data must be logically accessible by table, primary key, and column.
3. Null values must be uniformly treated as "missing information," not as empty strings, blanks, or zeros.
4. Metadata (data about the database) must be stored in the database just as regular data is.
5. A single language must be able to define data, views, integrity constraints, authorization, transactions, and data manipulation.
6. Views must show the updates of their base tables and vice versa.
7. A single operation must be available to do each of the following operations: retrieve data, insert data, update data, or delete data.
8. Batch and end-user operations are logically separate from physical storage and access methods.
9. Batch and end-user operations can change the database schema without having to re-create it or the applications built upon it.
10. Integrity constraints must be available and stored in the metadata, not in an application program.
11. The data manipulation language of the relational system should not care where or how the physical data is distributed and should not require alteration if the physical data is centralized or distributed.
12. Any row processing done in the system must obey the same integrity rules and constraints that set-processing operations do.

While these rules do not apply to application development, they continue to be the litmus test used to validate the "relational" characteristics of a database platform; a database that does not meet all of these rules is not fully relational. Currently, most commercial RDBMS products pass Codd's test, and all the platforms discussed in the reference material of *SQL in a Nutshell*, 4th edition, satisfy these requirements. The standard also specifies support for handling non-relational formats like JSON and XML; we'll discuss this in Chapter 10.

Understanding Codd's principles assists developers in the proper development and design of relational databases (RDBs). The following sections detail how some of these requirements are met within SQL using RDBs.

Data structures (rules 1, 2, 8, and 9)

Codd's rules 1 and 2 state that "information is represented logically in tables" and that "data must be logically accessible by table, primary key, and column." So, the process of defining a table for a relational database does not require that programs instruct the database how to interact with the underlying physical data structures. Furthermore, SQL logically isolates the processes of accessing data and physically maintaining that data, as required by rules 8 and 9, which state that batch and end-user operations "are logically separate from physical storage and access methods" and "can change the database schema without having to re-create it or the applications built upon it."

In the relational model, data is shown logically as a two-dimensional *table* that describes a single entity (for example, business expenses). Academics refer to tables as *entities* and to columns as *attributes*. Tables are composed of *rows*, or *records* (academics call them *tuples*), and *columns* (called *attributes*, since each column of a table describes a specific attribute of the entity). The intersection of a record and a column provides a single *value*. However, it is quite common to hear this referred to as a *field*, from spreadsheet parlance. The column or columns whose values uniquely identify each record can act as a *primary key*. These days this representation seems elementary, but it was actually quite innovative when it was first proposed.

The SQL standard defines a whole data structure hierarchy beyond simple tables, though tables are the core data structure. Relational design handles data on a table-by-table basis, not on a record-by-record basis. This table-centric orientation is the heart of set programming. Consequently, almost all SQL commands operate much more efficiently against sets of data within or across tables than against individual records. Said another way, effective SQL programming requires that you think in terms of sets of data, rather than of individual rows.

Figure 1-1 is a description of SQL's terminology used to describe the hierarchical data structures used by a relational database: *catalogs* contain sets of *schemas*; *schemas* contain sets of *objects*, such as *tables* and *views*; and *tables* are composed of sets of *columns* and *records*.

For example, in a *Business_Expense* table, a column called *Expense_Date* might show when an expense was incurred. Each record in the table describes a specific entity; in this case, everything that makes up a business expense (when it happened, how much it cost, who incurred the expense, what it was for, and so on).

Each attribute of an expense—in other words, each column—is supposed to be *atomic*; that is, each column is supposed to contain one, and only one, value. If a table is constructed in which the intersection of a row and column can contain more than one distinct value, one of SQL's primary design guidelines has been violated. (That said, some of the database platforms discussed in this book do allow you to place more than one value into a column, via the `VARRAY` or `TABLE` data types or, more commonly in the last several years, `XML` or `JSON` data types.)

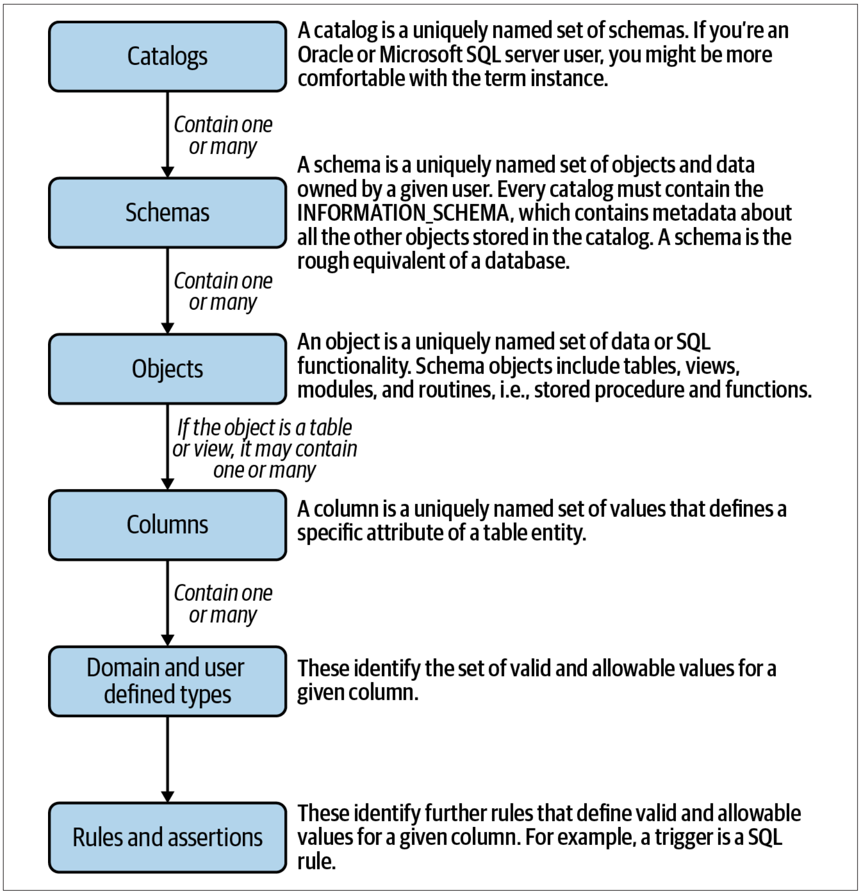
Catalogs
A catalog is a uniquely named set of schemas. If you're an Oracle or Microsoft SQL server user, you might be more comfortable with the term instance.
Contain one or many
Schemas
A schema is a uniquely named set of objects and data owned by a given user. Every catalog must contain the INFORMATION_SCHEMA, which contains metadata about all the other objects stored in the catalog. A schema is the rough equivalent of a database.
Contain one or many
Objects
An object is a uniquely named set of data or SQL functionality. Schema objects include tables, views, modules, and routines, i.e., stored procedure and functions.
If the object is a table or view, it may contain one or many
Columns
A column is a uniquely named set of values that defines a specific attribute of a table entity.
Contain one or many
Domain and user defined types
These identify the set of valid and allowable values for a given column.
Rules and assertions
These identify further rules that define valid and allowable values for a given column. For example, a trigger is a SQL rule.

Figure 1-1. SQL dataset hierarchy

Rules of behavior are specified for column values. Foremost is that column values must share a common *domain*, better known as a *data type*. For example, if the *Expense_Date* field is defined as having a `DATE` data type, the value `ELMER` cannot be placed into that field because it is a string, not a date, and the *Expense_Date* field can contain only dates. In addition, the SQL standard allows further control of column values through the application of *constraints* (discussed in detail in Chapter 2) and *assertions*. A SQL constraint might, for instance, check to ensure when inserting a new expense record that its *Expense_Date* value is no more than 90 days old, matching the company policy for expense reporting.

Additionally, data access for all individuals and computer processes is controlled at the schema level by an *AuthorizationID* or *user*. Permissions to access or modify specific sets of data may be granted or restricted on a per-user basis.

SQL databases also employ *character sets* and *collations*. Character sets are the "symbols" or "alphabets" used by the "language" of the data. For example, the

American English character set does not contain the special character for *ñ* in the Spanish character set. Collations are sets of sorting rules that operate on a character set. A collation defines how a given data manipulation operation sorts data. For example, an American English character set might be sorted either by *character-order, case-insensitive*, or by *character-order, case-sensitive*.

The SQL standard does not say how data should be sorted, only that platforms must provide common collations found in a given language.

It is important to know what collation you are using when writing SQL code against a database platform, as it can have a direct impact on how queries behave, and particularly on the behavior of the clauses of a `SELECT` statement, such as `WHERE`, `ORDER BY`, `GROUP BY`, and `PARTITION BY`. For example, a query that sorts data using a binary collation will return data in a very different order than one that sorts data using, say, a Swedish collation. This is also very important when migrating SQL code between database platforms since their default sorting behavior may vary widely. For example, Oracle is normally case-sensitive, while Microsoft SQL Server is not. Moving an unmodified query from Oracle to SQL Server might therefore produce a wildly different result set because Oracle will evaluate values like "Halloween" and "HALLOWEEN" as unequal, whereas SQL Server will see them as equal by default.

NULLs (rule 3)

Most databases allow any of their supported data types to store NULL values. Inexperienced SQL developers tend to think of NULL values as zero-length strings, but in SQL NULL literally means that the value is unknown or indeterminate. (This question alone—whether NULL should be considered unknown or indeterminate—is the subject of much academic debate.) This differentiation enables a database designer to distinguish between those entries that represent a deliberately placed zero, for example, and those where either the data is not recorded in the system or a NULL has been explicitly entered. As an illustration of this semantic difference, consider a system that tracks payments. If a product has a NULL price, that does not mean the product is free; instead, a NULL price indicates that the amount is not known or perhaps has not yet been determined.

There is a good deal of differentiation between the database platforms in terms of how they handle NULL values. This leads to some major porting issues relating to these values. For example, an empty string (i.e., a NULL string) is inserted as a NULL value on Oracle. All the other databases covered in this book permit the insertion of an empty string into `VARCHAR` and `CHAR` columns.

One side effect of the indeterminate nature of a NULL value is that it cannot be used in a calculation or a comparison. Here are a few brief but very important rules, from the ANSI/ISO standard, to remember about the behavior of NULL values when dealing with NULLs in SQL statements:

- A NULL value cannot be inserted into a column defined with the `NOT NULL` constraint.
- NULL values are not equal to each other. It is a frequent mistake to compare two columns that contain NULL and expect the NULL values to match. (The proper way to identify a NULL value in a `WHERE` clause or in a Boolean expression is to use phrases such as "value IS NULL" and "value IS NOT NULL".)
- A column containing a NULL value is ignored in the calculation of aggregate values such as `AVG`, `SUM`, or `MAX COUNT`.
- When columns that contain NULL values are listed in the `GROUP BY` clause of a query, the query output contains a single row for NULL values. In essence, the ANSI/ISO standard considers all NULLs found to be in a single group.
- `DISTINCT` and `ORDER BY` clauses, like `GROUP BY`, also see NULL values as indistinguishable from each other. With the `ORDER BY` clause, the vendor is free to choose whether NULL values sort high (first in the result set) or sort low (last in the result set) by default. Some database vendors allow you to define how NULL values are sorted on a per-query basis using the `NULL FIRST` or `NULL LAST` keywords.

Metadata (rules 4 and 10)

Codd's fourth rule for relational databases states that data about the database must be stored in standard tables, just as all other data is. Data that describes the database itself is called *metadata*. For example, every time you create a new table or view in a database, records are created and stored that describe the new table. Additional records are needed to store any columns, keys, or constraints on the table. This technique is implemented in most commercial and open source SQL database products. For example, SQL Server uses what it calls "system tables" to track all the information about the databases, tables, and database objects in any given database. It also has "system databases" that keep track of information about the server on which the database is installed and configured.

In addition to system tables, the SQL standard defines a set of basic metadata available through a widely adopted set of views stored in a special schema called `INFORMATION_SCHEMA`. Notably, Oracle (since 2015) and IBM DB2 do not support this schema. Operationally, this should not pose a problem for you since there are open source scripts to map Oracle database catalog views to the SQL standard `INFORMATION_SCHEMA` format.

The Language (Rules 5 and 11)

Codd's rules do *not* require SQL to be used with a relational database. His rules, particularly rules 5 and 11, only specify how the language should behave when coupled with a relational database. At one time SQL competed with other languages (such as Digital's RDO and Fox/PRO) that might have fit the relational bill, but SQL won out for three reasons. First, SQL is a relatively simple, intuitive, English-like language that handles most aspects of data manipulation. If you can read and speak English, SQL simply makes sense. Second, SQL is satisfyingly high-level. A developer or database administrator (DBA) does not have to spend time ensuring that data is stored in the proper memory registers or that data is cached from disk to memory; the database management system (DBMS) handles that task automatically. Finally, because no single vendor owns SQL it was adopted across a number of platforms, ensuring broad support and wide popularity.

Views (rule 6)

A *view* is a virtual table that does not exist as a physical repository of data, but is instead constructed on the fly from a `SELECT` statement whenever that view is queried. Views enable you to construct different representations of the same source data for a variety of audiences without having to alter the way in which the data is stored.

> Some vendors support database objects called *materialized views*, also known as *indexed views*. Don't let the similarity of these terms confuse you; materialized views are not governed by the same rules as SQL standard views.

Set operations (rules 7 and 12)

Other database manipulation languages, such as Ruby on Rails, Django, and LINQ for .NET, perform their data operations quite differently from SQL. These languages require you to tell the program exactly how to treat the data, one record at a time. Since the program iterates down through a list of records, performing its logic on one record after another, this style of programming is frequently called *row processing* or *procedural programming*.

In contrast, SQL programs operate on logical *sets* of data. Set theory is applied in almost all SQL statements, including `SELECT`, `INSERT`, `UPDATE`, and `DELETE` statements. In effect, data is selected from a set called a "table." Unlike the row-processing style, *set processing* allows a programmer to tell the database simply *what* is required, not *how* each individual piece of data should be handled. Sometimes set processing is referred to as *declarative processing* since a developer declares only what data is wanted (as in the declaration, "Return all employees in the southern region who earn more than $70,000 per year") rather than describing the exact steps used to retrieve or manipulate the data.

Set theory was the brainchild of mathematician Georg Cantor, who developed it at the end of the 19th century. At the time, set theory (and Cantor's theory of the infinite) was quite controversial. Today, set theory is such a common part of life that it is learned in elementary school. Things like the selection catalogs for your favorite movie streaming service, online console gaming services, and popular music applications are all simple and common examples of applied set theory.

Relational databases use relational algebra and tuple relational calculus to mathematically model the data in a given database and queries acting upon that data. These theories were also introduced by E. F. Codd, along with his 12 rules for relational databases.

Examples of set theory in conjunction with relational databases are detailed in the following section.

Codd's Rules in Action: Simple SELECT Examples

Up to this point, this chapter has focused on the individual aspects of a relational database platform as defined by Codd and implemented under the SQL standard. This section presents a high-level overview of the most important SQL statement, `SELECT`, and some of its most salient points—namely, the following three relational operations:

Projections
  Retrieve specific columns of data.

Selections
  Retrieve specific rows of data.

Joins
  Return columns and rows from two or more tables in a single result set.

Although at first glance it might appear as though the `SELECT` statement deals only with the relational selection operation, in actuality, `SELECT` deals with all three operations.

The following statement embodies the projection operation by selecting the first and last names of an author, plus their home state, from the *authors* table:

```
SELECT au_fname, au_lname, state
FROM   authors;
```

The results from any such `SELECT` statement are presented as another table of data:

```
au_fname             au_lname                             state
---------------- ---------------------------- ----------------
Johnson              White                                CA
Marjorie             Green                                CA
Cheryl               Carson                               CA
```

```
Michael          O'Leary                              CA
Meander          Smith                                KS
Morningstar      Greene                               TN
Reginald         Blotchet-Halls                       OR
Innes            del Castillo                         MI
```

The resulting data is sometimes called a *result set*, *work table*, or *derived table*, differentiating it from the *base table* in the database that is the target of the SELECT statement.

It is important to note that the relational operation of projection, not selection, is specified using the SELECT clause (that is, the keyword SELECT followed by a list of expressions to be retrieved) of a SELECT statement. Selection—the operation of retrieving specific rows of data—is specified using the WHERE clause in a SELECT statement. WHERE filters out unwanted rows of data and retrieves only the requested rows. Continuing with the previous example, the following statement selects authors from states other than California:

```
SELECT au_fname, au_lname, state
FROM   authors
WHERE  state <> 'CA';
```

Whereas the first query retrieved all authors, the result of this second query is a much smaller set of records:

```
au_fname         au_lname                            state
---------------- ----------------------------------- -------------
Meander          Smith                               KS
Morningstar      Greene                              TN
Reginald         Blotchet-Halls                      OR
Innes            del Castillo                        MI
```

Different vendors allow you to join varying numbers of tables in a single query. Whereas older database platforms allowed no more than 256 joins within a given query, today most database platforms are limited only by available system resources.

However, keep in mind that your database engine will consume more system resources and incur more latency the more tables you join in a single query. For example, a single SELECT statement joining 12 tables will have to consider up to 28,158,588,057,600 possible join orders.

Today's database query optimizers are very sophisticated and employ cost-based optimizations and heuristics to make performing queries involving a dozen or more joins a manageable task. However, many experienced SQL developers try to limit their SELECT statements to 16 or fewer joins in order to keep the query's logic easy to understand. In other situations, experienced SQL developers might use alternative coding practices, such as common table expressions (CTEs), temporary tables, or subqueries, to achieve good performance.

By combining the capabilities of projection and selection in a single query, you can use SQL to retrieve only the columns and records that you need at any given time.

Joins are the next, and last, relational operation covered in this section. A join relates one table to another in order to return a result set consisting of related data from both tables.

The ANSI/ISO standard method of performing joins is to use the `JOIN` clause in a `SELECT` statement. An older method, sometimes called a *theta join*, analyzes the join search argument in the `WHERE` clause. The following example shows both approaches. Each statement retrieves employee information from the *employee* base table as well as job descriptions from the *jobs* base table. The first `SELECT` uses the newer ANSI/ISO SQL `JOIN` clause, while the second `SELECT` uses a theta join:

```
-- ANSI/ISO style
SELECT a.au_fname, a.au_lname, t.title_id
FROM   authors AS a
JOIN   titleauthor AS t ON a.au_id = t.au_id
WHERE  a.state <> 'CA';

-- Theta style
SELECT a.au_fname, a.au_lname, t.title_id
FROM   authors AS a,
       titleauthor AS t
WHERE  a.au_id = t.au_id
   AND a.state <> 'CA';
```

Although theta joins are universally supported across the various platforms and incur no performance penalty, this is considered an inferior coding pattern because anyone reading or maintaining the query cannot immediately discern the arguments used to define the join condition from those used as filtering conditions.

There are more issues with theta joins than ease of readability. For example, Oracle allows only one outer join comparison using (+), which can be quite a problem when logically constructing an outer join on a multicolumn key. In a situation like this, it can be difficult to avoid syntax errors or even retrieving the wrong result set.

For more information about joins, see the "JOIN Subclause" on page 278.

History of the SQL Standard

In response to the proliferation of SQL dialects, ANSI published its first SQL standard in 1986 to bring about greater conformity among vendors. This was approved by the ISO in 1987 and followed by a second, widely adopted standard in 1989 (also approved by the ISO). ANSI/ISO released their first joint update in 1992, known as SQL2, SQL-92, or SQL:1992, and a second in 1999, termed SQL3, SQL-99, or SQL:1999. The next update, made in 2003, is referred to as SQL:2003 and so on.

Between the release of SQL:1992 and the development of SQL:1999, the SQL draft specifications were divided into SQL3 and SQL4. However, the SQL4 draft was pruned, and the SQL3 draft was adopted as SQL:1999. After this point, the names of the SQL standards transitioned permanently to the SQL:*yyyy* designation.

Each revision of the SQL standard, officially known as ISO/IEC 9075 Database Language SQL, adds new features and incorporates new commands and capabilities into the language. Here is a brief list of the releases and some of their major contributions (features or specifications):

SQL-87
: Standard first formalized by ANSI; support for transactions and `CREATE`, `READ`, `UPDATE`, and `DELETE` operations

SQL-89
: Minor revision, added referential integrity constraints

SQL-92
: Major revision (ISO 9075), added support for internationalization, etc.

SQL:1999
: Added support for user-defined types, regular expression mapping, triggers, procedural and control-flow statements, and more

SQL:2003
: Added support for XML and OLAP (window functions), sampling, and enhanced numeric functions

SQL:2006
: Clarified how SQL and SML interact and added support for XQuery

SQL:2008
: Incorporated various improvements and enhancements that had been made in several of the most prominent RDBMS platforms (`INSTEAD OF` triggers, `TRUNCATE` statement, `FETCH` clause, etc.) and expanded the XML specification

SQL:2011
: Introduced new features for managing temporal data

SQL:2016
: Described how SQL interacts with JavaScript Object Notation (JSON) and added support for polymorphic table functions and row pattern matching

SQL:2019
: Described how SQL interacts with multidimensional arrays (MDAs)

The capabilities added in SQL:2019 and the planned SQL/PGQ (Graph Query Language) extension are not yet supported in the products considered in this edition of *SQL in a Nutshell*, so our coverage in this book extends only to SQL:2016. SQL:2019 coverage will come in future editions.

Levels of Conformance

SQL-92 introduced three *levels of conformance* indicating degrees of compliance with the standard: *Entry*, *Intermediate*, and *Full* (the U.S. National Institute of Standards and Technology later added a *Transitional* level between the first two). Vendors had to achieve at least Entry-level conformance to claim ANSI/ISO SQL compliance. Each higher level of the standard was a superset of the subordinate level, meaning that each higher level included all the features of the lower levels of conformance.

Later, SQL:1999 altered the base levels of conformance, doing away with the original three categories. Instead, it required vendors to implement a minimum set of mandatory features collectively called "Core SQL" in order to claim (and advertise) that they are SQL:1999 compliant. This included the old Entry Level SQL-92 feature set, features from other SQL-92 levels, and some new features. Vendors could also opt to implement additional parts of the standard, described in the next section.

Parts of the SQL Standard

Since SQL:1999, the SQL standard has been divided into a set of parts, numbered 1 to 14 (as of SQL:2016). Not all of these were publicly released, and not all achieved widespread adoption. The following list describes the different parts of the standard:

Part 1, SQL/Framework
: Includes common definitions and concepts used throughout the standard. Defines the way the standard is structured and how the various parts relate to one another, and describes the conformance requirements set out by the standards committee.

Part 2, SQL/Foundation
: Includes the Core, the central elements of the language, including both mandatory and optional features. This is the largest and most important part of the standard.

Part 3, SQL/CLI (Call-Level Interface)
: Defines the call-level interface for dynamically invoking SQL statements from external application programs. Also includes more than 60 routine specifications to facilitate the development of truly portable shrinkwrapped software.

Part 4, SQL/PSM (Persistent Stored Modules)
: Standardizes procedural language constructs similar to those found in platform-specific SQL dialects such as PL/SQL and Transact-SQL.

Part 9, SQL/MED (Management of External Data)
: Defines the management of data located outside of the database platform using datalinks and a wrapper interface.

Part 10, SQL/OLB (Object Language Binding)
: Describes how to embed SQL statements in Java programs. It is closely related to JDBC, but offers a few advantages. It is also very different from the traditional host language binding possible in early versions of the standard.

Part 11, SQL/Schemata
: Defines over 85 views used to describe the metadata of each database and stored in a special schema called `INFORMATION_SCHEMA`.

Part 13, SQL/JRT (Java Routines and Types)
: Defines a number of SQL routines and types using the Java programming language. Several features of Java, such as Java static methods and classes, are supported.

Part 14, SQL/XML
: Adds a new type called `XML`, four new operators (`XMLPARSE`, `XMLSERIALIZE`, `XMLROOT`, and `XMLCONCAT`), several new functions (described in Chapter 7), and the new `IS DOCUMENT` predicate. Also includes rules for mapping SQL-related elements (like identifiers, schemas, and objects) to XML-related elements.

There is also a Part 15, SQL/MDA, which, as mentioned earlier, first appeared in 2019 and is'nt included in the SQL:2016 standard. Note that Parts 5–8 and Part 12 were not released to the public by design. Parts 5 and 8 were originally defined within Part 2, SQL/Foundation, then split out, but were later merged back into the same part. Parts 7 and 12 were canceled due to lack of progress, and the key requirement for Part 7, temporal support, was ultimately added to Part 2 in SQL:2011.

The SQL standard, which covers retrieval, manipulation, and management of data, formalizes many SQL behaviors and syntax structures across a variety of platforms. This standard has become even more important as open source database products, such as MySQL and PostgreSQL, have grown in popularity and begun being developed by virtual teams rather than large corporations.

Be aware that an RDBMS platform may claim SQL compliance by meeting the basic Core SQL:1999 standards, so read the vendor's fine print for a full description of its ANSI/ISO conformity. An understanding of the various parts of the standard will help you get a clearer idea of the capabilities of a particular RDBMS and of how different features might behave when SQL code is transported to other database products.

This book details the SQL implementations of four popular RDBMSs. These vendors do not fully support everything defined in the SQL standard; all RDBMS platforms play a constant game of tag with the standards bodies, which often update, refine, or otherwise change the benchmark as soon as vendors start to close in on the standard. Conversely, the vendors often implement new features that are not yet a part of the standard but that boost the effectiveness of their users.

SQL Statement Classes

SQL-92 grouped statements into three broad categories:

Data Manipulation Language (DML)
: Provides specific data-manipulation commands such as `SELECT`, `INSERT`, `UPDATE`, and `DELETE`

Data Definition Language (DDL)
: Includes commands that handle the accessibility and manipulation of database objects, such as `CREATE` and `DROP`

Data Control Language (DCL)
: Includes permission-related commands such as `GRANT` and `REVOKE`

In contrast, SQL:1999 and later define seven core categories, or *classes*, that provide a general framework for the types of commands available in SQL. This new framework attempts to identify the statements within each class more accurately and logically, and provides for the development of new features and statement classes. It also allowed some "orphaned" statements that did not fit well into any of the old categories to be properly classified.

Table 1-1 identifies the SQL statement classes and lists some of the commands in each class, each of which is fully discussed later. At this point, the key is to remember the statement class titles.

Table 1-1. SQL statement classes

Class	Description	Example commands
Connection statements	Start and end a client connection.	`CONNECT`, `DISCONNECT`
Control statements	Control the execution of a set of SQL statements.	`CALL`, `RETURN`
Data statements	May have a persistent and enduring effect upon data.	`SELECT`, `INSERT`, `UPDATE`, `DELETE`
Diagnostic statements	Provide diagnostic information and raise exceptions and errors.	`GET DIAGNOSTICS`
Schema statements	May have a persistent and enduring effect on a database schema and objects within that schema.	`ALTER`, `CREATE`, `DROP`
Session statements	Control default behavior and other parameters for a session.	`SET` statements like `SET CONSTRAINT`
Transaction statements	Set the starting and ending points of a transaction.	`COMMIT`, `ROLLBACK`

Those who work with SQL regularly should become familiar with both the old (SQL-92) and the new (SQL:1999 and later) statement classes since both nomenclatures are still used to refer to SQL features and statements.

SQL Dialects

The constantly evolving nature of the SQL standard has given rise to a number of SQL *dialects* among the various vendors and platforms. These dialects commonly evolved because a given database vendor's users requested that new capabilities be added to the database before (sometimes many years before) the ANSI/ISO committees drafted the applicable standards. Occasionally, the academic or research communities also introduced new features in response to pressures from competing technologies. For example, many database vendors have augmented their current programmatic offerings with JSON and XML, or found other ways to offer features found in non-relational database platforms (Chapter 10 discusses how to use XML and JSON to store and query non-relational data in a relational database).

Many of these dialects include conditional processing capabilities (such as those that control processing through `IF ... THEN` statements), control-of-flow functions (such as `WHILE` loops), variables, and error-handling capabilities. Because the ANSI/ISO committees had not yet developed standards for these important features at the time users began to demand them, RDBMS vendors created their own commands and syntax. In fact, some of the earliest vendors from the 1980s have variances in the most elementary commands, such as `SELECT`, because their implementations predate the standards. When attempting to create SQL code that is interoperable across database platforms, keep in mind that your mileage may vary.

Part 4 of the standard provides many features associated with programming stored procedures and incorporates many of the extensions offered by these dialects.

Some popular dialects of SQL include:

PL/pgSQL
The SQL dialect and extensions implemented in PostgreSQL. The acronym stands for Procedural Language/PostgreSQL.

PL/SQL
Oracle's procedural extension to SQL. PL/SQL stands for Procedural Language/SQL; this dialect bears many similarities to the language Ada.

SQL/PSM
An extension of SQL with a procedural language for use in stored procedures. MySQL, MariaDB, and PostgreSQL implement the SQL/Persistent Stored Module of the Core SQL standard. MariaDB also supports PL/SQL.

Transact-SQL
: Used by both Microsoft SQL Server and Sybase Adaptive Server, now owned by SAP. As Microsoft and SAP/Sybase have moved away from the common platform they shared in the early 1990s, their implementations of Transact-SQL have also diverged widely, but the most basic commands are still very similar.

Users who plan to work extensively with a single database system should learn the intricacies of their preferred SQL dialect or platform.

NoSQL

There are many non-relational database platforms that have eschewed SQL, commonly known as *NoSQL* databases. These are non-tabular databases designed to satisfy very different requirements than relational databases; they use different data structures, such as key/value pairs, graphs, and documents, facilitating certain kinds of operations. Ironically (given the name), many of the most popular NoSQL offerings do provide some level of support for SQL. For example, users of Apache Hadoop typically solve their query language challenges by using Apache Hive, developed by Facebook, or Apache Pig, developed by Yahoo; Hive supports a significant subset of the SQL standard, and Pig's query language uses SQL-like syntax. Similarly, Cassandra Query Language (CQL), used by the Cassandra NoSQL platform, includes familiar syntax for queries, data manipulation, and data definition.

It may seem counterintuitive, but the reality is that both open source and commercial NoSQL database implementations quickly came to appreciate the market value of SQL. Those who wanted the most rapid path to widespread adoption and the least friction for users getting started with the database learned that adopting SQL gave them access to a wide world of data professionals. So, while NoSQL first entered the lexicon meaning "a non-relational database platform that does not use SQL," today it's understood as "a non-relational database platform that uses *not only SQL*, but other programming languages as well." SQL has impressive staying power, and the skills you learn with this book are likely to outlast your career.

How Do You Say It?

Veterans of the various database platforms covered in this book are known from time to time to argue over whether SQL is best pronounced acronymically, as in "S-Q-L," or phonetically, as in "Sequel." Based on broad experience, the most prevalent usage is to refer to the language and its implementations by the acronym: for example, most Oracle users refer to PL/SQL as "P-L-S-Q-L" and most SQL Server users refer to Transact-SQL as "T-S-Q-L." However, when referring to proper names containing "SQL," it typically takes on its phonetic form: for example, Microsoft users will say "Azure Sequel" and "Sequel Server" when speaking of Azure SQL Database and SQL Server, and MySQL is usually pronounced "MySequel." If you ever want to start a lively conversation (or a heated argument), just tell a database person that they say SQL the wrong way—then watch the sparks fly.

2
Foundational Concepts

SQL provides an easy, intuitive way to interact with a database. While the SQL standard does not define the concept of a "database," it does define all the functions and concepts needed for a user to create, retrieve, update, and delete data. It is important to know the types of syntax in the ANSI/ISO SQL standard and the particular platform-specific syntax guidelines. This chapter will provide you with a grounding in those areas. For brevity, we will refer to the ANSI/ISO standard as simply "SQL" or "the SQL standard" in the remainder of this chapter.

Database Platforms Described in This Book

In this book, we will describe the SQL standard and the platform-specific implementations of several leading RDBMSs:

MySQL/MariaDB
: MySQL is a popular open source DBMS that is known for its ease of use and good performance. It runs on numerous operating systems, including most Linux variants. To improve performance, it has a slimmer feature set than many other DBMSs. Since the purchase of Sun Microsystems by Oracle, the MySQL user base has been split into two factions: users of MySQL (maintained by Oracle) and MariaDB (from the MariaDB Foundation, whose head, Monty Widenius, was the original creator of MySQL). This book covers MySQL 8, now owned by Oracle, and the most popular MySQL fork, MariaDB 10.5. Their functionality is largely equivalent and compatible. Where they deviate most is in the storage engines they support, their compression and encryption features, their release cycles, their geographic information system (GIS) and JSON support, the plug-ins they support, and the speed at which they adopt SQL standards. MariaDB tends to adopt SQL standards faster than MySQL, but this may change in the future. This book highlights key areas where they deviate.

Oracle
: Oracle is a leading RDBMS in the commercial sector. It was the first commercially available SQL database platform, released in the summer of 1979, running on VAX computers as Oracle v2. Since that time, Oracle has grown to run on a multitude of operating systems and hardware platforms. Its scalable, reliable architecture has made it the platform of choice for many users. In this edition we cover Oracle Database 19c, which is the latest long-term support (LTS) release available at the time of writing. The latest feature release (with a limited lifetime for support) is Oracle Database 21c. Note that the way Oracle releases software is a bit different from other databases, with newer features often backported to an LTS version. For example, Oracle has already backported a number of features from Oracle 21c to Oracle 19c.

PostgreSQL
: PostgreSQL is the most feature-rich open source database platform available, and it has seen a strong upward trend in popularity over the last several years. PostgreSQL is best known for its excellent support for ANSI/ISO standards and robust transaction processing capabilities, as well as its rich data type and database object support. In addition to its full set of features, PostgreSQL runs on a wide variety of operating systems and hardware platforms. This book covers PostgreSQL 14.

SQL Server
: Microsoft SQL Server is a popular RDBMS that runs on the Windows and Linux operating systems. Its attractive features include ease of use, an all-inclusive feature set covering Online Transaction Processing (OLTP) and analytic workloads, low cost, and high performance. This book covers Microsoft SQL Server 2019.

Categories of Syntax

To begin to use SQL, readers should understand how statements are written. SQL syntax falls into four main categories, introduced in the following list and then explained in further detail in the sections that follow:

Identifiers
: User- or system-supplied names for database objects, such as databases, tables, constraints on tables, columns in tables, views, etc.

Literals
: User- or system-supplied strings or values that are not identifiers or keywords. Literals may be strings like `'hello'`, numbers like `1234`, dates like `'Jan 01, 2022'`, or Boolean values like `TRUE`.

Operators
: Symbols specifying an action to be performed on one or more expressions, most often in `DELETE`, `INSERT`, `SELECT`, or `UPDATE` statements. Operators are also used frequently in the creation of database objects.

Reserved words and keywords

Words with special meaning to the database SQL parser. *Reserved words* (such as words used in commands and SQL statements) are words that cannot be used as identifiers because they are either currently used or planned to be used directly within syntax structures, and their use as user-defined names would make parsing ambiguous. The term *keywords* is often used to refer to non-reserved words that only have a special meaning in particular contexts and can be used as identifiers in other contexts (though this is still generally best avoided). Elsewhere in the book, we use the term keyword to encompass both reserved and non-reserved words.

Note that you can circumvent the restriction on using reserved words as identifiers by using *delimited identifiers*, the most common delimiters being quote marks (“”) or brackets (*[]*). Non-quote delimiters are unlikely to be incorporated into the SQL standard, but are under consideration for the proposed Graph Query Language (GQL) standard.

Identifiers

In its simplest terms, an identifier is the name of an object you create on your database platform. However, you can create identifiers at a variety of levels within a database. Let’s start at the top. In the terms used in the SQL standard, *catalogs* contain sets of schemas, *schemas* contain sets of objects, and so on. Most database platforms use corollary terms: *instances* contain one or more databases; *databases* contain one or more schemas; and *schemas* contain zero or more tables, views, or stored procedures, and the privileges associated with each object. At each level of this structure, items require unique names (that is, identifiers) so that they can be referenced by applications and system processes. This means that each *object* (whether a database, table, view, column, index, key, trigger, stored procedure, or constraint) in an RDBMS must be identified. When issuing the command that creates a database object, you must therefore specify an identifier (i.e., a name) for that new object.

There are two important categories of rules that experienced developers keep in mind when choosing an identifier for a given item:

Naming conventions

Logical rules of thumb that govern how database designers name objects. Consistently following these rules ultimately creates better database structures and enables improved data tracking. These are not so much SQL requirements as the distilled experience of practiced programmers.

Identifier rules

Naming rules set by the SQL standard and implemented by the platforms. These rules govern characteristics such as how long a name may be. These identifier conventions are covered for each vendor later in this chapter.

Naming conventions

Naming conventions establish a standard baseline for choosing object identifiers. In this section, we present a list of naming conventions (rules for picking your identifiers) that are based on long years of experience. The SQL standard has no comment on naming conventions outside of the uniqueness of an identifier, its length, and the characters that are valid within the identifier. However, here are some conventions that you should follow:

Select a name that is meaningful, relevant, and descriptive
: Avoid names that are encoded, such as a table named *XP21*, and instead use human-readable names like *Expenses_2022*, so that others can immediately know that the table stores expenses for the year 2022. Remember that other developers and DBAs may be maintaining the database objects you create, perhaps long after you have gone, so the names you use should make sense at a glance. Each database vendor has limits on object name size, but names generally can be long enough to make sense to anyone reading them.

Choose and apply the same case throughout
: Use either all uppercase or all lowercase names for all objects throughout the database. Some database servers are case-sensitive, so using mixed-case identifiers might cause problems later. Many object–relational mapping (ORM) products, such as Entity Framework, default to CamelCase notation, but this can cause problems down the road if you need to port your application to a database platform that is case-sensitive. For Oracle you should use all uppercase, and for PostgreSQL use all lowercase.

Use abbreviations and spellings consistently
: Once you've chosen an abbreviation or spelling, use it consistently throughout the database. For example, if you use `EMP` as an abbreviation for `EMPLOYEE`, you should use `EMP` throughout the database; do not use `EMP` in some places and `EMPLOYEE` in others.

Use complete, descriptive, meaningful names with underscores for reading clarity
: A column name like `UPPERCASEWITHUNDERSCORES` is not as easy to read as `UPPERCASE_WITH_UNDERSCORES`.

Do not put company or product names in database object names
: Companies get acquired, and products' names change. These elements are too transitory to be included in database object names.

Do not use overly obvious prefixes or suffixes
: For example, don't use *DB_* as a prefix for a database, and don't prefix every view with *V_*. Simple queries to the system table of the database can tell the DBA or database programmer what type of object an identifier represents.

Do not fill up all available space for the object name

If the database platform allows a 64-character table name, try to leave at least a few free characters at the end. Some database platforms append prefixes or suffixes to table names when manipulating temporary copies of the tables.

Do not use quoted identifiers

Quoted identifiers are object names stored within double quotation marks. (The SQL standard calls these *delimited identifiers*, since the delimiter could be something other than a double quote; SQL Server, for instance, frequently uses square brackets.) These identifiers are always case-sensitive. Furthermore, encapsulating an identifier within double quotes allows the creation of names that may be difficult to use and may cause problems later. For example, users could embed spaces, special characters, or even escape sequences within a quoted identifier, but some third-party tools (and even vendor-supplied tools) cannot handle special characters in names.

There are several benefits to following a consistent set of naming conventions. First, your SQL code becomes, in a sense, self-documenting, because the chosen names are meaningful and understandable to other users. Second, your SQL code and database objects are easier to maintain—especially for other users who come later—because the objects are consistently named. Finally, consistent and descriptive naming will save time and energy if the database ever has to be transferred or migrated to another RDBMS platform. Giving a few minutes of thought to naming SQL objects at the beginning of a project can prevent problems later.

Identifier rules

Identifier rules are rules for identifying objects within the database that are rigidly enforced by the database platforms. These rules apply to normal identifiers, not quoted identifiers. Rules specified by the SQL standard generally differ somewhat from those of specific database vendors. Table 2-1 contrasts the SQL rules with those of the RDBMS platforms covered in this book.

Table 2-1. Platform-specific rules for regular object identifiers (excludes quoted identifiers)

Characteristic	Platform	Specification
Identifier size	SQL	128 characters.
	MySQL	64 characters; aliases may be 255 characters.
	Oracle	128 bytes (the number of characters depends on the character set).
	PostgreSQL	63 characters (`NAMEDATALEN` property minus 1).
	SQL Server	128 characters; temp tables are limited to 116 characters.
Identifier may contain	SQL	Any number or character, and the underscore (_) symbol.
	MySQL	Any number, character, or symbol. Cannot be composed entirely of numbers.

Characteristic	Platform	Specification
	Oracle	Any number or character, and the underscore (_), pound sign (#), and dollar sign ($) symbols (though the last two are discouraged). Database links may also contain a period (.).
	PostgreSQL	Any number or character, and the underscore (_) symbol. Unquoted uppercase characters are equivalent to lowercase.
	SQL Server	Any number or character, and the underscore (_), at sign (@), pound sign (#), and dollar sign ($) symbols.
Identifier must begin with	SQL	A letter.
	MySQL	A letter or number. Cannot be composed entirely of numbers.
	Oracle	A letter.
	PostgreSQL	A letter or underscore (_).
	SQL Server	A letter, underscore (_), at sign (@), or pound sign (#).
Identifier cannot contain	SQL	Spaces or special characters.
	MySQL	A period (.), slash (/), or ASCII 0 (null) or 255 (non-breaking space) character. Single quotes (' ') and double quotes (" ") are allowed only in quoted identifiers. Identifiers should not end with space characters.
	Oracle	Spaces, double quotes (" "), or special characters.
	PostgreSQL	Double quotes (" ").
	SQL Server	Spaces or special characters.
Allows quoted identifiers	SQL	Yes.
	MySQL	Yes.
	Oracle	Yes.
	PostgreSQL	Yes.
	SQL Server	Yes.
Quoted identifier symbol	SQL	Double quotes (" ").
	MySQL	Single quotes (' ') or double quotes (" ") in ANSI compatibility mode.
	Oracle	Double quotes (" ").
	PostgreSQL	Double quotes (" ").
	SQL Server	Double quotes (" ") or brackets ([ ]); brackets are preferred.
Identifier may be reserved	SQL	No, unless as a quoted identifier.
	MySQL	No, unless as a quoted identifier.
	Oracle	No, unless as a quoted identifier.
	PostgreSQL	No, unless as a quoted identifier.

Characteristic	Platform	Specification
	SQL Server	No, unless as a quoted identifier.
Schema addressing	SQL	*<catalog>.<schema>.<object>*.
	MySQL	*<database>.<object>*.
	Oracle	*<schema>.<object>*.
	PostgreSQL	*<database>.<schema>.<object>*.
	SQL Server	*<server>.<database>.<schema>.<object>*.
Identifier must be unique	SQL	Yes.
	MySQL	Yes.
	Oracle	Yes.
	PostgreSQL	Yes.
	SQL Server	Yes.
Case sensitive	SQL	No.
	MySQL	Only if the underlying filesystem is case-sensitive (e.g., macOS or Unix). Triggers, logfile groups, and tablespaces are always case-sensitive.
	Oracle	No by default, but can be changed.
	PostgreSQL	No.
	SQL Server	No by default, but can be changed.
Other rules	SQL	None.
	MySQL	May not contain only numbers.
	Oracle	Database links are limited to 128 bytes and may not be quoted identifiers.
	PostgreSQL	None.
	SQL Server	Microsoft commonly uses brackets rather than double quotes for quoted identifiers.

Identifiers must be unique within their scope. Thus, given our earlier discussion of the hierarchy of database objects, database names must be unique on a particular instance of a database server, while the names of tables, views, functions, triggers, and stored procedures must be unique within a particular schema. On the other hand, a table and a stored procedure *can* have the same name since they are different types of objects. Two tables can also have the same name if they are located in different schemas. The names of columns, keys, and indexes must be unique in a single table or view, and so forth. Check your database platform's documentation for more information—some platforms require unique identifiers where others may not. For example, Oracle requires that all index identifiers be unique throughout the database, while PostgreSQL requires index identifiers to be unique across a schema but only requires `CHECK` constraint names to be unique within a table, and other platforms (such as SQL Server) require that an index identifier be unique only for the table on which it depends.

Remember, quoted identifiers (object names encapsulated within a special delimiter, usually double quotes or brackets `[LikeThis]`) may be used to break some of the identifier rules specified here. One example is that delimited identifiers are case-sensitive—that is, `"foo"` does not equal `"FOO"` or `"Foo"`. Furthermore, quoted identifiers may be used to bestow a reserved word as a name, or to allow normally unusable characters and symbols within a name. For instance, you normally can't use the percent sign (`%`) in a table name. However, you can, if you must, use that symbol in a table name, so long as you always enclose that table name within double quotes. That is, to name a table *expense%%ratios*, you would specify the name as *"expense%%ratios"* or *[expense%%ratios]*.

Once you have created an object name as a quoted identifier, we recommend that users always reference it using its delimiters. Inconsistency often leads to problematic or poorly performing code.

Literals

SQL defines a literal value as any explicit numeric value, character string, temporal value (e.g., date or time), or Boolean value that is not an identifier or a keyword. SQL databases allow a variety of literal values in a SQL program. Literal values are allowed for most of the numeric, character, Boolean, and date data types. For example, SQL Server's numeric data types include (among others) `INTEGER`, `REAL`, and `MONEY`. Thus, *numeric literals* can look like:

```
30
–117
+883.3338
–6.66
$70000
2E5
7E-3
```

As these examples illustrate, SQL Server allows signed and unsigned numerals in scientific or normal notation, and since it has a `MONEY` data type, a currency symbol (the dollar sign, under the default regional collation for US settings) can even be included. SQL Server does *not* allow other symbols in numeric literals (besides `0 1 2 3 4 5 6 7 8 9 + - $ . E e`), including commas, which can be problematic because in most European countries a comma is used in place of a period in decimal or monetary values. Most databases interpret a comma in a numeric literal as a *list item separator*. Thus, the literal value `3,000` would likely be interpreted as two values: `3` and, separately, `000`.

Boolean, character string, and date literals look like this:

```
TRUE
'Hello world!'
'OCT-28-1966 22:14:30.00'
```

Character string literals should always be enclosed in single quotation marks ('')—the standard delimiter—but are not restricted just to the letters of the alphabet. In fact, any character in the character set can be represented as a string literal. All of the following are string literals:

```
'1998'
'70,000 + 14000'
'There once was a man from Nantucket,'
'Oct 28, 1966'
```

and are compatible with the `CHARACTER` data type. Remember not to confuse the string literal `'1998'` with the numeric literal `1998`. It's poor practice to use such a string literal in arithmetic operations without explicitly converting it to a numeric data type. Some database products will perform automatic conversion of string literals containing numbers when comparing them against any `DATE` or `NUMBER` data type values, but not all. On some database platforms, performance declines when you do not explicitly convert such data types.

By doubling the delimiter, you can effectively represent a single quotation mark in a literal string, if necessary. That is, you can use two quotation marks each time a single quotation mark is part of the value. This example, taken from SQL Server, illustrates the idea:

```
SELECT 'So he said ''Who''s Le Petomaine?'''
```

This statement gives the following result:

```
-----------------
So he said 'Who's Le Petomaine?'
```

Operators

An *operator* is a symbol specifying an action to be performed on one or more expressions. Operators are used most often in `DELETE`, `INSERT`, `SELECT`, and `UPDATE` statements, but they are also used frequently in the creation of database objects such as stored procedures, functions, triggers, and views.

Operators typically fall into these categories:

Arithmetic operators
    Supported by all databases

Assignment operators
    Supported by all databases

Bitwise operators
    Supported by all databases

Comparison operators
    Supported by all databases

Logical operators
: Supported by all databases

Set operators
: Supported by all databases

Unary operators
: Supported by MySQL, Oracle, and SQL Server

Arithmetic operators

Arithmetic operators perform mathematical operations on two expressions of any data type in the numeric data type category. See Table 2-2 for a listing of the arithmetic operators.

Table 2-2. Arithmetic operators

Arithmetic operator	Meaning
+	Addition
–	Subtraction
*	Multiplication
/	Division
%	Modulo or `MOD()`; returns the remainder of a division operation as an integer value

In Oracle and PostgreSQL, the + and – operators can be used to add and subtract days in date values. The various other platforms also offer their own unique methods for performing arithmetic operations on date values.

Assignment operators

Except in Oracle, which uses :=, the *assignment operator* (=) assigns a value to a variable or the alias of a column heading. In all of the database platforms covered in this text, the keyword `AS` may serve as an operator for assigning table- or column-heading aliases.

Bitwise operators

All databases support *bitwise operators* (see Table 2-3) as a shortcut to perform bit manipulations between two-integer expressions. Valid data types that are accessible to bitwise operators include `BINARY`, `BIT`, `INT`, `SMALLINT`, `TINYINT`, and `VARBINARY`. PostgreSQL supports the `INT`, `BIT`, and `BIT VARYING` data types; it also supports the bitwise operators `AND`, `OR`, `XOR`, concatenation, `NOT`, and shifts left and right. For PostgreSQL, use the # rather than ^ because ^ is used to indicate exponents.

Table 2-3. Bitwise operators

Bitwise operator	Meaning
&	Bitwise AND (two operands)
|	Bitwise OR (two operands)
^ (PostgreSQL #)	Bitwise exclusive OR (two operands)

Comparison operators

Comparison operators test whether two expressions are equal or unequal. The result of a comparison operation is a Boolean value: `TRUE`, `FALSE`, or `UNKNOWN`. Also, note that the SQL standard behavior for a comparison operation where one or more of the expressions is NULL is to return NULL. For example, the expression `23 + NULL` returns NULL, as does the expression `Feb 23, 2022 + NULL`. See Table 2-4 for a list of the comparison operators.

Table 2-4. Comparison operators

Comparison operator	Meaning
=	Equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to
<>	Not equal to
!=	Not equal to (not SQL standard)
!<	Not less than (not SQL standard)
!>	Not greater than (not SQL standard)

Boolean comparison operators are used most frequently in a `WHERE` clause to filter the rows that qualify for the search conditions. The following example uses the greater than or equal to comparison operator:

```
SELECT *
  FROM Products
  WHERE ProductID >= 347
```

Logical operators

Logical operators are commonly used in a `WHERE` clause to test for the truth of some condition. They return a Boolean value of either `TRUE` or `FALSE`. Table 2-5 shows a list of logical operators. Note that not all database systems support all operators.

Table 2-5. Logical operators

Logical operator	Meaning
`ALL`	TRUE if all of a set of comparisons are TRUE
`AND`	TRUE if both Boolean expressions are TRUE
`ANY`	TRUE if any one of a set of comparisons is TRUE
`BETWEEN`	TRUE if the operand is within a range inclusive of lower and upper bounds (e.g., 2 `BETWEEN 2 AND 5` and 5 `BETWEEN 2 AND 5` both result in TRUE)
`EXISTS`	TRUE if a subquery contains any rows
`IN`	TRUE if the operand is equal to one of a list of expressions or one or more rows returned by a subquery
`LIKE`	TRUE if the operand matches a pattern
`NOT`	Reverses the value of any other Boolean operator
`OR`	TRUE if either Boolean expression is TRUE
`SOME`	TRUE if some of a set of comparisons are TRUE

Set operators

Set operators manipulate the results of two or more `SELECT` statements and return a single result set based on the function of the set operator itself. Some set operators act in much the same way as inner joins or outer joins. To use a set operator, place it after the first query and before the second query. Each `SELECT` statement must have the same number of columns in the `SELECT` item list and the columns in each query must be of the same or a compatible data type (refer to Chapter 4 for detailed explanations and examples of set operators in action).

While you can have more than two `SELECT` statements in a query using set operators, the logic can become confusing after the second `SELECT` statement. Therefore, we recommend that you limit your queries to two `SELECT` statements with a single set operator until you become very experienced with their behavior. The explanations in Table 2-6, which lists the available set operators, are based on using only two `SELECT` statements in your query.

Table 2-6. Set operators

Set operator	Meaning
`UNION`	Returns all distinct rows selected by either `SELECT` statement in the query, returning only one record if there are any duplicates within the result set
`UNION ALL`	Returns all rows selected by either `SELECT` statement in the query, including duplicates
`INTERSECT`	Returns all distinct rows that are in common between the first and second `SELECT` statements in the query, returning only one record if there are any duplicates within the result set

Set operator	Meaning
`INTERSECT ALL`	Returns all rows selected by the first and second `SELECT` statements within the query that are in common between them, including duplicates
`MINUS`	Returns all distinct rows retrieved by the first `SELECT` statement in the query, removing from the record set any records retrieved by the second query
`MINUS ALL`	Returns all rows retrieved by the first `SELECT` statement in the query, removing from the record set any records retrieved by the second query, including duplicates
`EXCEPT`	A synonym for `MINUS`
`EXCEPT ALL`	A synonym for `MINUS ALL`

Unary operators

Unary operators perform an operation on only one expression of any of the data types in the numeric data type category. In general the unary operators (listed in Table 2-7) may be used on any numeric data type, though the bitwise operator (~) can be used only on integer data types.

Table 2-7. Unary operators

Unary operator	Meaning
+	Numeric value is positive
–	Numeric value is negative
~	A bitwise `NOT`; returns the complement of the number (not supported in Oracle)

Operator precedence

Sometimes operator expressions become rather complex, with multiple levels of nesting. When an expression has multiple operators, *operator precedence* determines the sequence in which the operations are performed. The order of execution can significantly affect the resulting value.

Operators have different precedence levels. An operator on a higher level is evaluated before an operator on a lower level. The following listing shows the operators' precedence levels, from highest to lowest:

- `()` (parenthetical expressions)
- +, –, ~ (unary operators)
- `*`, `/`, `%` (mathematical operators)
- `+`, `-` (arithmetic operators)
- =, >, <, >=, <=, <>, `!=`, `!>`, `!<` (comparison operators)
- `^` (bitwise exclusive `OR`), `&` (bitwise `AND`), `|` (bitwise `OR`)
- `NOT`

- `AND`
- `ALL`, `ANY`, `BETWEEN`, `IN`, `LIKE`, `OR`, `SOME`
- `=` (variable assignment)

Operators are evaluated from left to right when they are of equal precedence. However, parentheses can be used to override the default precedence of the operators in an expression. Expressions within a set of parentheses are evaluated first, while operations outside the parentheses are evaluated next.

For example, the following expressions in an Oracle query return very different results:

```
SELECT 2 * 4 + 5 FROM DUAL
-- Evaluates to 8 + 5, which yields an expression result of 13

SELECT 2 * (4 + 5) FROM DUAL
-- Evaluates to 2 * 9, which yields an expression result of 18
```

In expressions with nested parentheses, the most deeply nested expression is evaluated first.

This next example contains nested parentheses, with the expression `5 - 3` appearing in the most deeply nested set of parentheses. This expression yields a value of `2`. The addition operator (+) then adds this result to `4`, which yields a value of `6`. Finally, the `6` is multiplied by `2` to yield an expression result of `12`:

```
SELECT 2 * (4 + (5 - 3) ) FROM DUAL
-- Evaluates to 2 * (4 + 2), which further evaluates to 2 * 6,
-- and yields an expression result of 12
RETURN
```

We recommend using parentheses to clarify precedence in all complex queries.

System delimiters and operators

String delimiters mark the boundaries of a string of alphanumeric characters. *System delimiters* are symbols within the character set that have special significance to your database server. *Delimiters* are symbols that are used to judge the order or hierarchy of processes and list items. *Operators* are those delimiters used to judge values in comparison operations, including symbols commonly used for arithmetic or mathematical operations. Table 2-8 lists the system delimiters and operators allowed by SQL.

Table 2-8. SQL delimiters and operators

Symbol	Usage	Example
+	Addition operator; in SQL Server, also serves as a concatenation operator	On all database platforms: `SELECT MAX(emp_id) + 1 FROM employee`
–	Subtraction operator; on some database platforms it also serves as a range indicator in string pattern matching, but is not a part of the SQL standard	As a subtraction operator: `SELECT MIN(emp_id) - 1 FROM employee-`
		As a range operator, in a CHECK constraint: `ALTER TABLE authors ADD CONSTRAINT authors_zip_num CHECK (zip LIKE %[0-9]%)`
*	Multiplication operator	`SELECT salary * 0.05 AS bonus FROM employee`
/	Division operator	`SELECT salary / 12 AS monthly FROM employee`
=	Equality operator	`SELECT * FROM employee WHERE lname = 'Fudd'`
< >	Inequality operators (!= is a nonstandard equivalent on several platforms)	On all platforms: `SELECT * FROM employee WHERE lname <> 'Fudd'`
< <=	Less than operator Less than or equal to operator	`SELECT lname, emp_id, (salary * 0.05) AS bonus FROM employee WHERE (salary * 0.05) <= 10000 AND exempt_status < 3`
> >=	Greater than operator Greater than or equal to operator	`SELECT lname, emp_id, (salary * 0.025) AS bonus FROM employee WHERE (salary * 0.025) > 10000 AND exempt_status >= 4`

()	Used in expressions and function calls, to specify order of operations, and as a subquery delimiter	Expression:
		`SELECT (salary / 12) AS monthly FROM employee WHERE exempt_status >= 4`
		Function call:
		`SELECT SUM(travel_expenses) FROM "expense%%ratios"`
		Order of operations:
		`SELECT (salary / 12) AS monthly, ((salary / 12) / 2) AS biweekly FROM employee WHERE exempt_status >= 4`
		Subquery:
		`SELECT * FROM stores WHERE stor_id IN (SELECT stor_id FROM sales WHERE ord_date > '01-JAN-2014')`

Symbol	Usage	Example
%	Wildcard attribute indicator	`SELECT * FROM employee WHERE lname LIKE 'Fud%'`
,	List item separator	`SELECT lname, fname, ssn, hire_date FROM employee WHERE lname = 'Fudd'`
.	Identifier qualifier separator	`SELECT * FROM scott.employee WHERE lname LIKE 'Fud%'`
''	Character string indicators	`SELECT * FROM employee WHERE lname LIKE 'FUD%' OR fname = 'ELMER'`
""	Quoted identifier indicators	`SELECT expense_date, SUM(travel_expense) FROM "expense%%ratios" WHERE expense_date BETWEEN '01-JAN-2014' AND '01-APR-2014'`
--	Single-line comment delimiter (two dashes followed by a space)	-- Finds all employees like Fudd, Fudge, and Fudston: `SELECT * FROM employee WHERE lname LIKE 'Fud%'`
/*	Beginning multiline comment delimiter	/* Finds all employees like Fudd, Fudge, and Fudston: `SELECT * FROM employee WHERE lname LIKE 'Fud%' */`
*/	Ending multiline comment indicator	

Keywords and Reserved Words

Just as certain symbols have special meaning and functionality within SQL, certain words and phrases, commonly known as *keywords*, have special significance. As mentioned earlier, keywords can be either reserved or non-reserved words. *Reserved words* are words whose meanings are so closely tied to the operation of the RDBMS that they should not be used for any other purpose. These include words used in SQL statements; for example, "select" is a reserved word and should not be used as a table name. It's strongly recommended that reserved words never be used as user-defined names, although many database platforms do technically allow this through the use of delimited identifiers. Non-reserved keywords, such as the names of built-in tables and functions, have special meanings only in certain contexts; however, to avoid confusion it's best to avoid using them as identifiers too.

Reserved words and keywords are not always words used in SQL statements; they may also be words commonly associated with database technology. For example, `CASCADE` is used to describe data manipulations that allow their actions, such as a delete or update operation, to "flow down," or cascade, to any subordinate tables. Lists of reserved words and keywords are widely published so that developers will not use them as identifiers that might, either now or in some later revision, cause a problem.

SQL specifies its own set of reserved words and keywords, as do the database platforms, because they each have their own extensions to the SQL command set.

You'll find lists of SQL standard keywords and keywords used in the different vendor implementations discussed in the Appendix.

It is generally a good idea to avoid naming columns or tables after a keyword that occurs in *any* major platform because database applications are frequently migrated from one platform to another.

SQL and Platform-Specific Data Types

A table can contain one or many columns. Each column must be defined with a data type that provides a general classification of the data stored in the column. In real-world applications, data types improve efficiency and provide some control over how tables are defined and how the data is stored within a table. Using specific data types enables better, more understandable queries and helps control the integrity of the data.

Data types are also used when declaring variables and parameters within stored procedures and user-defined functions.

The tricky thing about SQL data types is that they do not always map directly to identical data types on different database platforms. Although the various platforms specify types that correspond to the SQL data types, these are not always true SQL data types implemented in the exact same way. For example, MySQL's implementation of a `BIT` data type is actually identical to a `CHAR(1)` data type value in the SQL standard. That said, the platform-specific data types are typically close enough to the standard to be both easily understandable and job-ready.

The official SQL data types (as opposed to platform-specific data types) fall into the general categories described in Table 2-9. Note that the SQL standard contains a few rarely used data types (such as `ARRAY`, `MULTISET`, `REF`, and `ROW`) that are shown only in this table and not discussed elsewhere in the book.

Table 2-9. SQL data type categories

Category	Example data types and abbreviations	Description
`BINARY`	`BINARY LARGE OBJECT (BLOB)`	Stores binary string values in hexadecimal format. Binary string values are stored without reference to any character set and without any length limit.
`BOOLEAN`	`BOOLEAN`	Stores truth values (either `TRUE` or `FALSE`).

Category	Example data types and abbreviations	Description
CHARACTER string types	CHAR CHARACTER VARYING (VARCHAR)	Can store any combination of characters from the applicable character set. The varying data types allow variable lengths, while the other data types allow only fixed lengths. Also, the variable-length data types automatically trim trailing spaces, while the other data types pad any unused space with spaces.
	CHARACTER LARGE OBJECT (CLOB)	Used to store a large amount of textual data (up to 2,147,483,647 characters).
	NATIONAL CHARACTER (NCHAR) NATIONAL CHARACTER VARYING (NCHAR VARYING)	Designed to support a particular implementation-defined character set.
	NATIONAL CHARACTER LARGE OBJECT (NCLOB)	Same as CHARACTER LARGE OBJECT, but supports a particular implementation-defined character set.
DATALINK	DATALINK	Defines a reference to a file or other external data source that is not part of the SQL environment.
INTERVAL	INTERVAL	Specifies a duration or span of time.
COLLECTION	ARRAY MULTISET	Store collections of elements of a predefined data type. An ARRAY is a set-length, ordered collection of elements, and a MULTISET is a variable-length, unordered collection of elements.
NUMERIC	INTEGER (INT) BIGINT SMALLINT NUMERIC(p,s) DEC[IMAL](p,s) FLOAT(p,s) REAL DOUBLE PRECISION	Store exact numeric values (integers or decimals) or approximate (floating-point) values. INT, BIGINT, and SMALLINT store exact numeric values with a predefined precision and a scale of zero. NUMERIC and DEC store exact numeric values with a definable precision and a definable scale. FLOAT stores approximate numeric values with a definable precision, while REAL and DOUBLE PRECISION have predefined precisions. You may define a precision (*p*) and scale (*s*) for a DECIMAL, FLOAT, or NUMERIC data type to indicate the total number of allowed digits and the number of decimal places, respectively. INT, SMALLINT, and DEC are sometimes referred to as *exact numeric types*, while FLOAT, REAL, and DOUBLE PRECISION are sometimes called *approximate numeric types*.

Category	Example data types and abbreviations	Description
TEMPORAL	DATE TIME TIME WITH TIME ZONE TIMESTAMP TIMESTAMP WITH TIME ZONE	Handle values related to time. DATE and TIME are self-explanatory. Data types with the WITH TIME ZONE suffix also include a time zone offset. The TIMESTAMP data types are used to store a value that represents a precise moment in time. Temporal types are also known as *datetime types*.
XML	XML	Introduced in SQL:2003 (Part 14), this data type stores XML data and can be used wherever a SQL data type is allowed (e.g., for a column of a table, a field in a row, etc.). Operations on the values of an XML type assume a tree-based internal data structure. The internal data structure is based on the XML Information Set (Infoset) recommendation , using a new document information item called the *XML root information item*.

Not every database platform supports every SQL data type. Table 2-10 lists the data types implemented by the platforms discussed in this book, giving the SQL standard equivalent where applicable.

Be careful to look for footnotes when reading this table because some platforms support a data type of a given name but implement it in a different way than the SQL standard and/or other vendors.

While the different platforms may support data types of the same name, the details of their implementations may vary. The sections that follow this table list the specific requirements of each platform's data types.

Table 2-10. Comparison of platform-specific data types

Vendor data type	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server	SQL data type
BFILE		Y			None
BIGINT	Y		Y	Y	BIGINT
BINARY	Y			Y	BLOB
BINARY_DOUBLE		Y			DOUBLE PRECISION
BINARY_FLOAT		Y			FLOAT
BIT	Y		Y	Y	None
BIT VARYING, VARBIT			Y		None
BLOB	Y	Y			BLOB
BOOL, BOOLEAN	Y		Y		BOOLEAN

Vendor data type	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server	SQL data type
BOX			Y		None
BYTEA			Y		BLOB
CHAR, CHARACTER	Y	Y	Y	Y	CHARACTER
CIDR			Y		None
CIRCLE			Y		None
CLOB		Y			CLOB
CURSOR				Y	None
DATE	Y	Y	Y	Y	DATE
DATETIME	Y			Y	TIMESTAMP
DATETIMEOFFSET				Y	TIMESTAMP
DATETIME2				Y	TIMESTAMP WITH TIME ZONE
DEC, DECIMAL	Y	Y	Y	Y	DECIMAL
DOUBLE, DOUBLE PRECISION	Y	Y	Y[a]	Y	FLOAT
ENUM	Y		Y		None
FLOAT	Y	Y	Y	Y	DOUBLE PRECISION
FLOAT4			Y[b]		FLOAT(p)
FLOAT8			Y[c]		FLOAT(p)
GEOGRAPHY				Y	None
GEOMETRY				Y	None
HIERARCHYID				Y	None
IMAGE				Y	None
INET			Y		None
INT, INTEGER	Y	Y	Y	Y	INTEGER
INT2			Y		SMALLINT
INT4[d]			Y		INT, INTEGER
INTERVAL			Y		INTERVAL
INTERVAL DAY TO SECOND		Y	Y		INTERVAL DAY TO SECOND
INTERVAL YEAR TO MONTH		Y	Y		INTERVAL YEAR TO MONTH
JSON	Y		Y		BLOB
JSONB			Y		BLOB

Vendor data type	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server	SQL data type
LINE			Y		None
LONG		Y			None
LONGBLOB	Y				BLOB
LONG RAW		Y			BLOB
LONGTEXT	Y				None
LSEG			Y		None
MACADDR			Y		None
MEDIUMBLOB	Y				None
MEDIUMINT	Y				INT
MEDIUMTEXT	Y				None
MONEY			Y[e]	Y	None
NATIONAL CHARACTER VARYING, NATIONAL CHAR VARYING, NCHAR VARYING, NVARCHAR	Y	Y	Y	Y	NATIONAL CHARACTER VARYING
NCHAR, NATIONAL CHAR, NATIONAL CHARACTER	Y	Y	Y	Y	NATIONAL CHARACTER
NCLOB		Y			NCLOB
NTEXT, NATIONAL TEXT				Y	NCLOB
NVARCHAR2(n)		Y			None
NUMBER	Y	Y	Y[f]	Y	None
NUMERIC				Y	NUMERIC
OID			Y		None
PATH			Y		None
POINT			Y		None
POLYGON			Y		None
RAW		Y			None
REAL	Y	Y	Y	Y	REAL
ROWID		Y			None
ROWVERSION				Y	None
SERIAL, SERIAL4	Y[g]		Y		None
SERIAL8, BIGSERIAL			Y		None
SET	Y				None
SMALLDATETIME				Y	None
SMALLINT	Y	Y	Y	Y	SMALLINT

Vendor data type	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server	SQL data type
SMALLMONEY				Y	None
SQL_VARIANT				Y	None
TABLE				Y	None
TEXT	Y		Y	Y	None
TIME	Y		Y	Y	TIME
TIMESPAN					INTERVAL
TIMESTAMP	Y	Y	Y	Y[h]	TIMESTAMP
TIMESTAMP WITH TIME ZONE, TIMESTAMPTZ			Y		TIMESTAMP WITH TIME ZONE
TIMETZ			Y		TIME WITH TIME ZONE
TINYBLOB	Y			Y	None
TINYINT	Y			Y	None
TINYTEXT	Y				None
UNIQUEIDENTIFIER				Y	None
UROWID		Y			None
VARBINARY	Y			Y	BLOB
VARCHAR, CHAR VARYING, CHARACTER VARYING	Y	Y[i]	Y	Y	CHARACTER VARYING(n)
VARCHAR2		Y			CHARACTER VARYING
YEAR	Y				TINYINT
XML			Y	Y	XML
XMLTYPE		Y			XML

[a] Synonym for FLOAT.

[b] Synonym for REAL.

[c] Synonym for DOUBLE PRECISION.

[d] Available on MariaDB but not MySQL.

[e] Synonym for DECIMAL(9,2).

[f] Synonym for DECIMAL.

[g] Synonym for BIGINT UNSIGNED NOT NULL AUTO_INCREMENT UNIQUE.

[h] Implemented as a non-date data type.

[i] Oracle vastly prefers VARCHAR2.

The following sections list platform-specific data types, their SQL data type categories (if any), and pertinent details.

MySQL Data Types

Both MySQL 8 and MariaDB 10.5 have support for spatial data. It's handled in a variety of classes provided in the OpenGIS Geometry Model, which is supported by the MyISAM, InnoDB, Aria, anNDB, and ARCHIVE database engines. Only the MyISAM, InnoDB, and Aria storage engines support both spatial and non-spatial indexes; the other database engines only support non-spatial indexes.

MySQL's numeric data types support the following optional attributes:

`UNSIGNED`
: The numeric value is assumed to be non-negative (positive or zero). For fixed-point data types such as `DECIMAL` and `NUMERIC`, the space normally used to show a positive or negative condition of the numeric value can be used as part of the value, providing a little extra numeric range in the column for these types. (There is no `SIGNED` optional attribute.)

`ZEROFILL`
: Used for display formatting, this attribute tells MySQL that the numeric value is padded to its full size with zeros rather than spaces. `ZEROFILL` automatically forces the `UNSIGNED` attribute as well.

MySQL also enforces a maximum display size for columns of up to 255 characters. Columns longer than 255 characters are stored properly, but only 255 characters are shown. Floating-point numeric data types may have a maximum of 30 digits after the decimal point.

The following list enumerates the data types MySQL supports. These include most of the SQL standard data types, plus several additional data types used to contain lists of values, as well as data types used for binary large objects (`BLOB`s). Data types that extend the SQL standard include `TEXT`, `ENUM`, `SET`, and `MEDIUMINT`. Special data type attributes that go beyond the ANSI/ISO standard include `AUTO_INCREMENT`, `BINARY`, `FIXED`, `NULL`, `UNSIGNED`, and `ZEROFILL`. The data types supported by MySQL are:

`BIGINT[(n)] [UNSIGNED] [ZEROFILL]` *(SQL standard data type:* `BIGINT`*)*
: This stores signed or unsigned integers. The signed range is –9,223,372,036,854,775,808 to 9,223,372,036,854,775,807. The unsigned range is 0 to 18,446,744,073,709,551,615. `BIGINT` may perform imprecise calculations with very large numbers (63 bits), due to rounding issues.

`BINARY[(n)]` *(SQL standard data type:* `BLOB`*)*
: Stores binary byte strings of optional length *n*. Otherwise, similar to the `BLOB` data type.

`BIT[(n)]`, `BOOL`, `BOOLEAN` *(SQL standard data type:* `BOOLEAN`*)*
: Synonyms for `TINYINT`, usually used to store only 0s or 1s. *`n`* specifies the number of bits, from 1 to 64. If *`n`* is omitted, the default is 1 bit.

`BLOB` *(SQL standard data type:* `BLOB`*)*
: Stores up to 65,535 characters of data. Support for indexing `BLOB` columns is found only in MySQL 3.23.2 and greater (this feature is not found in any other platform covered in this book). In MySQL, `BLOB`s are functionally equivalent to the MySQL data type `VARCHAR BINARY` (discussed later) with the default upper limit. `BLOB`s always require case-sensitive comparisons. `BLOB` columns differ from MySQL `VARCHAR BINARY` columns by not allowing DEFAULT values. You cannot perform a `GROUP BY` or `ORDER BY` on `BLOB` columns. Depending on the storage engine being used, `BLOB`s also are sometimes stored separately from their tables, whereas all other data types in MySQL (with the exception of `TEXT`) are stored in the table file structure itself.

`CHAR(n) [BINARY], CHARACTER(n) [BINARY]` *(SQL standard data type:* `CHARACTER(n)`*)*
: Contains a fixed-length character string of 1 to 255 characters. `CHAR` pads with blank spaces when it stores values but trims spaces upon retrieval, just as the SQL standard `VARCHAR` does. The `BINARY` option allows binary searches rather than dictionary-order, case-insensitive searches.

`DATE` *(SQL standard data type:* `DATE`*)*
: Stores a date within the range of 1000-01-01 to 9999-12-31 (delimited by quotes). MySQL displays these values by default in the format YYYY-MM-DD, though the user may specify some other display format.

`DATETIME` *(SQL standard data type:* `TIMESTAMP`*)*
: Stores date and time values within the range of 1000-01-01 00:00:00 to 9999-12-31 23:59:59.

`DECIMAL[(p[,s])] [UNSIGNED] [ZEROFILL]`, `DEC[(p[,s])] [UNSIGNED] [ZEROFILL]`, `FIXED [(p[,s])] [UNSIGNED] [ZEROFILL]` *(SQL standard data type:* `DECIMAL(PRECISION, SCALE)`*)*
: Stores exact numeric values as if they were strings, using a single character for each digit, up to 65 digits in length. Precision is 10 if omitted, and scale is 0 if omitted. `FIXED` is a synonym for `DECIMAL` provided for backward compatibility with other database platforms.

`DOUBLE[(p,s)] [ZEROFILL], DOUBLE PRECISION[(p,s)] [ZEROFILL]` *(SQL standard data type:* `DOUBLE PRECISION`*)*
: Holds double-precision numeric values and is otherwise identical to the double-precision `FLOAT` data type, except for the fact that its allowable range is −1.7976931348623157E+308 to −2.2250738585072014E−308, 0, and 2.2250738585072014E−308 to 1.7976931348623157E+308.

`ENUM("val1", "val2", ... n) [CHARACTER SET cs_name] [COLLATE collation_name]` *(SQL standard data type: none)*

Holds a list of allowable values (expressed as strings but stored as integers). Other possible values for the data type are `NULL`, or an empty string (`""`) as an error value. Up to 65,535 distinct values are allowed.

`FLOAT[(p[,s])] [ZEROFILL]` *(SQL standard data type:* `FLOAT(P)`*)*

Stores floating-point numbers in the range −3.402823466E+38 to −1.175494351E−38 and 1.175494351E−38 to 3.402823466E+38. `FLOAT` without a precision, or with a precision of <= 24, is single-precision. Otherwise, `FLOAT` is double-precision. When specified alone, the precision can range from 0 to 53. When you specify both precision and scale, the precision may be as high as 255 and the scale may be as high as 253. All `FLOAT` calculations in MySQL are done with double precision and may, since `FLOAT` is an approximate data type, encounter rounding errors. This differs quite a bit with MariaDB, where you cannot specify precision and `FLOAT` is only single-precision.

`INT[EGER][(n)] [UNSIGNED] [ZEROFILL] [AUTO_INCREMENT]` *(SQL standard data type:* `INTEGER`*)*

Stores signed or unsigned integers. For ISAM tables, the signed range is from −2,147,483,648 to 2,147,483,647 and the unsigned range is from 0 to 4,294,967,295. The range of values varies slightly for other types of tables. `AUTO_INCREMENT` is available to all of the `INT` variants; it creates a unique row identity for all new rows added to the table. (Refer to the section "CREATE/ALTER DATABASE Statement" on page 72 for more information on `AUTO_INCREMENT`.)

`JSON` *(SQL standard data type: none)*

Stores JSON data and validates it is valid JSON. In addition, allows for in-place partial updates of the subelements of the JSON data.

`LONGBLOB` *(SQL standard data type:* `BLOB`*)*

Stores `BLOB` data up to 4,294,967,295 characters in length. Note that this might be too much information for some client/server protocols to support.

`LONGTEXT [CHARACTER SET cs_name] [COLLATE collation_name]` *(SQL standard data type:* `CLOB`*)*

Stores `TEXT` data up to 4,294,967,295 characters in length (less if the characters are multibyte). Note that this might be too much data for some client/server protocols to support.

`MEDIUMBLOB` *(SQL standard data type: none)*

Stores `BLOB` data up to 16,777,215 bytes in length. The first three bytes are consumed by a prefix indicating the total number of bytes in the value.

`MEDIUMINT[(n)] [UNSIGNED] [ZEROFILL]` *(SQL standard data type: none)*

Stores signed or unsigned integers. The signed range is from 8,388,608 to −8,388,608, and the unsigned range is 0 to 16,777,215.

`MEDIUMTEXT [CHARACTER SET cs_name] [COLLATE collation_name]` *(SQL standard data type: none)*

Stores `TEXT` data up to 16,777,215 characters in length (less if the characters are multibyte). The first three bytes are consumed by a prefix indicating the total number of bytes in the value.

`NCHAR(n) [BINARY], [NATIONAL] CHAR(n) [BINARY]` *(SQL standard data type:* `NCHAR(n)`*)*

Synonyms for `CHAR`. The `NCHAR` data types provide Unicode support beginning in MySQL 4.1.

`NUMERIC(p,s)` *(SQL standard data type:* `DECIMAL(p,s)`*)*

Synonym for `DECIMAL`.

`NVARCHAR(n) [BINARY], [NATIONAL] VARCHAR(n) [BINARY], NATIONAL CHARACTER VARYING(n) [BINARY]` *(SQL standard data type:* `NCHAR VARYING`*)*

Synonyms for `VARYING [BINARY]`. Hold variable-length character strings up to 255 characters in length. Values are stored and compared in a case-insensitive fashion unless the `BINARY` keyword is used.

`REAL(p,s)` *(SQL standard data type:* `REAL`*)*

Synonym for `DOUBLE PRECISION`.

`SERIAL` *(SQL standard data type: none)*

Synonym for `BIGINT UNSIGNED NOT NULL AUTO_INCREMENT UNIQUE`. `SERIAL` is useful as an auto-incrementing primary key.

`SET("val1", "val2", ... n) [CHARACTER SET cs_name] [COLLATE collation_name]` *(SQL standard data type: none)*

A `CHAR` data type whose value must be equal to zero or more values specified in the list of values. Up to 64 items are allowed in the list.

`SMALLINT[(n)] [UNSIGNED] [ZEROFILL]` *(SQL standard data type:* `SMALLINT`*)*

Stores signed or unsigned integers. The signed range is from –32,768 to 32,767, and the unsigned range is from 0 to 65,535.

`TEXT` *(SQL standard data type: none)*

Stores up to 65,535 characters of data. `TEXT` data types are sometimes stored separately from their tables, depending on the storage engine used, whereas all other data types (with the exception of `BLOB`) are stored in their respective table file structures. `TEXT` is functionally equivalent to `VARCHAR` with no specific upper limit (besides the maximum size of the column), and it requires case-insensitive comparisons. `TEXT` differs from a standard `VARCHAR` column by not allowing DEFAULT values. `TEXT` columns cannot be used in `GROUP BY` or `ORDER BY` clauses. In addition, support for indexing `TEXT` columns is provided only in MySQL 3.23.2 and greater.

`TIME` *(SQL standard data type: none)*
: Stores time values in the range of –838:59:59 to 838:59:59 in the format HH:MM:SS. The values may be assigned as strings or numbers.

`TIMESTAMP` *(SQL standard data type:* `TIMESTAMP`*)*
: Stores date values in the range of 1970-01-01 00:00:01 to partway through the year 2038. The values are expressed as the number of seconds since 1970-01-01 00:00:01. Timestamp values are always displayed in the format YYYY-MM-DD HH:MM:SS.

`TINYBLOB` *(SQL standard data type:* `BLOB`*)*
: Stores `BLOB` values of up to 255 bytes, the first byte being consumed by a prefix indicating the total number of bytes in the value.

`TINYINT[(n)] [UNSIGNED] [ZEROFILL]` *(SQL standard data type:* `INTEGER`*)*
: Stores very small signed or unsigned integers ranging from −128 to 127 if signed, and from 0 to 255 if unsigned.

`TINYTEXT` *(SQL standard data type: none)*
: Stores `TEXT` values of up to 255 characters (less if they are multibyte characters). The first byte is consumed by a prefix indicating the total number of bytes in the value.

`VARBINARY(n)` *(SQL standard data type:* `BLOB`*)*
: Stores variable-length binary byte strings of length *n*. Otherwise, similar to the `VARCHAR` data type.

`YEAR` *(SQL standard data type: none)*
: Stores the year in a two- or four-digit (the default) format. Two-digit years allow values of 70 to 69, meaning 1970 to 2069, while four-digit years allow values of 1901 to 2155, plus 0000. `YEAR` values are always displayed in YYYY format but may be assigned as strings or numbers.

Oracle Data Types

As you'll see in this section, Oracle supports a rich variety of data types, including most of the SQL data types, some special data types, and more besides. The special data types, however, often require optional components to be installed. For example, Oracle supports spatial data types, but only if you have installed the Oracle Spatial add-on. The Oracle Spatial data types, including `SDO_GEOMETRY`, `SDO_TOPO_GEOMETRY`, and `SDO_GEORASTER`, are beyond the scope of this book. Refer to the Oracle Spatial documentation for further details on these types.

Oracle Multimedia data types use object types, similar to Java or C++ classes for multimedia data. Oracle Multimedia data types include `ORDAudio`, `ORDImage`, `ORDVideo`, `ORDDoc`, `ORDDicom`, `SI_Stillimage`, `SI_Color`, `SI_AverageColor`, `SI_ColorHistogram`, `SI_PositionalColor`, `SI_Texture`, `SI_FeatureList`, and `ORDImageSignature`.

Oracle also supports "Any Types" data types. These highly flexible data types are intended for use as procedure parameters and for table columns where the actual type is unknown. The Any Type data types are ANYTYPE, ANYDATA, and ANYDATASET.

A complete listing of the Oracle data types follows:

BFILE *(SQL standard data type:* DATALINK*)*
: Holds a pointer to a BLOB stored outside the database, but present on the local server, of up to 4 GB in size. The database streams input (but not output) access to the external BLOB. If you delete a row containing a BFILE value, only the pointer value is deleted; the actual file structure is not affected.

BINARY_DOUBLE *(SQL standard data type:* FLOAT*)*
: Holds a 64-bit floating-point number.

BINARY_FLOAT *(SQL standard data type:* FLOAT*)*
: Holds a 32-bit floating-point number.

BLOB *(SQL standard data type:* BLOB*)*
: Holds a BLOB value of between 8 and 128 TB in size, depending on the database block size. In Oracle, large binary objects (BLOBs, CLOBs, and NCLOBs) have the following restrictions:

  - They cannot be selected remotely.
  - They cannot be stored in clusters.
  - They cannot compose a VARRAY.
  - They cannot be a component of an ORDER BY or GROUP BY clause in a query.
  - They cannot be used by an aggregate function in a query.
  - They cannot be referenced in queries using DISTINCT, UNIQUE, or joins.
  - They cannot be referenced in ANALYZE ... COMPUTE or ANALYZE ... ESTIMATE statements.
  - They cannot be part of a primary key or index key.
  - They cannot be used in the UPDATE OF clause in an UPDATE trigger.

CHAR(n) [BYTE | CHAR], CHARACTER(n) [BYTE | CHAR] *(SQL standard data type:* CHARACTER(n)*)*
: Holds fixed-length character data of up to 2,000 bytes in length. BYTE tells Oracle to use bytes for the size measurement. CHAR tells Oracle to use characters for the size measurement.

`CLOB` *(SQL standard data type:* `CLOB`*)*
: Stores a character large object (`CLOB`) value of between 8 and 128 TB in size, depending on the database block size. See the description of the `BLOB` data type for a list of restrictions on the use of the `CLOB` type.

`DATE` *(SQL standard data type:* `DATE`*)*
: Stores a valid date and time within the range of 4712BC-01-01 00:00:00 to 9999AD-12-31 23:59:59.

`DECIMAL(p,s)` *(SQL standard data type:* `DECIMAL(p,s)`*)*
: A synonym for `NUMBER` that accepts precision and scale arguments.

`DOUBLE PRECISION` *(SQL standard data type:* `DOUBLE PRECISION`*)*
: Stores floating-point values with double precision, the same as `FLOAT(126)`.

`FLOAT(n)` *(SQL standard data type:* `FLOAT(n)`*)*
: Stores floating-point numeric values with a binary precision of up to 126.

`INTEGER(n)` *(SQL standard data type:* `INTEGER`*)*
: Stores signed and unsigned integer values with a precision of up to 38. `INTEGER` is treated as a synonym for `NUMBER`.

`INTERVAL DAY(n) TO SECOND(x)` *(SQL standard data type:* `INTERVAL`*)*
: Stores a time span in days, hours, minutes, and seconds, where *`n`* is the number of digits in the day field (values from `0` to `9` are acceptable, and `2` is the default) and *`x`* is the number of digits used for fractional seconds in the seconds field (values from `0` to `9` are acceptable, and `6` is the default).

`INTERVAL YEAR(n) TO MONTH` *(SQL standard data type:* `INTERVAL`*)*
: Stores a time span in years and months, where *`n`* is the number of digits in the year field. The value of *`n`* can range from `0` to `9`, with a default of `2`.

`LONG` *(SQL standard data type: none)*
: Stores variable-length character data of up to 2 GB in size. Note, however, that `LONG` is not scheduled for long-term support by Oracle. Use another data type, such as `CLOB`, instead of `LONG` whenever possible.

`LONG RAW` *(SQL standard data type: none)*
: Stores raw variable-length binary data of up to 2 GB in size. `LONG RAW` and `RAW` are typically used to store graphics, sounds, documents, and other large data structures. `BLOB` is preferred over `LONG RAW` in Oracle because there are fewer restrictions on its use. `LONG RAW` is deprecated.

`NATIONAL CHARACTER VARYING(n), NATIONAL CHAR VARYING(n), NCHAR VARYING(n)` *(SQL standard data type:* `NCHAR VARYING (n)`*)*
: Synonyms for `NVARCHAR2`.

`NCHAR(n), NATIONAL CHARACTER(n), NATIONAL CHAR(n)` *(SQL standard data type:* `NATIONAL CHARACTER`*)*
: Holds Unicode character data of 1 to 2,000 bytes in length. Default size is 1 byte.

`NCLOB` *(SQL standard data type:* `NCLOB`*)*
: Represents a `CLOB` that supports multibyte and Unicode values of between 8 and 128 TB in size, depending on the database block size. See the description of the `BLOB` data type for a list of restrictions on the use of the `NCLOB` type.

`NUMBER(p,s), NUMERIC(p,s)` *(SQL standard data type:* `NUMERIC(p,s)`*)*
: Stores a number with a precision of 1 to 38 and a scale of −84 to 127.

`NVARCHAR2(n)` *(SQL standard data type: none)*
: Represents Oracle's preferred Unicode variable-length character data type. Can hold data of 1 to 4,000 bytes in size.

`RAW(n)` *(SQL standard data type: none)*
: Stores raw, variable-length binary data of up to 2,000 bytes in size. The value *`n`* is the specified size of the data type. `RAW` is deprecated. (See also `LONG RAW`.)

`REAL` *(SQL standard data type:* `REAL`*)*
: Stores floating-point values with single precision. Same as `FLOAT(63)`.

`ROWID` *(SQL standard data type: none)*
: Represents a unique, base-64 identifier for each row in a table, often used in conjunction with the `ROWID` pseudocolumn.

`SMALLINT` *(SQL standard data type:* `SMALLINT`*)*
: Synonym for `INTEGER`.

`TIMESTAMP(n) {[WITH TIME ZONE] | [WITH LOCAL TIME ZONE]}` *(SQL standard data type:* `TIMESTAMP [WITH TIME ZONE]`*)*
: Stores a full date and time value, where *`n`* is the number of digits (values from `0` to `9` are acceptable, and `6` is the default) in the fractional part of the seconds field. `WITH TIME ZONE` stores whatever time zone you pass to it (the default is your session time zone) and returns a time value in that same time zone. `WITH LOCAL TIME ZONE` stores data in the time zone of the current session and returns data in the time zone of the user's session.

`URITYPE` *(SQL standard data type:* `XML`*)*
: Stores a uniform resource identifier (URI), operating much like a standard URL that references a document or even a specific point within a document. This data type is a supertype containing three subtypes, existing in an inheritance hierarchy: `DBURITYPE`, `XDBURITYPE`, and `HTTPURITYPE`. You would typically create a table using the `URITYPE`, then store `DBURITYPE` (for `DBURIREF` values using an XPath nomenclature to reference data stored elsewhere in the database or in another database), `HTTPURITYPE` (for HTTP web pages and files),

or `XDBURITYPE` (for exposing documents in the XML database hierarchy) in the column. You will typically manipulate this type of data using the URIFactory package. Refer to the vendor documentation for more information on the URIFactory package.

`UROWID[(n)]` *(SQL standard data type: none)*
Stores a base-64 value showing the logical address of the row in its table. Defaults to 4,000 bytes in size, but you may optionally specify a size of anywhere up to 4,000 bytes.

`VARCHAR(n), CHARACTER VARYING(n), CHAR VARYING(n)` *(SQL standard data type:* `CHARACTER VARYING(n)`*)*
Holds variable-length character data of 1 to 4,000 bytes in size.

Oracle does not recommend using `VARCHAR` and has for many years instead encouraged the use of `VARCHAR2`.

`VARCHAR2(n [BYTE | CHAR])` *(SQL standard data type:* `CHARACTER VARYING(n)`*)*
Holds variable-length character data of up to 4,000 bytes in length, as defined by *`n`*. `BYTE` tells Oracle to use bytes for the size measurement. `CHAR` tells Oracle to use characters for the size measurement. If you use `CHAR`, Oracle internally must still transform that into some number of bytes, which is then subject to the 4,000-byte upper limit.

`XMLTYPE` *(SQL standard data type:* `XML`*)*
Stores XML data within the Oracle database. The XML data is accessed using XPath expressions as well as a number of built-in XPath functions, SQL functions, and PL/SQL packages. The `XMLTYPE` data type is a system-defined type, so it is usable as an argument in functions, or as the data type of a column in a table or view. When used in a table, the data can be stored in a `CLOB` column or object-relationally.

PostgreSQL Data Types

The PostgreSQL database supports most SQL standard data types, plus an extremely rich set of data types that store spatial and geometric data. PostgreSQL also provides a wealth of operators and functions especially for the geometric data types, including capabilities such as rotation, finding intersections, and scaling. These have existed for a while but are not widely used, since they predate standards for managing spatial data.

Compliance with Open Geospatial Consortium (OGC) standards is provided via an open source extension called PostGIS, which is more commonly used than the built-in PostgreSQL geometric support. PostGIS provides *geometry* (flat-earth) and *geography* (round-earth) data types, as well as support for transforming between spatial projections. There are also numerous subtypes that can be used as type modifiers; for example, `geometry(POLYGON,4326)` describes a polygon column storing WGS84-style longitude and latitude values. Additionally, PostGIS implements the SQL/MM standard, which includes support for three-dimensional types such as triangular irregular networks (TINs) and polyhedral surfaces.

PostgreSQL also provides additional versions of existing data types that are smaller and take up less disk space than their corresponding primary data types. For example, it offers several variations on `INTEGER` to accommodate small or large numbers and thereby consume proportionally less or more space. Here's a list of the data types PostgreSQL supports:

`BIGINT, INT8` *(SQL standard data type: none)*
: Stores signed or unsigned 8-byte integers within the range of –9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

`BIGSERIAL` *(SQL standard data type: none)*
: See `SERIAL`.

`BIT` *(SQL standard data type:* `BIT`*)*
: Stores a fixed-length bit string.

`BIT VARYING(n), VARBIT(n)` *(SQL standard data type:* `BIT VARYING`*)*
: Stores a variable-length bit string whose maximum length is denoted by *`n`*.

`BOOL, BOOLEAN` *(SQL standard data type:* `BOOLEAN`*)*
: Stores a logical Boolean (true/false) value. The keywords `TRUE` and `FALSE` are preferred, but PostgreSQL supports the following valid literal values for the "true" state: `TRUE`, `t`, `true`, `y`, `yes`, and `1`. Valid "false" values are: `FALSE`, `f`, `false`, *`n`*, `no`, and `0`.

`BOX( (x1, y1), (x2, y2) )` *(SQL standard data type: none)*
: Stores the values of a rectangular box in a 2D plane. Values are stored in 32 bytes and are represented as `( (x1, y1), (x2, y2) )`, signifying the opposite corners of the box (the upper-right and lower-left corners, respectively). The outer parentheses are optional.

`BYTEA` *(SQL standard data type:* `BINARY LARGE OBJECT`*)*
: Holds raw, binary data; typically used to store graphics, sounds, or documents. For storage, this data type requires 4 bytes plus the actual size of the binary string.

`CHAR(n), CHARACTER(n)` *(SQL standard data type:* `CHARACTER(n)`*)*
: Contains a fixed-length character string padded with spaces up to a length of *`n`*. Attempting to insert a value longer than *`n`* results in an error (unless the extra length is composed of spaces, which are then truncated such that the result fits in *`n`* characters).

`CIDR(x.x.x.x/y)` *(SQL standard data type: none)*
: Describes an IP version 4 (IPv4) network or host address in a 12-byte storage space. The range is any valid IPv4 network address. Data in `CIDR` data types is represented as `x.x.x.x/y`, where the *x*s are the IP address and *y* is the number of bits in the netmask. `CIDR` does not accept non-zero bits to the right of a zero bit in the netmask.

`CIRCLE(x, y, r)` *(SQL standard data type: none)*
: Describes a circle in a 2D plane. Values are stored in 24 bytes of storage space and are represented as `(x, y, r)`. The *x, y* value represents the coordinates of the center of the circle, while *r* represents the length of the radius. Parentheses or arrow brackets may optionally delimit the values for *x*, *y*, and *r*.

`DATE` *(SQL standard data type:* `DATE`*)*
: Holds a calendar date (year, day, and month) without the time of day in a 4-byte storage space. Dates must be between 4713 BC and 32767 AD. `DATE`'s lowest resolution, naturally, is to the day.

`DATERANGE` *(SQL standard data type: none)*
: Holds two calendar dates (year, day, and month) without the time of day, each in a 4-byte storage space. Dates must be between 4713 BC and 32767 AD. The `DATERANGE` type is used to store a specific period of time, with the first date being the start of the range and last date being the end. As such, the first date must be smaller than the second date. This data type also stores information determining whether the dates are inclusive or exclusive. The lowest resolution is to the day.

`DECIMAL[(p,s)], NUMERIC[(p,s)]` *(SQL standard data type:* `DECIMAL(p,s), NUMERIC(p,s)`*)*
: Stores exact numeric values with a precision (*p*) in the range of `0` to `9` and a scale (*s*) of `0`, with no upper limit.

`FLOAT4`, `REAL` *(SQL standard data type:* `FLOAT(p)`*)*
: Stores floating-point numbers with a precision of `0` to `8` and 6 decimal places.

`FLOAT8, DOUBLE PRECISION` *(SQL standard data type:* `FLOAT(p), 7 <= p < 16`*)*
: Stores floating-point numbers with a precision of 0 to 16 and 15 decimal places.

`INET(x.x.x.x/y)` *(SQL standard data type: none)*
: Stores an IPv4 network or host address in a 12-byte storage space. The range is any valid IPv4 network address. The *x*s represent the IP address, and *y* is the number of bits in the netmask. The netmask defaults to 32. Unlike `CIDR`, `INET` accepts non-zero bits to the right of the netmask.

`INTEGER, INT, INT4` *(SQL standard data type:* `INTEGER`*)*
: Stores signed or unsigned 4-byte integers within the range of –2,147,483,648 to 2,147,483,647.

`INTERVAL(p)` *(SQL standard data type: none)*
: Holds general-use time span values within the range of –178,000,000 to 178,000,000 years in a 12-byte storage space. `INTERVAL`'s lowest resolution is to the microsecond. This is a different data type than that provided by the SQL standard, which requires an interval qualifier such as `INTERVAL YEAR TO MONTH`.

`JSON` *(SQL standard data type:* `BLOB`*)*
: Stores JSON data as plain text. It maintains the fidelity of the data put in it and adds on JSON validation checking to prevent invalid JSON data being stored. The size cannot exceed 1 GB.

`JSONB` *(SQL standard data type:* `BLOB`*)*
: Stores JSON data as binary. `JSONB` has richer support for indexing than `JSON` and is more compact; it also enables subelements of the data to be pulled out faster. This is the preferred data type for storing JSON data. Unlike with the `JSON` type, data added to it is restored for more efficient query handling, and it does not allow duplication of keys. In case of duplicates, the last value wins. As such, you will find it may not match exactly what you inserted into it, so it's not suitable if you need to maintain the exactness of what was inserted. The size cannot exceed 1 GB.

> PostgreSQL also includes a `JSONPATH` type that is not normally used as a column data type but can be used if you want to store JSON path queries. You'll find much more on the different platforms' support for JSON in Chapter 10.

`LINE( ( x1, y1), (x2, y2) )` *(SQL standard data type: none)*
: Holds line data, without endpoints, in 2D plane values. Values are stored in 32 bytes and are represented as `( (x1, y1), (x2, y2) )`, indicating the start and end points of a line. The enclosing parentheses are optional for line syntax.

`LSEG( ( x1, y1), (x2, y2) )` *(SQL standard data type: none)*
: Holds line segment (`LSEG`) data, with endpoints, in a 2D plane. Values are stored in 32 bytes and are represented as `( (x1, y1), (x2, y2) )`. The outer parentheses are optional for `LSEG` syntax. For those who are interested, the "line segment" is what most people traditionally think of as a line. For example, the lines on a playing field are actually line segments.

> In true geometric nomenclature, a *line* stretches to infinity, having no terminus at either end, while a *line segment* has endpoints. PostgreSQL has data types for both, but they are functionally equivalent.

`MACADDR` *(SQL standard data type: none)*
Holds a value for the MAC address of a computer's network interface card in a 6-byte storage space. `MACADDR` accepts a number of industry standard representations, such as:

- 08002B:010203
- 08002B-010203
- 0800.2B01.0203
- 08-00-2B-01-02-03
- 08:00:2B:01:02:03

`MONEY, DECIMAL(9,2)` *(SQL standard data type: none)*
Stores US-style currency values in the range of −21,474,836.48 to 21,474,836.47.

`NUMERIC[(p,s)], DECIMAL[(p,s)]` *(SQL standard data type: none)*
Stores exact numeric values with a precision (*p*) and scale (*s*).

`OID` *(SQL standard data type: none)*
Stores unique object identifiers.

`PATH((x1, y1), ... n), PATH[(x1, y1), ... n]` *(SQL standard data type: none)*
Describes an open and closed geometric path in a 2D plane. Values are represented as `[(x1, y1), ... n]` and consume 4 + 32*n* bytes of storage space. Each `(x, y)` value represents a point on the path. Paths are either open, where the first and last points do not intersect, or closed, where the first and last points do intersect. Parentheses are used to encapsulate closed paths, while brackets encapsulate open paths.

`POINT(x, y)` *(SQL standard data type: none)*
Stores values for a geometric point in a 2D plane in a 16-byte storage space. Values are represented as `(x, y)`. The point is the basis for all other two-dimensional spatial data types supported in PostgreSQL. Parentheses are optional for point syntax.

`POLYGON( (x1, y1), ... n )` *(SQL standard data type: none)*
Stores values for a closed geometric path in a 2D plane using 4 + 32*n* bytes of storage. Values are represented as `( (x1,y1), ... n )`; the enclosing parentheses are optional. `POLYGON` is essentially a closed-path data type.

`SERIAL, SERIAL4` *(SQL standard data type: none)*
Stores an auto-incrementing, unique integer ID for indexing and cross-referencing referred to as a `SEQUENCE`. Can contain up to 4 bytes of data (a range of numbers from 1 to 2,147,483,647). Dropping the table containing this data type also drops the `SEQUENCE`.

`SERIAL8, BIGSERIAL` *(SQL standard data type: none)*
: Stores an auto-incrementing, unique integer ID for indexing and cross-referencing. Can contain up to 8 bytes of data (a range of numbers from 1 to 9,223,372,036,854,775,807), but otherwise functions in the same way as the `SERIAL` (and `SERIAL4`) data type.

`SMALLINT, INT2` *(SQL standard data type:* `SMALLINT`*)*
: Stores signed or unsigned 2-byte integers within the range of –32,768 to 32,767.

`TEXT` *(SQL standard data type:* `CLOB`*)*
: Stores large, variable-length character string data of up to 1 GB in size. PostgreSQL automatically compresses `TEXT` strings, so the disk size may be less than the string size.

`TIME[(p)] [WITHOUT TIME ZONE | WITH TIME ZONE]` *(SQL standard data type:* `TIME`*)*
: Holds the time of day and stores either no time zone (using 8 bytes of storage space) or the time zone of the database server (using 12 bytes of storage space). The allowable range is from 00:00:00.00 to 23:59:59.99. The lowest granularity is 1 microsecond. Note that time zone information on most Unix systems is available only for the years 1902 through 2038.

`TIMESTAMP[(p)] [WITHOUT TIME ZONE | WITH TIME ZONE]` *(SQL standard data type:* `TIMESTAMP [WITH TIME ZONE | WITHOUT TIMEZONE]`*)*
: Holds the date and time and stores either no time zone or the time zone of the database server (`TIMESTAMPTZ` is shorthand for `TIMESTAMP WITH TIME ZONE`). The range of values is from 4713 BC to 1465001 AD. `TIMESTAMP` uses 8 bytes of storage space per value. The lowest granularity is 1 microsecond. Note that time zone information on most Unix systems is available only for the years 1902 through 2038.

`TIMETZ` *(SQL standard data type:* `TIME WITH TIME ZONE`*)*
: Holds the time of day, including the time zone.

`TSQUERY` *(SQL standard data type: none)*
: Used for full text search. This is a textual way of defining a full text query that is then applied to a `TSVECTOR`.

`TSVECTOR` *(SQL standard data type: none)*
: Used for full text search. This is a binary format consisting of lexemes and frequency.

`TZRANGE` *(SQL standard data type: none)*
: Holds two `TIMESTAMP WITH TIME ZONE` values that denote the start and end of a period of time.

`VARCHAR(n), CHARACTER VARYING(n)` *(SQL standard data type:* `CHARACTER VARYING(n)`*)*
: Stores variable-length character strings of up to a length of *n*. Trailing spaces are not stored.

`XML` *(SQL standard data type:* `XML`*)*
: Stores XML data in a column or a variable of variable size in storage space up to but not exceeding 1 GB in size.

SQL Server Data Types

Microsoft SQL Server supports most SQL data types, as well as some additional data types used to uniquely identify rows of data within a table and across multiple servers, such as `UNIQUEIDENTIFIER`. These data types are included in support of Microsoft's hardware philosophy of "scaling out" (that is, deploying on many Intel-based servers) rather than "scaling up" (deploying on a single huge, high-end Unix server or a Windows Data Center Server).

Like PostgreSQL, SQL Server has OGC support. It's similar to PostGIS in how it implements spatial data types, with a dedicated *geometry* type for flat-earth (planar, Euclidean) data and a *geography* type for round-earth (ellipsoidal) data, such as latitude and longitude coordinates. It has the richest support for curved geometries and round-earth data of all the databases discussed in this book, but lacks the spatial reprojection support provided by both PostGIS and Oracle, which is commonly needed for GIS work.

The data types SQL Server supports are:

`BIGINT` *(SQL standard data type:* `BIGINT`*)*
: Stores signed and unsigned integers in the range of –9,223,372,036,854,775,808 to 9,223,372,036,854,775,807, using 8 bytes of storage space. See `INT` for `IDENTITY` property rules that also apply to `BIGINT`.

`BINARY[(n)]` *(SQL standard data type:* `BLOB`*)*
: Stores a fixed-length binary value of 1 to 8,000 bytes in size. `BINARY` data types consume *n* + 4 bytes of storage space.

`BIT` *(SQL standard data type:* `BOOLEAN`*)*
: Stores a value of 1, 0, or NULL (to indicate "unknown"). Up to eight `BIT` columns in a single table will be stored in a single byte. An additional eight `BIT` columns consume one more byte of storage space. `BIT` columns cannot be indexed.

`CHAR[(n)], CHARACTER[(n)]` *(SQL standard data type:* `CHARACTER(n)`*)*
: Holds fixed-length character data of 1 to 8,000 characters in length. Any unused space is, by default, padded with spaces. (You can disable the automatic padding.) The storage size is *n* bytes.

`CURSOR` *(SQL standard data type: none)*
: A special data type used to describe a cursor as a variable or stored procedure `OUTPUT` parameter. It cannot be used in a `CREATE TABLE` statement. The `CURSOR` data type is always nullable.

`DATE` *(SQL standard data type:* `DATE`*)*
: Holds a date in the range of January 1, 0001 AD, to December 31, 9999 AD. Values are stored in a 3-byte storage space.

`DATETIME` *(SQL standard data type:* `TIMESTAMP`*)*
: Holds a date and time within the range of 1753-01-01 00:00:00 to 9999-12-31 23:59:59. Values are stored in an 8-byte storage space.

> Why can't you store dates prior to January 1, 1753, using SQL Server's `DATETIME` data type? The rationale (from the database's Sybase roots) is that the English-speaking world switched from the Julian to the Gregorian calendar in September 1752, and the transition resulted in several days being "lost." Converting dates prior to 1753 from the Julian to the Gregorian calendar can thus be quite challenging. This constraint does not apply to the date-related data types added in SQL Server 2008 (`DATE`, `DATETIME2`, and `DATETIMEOFFSET`).

`DATETIME2` *(SQL standard data type:* `TIMESTAMP`*)*
: Holds a date and time within the range of January 1, 0001 AD, to December 31, 9999 AD, to an accuracy of 100 nanoseconds. Values are stored in a 6- to 8-byte storage space, depending on the precision.

`DATETIMEOFFSET` *(SQL standard data type:* `TIMESTAMP`*)*
: Holds a date and time within the range of January 1, 0001 AD, to December 31, 9999 AD, to an accuracy of 100 nanoseconds. Also includes time zone information. Values are stored in a 10-byte storage space.

`DECIMAL(p,s), DEC(p,s), NUMERIC(p,s)` *(SQL standard data type:* `DECIMAL(p,s), NUMERIC(p,s)`*)*

Stores decimal values up to 38 digits long. The values *p* and *s* define the precision and scale, respectively. The default value for the scale is 0. The precision of the data type determines how much storage space it will consume:

- Precision 1–9 uses 5 bytes
- Precision 10–19 uses 9 bytes
- Precision 20–28 uses 13 bytes
- Precision 29–39 uses 17 bytes

See `INT` for `IDENTITY` property rules that also apply to `DECIMAL`.

`DOUBLE PRECISION` *(SQL standard data type: none)*
: Synonym for `FLOAT(53)`.

`FLOAT[(n)]` *(SQL standard data type:* `FLOAT`, `FLOAT(n)`*)*
: Holds floating-point numbers in the range of –1.79E+308 through 1.79E+308. The precision, represented by *n*, may be in the range of 1 to 53. The storage size is 4 bytes for 7 digits, where *n* is in the range of 1 to 24. Anything larger requires 8 bytes of storage.

`HIERARCHYID` *(SQL standard data type: none)*
: Represents a hierarchy or tree structure within the relational data. Although it may consume more space, `HIERARCHYID` will usually consume 5 bytes or less. Refer to the vendor documentation for more information on this special data type.

`IMAGE` *(SQL standard data type:* `BLOB`*)*
: Stores a variable-length binary value of up to 2,147,483,647 bytes in length. Consider this data type to be deprecated, and use `VARBINARY(MAX)` instead. This data type is commonly used to store graphics, sounds, and files such as MS-Word documents and MS-Excel spreadsheets. `IMAGE` cannot be freely manipulated; both `IMAGE` and `TEXT` columns have a lot of constraints on how they can be used. See `TEXT` for a list of the commands and functions that work on an `IMAGE` data type.

`INT [IDENTITY [ (seed, increment) ]]` *(SQL standard data type:* `INTEGER`*)*
: Stores signed or unsigned integers within the range of –2,147,483,648 to 2,147,483,647 in 4 bytes of storage space. All integer data types, as well as the decimal type, support the `IDENTITY` property. An identity is an automatically incrementing row identifier. Refer to the section "CREATE/ALTER DATABASE Statement" on page 72 for more information.

`MONEY` *(SQL standard data type: none)*
: Stores monetary values within the range of –922,337,203,685,477.5808 to 922,337,203,685,477.5807 in an 8-byte storage space.

`NCHAR(n), NATIONAL CHAR(n), NATIONAL CHARACTER(n)` *(SQL standard data type:* `NATIONAL CHARACTER(n)`*)*
: Holds fixed-length Unicode data of up to 4,000 characters in length. The storage space consumed is double the character length inserted into the field (2 * *n*).

`NTEXT, NATIONAL TEXT` *(SQL standard data type:* `NCLOB`*)*
: Holds Unicode text passages of up to 1,073,741,823 characters in length. See `TEXT` for rules about the commands and functions available for `NTEXT`.

`NUMERIC(p,s)` *(SQL standard data type:* `DECIMAL(p,s)`*)*
: Synonym for `DECIMAL`. See `INT` for rules about the `IDENTITY` property that also apply to this type.

`NVARCHAR(n)`, `NATIONAL CHAR VARYING(n)`, `NATIONAL CHARACTER VARYING(n)` *(SQL standard data type:* `NATIONAL CHARACTER VARYING(n)`*)*
: Holds variable-length Unicode data of up to 4,000 characters in length. The storage space consumed is double the character length inserted into the field (2 * *n*). The system setting `SET ANSI_PADDING` is always enabled (`ON`) for `NCHAR` and `NVARCHAR` fields in SQL Server. You may instead define this as `NVARCHAR(MAX)` for text fields exceeding 8,000 bytes in size with no upper limit. Use as a replacement for the `IMAGE` data type.

`REAL`, `FLOAT(24)` *(SQL standard data type:* `REAL`*)*
: Holds floating-point numbers in the range of –3.40E+38 through 3.40E+38 in a 4-byte storage space. `REAL` is functionally equivalent to `FLOAT(24)`.

`ROWVERSION` *(SQL standard data type: none)*
: Stores a number that is unique within the database whenever a row in the table is updated. Called `TIMESTAMP` in earlier versions.

`SMALLDATETIME` *(SQL standard data type: none)*
: Holds a date and time within the range of 1900-01-01 00:00 through 2079-06-06 23:59, accurate to the nearest minute. (Minutes are rounded down when seconds are 29.998 or less; otherwise, they are rounded up.) Values are stored in 4 bytes.

`SMALLINT` *(SQL standard data type:* `SMALLINT`*)*
: Stores signed or unsigned integers in the range of –32,768 to 32,767, in 2 bytes of storage space. See `INT` for rules about the `IDENTITY` property that also apply to this type.

`SMALLMONEY` *(SQL standard data type: none)*
: Stores monetary values within the range of –214,748.3648 to 214,748.3647, in 4 bytes of storage space.

`SQL_VARIANT` *(SQL standard data type: none)*
: Stores values of other SQL Server–supported data types, except `TEXT`, `NTEXT`, `ROWVERSION`, and other `SQL_VARIANT` commands. Can store up to 8,016 bytes of data and supports NULL and DEFAULT values. `SQL_VARIANT` is used in columns, parameters, variables, and return values of functions and stored procedures.

`TABLE` *(SQL standard data type: none)*
: Special data type that stores a result set for a later process. Used solely in procedural processing, and cannot be used in a `CREATE TABLE` statement. This data type alleviates the need for temporary tables in many applications. It can reduce the need for stored procedure recompiles, thus speeding execution of stored procedures and user-defined functions.

`TEXT` *(SQL standard data type:* `CLOB`*)*
: Stores very large passages of text (up to 2,147,483,647 characters in length). Consider this data type to be deprecated, and use `VARCHAR(MAX)` or `NVARCHAR(MAX)` instead. This is because `TEXT` and `IMAGE` values are often more difficult to manipulate than, say, `VARCHAR` values. For example, you cannot place an index on a `TEXT` or `IMAGE` column. `TEXT` values can can be manipulated using the functions `DATALENGTH`, `PATINDEX`, `SUBSTRING`, `TEXTPTR`, and `TEXTVALID` as well as the commands `READTEXT`, `SET TEXTSIZE`, `UPDATETEXT`, and `WRITETEXT`.

`TIME` *(SQL standard data type:* `TIME`*)*
: Stores an automatically generated binary number that guarantees uniqueness in the current database and is therefore different from the SQL standard `TIME STAMP` data type. Values are stored in 8 bytes of storage space. `ROWVERSION` is now preferred over `TIME` to uniquely track each row.

`TIMESTAMP` *(SQL standard data type:* `TIMESTAMP`*)*
: Stores the time of day based on a 24-hour clock without time zone awareness, to an accuracy of 100 nanoseconds, in a 5-byte storage space.

`TINYINT` *(SQL standard data type: none)*
: Stores unsigned integers within the range 0 to 255 in 1 byte of storage space. See `INT` for rules about the `IDENTITY` property that also apply to this type.

`UNIQUEIDENTIFIER` *(SQL standard data type: none)*
: Represents a value that is globally unique across all databases and all servers. Values are represented as `xxxxxxxx-xxxx-xxxx-xxxxxxxxxxxxxxxx`, where each *x* is a hexadecimal digit in the range 0 to 9 or a to f. The only operations allowed against `UNIQUEIDENTIFIER`s are comparisons and NULL checks. Column constraints and properties are allowed on `UNIQUEIDENTIFIER` columns, with the exception of the `IDENTITY` property.

`VARBINARY[(n)]` *(SQL standard data type:* `BLOB`*)*
: Describes a variable-length binary value of up to 8,000 bytes in size. The storage space consumed is equivalent to the size of the data inserted, plus 4 bytes. You may define this as `VARBINARY(MAX)` for binary fields exceeding 8,000 bytes in size with no upper limit. Use as a replacement for the `IMAGE` data type.

`VARCHAR[(n)], CHAR VARYING[(n)], CHARACTER VARYING[(n)]` *(SQL standard data type:* `CHARACTER VARYING(n)`*)*
: Holds variable-length character data of 1 to 8,000 characters in length. The amount of storage space required is determined by the actual size of the value entered in bytes, not the value of *n*. You may define this as `VARCHAR(MAX)` for text fields exceeding 8,000 bytes in size with no upper limit. Use as a replacement for the `IMAGE` data type.

XML *(SQL standard data type:* XML*)*
: Stores XML data in a column or a variable of variable size in storage space up to but not exceeding 2 GB in size.

Constraints

Constraints allow you to automatically enforce the rules of data integrity and to filter the data that is placed in a database. In a sense, constraints are rules that define which data values are valid during INSERT, UPDATE, and DELETE operations. When a data-modification transaction breaks the rules of a constraint, the statement is rejected or the effect of the statement is undone.

In the SQL standard, there are four constraint types: CHECK, PRIMARY KEY, UNIQUE, and FOREIGN KEY. (The RDBMS platforms may allow more; refer to Chapter 3 for details.)

Scope

Constraints may be applied at the column level or the table level:

Column-level constraints
: Are declared as part of a column definition and apply only to that column.

Table-level constraints
: Are declared independently from any column definitions (traditionally, at the end of a CREATE TABLE statement) and may apply to one or more columns in the table, or even one or more columns in other tables. A table constraint is required when you wish to define a constraint that applies to more than one column.

Syntax

Constraints are defined when you create or alter a table. The general syntax for constraints is shown here:

```
CONSTRAINT [constraint_name] constraint_type [(column[, ...])]
[predicate] [constraint_deferment] [deferment_timing]
```

The syntax elements are as follows:

CONSTRAINT [*constraint_name*]
: Begins a constraint definition and, optionally, provides a name for the constraint. When you omit *constraint_name*, the system will create a name for you automatically. On some platforms, you may omit the CONSTRAINT keyword as well.

System-generated names are often incomprehensible. It is good practice to specify human-readable, sensible names for constraints.

`constraint_type`
: Declares the constraint as one of the allowable types: `CHECK`, `PRIMARY KEY`, `UNIQUE`, or `FOREIGN KEY`. More information about each type of constraint appears later in this section.

`(`*`column`*`[, ... ])`
: Associates one or more columns with the constraint. Specify the columns in a comma-delimited list, enclosed in parentheses. The column list should be omitted for column-level constraints. Columns are not used in every constraint. For example, `CHECK` constraints do not generally use column references.

`predicate`
: Defines a predicate for `CHECK` constraints.

`constraint_deferment`
: Declares a constraint is `DEFERRABLE` or `NOT DEFERRABLE`. When a constraint is deferrable, you can specify that it be checked for a rules violation at the end of a transaction. When a constraint is not deferrable, it is checked for a rules violation at the conclusion of every SQL statement.

`deferment_timing`
: Declares a deferrable constraint as `INITIALLY DEFERRED` or `INITIALLY IMMEDIATE`. When set to `INITIALLY DEFERRED`, the constraint check time will be deferred until the end of a transaction, even if the transaction is composed of many SQL statements. In this case, the constraint must also be `DEFERRABLE`. When set to `INITIALLY IMMEDIATE`, the constraint is checked at the end of every SQL statement. In this case, the constraint may be either `DEFERRABLE` or `NOT DEFERRABLE`. The default is `INITIALLY IMMEDIATE`.

Note that this syntax may vary among the different vendor platforms. Check the individual platform sections in Chapter 3 for more details.

PRIMARY KEY Constraints

A `PRIMARY KEY` constraint declares one or more columns whose value(s) uniquely identify each record in the table. It is considered a special case of the `UNIQUE` constraint. Here are some rules about primary keys:

- Only one primary key may exist on a table at a time.
- Columns in the primary key cannot have data types of `BLOB`, `CLOB`, `NCLOB`, or `ARRAY`.

- Primary keys may be defined at the column level for a single column key or at the table level if multiple columns make up the primary key.
- Values in the primary key column(s) must be unique and not NULL.
- In a multicolumn primary key, the combination of values in all of the key columns must be unique and not NULL. Multicolumn primary keys are also known as *concatenated keys* or *natural keys*.
- Foreign keys can be declared that reference the primary key of a table to establish direct relationships between tables (or possibly, though rarely, within a single table).

The following SQL standard code includes the options for creating both a table- and column-level primary key constraint on a table called *distributors*. The first example shows a column-level primary key constraint, while the second shows a table-level constraint:

```
-- Creating a column-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)    NOT NULL PRIMARY KEY,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    ,
     phone         CHAR(12)   ,
     sales_rep     INT        );

-- Creating a table-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)     NOT NULL,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    ,
     phone         CHAR(12)   ,
     sales_rep     INT        ,
CONSTRAINT     pk_dist_id  PRIMARY KEY (dist_id));
```

In the example showing a table-level primary key, we could easily have created a concatenated key by listing several columns separated by commas.

FOREIGN KEY Constraints

A `FOREIGN KEY` constraint defines one or more columns in a table as referencing columns in a unique or primary key in another table. (A foreign key can reference a unique or primary key in the same table as the foreign key itself, but such foreign keys are rare). Foreign keys can then prevent the entry of data into a table when there is no matching value in the related table. They are the primary means of identifying the relationships between tables in a relational database. Here are some rules about foreign keys:

- Many foreign keys may exist on a table at a time.
- A foreign key must be declared to reference either the primary key or a unique key of another table to establish a direct relationship between the two tables.
- When a parent table has a multicolumn primary key or unique key, then any foreign keys that reference them must also be multicolumn in the same way. Further, each column in such a multicolumn foreign key must possess a value or possess only NULL values throughout.

The full SQL syntax for foreign keys is more elaborate than the general syntax for constraints shown earlier, and it's dependent on whether you are making a table-level or column-level declaration. However, it is important to note that in either case shown in the following example, the foreign key declaration is a part of the `CREATE TABLE` statement. The only true syntactical difference is where in the foreign key declaration appears. (Also keep in mind that SQL offers distinct statements to `CREATE`, `ALTER`, and `DROP` foreign keys independently of the `CREATE TABLE` statement, as you will see in Chapter 3.) Here is the syntax for table-level and column-level foreign key declarations:

```
-- Table-level foreign key
table_definition
[CONSTRAINT [constraint_name] ]
FOREIGN KEY (local_column[, ...])
REFERENCES referenced_table [ (referenced_column[, ...]) ]
[MATCH {FULL | PARTIAL | SIMPLE} ]
[ON UPDATE {NO ACTION | CASCADE | RESTRICT |
   SET NULL | SET DEFAULT} ]
[ON DELETE {NO ACTION | CASCADE | RESTRICT |
   SET NULL | SET DEFAULT} ]
[constraint_deferment] [deferment_timing]

-- Column-level foreign key
[CONSTRAINT [constraint_name] ]
REFERENCES referenced_table [(referenced_column[, ...])]
[MATCH {FULL | PARTIAL | SIMPLE} ]
[ON UPDATE {NO ACTION | CASCADE | RESTRICT |
   SET NULL | SET DEFAULT} ]
[ON DELETE {NO ACTION | CASCADE | RESTRICT |
   SET NULL | SET DEFAULT} ]
[constraint_deferment] [deferment_timing]
```

The keywords common to a standard constraint declaration were described in the "Syntax" on page 60. Keywords specific to foreign keys are described in the following list:

FOREIGN KEY (*local_column*[, ...])
: Declares one or more columns of the table being created or altered that are subject to the foreign key constraint. This syntax is used *only* in table-level declarations and is excluded from column-level declarations. We recommend that the ordinal positions and data types of the columns in the *local_column* list match the ordinal positions and data types of the columns in the *referenced_column* list.

REFERENCES *referenced_table* [(*referenced_column* [, ...])]
: Names the table and, where appropriate, the column or columns that hold the valid list of values for the foreign key. A *referenced_column* must already be named in a NOT DEFERRABLE PRIMARY KEY or NOT DEFERRABLE UNIQUE KEY statement. The table types must also match; for example, if one is a local temporary table, both must be local temporary tables.

MATCH {FULL | PARTIAL | SIMPLE}
: Defines the degree of matching required between the local and referenced columns in foreign key constraints when NULLs are present:

    FULL
    : Declares that a match is acceptable when either all the values in the referencing columns are NULL, or none of them are NULL and there is a row in the referenced table that matches all the values. In general, you should either use MATCH FULL or ensure that all columns involved have NOT NULL constraints.

    PARTIAL
    : Declares that a match is acceptable when one or more of the referenced columns contains NULL and the other referenced columns have a match in the referenced table.

    SIMPLE
    : Declares that a match is acceptable when any of the values of the referencing column is NULL or a match. This is the default.

ON UPDATE
: Specifies that, when an UPDATE operation affects one or more referenced columns of the primary or unique key on the referenced table, a corresponding action should be taken to ensure that the foreign key does not lose data integrity. ON UPDATE may be declared independently of or together with the ON DELETE clause. When omitted, the default for the SQL standard is ON UPDATE NO ACTION.

ON DELETE
: Specifies that, when a DELETE operation affects one or more referenced columns of the primary or unique key on the referenced table, a corresponding action should be taken to ensure that the foreign key does not lose data integrity. ON DELETE may be declared independently of or together with the ON

UPDATE clause. When omitted, the default for the SQL standard is ON DELETE NO ACTION.

NO ACTION | CASCADE | RESTRICT | SET NULL | SET DEFAULT
: Defines the action the database takes to maintain the data integrity of the foreign key when a referenced primary or unique key constraint value is changed or deleted:

  NO ACTION
  : Tells the database to do nothing when a primary key or unique key value referenced by a foreign key is changed or deleted.

  CASCADE
  : Tells the database to perform the same action (i.e., DELETE or UPDATE) on the matching foreign key when a primary key or unique key value is changed or deleted.

  RESTRICT
  : Tells the database to prevent changes to the primary key or unique key value referenced by the foreign key.

  SET NULL
  : Tells the database to set the value in the foreign key to NULL when a primary key or unique key value is changed or deleted.

  SET DEFAULT
  : Tells the database to set the value in the foreign key to the default (using default values you specify for each column) when a primary key or unique key value is changed or deleted.

As with the code for primary keys, you can adapt this generic syntax to both column-level and table-level foreign key constraints. Note that column-level and table-level constraints perform their function in exactly the same way; they are merely defined at different levels of the CREATE TABLE command. In the following example, we create a single-column foreign key on the *salesrep* column referencing the *empid* column of the *employee* table. We create the foreign key two different ways, first at the column level and then at the table level:

```
-- Creating a column-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)    PRIMARY KEY,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    ,
     phone         CHAR(12)   ,
     sales_rep     INT        NOT NULL
   REFERENCES employee(empid));
```

```
-- Creating a table-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)    NOT NULL,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    ,
     phone         CHAR(12)   ,
     sales_rep     INT        ,
CONSTRAINT pk_dist_id  PRIMARY KEY (dist_id),
CONSTRAINT fk_empid
   FOREIGN KEY (sales_rep)
   REFERENCES employee(empid));
```

UNIQUE Constraints

A UNIQUE constraint, sometimes called a *candidate key* or an *alternate key*, declares that the values in one column, or the combination of values in more than one column, must be unique. Rules concerning unique constraints include:

- Columns in a unique key cannot have data types of BLOB, CLOB, NCLOB, or ARRAY.
- The column or columns in a unique key may not be identical to those in any other unique keys, or to any columns in the primary key of the table.
- A single NULL value, if the unique key allows NULL values, is allowed.
- The SQL standard allows you to substitute the column list shown in the general syntax diagram for constraints with the keyword VALUE. UNIQUE (VALUE) indicates that all columns in the table are part of the unique key. The VALUE keyword also disallows any other unique or primary keys on the table.

In the following example, we limit the number of distributors we do business with to only one distributor per zip code. We also allow one (and only one) "catch-all" distributor with a NULL zip code. This functionality can be implemented easily using a UNIQUE constraint, either at the column or the table level:

```
-- Creating a column-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)    PRIMARY KEY,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    UNIQUE,
     phone         CHAR(12)   ,
     sales_rep     INT        NOT NULL
```

```
   REFERENCES employee(empid));

-- Creating a table-level constraint
CREATE TABLE distributors
    (dist_id       CHAR(4)    NOT NULL,
     dist_name     VARCHAR(40),
     dist_address1 VARCHAR(40),
     dist_address2 VARCHAR(40),
     city          VARCHAR(20),
     state         CHAR(2)    ,
     zip           CHAR(5)    ,
     phone         CHAR(12)   ,
     sales_rep     INT        ,
CONSTRAINT pk_dist_id  PRIMARY KEY (dist_id),
CONSTRAINT fk_emp_id   FOREIGN KEY (sales_rep)
   REFERENCES employee(empid),
CONSTRAINT unq_zip     UNIQUE (zip));
```

CHECK Constraints

CHECK constraints allow you to perform comparison operations to ensure that values match specific conditions that you set out. The syntax for a check constraint is very similar to the general syntax for constraints:

```
[CONSTRAINT] [constraint_name] CHECK (search_conditions)
[constraint_deferment] [deferment_timing]
```

Most of the elements of the check constraint were introduced in the "Syntax" on page 60. The following element is unique to this constraint:

search_conditions
: Specifies one or more search conditions that constrain the values inserted into the column or table, using one or more expressions and a predicate. Multiple search conditions may be applied to a column in a single check constraint using the AND and OR operators (think of a WHERE clause).

A check constraint is considered matched when the search conditions evaluate to TRUE or NULL. Check constraints are limited to Boolean operations (e.g., =, >=, <=, or <>), though they may include any standard SQL predicate, such as IN or LIKE. Check constraints may be appended to one another (when checking a single column) using the AND and OR operators. Here are some other rules about check constraints:

- A column or table may have one or more check constraints.
- A search condition cannot contain aggregate functions, except in a subquery.
- A search condition cannot use nondeterministic functions or subqueries.
- A check constraint must be referenced like an object. That is, if a check constraint is declared on a global temporary table, it cannot then reference a permanent table as part of its definition.

- A search condition cannot reference these functions from the SQL standard: CURRENT_USER, SYSTEM_USER, USER, CURRENT_PATH, CURRENT_DATE, CURRENT_TIME, CURRENT_TIMESTAMP, LOCALTIME, and LOCALTIMESTAMP.

The following example adds a check constraint to the *dist_id* and *zip* columns. (This example uses generic code run on SQL Server.) The zip code must fall into the normal ranges for postal zip codes, while the *dist_id* values are allowed to contain either four alphabetic characters or two alphabetic and two numeric characters:

```
-- Creating column-level CHECK constraints
CREATE TABLE distributors
   (dist_id       CHAR(4)
      CONSTRAINT pk_dist_id PRIMARY KEY
      CONSTRAINT ck_dist_id CHECK
         (dist_id LIKE '[A-Z][A-Z][A-Z][A-Z]' OR
          dist_id LIKE '[A-Z][A-Z][0-9][0-9]'),
    dist_name     VARCHAR(40),
    dist_address1 VARCHAR(40),
    dist_address2 VARCHAR(40),
    city          VARCHAR(20),
    state         CHAR(2),
    zip           CHAR(5)
      CONSTRAINT unq_dist_zip UNIQUE
      CONSTRAINT ck_dist_zip CHECK
         (zip LIKE '[0-9][0-9][0-9][0-9][0-9]'),
    phone         CHAR(12),
    sales_rep     INT
      NOT NULL DEFAULT USER REFERENCES employee(emp_id))
```

3 Structuring Your Data

Newcomers to SQL usually take one of two learning paths when learning to program in the language. Developers and analysts often start with the `SELECT` statement and the other DML statements, `INSERT`, `UPDATE`, `DELETE`, and `MERGE`. That's because they are frequently tasked with helping either to write the frontend applications that access the database, in the case of developers, or to write reports and retrieve information for better business decisions, in the case of business analysts. The second learning path, that of DBAs and database architects, is to start with the SQL statements needed to create a database from whole cloth.

In this chapter, we will explore the various statements you will need to create a database from scratch, by populating it with tables, views, and many other important database objects. We will also detail the statements needed to alter existing objects and to remove those objects when required.

How to Use This Chapter

When researching a command in this chapter:

1. Read "SQL Platform Support" on page 70.
2. Check Table 3-1.
3. Look up the specific SQL statement, check the syntax, and read the "Keywords," "Rules at a glance," and "Programming tips and gotchas" sections. Do this even if you are looking for a specific platform implementation.
4. Finally, read the platform-specific implementation information, which notes the differences between the standard and the vendor's implementation of the standard.

You will note that the entry for a given platform implementation does not duplicate information on any clauses that do not differ from the standard. So, it is possible that you will need to flip between the descriptions for a vendor variation and the SQL standard to cover all possible details of that command.

In our discussions of MySQL, we will also include MariaDB, a fork of MySQL. For the most part, MySQL and MariaDB provide fully code-compatible syntax. In these cases we will refer to them collectively as MySQL. We will explicitly mention MariaDB only in situations where it deviates from MySQL in an important way.

Finally, keep in mind that the descriptions of the various SQL statements throughout this book are organized alphabetically, as you would expect with a command reference. However, a more typical workflow sequence for the commands in this chapter would look like:

- `CREATE DATABASE`
- `CREATE SCHEMA`
- `CREATE DOMAIN`
- `CREATE TYPE`
- `CREATE TABLE`
- `CREATE INDEX`
- `CREATE VIEW`
- `ALTER` commands
- `DROP` commands

SQL Platform Support

Table 3-1 provides a listing of the SQL statements covered in this chapter, the platforms that support them, and the degrees to which they support them. The following list offers useful tips for reading Table 3-1, as well as an explanation of what each abbreviation stands for:

1. The first column contains the SQL commands, in alphabetical order.
2. The SQL statement class for each command is indicated in the second column.
3. The subsequent columns list the level of support for each vendor:

   Supported (S)
   : The platform supports the SQL standard for the particular command.

   Supported, with variations (SWV)
   : The platform supports the SQL standard for the particular command, using vendor-specific code or syntax.

Supported, with limitations (SWL)
: The platform supports some but not all of the features specified by the SQL standard for the particular command.

Not supported (NS)
: The platform does not support the particular command according to the SQL standard.

The sections that follow the table describe the commands in detail. Related `CREATE` and `ALTER` commands (e.g., `CREATE DATABASE` and `ALTER DATABASE`) are discussed together in "CREATE/ALTER DATABASE Statement" on page 72.

Remember that even if a specific SQL command is listed in the table as "Not supported," the platform usually has alternative coding or syntax to enact the same command or function. Therefore, be sure to read the discussion and examples for each command later in this chapter. Likewise, a few of the commands in Table 3-1 are not found in the SQL standard; these are indicated with the term "Non-standard" in the "SQL class" column of the table.

Since this book focuses on the implementation of the SQL language, statements from the SQL standard that are unsupported by any of the database vendors we consider are not included in these tables or discussed in the text.

Table 3-1. Alphabetical quick SQL command reference

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`ALTER DATABASE`	SQL-schema	SWV	SWV	SWV	SWV
`ALTER INDEX`	Non-standard	NS	SWV	SWV	SWV
`ALTER SCHEMA`	Non-standard	SWV	NS	SWV	SWV
`ALTER TABLE`	SQL-schema	SWV	SWV	SWV	SWV
`ALTER TYPE`	SQL-schema	NS	SWV	SWV	NS
`ALTER VIEW`	Non-standard	SWV	SWV	SWV	SWV
`CREATE DATABASE`	Non-standard	SWV	SWV	SWV	SWV
`CREATE DOMAIN`	SQL-schema	NS	NS	S	NS
`CREATE INDEX`	Non-standard	SWV	SWV	SWV	SWV
`CREATE SCHEMA`	SQL-schema	SWL	SWV	SWL	SWL
`CREATE TABLE`	SQL-schema	SWV	SWV	SWV	SWV
`CREATE TYPE`	SQL-schema	NS	SWL	SWV	SWV
`CREATE VIEW`	SQL-schema	SWV	SWV	SWV	SWV
`DROP DATABASE`	Non-standard	SWV	S	SWV	SWV
`DROP DOMAIN`	SQL-schema	NS	NS	S	NS
`DROP INDEX`	Non-standard	SWV	SWV	SWV	SWV
`DROP ROLE`	SQL-schema	SVW	SWV	SWV	SWV

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`DROP SCHEMA`	SQL-schema	SWV	SWV	SWV	SWV
`DROP TABLE`	SQL-schema	SWV	SWV	SWV	SWV
`DROP TYPE`	SQL-schema	NS	S	S	S
`DROP VIEW`	SQL-schema	SWV	S	S	S

SQL Command Reference

CREATE/ALTER DATABASE Statement

The SQL standard does not address creating a database or physical constructs such as mapping paths. However, most database platforms do provide a `CREATE DATABASE` and an `ALTER DATABASE` statement for this purpose. Since it is nearly impossible to operate a SQL database without this command, we've included it here.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
CREATE DATABASE [IF NOT EXISTS] database_name [vendor_specific_options]

ALTER DATABASE database_name [vendor_specific_options]
```

Keywords

`CREATE DATABASE` *`database_name`*
: Creates a new database named *`database_name`* on the current server.

`IF NOT EXISTS`
: Only creates the database if it doesn't already exist. This is mostly to prevent raising errors.

`database_name`
: Declares the name of the new database.

`vendor_specific_options`
: Includes additional options, which vary by vendor. Refer to the vendor sections for vendor-specific details.

`ALTER DATABASE` *`database_name`*
: Allows changing the settings of an already created database.

Rules at a glance

This command creates a new, empty database with a specific name. Most DBMS platforms require the user to possess administrator privileges in order to create a new database. Once the new database is created, you can populate it with database objects (such as tables, views, triggers, and so on) and populate the tables with data.

Depending on the platform, CREATE/ALTER DATABASE may also create corresponding files on the filesystem that contain the data and metadata of the database.

Programming tips and gotchas

Since CREATE/ALTER DATABASE is not an official SQL statement, it is prone to rather extreme variation in syntax and functionality between platforms.

MySQL and MariaDB

In MySQL and MariaDB, the SCHEMA keyword is synonymous with DATABASE. CREATE DATABASE essentially creates a new directory that holds the database objects:

```
CREATE { DATABASE | SCHEMA } [IF NOT EXISTS] database_name
   [ [DEFAULT] CHARACTER SET [=] character_set ]
   [ [DEFAULT] COLLATE [=] collation ]
   [ [DEFAULT] ENCRYPTION [=] {'Y' | 'N'} ]
```

MariaDB (from version 10.5) also offers a CREATE OR REPLACE DATABASE statement. The MariaDB syntax is as follows:

```
CREATE [ OR REPLACE ]{ DATABASE | SCHEMA } [IF NOT EXISTS] database_name
   [ [DEFAULT] CHARACTER SET [=] character_set ]
   [ [DEFAULT] COLLATE [=] collation ]
   [ [DEFAULT] ENCRYPTION [=] {'Y' | 'N'} ]
   [ COMMENT [=] comment ]
```

The following is the syntax for MySQL's implementation of the ALTER DATABASE statement:

```
ALTER { DATABASE | SCHEMA } database_name
{ [ [DEFAULT] CHARACTER SET [=] character_set ]
  [ [DEFAULT] COLLATE [=] collation ]
  [ [DEFAULT] ENCRYPTION [=] {'Y' | 'N'} ]
  [ READ ONLY [=] {DEFAULT | 0 | 1} ]
 }
```

MariaDB's ALTER DATABASE is a superset of MySQL's ALTER DATABASE. The following is the syntax for MariaDB's implementation of the ALTER DATABASE statement:

```
ALTER { DATABASE | SCHEMA } database_name
{ [ [DEFAULT] CHARACTER SET [=] character_set ]
  [ [DEFAULT] COLLATE [=] collation ]
  [ [DEFAULT] ENCRYPTION [=] {'Y' | 'N'} ]
  [ READ ONLY [=] {DEFAULT | 0 | 1} ]
  [ COMMENT [=] comment ]
```

```
    }
    and
    ALTER DATABASE database_name
        UPGRADE DATA DIRECTORY NAME
```

where:

`{CREATE | ALTER} { DATABASE | SCHEMA } database_name`
: Creates a database and directory called *database_name*. The database directory appears under the MySQL data directory. Tables in MySQL then appear as files in the database directory.

`OR REPLACE`
: Is shorthand for `DROP DATABASE ... IF EXISTS; CREATE DATABASE`.

`IF NOT EXISTS`
: Avoids an error if the database already exists.

`[DEFAULT] CHARACTER SET [=] character_set`
: Optionally defines the default character set used by the database. Refer to the MySQL documentation for a full listing of the available character sets.

`[DEFAULT] COLLATE [=] collation`
: Optionally defines the default database collation used by the database. Refer to the MySQL documentation for a full listing of the available collations.

`[DEFAULT] ENCRYPTION [=] {'Y' | 'N'}`
: Optionally defines whether the database and all tables within it are encrypted by default. This setting was introduced in MySQL 8.0.16 and can also be specified in the default_table_encryption system variable.

`READ ONLY [=] {DEFAULT | 0 | 1}`
: Optionally defines whether the database and objects within it should only allow read access (1 indicates that the database should be read only, and DEFAULT or 0 indicates that it should not be). This setting was introduced in MySQL 8.0.22 and is only available with the `ALTER DATABASE` command.

`COMMENT [=] comment`
: Allows you to add a comment of up to 1,024 bytes in length, which is included in the *db.opt* file and the *information_schema.schemata* table (MariaDB only).

Oracle

Oracle provides an extraordinary level of control over database file structures, far beyond merely naming the database and specifying a path for the database files. `CREATE` and `ALTER DATABASE` are very powerful commands in Oracle, and some of the more sophisticated clauses are best used only by experienced DBAs. These commands can be very large and complex—the description of `ALTER DATABASE` alone takes up over 50 pages in the Oracle vendor documentation!

Oracle introduced a new multitenant architecture, pluggable databases, in release 12c. This essentially allows an instance of Oracle to support multiple distinct databases simultaneously. Implementing pluggable databases is a complex task. In fact, it is complex enough for the vendor to encourage you to use tools such as the Oracle Database Configuration Assistant (DBCA), rather than using hand-scripted SQL. We encourage you to read Oracle's documentation. Consequently, we are limiting our coverage to standard non-multitenant databases.

Novices should be aware that `CREATE DATABASE`, when run, erases all data that is already in existence in the specified datafiles. The Oracle installer generally performs the `CREATE DATABASE` step for you, so most users don't need to do it. It is also highly recommended that you use DBCA when creating new databases and only resort to the `CREATE DATABASE` command directly if you need to script creation of a database.

Following is a subset of the syntax to create a new database in Oracle:

```
CREATE DATABASE [database_name]
{[USER SYS IDENTIFIED BY password |
USER SYSTEM IDENTIFIED BY password]}
[CONTROLFILE REUSE]
[MAXDATAFILES int]
[MAXINSTANCES int]
[CHARACTER SET charset]
[NATIONAL CHARACTER SET charset]
[SET DEFAULT {BIGFILE | SMALLFILE} TABLESPACE]
{[LOGFILE definition[, ...]] [MAXLOGFILES int] [[MAXLOGMEMBERS] int]
   [[MAXLOGHISTORY] int] [{ARCHIVELOG | NOARCHIVELOG}] [FORCE LOGGING]
  [SET STANDBY NOLOGGING FOR {DATA AVAILABILITY | LOAD PERFORMANCE}] }
[EXTENT MANAGEMENT {DICTIONARY | LOCAL
   [ {AUTOALLOCATE | UNIFORM [SIZE int [K | M]]} ]}]
[DATAFILE definition[, ...]]
[SYSAUX DATAFILE definition[, ...]]
[DEFAULT TABLESPACE tablespace_name
   [DATAFILE file_definition]
   EXTENT MANAGEMENT {DICTIONARY |
      LOCAL {AUTOALLOCATE | UNIFORM [SIZE int [K | M]]}}]
[ [{BIGFILE | SMALLFILE}] DEFAULT TEMPORARY TABLESPACE tablespace_name
   [TEMPFILE file_definition]
   EXTENT MANAGEMENT {DICTIONARY |
      LOCAL {AUTOALLOCATE | UNIFORM [SIZE int [K | M]]}} ]
[ [{BIGFILE | SMALLFILE}] UNDO TABLESPACE tablespace_name
   [DATAFILE temp_datafile_definition] ]
[SET TIME_ZONE = '{ {+ | -} hh:mi| time_zone_region }']
```

Following is a subset of the syntax to alter an existing database:

```
ALTER DATABASE [database_name]
[ARCHIVELOG | NOARCHIVELOG] |
   {MOUNT [{STANDBY | CLONE} DATABASE] | OPEN [READ ONLY | READ WRITE]
      [RESETLOGS | NORESETLOGS] | [UPGRADE | DOWNGRADE]} |
   {ACTIVATE [PHYSICAL | LOGICAL] STANDBY DATABASE [FINISH APPLY]
      [SKIP [STANDBY LOGFILE]] |
   SET STANDBY [DATABASE] TO MAXIMIZE {PROTECTION | AVAILABILITY |
      PERFORMANCE} |
   REGISTER [OR REPLACE] [PHYSICAL | LOGICAL] LOGFILE ['file']
      [FOR logminer_session_name] |
   {COMMIT | PREPARE} TO SWITCHOVER TO
      {{[PHYSICAL | LOGICAL] PRIMARY | STANDBY} [WITH[OUT]
         SESSION SHUTDOWN] [WAIT | NOWAIT]} |
       CANCEL} |
   START LOGICAL STANDBY APPLY [IMMEDIATE] [NODELAY]
      [{INITIAL int | NEW PRIMARY dblink_name | {FINISH |
         SKIP FAILED TRANSACTION}}] |
   {STOP | ABORT} LOGICAL STANDBY APPLY |
   [CONVERT TO {PHYSICAL | SNAPSHOT} STANDBY] |
{RENAME GLOBAL_NAME TO database[.domain[.domain ...]] |
   CHARACTER SET character_set |
   NATIONAL CHARACTER SET character_set |
   DEFAULT TABLESPACE tablespace_name |
   DEFAULT TEMPORARY TABLESPACE {GROUP int | tablespace_name} |
   {DISABLE BLOCK CHANGE TRACKING | ENABLE BLOCK CHANGE TRACKING [USING
      FILE 'file'] [REUSE]} |
   FLASHBACK {ON | OFF} |
   SET TIME_ZONE = '{ {+ | -} hh:mi | time_zone_region }' |
   SET DEFAULT {BIGFILE | SMALLFILE} TABLESPACE} |
{ENABLE | DISABLE} { [PUBLIC] THREAD int | INSTANCE 'instance_name' } |
{GUARD {ALL | STANDBY | NONE}} |
{CREATE DATAFILE 'file'[, ...] [AS {NEW | file_definition[, ...]}] |
   {DATAFILE 'file' | TEMPFILE 'file'}[, ...]
      {ONLINE | OFFLINE [FOR DROP | RESIZE int [K | M]] |
         END BACKUP | AUTOEXTEND {OFF | ON [NEXT int [K | M]]} [MAXSIZE
         [UNLIMITED | int [K | M]]] |
   {TEMPFILE 'file' | TEMPFILE 'file'}[, ...]
      {ONLINE | OFFLINE | DROP [INCLUDING DATAFILES] |
         RESIZE int [K | M] | AUTOEXTEND {OFF | ON [NEXT int [K | M]]}
         [MAXSIZE [UNLIMITED | int [K | M]]] |
   RENAME FILE 'file'[, ...] TO 'new_file_name'[, ...]} |
{[[NO] FORCE LOGGING] | [[NO]ARCHIVELOG [MANUAL]] |
      [ADD | DROP] SUPPLEMENTAL LOG DATA [(ALL | PRIMARY KEY | UNIQUE |
         FOREIGN KEY | FOR PROCEDURAL REPLICATION)[, ...]] COLUMNS |
      [ADD | DROP] [STANDBY] LOGFILE
         {{[THREAD int | INSTANCE 'instance_name']} {[GROUP int |
             logfile_name[, ...]]} [SIZE int [K | M]] | [REUSE] |
         [MEMBER] 'file' [REUSE][, ...] TO logfile_name[, ...]} |
      ADD LOGFILE MEMBER 'file' [REUSE][, ...] TO {[GROUP int |
         logfile_name[, ...]]} |
      DROP [STANDBY] LOGFILE {MEMBER 'file' | {[GROUP int |logfile_name
         [, ...]]}}
      CLEAR [UNARCHIVED] LOGFILE {[GROUP int |
      logfile_name[, ...]]}[, ...]
         [UNRECOVERABLE DATAFILE]} |
{CREATE [LOGICAL | PHYSICAL] STANDBY CONTROLFILE AS 'file' [REUSE] |
   BACKUP CONTROLFILE TO
      {'file' [REUSE] | TRACE [AS 'file' [REUSE]]} [ {RESETLOGS |
         NORESETLOGS} ]} |
{RECOVER
   {[AUTOMATIC [FROM 'location']] |
      {[STANDBY] DATABASE
         {[UNTIL {CANCEL | TIME date | CHANGE int}] |
         USING BACKUP CONTROLFILE} |
      {{[STANDBY] {TABLESPACE tablespace_name[, ...] | DATAFILE
         'file'[, ...]} [UNTIL [CONSISTENT WITH] CONTROLFILE]} |
         TABLESPACE tablespace_name[, ...] |
         DATAFILE 'file'[, ...]} |
      LOGFILE filename[, ...]} [{TEST | ALLOW int CORRUPTION |
       [NO]PARALLEL int}]} |
      CONTINUE [DEFAULT] |
      CANCEL}
   {MANAGED STANDBY DATABASE
      {[USING CURRENT LOGFILE]
       [DISCONNECT [FROM SESSION]]
       [NODELAY]
       [UNTIL CHANGE int]
       [FINISH]
       [CANCEL]} |
   TO LOGICAL STANDBY {database_name | KEEP IDENTITY}}
{{BEGIN | END} BACKUP}
```

The syntax elements in Oracle are as follows. First, for `CREATE DATABASE`:

`{CREATE | ALTER} DATABASE [`*`database_name`*`]`
: Creates or alters a database with the name *`database_name`*. The database name can be up to 8 bytes in length and may not contain European or Asian characters. You can omit the database name and allow Oracle to create the name for you, but beware that the names Oracle creates can be counterintuitive.

`USER SYS IDENTIFIED BY `*`password`*` | USER SYSTEM IDENTIFIED BY `*`password`*
: Specifies passwords for the `SYS` and `SYSTEM` users. You may specify neither or both of these clauses, but not just one of them.

`CONTROLFILE REUSE`
: Causes existing control files to be reused, enabling you to specify existing files in the `CONTROL_FILES` parameter in *init.ora*. Oracle will then overwrite any information those files may contain. This clause is normally used when recreating a database. Consequently, you probably don't want to use this clause in conjunction with `MAXLOGFILES`, `MAXLOGMEMBER`, `MAXLOGHISTORY`, `MAXDATAFILES`, or `MAXINSTANCES`.

`MAXDATAFILES` *`int`*

Sets the initial number of datafiles, *`int`*, available to the database being created. Note that the *init.ora* setting `DB_FILES` also limits the number of datafiles accessible to the database instance.

`MAXINSTANCES` *`int`*

Sets the maximum number of instances, *`int`*, that may mount and open the database being created. The minimum value is 1, while the maximum and default values for this clause are OS-dependent.

`CHARACTER SET` *`charset`*

Controls the language character set in which the data is stored. The value for *`charset`* cannot be `AL16UTF16`. The default value is OS-dependent.

`NATIONAL CHARACTER SET` *`charset`*

Controls the national language character set for data stored in `NCHAR`, `NCLOB`, and `NVARCHAR2` columns. The value for *`charset`* must be either `AL16UTF16` (the default) or `UTF8`.

`SET DEFAULT {BIGFILE | SMALLFILE} TABLESPACE`

Sets all tablespaces created by the current `CREATE DATABASE` or `ALTER DATABASE` statement as either `BIGFILE` or `SMALLFILE`. When creating databases, this clause also applies to the `SYSTEM` and `SYSAUX` tablespaces.

`LOGFILE` *`definition`*

Specifies one or more logfiles for the database. You may define multiple files all with the same size and characteristics, using the `'`*`file`*`'` parameter, or you may define multiple files each with its own size and characteristics. The entire logfile definition syntax is rather ponderous, but it offers a great deal of control:

```
LOGFILE { ('file'[, ...]) [SIZE int [K | M]]
[GROUP int] [REUSE] }[, ...]
```

`LOGFILE ('`*`file`*`'[, ... ])`

Defines one or more files that will act as redo logfiles; *`file`* is both the filename and the path. Any files defined in the `CREATE DATABASE` statement are assigned to redo log thread number 1. When specifying multiple redo logfiles, each filename should be enclosed in single quotes and separated from the other names by commas. The entire list should be enclosed in parentheses.

`SIZE` *`int`* `[K | M]`

Specifies the size of the redo logfile in bytes as an integer value, *`int`*. Alternatively, you may define the redo logfile in larger units than bytes by appending a `K` (for kilobytes) or an `M` (for megabytes).

`GROUP` *`int`*

Defines the integer ID, *`int`*, of the redo logfile group. The value may be from 1 to the value of the `MAXLOGFILES` clause. An Oracle database must have at least two redo logfile groups. Oracle will create a redo logfile group for you, with a default size of 100 MB, if you omit this group ID.

`REUSE`
: Reuses an existing redo logfile.

`MAXLOGFILES` *`int`*
: Sets the maximum number of logfiles, *`int`*, available to the database being created. The minimum, maximum, and default values for this clause are OS-dependent.

`MAXLOGMEMBERS` *`int`*
: Sets the maximum number of members (i.e., copies) for a redo logfile group. The minimum value is 1, while the maximum and default values for this clause are OS-dependent.

`MAXLOGHISTORY` *`int`*
: Sets the maximum number of archived redo logfiles available to a Real Application Cluster (RAC). You can use the `MAXLOGHISTORY` clause only when Oracle is in `ARCHIVELOG` mode on a RAC. The minimum value is 0, while the maximum and default values for this clause are OS-dependent.

`ARCHIVELOG | NOARCHIVELOG`
: Defines how redo logs operate. When used with `ALTER DATABASE`, specifying one of these allows the current setting to be changed. `ARCHIVELOG` saves data stored in the redo log(s) to an archiving file, providing for media recoverability. Conversely, `NOARCHIVELOG` allows a redo log to be reused without archiving the contents. Both options provide recoverability, although `NOARCHIVELOG` (the default) does *not* provide media recovery.

`FORCE LOGGING`
: Places all instances of the database into `FORCE LOGGING` mode, in which all changes to the database are logged, except for changes to temporary tablespaces and segments. This setting takes precedence over any tablespace- or object-level settings.

`EXTENT MANAGEMENT {DICTIONARY | LOCAL}`
: Creates a locally managed `SYSTEM` tablespace (otherwise, the `SYSTEM` tablespace will be dictionary-managed). This clause requires a default temporary tablespace. If you omit the `DATAFILE` clause, you can also omit the default temporary tablespace because Oracle will create them both for you.

`DATAFILE` *`definition`*
: Specifies one or more datafiles for the database. (All these datafiles become part of the `SYSTEM` tablespace.) You may repeat filenames to define multiple files with the same size and characteristics. Alternatively, you may repeat the entire `DATAFILE` clause, with each occurrence defining one or more files with the same

size and characteristics. The entire datafile definition syntax is rather large, but it offers a great deal of control:

```
DATAFILE { ('file'[, ...]) [GROUP int ] [SIZE int [K | M]] [REUSE]
[AUTOEXTEND {OFF | ON [NEXT int [K | M]]}]
[MAXSIZE [UNLIMITED | int [K | M]]] } [,...]
```

`DATAFILE ('`*`file`*`'[, ... ])`
: Defines one or more files that will act as the datafile(s), where *`file`* is both the filename and the path. For multiple files, each filename should be enclosed in single quotes and separated from the others by a comma. The entire list should be enclosed in parentheses.

`GROUP` *`int`*
: Defines the integer ID, *`int`*, of the datafile group. The value may be from 1 to the value of the `MAXLOGFILES` clause. An Oracle database must have at least two datafile groups. Oracle will create them for you, with a default size of 100 MB each, if you omit this clause.

`SIZE` *`int`* `[K | M]`
: Specifies the size of the datafile in bytes as an integer value, *`int`*. Alternatively, you may define the datafile in larger units by appending a `K` (for kilobytes) or an `M` (for megabytes).

`REUSE`
: Reuses an existing datafile.

`AUTOEXTEND {OFF | ON [NEXT` *`int`* `[K | M]]}`
: Enables (`ON`) the automatic extension of new or existing datafiles or tempfiles (but does not redo logfiles). `NEXT` specifies the next increment of space allocated to the file in bytes, kilobytes (`K`), or megabytes (`M`) when more space is needed.

`MAXSIZE [UNLIMITED |` *`int`* `[K | M]]`
: Specifies the maximum disk space allowed for automatic extension of the file. `UNLIMITED` allows the file to grow without an upper limit (except, of course, the total capacity of the drive). Otherwise, you may define the maximum size limit as an integer, *`int`*, in bytes (the default), kilobytes (`K`), or megabytes (`M`).

`SYSAUX DATAFILE` *`definition`*
: Specifies one or more datafiles for the `SYSAUX` tablespace. By default, Oracle creates and manages the `SYSTEM` and `SYSAUX` tablespaces automatically. You must use this clause if you have specified a datafile for the `SYSTEM` tablespace. If you omit the `SYSAUX` clause when using Oracle-managed files, Oracle will create the `SYSAUX` tablespace as an online, permanent, locally managed tablespace with a single datafile of 100 MB, using automatic segment space management and logging.

DEFAULT TABLESPACE *tablespace_name*

Specifies a default permanent tablespace for the database for all non-SYSTEM users. When this clause is omitted, the SYSTEM tablespace is the default permanent tablespace for non-SYSTEM users.

BIGFILE | SMALLFILE

Specifies the default file type of a subsequently created tablespace. BIGFILE indicates that the tablespace will contain a single datafile or tempfile of up to 8 exabytes (8 million terabytes) in size, while SMALLFILE indicates the tablespace is a traditional Oracle tablespace. The default, when omitted, is SMALLFILE.

DEFAULT TEMPORARY TABLESPACE *tablespace_name* [TEMPFILE *file_definition*]

Defines the name and location of the default temporary tablespace for the database. Users who are not explicitly assigned to a temporary tablespace will operate in this one. If you don't create a default temporary tablespace, Oracle uses the SYSTEM tablespace. Under ALTER DATABASE, this clause allows you to change the default temporary tablespace.

TEMPFILE *file_definition*

The tempfile definition is optional when the DB_CREATE_FILE_DEST init.ora parameter is set. Otherwise, you'll have to define the tempfile yourself. The TEMPFILE definition syntax is identical to the DATAFILE definition syntax described earlier in this section.

EXTENT MANAGEMENT {DICTIONARY | LOCAL {AUTOALLOCATE | UNIFORM [SIZE *int* [K | M]]}}

Defines the way in which the SYSTEM tablespace is managed. When this clause is omitted, the SYSTEM tablespace is dictionary-managed. Once created as a locally managed tablespace, it cannot be converted back to a dictionary-managed tablespace, nor can any new dictionary-managed tablespaces be created in the database.

DICTIONARY

Specifies that the Oracle data dictionary manages the tablespace. This is the default. The AUTOALLOCATE and UNIFORM subclauses are not used with this clause.

LOCAL

Declares that the tablespace is locally managed. This clause is optional since all temporary tablespaces have locally managed extents by default. Use of this clause requires a default temporary tablespace. If you do not manually create one, Oracle will automatically create one called TEMP, of size 10 MB, with AUTOEXTEND disabled.

AUTOALLOCATE

Specifies that new extents will be allocated as needed by the locally managed tablespace.

`UNIFORM [SIZE` *`int`* `[K | M]]`

Specifies that all extents of the tablespace are t*he same size. The* `SIZE` *clause allows you to configure the size of the extents to your liking as an integer,* `int`, in bytes (the default), kilobytes (`K`), or megabytes (`M`). The default is 1M.

`UNDO TABLESPACE` *`tablespace_name`* `[DATAFILE` *`temp_datafile_definition`*`]`

Defines the name and location for undo data, creating a tablespace named *`tablespace_name`*, but only if you have set the `UNDO_MANAGEMENT` `init.ora` parameter to `AUTO`. If you don't use this clause, Oracle manages undo space via rollback segments. (You may also set the `init.ora` parameter `UNDO_TABLESPACE`. If you do so, the value of the parameter and the *`tablespace_name`* used here must be identical.)

`DATAFILE` *`temp_datafile_definition`*

Creates and assigns the datafile, as you have defined it, to the undo tablespace. Refer to the earlier description of `DATAFILE` for the full syntax of this clause. This clause is required if you have not specified a value for the `init.ora` parameter `DB_CREATE_FILE_DEST`.

`SET TIME_ZONE = ' {{+ | -}` *`hh:mi`* `|` *`time_zone_region`* `}'`

Sets the time zone for the database, either by specifying a delta from Greenwich Mean Time (now called Coordinated Universal Time, or UTC) or by specifying a time zone region. (For a list of time zone regions, query the *tzname* column of the `V$TIMEZONE_NAMES` view.) If you do not use this clause, Oracle defaults to the operating system time zone.

And for `ALTER DATABASE`*:*

`MOUNT [{STANDBY | CLONE}] DATABASE]`

Mounts a database for users to access. The `STANDBY` keyword mounts a physical standby database, enabling it to receive archived redo logs from the primary instance. The `CLONE` keyword mounts a clone database. This clause cannot be used with `OPEN`.

`OPEN [READ WRITE | READ ONLY] [RESETLOGS | NORESETLOGS] [UPGRADE | DOWNGRADE]`

Opens the database separately from the mounting process. (Mount the database first.) `READ WRITE` opens the database in read/write mode, allowing users to generate redo logs. `READ ONLY` allows reads of but disallows changes to redo logs. `RESETLOGS` discards all redo information not applied during recovery and sets the log sequence number to 1. `NORESETLOGS` retains the logs in their present condition. The optional `UPGRADE` and `DOWNGRADE` clauses tell Oracle to dynamically modify the system parameters as required for database upgrade or downgrade, respectively. The default is `OPEN READ WRITE NORESETLOGS`.

`ACTIVATE [PHYSICAL | LOGICAL] STANDBY DATABASE [FINISH APPLY] [SKIP [STANDBY LOGFILE]]`

Promotes a standby database to the primary database. You can optionally specify a `PHYSICAL` standby, the default, or a `LOGICAL` standby. `FINISH APPLY` initiates the application of the remaining redo log, bringing the logical standby database to the same state as the primary database. When it's finished, the database completes the switchover from the logical standby to the primary database. Use the `SKIP` clause to immediately promote a physical standby and discard any data still unapplied by the `RECOVER MANAGED STANDBY DATABASE FINISH` statement. The clause `STANDBY LOGFILE` is noise.

`SET STANDBY [DATABASE] TO MAXIMIZE {PROTECTION | AVAILABILITY | PERFORMANCE}`

Sets the level of protection for data in the primary database. The old terms `PROTECTED` and `UNPROTECTED` equate to `MAXIMIZE PROTECTION` and `MAXIMIZE PERFORMANCE`, respectively:

`PROTECTION`

Provides the highest level of data protection, but has the greatest overhead and negatively impacts availability. This setting commits transactions only after all data necessary for recovery has been physically written in at least one physical standby database that uses the `SYNC` log transport mode.

`AVAILABILITY`

Provides the second highest level of data protection, but the highest level of availability. This setting commits transactions only after all data necessary for recovery has been physically written in at least one physical or logical standby database that uses the `SYNC` log transport mode.

`PERFORMANCE`

Provides the highest level of performance, but compromises on data protection and availability. This setting commits transactions before all data necessary for recovery has been physically written to a standby database.

`REGISTER [OR REPLACE] [PHYSICAL | LOGICAL] LOGFILE ['`*`file`*`']`

Manually registers redo logfiles from a failed primary server when issued from a standby server. The logfile may optionally be declared as `PHYSICAL` or `LOGICAL`. The `OR REPLACE` clause allows updates to details of an existing archive log entry.

`FOR` *`logminer_session_name`*

Registers the logfile with a single, specific LogMiner session in an Oracle Streams environment.

`{COMMIT | PREPARE} TO SWITCHOVER TO {[PHYSICAL | LOGICAL] PRIMARY | STANDBY}`

Performs a graceful switchover, moving the current primary database to standby status and promoting a standby database to primary. (In a RAC environment, all instances other than the current instance have to be shut down.) To gracefully switch over, you should issue the command twice (the first time to prepare the primary and standby databases to begin exchanging logfiles in advance of the switchover) using `PREPARE TO SWITCHOVER`. To demote the primary database and switch over to the standby, use `COMMIT TO SWITCHOVER`. The `PHYSICAL` clause puts the primary database into physical standby mode. The `LOGICAL` clause puts the primary database into logical standby mode. However, you must then issue an `ALTER DATABASE START LOGICAL STANDBY APPLY` statement.

`[WITH[OUT] SESSION SHUTDOWN] [WAIT | NOWAIT]`
: `WITH SESSION SHUTDOWN` closes any open application sessions and rolls back any uncommitted transactions during a switchover of physical databases (but not logical ones). `WITHOUT SESSION SHUTDOWN`, the default, causes the `COMMIT TO SWITCHOVER` statement to fail if it encounters any open application sessions. `WAIT` returns control to the console after completion of the `SWITCHOVER` command, while `NOWAIT` returns control before the command completes.

`START LOGICAL STANDBY APPLY [IMMEDIATE] [NODELAY] [{INITIAL` *`int`* `| NEW PRIMARY` *`dblink_name`*`} | {FINISH | SKIP FAILED TRANSACTION}]`
: Starts to apply redo logs to the logical standby database. `IMMEDIATE` tells the Oracle LogMiner to read the redo data in the standby redo logfiles. `NODELAY` tells Oracle to ignore a delay for the apply, such as when the primary database is unavailable or disabled. `INITIAL` is used the first time you apply logs to the standby database. `NEW PRIMARY` is required after a switchover has completed or after a standby database has processed all redo logs and another standby is promoted to primary. Use `SKIP FAILED TRANSACTION` to skip the last transaction and to restart the `APPLY`. Use `FINISH` to apply the data in the redo logs if the primary database is disabled.

`[STOP | ABORT] LOGICAL STANDBY APPLY`
: Stops the application of redo logs to a logical standby server. `STOP` performs an orderly stop, while `ABORT` performs an immediate stop.

`CONVERT TO {PHYSICAL | SNAPSHOT} STANDBY`
: Converts a primary database or snapshot standby database into a physical standby database (for `PHYSICAL`), or converts a physical standby database into a snapshot standby database (for `SNAPSHOT`).

`RENAME GLOBAL_NAME TO` *`database`*`[.`*`domain`*`[.`*`domain`* `... ]]`
: Changes the global name of the database, where *`database`* is the new name of up to 8 bytes in length. The optional *`domain`* specifications identify the database's location in the network. This does not propagate database name changes to any dependent objects like synonyms, stored procedures, etc.

`{DISABLE | ENABLE} BLOCK CHANGE TRACKING [USING FILE '`*`file`*`'] [REUSE]`

Tells Oracle to stop or start tracking the physical locations of all database updates, respectively, and maintain the information in a special file called the *block change tracking file*. Oracle will automatically create the file as defined by the `DB_CREATE_FILE_DEST` parameter, unless you add the `USING FILE '`*`file`*`'` clause, where `'`*`file`*`'` is the path and name of the file. `REUSE` tells Oracle to overwrite an existing block change tracking file of the same name as `'`*`file`*`'`. The `USING` and `REUSE` subclauses are allowed only with the `ENABLE BLOCK` clause.

`FLASHBACK {ON | OFF}`

Places the database into or out of `FLASHBACK` mode, respectively. When in flashback mode, an Oracle database automatically creates and maintains flashback database logs in the flash recovery area. When `OFF`, the flashback database logs are deleted and unavailable.

`SET TIME ZONE`

Specifies the time zone for the server. Refer to the description of the `SET TIME ZONE` statement in the discussion of the `CREATE DATABASE` syntax for more information.

`{ENABLE | DISABLE} { [PUBLIC] THREAD `*`int`*` | INSTANCE '`*`instance_name`*`'}`

In RAC environments, you can `ENABLE` or `DISABLE` a redo log thread by number (*`int`*). You may optionally specify an *`instance_name`* to enable or disable a thread mapped to a specific database instance in an Oracle RAC environment. The *`instance_name`* may be up to 80 characters long. The `PUBLIC` keyword makes the thread available to any instance. When omitted, the thread is available only when explicitly requested. To enable a thread, the thread must have at least two redo logfile groups. To disable a thread, the database must be open but not mounted by an instance using the thread.

`GUARD {ALL | STANDBY | NONE}`

Protects the data in a database from changes. `ALL` prevents users other than `SYS` from making any changes. `STANDBY` prevents all users other than `SYS` from making changes in a logical standby. `NONE` provides normal security for the database.

`CREATE DATAFILEn'`*`file`*`'[, ... ] [AS {NEW | `*`file_definition`*`}]`

Creates a new, empty datafile, replacing an existing one. The value `'`*`file`*`'` identifies a file (either by filename or file number) that was lost or damaged without a backup. `AS NEW` creates a new file in the default filesystem using an Oracle-supplied name. `AS `*`file_definition`* allows you to specify a filename and sizing details, as described in the discussion of `TEMPFILE `*`file_definition`* in the preceding list.

`DATAFILE 'file' | TEMPFILE 'file'}[, ... ] {ONLINE | OFFLINE [FOR DROP] | RESIZE int [K | M]] | END BACKUP | AUTOEXTEND {OFF | ON [NEXT int [K | M]]} [MAXSIZE [UNLIMITED | int [K | M]]]`

Changes the attributes, such as the size, of one or more existing datafiles or tempfiles. You may alter one or more files in a comma-delimited list, identified in the value '*file*' by filename or file number. Do not mix datafile and tempfile declarations; only one or the other should appear in this clause at a time:

`ONLINE`

Sets the file online.

`OFFLINE [FOR DROP]`

Sets the file offline, allowing media recovery. `FOR DROP` is required to take a file offline in `NOARCHIVELOG` mode, but it does not actually destroy the file. It is ignored in `ARCHIVELOG` mode.

`RESIZE int [K | M]`

Sets a new size for an existing datafile or tempfile.

`END BACKUP`

Described later in the main list, under `END BACKUP`. Used only with the `DATAFILE` clause.

`AUTOEXTEND {OFF | ON [NEXT int [K | M]]} [MAXSIZE [UNLIMITED | int [K | M]]]`

Described in the preceding list, under `DATAFILE` *definition*.

`DROP [INCLUDING DATAFILES]`

Drops not only the tempfile, but all datafiles on the filesystem associated with the tempfile. Oracle also adds an entry to the alert log for each file that is erased. Used only with the `TEMPFILE` clause.

`RENAME FILE 'file'[, ... ] TO 'new_file_name'[, ... ]`

Renames a datafile, tempfile, or redo logfile member from the old name, *file*, to the *new_file_name*. You can rename multiple files at once by specifying multiple old and new filenames, separated by commas. This command does not rename files at the operating system level. Rather, it specifies new names that Oracle will use to open the files. You need to rename at the operating system level yourself.

`[NO] FORCE LOGGING`

Puts the database into force logging mode (`FORCE LOGGING`) or takes it out of force logging mode (`NO FORCE LOGGING`). In the former, Oracle logs all changes to the database except in temporary tablespaces or segments. This database-level `FORCE LOGGING` setting supersedes all tablespace-level declarations regarding force logging mode.

`[NO]ARCHIVELOG [MANUAL]`

Tells Oracle to create redo logfiles, but that the user will handle the archiving of the redo logfiles explicitly. This is used only with the `ALTER DATABASE` statement and *only* for backward compatibility for users with older tape backup systems. When this clause is omitted, Oracle defaults the redo logfile destination to the `LOG_ARCHIVE_DEST_n` initialization parameter.

`[ADD | DROP] SUPPLEMENTAL LOG DATA [(ALL | PRIMARY KEY | UNIQUE | FOREIGN KEY | FOR PROCEDURAL REPLICATION)[, ... ] COLUMNS`

`ADD` places additional column data into the log stream whenever an update is executed. It also enables *minimal supplemental logging*, which ensures that LogMiner can support chained rows and special storage arrangements such as clustered tables. Supplemental logging is disabled by default. You can add the clauses `PRIMARY KEY COLUMNS`, `UNIQUE KEY COLUMNS`, `FOREIGN KEY COLUMNS`, or `ALL` (to get all three options) if you need to enable full referential integrity via foreign keys in another database, such as a logical standby, or `FOR PROCEDURAL REPLICATION` for logging PL/SQL calls. In either case, Oracle places either the primary key columns, the unique key columns (or, if none exist, a combination of columns that uniquely identify each row), the foreign key columns, or all three into the log. `DROP` tells Oracle to suspend supplemental logging.

`[ADD | DROP] [STANDBY] LOGFILE {{[THREAD` *`int`* `| INSTANCE '`*`instance_name`*`']} {[GROUP`*`int`* `|` *`logfile_name`*`[, ... ]]} [SIZE` *`int`* `[K | M]] | [REUSE] | [MEMBER] '`*`file`*`' [REUSE][, ... ]`

`ADD` includes one or more primary or standby redo logfile groups to the specified instance. `THREAD` assigns the added files to a specific thread number (*`int`*) on a RAC. When omitted, the default is the thread assigned to the current instance. `GROUP` assigns the redo logfile groups to a specific group within the thread. `MEMBER` adds the specified `'`*`file`*`'` (or files in a comma-delimited list) to an existing redo logfile group. `REUSE` is needed if the file already exists. `DROP LOGFILE MEMBER` drops one or more redo logfile members, after issuing an `ALTER SYSTEM SWITCH LOGFILE` statement.

`CLEAR [UNARCHIVED] LOGFILE {[GROUP` *`int`* `|` *`logfile_name`*`[, ... ]]} [, ... ] [UNRECOVERABLE DATAFILE]`

Reinitializes one or more (in a comma-delimited list) specified online redo logs. `UNRECOVERABLE DATAFILE` is required when any datafile is offline and the database is in `ARCHIVELOG` mode.

`CREATE {LOGICAL | PHYSICAL} STANDBY CONTROLFILE AS '`*`file`*`' [REUSE]}`

Creates a control file that maintains a logical or physical standby database. `REUSE` is needed if the file already exists.

`BACKUP CONTROLFILE TO {'`*`file`*`' [REUSE] | TRACE [AS '`*`file`*`' [REUSE]]`
`[ {RESETLOGS | NORESETLOGS} ]`

Backs up the current control file of an open or mounted database. `TO '`*`file`*`'` identifies a full path and filename for the control file. `TO TRACE` writes SQL statements to re-create the control file to a trace file. `TO TRACE AS '`*`file`*`'` writes all the SQL statements to a standard file rather than a trace file. `REUSE` is needed if the file already exists. `RESETLOGS` initializes the trace file with the statement `ALTER DATABASE OPEN RESETLOGS` and is valid only when online logs are unavailable. `NORESETLOGS` initializes the trace file with the statement `ALTER DATABASE OPEN NORESETLOGS` and is valid only when online logs are available.

`RECOVER`

Controls media recovery for the database, standby database, tablespace, or file. In Oracle, the `ALTER DATABASE` command is one of the primary means of recovering a damaged or disabled database, file, or tablespace. Use `RECOVER` when the database is mounted (in exclusive mode), the files and tablespaces involved are not in use (offline), and the database is in either an open or closed state. The entire database can be recovered only when it is closed, but specific files or tablespaces can be recovered in a database that is open.

`AUTOMATIC [FROM '`*`location`*`']`

Tells Oracle to automatically generate the name of the next archived redo logfile necessary for continued operation during recovery. Oracle will prompt you if it cannot find the next file. The `FROM '`*`location`*`'` clause tells Oracle where to find the archived redo logfile group. The following subclauses may be applied to an automatically recovered database:

`STANDBY`

Specifies that the database or tablespace to recover is a standby type.

`DATABASE {[UNTIL {CANCEL | TIME `*`date`*` | CHANGE `*`int`*`}] | USING BACKUP CONTROLFILE}`

Tells Oracle to recover the entire database. The `UNTIL` keyword tells Oracle to continue recovery until `ALTER DATABASE ... RECOVER CANCEL` (`CANCEL`) is issued, until a specified time in the format YYYY-MMDD:HH24:MI:SS is reached (`TIME`), or until a specific system change number is reached (`CHANGE `*`int`*, where *`int`* is the number). The clause `USING BACKUP CONTROLFILE` enables use of the backup, rather than current, control file.

`[STANDBY] [TABLESPACE `*`tablespace_name`*`[, ... ] | DATAFILE '`*`file`*`'[, ... ]]`

Recovers one or more specific tablespaces or datafiles, respectively. You may specify more than one tablespace or datafile using a comma-delimited list. You may also recover a datafile by datafile number, rather than by name. The tablespace may be in normal or standby mode. The standby tablespace or datafile is reconstructed using archived redo logfiles copied from the primary database and a control file.

`UNTIL [CONSISTENT WITH] CONTROLFILE`
: Tells Oracle to recover an older standby tablespace or datafile by using the current standby control file. `CONSISTENT WITH` are noise words.

`LOGFILE` *`filename`*`[, ... ]`
: Continues media recovery by applying one or more redo logfiles that you specify in a comma-delimited list.

`TEST | ALLOW` *`int`* `CORRUPTION | [NO]PARALLEL` *`int`*
: `TEST` performs a trial recovery, allowing you to foresee any problems. `ALLOW` *`int`* `CORRUPTION` tells how many corrupt blocks (*`int`*) to tolerate before causing recovery to abort. *`int` must* be `1` for a real recovery, but may be any number you choose when paired with `TEST`. `[NO]PARALLEL` determines whether parallel recovery of media is used. `NOPARALLEL` is the default and enforces serial reading of the media. `PARALLEL` with no *`int`* value tells Oracle to choose the degree of parallelism to apply. Specifying *`int`* declares the degree of parallelism to apply.

`CONTINUE [DEFAULT]`
: Determines whether multi-instance recovery continues after interruption. `CONTINUE DEFAULT` is the same as `RECOVER AUTOMATIC`, but it does not result in a prompt for a filename.

`CANCEL`
: Cancels a managed recovery operation at the next archived log boundary, if it was started with the `USING CANCEL` clause.

`MANAGED STANDBY DATABASE`
: Specifies managed physical standby recovery mode on an active component of a standby database. This command is used for media recovery only and not to construct a new database, using the following parameters:

`USING CURRENT LOGFILE`
: Invokes *real time apply*, which allows recovery of redos from standby online logs as they are being filled, without first requiring that they be archived by the standby database.

`DISCONNECT [FROM SESSION]`
: Causes the managed redo process to occur in the background, leaving the current process available for other tasks. `FROM SESSION` are noise words. `DISCONNECT` is incompatible with `TIMEOUT`.

`NODELAY`
: Overrides the `DELAY` attribute of the `LOG_ARCHIVE_DEST_n` parameter on the primary database. When omitted, Oracle delays the application of the archived redo log according to that attribute's value.

`UNTIL CHANGE` *`int`*
: Conducts a managed recovery up to (but not including) the specified system change number *`int`*.

`FINISH`
: Recovers all available online redo logfiles immediately in preparation of the standby assuming the primary database role. The `FINISH` clause is known as a *terminal recovery* and should be used only in the event of a failure of the primary database.

`CANCEL`
: Stops application of redo applies immediately and returns control as soon as the redo apply stops.

`TO LOGICAL STANDBY {`*`database_name`*`|KEEP IDENTITY}`
: Converts the physical standby database into a logical standby database. The *`database_name`* identifies the new logical standby database. The `KEEP IDENTITY` subclause tells Oracle that the logical standby is used for a rolling upgrade and is not usable as a general-purpose logical standby database.

`{BEGIN|END} BACKUP`
: Controls the online backup mode for any datafiles. `BEGIN` places all datafiles into online backup mode. The database must be mounted and open, in archivelog mode with media recovery enabled. (Note that while the database is in online backup mode the instance cannot be shut down and individual tablespaces cannot be backed up, taken offline, or made read-only.) `END` takes all datafiles currently in online backup mode out of that mode. The database must be mounted but need not be open.

After that long discussion of specific syntax, it's important to establish some Oracle basics.

Oracle allows the use of *primary* and *standby* databases. A *primary* database is a mounted and open database accessible to users. The primary database regularly and frequently ships its redo logs to a *standby* database where they are recovered, thus making the standby database a very up-to-date copy of the primary.

Unique to the Oracle environment is the server parameter file (*spfile*) that is often called *init.ora*, which specifies the database name and a variety of other options that you can use when creating and starting up a database. When a group of logfiles is listed, they are usually shown in parentheses. The parentheses aren't needed when creating a group with only one member, but this is seldom done. Here's an example using a parenthetical list of logfiles:

```
CREATE DATABASE publications
LOGFILE ('/s01/oradata/loga01','/s01/oradata/loga02') SIZE 5M
DATAFILE;
```

That example creates a database called *publications* with an explicitly defined logfile clause and an automatically created datafile. The following example of an Oracle `CREATE DATABASE` command is much more sophisticated:

```
CREATE DATABASE sales_reporting
CONTROLFILE REUSE
LOGFILE
   GROUP 1 ('diskE:log01.log', 'diskF:log01.log') SIZE 15M,
   GROUP 2 ('diskE:log02.log', 'diskF:log02.log') SIZE 15M
MAXLOGFILES 5
MAXLOGHISTORY 100
MAXDATAFILES 10
MAXINSTANCES 2
ARCHIVELOG
CHARACTER SET AL32UTF8
NATIONAL CHARACTER SET AL16UTF16
DATAFILE
   'diskE:sales_rpt1.dbf' AUTOEXTEND ON,
   'diskF:sales_rpt2.dbf' AUTOEXTEND ON NEXT 25M MAXSIZE UNLIMITED
DEFAULT TEMPORARY TABLESPACE temp_tblspc
UNDO TABLESPACE undo_tblspc
SET TIME_ZONE = '-08:00';
```

This example defines logfiles and datafiles, as well as all appropriate character sets. We also define a few characteristics for the database, such as the use of `ARCHIVELOG` mode and `CONTROLFILE REUSE` mode, the time zone, the maximum number of instances and datafiles, etc. The example assumes that the `DB_CREATE_FILE_DEST` parameter in *init.ora* has already been set, so we don't have to provide file definitions for the `DEFAULT TEMPORARY TABLESPACE` and `UNDO TABLESPACE` clauses.

When issued by a user with `SYSDBA` privileges, this statement creates a database and makes it available to users in either exclusive or parallel mode, as defined by the value of the `CLUSTER_DATABASE` initialization parameter. Any data that exists in predefined datafiles is erased. You will usually want to create tablespaces and rollback segments for the database. (Refer to the vendor documentation for details on the platform-specific commands `CREATE TABLESPACE` and `CREATE ROLLBACK SEGMENT`.) You'll also need to manually unlock and assign a new password to all locked and expired accounts (which includes most of the predefined database administrative user accounts), as well as assigning passwords to the `SYS` and `SYSTEM` accounts, during the initial installation.

In the next example, we add more logfiles to the current database, and then add a datafile:

```
ALTER DATABASE ADD LOGFILE GROUP 3
   ('diskf: log3.sales_arch_log','diskg:log3.sales_arch_log')
SIZE 50M;
ALTER DATABASE sales_archive
CREATE DATAFILE 'diskF:sales_rpt4.dbf'
AUTOEXTEND ON NEXT 25M MAXSIZE UNLIMITED;
```

We can set a new default temporary tablespace as shown here:

```
ALTER DATABASE DEFAULT TEMPORARY TABLESPACE sales_tbl_spc_2;
```

Next, we'll perform a simple full database recovery:

```
ALTER DATABASE sales_archive RECOVER AUTOMATIC DATABASE;
```

And here we perform a more elaborate partial database recovery:

```
ALTER DATABASE RECOVER STANDBY DATAFILE 'diskF:sales_rpt4.dbf'
UNTIL CONTROLFILE;
```

Now, we'll perform a simple recovery of a standby database in managed standby recovery mode:

```
ALTER DATABASE RECOVER sales_archive MANAGED STANDBY DATABASE;
```

In the following example, we gracefully switch over from a primary database to a logical standby, and promote the logical standby to primary:

```
-- Demotes the current primary to the logical standby database.
ALTER DATABASE COMMIT TO SWITCHOVER TO LOGICAL STANDBY;
-- Applies changes to the new standby.
ALTER DATABASE START LOGICAL STANDBY APPLY;
-- Promotes the current standby to the primary database.
ALTER DATABASE COMMIT TO SWITCHOVER TO PRIMARY;
```

PostgreSQL

PostgreSQL's implementation of the `CREATE DATABASE` command creates a database and a file location for the datafiles:

```
CREATE DATABASE database_name [ WITH ]
   [OWNER [=] database_owner]
   [TEMPLATE [=] tmp_name]
   [ENCODING [=] enc_value]
   [LC_COLLATE [=] lc_collate]
   [LC_CTYPE [=] lc_ctype]
   [LOCALE [=] locale]
   [TABLESPACE [=] tablespace_name]
   [CONNECTION LIMIT [=] int]
   [ALLOW_CONNECTIONS [=] boolean]
   [IS_TEMPLATE [=] boolean]
```

PostgreSQL's syntax for `ALTER DATABASE` is:

```
ALTER DATABASE database_name [ WITH ]
   [ALLOW_CONNECTIONS boolean]
   [CONNECTION LIMIT int]
   [IS_TEMPLATE boolean]
   | [OWNER TO new_database_owner]
   | [RENAME TO new_database_name]
   | [SET TABLESPACE new_tablespace]
```

```
      | [RESET {parameter | ALL}]
      | [SET parameter [{TO | =} {value | DEFAULT} | FROM CURRENT]
```

where:

`WITH`
: Is an optional keyword to further define the details of the database. All options that follow `WITH` are optional.

`OWNER [=] *database_owner*`
: Specifies the name of the database owner if it is different from the name of the user executing the statement.

`TEMPLATE [=] *tmp_name*`
: Names a template to use for creating the new database. You can omit this clause to accept the default template (or use the clause `TEMPLATE = DEFAULT`). The default is to copy the database *template1*. You can get a pristine database (one that contains only required database objects) with no predefined collation by specifying `TEMPLATE =` *template0*. If you use *template1* you cannot set `LC_COLLATE`, as the collation has to be the same as that used by *template1*. If you need a different collation from what *template1* has, you should use *template0*.

`ENCODING [=] *enc_value*`
: Specifies the multibyte encoding method to use in the new database, using either a string literal (such as `'UTF8'`), an integer encoding number, or `DEFAULT` for the default encoding.

`LC_COLLATE [=] *lc_collate*`
: Specifies the collation order for the database. This affects sort order using SQL's `ORDER BY` and index sort. Collation options include `C`, `POSIX`, and additional platform-specific choices. More details can be found in the documentation.

`LC_CTYPE [=] *lc_ctype*`
: Specifies the character classification rules for the database. This affects categorization of characters (uppercase, lowercase, digits, etc.). Defaults to the template database setting when neither `LC_CTYPE` nor `LOCALE` is specified.

`LOCALE [=] *locale*`
: Shorthand for setting both `LC_CTYPE` and `LC_COLLATE`. If this is specified, then the other two cannot be specified. The locale defaults to that of the template database when not specified.

`TABLESPACE [=] *tablespace_name*`
: Specifies the name of the tablespace associated with the database. This corresponds to a physical location on disk; PostgreSQL provides a `CREATE TABLESPACE` command for creating these. In `CREATE DATABASE` only the name of the tablespace is used, not the actual path.

`CONNECTION LIMIT` *`int`*
: Specifies how many concurrent connections to the database are allowed. A value of `-1` means no limit.

`ALLOW_CONNECTIONS` *`boolean`*
: Defaults to `true`. If `false`, then no one can connect to this database.

`IS_TEMPLATE` *`boolean`*
: Indicates whether this database can be used as a template for new databases. Although superusers can use any database as a template, only databases marked as `IS_TEMPLATE = true` can be used by non-superusers with `CREATE DATABASE` permissions.

`OWNER TO` *`new_database_owner`*
: Assigns a new owner to the database.

`RENAME TO` *`new_database_name`*
: Assigns a new name to the database.

`SET TABLESPACE` *`new_tablespace`*
: Defines a new default tablespace for the database.

`RESET {`*`parameter`*` | ALL}`
: Resets the database-specific setting for the named parameter or all parameters to the system-wide default. This change takes effect from the next session (not immediately).

`SET` *`parameter`* `[{TO | =} {`*`value`*` | DEFAULT} | FROM CURRENT]`
: Specifies a default value for the named configuration parameter for the current database session. `FROM CURRENT` uses the session's current value for the parameter as the database-specific value.

PostgreSQL has many variables that control the query planner, how much memory can be used, etc. These are called *Grand Unified Configuration variables* (GUCs). Many GUCs can be set at the server, database, user, or session level using the `SET` command. To set a GUC at the database level, you'd use the `ALTER DATABASE` command as follows:

```
ALTER DATABASE nutshell
SET work_mem='100MB';
```

To reset it back to default for the server, you'd do:

```
ALTER DATABASE nutshell RESET work_mem;
```

SQL Server

SQL Server offers a lot of control over the OS filesystem structures that hold the database and its objects. The syntax of its `CREATE DATABASE` statement is as follows:

```
CREATE DATABASE database_name
   [ CONTAINMENT = {NONE | PARTIAL} ]
```

```
      [ ON file_definition[, ...] ]
      [, FILEGROUP filegroup_name [ [ CONTAINS FILESTREAM ] [ DEFAULT ] |
         CONTAINS MEMORY_OPTIMIZED_DATA ] file_definition[, ...] ]
      [ LOG ON file_definition[, ...] ] ]
      [ COLLATE collation_name ]
      [ WITH
         [FILESTREAM (filestream_option[, ...])]
         [DEFAULT_FULLTEXT_LANGUAGE = {lcid | language_name |
            language_alias}]
         [DEFAULT_LANGUAGE = {lcid | language_name | language_alias}]
         [NESTED_TRIGGERS {ON | OFF}]
         [TRANSFORM_NOISE_WORDS {ON | OFF}]
         [TWO_DIGIT_YEAR_CUTOFF two_digit_year_cutoff]
         [DB_CHAINING {ON | OFF}]
         [TRUSTWORTHY {ON | OFF}]]
         [PERSISTENT_LOG_BUFFER = ON (DIRECTORY_NAME = 'filepath')] ]
    | [ FOR { { ATTACH [WITH {ENABLE_BROKER | NEW_BROKER |
         ERROR_BROKER_CONVERSATIONS | RESTRICTED USER |
         FILESTREAM (DIRECTORY_NAME = {'directory_name' | NULL})}] } |
         ATTACH_REBUILD_LOG } ]
    | [ AS SNAPSHOT OF source]
```

where:

`CREATE DATABASE` *`database_name`*
: Creates a database with the name *`database_name`*. The name cannot be longer than 128 characters. You should limit the database name to 123 characters when no logical filename is supplied, since SQL Server will create a logical filename by appending a suffix to the database name.

`[ CONTAINMENT = {NONE | PARTIAL} ]`
: Specifies either a non-contained database (`NONE`) or a partially contained database (`PARTIAL`).

`ON` *`file_definition`*`[, ... ]`
: Defines the disk file(s) that store(s) the data components of the database. This clause is required for `CREATE DATABASE` only if you wish to provide one or more file definitions. The syntax for *`file_definition`* is:

```
{[PRIMARY] ( [NEW][NAME = filename]
[, FILENAME = {'os_filename' | 'filestream_name'}]
[, SIZE = int [KB | MB | GB | TB]]
[, MAXSIZE = { int [KB | MB | GB | TB] | UNLIMITED }]
[, FILEGROWTH = int [KB | MB | GB | TB | %]
```

where:

`PRIMARY`
: Defines the *`file_definition`* as the primary file. Only one primary file is allowed per database. (If you don't define a primary file, SQL Server defaults primary status to the file that it autocreates, in the absence of any user-defined file, or to the first file that you define.) The primary file

or group of files (also called a *filegroup*) contains the logical start of the database, all the database system tables, and all other objects not contained in user filegroups.

`NAME =` *`filename`*
: Provides the logical name of the file defined by the *`file_definition`*. The name must be unique within the database. This clause is optional when using `FOR ATTACH`.

`FILENAME = {'`*`os_filename`*`' | '`*`filestream_name`*`'}`
: Specifies the operating system path and filename for the file defined by the *`file_definition`*. The file must be in a noncompressed directory on the filesystem. For raw partitions, specify only the drive letter of the raw partition.

`SIZE =` *`int`* `[KB | MB | GB | TB]`
: Sets the size of the file defined by the *`file_definition`*. This clause is optional, but it defaults to the file size for the primary file of the model database, which is usually very small. Logfiles and secondary datafiles default to a size of 1 MB. The value of *`int`* defaults to megabytes; however, you can explicitly define the size of the file using the suffixes for kilobyte (`KB`), megabyte (`MB`), gigabyte (`GB`), and terabyte (`TB`). The size cannot be smaller than 512 KB or the size of the primary file of the model database.

`MAXSIZE = {` *`int`* `[KB | MB | GB | TB] | UNLIMITED }`
: Defines the maximum size to which the file may grow. Suffixes, as described under the entry for `SIZE`, are allowed. The default, `UNLIMITED`, allows the file to grow until all available disk space is consumed. Not required for files on raw partitions.

`FILEGROWTH =` *`int`* `[KB | MB | GB | TB | %]`
: Defines the growth increment for the file each time it grows. Suffixes, as described under the entry for `SIZE`, are allowed. You may also use the percentage (`%`) suffix to indicate that the file should grow by a percentage of the total disk space currently consumed. If you omit the `FILEGROWTH` clause, the file will grow in 10% increments, but never by less than 64 KB. Not required for files on raw partitions.

`FILEGROUP` *`filegroup_name`* `[CONTAINS FILESTREAM] [DEFAULT] [CONTAINS MEMORY_OPTIMIZED_DATA]` *`file_definition`*`[, ...]`
: Defines any user filegroups used by the database, and their file definitions. All databases have at least one primary filegroup (though many databases only use the primary filegroup that comes with SQL Server by default). Adding filegroups and then moving files to those filegroups allows greater control over disk I/O. (However, we recommend that you do not add filegroups without careful analysis and testing).

`CONTAINS FILESTREAM`
: Indicates that the filegroup stores FILESTREAM `BLOB`s in the filesystem.

`DEFAULT`
: Defines the specified filegroup as the default filegroup for the database.

`CONTAINS MEMORY_OPTIMIZED_DATA`
: Indicates that the filegroup stores memory-optimized tables in the filesystem. Only one `MEMORY_OPTIMIZED_DATA` filegroup is allowed per database.

`LOG ON` *`file_definition`*
: Defines the disk file or files that store the log component of the database. You can provide one or more *`file_definition`*s for the transaction logs in a comma-delimited list. Refer to the preceding sublist for the full syntax of *`file_definition`*.

`COLLATE` *`collation_name`*
: Defines the default collation used by the database. *`collation_name`* can be either a SQL Server collation name or a Windows collation name. By default, all new databases receive the collation of the SQL Server instance. (You can execute the query `SELECT * FROM ::fn_helpcollations()` to see all the collation names available.) To change the collation of a database, you must be the only user in the database, no schema-bound objects that depend on the current collation may exist in the database, and the collation change must not result in the duplication of any object names in the database.

`FILESTREAM (`*`filestream_option`*`[, ...])`
: `FILESTREAM` is used for storing unstructured data such as documents and images. You can specify the level of non-transactional FILESTREAM access to the database with `NON_TRANSACTED_ACCESS = { OFF> | READ_ONLY | FULL }`, or the name of a Windows-compatible directory with `DIRECTORY_NAME = '`*`directory_name`*`'`. Attaching a database that contains a `FILESTREAM` option of `DIRECTORY_NAME` into a SQL Server instance will prompt SQL Server to verify that the *Database_Directory* name is unique. If it is not, the attach operation fails with the error "FILESTREAM Database_Directory name <name> is not unique in this SQL Server instance." To avoid this error, the optional `DIRECTORY_NAME` parameter should be passed into this operation.

`DEFAULT_FULLTEXT_LANGUAGE =` *`lcid`* `|` *`language_name`* `|` *`language_alias`*
: Specifies the default language option used in a full-text index when no language is otherwise specified by the `CREATE` or `ALTER FULLTEXT INDEX` statement.

`DEFAULT_LANGUAGE =` *`lcid`* `|` *`language_name`* `|` *`language_alias`*
: Specifies the default language for the server when using SQL Server Management Studio or Transact-SQL, applying that option to all newly created logins. This setting applies for logins associated with the database unless overridden by `CREATE/ALTER LOGIN`.

`NESTED_TRIGGERS = {OFF | ON}`
: Specifies the nested trigger configuration opttion when using SQL Server Management Studio or Transact-SQL. In particular, this setting controls whether `AFTER` triggers can cascade. `OFF` indicates no cascading triggers, while `ON` indicates that triggers can cascade up to 32 levels deep. `INSTEAD OF` triggers can always cascade regardless of this setting.

`TRANSFORM_NOISE_WORDS = { OFF | ON}`
: When set to `ON`, this option transforms noise words (for example, "the" in the string "the product") and suppresses error messages if noise words cause a Boolean operation on a full-text query to return zero rows. Most useful with full-text queries that use the `CONTAINS` predicate of the `NEAR` operation.

`TWO_DIGIT_YEAR_CUTOFF` *`two_digit_year_cutoff`*
: Specifies the default interpretation by SQL Server when handling two-digit years. Normally, SQL Server accepts a default time span of 1950 through 2049. In this case, the two-digit year 51 would be interpreted by SQL Server as 1951, but 41 would be interpreted as 2041. You can instead manually specify any year between 1753 through 9999 as your two-digit year cutoff, if needed. The default value is backward compatible.

`DB_CHAINING {OFF | ON }`
: Specifies that the database can be involved in a cross-database ownership chain (`DB_CHAINING ON`). When omitted, the default is `OFF`, which disallows cross-database ownership chains. Not allowed on *master*, *model*, and *tempdb* databases.

`TRUSTWORTHY {ON|OFF}]`
: Setting `TRUSTWORTHY ON` specifies that database routines (such as views, functions, or procedures) that use an impersonation context can access resources outside of the database. When omitted, the default is `OFF`, which disallows accessing external resources from within a routine running in an impersonation context. `TRUSTWORTHY` is set to `OFF` whenever a database is attached. Not allowed on *master*, *model*, and *tempdb* databases.

`PERSISTENT_LOG_BUFFER=ON ( DIRECTORY_NAME = '`*`filepath`*`' )`
: Creates the transaction log buffer on a high-speed volume backed by a disk device using storage class memory, such as NVDIMM-N nonvolatile storage. Due to the performance requirements of a persistent log buffer, make sure to follow the documented specifications closely.

`CONTAINS MEMORY_OPTIMIZED_DATA`
: This specifies that the filegroup of the `CREATE/ALTER` statement stores memory-optimized tables on the filesystem. SQL Server allows only one memory-optimized data filegroup per database. Refer to the vendor documentation for details on memory-optimized databases and workloads.

FOR { { ATTACH [WITH {ENABLE_BROKER | NEW_BROKER | ERROR_BROKER_CONVERSATIONS | RESTRICTED_USER | FILESTREAM (DIRECTORY_NAME = {'*directory_name*' | NULL})}] } | ATTACH_REBUILD_LOG }

Places the database in special startup mode. FOR ATTACH creates the database from a set of preexisting operating system files (almost always database files created previously). Because of this, the new database must have the same code page and sort order as the previous database. You only need the *file_definition* of the first primary file or those files that have a different path from the last time the database was attached. The FOR ATTACH_REBUILD_LOG clause specifies that the database is created by attaching an existing set of OS files, rebuilding the log in the process in case any logfiles are missing. In general, you should use the *sp_attach_db* system stored procedure instead of the CREATE DATABASE FOR ATTACH statement unless you need to specify more than 16 *file_definition*s.

Service Broker options may be specified when using the FOR ATTACH clause:

ENABLE_BROKER
: Specifies that Service Broker is enabled for the database.

NEW_BROKER
: Creates a new *service_broker_guid* and ends all conversation endpoints with a cleanup.

ERROR_BROKER_CONVERSATIONS
: Terminates all Service Broker conversations with an error indicating that a database has been attached or restored. The broker is disabled during the operation and then reenabled afterward.

RESTRICTED_USER
: Allows only members of the *db_owner* database role and the *dbcreator* and *sysadmin* server roles to connect to the database.

AS SNAPSHOT OF *source*

Declares that the database being created is a snapshot of the *source* database. The source and snapshot must exist on the same instance of SQL Server.

Following is the syntax for ALTER DATABASE:

```
ALTER DATABASE {database_name | CURRENT}
{ MODIFY NAME = new_database_name
| COLLATE collation_name
| file_and_filegroup_options
| SET {option_spec}[, ...] [WITH termination_option]
file_and_filegroup_options ::=
{ { ADD FILE file_definition[, ...] [TO FILEGROUP filegroup_name]
   | ADD LOG FILE file_definition[, ...]
   | REMOVE FILE filename
   | MODIFY FILE file_definition } |
  { ADD FILEGROUP filegroup_name [ CONTAINS FILESTREAM |
      CONTAINS MEMORY_OPTIMIZED_DATA ]
   | REMOVE FILEGROUP filegroup_name
   | MODIFY NAME = new_database_name
   | MODIFY FILEGROUP filegroup_name
      { NAME = new_filegroup_name | filegroup_property |
         {AUTOGROW_SINGLE_FILE | AUTOGROW_ALL_FILES} }
```

where:

`ALTER DATABASE {`*`database_name`*`| CURRENT}`
: Specifies the name of the database to be modified. `CURRENT` designates the database currently in use.

`MODIFY NAME =` *`new_database_name`*
: Changes the database's name from its current name to *`new_database_name`*.

`ADD FILE` *`file_definition`*`[, ... ] [TO FILEGROUP` *`filegroup_name`*`]`
: Adds a file to the database, in the designated filegroup. See the previous list for a description of *`file_definition`*.

`ADD LOG FILE` *`file_definition`*
: Adds a log file to the database.

`REMOVE FILE` *`filename`*
: Removes a file from the database and deletes the physical file. The file must be emptied of all content first.

`MODIFY FILE` *`file_definition`*
: Changes the definition of a file. For example: `MODIFY FILE (NAME =` *`file_name`*`, NEWNAME =` *`new_file_name`*`, SIZE =` *`int`* `... )`.

`ADD FILEGROUP` *`filegroup_name`* `[CONTAINS FILESTREAM] [CONTAINS MEMORY_OPTIMIZED_DATA]`
: Adds a filegroup to the database. You can specify that the filegroup stores FILESTREAM `BLOB`s or memory-optimized data in the filesystem. Only one `MEMORY_OPTIMIZED_DATA` filegroup is allowed per database.

`REMOVE FILEGROUP` *`filegroup_name`*
: Removes a filegroup from the database and deletes all the files in the filegroup. The files and the filegroup must be empty first.

`MODIFY FILEGROUP` *`filegroup_name`* `{NAME =` *`new_filegroup_name`* `|` *`filegroup_property`* `| {AUTOGROW_SINGLE_FILE | AUTOGROW_ALL_FILES}}`
: Allows you to change a filegroup's name (with `NAME =` *`new_filegroup_name`*) or to specify a *`filegroup_property`* for the filegroup, which must be one of the following:

  `READONLY`
  : Sets the filegroup to read-only and disallows updates to all objects within the filegroup. `READONLY` can only be enabled by users with exclusive

database access and cannot be applied to the primary filegroup. You may also use READ_ONLY.

READWRITE
: Disables the READONLY property and allows updates to objects within the filegroup. READWRITE can only be enabled by users with exclusive database access. You may also use READ_WRITE.

DEFAULT
: Sets the filegroup as the default filegroup for the database. All new tables and indexes are assigned to the default filegroup unless explicitly assigned elsewhere. Only one default filegroup is allowed per database. (By default, the CREATE DATABASE statement sets the primary filegroup as the default filegroup.)

In SQL Server 2016 and later, you can specify AUTOGROW_SINGLE_FILE or AUTOGROW_ALL_FILES to indicate that when a file in the filegroup meets the autogrow threshold only that file grows (the default), or all files grow.

SET *option_spec*[, ...]
: Controls a wide variety of behaviors for the database. These are discussed in the rules and information later in this section; for complete details, see the documentation.

WITH *termination_option*
: Used after the SET clause, WITH sets the rollback behavior for incomplete transactions whenever the database is in transition. When this clause is omitted, transactions must commit or roll back on their own with the database state changes. There are two *termination_option* settings:

ROLLBACK AFTER *int* [SECONDS] | ROLLBACK IMMEDIATE
: Causes the database to roll back in *int* number of seconds, or immediately. SECONDS is a noise word and does not change the behavior of the ROLLBACK AFTER clause.

NO_WAIT
: Causes database state or option changes to fail if a change cannot be completed immediately, without waiting for the current transaction to independently commit or roll back.

The CREATE DATABASE command should be issued from the *master* system database. You can, in fact, issue the command CREATE DATABASE *database_name*, with no other clauses, to get a very small default database.

SQL Server uses *files*, formerly called *devices*, to act as a repository for databases. Files are grouped into one or more *filegroups*, with at least a PRIMARY filegroup assigned to each database. A file is a predefined block of space created on the disk structure. A database may be stored on one or more files or filegroups. SQL Server also allows the transaction log to be placed in a separate location from the database using the `LOG ON` clause. These functions allow sophisticated file planning for optimal control of disk I/O. For example, we can create a database called *sales_report* with a data and transaction logfile as follows:

```
USE master
GO
CREATE DATABASE sales_report
ON
( NAME = sales_rpt_data, FILENAME =
   'c:\mssql\data\salerptdata.mdf',
   SIZE = 100, MAXSIZE = 500, FILEGROWTH = 25 )
LOG ON
( NAME = 'sales_rpt_log',
   FILENAME = 'c:\mssql\log\salesrptlog.ldf',
   SIZE = 25MB, MAXSIZE = 50MB,
   FILEGROWTH = 5MB )
GO
```

When a database is created, all objects in the model database are copied into the new database. All of the empty space within the file or files defined for the database is then initialized (i.e., emptied out), which means that creating a new database that's very large can take a while, especially on a slow disk.

A database always has at least a primary datafile and a transaction logfile, but it may also have secondary files for both the data and log components of the database. SQL Server uses default filename extensions: *.mdf* for primary datafiles, *.ndf* for secondary files, and *.ldf* for transaction logfiles. The following example creates a database called *sales_archive* with several very large files that are grouped into a couple of filegroups:

```
USE master
GO
CREATE DATABASE sales_archive
ON
PRIMARY (NAME = sales_arch1, FILENAME = 'c:\mssql\data\archdata1.mdf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
   (NAME = sales_arch2,
      FILENAME = 'c:\mssql\data\archdata2.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
   (NAME = sales_arch3,
      FILENAME = 'c:\mssql\data\archdat3.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB)
FILEGROUP sale_rpt_grp1
   (NAME = sale_rpt_grp1_1_data,
      FILENAME = 'c:\mssql\data\SG1Fi1dt.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
  (NAME = sale_rpt_grp1_1_data,
      FILENAME = 'c:\mssql\data\SG1Fi2dt.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
FILEGROUP sale_rpt_grp2
   (NAME = sale_rpt_grp2_1_data, FILENAME = 'c:\mssql\data\SRG21dt.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
   (NAME = sale_rpt_grp2_2_data, FILENAME = 'c:\mssql\data\SRG22dt.ndf',
      SIZE = 100GB, MAXSIZE = 200GB, FILEGROWTH = 20GB),
LOG ON
   (NAME = sales_archlog1,
      FILENAME = 'd:\mssql\log\archlog1.ldf',
      SIZE = 100GB, MAXSIZE = UNLIMITED, FILEGROWTH = 25%),
   (NAME = sales_archlog2,
      FILENAME = 'd:\ mssql\log\archlog2.ldf',
      SIZE = 100GB, MAXSIZE = UNLIMITED, FILEGROWTH = 25%)
GO
```

The `FOR ATTACH` clause is commonly used for situations like a salesperson traveling with a database on a thumbdrive. This clause tells SQL Server that the database is attached from an existing operating system file structure, such as a file downloaded from the web. When using `FOR ATTACH`, the new database inherits all the objects and data of the parent database, not the model database.

The following examples show how to change the name of a database, file, or filegroup:

```
-- Rename a database
ALTER DATABASE sales_archive MODIFY NAME = sales_history
GO
-- Rename a file
ALTER DATABASE sales_archive MODIFY FILE
NAME = sales_arch1,
NEWNAME = sales_hist1
GO
-- Rename a filegroup
ALTER DATABASE sales_archive MODIFY FILEGROUP
sale_rpt_grp1
NAME = sales_hist_grp1
GO
```

There may be times when you want to add new free space to a database, especially if you have not enabled it to auto-grow:

```
USE master
GO
ALTER DATABASE sales_report ADD FILE
( NAME = sales_rpt_added01,
FILENAME = 'c:\mssql\data\salerptadded01.mdf',
   SIZE = 50MB, MAXSIZE = 250MB, FILEGROWTH = 25MB )
GO
```

When you alter a database, you can set many behavior options on the database. State options (shown as *`state_option`* in the earlier syntax diagram) control how users access the database. Following is a list of valid state options:

`SINGLE_USER | RESTRICTED_USER | MULTI_USER`
: Sets the number and type of users with access to the database. `SINGLE_USER` mode allows only one user to access the database at a time. `RESTRICTED_USER`

mode allows access only to members of the system roles *db_owner*, *dbcreator*, or *sysadmin*. `MULTI_USER`, the default, allows concurrent database access from all users who have permission.

`OFFLINE | ONLINE`
: Sets the database to offline (unavailable) or online (available).

`READ_ONLY | READ_WRITE`
: Sets the database to `READ_ONLY` mode, where no modifications are allowed, or to `READ_WRITE` mode, where data modifications are allowed. `READ_ONLY` databases can be very fast for query-intensive operations, since almost no locking is needed.

Cursor options control default behavior for cursors in the database. In the `ALTER DATABASE` syntax shown earlier, you can replace *`cursor_option`* with any of the following:

`CURSOR_CLOSE_ON_COMMIT { ON | OFF }`
: When set to `ON`, any open cursors are closed when a transaction commits or rolls back. When set to `OFF`, any open cursors remain open when transactions are committed and close when a transaction rolls back, unless the cursor is `INSENSITIVE` or `STATIC`.

`CURSOR_DEFAULT { LOCAL | GLOBAL }`
: Sets the default scope of all cursors in the database to either `LOCAL` or `GLOBAL`. (See "DECLARE CURSOR Statement" on page 711 for more on this.)

In the `SET` clause, *`auto_option`* controls the automatic file handling behaviors of the database. The following are valid replacements for *`auto_option`*:

`AUTO_CLOSE { ON | OFF }`
: When set to `ON`, the database automatically shuts down cleanly and frees all resources when the last user exits. When set to `OFF`, the database remains open when the last user exits. The default is `OFF`.

`AUTO_CREATE_STATISTICS { ON | OFF }`
: When set to `ON`, statistics are automatically created when SQL Server notices they are missing during query optimization. When set to `OFF`, statistics are not created during optimization. The default is `ON`.

`AUTO_SHRINK { ON | OFF }`
: When set to `ON`, the database files may automatically shrink (the database periodically looks for an opportunity to shrink files, though the time is not always predictable). When set to `OFF`, files will shrink only when you explicitly and manually shrink them. The default is `OFF`.

`AUTO_UPDATE_STATISTICS { ON | OFF }`
: When set to `ON`, out-of-date statistics are reassessed during query optimization. When set to `OFF`, statistics are reassessed only by explicitly and manually

recompiling them using the SQL Server command `UPDATE STATISTICS`. The default is `ON`.

The *`sql_option`* clause controls the SQL compatibility of the database. You can replace *`sql_option`* with any of the following:

`ANSI_NULL_DEFAULT { ON | OFF }`
: When set to `ON`, the `CREATE TABLE` statement causes columns with no nullability setting to default to NULL. When set to `OFF`, the nullability of a column defaults to `NOT NULL`. The default is `OFF`.

> You can use the standalone SQL Server command `SET ANSI_DEFAULTS ON` to enable all the `ANSI_` behaviors at once, rather than using individual statements.

`ANSI_NULLS { ON | OFF }`
: When set to `ON`, comparisons to NULL yield `UNKNOWN`. When set to `OFF`, comparisons to NULL yield NULL if both non-Unicode values are NULL. The default is `OFF`.

`ANSI_PADDING { ON | OFF }`
: When set to `ON`, strings are padded to the same length for insertion or comparison operations on `VARCHAR` and `VARBINARY` columns. When set to `OFF`, strings are not padded. The default is `ON`. (We recommend that you *do not* change this!)

`ANSI_WARNINGS { ON | OFF }`
: When set to `ON`, the database warns when problems like “divide by zero” or “NULL in aggregates” occur. When set to `OFF`, these warnings are not raised. The default is `OFF`.

`ARITHABORT { ON | OFF }`
: When set to `ON`, divide-by-zero and overflow errors cause a query or Transact-SQL batch to terminate and roll back any open transactions. When set to `OFF`, a warning is raised but processing continues. The default is `ON`. (We recommend that you *do not* change this!)

`CONCAT_NULL_YIELDS_NULL { ON | OFF }`
: When set to `ON`, returns a NULL when a NULL is concatenated to a string. When set to `OFF`, NULLs are treated as empty strings when concatenated to a string. The default is `OFF`.

`NUMERIC_ROUNDABORT { ON | OFF }`
: When set to `ON`, an error is raised when a numeric expression loses precision. When set to `OFF`, losses of precision result in rounding of the result from the numeric expression. The default is `OFF`.

`QUOTED_IDENTIFIER { ON | OFF }`

When set to `ON`, double quotation marks identify an object identifier that contains special characters or is a reserved word (e.g., a table named *SELECT*). When set to `OFF`, identifiers may not contain special characters or reserved words, and all occurrences of double quotation marks signify a literal string value. The default is `OFF`.

`RECURSIVE_TRIGGERS { ON | OFF }`

When set to `ON`, triggers can fire recursively. That is, the actions taken by one trigger may cause another trigger to fire, and so on. When set to `OFF`, triggers cannot cause other triggers to fire. The default is `OFF`.

Recovery options control the recovery model used by the database. Use any of the following in place of *`recovery_option`* in the `ALTER DATABASE` syntax:

`RECOVERY { FULL | BULK_LOGGED | SIMPLE }`

When set to `FULL`, database backups and transaction logs provide full recoverability even for bulk operations like `SELECT ... INTO`, `CREATE INDEX`, etc. `FULL` provides the most recoverability, even from a catastrophic media failure, but uses more space. When set to `BULK_LOGGED`, logging for bulk operations is minimized. Space is saved and fewer I/O operations are incurred, but risk of data loss is greater than under `FULL`. When set to `SIMPLE`, the database can only be recovered to the last full or differential backup.

`TORN_PAGE_DETECTION { ON | OFF }`

When set to `ON`, SQL Server can detect incomplete I/O operations at the disk level by checking each 512-byte sector per 8 KB database page. (Torn pages are usually detected in recovery.) The default is `ON`.

For example, we can change some behavior settings for the *sales_report* database without actually changing the underlying file structure as follows:

```
ALTER DATABASE sales_report SET ONLINE, READ_ONLY,
AUTO_CREATE_STATISTICS ON
GO
```

This statement puts the database online and in read-only mode. It also sets the `AUTO_CREATE_STATISTICS` behavior to `ON`.

See also

- `CREATE/ALTER SCHEMA`
- `DROP`

CREATE DOMAIN Statement

The SQL standard defines a `CREATE DOMAIN` statement for defining a new data type that constrains an existing data type. However, in our set of databases, only PostgreSQL supports this construct. For Oracle and SQL Server, the `CREATE TYPE` statement can be used instead to produce the same result. There is no counterpart to this statement in MySQL that can achieve the same goal.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
CREATE DOMAIN domain_name AS data_type
(constraint[, ...])
```

Keywords

`CREATE DOMAIN` *`domain_name`*
: Creates a new domain with name *`domain_name`* in the current database and schema context.

`data_type`
: The data type that this domain is based on. This often includes a qualifier where the base *`data_type`* supports it, such as *varchar*(*20*) instead of just *varchar*.

`constraint`
: A domain can have one or more constraints that restrict the values of the domain. The constraint can take one of the following forms:

```
NOT NULL
CHECK (expression)
```

Rules at a glance

This command creates a data type that can be used as a table column type. It is often used to create aliases for existing data types or to constrain a type with a length or denote whether it should be `NOT NULL`.

Programming tips and gotchas

Since `CREATE DOMAIN` is not supported by most databases, please refer to `CREATE/ALTER TYPE`.

PostgreSQL

PostgreSQL follows the standard. A simple domain creation statement would look like this:

```
CREATE DOMAIN empid AS char(9) NOT NULL;
```

A statement to create a domain with checks would look like this:

```
CREATE DOMAIN email AS varchar(75)
  CHECK ( value ~ '^[A-Za-z0-9._%-]+@[A-Za-z0-9.-]+[.][A-Za-z]+$' );
```

For more complex checks, you can employ the use of functions that return a Boolean.

See also

- `CREATE/ALTER TYPE`

CREATE/ALTER INDEX Statement

Indexes are special objects built on top of tables that speed many data manipulation operations (such as `SELECT`, `UPDATE`, and `DELETE` statements) by providing very fast lookup using pointers to individual records within a table. Improving the speed of `WHERE` and/or `JOIN` clauses are two common reasons to build indexes. Each database vendor provides a cost-based optimizer to determine the least expensive means of answering a query by building execution plans, usually based upon the quality of the indexes that have been placed on the table in a given database. To reemphasize, proper indexing is your first and best step for high-performance database applications.

The `CREATE INDEX` command was not a part of the early SQL standard, and thus its syntax varies greatly among vendors. `ALTER INDEX` is not part of the SQL standard but is implemented (with variations) by most of the database platforms discussed here.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
CREATE [UNIQUE] INDEX index_name ON table_name
(column_name[, ...])
```

Keywords

`CREATE [UNIQUE] INDEX` *`index_name`*
: Creates a new index named *`index_name`* in the current database and schema context. The `UNIQUE` keyword defines the index as a unique constraint for the table and disallows any duplicate values in the indexed column or columns of the table. (Refer to "Constraints" on page 60 for details.)

`table_name`
: Declares the preexisting table with which the index is associated. The index is dependent upon the table: if the table is dropped, so is the index.

`column_name[, ... ])`
: Defines one or more columns in the table that are indexed. The pointers derived from the indexed column or columns enable the database query optimizer to greatly speed up data manipulation operations such as `SELECT` and `DELETE` statements. All major vendors support *composite indexes*, also known as *concatenated indexes*, which are used when two or more columns are best searched as a unit (for example, *last_name* and *first_name* columns).

Rules at a glance

Indexes are created upon a specified column or columns in a table to speed up data manipulation operations against those tables, such as those in a `WHERE` or `JOIN` clause. Indexes may also speed up other operations, including:

- Identifying a `MIN()` or `MAX()` value in an indexed column.
- Sorting or grouping columns of a table.
- Searching based on `IS NULL` or `IS NOT NULL`.
- Fetching data quickly when the indexed data is all that is requested. A `SELECT` statement that retrieves data from an index and not directly from the table itself is called a *covering query*. An index that answers a query in this way is a *covering index*.

After creating a table, you can create indexes on columns within the table. It is a good idea to create indexes on columns that are frequently part of the `WHERE` clauses or `JOIN` clauses of the queries made against a table. For example, the following statement creates an index on a column in the *sales* table that is frequently used in the `WHERE` clauses of queries against that table:

```
CREATE INDEX ndx_ord_date ON sales(ord_date);
```

In another case, we may want to set up the *pub_name* and *country* as a unique index on the *publishers* table:

```
CREATE UNIQUE INDEX unq_pub_id ON publishers(pub_name, country);
```

Since the index declares that the combined value of the two columns must be unique, any new record entered into the *publishers* table must have a unique combination of publisher name and country.

Some vendor platforms allow you to create indexes on views as well as tables.

Programming tips and gotchas

Concatenated indexes are most useful when queries address the columns of the index starting from the left and moving to the right in ordinal position. If you omit left-side columns in a query against a concatenated index, the query may not perform as well because all or part of the index may be ignored by the query optimizer. For example, assume that we have a concatenated index on *(last_name, first_name)*. If we query only by *first_name*, the concatenated index that starts with *last_name* and includes *first_name* may not be any good to us. That said, some of the vendor platforms have now advanced their query engines to the point where this is much less of a problem than it used to be.

You should be aware that there are situations in which too many indexes can actually slow down system performance. In general, indexes greatly speed lookup operations against a table or view, especially in `SELECT` statements. However, every index you create adds overhead whenever you perform an `UPDATE`, `DELETE`, or `INSERT` operation because the database must update all dependent indexes with the values that have changed in the table. As a rule of thumb, 6 to 12 indexes are about the most you'll want to create on a single table.

In addition, indexes take up extra space within the database. The more columns there are in an index, the more space it consumes. This is not usually a problem, but it sometimes catches the novices off guard when they're developing a new database.

Creating an index on a table may cause that table to take up as much as 1.2 to 1.5 times more space than the table currently occupies. Make sure you have enough room! Most of that space is released after the index has been created.

Most databases use indexes to create statistical samplings (usually just called *statistics*), so the query engine can quickly determine which, if any, index or combination of indexes will be most useful for a query. These indexes are always fresh and useful when first created, but they may become stale and less useful over time as records in the table are deleted, updated, and inserted. Consequently, indexes, like day-old bread, are not guaranteed to be useful as they age. You need to be sure to refresh, rebuild, and maintain your databases regularly to keep index statistics fresh.

MySQL and MariaDB

MySQL supports a form of the `CREATE INDEX` statement, but not the `ALTER INDEX` statement. (To accomplish the equivalent behavior of the `ALTER INDEX` statement, first `DROP` the old index then `CREATE` the new index.) The types of indexes you can create in MySQL are determined by the engine type, and the indexes are not necessarily stored in B-tree structures on the filesystem. Strings within an index are automatically prefix- and end space–compressed. MySQL's `CREATE INDEX` syntax is:

```
CREATE [UNIQUE | FULLTEXT | SPATIAL] INDEX index_name
[USING {BTREE | HASH}]
ON table_name (column_name(length) (expr) [ASC | DESC][, ...])
[ KEY_BLOCK_SIZE [=] int
  | [USING {BTREE | HASH}]
  | WITH PARSER parser_name
  | COMMENT 'string'
  | {VISIBLE | INVISIBLE}
  | ENGINE_ATTRIBUTE [=] 'string'
  | SECONDARY_ENGINE_ATTRIBUTE [=] 'string'
]
[ ALGORITHM [=] {DEFAULT | INPLACE | COPY}
  | LOCK [=] {DEFAULT | NONE | SHARED | EXCLUSIVE} ]
```

MariaDB supports more or less the same features as MySQL, with the addition of `IF NOT EXISTS`, `CREATE OR REPLACE`, `IGNORED`, and `WAIT`. Although `KEY_BLOCK_SIZE` is accepted, it is ignored. The syntax is as follows:

```
CREATE [OR REPLACE] [UNIQUE | FULLTEXT | SPATIAL] INDEX
[IF NOT EXISTS] index_name
USING {BTREE | HASH}
ON table_name (column_name [(length)] [ASC | DESC][, ...])
[WAIT n | NOWAIT]
[ KEY_BLOCK_SIZE [=] int
  | USING {BTREE | HASH}
  | WITH PARSER parser_name
  | COMMENT 'string'
  | CLUSTERING [=] {YES| NO}]
  | [IGNORED | NOT IGNORED]
[ ALGORITHM [=] {DEFAULT | INPLACE | COPY | NOCOPY | INSTANT}
[ON ALL SERVER] | LOCK [=] {DEFAULT | NONE | SHARED | EXCLUSIVE} ]
```

where:

`OR REPLACE`
: Only supported by MariaDB. If an index already exists, then the `OR REPLACE` clause will drop the index and re-create it with the new definition.

`FULLTEXT`
: Creates a full-text search index against a column. Full-text indexes are only supported on MyISAM and InnoDB table types and `CHAR`, `VARCHAR`, or `TEXT` data types. Refer to the MySQL vendor documentation for details.

`SPATIAL`
: Creates an R-tree index for storage engines that support these. For storage engines that don't support R-tree indexes, it creates a B-tree index, which can only be used for exact matches, not range matches. The InnoDB and MyISAM storage engines on MySQL and MariaDB support R-tree indexes, as does the Aria engine on MariaDB. Refer to the vendor documentation for further details.

`USING {BTREE | HASH}`
: Specifies a particular type of index to use. Use this hint sparingly, since different storage engines allow different index types. Hash indexes are generally reserved for key/value stores since they can only be used for exact match queries, but they're much better at those than B-tree indexes. NDB allows only `HASH` (and allows the `USING` clause only for unique keys and primary keys), and `MEMORY/HEAP` allows `HASH` and `BTREE`. `RTREE` can also be specified, but only for `SPATIAL` indexes.

`WAIT` *`n`*
: A MariaDB extension allows you to specify how long to wait to get a lock on the table before the `CREATE INDEX` cancels.

`KEY BLOCK SIZE [=]` *`int`*
: Provides a hint to the storage engine about the size to use for index key blocks, where *`int`* is the value in kilobytes to use. A value of 0 means that the default for the storage engine should be used. Ignored by MariaDB in all cases.

`WITH PARSER` *`parser_name`*
: Used only with `FULLTEXT` indexes, this clause associates a parser plug-in with the index. Plug-ins are fully documented in the MySQL documentation.

`COMMENT '`*`string`*`'`
: Used to provide a description that gets displayed in various database user interfaces and is also stored in the system catalogs.

`VISIBLE | INVISIBLE`
: Indicates whether the index is visible to the query planner (MySQL only). An invisible index is one that exists but can never be used by the planner. Indexes are visible unless explicitly marked `INVISIBLE`.

`ENGINE_ATTRIBUTE [=] '`*`string`*`' >| SECONDARY_ENGINE_ATTRIBUTE [=] '`*`string`*`'`
: Used to specify index attributes for primary and secondary storage engines (MySQL only). See the vendor documentation for details.

`CLUSTERING [=] {YES | NO}`
: Forces data to be physically sorted in the same order as the index (MariaDB only). There can only be one clustered index. By default when not specified both MariaDB and MySQL use the primary key as the clustered index.

`IGNORED | NOT IGNORED`
: Indicates whether or not an index should be ignored by the query planner (MariaDB only). `NOT IGNORED` is the default when not specified. This is equivalent to the MySQL `VISIBLE | INVISIBLE` clause.

`ALGORITHM [=] {DEFAULT | INPLACE | COPY | NOCOPY | INSTANT}`
: Controls how online data definition changes are handled. When not specified, the default behavior for the storage engine for index creation is used. Only

MariaDB supports the NOCOPY and INSTANT options for index creation. Refer to the MariaDB and MySQL documentation for details.

LOCK [=] {DEFAULT | NONE | SHARED | EXCLUSIVE}
: Used to specify what kind of locking action should be performed when creating the index. DEFAULT acquires the least restrictive lock on the table allowed to perform the operation. SHARED allows read-only queries to continue while the index is being created. EXCLUSIVE blocks from both reads and writes.

MySQL and MariaDB support the basic industry standard syntax for the CREATE INDEX statement. Interestingly, MySQL (but not MariaDB) also lets you build an index on the first *length* characters of a CHAR or VARCHAR column. MySQL requires the *length* clause for BLOB and TEXT columns. Specifying a length can be useful when selectivity is sufficient in the first, say, 10 characters of a column, and in those situations where saving disk space is very important. This example indexes only the first 25 characters of the *pub_name* column and the first 10 characters of the *country* column:

```
CREATE UNIQUE INDEX unq_pub_id ON publishers(pub_name(25),
   country(10));
```

As a general rule, MySQL allows at least 16 keys per table, with a total maximum length of at least 256 bytes. This can vary by storage engine, however.

MySQL 8.0.13 supports functional key parts, often referred to as functional indexes in other databases. Functional key parts cannot use columns with length specifiers; however, you can use functions like SUBSTRING() to work around that. Functional key parts can only reference columns, not records in other rows, and they cannot be used in indexes used for foreign key or primary key constraints. The following is an example of a functional key part index:

```
CREATE INDEX ix_sales_abs_qty ON sales( ABS(qty) );
```

For an index with a functional key part to be useful, the functional expression should be in the WHERE clause of a SELECT statement, as in:

```
SELECT * FROM sales WHERE ABS(qty) > 50;
```

Oracle

Oracle allows the creation of indexes on tables, partitioned tables, clusters, and index-organized tables, as well as on scalar type object attributes of a typed table or cluster and on nested table columns, using the CREATE INDEX statement. Oracle also allows several types of indexes, including normal B-tree indexes, bitmap indexes (useful for columns that have each value repeated 100 or more times), partitioned indexes, function-based indexes (based on an expression rather than a column value), and domain indexes.

Oracle index names must be unique within a schema, not just to the table to which they are assigned.

Oracle also supports the `ALTER INDEX` statement, which is used to change or rebuild an existing index without forcing the user to drop and re-create the index. Oracle's `CREATE INDEX` syntax is:

```
CREATE [UNIQUE | BITMAP] INDEX index_name
{ON
   {table_name ({column | expression} [ASC | DESC][, ...])
      [{INDEXTYPE IS index_type [PARALLEL [int] | NOPARALLEL]
      [PARAMETERS ('values')] }] |
   CLUSTER cluster_name |
   FROM table_name WHERE condition [LOCAL partitioning]}
[ {LOCAL partitioning | GLOBAL partitioning} ]
[physical_attributes_clause] [{LOGGING | NOLOGGING}] [ONLINE]
[COMPUTE STATISTICS] [{TABLESPACE tablespace_name | DEFAULT}]
[{COMPRESS int | NOCOMPRESS}] [{NOSORT | SORT}] [REVERSE]
[{VISIBLE | INVISIBLE}] [{PARALLEL [int] | NOPARALLEL}] }
```

and the syntax for `ALTER INDEX` is:

```
ALTER INDEX index_name
{ {ENABLE | DISABLE} | UNUSABLE | {VISIBLE | INVISIBLE} |
   RENAME TO new_index_name | COALESCE |
   [NO]MONITORING USAGE | UPDATE BLOCK REFERENCES |
   PARAMETERS ('ODCI_params') | alter_index_partitioning_clause |
   rebuild_clause |
      [DEALLOCATE UNUSED [KEEP int [K | M | G | T]]]
      [ALLOCATE EXTENT ( [SIZE int [K | M | G | T]]
      [DATAFILE 'filename']
         [INSTANCE int] )]
      [SHRINK SPACE [COMPACT] [CASCADE]]
      [{PARALLEL [int] | NOPARALLEL}]
      [{LOGGING | NOLOGGING}]
      [physical_attributes_clause] }
```

where the non-SQL-standard clauses are:

`BITMAP`
: Creates an index bitmap for each index value, rather than indexing each individual row. Bitmaps are best for low-concurrency tables (e.g., read-intensive tables). Bitmap indexes are incompatible with global partitioned indexes, the `INDEXTYPE` clause, and index-organized tables without a mapping table association.

`ASC | DESC`
: Specifies that the values in the index be stored in either ascending (`ASC`) or descending (`DESC`) order. When `ASC` or `DESC` is omitted, `ASC` is used by default.

However, be aware that Oracle treats DESC indexes as function-based indexes, so there is some difference in functionality between the two. You may not use ASC or DESC when you are using the INDEXTYPE clause. DESC is ignored on bitmap indexes.

INDEXTYPE IS *index_type* [PARAMETERS ('*values*')]
: Creates an index on a user-defined type of *index_type*. Domain indexes require that the user-defined type already exists. If the user-defined type requires arguments, pass them in using the optional PARAMETERS clause. You may also optionally parallelize the creation of the type index using the PARALLEL clause (explained in more detail later in this list).

CLUSTER *cluster_name*
: Declares a clustering index based on the specified preexisting *cluster_name*. On Oracle, a clustering index physically colocates two tables that are frequently queried on the same columns, usually a primary key and a foreign key. (Clusters are created with the Oracle-specific command CREATE CLUSTER.) You do not declare a table or columns on a CLUSTER index, since both the tables involved and the columns indexed are already declared with the previously issued CREATE CLUSTER statement.

GLOBAL *partitioning*
: Includes the full syntax:

```
GLOBAL PARTITION BY
   {RANGE (column_list) ( PARTITION [partition_name] VALUE LESS THAN
      (value_list) [physical_attributes_clause]
      [TABLESPACE tablespace_name] [LOGGING | NOLOGGING][, ...] )} |
   {HASH (column_list) ( PARTITION [partition_name] )
      {[TABLESPACE tablespace_name] [[OVERFLOW] TABLESPACE
         tablespace_name] [VARRAY varray_name STORE AS LOB
            lob_segment_name] [LOB (lob_name) STORE AS
            [lob_segment_name]]
         [TABLESPACE tablespace_name]} |
      [STORE IN (tablespace_name[, ...])] [OVERFLOW STORE IN
         (tablespace_name[,...])]}[, ...]
```

The GLOBAL PARTITION clause declares that the global index is manually partitioned via either range or hash partitioning onto *partition_name*. (The default is to partition the index equally in the same way the underlying table is partitioned, if at all.) You can specify a maximum of 32 columns, though none may be ROWID. You may also apply the [NO]LOGGING clause, the TABLESPACE clause, and the *physical_attributes_clause* (defined earlier) to a specific partition. You cannot partition on ROWID. You may include one or more partitions, along with any attributes, in a comma-delimited list, according to the following:

RANGE
: Creates a range-partitioned global index based on the range of values from the table columns listed in the *column_list*.

`VALUE LESS THAN (`*`value_list`*`)`
: Sets an upper bound for the current partition of the global index. The values in the *`value_list`* correspond to the columns in the *`column_list`*, both of which are comma-delimited lists of columns. Both lists are prefix-dependent, meaning that for a table with columns *a*, *b*, and *c*, you could define partitioning on (*a*, *b*) or (*a*, *b*, *c*), but not (*b*, *c*). The last value in the list should always be the keyword `MAXVALUE`.

`HASH`
: Creates a hash-partitioned global index, assigning rows in the index to each partition based on a hash function of the values of the columns in the *`column_list`*. You may specify the exact tablespace to store special database objects such as `VARRAY`s and `LOB`s, and for any `OVERFLOW` of the specified (or default) tablespaces.

`LOCAL` *`partitioning`*

Supports local index partitioning on *range*-partitioned indexes, *list*-partitioned indexes, *hash*-partitioned indexes, and *composite*-partitioned indexes. You may include zero or more partitions, along with any attributes, in a comma-delimited list. When this clause is omitted, Oracle generates one or more partitions consistent with those of the table partition. Index partitioning is done in one of three ways:

Range- and list-partitioned indexes

Applied to regular or equipartitioned tables. Range- and list-partitioned indexes (synonyms for the same concept) follow the syntax:

```
LOCAL [ (PARTITION [partition_name]
  { [physical_attributes_clause] [TABLESPACE tablespace_name]
    [LOGGING | NOLOGGING] |
    [COMPRESS | NOCOMPRESS] }[, ...]) ]
```

All of the options are the same as for `GLOBAL PARTITION` (see earlier), except that the scope is for a local index.

Hash-partitioned indexes

Applied to hash-partitioned tables. Hash-partitioned indexes allow you to choose between the earlier syntax and the following optional syntax:

```
LOCAL {STORE IN (tablespace_name[, ...]) |
    (PARTITION [partition_name] [TABLESPACE tablespace_name])}
```

to store the index partition on a specific tablespace. When you supply more tablespace names than index partitions, Oracle will cycle through the tablespaces when it partitions the data.

Composite-partitioned indexes

Applied to composite-partitioned tables, using the following syntax:

```
LOCAL [STORE IN (tablespace_name[, ...])]
PARTITION [partition_name]
   {[physical_attributes_clause] [TABLESPACE tablespace_name]
```

```
            [LOGGING | NOLOGGING] |
            [COMPRESS | NOCOMPRESS]}
               [ {STORE IN (tablespace_name[, ...]) |
               (SUBPARTITION [subpartition_name]
               [TABLESPACE tablespace_name])} ]
```

You may use the `LOCAL STORE` clause shown under the hash-partitioned indexes entry, or the `LOCAL` clause shown under the range- and list-partitioned indexes entry. (When using the `LOCAL` clause, substitute the keyword `SUBPARTITION` for `PARTITION`.)

`physical_attributes_clause`

Establishes values for one or more of the following settings: `PCTFREE` *`int`*, `PCTUSED` *`int`*, and `INITRANS` *`int`*. When this clause is omitted, Oracle defaults to `PCTFREE 10`, `PCTUSED 40`, and `INITRANS 2`.

`PCTFREE` *`int`*

Designates the percentage of free space to leave in each block of the index as it is created. This speeds up new entries and updates on the table. However, `PCTFREE` is applied only when the index is created, and is not maintained. Therefore, the amount of free space can erode over time as records are inserted, updated, and deleted from the index. This clause is not allowed on index-organized tables.

`PCTUSED` *`int`*

Designates the minimum percentage of used space to be maintained in each data block. A block becomes available to row insertions when its used space falls below the value specified for `PCTUSED`. The default is 40. The sum of `PCTFREE` and `PCTUSED` must be equal to or less than 100.

`INITRANS` *`int`*

Designates the initial number of concurrent transactions allocated to each data block of the database. The value may range from 1 to 255.

In versions prior to 11*g* the `MAXTRANS` parameter was used to define the maximum allowed number of concurrent transactions on a data block, but this parameter has now been deprecated. Oracle 11*g* and later automatically set `MAXTRANS` to 255, silently overriding any other value that you specify for this parameter (although existing objects retain their established `MAXTRANS` settings).

`LOGGING | NOLOGGING`

Tells Oracle to log the creation of the index in the redo logfile (`LOGGING`), or not to log it (`NOLOGGING`). This clause also sets the default behavior for subsequent bulk loads using Oracle SQL*Loader. For partitioned indexes, it establishes the default value for all partitions and segments associated with the partitions, and the default used on any partitions or subpartitions added later with an ALTER TABLE ... ADD PARTITION statement. (When using NOLOGGING, we recommend that you take a full backup after the index has been loaded in case the index has to be rebuilt due to a failure.)

ONLINE
: Allows data manipulation on the table while the index is being created. Even with ONLINE, there is a very small window at the end of the index creation operation where the table will be locked while the operation completes. Any changes made to the base table at that time will then be reflected in the newly created index. ONLINE is incompatible with BITMAP, CLUSTER, and PARALLEL clauses. It also cannot be used on indexes on a UROWID column or on index-organized tables with more than 32 columns in their primary keys.

COMPUTE STATISTICS
: Collects statistics while the index is being created, when it can be done with relatively little cost. Otherwise, you will have to collect statistics after the index is created.

TABLESPACE {*tablespace_name* | DEFAULT}
: Assigns the index to a specific tablespace. When omitted, the index is placed in the default tablespace. You can also use the DEFAULT keyword to explicitly place an index into the default tablespace. When local partitioned indexes are placed in TABLESPACE DEFAULT, the index partition (or subpartition) is placed in the corresponding tablespace of the base table partition (or subpartition).

COMPRESS [*int*] | NOCOMPRESS
: Enables or disables key compression, respectively. Compression eliminates repeated occurrences of key column values, yielding substantial space savings at the cost of speed. The integer value *int* defines the number of prefix keys to compress. The value can range from 1 to the number of columns in the index for nonunique indexes, and from 1 to *n*–1 columns for unique indexes. The default is NOCOMPRESS, but if you specify COMPRESS without an *int* value, the default is COMPRESS *n* (for nonunique indexes) or COMPRESS *n*–1 (for unique indexes), where *n* is the number of columns in the index. COMPRESS can only be used on nonpartitioned and nonbitmapped indexes.

NOSORT | REVERSE
: NOSORT allows an index to be created quickly for a column that is already sorted in ascending order. If the values of the column are not in perfect ascending order, the operation aborts, allowing a retry without the NOSORT option. REVERSE, by contrast, places the index blocks in storage in reverse order (excluding ROWID). REVERSE is mutually exclusive of NOSORT and cannot be used on a bitmap index or an index-organized table. NOSORT is most useful for creating indexes immediately after a base table is loaded with data in presorted order.

`VISIBLE | INVISIBLE`
: Declares whether the index is visible or invisible to the optimizer. Invisible indexes are maintained by DML operations but are not normally used by the optimizer for query performance. This is very useful when you cannot alter an index to disable it, but you really need Oracle to ignore the index.

`PARALLEL [`*`int`*`] | NOPARALLEL`
: Allows the parallel creation of the index using multiple server processes, each operating on a distinct subset of the index, to speed up the operation. An optional integer value, *`int`*, may be supplied to define the exact number of parallel threads used in the operation. When omitted, Oracle calculates the number of parallel threads to use. `NOPARALLEL`, the default, causes the index to be created serially.

`ENABLE | DISABLE`
: Enables or disables a preexisting function-based index, respectively. You cannot specify any other clauses of the `ALTER INDEX` statement with `ENABLE` or `DISABLE`.

`UNUSABLE`
: Marks the index (or index partition or subpartition) as unusable. When `UNUSABLE`, an index (or index partition or subpartition) may only be rebuilt or dropped and re-created before it can be used.

`RENAME TO` *`new_index_name`*
: Renames the index from *`index_name`* to *`new_index_name`*.

`COALESCE`
: Merges the contents of index blocks used to maintain the index-organized table so that the blocks can be reused. `COALESCE` is similar to `SHRINK`, though `COALESCE` compacts the segments less densely than `SHRINK` and does not release unused space.

`[NO]MONITORING USAGE`
: Declares that Oracle should clear existing information on index usage and monitor the index, posting information in the `V$OBJECT_USAGE` dynamic performance view, until `ALTER INDEX ... NOMONITORING USAGE` is executed. The `NOMONITORING USAGE` clause explicitly disables this behavior.

`UPDATE BLOCK REFERENCES`
: Updates all stale guess data block addresses stored as part of the index row on normal or domain indexes of an index-organized table. The guess data blocks contain the correct database addresses for the corresponding blocks identified by the primary key. This clause cannot be used with other clauses of the `ALTER INDEX` statement.

`PARAMETERS ('`*`ODCI_params`*`')`
: Specifies a parameter string passed, without interpretation, to the Oracle Data Cartridge Interface (ODCI) indextype routine of a domain index. The parameter string, called `'`*`ODCI_params`*`'`, may be up to 1,000 characters long. Refer to the vendor documentation for more information on ODCI parameter strings.

`alter_index_partitioning_clause`
: Modifies the index partitions. Refer to the vendor documentation for more details.

`rebuild_clause`
: Rebuilds the index, or a specific partition (or subpartition) of the index. A successful rebuild marks an `UNUSABLE` index as `USABLE`. The syntax for the *`rebuild_clause`* is:

```
REBUILD {[NO]REVERSE | [SUB]PARTITION partn_name}
   [{PARALLEL [int] | NOPARALLEL}] [TABLESPACE tablespace_name]
   [PARAMETERS ('ODCI_params')] [ONLINE] [COMPUTE STATISTICS]
   [COMPRESS int | NOCOMPRESS] [[NO]LOGGING]
   [physical_attributes_clause]
```

where:

`[NO]REVERSE`
: Stores the bytes of the index blocks in reverse order and excludes rows when the index is rebuilt (`REVERSE`), or stores the bytes of the index blocks in regular order (`NOREVERSE`).

`DEALLOCATE UNUSED [KEEP >`*`int`*` [K | M | G | T]]`
: Deallocates unused space at the end of the index (or at the end of each range or hash partition of a partitioned index) and frees the space for other segments in the tablespace. The optional `KEEP` keyword defines how many bytes (*`int`*) above the high-water mark the index will keep after deallocation. You can append a suffix to the *`int`* value to indicate that the value is expressed in kilobytes (`K`), megabytes (`M`), gigabytes (`G`), or terabytes (`T`). When the `KEEP` clause is omitted, all unused space is freed.

`ALLOCATE EXTENT ( [SIZE `*`int`*` [K | M | G | T]] [DATAFILE '`*`filename`*`'] [INSTANCE `*`int`*`] )`
: Explicitly allocates a new extent for the index using the specified parameters. You may mix and match any of the parameters. `SIZE` specifies the size of the next extent, in bytes (no suffix), kilobytes (`K`), megabytes (`M`), gigabytes (`G`), or terabytes (`T`). `DATAFILE` allocates an entirely new datafile to the index extent. `INSTANCE`, used only on Oracle RACs, makes a new extent available to a freelist group associated with the specified instance.

`SHRINK SPACE [COMPACT] [CASCADE]`
: Shrinks the index segments, though only segments in tablespaces with automatic segment management may be shrunk. Shrinking a segment moves rows

in the table, so make sure ENABLE ROW MOVEMENT is also used in the ALTER TABLE ... SHRINK statement. Oracle compacts the segment, releases the emptied space, and adjusts the high-water mark, unless the optional keywords COMPACT and/or CASCADE are applied. The COMPACT keyword only defragments the segment space and compacts the index; it does not readjust the high-water mark or empty the space immediately. The CASCADE keyword performs the same shrinking operation (with some restrictions and exceptions) on all dependent objects of the index. The statement ALTER INDEX ... SHRINK SPACE COMPACT is functionally equivalent to ALTER INDEX ... COALESCE.

By default, Oracle indexes are nonunique. It is also important to know that Oracle's regular B-tree indexes do not include records that have a NULL key value.

Oracle does not support indexes on columns with the following data types: LONG, LONG RAW, REF (with the SCOPE attribute), or any user-defined data type. You may create indexes on functions and expressions, but they cannot allow NULL values or aggregate functions. When you create an index on a function, if it has no parameters the function should show an empty set (for example, *function_name()*). If the function is a user-defined function (UDF), it must be DETERMINISTIC.

Oracle supports a special index structure called an *index-organized table* (IOT) that combines the table data and primary key index in a single physical structure, instead of having separate structures for the table and the index. IOTs are created using the CREATE TABLE ... ORGANIZATION INDEX statement. Refer to "CREATE/ALTER TABLE Statement" on page 140 for more information on making an IOT.

Oracle automatically creates any additional indexes on an IOT as secondary indexes. Secondary indexes do not support the REVERSE clause.

Oracle allows the creation of partitioned indexes and tables with the PARTITION clause. Consequently, Oracle's indexes also support partitioned tables. The LOCAL clause tells Oracle to create separate indexes for each partition of a table. The GLOBAL clause tells Oracle to create a common index for all the partitions.

Note that any time an object name is referenced in the syntax diagram, you may optionally supply the schema. This applies to indexes, tables, etc., but not to tablespaces. You must have the explicitly declared privilege to create an index in a schema other than the current one.

As an example, you can use a statement such as the following to create an Oracle index that is compressed and created in parallel, with compiled statistics, but without logging the creation:

```
CREATE UNIQUE INDEX unq_pub_id ON publishers(pub_name, country)
COMPRESS 1 PARALLEL NOLOGGING COMPUTE STATISTICS;
```

As with other Oracle object creation statements, you can control how much space the index consumes and in what increments it grows. The following example constructs an index in Oracle on a specific tablespace with specific instructions for how the data is to be stored:

```
CREATE UNIQUE INDEX unq_pub_id ON publishers(pub_name, country)
STORAGE (INITIAL 10M NEXT 5M PCTINCREASE 0)
TABLESPACE publishers;
```

For example, when you create the *housing_construction* table as a partitioned table on an Oracle server, you should also create a partitioned index with its own index partitions:

```
CREATE UNIQUE CLUSTERED INDEX project_id_ind
ON housing_construction(project_id)
GLOBAL PARTITION BY RANGE (project_id)
   (PARTITION part1 VALUES LESS THAN ('H')
      TABLESPACE construction_part1_ndx_ts,
   PARTITION part2 VALUES LESS THAN ('P')
      TABLESPACE construction_part2_ndx_ts,
   PARTITION part3 VALUES LESS THAN (MAXVALUE)
      TABLESPACE construction_part3_ndx_ts);
```

If in fact the *housing_construction* table used a composite partition, we could accommodate that here:

```
CREATE UNIQUE CLUSTERED INDEX project_id_ind
ON housing_construction(project_id)
STORAGE (INITIAL 10M MAXEXTENTS UNLIMITED)
LOCAL (PARTITION part1 TABLESPACE construction_part1_ndx_ts,
       PARTITION part2 TABLESPACE construction_part2_ndx_ts
          (SUBPARTITION subpart10, SUBPARTITION subpart20,
           SUBPARTITION subpart30, SUBPARTITION subpart40,
           SUBPARTITION subpart50, SUBPARTITION subpart60),
       PARTITION part3 TABLESPACE construction_part3_ndx_ts);
```

In the following example, we rebuild the *project_id_ind* index that was created earlier by using parallel execution processes to scan the old index and build the new index in reverse order:

```
ALTER INDEX project_id_ind
REBUILD REVERSE PARALLEL;
```

Similarly, we can split out an additional partition on *project_id_ind*:

```
ALTER INDEX project_id_ind
SPLIT PARTITION part3 AT ('S')
INTO (PARTITION part3_a TABLESPACE constr_p3_a LOGGING,
      PARTITION part3_b TABLESPACE constr_p3_b);
```

PostgreSQL

PostgreSQL allows the creation of ascending and descending indexes, as well as `UNIQUE` indexes. Its implementation also includes a performance enhancement under the `USING` clause.

Unlike in most other databases, in PostgreSQL index, unique key, and primary key names have to be unique across a schema, not just the table. PostgreSQL's `CREATE INDEX` syntax is:

```
CREATE [UNIQUE] INDEX [CONCURRENTLY] [IF NOT EXISTS] index_name
ON [ONLY] table_name
[USING method]
( {column_name | expression} [COLLATE collation]
  [opclass [(opclass_parameter = value[, ...])]]
  [ASC | DESC] [NULLS {FIRST | LAST}][, ...] )
[INCLUDE (column_name[, ...])]
[WITH parameter [= value][, ...]]
[TABLESPACE tablespace_name]
[WHERE predicate]
```

and the syntax for ALTER INDEX is:

```
ALTER INDEX
[ [IF EXISTS] index_name
   { RENAME TO new_index_name |
     SET TABLESPACE new_tablespace_name |
     SET parameter [= value][, ...] |
     RESET parameter[, ...] |
     ALTER [COLUMN] column_number SET STATISTICS int } ]
| index_name ATTACH PARTITION index_to_attach
| index_name [NO] DEPENDS ON EXTENSION extension
| ALL IN TABLESPACE index_name [OWNED BY role[, ...]]
   SET TABLESPACE tablespace_name [NOWAIT]
```

where:

`CONCURRENTLY`
: Builds the index without acquiring any locks that would prevent concurrent inserts, updates, or deletes on the table. Normally, PostgreSQL locks the table to writes (but *not* reads) until the operation completes.

`IF NOT EXISTS`
: Causes a notice to be issued instead of an error if a relation with the specified name already exists.

`ONLY`
: Avoids recursion when creating indexes on partitions. The default is to recurse.

`USING` *`method`*
: Specifies one of several dynamic access methods to optimize performance. When no *`method`* is specified, it defaults to `BTREE`. The *`method`* options are as follows:

  `BRIN`
  : Block Range INdexes (BRINs) are used for indexing a block of pages in a B-tree-like format. BRIN is a lossy format typically used for indexing large-scale data, such as instrumentation data, that is usually queried in contiguous blocks. It takes up much less space than a B-tree index, but performs worse for most queries and supports fewer operators.

`BTREE`
: Uses Lehman and Yao's high-concurrency B-tree structures to optimize the index. This is the default method when no other is specified. B-tree indexes can be invoked for comparisons using =, <, <=, >, and >=. B-tree indexes can be multi-column.

`GIST`
: Generalized Index Search Tree (GiST) is an index type used for geospatial, JSON, hierarchical tree (`ltree` type), full text search, and HStore (a key/value store) indexes. It is lossy and as such generally requires a recheck step against the real data to throw out false positives from the index check.

`GIN`
: Generalized INverted (GIN) indexes are used for JSON, full text search, and fuzzy text or regular expression search. A GIN index is lossless, which means the data in the index is the same as the actual data, and thus can be used as a covering index.

`HASH`
: Uses Litwin's linear hashing algorithm to optimize the index. Hash indexes can be invoked for comparisons using =. Hash indexes must be single-column indexes.

`SPGIST`
: Space-Partitioned Generalized Index Search Tree (SP-GiSTs) is an index type generally used for geospatial and textural data.

`column_name | expression`
: Defines one or more columns in the table or a function call involving one or more columns of a table, rather than just a column from the base table, as the basis of the index values. The function used in a function-based index must be immutable. If you use a user-defined function and change its underlying definition in a way that results in value changes, you should reindex your table to prevent erroneous query results. You can optionally specify the collation and sort order, and the name of an operator class with optional parameters for each column.

`INCLUDE =` *`column_name[, ... ]`*
: Defines an additional list of columns to include data for. These columns are almost never part of the index. You use `INCLUDE` mostly to ensure that you'll be able to use the index as a covering index. For example, you might create a primary key or unique index on *au_id*, then `INCLUDE(au_lname, au_fname)`. You can't include these in the primary key definition because you need *au_id* to be treated as unique; however, if many of your queries involve *au_id*, *au_lname*, and *au_fname*, they can then use this index as a covering index and not have to check the table.

`WITH` *`parameter`* `[=` *`value`*`][, ... ]`
: Specifies default storage parameters for the index. B-tree, hash, GiST, and SP-GiST indexes accept the *fillfactor* parameter, which defines a percentage for PostgreSQL to fill each index page during the creation process. For B-tree indexes, this applies during the initial index creation process and when extending the index. The default is 90. PostgreSQL does not maintain the fill factor over time, so it is advisable to rebuild the index at regular intervals to avoid excessive fragmentation and page splits. B-tree indexes additionally accept the Boolean *deduplicate_items* parameter.

`TABLESPACE` *`tablespace_name`*
: Defines the tablespace where the index is created.

`WHERE` *`predicate`*
: Defines a `WHERE` clause search condition, which is then used to generate a partial index. A partial index contains entries for a select set of records in the table, not all records. You can get some interesting effects from this clause. For example, you can pair `UNIQUE` and `WHERE` to enforce uniqueness for a subset of the table rather than for the whole table. The `WHERE` clause must:

  - Reference columns in the base table (though they need not be columns of the index itself)
  - Reference expressions that involve immutable functions and columns in the base table
  - Not make use of aggregate functions
  - Not use subqueries

`RENAME TO` *`new_index_name`*
: Changes the name of the index.

`SET TABLESPACE` *`new_tablespace_name`* `| ALL IN TABLESPACE` *`index_name`*
`[OWNED BY role [, ... ]] SET TABLESPACE` *`tablespace_name`* `[NOWAIT]`
: Sets the index's tablespace to the specified tablespace and moves any data files associated with it to the new tablespace. The `ALL IN TABLESPACE` form allows you to move all indexes in the specified tablespace, or (with `OWNED BY`) only those indexes owned by the named roles. The indexes are locked before moving; `NOWAIT` causes the operation to fail if all of the required locks cannot be acquired.

`[SET` *`parameter`*`[ =` *`value`*`][, ... ] | RESET` *`parameter`*`[, ... ]`
: Allows you to alter the storage parameters of an existing index or, with `RESET`, reset them to their defaults. The available parameters are dependent on the indexing method. We recommend that you rebuild the index with the `REINDEX` command after issuing either of these commands because changes do not immediately take effect.

`ALTER [COLUMN]` *`column_number`* `SET STATISTICS` *`int`*
: Defines the per-column statistics-gathering target for subsequent `ANALYZE` operations. This form can be used only on index columns that are defined as an expression.

`ATTACH PARTITION`
: Attaches the named index to the index being altered.

`[NO] DEPENDS ON EXTENSION`
: Indicates that the index is dependent on (or no longer dependent on, with `NO`) the named extension. An index that's marked as dependent on an extension is automatically dropped when the extension is dropped.

`ALL IN TABLESPACE index_name [OWNED BY role[, ... ]] SET TABLESPACE tablespace_name [NOWAIT]`
: Sets the index's tablespace to the specified tablespace and moves any data files associated with it to the new tablespace.

Operator classes. In PostgreSQL, a column may have an associated operator class (*opclass*) based on the type of index and data type of the column. An operator class specifies the allowed operators for a particular index. Although users are free to define any valid operator class for a given column, there is a default opclass defined for each column type and index which is used when no opclass is specified.

In the following example, we create an index using the `BTREE` index type on the *pub_name* column, lowercased, and make sure that uniqueness is enforced only for publishers outside the US:

```
CREATE UNIQUE INDEX unq_pub_id
    ON publishers(lower(pub_name), lower(country) )
USING BTREE
WHERE country <> 'USA';
```

The default `BTREE` index opclass does not support `LIKE` operations. To support `LIKE`, you'd use the *varchar_pattern_ops* operator class as follows:

```
CREATE INDEX ix_authors_name_bpat
   ON authors USING btree
   (au_lname varchar_pattern_ops, au_fname varchar_pattern_ops );
```

The *ix_authors_name_bpat* index we just created will take care of expressions like:

```
 au_lname LIKE 'John%' AND au_fname LIKE 'Rich%'
```

However, it won't work for `ILIKE` or for `LIKE` phrases where there is a wildcard at the beginning, such as the following:

```
au_lname LIKE '%John%' AND au_fname LIKE '%Rich%'
```

The index to use to speed up these queries is known as a *trigram GIN index*. Using a trigram index requires first installing an extension (generally shipped with PostgreSQL) in your database, as follows:

```
CREATE EXTENSION pg_trgm;
```

pg_trgm is an extension for fuzzy text matching that includes many functions we will not be covering here. It also includes the operator class `gin_trgm_ops`, which is an opclass for the GIN index type. Once you have this extension installed, you can create an index as follows:

```
CREATE INDEX ix_authors_name_gin_trgm
   ON authors USING gin
   (au_lname gin_trgm_ops, au_fname gin_trgm_ops );
```

This new index will then be used to speed up ILIKE searches, regex searches, and LIKE searches where the wildcard is at the front.

Here is an example that uses `INCLUDE` to include commonly used columns with the primary key:

```
CREATE UNIQUE INDEX ux_author_id
   ON authors USING btree
   (au_id) INCLUDE(au_lname, au_fname);
```

PostgreSQL index and table statistics are kept up to date by a daemon process called *autovacuum* that analyzes and cleans up deleted data. After creating an index or adding a bulk load of data, you can force updating of table statistics using the `ANALYZE` command, as follows:

```
ANALYZE authors;
```

In addition, PostgreSQL has a `CREATE STATISTICS` statement that's useful for creating compound column statistics for columns where you know the data is correlated. For example, you might create a statistic on *state* and *city*, since these columns are highly correlated. Refer to the documentation for details.

SQL Server

For much of SQL Server's existence it has supported a single architecture for indexes, the *rowstore index*, using a B-tree algorithm. (Technically, the algorithm is called *B-tree K+*). In more recent versions, the platform added a new architecture for indexes made popular in big data applications called a *columnstore index,* for tables containing many millions or billions of records. All officially supported versions of SQL Server also support two additional types of indexes, XML indexes and spatial indexes, which we will discuss later in this section.

SQL Server's `CREATE INDEX` syntax is:

```
CREATE [UNIQUE] [[NON]CLUSTERED] INDEX index_name
ON {table_name | view_name} (column [ASC | DESC][, ...])
[INCLUDE (column [ASC | DESC][, ...])]
[WHERE index_filter_predicate]
[WITH [PAD_INDEX = {ON | OFF}] [FILLFACTOR = int]
      [IGNORE_DUP_KEY = {ON | OFF}]
      [STATISTICS_NORECOMPUTE = {ON | OFF}]
      [STATISTICS_INCREMENTAL = {ON | OFF}]
      [DROP_EXISTING = {ON | OFF}] [RESUMABLE = {ON | OFF}]
      [ONLINE = {ON | OFF}] [SORT_IN_TEMPDB = {ON | OFF}]
      [ALLOW_ROW_LOCKS = {ON | OFF}] [ALLOW_PAGE_LOCKS = {ON | OFF}]
      [MAXDOP = int] [MAX_DURATION = time [MINUTES] ]
      [DATA_COMPRESSION = {NONE | ROW | PAGE}]
      [ON PARTITIONS ( {partition_number | partition_range}]
      [, ...]]
[ON {filegroup | partition (column) | DEFAULT}]
[FILESTREAM_ON {filestream_filegroup_name | prtn | "NULL"}]
;
```

and the syntax for ALTER INDEX is:

```
ALTER INDEX {index_name | ALL} ON {object_name}
{ DISABLE |
   REBUILD [PARTITION = prtn_nbr]
      [WITH ( [ SORT_IN_TEMPDB = {ON | OFF} ][MAXDOP = int][, ...] )]
      [WITH [PAD_INDEX = {ON | OFF}][FILLFACTOR = int]
            [IGNORE_DUP_KEY = {ON | OFF}]
            [STATISTICS_NORECOMPUTE = {ON | OFF}]
            [SORT_IN_TEMPDB = {ON | OFF}]
            [ALLOW_ROW_LOCKS = {ON | OFF}]
            [ALLOW_PAGE_LOCKS = {ON | OFF}]
            [MAXDOP = int][, ...]] |
   REORGANIZE [PARTITION = prtn_nbr]
      [WITH (LOB_COMPACTION = {ON | OFF})] |
   SET [ALLOW_ROW_LOCKS = {ON | OFF}]
       [ALLOW_PAGE_LOCKS = {ON | OFF}]
       [IGNORE_DUP_KEY = {ON | OFF}]
       [STATISTICS_NORECOMPUTE = {ON | OFF}][, ...] }
;
```

where:

`[NON]CLUSTERED`
: Controls the physical ordering of data for the table using either a `CLUSTERED` or a `NONCLUSTERED` index. The columns of a clustered index determine the order in which the records of the table are physically written. Thus, if you create an ascending clustered index on column *a* of table *foo*, the records will be written to disk in ascending alphabetical order. The `NONCLUSTERED` clause (the default when a value is omitted) creates a secondary index containing only pointers and has no impact on how the actual rows of the table are written to disk.

`ASC | DESC`
: Specifies that the values in the index be kept in either ascending (`ASC`) or descending (`DESC`) order. When `ASC` or `DESC` is omitted, `ASC` is used by default.

`INCLUDE (column[, ...n] )`
: Specifies one or more nonkey columns to add to the leaf level of a nonclustered index. This subclause is useful to improve performance by avoiding key lookup execution plan operators. Although this technique initially appears to

be a method of creating a covering index—that is, an index whose columns retrieve all of the data requested by a query, thereby reducing I/O operations and improving performance—it is not truly a covering index. This is because included columns are not used to improve index cardinality or selectivity.

There are several restrictions on which nonkey columns may be added as included columns. Refer to the vendor documentation for additional details.

`WHERE` *`index_filter_predicate`*
: Allows the specification of one or more optional attributes for the index.

`WITH`
: Allows the specification of one or more optional attributes for the index.

`PAD_INDEX = {ON | OFF}`
: Specifies that space should be left open on each 8 KB index page, according to the value established by the `FILLFACTOR` setting.

`FILLFACTOR =` *`int`*
: Declares a percentage value, *`int`*, from 1 to 100 that tells SQL Server how much of each 8 KB data page should be filled at the time the index is created. This is useful to reduce I/O contention and page splits when a data page fills up. Creating a clustered index with an explicitly defined fill factor can increase the size of the index, but it can also speed up processing in certain circumstances.

`IGNORE_DUP_KEY = {ON | OFF}`
: Controls what happens when a duplicate record is placed into a unique index through an insert or update operation. If this value is set for a column, only the duplicate row is excluded from the operation. If this value is not set, all records in the operation (even nonduplicate records) are rejected as duplicates.

`DROP_EXISTING = {ON | OFF}`
: Drops any preexisting indexes on the table and rebuilds the specified index.

`STATISTICS_NORECOMPUTE = {ON | OFF}`
: Stops SQL Server from recomputing index statistics. This can speed up the `CREATE INDEX` operation, but it may mean that the index is less effective.

`ONLINE = {ON | OFF}`
: Specifies whether underlying tables and associated indexes are available for queries and data manipulation statements during the index operation. The default is `OFF`. When set to `ON`, long-term write locks are not held, only shared locks.

`SORT_IN_TEMPDB = {ON | OFF}`
: Stores any intermediate results used to build the index in the system database *tempdb*. This increases the space needed to create the index, but it

can speed up processing if *tempdb* is on a different disk than the table and index.

`ALLOW_ROW_LOCKS = {ON | OFF}`
: Specifies whether row locks are allowed. When omitted, the default is `ON`.

`ALLOW_PAGE_LOCKS = {ON | OFF}`
: Specifies whether page locks are allowed. When omitted, the default is `ON`.

`MAXDOP = `*`int`*
: Specifies the maximum degrees of parallelism for the duration of the indexing operation. A value of 1 suppresses parallelism, and a value greater than 1 restricts the operation to the number of processors specified. A value of 0, the default, allows SQL Server to choose up to the actual number of processors on the system.

`ON `*`filegroup`*
: Creates the index on a given preexisting filegroup. This enables the placing of indexes on a specific hard disk or RAID device. Issuing a `CREATE CLUSTERED INDEX ... ON FILEGROUP` statement effectively moves a table to the new filegroup since the leaf level of the clustered index is the same as the actual data pages of the table.

`DISABLE`
: Disables the index, making it unavailable for use in query execution plans. Disabled nonclustered indexes do not retain underlying data in the index pages. Disabling a clustered index makes the underlying table unavailable to user access. You can reenable an index with `ALTER INDEX REBUILD` or `CREATE INDEX WITH DROP_EXISTING`.

`REBUILD [PARTITION = `*`prtn_nbr`*`]`
: Rebuilds an index using the preexisting properties, including columns in the index, index type, uniqueness attributes, and sort order. You may optionally specify a new partition. This clause will *not* automatically rebuild associated nonclustered indexes unless you include the keyword `ALL`. When using this clause to rebuild an XML or spatial index, you may not also use the `ONLINE = ON` or `IGNORE_DUP_KEY = ON` clauses. Equivalent to `DBCC DBREINDEX`.

`REORGANIZE [PARTITION = `*`prtn_nbr`*`]`
: Performs an online reorganization of the leaf level of the index (i.e., no long-term blocking table locks are held and queries and updates to the underlying table can continue). You may optionally specify a new partition. Not allowed with `ALLOW_PAGE_LOCKS = OFF`. Equivalent to `DBCC INDEXDEFRAG`.

`WITH (LOB_COMPACTION = {ON | OFF})`
: Compacts all pages containing `LOB` data types, including `IMAGE`, `TEXT`, `NTEXT`, `VARCHAR(MAX)`, `NVARCHAR(MAX)`, `VARBINARY(MAX)`, and `XML`. When omitted, the

default is `ON`. The clause is ignored if no `LOB` columns are present. When `ALL` is specified, all indexes associated with the table or view are reorganized.

`SET`
: Specifies index options without rebuilding or reorganizing the index. `SET` cannot be used on a disabled index.

SQL Server allows up to 249 nonclustered indexes (unique or nonunique) on a table, as well as one primary key index. Index columns may not be of the data types `NTEXT`, `TEXT`, or `IMAGE`.

SQL Server automatically parallelizes the creation of the index according to the configuration option *max degree of parallelism* `(MAXDOP)`.

It is often necessary to build indexes that span several columns—i.e., with a *concatenated key*. Concatenated keys may contain up to 16 columns and/or a total of 900 bytes across all fixed-length columns. Here is an example:

```
CREATE UNIQUE INDEX project2_ind
ON housing_construction(project_name, project_date)
WITH PAD_INDEX, FILLFACTOR = 80
ON FILEGROUP housing_fg
GO;
```

Adding the `PAD_INDEX` clause and setting the `FILLFACTOR` to 80 tells SQL Server to leave the index and data pages 80% full, rather than 100% full. This example also tells SQL Server to create the index on the *housing_fg* filegroup, rather than the default filegroup.

Note that SQL Server allows the creation of a unique clustered index on a view, effectively materializing the view. This can greatly speed up data retrieval operations against the view. Once a view has a unique clustered index, nonclustered indexes can be added to the view. Note that the view also must be created using the `SCHEMA BINDING` option. Indexed views support data retrieval, but not data modification.

Columnstore indexes. SQL Server has supported columnstore indexes since the 2014 release, with subsequent releases further increasing their usability and manageability. Azure SQL Database supports all syntax for columnstore indexes, while only certain versions of on-premises SQL Server do. Columnstore indexes, in comparison to old-fashioned rowstore indexes, are much more effective for storing and querying massive tables, such as those commonly found in large data warehouses. Columnstore indexes feature their own form of data compression which, when combined with specific optimizer improvements for large batch processing, can yield 10x to 20x performance improvements over standard rowstore indexes. (Note that you should not use columnstore indexes on tables with less than several million rows.)

Columnstore indexes are complex, with many limitations, restrictions, prerequisites, and best practices for optimal usage and maintenance. Features and requirements vary widely across versions that support these indexes, with support for all features reaching maturity with SQL Server 2016. As an example of this heightened complexity, you cannot change the structure of a columnstore index using the `ALTER INDEX` statement or the `CREATE OR ALTER` syntax allowed for other SQL Server DML statements. (However, you can use `ALTER INDEX` to change a property of a columnstore index, such as to enable or disable the index.) Instead, to effect a change in a columnstore index you must either `DROP` then re-create it, or use the syntax `CREATE … WITH (DROP_EXISTING = ON)`.

The syntax to create a columnstore index is rather simple:

```
-- Columnstore index syntax
CREATE [[NON]CLUSTERED] COLUMNSTORE INDEX index_name
ON table_name [(column[,...])]
[WHERE index_filter_predicate]
[WITH (option[,...n])]
[ORDER (column[, ...])]
[ON {filegroup | partition (column) | DEFAULT}]
;
```

You are strongly encouraged to refer to the vendor documentation for extensive details on the underlying principles and concepts. Filtered indexes are only allowed for nonclustered columnstore indexes. Columnstore indexes may be created on heaps, on tables with rowstore indexes, and on *In_Memory* tables. The `ORDER` subclause is only used when creating clustered columnstore indexes on Azure Synapse Analytics data warehouses.

The arguments allowed for a columnstore index are as follows:

`ON` *`table_name`* `[ (`*`column`*`[, ... ] ) ]`
: When specifying a clustered columnstore index, only the *`table_name`* is needed. The *`table_name`* may use the one-, two-, or three-part naming convention `[<`*`database_name`*`>.[<`*`schema_name`*`>.]<`*`table_name`*`>`. When specifying a nonclustered columnstore index, you may declare up to 1,024 columns within it, assuming the columns are supportable data types.

`WITH` *`option`*
: Allows one or more options of the same functionality as the options for a regular index, but limited to `DROP_EXISTING`, `ONLINE`, `MAXDOP`, `COMPRESSION_DELAY`, and `DATA_COMPRESSION`. Unless otherwise noted, the options are defined in the same way as with rowstore indexes, with these exceptions:

  `COMPRESSION_DELAY = { 0 | delay | M[inutes] }`
  : Specifies an integer value for the minimum number of minutes that newly inserted or changed rows, also known as a *delta rowgroup*, must remain in the `CLOSED` state before it will be compressed into a columnstore rowgroup. The default is 0 minutes.

`DATA_COMPRESSION = { COLUMNSTORE | COLUMNSTORE_ARCHIVE }`
: Specifies the compression option for the table, offering a trade-off between speed and cost. The parameter accepts either a value of `COLUMNSTORE` (the default option, most useful for data that is actively used to answer queries) or `COLUMNSTORE_ARCHIVE` (offering maximal compression and thus requiring minimal storage, most useful for rarely used data that allows for slower retrieval).

XML indexes. SQL Server supports the creation of XML indexes and spatial indexes (discussed in the following section) on specified tables within a SQL Server database. These extended indexes are created on columns of the `XML` data type and spatial data types (such as `GEOMETRY` and `GEOGRAPHY`), respectively. The syntax for XML index creation is:

```
-- XML index syntax
CREATE [PRIMARY] XML INDEX index_name
ON table_name (xml_column_name)
[USING XML INDEX xml_index_name
  [FOR { VALUE | PATH | PROPERTY }]]
[WITH (option[,...n])]
;
```

XML indexes can only be created upon a single `XML` column in a user table, with a maximum of one primary XML index and possibly many secondary XML indexes based upon the primary XML index. The user table must also have a primary key that acts as the clustered index, with no more than 15 columns. As for columnstore indexes, the *`table_name`* may use the one-, two-, or three-part naming convention [<*`database_name`*>.[<*`schema_name`*>.]<*`table_name`*>.

Here are a few notes on the arguments for `CREATE XML INDEX`:

`PRIMARY`
: When specified, a clustered index is created based upon the user table's clustered index plus an XML node identifier. Each table can have up to 249 XML indexes.

`USING XML INDEX`
: When specified, identifies the primary XML index used to create a secondary XML index. The secondary index may be further categorized as:

  `FOR VALUE`
  : Specifies a secondary XML index on columns where the key columns are, ordinally, the node value and path of the primary XML index

  `FOR PATH`
  : Specifies a secondary XML index on columns using, ordinally, the path values and node values that are key columns to facilitate efficient seek operations when searching for paths

`FOR PROPERTY`
: Specifies a secondary XML index on columns using, ordinally, the primary key of the user table, path value, and node value to facilitate efficient seek operations when searching for paths

`WITH` *`option`*
: Allows one or more options of the same functionality as the options for a regular index, but limited to `PAD_INDEX`, `FILLFACTOR`, `SORT_IN_TEMPDB`, `IGNORE_DUP_KEY`, `DROP_EXISTING`, `ONLINE`, `ALLOW_ROW_LOCKS`, `ALLOW_PAGE_LOCKS`, and `MAXDOP`.

Spatial indexes. Spatial indexes are built using B-tree structures, so they can effectively represent two-dimensional spatial data in a linear and ordered B-tree. Consequently, SQL Server must hierarchically "decompose" the defined space into a four-level grid hierarchy of increasing granularity, from *level_1* (the top and least granular level) through *level_4* (the most granular level). Each level of the grid hierarchy is composed of an equal number of cells of equal size along the x- and y-axes (say, 4 × 4 or 8 × 8).

The number of cells per axis is called its *density* and is a measurement that is independent of the actual unit of measurement applied to each cell. For example, a spatial index containing four levels of a 4 × 4 grid hierarchy decomposes into a space of 65,536 *level_4* cells of equal measurement, but those cells might represent feet, meters, hectares, or miles depending on the specification of the user.

The syntax for spatial indexes follows:

```
-- Spatial index syntax
CREATE SPATIAL INDEX index_name
ON table_name (spatial_column_name)
USING [ {GEOMETRY_AUTO_GRID | GEOGRAPHY_AUTO_GRID |
         GEOMETRY_GRID | GEOGRAPHY_GRID} ]
[WITH (
  [BOUNDING_BOX = ( )],
  [GRIDS = ( )],
    [CELLS_PER_OBJECT = int],
    [option[, ...n]] )]
;
```

Spatial data types and spatial indexes upon those data types are rather complex. You are encouraged to refer to the vendor documentation for extensive details on the principles and concepts. The arguments allowed for a spatial index are as follows:

`USING`
: Specifies the *tessellation* of the spatial index, enabling an object to be associated with a specific cell or cells in the grid. Tessellation, in turn, allows the spatial database to quickly locate other objects in space relative to any other object of the `GEOGRAPHY` or `GEOMETRY` column stored in the index. When an object

completely fills an entire cell, the cell is covered by the object, averting the need to tessellate the cell.

`GEOMETRY_GRID | GEOGRAPHY_GRID`
: Used on the `GEOMETRY` or `GEOGRAPHY` data type, respectively, to manually specify the tessellation scheme to use in the spatial index.

`GEOMETRY_AUTO_GRID | GEOGRAPHY_AUTO_GRID`
: This is the default for geometry and geography and so does not need to be set.

`WITH`
: When used with one of the grid tessellation schemes, allows you to manually specify one or more parameters of the tessellation scheme. The `WITH` subclause may further be used to specify commonly used options for creating the index or specific properties of the index, such as data compression. The additional syntax of the `WITH` subclause follows:

`BOUNDING_BOX = (XMIN, YMIN, XMAX, YMAX)`
: Specifies the coordinates for the bounding box. Only applicable for the `USING GEOMETRY_GRID` clause. Each value may be represented as a float specifying the *x* and *y* coordinates as represented by their parameter name; for example, `XMIN` represents the float value of the x-axis in the lower-left corner of the bounding box while `YMAX` represents the float value of the y-axis at the upper-right corner of the bounding box. Alternatively, you may specify both the property name and the value of each corner of the bounding box using the syntax (`XMIN=a, YMIN=b, XMAX=c, YMAX=d`). Naturally, the max value in each min-max pair must be greater than the min value. This property does not have default values.

`GRIDS (`*`level_n`*`[ = { LOW | MEDIUM | HIGH }[, ... n] ] )`
: Manually specifies the density of one or more levels of the grid. Only usable with the `GEOMETRY_GRID` and `GEOGRAPHY_GRID` parameters. Using the level names `LEVEL_1`, `LEVEL_2`, `LEVEL_3`, and/or `LEVEL_4` allows you to specify one or more of the levels in any order and to omit one or more levels. When omitted, a level defaults to `MEDIUM`. Density may be set to `LOW` (a 4 × 4 grid of 16 cells), `MEDIUM` (an 8 × 8 grid of 64 cells), or `HIGH` (a 16 × 16 grid of 256 cells). You may alternatively skip the explicit naming of each level by specifying the density of all four levels, as in `GRIDS = (LOW, MEDIUM, HIGH)`, with the values applying in ordinal position of levels 1 through 4.

`CELLS_PER_OBJECT = `*`int`*
: Specifies an integer value for the number of tessellation cells per object (between 1 and 8,192, inclusive). When omitted, SQL Server sets the default value of `CELLS_PER_OBJECT` to 16 for `GEOMETRY_GRID`

and GEOGRAPHY_GRID, to 12 for GEOGRAPHY_AUTO_GRID, and to 8 for GEOMETRY_AUTO_GRID.

`WITH` *`option`*
: Allows one or more options of the same functionality as the options for a regular index, but limited to PAD_INDEX, FILLFACTOR, SORT_IN_TEMPDB, IGNORE_DUP_KEY, STATISTICS_NORECOMPUTE, DROP_EXISTING, ONLINE, ALLOW_ROW_LOCKS, ALLOW_PAGE_LOCKS, MAXDOP, and DATA_COMPRESSION.

See also

- CREATE/ALTER TABLE
- DROP

CREATE/ALTER SCHEMA Statement

The CREATE SCHEMA statement creates a *schema*—i.e., a named group of related objects contained within a database or instance of a database server. A schema is a collection of tables, views, and permissions granted to specific users or roles. According to the SQL standard, specific object permissions are not schema objects in themselves and do not belong to a specific schema. However, roles are sets of privileges that do belong to a schema. As an industry practice, it is common to see database designers create all of the necessary objects of a schema along with roles and permissions, such that the collection is a self-contained package.

ALTER SCHEMA is not part of the SQL standard but is implemented (with variations) by most of the database platforms discussed here.

Platform	Command
MySQL	Supported, with variations (as CREATE DATABASE)
Oracle	Supported, with variations
PostgreSQL	Supported, with limitations
SQL Server	Supported, with limitations

SQL standard syntax

```
CREATE SCHEMA [schema_name] [AUTHORIZATION owner_name]
[DEFAULT CHARACTER SET char_set_name]
[PATH schema_name[, ...]]
   [ CREATE statements [...] ]
   [ GRANT statements [...] ]
```

Keywords

`CREATE SCHEMA [`*`schema_name`*`]`
: Creates a schema called *`schema_name`*. When omitted, the database will create a schema name for you using the name of the user who owns the schema.

`AUTHORIZATION` *`owner_name`*
: Specifies the user who will be the owner of the schema. When this clause is omitted, the current user is set as the owner. The SQL standard allows you to omit either the *`schema_name`* or the `AUTHORIZATION` clause, or to use them both together.

`DEFAULT CHARACTER SET` *`char_set_name`*
: Declares a default character set of *`char_set_name`* for all objects created within the schema.

`PATH` *`schema_name`*`[`*`, ...`*` ]`
: Optionally declares a file path and filename for any unqualified routines (i.e., stored procedures, user-defined functions, user-defined methods) in the schema.

`CREATE` *`statements`*`[ ... ]`
: Contains one or more `CREATE TABLE` and `CREATE VIEW` statements. No commas are used between the `CREATE` statements.

`GRANT` *`statements`* `[ ... ]`
: Contains one or more `GRANT` statements that apply to previously defined objects. Usually, the objects were created earlier in the same `CREATE SCHEMA` statement, but they may also be preexisting objects. No commas are used between the `GRANT` statements.

Rules at a glance

The `CREATE SCHEMA` statement is a container that can hold many other `CREATE` and `GRANT` statements. The most common way to think of a schema is as all of the objects that a specific user owns. For example, the user *jake* may own several tables and views in his own schema, including a table called *publishers*. Meanwhile, the user *sarah* may own several other tables and views in her schema, but may also own her own separate copy of the *publishers* table. Schemas are also used to group logically related objects. For example, you can create an *accounting* schema to store ledgers, accounts, and related stored procedures and functions to work with these.

The SQL standard requires that all `CREATE` statements are allowed in a `CREATE SCHEMA` statement. In practice, however, most implementations of `CREATE SCHEMA` allow only three subordinate statements: `CREATE TABLE`, `CREATE VIEW`, and `GRANT`. The order of the commands is not important, meaning that (although it is not recommended) you can grant privileges on tables or views whose `CREATE` statements appear later in the `CREATE SCHEMA` statement.

Programming tips and gotchas

It is not required, but it is considered a best practice to arrange the objects and grants within a CREATE SCHEMA statement in an order that will execute naturally without errors. In other words, CREATE VIEW statements should follow the CREATE TABLE statements that they depend on, and the GRANT statements should come last.

If your database system uses schemas, we recommend that you always reference your objects by schema and then object name (as in *jake.publishers*). If you do not include a schema qualifier, the database platform will typically assume the default schema for the current user connection.

Some database platforms do not explicitly support the CREATE SCHEMA command. However, they implicitly create a schema when a user creates database objects. For example, Oracle creates a schema whenever a user is created. The CREATE SCHEMA command is simply a single-step method of creating all the tables, views, and other database objects along with their permissions.

MySQL

MySQL supports the CREATE SCHEMA and ALTER SCHEMA statements as synonyms for the CREATE DATABASE and ALTER DATABASE statements. Refer to "CREATE/ALTER SCHEMA Statement" on page 136 for more information on MySQL's implementation.

Oracle

In Oracle, the CREATE SCHEMA statement does not actually create a schema; only the CREATE USER statement does that. What CREATE SCHEMA does is allow a user to perform multiple CREATEs and GRANTs in a previously created schema in one SQL statement:

```
CREATE SCHEMA AUTHORIZATION schema_name
   [ CREATE statements [...] ]
   [ GRANT statements [...] ]
```

Note that Oracle only allows SQL standard CREATE TABLE, CREATE VIEW, and GRANT statements within a CREATE SCHEMA statement. You should *not* use any of Oracle's extensions to these commands when using the CREATE SCHEMA statement.

The following Oracle example places the permissions before the objects within the CREATE SCHEMA statement:

```
CREATE SCHEMA AUTHORIZATION emily
   GRANT SELECT, INSERT ON view_1 TO sarah
   GRANT ALL ON table_1 TO sarah
   CREATE VIEW view_1 AS
      SELECT column_1, column_2
      FROM table_1
      ORDER BY column_2
   CREATE TABLE table_1(column_1 INT, column_2 CHAR(20));
```

As this example shows, the order of the statements within the CREATE SCHEMA statement is unimportant; Oracle commits the CREATE SCHEMA statement only if all CREATE and GRANT statements in the statement complete successfully. Oracle does not have an ALTER SCHEMA command.

PostgreSQL

PostgreSQL supports both ALTER and CREATE SCHEMA statements without support for the PATH and DEFAULT CHARACTER SET clauses. The CREATE SCHEMA syntax follows:

```
CREATE SCHEMA [IF NOT EXISTS]
{ schema_name [AUTHORIZATION user_name] | AUTHORIZATION user_name }
   [ CREATE statements [...] ]
   [ GRANT statements [...] ]
```

When the *schema_name* is omitted, the *user_name* is used to name the schema. Currently, PostgreSQL supports only the following CREATE statements within a CREATE SCHEMA statement: CREATE TABLE, CREATE VIEW, CREATE INDEX, CREATE SEQUENCE, and CREATE TRIGGER. Other CREATE statements must be handled separately from the CREATE SCHEMA statement.

The ALTER SCHEMA syntax follows:

```
ALTER SCHEMA schema_name [RENAME TO new_schema_name]
[OWNER TO new_user_name]
```

The ALTER SCHEMA statement allows you to rename a schema or to specify a new owner, who must be a preexisting user on the database.

SQL Server

SQL Server supports the basic CREATE SCHEMA statement, without support for the PATH clause or the DEFAULT CHARACTER SET clause:

```
CREATE SCHEMA [schema_name] [AUTHORIZATION] [owner_name]
   [ CREATE statements [...] ]
   [ GRANT statements [...] ]
   [ REVOKE statements [...] ]
   [ DENY statements [...] ]
;
```

If any statement fails within the CREATE SCHEMA statement, the entire statement fails. Not only may you GRANT permissions within a SQL Server CREATE SCHEMA statement, but you may also revoke previously declared permissions or deny permissions.

SQL Server does not require that the CREATE or GRANT statements be in any particular order, except that nested views must be declared in their logical order. That is, if *view_100* references *view_10*, *view_10* must appear in the CREATE SCHEMA statement before *view_100*.

For example:

```
CREATE SCHEMA AUTHORIZATION katie
   GRANT SELECT ON view_10 TO public
   CREATE VIEW view_10(col1) AS SELECT col1 FROM foo
   CREATE TABLE foo(col1 INT)
   CREATE TABLE foo
      (col1 INT PRIMARY KEY,
       col2 INT REFERENCES foo2(col1))
   CREATE TABLE foo2
      (col1 INT PRIMARY KEY,
       col2 INT REFERENCES foo(col1));
```

SQL Server supports the `ALTER SCHEMA` statement for transferring objects to the schema from another schema.

```
ALTER SCHEMA [schema_name] TRANSFER [entity_type::] entity_name
```

`entity_type`
: If left out defaults to `OBJECT` and otherwise should be one of the following: `OBJECT | TYPE | XML SCHEMA COLLECTION`.

`entity_name`
: Is the one-part or two-part name of a schema-scoped entity to be moved into the schema.

For example:

```
ALTER SCHEMA katie TRANSFER johnny.authors;
```

See also

- `CREATE/ALTER TABLE`
- `CREATE/ALTER VIEW`
- `GRANT` in Chapter 6

CREATE/ALTER TABLE Statement

Manipulating tables is one of the most common activities that database administrators and programmers perform when working with database objects. This section details how to create and modify tables.

The SQL standard represents a sort of least common denominator among the vendors. Although not all vendors offer every option of the SQL standard versions of `CREATE TABLE` and `ALTER TABLE`, the standard does represent the basic form that can be used across all of the platforms. Conversely, the vendor platforms offer a variety of extensions and additions to the SQL standards for `CREATE` and `ALTER TABLE`.

Typically, a great deal of consideration goes into the design and creation of a table. This discipline is known as *database design*. The process of analyzing the relationship of a table to its own data and to other tables within the database is known as *normalization*. We recommend that database developers and database administrators alike study both database design and normalization principles thoroughly before issuing `CREATE TABLE` commands.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

The SQL statement `CREATE TABLE` creates a permanent or temporary table within the database where the command is issued. The syntax is as follows:

```
CREATE [{LOCAL TEMPORARY | GLOBAL TEMPORARY}] TABLE table_name
   (column_name data_type attributes[, ...]) |
   [column_name [data_type] GENERATED ALWAYS AS (expression)[,...]] |
   [column_name GENERATED {ALWAYS | BY DEFAULT}
      AS IDENTITY sequence_options] |
   [column_name WITH OPTIONS options] |
   [column_name_start data_type GENERATED ALWAYS AS ROW START] |
   [column_name_end data_type GENERATED ALWAYS AS ROW END] |
   [PERIOD FOR SYSTEM_TIME (column_name_start, column_name_end)] |
   [LIKE table_name] |
   [REF IS column_name
      {SYSTEM GENERATED | USER GENERATED | DERIVED}]
   [CONSTRAINT constraint_type [constraint_name]
       constraint_definition [, ...]]
[OF type_name [UNDER super_table] [table_definition]] |
[ON COMMIT {PRESERVE ROWS | DELETE ROWS}] |
[WITH SYSTEM_VERSIONING {ON|OFF}]

constraint_type ::= [UNIQUE | FOREIGN KEY | PRIMARY KEY | CHECK]
```

The SQL statement `ALTER TABLE` allows many useful modifications to be made to an existing table without dropping any existing indexes, triggers, or permissions assigned to it. Following is the `ALTER TABLE` syntax:

```
ALTER TABLE table_name
[ADD [COLUMN] column_name data_type attributes]
[ADD [COLUMN] column_name [data_type] GENERATED ALWAYS
   AS (expression)[,...]]
[ADD [COLUMN] column_name {GENERATED ALWAYS| BY DEFAULT}
```

```
     AS IDENTITY sequence_options]
   | [ALTER [COLUMN] column_name SET DEFAULT default_value]
   | [ALTER [COLUMN] column_name DROP DEFAULT]
   | [ALTER [COLUMN] column_name ADD SCOPE table_name]
   | [ALTER [COLUMN] column_name DROP SCOPE {RESTRICT | CASCADE}]
   | [DROP [COLUMN] column_name {RESTRICT | CASCADE}]
   | [ADD table_constraint]
   | [SET SYSTEM_VERSIONING {ON | OFF}]
   | [SET PERIOD FOR SYSTEM_TIME (column_name_start, column_name_end)]
   | [DROP CONSTRAINT table_constraint_name {RESTRICT | CASCADE}]
```

Keywords

`CREATE [{LOCAL TEMPORARY | GLOBAL TEMPORARY}] TABLE`
: Declares a permanent table or a temporary table of local or global scope. *Local temporary tables* are accessible only to the session that created them and are automatically dropped when that session terminates. *Global temporary tables* are accessible by all active sessions but are also automatically dropped when the session that created them terminates. Do not qualify a temporary table with a schema name. Depending on the database platform, you may use two- or even three-part naming conventions for permanent tables: <*schema_name*>.<*table_name*> or <*database_name*>.<*schema_name*>.<*table_name*>, respectively.

`(column_name data_type attributes[, ... ])`
: Defines a comma-delimited list of one or more columns, their data types, and any additional attributes (such as nullability). Every table declaration must contain at least one column, which may include:

  column_name
  : Specifies a name for a column. The name must be a valid identifier according to the rules of the specific DBMS. Make sure the name makes sense!

  data_type
  : Associates a specific data type with the column identified by *column_name*. An optional *length* may be specified for data types that allow user-defined lengths; for example, `VARCHAR(255)`. The data type must be valid on the specific DBMS in question. Refer to Chapter 2 for a full discussion of acceptable data types and vendor variations.

  attributes
  : Associates specific constraint attributes with the *column_name*. Many attributes may be applied to a single *column_name*, no commas required. Typical SQL attributes include:

    `NOT NULL`
    : Tells the column to reject NULL values or, when omitted, to accept them. Any `INSERT` or `UPDATE` statement that attempts to place a NULL value in a `NOT NULL` column will fail and roll back.

`DEFAULT` *`expression`*
: Tells the column to use the value of *`expression`* when no value is supplied by an `INSERT` or `UPDATE` statement. The expression must be acceptable according to the data type of the column; for example, no alphabetic characters may be used in an `INTEGER` column. *`expression`* may be a string or numeric literal, but you may also define a user-defined function or system function. SQL allows these system functions in a `DEFAULT` expression: `NULL`, `USER`, `CURRENT_USER`, `SESSION_USER`, `SYSTEM_USER`, `CURRENT_PATH`, `CURRENT_DATE`, `CURRENT_TIME`, `LOCALTIME`, `CURRENT_TIMESTAMP`, `LOCALTIMESTAMP`, `ARRAY`, and `ARRAY[]`.

`COLLATE` *`collation_name`*
: Defines a specific collation, or sort order, for the column to which it is assigned. The name of the collation is platform-dependent. If you do not define a collation, the columns of the table default to the collation of the character set used for the column.

`REFERENCES ARE [NOT] CHECKED [ON DELETE {RESTRICT | SET NULL}]`
: Indicates whether references are to be checked on a `REF` column defined with a scope clause. The optional `ON DELETE` clause tells whether any values in records referenced by a deleted record should be set to NULL, or whether the operation should be restricted.

`CONSTRAINT` *`constraint_type`* `[`*`constraint_name`*`[, ... ]]`
: Assigns a constraint and, optionally, a constraint name to the specific column. Constraint types are discussed in Chapter 2. Because the constraint is associated with a specific column, the constraint declaration assumes that the column is the only one in the constraint. After the table is created, the constraint is treated as a table-level constraint.

`column_name` `[`*`data_type`*`] GENERATED ALWAYS AS (`*`expression`*`)[, ... ]`
: Denotes a virtual column with the expression being a function of other columns and functions. Per the standard, the data type is optional.

`column_name` `GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY` *`sequence_options`*
: Denotes an auto-incrementing integer. `ALWAYS` means the value generated cannot be changed by a standard `UPDATE/INSERT`. `BY DEFAULT` means the column is updatable but defaults to next identity value when not specified. *`sequence_options`* are `[START WITH` *`int`*`][, INCREMENT BY` *`int`*`]`.

`column_name` `WITH OPTIONS` *`options`*
: Defines a column with special options, such as a scope clause, a default clause, a column-level constraint, or a `COLLATE` clause. For many implementations, the `WITH OPTIONS` clause is restricted to the creation of typed tables.

`column_name_start data_type GENERATED ALWAYS AS ROW START`
: Defines a column that specifies the start of the period for which the row is valid. Only applies to temporal tables (introduced in SQL:2011).

`column_name_end data_type GENERATED ALWAYS AS ROW END`
: Defines a column that specifies the end of the period for which the row is valid. Only applies to temporal tables.

`PERIOD FOR SYSTEM_TIME (column_name_start, column_name_end)`
: Denotes that this is a temporal table and indicates which columns to use to denote the start and end of the period that this row is valid for.

`LIKE table_name`
: Creates a new table with the same column definitions as the preexisting table named *`table_name`*.

`REF IS column_name {SYSTEM GENERATED | USER GENERATED | DERIVED}`
: Defines the object identifier column (OID) for a typed table. An OID is necessary for the root table of a table hierarchy. Based on the option specified, the `REF` might be automatically generated by the system (`SYSTEM GENERATED`), manually provided by the user when inserting the row (`USER GENERATED`), or derived from another `REF` (`DERIVED`). Requires the inclusion of a `REFERENCES` column attribute for *`column_name`*.

`CONSTRAINT constraint_type [constraint_name] constraint_definition[, ... ]`
: Assigns one or more constraints to the table. This option is noticeably different from the `CONSTRAINT` option at the column level because column-level constraints are assumed to apply only to the columns with which they are associated. Table-level constraints, however, give the option of associating multiple columns with a constraint. For example, in a *sales* table you might wish to declare a unique constraint on a concatenated key of *store_id*, *order_id*, and *order_date*. This can only be done using a table-level constraint. For unique and primary key constraints the *`constraint_definition`* consists of the column names. Refer to Chapter 2 for a full discussion of constraints.

`OF type_name [UNDER super_table] [table_definition]`
: Declares that the table is based upon a preexisting user-defined type. In this situation, the table may have only a single column for each attribute of the structured type, plus an additional column, as defined in the `REF IS` clause. This clause is incompatible with the `LIKE` *`table_name`* clause.

`[UNDER super_table] [table_definition]`
: Declares the direct supertable of the currently declared table within the same schema, if any exists. The table being created is thus a direct subtable of the supertable. You may optionally provide a complete *`table_definition`* of the new subtable, with columns, constraints, etc.

`ON COMMIT {PRESERVE ROWS | DELETE ROWS}`
: `ON COMMIT PRESERVE ROWS` preserves data rows in a temporary table on issuance of a `COMMIT` statement. `ON COMMIT DELETE ROWS` deletes all data rows in a temporary table on `COMMIT`.

`WITH SYSTEM_VERSIONING {ON | OFF}`
: Indicates whether to enable or disable system-versioned tables. The default is `OFF`, which leaves table behavior unchanged. When set `ON`, system-versioned tables keep a history of all changes to their data at all points in time. This functionality enables a user to query data "as of" a specific date, even if the data has been deleted or updated (or new data has been inserted) after the "as of" date. System-versioned tables are rather complex, thus we encourage you to refer to the documentation of each of the vendor platforms to implement them properly.

`ADD [COLUMN]` *`column_name data_type attributes`*
: Adds a column to a table, along with the appropriate data type and attributes.

`ADD [COLUMN]` *`column_name`* `[`*`data_type`*`] GENERATED ALWAYS AS (`*`expression`*`) [, ... ]`
: Adds a virtual column.

`ADD [COLUMN]` *`column_name`* `{GENERATED ALWAYS | BY DEFAULT} AS IDENTITY sequence_options`
: Adds an identity column.

`ALTER [COLUMN]` *`column_name`* `SET DEFAULT` *`default_value`*
: Adds a default value to the column if none exists, and resets the default value if a previous one exists.

`ALTER [COLUMN]` *`column_name`* `DROP DEFAULT`
: Completely removes a default from the named column.

`ALTER [COLUMN]` *`column_name`* `ADD SCOPE` *`table_name`*
: Adds a scope to the named column. A scope is a reference to a user-defined data type.

`ALTER [COLUMN]` *`column_name`* `DROP SCOPE {RESTRICT | CASCADE}`
: Drops a scope from the named column. The `RESTRICT` and `CASCADE` clauses are defined at the end of this list.

`DROP [COLUMN]` *`column_name`* `{RESTRICT | CASCADE}`
: Drops the named column from the table.

`ADD` *`table_constraint`*
: Adds a table constraint of the specified name and characteristics to the table.

`DROP CONSTRAINT` *`table_constraint_name`* `{RESTRICT | CASCADE}`
: Drops a previously defined constraint from the table.

`RESTRICT`
: Tells the DBMS to abort the command if it finds any other objects in the database that depend on the object.

`CASCADE`
: Tells the DBMS to drop any other objects that depend on the object.

Rules at a glance

The typical `CREATE TABLE` statement is very simple, although the major database vendors have added a dizzying array of variations. Generally, it names the table and any columns (and attributes of those columns) contained in the table. Many table definitions also include a nullability constraint for most of the columns, as in this example:

```
CREATE TABLE housing_construction
   (project_number      INT          NOT NULL,
    project_date        DATE         NOT NULL,
    project_name        VARCHAR(50)  NOT NULL,
    construction_color  VARCHAR(20)    ,
    construction_height DECIMAL(4,1),
    construction_length DECIMAL(4,1),
    construction_width  DECIMAL(4,1),
    construction_volume INT         );
This example adds a table with a primary key:
CREATE TABLE category
(cat_name varchar(40) PRIMARY KEY);
```

This example adds a foreign key to the example table:

```
-- Creating a column-level constraint
CREATE TABLE favorite_books
   (isbn          CHAR(100)    PRIMARY KEY,
    book_name     VARCHAR(40)  UNIQUE,
    category      VARCHAR(40)  ,
    subcategory   VARCHAR(40)  ,
    pub_date      DATE         NOT NULL,
    purchase_date DATE         NOT NULL,
       CONSTRAINT fk_categories FOREIGN KEY (category)
          REFERENCES category(cat_name));
```

The foreign key on the *categories* column relates it to the *cat_name* table in the *category* table. All the vendors discussed in this book support this syntax.

> Examples for creating a table with each constraint type are shown in Chapter 2.

Similarly, the foreign key could be added after the fact as a multicolumn key including both the *category* and *subcategory* columns. However, all existing data must be valid for the foreign key constraint:

```
ALTER TABLE favorite_books ADD CONSTRAINT fk_categories
   FOREIGN KEY (category, subcategory)
   REFERENCES category(cat_name, subcat_name);
```

Now, we can use an `ALTER TABLE` statement to drop the constraint altogether:

```
ALTER TABLE favorite_books DROP CONSTRAINT fk_categories RESTRICT;
```

The following are more full examples from *pubs*, the sample database that ships with early releases of SQL Server:

```
-- For a SQL Server database
CREATE TABLE jobs
   (job_id   SMALLINT IDENTITY(1,1) PRIMARY KEY CLUSTERED,
    job_desc VARCHAR(50) NOT NULL DEFAULT 'New Position',
    min_lvl  TINYINT NOT NULL CHECK (min_lvl >= 10),
    max_lvl  TINYINT NOT NULL CHECK (max_lvl <= 250))
-- For a MySQL database
CREATE TABLE employee
   (emp_id INT AUTO_INCREMENT CONSTRAINT PK_emp_id PRIMARY KEY,
    fname VARCHAR(20) NOT NULL,
    minit CHAR(1) NULL,
    lname VARCHAR(30) NOT NULL,
    job_id SMALLINT NOT NULL DEFAULT 1
       REFERENCES jobs(job_id),
    job_lvl TINYINT DEFAULT 10,
    pub_id CHAR(4) NOT NULL DEFAULT ('9952')
       REFERENCES publishers(pub_id),
    hire_date DATETIME NOT NULL DEFAULT (CURRENT_DATE());
CREATE TABLE publishers
   (pub_id char(4) NOT NULL
      CONSTRAINT UPKCL_pubind PRIMARY KEY CLUSTERED
      CHECK (pub_id IN ('1389', '0736', '0877', '1622', '1756')
      OR pub_id LIKE '99[0-9][0-9]'),
    pub_name varchar(40) NULL,
    city varchar(20) NULL,
    state char(2) NULL,
    country varchar(30) NULL DEFAULT('USA'))
```

Once you get into the vendor extensions, the `CREATE TABLE` statement is no longer portable between database platforms. The following is an example of an Oracle `CREATE TABLE` statement with many storage properties that are not part of the SQL standard:

```
CREATE TABLE classical_music_cds
   (music_id        INT,
    composition     VARCHAR2(50),
    composer        VARCHAR2(50),
    performer       VARCHAR2(50),
    performance_date DATE DEFAULT SYSDATE,
    duration         INT,
    cd_name          VARCHAR2(100),
CONSTRAINT pk_class_cds PRIMARY KEY (music_id)
   USING INDEX TABLESPACE index_ts
   STORAGE (INITIAL 100K NEXT 20K),
CONSTRAINT uq_class_cds UNIQUE
   (composition, performer, performance_date)
   USING INDEX TABLESPACE index_ts
   STORAGE (INITIAL 100K NEXT 20K))
TABLESPACE tabledata_ts;
```

When issuing a CREATE or ALTER statement, we recommend that it be the only statement in your transaction. For example, do not attempt to create a table and select from it in the same batch. Instead, first create the table, then verify the operation, issue a COMMIT, and finally perform any subsequent operations against the table.

table_name is the name of a new or existing table. New table names should start with an alphabetic character and in general should contain no other special symbol besides the underscore (_). Rules for the length of the name and its exact composition differ according to the vendor.

When creating or altering a table, the list of column definitions is always encapsulated within parentheses, and the individual column definitions are separated by commas.

Programming tips and gotchas

The user issuing the CREATE TABLE command must have the appropriate permissions. Similarly, any user wishing to ALTER or DROP a table should own the table or have adequate permissions to alter or drop the table. Since the SQL standard does not specify the privileges required, expect some variation between vendors.

You can encapsulate a CREATE TABLE or ALTER TABLE statement within a transaction using a COMMIT or ROLLBACK statement to explicitly conclude the transaction. We recommend that the CREATE/ALTER TABLE statement be the *only* command in the transaction.

Extensions to the SQL standard can give you a great deal of control over the way that the records of a table are physically written to the disk subsystem. SQL Server uses a technique called *clustered indexes* to control the way that records are written to disk. Oracle offers a technique that is functionally similar, called an *index-organized table*, although it is not a requirement for good performance. PostgreSQL offers a CLUSTER ON clause that allows sorting a table by an index, similar to SQL Server's clustered indexes. However, this sort is not maintained and requires a CLUSTER <*sometable*> to physically re-sort a specific clustered table. Use CLUSTER without a table name to physically re-sort all clustered tables.

Some databases will lock a table that is being modified by an ALTER TABLE statement, possibly blocking one or many other users attempting to access the table. It is therefore wise to issue this command only on tables that are not in use on a production database, or during low-usage times. Furthermore, some databases will lock the target *and* source tables when using the CREATE TABLE ... LIKE statement. Use caution.

MySQL and MariaDB

The MySQL and MariaDB shared syntax for CREATE TABLE creates a permanent or local temporary table within the database in which the command is issued. Two notable augmentations exist for MariaDB that (at the time of writing) are not supported by MySQL. First, MariaDB supports the CREATE OR REPLACE TABLE syntax, enabling users to change the table definition without having to DROP an existing table and then re-create it. Second, it supports a PERIOD FOR clause, similar to the Oracle syntax discussed in the next section. There are numerous *table_option* settings that are rarely set or are specific to certain storage engines. We will only highlight the ones that are commonly changed. With these exceptions, the syntax for MySQL and MariaDB's CREATE TABLE statement follows:

```
CREATE [TEMPORARY] TABLE [IF NOT EXISTS] table_name
{(column_name data_type attributes
  constraint_type constraint_name[, ...])
 [CONSTRAINT constraint_type [constraint_name]
   constraint_definition[, ...]]
LIKE other_table_name}
  {[TABLESPACE tablespace_name STORAGE DISK] |
   [table_option [,...]
  }
[partition_definition[, ...]]
[ [IGNORE | REPLACE] select_statement ]

table_option ::=
   [AUTO_INCREMENT [=] int] |
   [COMPRESSION [=] {'ZLIB' | 'LZ4' | 'NONE'}] |
   [CONNECTION [=] 'connection_string'] |
   [[DEFAULT] CHARACTER SET charset_name] |
   [CHECKSUM [=] {0 | 1}] |
   [[DEFAULT] COLLATE collation_name] |
   [COMMENT [=] 'string'] |
   [DATA DIRECTORY [=] 'path_to_directory'] |
   [DELAY_KEY_WRITE [=] {0 | 1}] |
   [ENGINE [=] engine_name] |
   [ENGINE_ATTRIBUTE [=] 'string' ] |
   [INDEX DIRECTORY [=] 'path_to_directory'] |
   [INSERT_METHOD [=] {NO | FIRST | LAST}] |
   [KEY_BLOCK_SIZE [=] int] |
   [PACK_KEYS [=] {0 | 1}] |

   WITH SYSTEM VERSIONING
```

There are some variations between MySQL and MariaDB in what they support and how they support it, primarily in the *table_option* clause. Refer to the respective vendor documentation for the full set of properties supported.

The following are MySQL extensions not supported by MariaDB:

```
CREATE ... TABLE [IF NOT EXISTS] table_name
{(column_name data_type [INVISIBLE] attributes
```

MariaDB also supports some features that MySQL doesn't, such as an `IGNORED` clause that is equivalent to MySQL's `INVISIBLE` clause for columns. It also supports a `CREATE OR REPLACE TABLE` clause:

```
CREATE OR REPLACE ... TABLE ...
{(column_name data_type [IGNORED] attributes
```

When the `ENGINE` clause is specified in `ALTER TABLE`, MySQL always rebuilds the table, even when the current `ENGINE` is the same as the one specified. This feature is often used to defragment a table. The MySQL syntax for `ALTER TABLE` allows modifications to a table or even renaming of a table. Notably, MySQL allows you to rename columns and indexes while MariaDB does not. The shared `ALTER TABLE` syntax is as follows (see the vendor documentation for full details):

```
ALTER [IGNORE] TABLE table_name
{ [ENGINE = engine_name ]
| [ADD [COLUMN] (column_name data_type attributes)
   [FIRST | AFTER column_name][, ...]]
| [ADD {FULLTEXT | SPATIAL} [INDEX | KEY]
  [index_name](index_col_name[, ...]) ]
| [ADD CONSTRAINT constraint_type [constraint_name]
   constraint_definition]
   [INDEX | KEY] [index_name](index_col_name[, ...])]
| [ALTER [COLUMN] column_name
   {SET DEFAULT literal | DROP DEFAULT}]
| [CHANGE | MODIFY] [COLUMN] old_col_name new_col_name
   column_definition [FIRST | AFTER column_name]
| [DROP [COLUMN | FOREIGN KEY | PRIMARY KEY | INDEX | KEY]
   [object_name]]
| [{ENABLE | DISABLE} KEYS]
| [RENAME [TO | AS] new_tbl_name]
| [RENAME COLUMN old_col_name TO new_col_name]
| [RENAME {INDEX | KEY} old_index_name TO new_index_name]
| [ORDER BY column_name[, ...]]
| [CONVERT TO CHARACTER SET charset_name [COLLATE collation_name]]
| [{DISCARD | IMPORT} TABLESPACE]
| [{ADD | DROP | COALESCE int | ANALYZE | CHECK | OPTIMIZE |
      REBUILD | REPAIR} PARTITION]
| [REORGANIZE PARTITION prtn_name INTO (partition_definition)]
| [REMOVE PARTITIONING]
| [table_options] }[, ...]
| {WITHOUT | WITH} VALIDATION
```

Keywords and parameters are as follows:

`TEMPORARY`
: Creates a table that persists for the duration of the connection under which it was created. Once that connection closes, the temporary table is automatically deleted.

`IF NOT EXISTS`
: Prevents an error if the table already exists. A schema specification is not required.

`FULLTEXT [ {INDEX|KEY} ]`
: Creates a full-text search index to facilitate rapid searches of large blocks of text. Note that only MyISAM tables support `FULLTEXT` indexes, and that they can only be made on `CHAR`, `VARCHAR`, and `TEXT` columns.

`SPATIAL [ {INDEX|KEY} ]`
: Creates an R-tree spatial index or key on the column. Only MyISAM and InnoDB engines support R-tree spatial indexes. If a spatial index is specified for a storage engine that doesn't support R-tree indexes, then a B-tree index is created instead.

`constraint_type`
: Allows standard SQL constraints to be assigned at the column or table level. MySQL fully supports primary key and unique constraints. It provides syntax support for check, foreign key, and references constraints, but they are not functional except on InnoDB tables. Foreign keys cannot be used on partitioned tables. The primary key of a table is always called `PRIMARY`, which thus cannot be used as the name for any other kind of index. The primary key is used to cluster the data and is also included in every secondary index.

`ENGINE`
: Describes how the data should be physically stored. You can convert tables between types using the `ALTER TABLE` statement. MyISAM and many other storage engines do not offer recoverability with the `COMMIT` or `ROLLBACK` statements. In absence of recoverability there will often be loss of data if the database crashes. The default engine is InnoDB for MySQL 8 and MariaDB 10. The following is the list of MySQL/MariaDB engine types. The offerings of engines vary a bit by installs, and additional ones are made available by third parties. To find out which storage engines your database supports, use the `SHOW ENGINES` command on the MySQL command line. Common engines you will find installed are:

    `ARIA`
    : A safer alternative to MyISAM, generally available only on MariaDB installations. It provides a `TRANSACTIONAL` keyword that dictates whether it should provide crash safety or not. ARIA currently doesn't support

transactions, so commands such as `BEGIN TRANSACTION` or `COMMIT` have no effect.

`ARCHIVE`
: Good for storing large amounts of data without indexes in a small footprint. The data is compressed. When creating an `ARCHIVE` table, the metadata filename is the table's name with an *.FRM* extension. Data tables have the table name as the filename and extensions of *.ARZ*. A file with an *.ARN* extension may appear occasionally during optimizations.

`BLACKHOLE`
: Acts as a "black hole" that accepts data but throws it away and does not store it. Retrievals always return an empty result. Useful for testing the validity of commands.

`CSV`
: Stores rows in comma-separated values (CSV) format. When creating a CSV table, the filename is the table name with an *.FRM* extension. Data is stored in a file with the table name as the filename and an extension of *.CSV*. The data is stored in plain text, so be careful with security on these tables.

`CONNECTION`
: A MariaDB storage engine introduced in v10.0, but installed separately. It allows for connecting to many kinds of remote data sources and loosely follows the SQL/MED standard.

`EXAMPLE`
: A stub engine that does nothing. No data can be stored in an `EXAMPLE` table.

`FEDERATED`
: Lets you access data from a remote MySQL database without using replication or cluster technology. No data is stored in the local tables.

`INNODB`
: Creates a transaction-safe table with row-level locking. It also provides an independently managed tablespace, checkpoints, non-locking reads, and fast reads from large datafiles for heightened concurrency and performance. Requires the *innodb_data_file_path* startup parameter. InnoDB supports all SQL constraints, including `CHECK` and `FOREIGN KEY`. Well-known developer websites such as Slashdot.org run on MySQL with InnoDB because of its excellent performance. InnoDB tables and indexes are stored together in their own tablespace (unlike other table formats, such as MyISAM, which store tables in separate files).

`MEMORY`
: Creates a memory-resident table that uses hashed indexes. Synonymous with `HEAP`. Since they are memory-resident, the indexes are not

transaction-safe; any data they contain will be lost if the server crashes. MEMORY tables can have up to 32 indexes per table and 16 columns per index, for a maximum index length of 500 bytes. Think of MEMORY tables as an alternative to temporary tables; like temporary tables, they are shared by all clients. If you use MEMORY tables, always specify the MAX_ROWS option so that you do not use all available memory. MEMORY tables do not support BLOB or TEXT columns, ORDER BY clauses, or the variable-length record format, and there are many additional rules concerning these tables. Be sure to read the vendor documentation before implementing MEMORY tables.

MERGE
: Collects several identically structured MyISAM tables for use as one table, providing some of the performance benefits of a partitioned table. SELECT, DELETE, and UPDATE statements operate against the collection of tables as if they were one table. Think of a MERGE table as the collection, but not as the table(s) containing the data. Dropping a MERGE table only removes it from the collection; it does not erase the table or its data from the database. Specify a MERGE table by using the statement UNION = (<*table1*>, <*table2*>, ...). The two keywords MERGE and MRG_MyISAM are synonyms.

MyISAM
: Stores data in *.MYD* files and indexes in *.MYI* files. MyISAM is based on ISAM code, with several extensions. It's a binary storage structure that is more portable than ISAM. MyISAM supports AUTO_INCREMENT columns, compressed tables (with the *myisampack* utility), and large table sizes. Under MyISAM, BLOB and TEXT columns can be indexes, and up to 64 indexes are allowed per table, with up to 16 columns per index and a maximum key length of 1,000 bytes.

NDBCLUSTER
: Creates clustered, fault-tolerant, memory-based tables called NDBs. This is MySQL's special high-availability table format. Refer to the vendor documentation for additional information on implementing NDBs. The NDBCluster engine is only available in the NDBCluster version of MySQL.

TABLESPACE ... STORAGE DISK
: Assigns the table to a Cluster Disk Data tablespace when using NDB Cluster tables. The tablespace named in the clause must already have been created using CREATE TABLESPACE.

AUTO_INCREMENT [=] *int*
: Sets the auto-increment value (*int*) for the table. This works for MyISAM, Aria, InnoDB/XtraDB, MEMORY, and ARCHIVE tables.

[DEFAULT] CHARACTER SET
: Specifies the CHARACTER SET (or CHARSET) for the table, or for specific columns.

`CHECKSUM [=] {0 | 1}`
: When set to `1`, maintains a checksum for all rows in the table (MyISAM only). This makes processing slower but leaves your data less prone to corruption.

`[DEFAULT] COLLATE`
: Specifies the collation set for the table, or for specific columns.

`COMMENT [=] '`*`string`*`'`
: Allows inclusion of a comment.

`CONNECTION [=] '`*`connection_string`*`'`
: Specifies the connection string required to connect to a `FEDERATED` table. Otherwise, this is a noise word. Older versions of MySQL used the `COMMENT` option for the connection string.

`DATA DIRECTORY [=] '`*`path_to_directory`*`'`
: Overrides the default path and directory that MySQL should use for MyISAM table storage.

`DELAY_KEY_WRITE = {0 | 1}`
: When set to `1`, delays key table updates until the table is closed (MyISAM only).

`INDEX DIRECTORY [=] '`*`path_to_directory`*`'`
: Overrides the default path and directory that MySQL should use for MyISAM index storage.

`INSERT_METHOD [=] {NO | FIRST | LAST}`
: Required for `MERGE` tables. If no setting is specified for a `MERGE` table or the value is `NO`, `INSERT`s are disallowed. `FIRST` inserts all records into the first table in the collection, while `LAST` inserts them all into the last table in the collection.

`KEY_BLOCK_SIZE [=]` *`int`*
: Allows the storage engine to change the value used for the size of the index key block. A value of `0` tells MySQL to use the default.

`PACK_KEYS [=] {0 | 1}`
: When set to `1`, compacts the indexes of the table, making reads faster but updates slower (MyISAM and ISAM only). With the `DEFAULT` value, only long strings will be compacted. When set to `0` no compacting is done.

`WITH SYSTEM VERSIONING`
: This setting is supported only by MariaDB and is required for system-versioned tables. In addition, you can specify `PERIOD FOR SYSTEM_TIME` to control which columns will be used to track the beginning and end of life of a row. If you do not specify `PERIOD FOR SYSTEM_TIME`, `ROW_START` and `ROW_END` pseudocolumns will be created to autorecord this information. These pseudocolumns are not normally output with `SELECT *`, but can be explicitly included with a query like `SELECT * FROM ROW_START, ROW_END`.

partition_definition

Specifies a partition or subpartition for a MySQL table. Refer to "Partitioned tables" on page 157 for more details on partitioning and subpartitioning MySQL tables. Note that all of the definition options are usable for subpartitions, with the exception of the `VALUE` subclause.

`[IGNORE | REPLACE]` *select_statement*

Creates a table with columns based upon the elements listed in the `SELECT` statement. The new table will be populated with the results of the `SELECT` statement if the statement returns a result set.

`ALTER [IGNORE]`

The altered table will include all duplicate records unless the `IGNORE` keyword is used. If it is not used, the statement will fail if a duplicate row is encountered and if the table has a unique index or primary key.

`{ADD | COLUMN} [FIRST | AFTER` *column_name*`]`

Adds or moves a column, index, or key to the table. When adding or moving columns, the new column appears as the last column in the table unless it is placed `AFTER` another named column.

`ALTER COLUMN`

Allows the definition or resetting of a default value for a column. If you reset a default, MySQL will assign a new default value to the column.

`CHANGE`

Renames a column, or changes its data type.

`MODIFY`

Changes a column's data type or attributes such as `NOT NULL`. Existing data in the column is automatically converted to the new data type.

`DROP`

Drops the column, key, index, or tablespace. A dropped column is also removed from any indexes in which it participated. When dropping a primary key, MySQL will drop the first unique key if no primary key is present.

`{ENABLE | DISABLE} KEYS`

Enables or disables all nonunique keys on a MyISAM table simultaneously. This can be useful for bulk loads where you want to temporarily disable constraints until after the load is finished. It also speeds up performance by finishing all index block flushing at the end of the operation.

`RENAME COLUMN` *old_col_name* `TO` *new_col_name*

Renames the column.

`RENAME {INDEX | KEY}` *old_index_name* `TO` *new_index_name*

Renames the index or key.

`RENAME [TO | AS]` *`new_tbl_name`*
: Renames the table.

`ORDER BY` *`column_name`*`[, ... ]`
: Orders the rows in the specified order.

`CONVERT TO CHARACTER SET` *`charset_name`* `[COLLATE` *`collation_name`*`]`
: Converts the table to a character set (and optionally a collation) that you specify.

`DISCARD | IMPORT TABLESPACE`
: Deletes the current *.IDB* file (using `DISCARD`), or makes a tablespace available after restoring from a backup (using `IMPORT`).

`{ADD | DROP | COALESCE` *`int`* `| ANALYZE | CHECK | OPTIMIZE | REBUILD | REPAIR} PARTITION`
: Adds or drops a partition on a table. Other options perform preventative maintenance behaviors analogous to those available for MySQL tables (i.e., `CHECK TABLE` and `REPAIR TABLE`). Only `COALESCE PARTITION` has a unique behavior, in which MySQL reduces the number of `KEY` or `HASH` partitions to the number specified by *`int`*.

`REORGANIZE PARTITION` *`prtn_name`* `INTO (`*`partition_definition`*`)`
: Alters the definition of an existing partition according to the new *`partition_definition`* specified.

`REMOVE PARTITIONING`
: Removes a table's partitioning without otherwise affecting the table or its data.

`{WITHOUT | WITH} VALIDATION`
: Affects whether `ALTER TABLE` performs an in-place operation for a virtually generated column or not. `WITHOUT`, the default, offers faster performance by not checking data integrity. `ALTER TABLE ... WITH VALIDATION` first copies the data and returns an error if any values are out of range. This clause is permitted only with `ADD COLUMN`, `CHANGE COLUMN`, and `MODIFY COLUMN` operations.

For example, the following transaction creates a heap table with three columns, *column_a*, *column_b*, and *column_c*:

```
CREATE TABLE test_example
  (column_a INT NOT NULL AUTO_INCREMENT,
   PRIMARY KEY(column_a),
   INDEX(column_b))
  TYPE=HEAP
IGNORE
SELECT column_b,column_c FROM samples;
```

Later, we could change this table to the MyISAM type:

```
ALTER TABLE example TYPE=MyISAM;
```

Three operating system files are created when MySQL creates a MyISAM table: a table definition file with the extension *.FRM*, a datafile with the extension *.MYD*, and an index file with the extension *.MYI*. The *.FRM* datafile is used for all other tables.

The following example creates two base MyISAM tables and then creates a MERGE table from them:

```
CREATE TABLE message1
   (message_id INT AUTO_INCREMENT PRIMARY KEY,
    message_text CHAR(20));
CREATE TABLE message2
   (message_id INT AUTO_INCREMENT PRIMARY KEY,
    message_text CHAR(20));
CREATE TABLE all_messages
   (message_id INT AUTO_INCREMENT PRIMARY KEY,
    message_text CHAR(20))
    TYPE=MERGE UNION=(message1, message2) INSERT_METHOD=LAST;
```

Partitioned tables. MySQL allows partitioning of tables for greater control of I/O and space management. The syntax for the partitioning clause (*partition_definition*) is:

```
PARTITION BY function
[  [SUB]PARTITION prtn_name
   [VALUES {LESS THAN {(expr) | MAXVALUE} | IN (value_list)}]
   [[STORAGE] ENGINE [=] engine_name]
   [COMMENT [=] 'comment_text']
   [DATA DIRECTORY [=] 'data_path']
   [INDEX DIRECTORY [=] 'index_path']
   [MAX_ROWS [=] max_rows]
   [MIN_ROWS [=] min_rows]
   [TABLESPACE [=] (tablespace_name)]
   [NODEGROUP [=] node_group_id]
   [(subprtn[, subprtn] ...)][, ...]]
```

where (values not described below are redundant with the list of table options and are presented in the earlier listing):

function
: Specifies the function used to create the partition. Allowable values include: HASH(*expr*), where *expr* is a hash of one or more columns in an allowable SQL format (including function calls that return any single integer value); LINEAR KEY(*column_list*), where MySQL's hashing function more evenly distributes data; and RANGE(*expr*) and LIST(*expr*), where *expr* is one or more columns in an allowable SQL format with the VALUES clause telling exactly which partition holds which values.

[SUB]PARTITION *prtn_name*
: Names the partition or subpartition.

`VALUES {LESS THAN {(`*`expr`*`) | MAXVALUE} | IN (`*`value_list`*`)}`
: Specifies which values are assigned to which partitions.

`NODEGROUP [=]` *`node_group_id`*
: Makes the partition or subpartition act as part of a node group identified by *`node_group_id`*. Only applicable for NDB tables.

Note that partitions and subpartitions must all use the same storage engine.

The following example creates three tables, each with a different partitioning function:

```
CREATE TABLE employee (emp_id INT, emp_fname VARCHAR(30),
   emp_lname VARCHAR(50))
PARTITION BY HASH(emp_id);

CREATE TABLE inventory (prod_id INT, prod_name VARCHAR(30),
   location_code CHAR(5))
PARTITION BY KEY(location_code)
PARTITIONS 4;

CREATE TABLE inventory (prod_id INT, prod_name VARCHAR(30),
   location_code CHAR(5))
PARTITION BY LINEAR KEY(location_code)
PARTITIONS 5;
```

The following two examples show somewhat more elaborate examples of partitioning using `RANGE` partitioning and `LIST` partitioning:

```
CREATE TABLE employee (emp_id INT, emp_fname VARCHAR(30),
   emp_lname VARCHAR(50), hire_date DATE)
PARTITION BY RANGE(hire_date)
   (PARTITION prtn1 VALUES LESS THAN ('01-JAN-2014'),
    PARTITION prtn2 VALUES LESS THAN ('01-JAN-2016'),
    PARTITION prtn3 VALUES LESS THAN ('01-JAN-2018'),
    PARTITION prtn4 VALUES LESS THAN MAXVALUE);

CREATE TABLE inventory (prod_id INT, prod_name VARCHAR(30),
   location_code CHAR(5))
PARTITION BY LIST(prod_id)
   (PARTITION prtn0 VALUES IN (10, 50, 90, 130, 170, 210),
    PARTITION prtn1 VALUES IN (20, 60, 100, 140, 180, 220),
    PARTITION prtn2 VALUES IN (30, 70, 110, 150, 190, 230),
    PARTITION prtn3 VALUES IN (40, 80, 120, 160, 200, 240));
```

The following example renames both a table and a column:

```
ALTER TABLE employee RENAME AS emp;
ALTER TABLE employee CHANGE employee_ssn emp_ssn INTEGER;
```

Since MySQL allows the creation of indexes on a portion of a column (for example, the first 10 characters), you can also build short indexes on very large columns.

MySQL can redefine the data type of an existing column, but to avoid losing any data, the values contained in the column must be compatible with the new data type. For example, a date column could be redefined to a character data type, but a character data type could not be redefined to an integer. Here's an example:

```
ALTER TABLE mytable MODIFY mycolumn LONGTEXT
```

MySQL offers some additional flexibility in the `ALTER TABLE` statement by allowing users to include multiple `ADD`, `ALTER`, `DROP`, and `CHANGE` clauses in a comma-delimited list in a single `ALTER TABLE` statement. However, be aware that the `CHANGE` ***`column_name`*** and `DROP INDEX` clauses are MySQL extensions not found in SQL. MySQL also supports the clause `MODIFY` ***`column_name`*** to mimic the same feature found in Oracle.

Oracle

The Oracle syntax for `CREATE TABLE` creates a relational table either by declaring the structure or by referencing an existing table. You can modify a table after it is created using the `ALTER TABLE` statement. Oracle also allows the creation of a relational table that uses user-defined types for column definitions, an *object table* that is explicitly defined to hold a specific user-defined type (usually a `VARRAY` or `NESTED TABLE` type), or an XMLType table. New in Oracle 21c is the `BLOCKCHAIN` table type for use in building blockchain applications. We will not be covering this type; for more details, refer to Oracle's documentation.

The SQL standard `CREATE TABLE` statement is supported, but Oracle has added many sophisticated extensions to the command that would take a whole book to cover and are rarely used in practice. For example, Oracle allows significant control over the storage and performance parameters of a table. In both the `CREATE TABLE` and `ALTER TABLE` statements, you'll see a great deal of nesting and reusable clauses. To make this somewhat easier to read, we have broken Oracle's `CREATE TABLE` statement into three distinct variations (relational table, object table, XMLType table) so that you can more easily follow the syntax.

The `CREATE TABLE` syntax for a standard relational table, which has no object or XML properties, is as follows:

```
CREATE [GLOBAL | PRIVATE] [TEMPORARY]
[SHARDED | DUPLICATED] TABLE table_name
[ ( {column | virtual_column |  attribute}
   [SORT] [DEFAULT expression]
   [PERIOD FOR valid_time_column
      [(start_time_column, end_time_column)]]
   [{column_constraint | inline_ref_constraint}] |
   {table_constraint_clause | table_ref_constraint} |
   {GROUP log_group (column [NO LOG][, ...]) [ALWAYS] |
      DATA (constraints[, ...]) COLUMNS} ) ]
[ON COMMIT {DELETE | PRESERVE} ROWS]
[table_constraint_clause]
{ [physical_attributes_clause] [TABLESPACE tablespace_name]
```

```
         [storage_clause] [[NO]LOGGING] |
      [CLUSTER (column[, ...])] |
      {[ORGANIZATION
        {HEAP [physical_attributes_clause][TABLESPACE tablespace_name]
            [storage_clause] [COMPRESS | NOCOMPRESS] [[NO]LOGGING] |
         INDEX [physical_attributes_clause] [TABLESPACE tablespace_name]
            [storage_clause] [PCTTHRESHOLD int]
            [COMPRESS [int] | NOCOMPRESS]
            [MAPPING TABLE | NOMAPPING] [...] [[NO]LOGGING]
            [[INCLUDING column] OVERFLOW
               [physical_attributes_clause] [TABLESPACE tablespace_name]
               [storage_clause] [[NO]LOGGING]}] |
         EXTERNAL ([TYPE driver_type]) DEFAULT DIRECTORY directory_name
            [ACCESS PARAMETERS {USING CLOB subquery | (opaque_format)}]
            LOCATION ([directory_name:]'location_spec'[, ...])
            [REJECT LIMIT {int | UNLIMITED}]} }
   [{ENABLE | DISABLE} ROW MOVEMENT]
   [[NO]CACHE] [[NO]MONITORING] [[NO]ROWDEPENDENCIES]
   [[NO]FLASHBACK ARCHIVE]
   [PARALLEL int | NOPARALLEL] [NOSORT] [[NO]LOGGING]
   [COMPRESS [int] | NOCOMPRESS]
   [{ENABLE | DISABLE} [[NO]VALIDATE]
      {UNIQUE (column[, ...]) | PRIMARY KEY |
       CONSTRAINT constraint_name}]
      [USING INDEX {index_name | CREATE_INDEX_statement}]
      [EXCEPTIONS INTO] [CASCADE] [{KEEP | DROP} INDEX]] |
   [partition_clause]
   [AS subquery]
```

The relational table syntax contains a large number of optional clauses. However, the table definition must contain, at a minimum, either column names and data type specifications or the AS *subquery* clause.

The Oracle syntax for an object table follows:

```
CREATE [GLOBAL] [TEMPORARY] TABLE table_name
AS object_type [[NOT] SUBSTITUTABLE AT ALL LEVELS]
[ ( {column | attribute} [DEFAULT expression] [{column_constraint |
      inline_ref_constraint}] |
   {table_constraint_clause | table_ref_constraint} |
   {GROUP log_group (column [NO LOG][, ...]) [ALWAYS] | DATA
      (constraints[, ...]) COLUMNS} ) ]
[ON COMMIT {DELETE | PRESERVE} ROWS]
[OBJECT IDENTIFIER IS {SYSTEM GENERATED | PRIMARY KEY}]
[OIDINDEX [index_name] ([physical_attributes_clause]
   [storage_clause])]
[physical_attributes_clause] [TABLESPACE tablespace_name]
[storage_clause]
```

Oracle also allows you to create, and later alter, XMLType tables. XMLType tables may have regular columns or virtual columns. The Oracle syntax for an XMLType table follows:

```
CREATE [GLOBAL] [TEMPORARY] TABLE table_name
OF XMLTYPE
[ ( {column | attribute} [DEFAULT expression] [{column_constraint |
      inline_ref_constraint}] |
   {table_constraint_clause | table_ref_constraint} |
   {GROUP log_group (column [NO LOG][, ...]) [ALWAYS] | DATA
      (constraints[, ...]) COLUMNS} ) ]
[XMLTYPE {OBJECT RELATIONAL [xml_storage_clause] |
   [ {SECUREFILE | BASICFILE} ]
   [ {CLOB | BINARY XML} [lob_segname] [lob_params]}]
   [xml_schema_spec] [ON COMMIT {DELETE | PRESERVE} ROWS]
   [OBJECT IDENTIFIER IS {SYSTEM GENERATED | PRIMARY KEY}]
   [OIDINDEX index_name ([physical_attributes_clause]
      [storage_clause])]
   [physical_attributes_clause] [TABLESPACE tablespace_name]
   [storage_clause]
```

The Oracle syntax for ALTER TABLE changes the table or column properties, storage characteristics, LOB or VARRAY properties, partitioning characteristics, and integrity constraints associated with a table and/or its columns. The statement can also do other things, like move an existing table into a different tablespace, free recuperated space, compact the table segment, and adjust the "high-water mark."

The SQL standard uses the ALTER keyword to modify existing elements of a table, while Oracle uses MODIFY for the same purpose. Since they are essentially the same thing, please consider the behavior of otherwise identical clauses (for example, SQL's ALTER TABLE ... ALTER COLUMN and Oracle's ALTER TABLE ... MODIFY COLUMN) to be functionally equivalent.

Oracle's ALTER TABLE syntax is:

```
ALTER TABLE table_name
-- Alter table characteristics
   [physical_attributes_clause] [storage_clause]
   [ {READ ONLY | READ WRITE} ]
   [[NO]LOGGING] [[NO]CACHE] [[NO]MONITORING] [[NO]COMPRESS]
   [[NO]FLASHBACK ARCHIVE] [SHRINK SPACE [COMPACT] [CASCADE]]
   [UPGRADE [[NOT] INCLUDING DATA] column_name data_type
      attributes]
   [[NO]MINIMIZE RECORDS_PER_BLOCK]
   [PARALLEL int | NOPARALLEL]
   [{ENABLE | DISABLE} ROW MOVEMENT]
   [{ADD | DROP} SUPPLEMENTAL LOG
      {GROUP log_group [(column_name [NO LOG][, ...]) [ALWAYS]] |
      DATA ( {ALL | PRIMARY KEY | UNIQUE | FOREIGN KEY}[, ...] )
      COLUMNS}]
   [ALLOCATE EXTENT [( [SIZE int [K | M | G | T]]
      [DATAFILE 'filename'] [INSTANCE int] )]
   [DEALLOCATE UNUSED [KEEP int [K | M | G | T]]]
   [ORGANIZATION INDEX ...
      [COALESCE] [MAPPING TABLE | NOMAPPING] [PCTTHRESHOLD int]
         [COMPRESS int | NOCOMPRESS]
      [ { ADD OVERFLOW [TABLESPACE tablespace_name] [[NO]LOGGING]
            [physical_attributes_clause] } |
          OVERFLOW { [ALLOCATE EXTENT ( [SIZE int [K | M | G | T]]
                [DATAFILE 'filename'] [INSTANCE int] ) |
             [DEALLOCATE UNUSED [KEEP int [K | M | G | T]]]] } ]]]
   [RENAME TO new_table_name]
-- Alter column characteristics
   [ADD (column_name data_type attributes[, ...])]
   [DROP { {UNUSED COLUMNS | COLUMNS CONTINUE} [CHECKPOINT int] |
      {COLUMN column_name | (column_name[, ...])} [CHECKPOINT int]
         [{CASCADE CONSTRAINTS | INVALIDATE}] }]
   [SET UNUSED {COLUMN column_name | (column_name[, ...])}
      [{CASCADE CONSTRAINTS | INVALIDATE}]]
   [MODIFY { (column_name data_type attributes[, ...]) |
      COLUMN column_name [NOT] SUBSTITUTABLE AT ALL LEVELS
      [FORCE] }]
   [RENAME COLUMN old_column_name TO new_column_name]
   [MODIFY {NESTED TABLE | VARRAY} collection_item
      [RETURN AS {LOCATOR | VALUE}]]
-- Alter constraint characteristics
   [ADD CONSTRAINT constraint_name table_constraint_clause]
   [MODIFY CONSTRAINT constraint_name constraint_state_clause]
   [RENAME CONSTRAINT old_constraint_name TO new_constraint_name]
   [DROP { { PRIMARY KEY | UNIQUE (column[, ...]) } [CASCADE]
         [{KEEP | DROP} INDEX] |
      CONSTRAINT constraint_name [CASCADE] } ]
-- Alter table partition characteristics
   [alter partition clauses]
-- Alter external table characteristics
   DEFAULT DIRECTORY directory_name
      [ACCESS PARAMETERS {USING CLOB subquery | (opaque_format)}]
      LOCATION ( [directory_name:]'location_spec'[, ...] )
   [ADD (column_name ...)] [DROP column_name ...]
   [MODIFY (column_name ...)]
   [PARALLEL int | NOPARALLEL]
   [REJECT LIMIT {int | UNLIMITED}]
   [PROJECT COLUMN {ALL | REFERENCED}]
-- Move table clauses
   [MOVE [ONLINE] [physical_attributes_clause]
      [TABLESPACE tablespace_name] [[NO]LOGGING]
      [PCTTHRESHOLD int]
      [COMPRESS int | NOCOMPRESS] [MAPPING TABLE | NOMAPPING]
      [[INCLUDING column] OVERFLOW
         [physical_attributes_clause] [TABLESPACE tablespace_name]
         [[NO]LOGGING]]
      [LOB ...] [VARRAY ...] [PARALLEL int | NOPARALLEL]]
-- Enable/disable attributes and constraints
   [{ {ENABLE | DISABLE} [[NO]VALIDATE] {UNIQUE (column[, ...]) |
      PRIMARY KEY | CONSTRAINT constraint_name}
      [USING INDEX {index_name | CREATE_INDEX_statement |
         [TABLESPACE tablespace_name] [physical_attributes_clause]
         [storage_clause]
         [NOSORT] [[NO]LOGGING] [ONLINE] [COMPUTE STATISTICS]
         [COMPRESS | NOCOMPRESS] [REVERSE]
         [{LOCAL | GLOBAL} partition_clause]
         [EXCEPTIONS INTO table_name] [CASCADE]
         [{KEEP | DROP} INDEX]]} |
   [{ENABLE | DISABLE}] [{TABLE LOCK | ALL TRIGGERS}] }]
```

The parameters are as follows:

`virtual_column`
: Allows the creation or alteration of a *virtual column* (i.e., a column whose value is derived from a calculation rather than directly from a physical storage location). For example, a virtual column *income* might be derived by summing the *salary*, *bonus*, and *commission* columns.

`PERIOD FOR` *`valid_time_column`* `[ (` *`start_time_column, end_time_column`*`) ]`
: Supports temporal history, useful for flashback reporting.

`column_constraint`
: Specifies a column constraint using the syntax described later.

`GROUP` *`log_group`* `(`*`column`* `[NO LOG][, ... ]) [ALWAYS] | DATA (`*`constraints`*`[, ... ]) COLUMNS`
: Specifies a log group rather than a single logfile for the table.

`ON COMMIT {DELETE | PRESERVE} ROWS`
: Declares whether a declared temporary table should keep the data in the table active for the entire session (`PRESERVE`) or only for the duration of the transaction in which the temporary table is created (`DELETE`).

`table_constraint_clause`
: Specifies a table constraint using the syntax described later.

`physical_attributes_clause`
: Specifies the physical attributes of the table using the syntax described later.

`TABLESPACE` *`tablespace_name`*
: Specifies the name of the tablespace where the table you are creating will be stored. If omitted, the default tablespace for the schema owner will be used.

`storage_clause`
: Specifies physical storage characteristics of the table using the syntax described later.

`[NO]LOGGING`
: Specifies whether redo log records will be written during object creation (`LOGGING`) or not (`NOLOGGING`). `LOGGING` is the default. `NOLOGGING` can speed up the creation of database objects; however, in case of database failure under the `NOLOGGING` option, the operation cannot be recovered by applying logfiles

and the object must be re-created. The `LOGGING` clause replaces the older `RECOVERABLE` clause, which is deprecated.

`CLUSTER(`*`column`*`[, ... ])`
: Declares that the table is part of a clustered index. The *`column`* list should correspond, one to one, with the columns in a previously declared clustered index. Because it uses the clustered index's space allocation, the `CLUSTER` clause is compatible with the *`physical_attributes_clause`*, *`storage_clause`*, or `TABLE SPACE` clause. Tables containing `LOB`s are incompatible with the `CLUSTER` clause.

`ORGANIZATION HEAP`
: Declares how the data of the table should be recorded to disk. `HEAP`, the default for an Oracle table, declares that no order should be associated with the storage of rows of data (i.e., the physical order in which records are written to disk) for this table. The `ORGANIZATION HEAP` clause allows several optional clauses, described in detail elsewhere in this list, that control storage, logging, and compression for the table.

`ORGANIZATION INDEX`
: Declares how the data of the table should be recorded to disk. `INDEX` declares that the records of the table should be physically written to disk in the sort order defined by the primary key of the table. Oracle calls this an *index-organized table*. A primary key is required. The *`physical_attributes_clause`*, the `TABLESPACE` clause, the *`storage_clause`*, and the `[NO]LOGGING` keyword (all described in greater detail elsewhere in this section) may all be associated with the new `INDEX` segment as you create it, as can the following subclauses:

    `PCTTHRESHOLD` *`int`*
    : Declares the percentage (*`int`*) of space in each index block to be preserved for data. On a record-by-record basis, data that cannot fit in this space will be placed in the overflow segment.

    `INCLUDING` *`column`*
    : Declares the point at which a record will split between the index and overflow portions. All columns that follow the specified *`column`* will be stored in the overflow segment. The *`column`* cannot be a primary key column.

    `MAPPING TABLE | NOMAPPING`
    : Tells the database to create a mapping of local to physical `ROWID`s. This mapping is required to create a bitmap index on an IOT. Mappings are also partitioned identically if the table is partitioned. `NOMAPPING` tells the database not to create the `ROWID` map.

    `[INCLUDING` *`column`*`] OVERFLOW`
    : Declares that a record that exceeds the `PCTTHRESHOLD` value be placed in a segment described in this clause. The *`physical_attributes_clause`*, the `TABLESPACE` clause, the *`storage_clause`*, and the `[NO]LOGGING` keyword

may all be associated with a specific `OVERFLOW` segment when you create it. The optional `INCLUDING` *`column`* clause defines a column at which to divide an IOT row into index and overflow portions. Primary key columns are always stored in the index. However, all non-primary key columns that follow *`column`* are stored in the overflow data segment.

`ORGANIZATION EXTERNAL`

Declares how the data of the table should be recorded to disk. `EXTERNAL` declares that the table stores its data outside of the database and is usually read-only (its metadata is stored in the database, but its data is stored outside of the database). There are some restrictions on external tables: they cannot be temporary; they cannot have constraints; they can only have column, data type, and attribute column descriptors; and `LOB` and `LONG` data types are disallowed. No other `ORGANIZATION` clauses are allowed with `EXTERNAL`. The following subclauses may be used with the `ORGANIZATION EXTERNAL` clause:

`TYPE` *`driver_type`*

Defines the access driver API for the external table. The default is `ORACLE_LOADER`.

`DEFAULT DIRECTORY` *`directory_name`*

Defines the default directory on the filesystem where the external table resides.

`ACCESS PARAMETERS {USING CLOB` *`subquery`* `| (`*`opaque_format`*`)}`

Assigns and passes specific parameters to the access driver. Oracle does not interpret this information. `USING CLOB` *`subquery`* tells Oracle to derive the parameters and their values from a subquery that returns a single row with a single column of the data type `CLOB`. The subquery cannot contain an `ORDER BY`, `UNION`, `INTERSECT`, or `MINUS/EXCEPT` clause. The *`opaque_format`* clause allows you to list parameters and their values.

`LOCATION (`*`directory_name`*`:'`*`location_spec`*`'[, ... ])`

Defines one or more external data sources, usually as files. Oracle does not interpret this information.

`REJECT LIMIT {`*`int`* `| UNLIMITED}`

Defines the number of conversion errors (*`int`*) that are allowed during the query to the external data source before Oracle aborts the query and returns an error. `UNLIMITED` tells Oracle to continue with the query no matter how many errors are encountered. The default is `0`.

`{ENABLE | DISABLE} ROW MOVEMENT`

Specifies that a row may (`ENABLE`) or may not (`DISABLE`) be moved to a different partition or subpartition if required due to an update of the key. The `DISABLE` keyword also specifies that Oracle return an error if an update to a key would require a move.

`[NO]CACHE`
: Buffers a table for rapid reads (`CACHE`), or turns off this behavior (`NOCACHE`). Index-organized tables offer `CACHE` behavior.

`[NO]MONITORING`
: Specifies whether modification statistics can be collected for this table (`MONITORING`) or not (`NOMONITORING`). `NOMONITORING` is the default.

`[NO]ROWDEPENDENCIES`
: Specifies whether a table will use *row-level dependency tracking*, a feature that applies a system change number (SCN) greater than or equal to the time of the last transaction affecting the row. The SCN adds 6 extra bytes of space to each record. Row-level dependency tracking is most useful in replicated environments with parallel data propagation. `NOROWDEPENDENCIES` is the default.

`[NO]FLASHBACK ARCHIVE`
: Enables or disables historical tracking for the table, if a flashback archive for the table already exists. `NO FLASHBACK ARCHIVE` is the default.

`PARALLEL [`*`int`*`] | NOPARALLEL`
: The `PARALLEL` clause allows for the parallel creation of the table by distinct CPUs to speed up the operation. It also enables parallelism for queries and other data manipulation operations against the table after its creation. An optional integer value may be supplied to define the exact number of parallel threads used to create the table in parallel, as well as the number of parallel threads allowed to service the table in the future. (Oracle calculates the best number of threads to use in a given parallel operation, so the *`int`* argument is optional.) `NOPARALLEL`, the default, creates the table serially and disallows future parallel queries and data manipulation operations.

`COMPRESS [`*`int`*`] | NOCOMPRESS`
: Specifies whether the table should be compressed or not. On index-organized tables, only the key is compressed; on heap-organized tables, the entire table is compressed. This can greatly reduce the amount of space that is consumed by the table. `NOCOMPRESS` is the default. In index-organized tables, you can specify the number of prefix columns (*`int`*) to compress. The default value for *`int`* is the number of keys in the primary key minus one. You need not specify an *`int`* value for other clauses, such as `ORGANIZATION`. When you omit the *`int`* value, Oracle will apply compression to the entire table.

`{ENABLE | DISABLE} [[NO]VALIDATE] {UNIQUE (`*`column`*`[, ... ]) | PRIMARY KEY | CONSTRAINT `*`constraint_name`*`}`
: Declares whether the named key or constraint applies to all of the data in the new table or not. `ENABLE` specifies that the key or constraint applies to all new data in the table while `DISABLE` specifies that the key or constraint is disabled for the new table, with the following options:

`[NO]VALIDATE`
: `VALIDATE` verifies that all existing data in the table complies with the key or constraint. When `NOVALIDATE` is specified with `ENABLE`, Oracle does not verify that existing data in the table complies with the key or constraint, but ensures that new data added to the table does comply with the constraint.

`UNIQUE (`*`column`*`[, ... ]) | PRIMARY KEY | CONSTRAINT` *`constraint_name`*
: Declares the unique constraint, primary key, or constraint that is enabled or disabled.

`USING INDEX` *`index_name`* `| CREATE_INDEX_`*`statement`*
: Declares the name (*`index_name`*) of a preexisting index (and its characteristics) used to enforce the key or constraint, or creates a new index (*`CREATE_INDEX_statement`*). If neither clause is declared, Oracle creates a new index.

`EXCEPTIONS INTO` *`table_name`*
: Specifies the name of a table into which Oracle places information about rows violating the constraint. Run the *utlexpt1.sql* script before using this keyword to explicitly create this table.

`CASCADE`
: Cascades the disablement/enablement to any integrity constraints that depend on the constraint named in the clause. Usable only with the `DISABLE` clause.

`{KEEP | DROP} INDEX`
: Lets you keep (`KEEP`) or drop (`DROP`) an index used to enforce a unique or primary key. You can drop the key only when disabling it.

`partition_clause`
: Declares partitioning and subpartitioning of a table. Partitioning syntax can be quite complex; refer to "Oracle partitioned and subpartitioned tables" on page 175 for the full syntax and examples.

`AS` *`subquery`*
: Declares a *`subquery`* that inserts rows into the table upon creation. The column names and data types used in the subquery can act as substitutes for column name and attribute declarations for the table.

`AS` *`object_type`*
: Declares that the table is based on a preexisting object type.

`[NOT] SUBSTITUTABLE AT ALL LEVELS`
: Declares whether row objects corresponding to subtypes can be inserted into the type table or not. When this clause is omitted, the default is `SUBSTITUTABLE AT ALL LEVELS`.

inline_ref_constraint and *table_ref_constraint*
: Declares a reference constraint used by an object-type table or XMLType table. These clauses are described in greater detail in "Oracle XMLType and object-type tables" on page 189.

OBJECT IDENTIFIER IS {SYSTEM GENERATED | PRIMARY KEY}
: Declares whether the object ID (OID) of the object-type table is SYSTEM GENERATED or based on the PRIMARY KEY. When omitted, the default is SYSTEM GENERATED.

OIDINDEX [*index_name*]
: Declares an index, and possibly a name for the index, if the OID is system generated. You may optionally apply a *physical_attributes_clause* and a *storage_clause* to the OIDINDEX. If the OID is based on the primary key, this clause is unnecessary.

OF XMLTYPE
: Declares that the table is based on Oracle's XMLTYPE data type.

XMLTYPE {OBJECT RELATIONAL [*xml_storage_clause*] | [{SECUREFILE | BASICFILE}] [{CLOB | BINARY XML} [*lob_segname*] [*lob_params*]]
: Declares how the underlying data of the XMLType table is stored: either in LOB, object-relational, or binary XML format. OBJECT RELATIONAL stores the data in object-relational columns and allows indexing for better performance. This subclause requires an *xml_schema_spec* and a schema that has been preregistered using the DBMS_XMLSCHEMA package. CLOB specifies that the XMLTYPE data will be stored in a LOB column for faster retrieval. You may optionally specify the LOB segment name and/or the LOB storage parameters, but you cannot specify LOB details and XML schema specifications in the same statement. BINARY XML stores the data in a compact binary XML format, with any LOB parameters applied to the underlying BLOB column.

xml_schema_spec
: Allows you to specify the URLs of one or more registered XML schemas and an XML element name. The element name is required, but the URL is optional. Multiple schemas are allowed only when using the BINARY XML storage format. You may further specify ALLOW ANYSCHEMA to store any schema-based document in the XMLType column, ALLOW NONSCHEMA to store non-schema-based documents, or DISALLOW NONSCHEMA to prevent storage of non-schema-based documents.

READ ONLY | READ WRITE
: Places the table in read-only mode (READ ONLY), which disallows all DML operations including SELECT ... FOR UPDATE. Regular SELECT statements are allowed, as are operations on indexes associated with a read-only table. READ WRITE reenables normal DML operations.

`ADD ...`
: Adds a new column, virtual column, constraint, overflow segment, or supplemental log group to an existing table. You may also alter an XMLType table by adding (or removing) one or more XML schemas.

`MODIFY ...`
: Changes an existing column, constraint, or supplemental log group on an existing table.

`DROP ...`
: Drops an existing column, constraint, or supplemental log group from an existing table. You can explicitly drop columns marked as unused from a table with `DROP UNUSED COLUMNS`; however, Oracle will also drop all unused columns when *any* other column is dropped. The `INVALIDATE` keyword causes any object that depends on the dropped object, such as a view or stored procedure, to become invalid and unusable until the dependent object is recompiled or reused. The `COLUMNS CONTINUE` clause is used only when a `DROP COLUMN` statement fails with an error and you wish to continue where it left off.

`RENAME ...`
: Renames an existing table, column, or constraint on an existing table.

`SET UNUSED ...`
: Declares a column or columns to be unused. Those columns are no longer accessible from `SELECT` statements, though they still count toward the maximum number of columns allowed per table (1,000). `SET UNUSED` is the fastest way to render a column unusable within a table, but it is not the best way. Only use `SET UNUSED` as a shortcut until you can actually use `ALTER TABLE ... DROP` to drop the column.

`COALESCE`
: Merges the contents of index blocks used to maintain the index-organized table so that the blocks can be reused. `COALESCE` is similar to `SHRINK`, though `COALESCE` compacts the segments less densely than `SHRINK` and does not release unused space.

`ALLOCATE EXTENT`
: Explicitly allocates a new extent for the table using the `SIZE`, `DATAFILE`, and `INSTANCE` parameters. You may mix and match any of these parameters. The size of the extent may be specified in bytes (no suffix), kilobytes (`K`), megabytes (`M`), gigabytes (`G`), or terabytes (`T`).

`DEALLOCATE UNUSED [KEEP` *`int`* `[K | M | G | T]]`
: Deallocates unused space at the end of the table, `LOB` segment, partition, or subpartition. The deallocated space is then usable by other objects in the database. The `KEEP` keyword indicates how much space you want to have left over after deallocation is complete.

`SHRINK SPACE [COMPACT] [CASCADE]`
: Shrinks the table, index-organized table, index, partition, subpartition, materialized view, or materialized log view, though only segments in tablespaces with automatic segment management may be shrunk. Shrinking a segment moves rows in the table, so make sure `ENABLE ROW MOVEMENT` is also used in the `ALTER TABLE ... SHRINK` statement. Oracle compacts the segment, releases the emptied space, and adjusts the high-water mark unless the optional keywords `COMPACT` and/or `CASCADE` are applied. The `COMPACT` keyword only defragments the segment space and compacts the table row for subsequent release; it does not readjust the high-water mark or empty the space immediately. The `CASCADE` keyword performs the same shrinking operation (with some restrictions and exceptions) on all dependent objects of the table, including secondary indexes on index-organized tables. Used only with `ALTER TABLE`.

`UPGRADE [NOT] INCLUDING DATA`
: Converts the metadata of object tables and relational tables with object columns to the latest version for each referenced type. The `INCLUDING DATA` clause will either convert the data to the latest type format (`INCLUDING DATA`) or leave it unchanged (`NOT INCLUDING DATA`).

`MOVE` ...
: Moves the tablespace, index-organized table, partition, or subpartition to a new location on the filesystem.

`[NO]MINIMIZE RECORDS_PER_BLOCK`
: Tells Oracle to restrict or leave open the number of records allowed per block. The `MINIMIZE` keyword tells Oracle to calculate the maximum number of records per block and set the limit at that number. (Best to do this when a representative amount of data is already in the table.) This clause is incompatible with nested tables and index-organized tables. `NOMINIMIZE` is the default.

`PROJECT COLUMN {REFERENCE | ALL}`
: Determines how the driver for the external data source validates the rows of the external table in subsequent queries. `REFERENCE` processes only those columns in the `SELECT` item list. `ALL` processes the values in all columns, even those not in the `SELECT` item list, and validates rows with full and valid column entries. Under `ALL`, rows are rejected when errors occur, even on columns that are not selected. `ALL` returns consistent results, while `REFERENCE` returns varying numbers of rows depending on the columns referenced.

`{ENABLE | DISABLE} {TABLE LOCK | ALL TRIGGERS}`
: Enables or disables table-level locks and all triggers on the table, respectively. `ENABLE TABLE LOCK` is required if you wish to perform DDL operations on the table.

A global temporary table is available to all user sessions, but the data stored within a global temporary table is visible only to the session that inserted it. The `ON COMMIT` clause, which is allowed only when creating temporary tables, tells Oracle either to truncate the table after each commit against the table (`DELETE ROWS`) or to truncate the table when the session terminates (`PRESERVE ROWS`). For example, this `CREATE TABLE` statement creates a global temporary table, *shipping_schedule*, which retains inserted rows across multiple transactions:

```
CREATE GLOBAL TEMPORARY TABLE shipping_schedule
  (ship_date DATE,
   receipt_date DATE,
   received_by VARCHAR2(30),
   amt NUMBER)
ON COMMIT PRESERVE ROWS;
```

The Oracle physical_attributes_clause. The *`physical_attributes_clause`* (shown in the following code block) defines storage characteristics for an entire local table, or, if the table is partitioned, for a specific partition (discussed later). To declare the physical attributes of a new table or change the attributes of an existing table, simply declare the new values:

```
-- physical_attributes_clause
[{PCTFREE int | PCTUSED int | INITRANS int |
   storage_clause}]
```

where:

`PCTFREE` *`int`*
: Defines the percentage of free space reserved for each data block in the table. For example, a value of 10 reserves 10% of the data space for new rows to be inserted.

`PCTUSED` *`int`*
: Defines the maximum percentage of space that can be used in a block in order for it to be able to receive new rows. For example, a value of 90 means new rows are inserted in the data block when the space used falls below 90%. The sum of `PCTFREE` and `PCTUSED` cannot exceed 100.

`INITRANS` *`int`*
: Rarely tinkered with; defines the allocation of from 1 to 255 initial transactions to a data block.

In versions prior to 11*g* the `MAXTRANS` parameter was used to define the maximum allowed number of concurrent transactions on a data block, but this parameter has now been deprecated. Oracle 11*g* and later automatically set `MAXTRANS` to 255, silently overriding any other value that you specify for this parameter (although existing objects retain their established `MAXTRANS` settings).

The Oracle storage_clause and LOBs. The *storage_clause* controls a number of attributes governing the physical storage of data:

```
-- storage_clause
STORAGE ( [ {INITIAL int [K | M | G | T]
            | NEXT int [K | M]
            | MINEXTENTS int
            | MAXEXTENTS {int | UNLIMITED}
            | PCTINCREASE int
            | FREELISTS int
            | FREELIST GROUPS int
            | BUFFER_POOL {KEEP | RECYCLE | DEFAULT}} ] [...] )
```

When delineating the storage clause attributes, enclose them in parentheses and separate them with spaces—for example, `(INITIAL 32M NEXTBM)`. The attributes are as follows:

`INITIAL` *`int`* `[K | M | G | T]`
: Sets the initial extent size of the table in bytes, kilobytes (`K`), megabytes (`M`), gigabytes (`G`), or terabytes (`T`).

`NEXT` *`int`* `[K | M]`
: Specifies how much additional space to allocate after `INITIAL` is filled.

`MINEXTENTS` *`int`*
: Tells Oracle to create a minimum number of extents. By default, only one is created, but more can be created when the object is initialized.

`MAXEXTENTS` *`int`* `| UNLIMITED`
: Tells Oracle the maximum number of extents allowed. This value may be set to `UNLIMITED`, but this should be used with caution since a table could grow until it consumes all free space on a disk.

`PCTINCREASE` *`int`*
: Controls the growth rate of the object after the first growth. The initial extent gets allocated as specified, the second extent is the size specified by `NEXT`, the third extent is `NEXT + (NEXT * PCTINCREASE)`, and so on. When `PCTINCREASE` is set to 0, `NEXT` is always used. Otherwise, each added extent of storage space is `PCTINCREASE` larger than the previous extent.

`FREELISTS` *`int`*
: Establishes the number of freelists for each group, defaulting to 1.

`FREELIST GROUPS` *`int`*
: Sets the number of groups of freelists, defaulting to 1.

`BUFFER_POOL {KEEP | RECYCLE | DEFAULT}`
: Specifies a default buffer pool or cache for any non-clustered table where all object blocks are stored. Index-organized tables may have a separate buffer pool for the index and overflow segments. Partitioned tables inherit the buffer

pool from the table definition unless they are specifically assigned a separate buffer pool.

`KEEP`
: Puts object blocks into the `KEEP` buffer pool; that is, directly into memory. This enhances performance by reducing I/O operations on the table. `KEEP` takes precedence over the `NOCACHE` clause.

`RECYCLE`
: Puts object blocks into the `RECYCLE` buffer pool.

`DEFAULT`
: Puts object blocks into the `DEFAULT` buffer pool. When this clause is omitted, `DEFAULT` is the default buffer pool behavior.

In the following example, the table *books_sales* is defined on the *sales* tablespace as consuming an initial 8 MB of space, to grow by no less than 8 MB when the first extent is full. The table has no less than one and no more than eight extents, limiting its maximum size to 64 MB:

```
CREATE TABLE book_sales
  (qty NUMBER,
   period_end_date DATE,
   period_nbr NUMBER)
TABLESPACE sales
STORAGE (INITIAL 8M NEXT 8M MINEXTENTS 1 MAXEXTENTS 8);
```

A `LOB` table called *large_objects* with special handling for text and image storage might look like this:

```
CREATE TABLE large_objects
  (pretty_picture BLOB,
   interesting_text CLOB)
STORAGE (INITIAL 256M NEXT 256M)
LOB (pretty_picture, interesting_text)
   STORE AS (TABLESPACE large_object_segment
      STORAGE (INITIAL 512M NEXT 512M)
      NOCACHE LOGGING);
```

The exact syntax used to define a `LOB`, `CLOB`, or `NCLOB` column is defined by the *`lob_parameter_clause`*. `LOB`s can appear at many different levels within an Oracle table. For instance, separate `LOB` definitions could exist in a single table in a partition definition, in a subpartition definition, and at the top table-level definition. The syntax of the *`lob_parameter_clause`* follows:

```
{TABLESPACE tablespace_name] [{SECUREFILE | BASICFILE}]
  [{ENABLE | DISABLE} STORAGE IN ROW]
  [storage_clause] [CHUNK int] [PCTVERSION int]
  [RETENTION [{MAX | MIN int | AUTO | NONE}]]
  [{DEDUPLICATE | KEEP_DUPLICATES}]
  [{NOCOMPRESS | COMPRESS [{HIGH | MEDIUM}]}]
```

```
    [FREEPOOLS int]
  [{CACHE | {NOCACHE | CACHE READS} [{LOGGING | NOLOGGING}]}]
```

In the *lob_parameter_clause*, each parameter is identical to that at the wider CREATE TABLE LOB object level. However, the following parameters are unique to LOBs:

SECUREFILE | BASICFILE
: Specifies use of either the high-performance LOB storage (SECUREFILE) or the traditional LOB storage (BASICFILE, the default). When using SECUREFILE, you get access to other features such as LOB compression, encryption, and deduplication.

{ENABLE | DISABLE} STORAGE IN ROW
: Defines whether the LOB value is stored inline with the other columns of the row and the LOB locator (ENABLE), when it is smaller than approximately 4,000 bytes, or outside of the row (DISABLE). This setting cannot be changed once it is set.

CHUNK *int*
: Allocates *int* number of bytes for LOB manipulation. *int* should be a multiple of the database block size; otherwise, Oracle will round up. *int* should also be less than or equal to the value of NEXT, from the *storage_clause*, or an error will be raised. When omitted, the default chunk size is one block. This setting cannot be changed once it is set.

PCTVERSION *int*
: Defines the maximum percentage (*int*) of the overall LOB storage dedicated to maintaining old versions of the LOB. When omitted, the default is 10%.

RETENTION [{MAX | MIN *int* | AUTO | NONE}]
: Used in place of PCTVERSION on databases in automatic undo mode. RETENTION tells Oracle to retain old versions of the LOB. When using SECUREFILE, you may specify additional options. MAX tells Oracle to allow the undo file to grow until the LOB segment has reached its maximum size, as defined by the MAXSIZE value of the *storage_clause*. MIN limits undo to *int* seconds if the database is in flashback mode. AUTO, the default, maintains enough undo for consistent reads. NONE specifies that the undo is not required.

DEDUPLICATE | KEEP_DUPLICATES
: Specifies whether to keep duplicate LOB values within an entire LOB segment (KEEP_DUPLICATES) or to eliminate duplicate copies (DEDUPLICATE, the default). Only usable with SECUREFILE LOBs.

NOCOMPRESS | COMPRESS [{HIGH | MEDIUM}]
: NOCOMPRESS, the default, disables server-side compression of LOBs in the SECUREFILE format. Alternatively, you may tell Oracle to compress LOBs using either

a MEDIUM (the default when a value is omitted) or HIGH degree of compression (HIGH compression incurs more overhead).

The following example shows our *large_objects* LOB table with added parameters to control inline storage and retention of old LOBs:

```
CREATE TABLE large_objects
  (pretty_picture BLOB,
   interesting_text CLOB)
STORAGE (INITIAL 256M NEXT 256M)
LOB (pretty_picture, interesting_text)
   STORE AS (TABLESPACE large_object_segment
      STORAGE (INITIAL 512M NEXT 512M)
      NOCACHE LOGGING
      ENABLE STORAGE IN ROW
      RETENTION);
```

The earlier example added parameter values for STORAGE IN ROW and RETENTION, but since we did not set one for CHUNK, that value is set to the Oracle default for the LOB.

Oracle nested tables. Oracle allows the declaration of a NESTED TABLE, in which a table is virtually stored within a column of another table. The STORE AS clause enables a proxy name for the table within a table, but the nested table must be created initially as a user-defined data type. This capability is valuable for sparse arrays of values, but we don't recommend it for day-to-day tasks. This example creates a table called *proposal_types* along with a nested table called *props_nt*, which is stored as *props_nt_table*:

```
CREATE TYPE prop_nested_tbl AS TABLE OF props_nt;
CREATE TABLE proposal_types
   (proposal_category VARCHAR2(50),
    proposals PROPS_NT)
NESTED TABLE props_nt STORE AS props_nt_table;
```

Oracle compressed tables. Oracle allows compression of both keys and entire tables. Although compression adds a tiny bit of overhead, it significantly reduces the amount of disk space consumed by a table. This is especially useful for databases pushing the envelope in terms of size. Key compression is handled in the ORGANIZE INDEX clause, while table compression is handled in the ORGANIZE HEAP clause.

Oracle partitioned and subpartitioned tables. Oracle allows tables to be partitioned and subpartitioned. You can also break out LOBs onto their own partition(s). A partitioned table may be broken into distinct parts, possibly placed on separate disk subsystems to improve I/O performance (based on four strategies: range, hash, list, or a composite of the first three), or on a system partition. The partitioning syntax is quite elaborate:

```
{ PARTITION BY RANGE (column[, ...])
   [INTERVAL (expression) [STORE IN (tablespace[, ...])]]
   (PARTITION [partition_name]
      VALUES LESS THAN ({MAXVALUE | value}[, ...])
      [table_partition_description]) |
   PARTITION BY HASH (column[, ...])
      {(PARTITION [partition_name]
         [partitioning_storage_clause][, ...]) |
         PARTITIONS hash_partition_qty [STORE IN (tablespace[, ...])]
         [OVERFLOW STORE IN (tablespace[, ...])]} |
   PARTITION BY LIST (column[, ...]) (PARTITION [partition_name]
      VALUES ({MAXVALUE | value}[, ...])
      [table_partition_description]) |
   PARTITION BY RANGE (column[, ...])
      {subpartition_by_list | subpartition_by_hash}
      (PARTITION [partition_name] VALUES LESS THAN
         ({MAXVALUE | value}[, ...])
      [table_partition_description]) |
   PARTITION BY SYSTEM [int] |
   PARTITION BY REFERENCE (constraint)
      [ (PARTITION [partition_name] [table_partition_description]
         [, ...]) ] }
```

The following example code shows the *orders* table partitioned by range:

```
CREATE TABLE orders
   (order_number NUMBER,
   order_date    DATE,
   cust_nbr      NUMBER,
   price         NUMBER,
   qty           NUMBER,
   cust_shp_id   NUMBER)
PARTITION BY RANGE(order_date)
   (PARTITION pre_yr_2010 VALUES LESS THAN
      TO_DATE('01-JAN-2010', 'DD-MON-YYYY'),
   PARTITION pre_yr_2014 VALUES LESS THAN
      TO_DATE('01-JAN-2014', 'DD-MON-YYYY'
   PARTITION post_yr_2014 VALUES LESS THAN
      MAXVALUE));
```

This example creates three partitions on the *orders* table—one for the orders taken before the year 2010 (*pre_yr_2010*), one for the orders taken before the year 2014 (*pre_yr_2014*), and another for the orders taken after the year 2014 (*post_yr_2014*)—all based on the range of dates that appear in the *order_date* column.

The `INTERVAL` clause further facilitates range partitioning on numeric or datetime values by automatically creating new partitions when the current range boundaries are exceeded. The interval *`expression`* defines a valid number for the range boundary. Use the `STORE IN` subclause to tell Oracle which tablespace(s) will store the interval partition data. You cannot use interval partitioning on index-organized tables, with domain indexes, or at a subpartition level.

The next example creates the *orders* table based on a hash value in the *cust_shp_id* column:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER)
PARTITION BY HASH (cust_shp_id)
   (PARTITION  shp_id1 TABLESPACE tblspc01,
    PARTITION  shp_id2 TABLESPACE tblspc02,
    PARTITION  shp_id3 TABLESPACE tblspc03)
ENABLE ROW MOVEMENT;
```

The big difference in how the records are divided among partitions between the hash partition example and the range partition example is that the range partition code explicitly defines where each record goes, while the hash partition code allows Oracle to decide (by applying a hash algorithm) which partition to place the record in. (Note that we also enabled row movement for the table).

In addition to breaking tables apart into partitions (for easier backup, recovery, or performance reasons), you may further break them apart into subpartitions. The *`subpartition_by_list`* clause syntax follows:

```
SUBPARTITION BY LIST (column)
[SUBPARTITION TEMPLATE
   { (SUBPARTITION subpartition_name
         [VALUES {DEFAULT | {val | NULL}[, ...]}]
         [partitioning_storage_clause]) |
      hash_subpartition_qty } ]
```

As an example, we'll re-create the *orders* table once again, this time using a range-hash composite partition. In a range-hash composite partition, the partitions are broken apart by range values, while the subpartitions are broken apart by hashed values. List partitions and subpartitions are broken apart by a short list of specific values. Because you must list out all the values by which the table is partitioned, the partition value is best taken from a small list of values. In this example, we've added a column (*shp_region_id*) that allows four possible regions:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER,
    shp_region    VARCHAR2(20))
PARTITION BY RANGE(order_date)
SUBPARTITION BY LIST(shp_region)
   SUBPARTITION TEMPLATE(
      (SUBPARTITION shp_region_north
         VALUES ('north','northeast','northwest'),
       SUBPARTITION shp_region_south
         VALUES ('south','southeast','southwest'),
       SUBPARTITION shp_region_central
         VALUES ('midwest'),
       SUBPARTITION shp_region_other
         VALUES ('alaska','hawaii','canada')
   (PARTITION pre_yr_2000 VALUES LESS THAN
      TO_DATE('01-JAN-2000', 'DD-MON-YYYY'),
   PARTITION pre_yr_2014 VALUES LESS THAN
      TO_DATE('01-JAN-2014', 'DD-MON-YYYY'
   PARTITION post_yr_2014 VALUES LESS THAN
      MAXVALUE) )
ENABLE ROW MOVEMENT;
```

This code example sends the records of the table to one of three partitions based on the *order_date*, and further partitions the records into one of four subpartitions based on the region where the order is being shipped and on the value of the *shp_region* column. By using the `SUBPARTITION TEMPLATE` clause, you apply the same set of subpartitions to each partition. You can manually override this behavior by specifying subpartitions for each partition.

You may also subpartition using a hashing algorithm. The *`subpartition_by_hash`* clause syntax follows:

```
SUBPARTITION BY HASH (column[, ...])
   {SUBPARTITIONS qty [STORE IN (tablespace_name[, ...])] |
    SUBPARTITION TEMPLATE
      { (SUBPARTITION subpartition_name [VALUES {DEFAULT | {val | NULL)
            [, ...])] [partitioning_storage_clause]) |
         hash_subpartition_qty ))
```

The *`table_partition_description`* clause referenced in the partitioning syntax is, in itself, very flexible and supports precise handling of `LOB` and `VARRAY` data:

```
[segment_attr_clause] [[NO] COMPRESS [int]]
    [OVERFLOW segment_attr_clause]
[partition_level_subpartition_clause]
[{ LOB { (lob_item[, ...]) STORE AS lob_param_clause |
      (lob_item) STORE AS {lob_segname (log_param_clause) |
         log_segname | (log_param_clause)} } |
   VARRAY varray_item [{[ELEMENT] IS OF [TYPE] (ONLY type_name) |
         [NOT] SUBSTITUTABLE AT ALL LEVELS}]
         STORE AS LOB { log_segname |
            [log_segname] (log_param_clause) } |
      [{[ELEMENT] IS OF [TYPE] (ONLY type_name) |
         [NOT] SUBSTITUTABLE AT ALL LEVELS}] }]
```

The *`partition_level_subpartition_clause`* syntax follows:

```
{SUBPARTITIONS hash_subpartition_qty
    [STORE IN (tablespace_name[, ...])] |
   SUBPARTITION subpartition_name
   [VALUES {DEFAULT | {val | NULL}[, ...] ]
      [partitioning_storage_clause] }
```

The *`partitioning_storage_clause`*, like the table-level *`storage_clause`* defined earlier, defines how elements of a partition (or subpartition) are stored. The syntax follows:

```
[[TABLESPACE tablespace_name] | [OVERFLOW TABLESPACE tablespace_name] |
   VARRAY varray_item STORE AS LOB log_segname |
   LOB (lob_item) STORE AS { (TABLESPACE tablespace_name) |
      log_segname [(TABLESPACE tablespace_name)] }]
```

`SYSTEM` partitioning is simple because it does not require partitioning key columns or range or list boundaries. Instead, `SYSTEM` partitions are equipartitioned subordinate tables, like nested tables or domain index storage tables, whose parent table is partitioned. If you leave off the *`int`* variable, Oracle will create one partition called *SYS_Pint*. Otherwise, it will create *`int`* number of partitions, up to a limit of 1,024K – 1. System partitioned tables are similar to other partitioned or subpartitioned tables, but they do not support the `OVERFLOW` clause within the *`table_partition_description`* clause.

`REFERENCE` partitioning is allowable only when the table is created. It enables equipartitioning of a table based on a referential integrity constraint found in an existing partitioned parent table. All maintenance on the subordinate table with `REFERENCE` partitioning occurs automatically,because operations on the parent partition automatically cascade to the subordinate table.

In this final partitioning example, we'll again re-create the *orders* table using a composite range-hash partition, this time with `LOB` (actually, an `NCLOB` column) and storage elements:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER,
    shp_region    VARCHAR2(20),
    order_desc    NCLOB)
PARTITION BY RANGE(order_date)
SUBPARTITION BY HASH(cust_shp_id)
   (PARTITION pre_yr_2000 VALUES LESS THAN
      TO_DATE('01-JAN-2000', 'DD-MON-YYYY') TABLESPACE tblspc01
         LOB (order_desc) STORE AS (TABLESPACE tblspc_a01
            STORAGE (INITIAL 10M NEXT 20M) )
         SUBPARTITIONS subpartn_a,
   PARTITION pre_yr_2014 VALUES LESS THAN
      TO_DATE('01-JAN-2014', 'DD-MON-YYYY') TABLESPACE tblspc02
         LOB (order_desc) STORE AS (TABLESPACE tblspc_a02
            STORAGE (INITIAL 25M NEXT 50M) )
      SUBPARTITIONS subpartn_b TABLESPACE tblspc_x07,
   PARTITION post_yr_2014 VALUES LESS THAN
      MAXVALUE (SUBPARTITION subpartn_1,
         SUBPARTITION subpartn_2,
         SUBPARTITION subpartn_3
         SUBPARTITION subpartn_4) )
ENABLE ROW MOVEMENT;
```

In this somewhat more complex example, we define the *orders* table with the added NCLOB table called *order_desc*. In the *pre_yr_2010* and *pre_yr_2014* partitions, we specify that all of the non-LOB data goes to tablespaces *tblspc01* and *tblspc02*, respectively. However, the NCLOB values of the *order_desc* column will be stored in the *tblespc_a01* and *tblspc_a02* partitions, respectively, with their own unique storage characteristics. Note that the subpartition *subpartn_b* under the partition *pre_yr_2014* is also stored in its own tablespace, *tblspc_x07*. Finally, the last partition (*post_yr_2014*) and its subpartitions are stored in the default tablespace for the *orders* table, because no partition- or subpartition-level TABLESPACE clause overrides the default.

Altering partitioned and subpartitioned tables. Anything about partitions and subpartitions that is explicitly set by the CREATE TABLE statement may be altered after the table is created. Many of the clauses shown here (for example, the SUBPARTITION TEMPLATE and MAPPING TABLE clauses) are merely repetitions of clauses that were described earlier; descriptions of these clauses will not be repeated. Altering the partitions and/or subpartitions of an Oracle table is governed by this syntax:

```
   ALTER TABLE table_name
      [MODIFY DEFAULT ATTRIBUTES [FOR PARTITION partn_name]
         [physical_attributes_clause] [storage_clause] [PCTTHRESHOLD int]
         [{ADD OVERFLOW ... | OVERFLOW ...}] [[NO]COMPRESS]
         [{LOB (lob_name) | VARRAY varray_name} [(lob_parameter_clause)]]
         [COMPRESS int | NOCOMPRESS]]
      [SET SUBPARTITION TEMPLATE {hash_subpartn_quantity |
         (SUBPARTITION subpartn_name [partn_list] [storage_clause])}]
      [ { SET INTERVAL (expression) |
          SET SET STORE IN (tablespace[, ...]) } ]
      [MODIFY PARTITION partn_name
         {[table_partition_description] |
            [[REBUILD] UNUSABLE LOCAL INDEXES] |
            [ADD [subpartn specification]] |
            [COALESCE SUBPARTITION [[NO]PARALLEL] [update_index_clause]] |
            [{ADD | DROP} VALUES (partn_value[, ...])] |
            [MAPPING TABLE {ALLOCATE EXTENT ... | DEALLOCATE UNUSED ...}]}
      [MODIFY SUBPARTITION subpartn_name {hash_subpartn_attributes |
         list_subpartn_attributes}]
      [MOVE {PARTITION | SUBPARTITION} partn_name
         [MAPPING TABLE] [table_partition_description] [[NO]PARALLEL]
         [update_index_clause]]
      [ADD PARTITION [partn_name] [table_partition_description]
         [[NO]PARALLEL] [update_index_clause]]
      [COALESCE PARTITION [[NO]PARALLEL] [update_index_clause]]
      [DROP {PARTITION | SUBPARTITION} partn_name [[NO]PARALLEL]
         [update_index_clause]]
      [RENAME {PARTITION | SUBPARTITION} old_partn_name TO new_partn_name]
      [TRUNCATE {PARTITION | SUBPARTITION} partn_name
         [{DROP | REUSE} STORAGE] [[NO]PARALLEL] [update_index_clause]]
      [SPLIT {PARTITION | SUBPARTITION} partn_name {AT | VALUES}
          (value[, ...])
         [INTO (PARTITION [partn_name1]
            [table_partition_description],
         PARTITION [partn_name2]
            [table_partition_description])]
         [[NO]PARALLEL] [update_index_clause]]
      [MERGE {PARTITION | SUBPARTITION} partn_name1, partn_name2
         [INTO PARTITION [partn_name] [partn_attributes]] [[NO]PARALLEL]
         [update_index_clause]]
      [EXCHANGE {PARTITION | SUBPARTITION} partn_name
         WITH TABLE table_name [{INCLUDING | EXCLUDING} INDEXES]
         [{WITH | WITHOUT} VALIDATION] [[NO]PARALLEL]
         [update_index_clause] [EXCEPTIONS INTO table_name]]
```

where:

`MODIFY DEFAULT ATTRIBUTES [FOR PARTITION` *`partn_name`*`]`
: Modifies a wide variety of attributes for the current partition or a specific partition identified by *`partn_name`*. Refer to the previous section for details on partition attributes.

`SET SUBPARTITION TEMPLATE {`*`hash_subpartn_quantity`*`|(SUBPARTITION` *`subpartn_name`*`[`*`partn_list`*`] [`*`storage_clause`*`])}`
: Sets a new subpartition template for the table.

`SET INTERVAL (`*`expression`*`|SET SET STORE IN (`*`tablespace`*`[, ... ])`
: Converts a range-partitioned table to an interval-partitioned table or, using `SET STORE IN`, changes the tablespace storage of an existing interval-partitioned table. You can change an interval-partitioned table back to a range-partitioned table using the syntax `SET INTERVAL ()`.

`MODIFY PARTITION` *`partn_name`*
: Changes a wide variety of physical and storage characteristics, including the storage properties of `LOB` and `VARRAY` columns, of a preexisting partition or subpartition called *`partn_name`*. Additional syntax may be appended to the `MODIFY PARTITION` *`partn_name`* clause:

```
    { [table_partition_description] | [[REBUILD] UNUSABLE LOCAL INDEXES] |
       [ADD [subpartn_specification]] |
       [COALESCE SUBPARTITION [[NO]PARALLEL] [update_index_clause]
          { [{UPDATE | INVALIDATE} GLOBAL INDEXES] |
             UPDATE INDEXES [ (index_name (
             {index_partn | index_subpartn} ))[, ...] ] } ] |
       [{ADD | DROP} VALUES (partn_value[, ...])] |
       [MAPPING TABLE {ALLOCATE EXTENT ... | DEALLOCATE UNUSED ...}] }
```

where:

`table_partition_description`
: Can be used on any partitioned table; described in the previous section.

`[REBUILD] UNUSABLE LOCAL INDEXES`
: Marks the local index partition as `UNUSABLE`. Adding the optional `REBUILD` keyword tells Oracle to rebuild the unusable local index partition as part of the operation performed by the `MODIFY PARTITION` statement. This clause may not be used with any other subclause of the `MODIFY PARTITION` statement, nor may it be used on tables with subpartitions. This clause may be used on any partitioned table.

`ADD [`*`subpartn_specification`*`]`
: Adds a hash or list subpartition specification, as described in the previous section, to an existing range partition. This clause may be used to define range-hash or range-list composite partitions only. Oracle populates the new subpartition with rows from other subpartitions using either the hash function or the list values you specify. We recommend the total number of subpartitions be set to a power of 2 for optimal load balancing. You may add range-list subpartitions only if the table does not already have a `DEFAULT` subpartition. When adding range-list subpartitions, the list value clause is required, but it cannot duplicate values found in any other subpartition of the current partition. The only storage or physical attribute you may couple with this clause for both range-hash and range-list subpartitions is the `TABLESPACE` clause. Adding the clause `DEPENDENT TABLES (`*`table_name`*` (`*`partn_specification`*`[, ... ])[, ... ]) [ {UPDATE | INVALIDATE} [GLOBAL] INDEXES (`*`index_name`*` (`*`index_partn`*`)[, ... ])) ]` instructs Oracle to cascade partition maintenance and alteration operations on a table to any reference-partitioned child tables (and/or indexes) that may exist.

`COALESCE SUBPARTITION [[NO]PARALLEL] [`*`update_index_clause`*`]`
: Coalesces the subpartition of a range-hash composite partitioned table. This clause tells Oracle to distribute the contents of the last hash subpartition to one or more remaining subpartitions in the set, and then drop the last hash subpartition. Oracle also drops local index subpartitions corresponding to the subpartition you are coalescing. The *`update_index_clause`* is described later in this list. Global indexes may be updated or invalidated using the syntax `{UPDATE | INVALIDATE} GLOBAL INDEXES`. In addition, local indexes, index partitions, or index subpartitions may be updated using the syntax `UPDATE INDEXES (`*`index_name`*` ({`*`index_partn`*` | `*`index_subpartn`*`}))`.

`{ADD | DROP} VALUES (`*`partn_value`*`[, ... ])`
: Adds a new value (or values) or drops existing values on an existing list-partitioned table, respectively. Local and global indexes are not affected by this clause. Values cannot be added to or dropped from a `DEFAULT` list partition.

`MAPPING TABLE {ALLOCATE EXTENT ... | DEALLOCATE UNUSED ... }`
: Defines a mapping table for a partitioned table that is an IOT. The `ALLOCATE EXTENT` and `DEALLOCATE UNUSED` clauses were described earlier, in the syntax description list for the `CREATE TABLE` statement. This clause may be used on any type of partitioned table, as long as the table is an index-organized table.

`MODIFY SUBPARTITION` *`subpartn_name`* `{`*`hash_subpartn_attributes`* `|` *`list_subpartn_attributes`*`}`
: Modifies a specific hash or list subpartition according to the subpartition attributes described in the previous section.

`MOVE {PARTITION | SUBPARTITION}` *`partn_name`* `[MAPPING TABLE] [`*`table_partition_description`*`] [[NO]PARALLEL] [`*`update_index_clause`*`]`
: Moves a specified partition (or subpartition) identified by *`partn_name`* to another partition (or subpartition) described in the *`table_partition_description`* clause. Moving a partition is I/O-intensive, so the optional `PARALLEL` clause may be used to parallelize the operation. When it's omitted, `NOPARALLEL` is the default. In addition, you may optionally update or invalidate the local and global index, as described in the *`update_index_clause`* discussed later in this list.

`ADD PARTITION [`*`partn_name`*`] [`*`table_partition_description`*`] [[NO]PARALLEL] [`*`update_index_clause`*`]`
: Adds a new partition (or subpartition) called *`partn_name`* to the table. The `ADD PARTITION` clause supports all aspects of creating a new partition or subpartition, via the *`table_partition_description`* clause. Adding a partition may be I/O-intensive, so the optional `PARALLEL` clause may be used to parallelize the operation. When it's omitted, `NOPARALLEL` is the default. In addition, you may optionally update or invalidate local and global indexes on the table using the *`update_index_clause`*.

`update_index_clause`
: Controls the status assigned to indexes once the partitions and/or subpartitions of a table are altered. By default, Oracle invalidates the entire index(es) of a table, not just those portions of the index on the partition and/or subpartition being altered. You may update or invalidate global indexes on the table *or* update one or more specific index(es) on the table, respectively, using this syntax:

```
[{UPDATE | INVALIDATE} GLOBAL INDEXES] |
  UPDATE INDEXES [(index_name ({index_partn|index_subpartn}))[, ...]]
```

COALESCE PARTITION [[NO]PARALLEL] [*update_index_clause*]

Takes the contents of the last partition of a set of hash partitions and rehashes the contents to one or more of the other partitions in the set. The last partition is then dropped. Obviously, this clause is only for use with hash partitions. The *update_index_clause* may be applied to update or invalidate the local and/or global indexes of the table being coalesced.

DROP {PARTITION | SUBPARTITION} *partn_name* [[NO]PARALLEL] [*update_index_clause*]

Drops an existing range or list partition or subpartition identified by *partn_name* from the table. The data within the partition is also dropped. If you want to keep the data, use the MERGE PARTITION clause. If you want to get rid of a hash partition or subpartition, use the COALESCE PARTITION clause. Tables with only a single partition are not affected by the ALTER TABLE ... DROP PARTITION statement; instead, use the DROP TABLE statement.

RENAME {PARTITION | SUBPARTITION} *old_partn_name* TO *new_partn_name*

Renames an existing partition or subpartition from *old_partn_name* to *new_partn_name*.

TRUNCATE {PARTITION | SUBPARTITION} *partn_name* [{DROP | REUSE} STORAGE] [[NO]PARALLEL] [*update_index_clause*]

Removes all of the rows of a partition or subpartition identified by *partn_name*. If you truncate a composite partition, all the rows of the subpartition(s) are also dropped. On IOTs, mapping table partitions and overflow partitions are also truncated. LOB data and index segments, if the table has any LOB columns, are also truncated. Finally, disable any existing referential integrity constraints on the data, or else delete the rows from the table first, then truncate the partition or subpartition. The optional DROP and REUSE STORAGE subclauses define whether the space freed by the truncated data is made available for other objects in the tablespace or remains allocated to the original partition or subpartition.

SPLIT {PARTITION | SUBPARTITION} *partn_name* {AT | VALUES} (*value*[, ...]) [INTO (PARTITION [*partn_name1*] [*table_partition_description*]), (PARTITION [*partn_name2*] [*table_partition_description*])] [[NO]PARALLEL] [*update_index_clause*]

Creates from the current partition (or subpartition) identified by *partn_name* two new partitions (or subpartitions) called *partn_name1* and *partn_name2*. These new partitions may have their own complete specification, as defined by the *table_partition_description* clause. When such a specification is omitted, the new partitions inherit all physical characteristics of the current partition. When splitting a DEFAULT partition, all of the split values go to *partn_name1*, while all of the default values go to *partn_name2*. For IOTs, Oracle splits any mapping table partition in a manner corresponding to the split. Oracle also splits LOB and OVERFLOW segments, but you may specify your own `LOB` and `OVERFLOW` storage characteristics, as described in "The Oracle storage_clause and LOBs" on page 172.

`{AT | VALUES} (`*`value`*`[, ... ])`
: Splits range partitions (using `AT`) or list partitions (using `VALUES`) according to the *`value`*(s) you specify. The `AT (`*`value`*`[, ... ])` clause defines the new noninclusive upper range for the first of the two new partitions. The new value should be less than the partition boundary of the current partition, but greater than the partition boundary of the next-lowest partition (if one exists). The `VALUES (`*`value1`*`[, ... ])` clause defines the values to go into the first of the two new list partitions. The first new list partition is built from *`value1`*, and the second is built from the remaining partition values in the current partition identified by *`partn_name`*. The value list must include values that already exist in the current partition, but it cannot contain all of the values of the current partition.

`INTO (PARTITION [`*`partn_name1`*`] [`*`table_partition_description`*`]),`
`(PARTITION [`*`partn_name2`*`] [`*`table_partition_description`*`])`
: Defines the two new partitions that result from the split. At a minimum, the two `PARTITION` keywords, in parentheses, are required. Any characteristics not explicitly declared for the new partitions are inherited from the current partition identified by *`partn_name`*, including any subpartitioning. There are a few restrictions to note. When subpartitioning range-hash composite partitioned tables, only the `TABLESPACE` value is allowed for the subpartitions. Subpartitioning is not allowed at all when splitting range-list composite partitioned tables. Any indexes on heap-organized tables are invalidated by default when the table is split. You must use the *`update_index_clause`* to update their status.

`MERGE {PARTITION | SUBPARTITION}` *`partn_name1, partn_name2`*
`[INTO PARTITION [`*`partn_name`*`] [`*`partn_attributes`*`]] [[NO]PARALLEL]`
`[`*`update_index_clause`*`]`
: Merges the contents of two or more partitions or subpartitions of a table into a single new partition. Oracle then drops the two original partitions. Merged range partitions must be adjacent and are then bound by the higher boundary of the original two partitions when merged. Merged list partitions need not be adjacent and result in a single new partition with a union of the two sets of partition values. If one of the list partitions was the `DEFAULT` partition, the new partition will be the `DEFAULT`. Merged range-list composite partitions are allowed but may not have a new subpartition template. Oracle creates a subpartition template from the existing one(s) or, if none exist, creates a new `DEFAULT` subpartition. Physical attributes not defined explicitly are inherited from the table-level settings. By default, Oracle makes all local index partitions and global indexes `UNUSABLE` unless you override this behavior using the *`update_index_clause`*. (The exception to this rule is with IOTs, which, being index-based, will remain `USABLE` throughout the merge operation.) Merge

operations are not allowed on hash-partitioned tables; use the `COALESCE PARTITION` clause instead.

`EXCHANGE {PARTITION | SUBPARTITION}` *`partn_name`* `WITH TABLE` *`table_name`*`[{INCLUDING | EXCLUDING} INDEXES] [{WITH | WITHOUT} VALIDATION] [[NO]PARALLEL] [`*`update_index_clause`*`] [EXCEPTIONS INTO` *`table_name`*`]`

Exchanges the data and index segments of a nonpartitioned table with those of a partitioned table, or the data and index segments of a partitioned table of one type with those of a partitioned table of another type. The structure of the tables in the exchange must be identical, including the same primary key. All segment attributes (e.g., tablespaces, logging, and statistics) of the current partitioned table, called *`partn_name`*, and the table it is being exchanged with, called *`table_name`*, are exchanged. Tables containing `LOB` columns will also exchange `LOB` data and index segments. Additional syntax details that have not previously been defined elsewhere in this list follow:

`WITH TABLE` *`table_name`*

Defines the table that will exchange segments with the current partition or subpartition.

`{INCLUDING | EXCLUDING} INDEXES`

Exchanges local index partitions or subpartitions with the table index (on nonpartitioned tables) or the local index (on hash-partitioned tables), using the `INCLUDING INDEXES` clause. Alternatively, marks all index partitions and subpartitions as well as regular indexes and partitioned indexes of the exchanged table with the `UNUSABLE` status, using the `EXCLUDING INDEXES` clause.

`{WITH | WITHOUT} VALIDATION`

Returns errors when any rows in the current table fail to map into a partition or subpartition of the exchanged table, using the `WITH VALIDATION` clause. Alternatively, the `WITHOUT VALIDATION` clause may be included to skip checking of row mapping between the tables.

`EXCEPTIONS INTO` *`table_name`*

Places the `ROWID`s of all rows violating a `UNIQUE` constraint (in `DISABLE VALIDATE` state) on the partitioned table. When this clause is omitted, Oracle assumes there is a table in the current schema called `EXCEPTIONS`. The `EXCEPTIONS` table is defined in the *utlexcpt.sql* and *utlexpt1.sql* scripts that ship with Oracle. Refer to the Oracle documentation if you need these scripts.

There are a couple of caveats to remember about altering a partitioned table. First, altering a partition on a table that serves as the source for one or more materialized views requires that the materialized views be refreshed. Second, bitmap join indexes defined on the partitioned table being altered will be marked `UNUSABLE`. Third, several restrictions apply if the partitions (or subpartitions) are ever spread across tablespaces that use different block sizes. Refer to the Oracle documentation when attempting these sorts of alterations to a partitioned table.

In the next few examples, assume we are using the *orders* table, partitioned as shown here:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER)
PARTITION BY RANGE(order_date)
   (PARTITION pre_yr_2010 VALUES LESS THAN
      TO_DATE('01-JAN-2010', 'DD-MON-YYYY'),
    PARTITION pre_yr_2014 VALUES LESS THAN
      TO_DATE('01-JAN-2014', 'DD-MON-YYYY'
    PARTITION post_yr_2014 VALUES LESS THAN
      MAXVALUE));
```

The following statement will mark all of the local index partitions as `UNUSABLE` in the *orders* table for the *post_yr_2014* partition:

```
ALTER TABLE orders MODIFY PARTITION post_yr_2014
   UNUSABLE LOCAL INDEXES;
```

However, say we've decided to now split the *orders* table partition *post_yr_2014* into two new partitions, *pre_yr_2018* and *post_yr_2018*. Values that are now less than `MAXVALUE` will be stored in the *post_yr_2018* partition, while values less than `'01-JAN-2018'` will be stored in *pre_yr_2018*:

```
ALTER TABLE orders SPLIT PARTITION post_yr_2014
   AT (TO_DATE('01-JAN-2018','DD-MON-YYYY'))
   INTO (PARTITION pre_yr_2018, PARTITION post_yr_2018);
```

Assuming that the *orders* table contained a `LOB` or a `VARRAY` column, we could further refine the alteration by including additional details for handling these columns, while also updating the global indexes as the operation completes:

```
ALTER TABLE orders SPLIT PARTITION post_yr_2014
   AT (TO_DATE('01-JAN-2018','DD-MON-YYYY'))
   INTO
      (PARTITION pre_yr_2018
         LOB (order_desc) STORE AS (TABLESPACE order_tblspc_a1),
       PARTITION post_yr_2018)
         LOB (order_desc) STORE AS (TABLESPACE order_tblspc_a1) )
   UPDATE GLOBAL INDEXES;
```

Now, assuming the *orders* table has been grown at the upper end, let's merge together the partitions at the lower end:

```
ALTER TABLE orders
   MERGE PARTITIONS pre_yr_2010, pre_yr_2014
   INTO PARTITION yrs_2014_and_earlier;
```

After a few more years have passed, we might want to get rid of the oldest partition, or at least give it a better name:

```
ALTER TABLE orders DROP PARTITION yrs_2014_and_earlier;
ALTER TABLE orders
  RENAME PARTITION yrs_2014_and_earlier TO pre_yr_2014;
```

Finally, let's truncate a table partition, delete all of its data, and return the empty space for use by other objects in the tablespace:

```
ALTER TABLE orders
   TRUNCATE PARTITION pre_yr_2014
   DROP STORAGE;
```

As these examples illustrate, anything related to partitioning and subpartitioning that can be created with the Oracle `CREATE TABLE` statement can later be changed, augmented, or cut down using the Oracle `ALTER TABLE` statement.

Organized tables: Heaps, IOTs, and external tables. Oracle offers powerful means of controlling the physical storage behavior of tables. The most useful aspect of the `ORGANIZATION HEAP` clause is that you can now compress an entire table within Oracle. This is extremely useful for reducing disk storage costs in database environments with multiterabyte tables. The following example creates the *orders* table in a compressed and logged heap, along with a primary key constraint and storage details:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER,
    shp_region    VARCHAR2(20),
    order_desc    NCLOB,
CONSTRAINT ord_nbr_pk PRIMARY KEY (order_number))
ORGANIZATION HEAP
   COMPRESS LOGGING
PCTTHRESHOLD 2
STORAGE
   (INITIAL 4M NEXT 2M PCTINCREASE 0 MINEXTENTS 1 MAXEXTENTS 1)
OVERFLOW STORAGE
   (INITIAL 4M NEXT 2M PCTINCREASE 0 MINEXTENTS 1 MAXEXTENTS 1)
ENABLE ROW MOVEMENT;
```

To define the same table using an index-organized table based on the *order_date* column, we would use this syntax:

```
CREATE TABLE orders
   (order_number  NUMBER,
    order_date    DATE,
    cust_nbr      NUMBER,
    price         NUMBER,
    qty           NUMBER,
    cust_shp_id   NUMBER,
    shp_region    VARCHAR2(20),
    order_desc    NCLOB,
CONSTRAINT ord_nbr_pk PRIMARY KEY (order_number))
ORGANIZATION HEAP
   INCLUDING order_date
PCTTHRESHOLD 2
STORAGE
   (INITIAL 4M NEXT 2M PCTINCREASE 0 MINEXTENTS 1 MAXEXTENTS 1)
OVERFLOW STORAGE
   (INITIAL 4M NEXT 2M PCTINCREASE 0 MINEXTENTS 1 MAXEXTENTS 1)
ENABLE ROW MOVEMENT;
```

Finally, we'll create an external table that stores our customer shipping information, called *cust_shipping_external*:

```
CREATE TABLE cust_shipping_external
   (external_cust_nbr  NUMBER(6),
    cust_shp_id        NUMBER,
    shipping_company   VARCHAR2(25) )
ORGANIZATION EXTERNAL
   (TYPE oracle_loader
    DEFAULT DIRECTORY dataloader
    ACCESS PARAMETERS
      (RECORDS DELIMITED BY newline
       BADFILE 'upload_shipping.bad'
       DISCARDFILE 'upload_shipping.dis'
       LOGFILE 'upload_shipping.log'
       SKIP 20
       FIELDS TERMINATED BY "," OPTIONALLY ENCLOSED BY '"'
         (client_id INTEGER EXTERNAL(6),
          shp_id CHAR(20),
          shipper CHAR(25)))
   LOCATION ('upload_shipping.ctl') )
REJECT LIMIT UNLIMITED;
```

In this example, the external table type is `ORACLE_LOADER` and the default directory is `DATALOADER`. This example illustrates the fact that you define the metadata of the table within Oracle and then describe how that metadata references a data source outside of the Oracle database server itself.

Oracle XMLType and object-type tables. When an Oracle XMLType table is created, Oracle automatically stores the data in a `CLOB` column, unless you create an XML schema–based table. (For details on Oracle's XML support, refer to the vendor documentation.) The following code example first creates an XMLType table, *distributors*, with the implicit CLOB data storage, then creates a second such table, *suppliers*, with a more sophisticated XML schema definition:

```
CREATE TABLE distributors OF XMLTYPE;
CREATE TABLE suppliers OF XMLTYPE
XMLSCHEMA "http://www.lookatallthisstuff.com/suppliers.xsd"
ELEMENT "vendors";
```

A key advantage of tables based on XML schemas is that you can create B-tree indexes on them. In the following example, we create an index on *suppliercity*:

```
CREATE INDEX suppliercity-index
ON suppliers
(S."XMLDATA"."ADDRESS"."CITY");
```

You may similarly create tables using a mix of standard and XMLTYPE columns. In this case, the XMLTYPE column may store its data as a CLOB, or it may store its data in an object-relational column of a structure determined by your specification. For example, here we re-create the *distributors* table (this time with some added storage specifications) and the *suppliers* table with both standard and XMLTYPE columns:

```
CREATE TABLE distributors
   (distributor_id NUMBER,
   distributor_spec XMLTYPE)
XMLTYPE distributor_spec
STORE AS CLOB
   (TABLESPACE tblspc_dist
   STORAGE (INITIAL 10M NEXT 5M)
   CHUNK 4000
   NOCACHE
   LOGGING);
CREATE TABLE suppliers
   (supplier_id NUMBER,
   supplier_spec XMLTYPE)
XMLTYPE supplier_spec STORE AS OBJECT RELATIONAL
   XMLSCHEMA "http://www.lookatallthisstuff.com/suppliers.xsd"
   ELEMENT "vendors"
OBJECT IDENTIFIER IS SYSTEM GENERATED
OIDINDEX vendor_ndx TABLESPACE tblspc_xml_vendors;
```

When creating XML and object tables, you may refer to *inline_ref_constraint* and *table_ref_constraint* clauses. The syntax for an *inline_ref_constraint* clause is:

```
{SCOPE IS scope_table |
   WITH ROWID |
   [CONSTRAINT constraint_name] REFERENCES object [ (column_name) ]
      [ON DELETE {CASCADE | SET NULL}]
      [constraint_state]}
```

The only difference between an inline reference constraint and a table reference constraint is that inline reference constraints operate at the column level and table reference constraints operate at the table level. (This is essentially the same behavior and coding rule of standard relational constraints like PRIMARY KEY or FOREIGN KEY.) The syntax for a *table_ref_constraint* follows:

```
{SCOPE FOR (ref_col | ref_attr) IS scope_table |
   REF (ref_col | ref_attr) WITH ROWID |
   [CONSTRAINT constraint_name] FOREIGN KEY (ref_col | ref_attr)
      REFERENCES object [ (column_name) ]
      [ON DELETE {CASCADE | SET NULL}]
      [constraint_state]}
```

The *constraint_state* clause contains a number of options that were defined earlier, in the discussion of the Oracle CREATE TABLE statement. However, these options are applied only to the condition of the scope reference:

```
[NOT] DEFERRABLE
INITIALLY {IMMEDIATE | DEFERRED}
{ENABLE | DISABLE}
{VALIDATE | NOVALIDATE}
{RELY | NORELY}
EXCEPTIONS INTO table_name
USING INDEX {index_name | (create_index_statement) | index_attributes}
```

Object-type tables are useful for creating tables containing user-defined types. For example, the following code creates the *building_type* type:

```
CREATE TYPE OR REPLACE building_type AS OBJECT
   (building_name VARCHAR2(100),
    building_address VARCHAR2(200));
```

We can then create a table called *offices-object-table* that contains the object and defines some of its characteristics, such as OID information. In addition, we'll create two more tables, based upon *building_type*, that reference the object type as an *inline_ref_constraint* and a *table_ref_constraint*, respectively:

```
CREATE TABLE offices_object_table
   OF building_type (building_name PRIMARY KEY)
OBJECT IDENTIFIER IS PRIMARY KEY;
CREATE TABLE leased_offices
   (office_nbr  NUMBER,
    rent        DEC(9,3),
    office_ref  REF building_type
    SCOPE IS    offices_object_table);
CREATE TABLE owned_offices
   (office_nbr  NUMBER,
    payment     DEC(9,3),
    office_ref  REF building_type
    CONSTRAINT  offc_in_bld REFERENCES offices_object_table);
```

In these examples, the SCOPE IS clause defines the *inline_ref_constraint*, while the CONSTRAINT clause defines the *table_ref_constraint*.

Oracle ALTER TABLE. When using the Oracle command ALTER TABLE, you are able to ADD, DROP, or MODIFY every aspect of each element of the table. For example, the syntax diagram shows that the method for adding or modifying an existing column includes its attributes, but you need to explicitly state that the *attributes* include any Oracle-specific extensions. So, while the SQL standard only lets you modify attributes such as DEFAULT or NOT NULL (as well as column-level constraints assigned to the column), Oracle also allows you to alter any special characteristics that might exist, such as LOB, VARRAY, NESTED TABLE, index-organized table, CLUSTER, or PARTITION settings.

For example, the following code adds a new column to a table in Oracle and adds a new, unique constraint to that table:

```
ALTER TABLE titles
ADD subtitle VARCHAR2(32) NULL
CONSTRAINT unq_subtitle UNIQUE;
```

When a foreign key constraint is added to a table, the DBMS verifies that all existing data in the table meets that constraint. If not, the ALTER TABLE fails.

> Any queries that use SELECT * return the new columns, even if this was not planned. Precompiled objects, such as stored procedures, can return any new columns if they use the %ROWTYPE attribute. Otherwise, a precompiled object may not return any new columns.

Oracle also allows you to perform multiple actions, such as ADD or MODIFY, on multiple columns by enclosing the actions within parentheses. For example, the following command adds several columns to a table with a single statement:

```
ALTER TABLE titles
ADD (subtitles VARCHAR2(32) NULL,
   year_of_copyright INT,
   date_of_origin DATE);
```

PostgreSQL

PostgreSQL supports the SQL standards for CREATE and ALTER TABLE, with a couple of extensions that enable you to quickly build a new table from existing table definitions. Following is the syntax for CREATE TABLE:

```
CREATE [LOCAL | [TEMP]ORARY | FOREIGN][UNLOGGED] TABLE table_name
   (column_name data_type attributes[, ...])
|   [column_name [data_type] GENERATED ALWAYS AS (expression)
      STORED][,...]]
|   [column_name {GENERATED ALWAYS| BY DEFAULT} AS IDENTITY
      sequence_options]
[, ...]
CONSTRAINT constraint_name [{NULL | NOT NULL}]
{[UNIQUE] | [PRIMARY KEY (column_name[, ...])] |
   [CHECK (expression)] |
   REFERENCES reference_table (reference_column[, ...])
```

```
      [MATCH {FULL | PARTIAL | default}]
      [ON {UPDATE | DELETE}
         {CASCADE | NO ACTION | RESTRICT | SET NULL |
          SET DEFAULT value}]
      [[NOT] DEFERRABLE] [INITIALLY {DEFERRED | IMMEDIATE}]}[, ...] |
      [table_constraint][, ...]
   [INHERITS (inherited_table[, ...])]
   [PARTITION BY {RANGE | LIST | HASH}
      ( {column_name | (expression)}
      [PARTITION OF partition_clause]
      [COLLATE collation] [opclass ][, ...] )]
   [USING method]
   [ON COMMIT {DELETE | PRESERVE} ROWS]
   [AS select_statement]
```

And the PostgreSQL syntax for `ALTER TABLE` is:

```
ALTER [FOREIGN ] TABLE [ONLY] table_name [*]
[ADD [COLUMN] column_name data_type attributes [...]
[column_name data_type GENERATED ALWAYS AS (expression)
   [STORED][,...] ]
[column_name {GENERATED ALWAYS| BY DEFAULT} AS IDENTITY
   sequence_options]
[, ...]
| [ALTER [COLUMN] column_name
   {SET DEFAULT value | DROP DEFAULT | SET STATISTICS int}]
| [RENAME [COLUMN] column_name TO new_column_name]
| [RENAME TO new_table_name]
| [ADD table_constraint]
| [DROP CONSTRAINT constraint_name RESTRICT]
| [SET { LOGGED | UNLOGGED }]
| [partition_clause]
| [OWNER TO new_owner]
```

The parameters are as follows:

`LOCAL | [TEMP]ORARY | FOREIGN`

There are three mutually exclusive kinds of tables you can create in PostgreSQL. When not specified, the table is `LOCAL`. A `LOCAL` table is one that resides in the database and can be queried and updated based on the user permissions set.

A `TEMPORARY` (often created using `TEMP` instead of fully spelled out) table is a table that exists only for the life of a session and is automatically deleted after the session is closed. It can, however, be deleted and re-created by the session. `TEMP` tables are always stored in a *pg_temp* schema determined by PostgreSQL. As such, they can never be qualified with a schema name. When naming a `TEMP` table care must be taken to use a prefix to distinguish it from real tables; otherwise, it is possible to accidentally delete a real table when deleting a `TEMP` table. This is because the `DROP TABLE` command does not take `TEMP` as a qualifier.

A `FOREIGN` table is a table that resides in another database, is a link to a file of data, and/or exists on another server. You'll see some examples of this later in this chapter.

`UNLOGGED`
: For `LOCAL` tables, you can qualify with the word `UNLOGGED`. `LOGGED` is assumed if `UNLOGGED` is not specified. An unlogged table is one in which only the `CREATION` DDL is logged, and not the loading or updating of it. This has a couple of consequences, which may be good or bad for your use case. Loading data into an unlogged table is much faster than loading into a logged one. Since unlogged tables are not logged, data residing in the tables is never replicated to database replicas; however, the creation of the unlogged table is replicated. In the event of a database crash, an unlogged table is purged of its contents. Therefore, you should never store data in an unlogged table that you cannot replenish from other sources. An unlogged table can be easily converted to a logged table using `ALTER TABLE <> SET LOGGED`.

`table_constraint`
: Allows standard SQL constraints to be assigned at the column or table level. PostgreSQL fully supports `PRIMARY KEY`, `UNIQUE`, `NOT NULL`, and `DEFAULT` constraints and provides syntax support for `CHECK`, `FOREIGN KEY`, and `REFERENCES` constraints. In addition, PostgreSQL provides an `EXCLUDE` constraint that is an extension to the standard. Exclusion constraints are used to guarantee two records don't overlap, given a set of columns. For example, you might define a table with schedules for each room and put in an exclusion constraint to prevent the room from having overlapping bookings.

`REFERENCES ... MATCH ... ON {UPDATE|DELETE} ...`
: Checks a value inserted into the column against the values of a column in another table. This clause can also be used as part of a `FOREIGN KEY` declaration. The `MATCH` options are `FULL`, `PARTIAL`, and the default, where `MATCH` has no other keyword. A `FULL` match forces all columns of a multicolumn foreign key either to be NULL or to contain a valid value. The default allows mixed NULLs and values. `PARTIAL` matching is a valid syntax, but is not supported. The `REFERENCES` clause also allows several different behaviors to be declared for `ON DELETE` and/or `ON UPDATE` referential integrity:

  `NO ACTION`
  : Produces an error when the foreign key is violated (the default).

  `RESTRICT`
  : Synonym for `NO ACTION`.

  `CASCADE`
  : Sets the value of the referencing column to the value of the referenced column.

`SET NULL`
: Sets the value of the referencing column to NULL.

`SET DEFAULT` *`value`*
: Sets the referencing column to its declared default value or NULL, if no default value exists.

`[NOT] DEFERRABLE [INITIALLY {DEFERRED | IMMEDIATE}]`
: The `DEFERRABLE` option of the `REFERENCES` clause tells PostgreSQL to defer evaluation of all constraints until the end of a transaction. `NOT DEFERRABLE` is the default behavior for the `REFERENCES` clause. Similar to the `DEFERRABLE` clause is the `INITIALLY` clause: specifying `INITIALLY DEFERRED` checks constraints at the end of a transaction; `INITIALLY IMMEDIATE` checks constraints after each statement (the default).

`PARTITION BY`
: A table with a `PARTITION BY` clause is called a partitioned table. See "PostgreSQL partitioned tables" on page 197 for details.

`PARTITION OF`
: A table with a `PARTITION OF` clause is a partition of a partitioned table. It can be a `LOCAL` table or a `FOREIGN` table. See "PostgreSQL partitioned tables" on page 197 for details.

`FOREIGN KEY`
: Can be declared only as a table-level constraint, not as a column-level constraint. All options for the `REFERENCES` clause are supported as part of the `FOREIGN KEY` clause. The syntax follows:

```
[FOREIGN KEY (column_name[, ...]) REFERENCES...]
```

`INHERITS` *`inherited_table`*
: Specifies a table or tables from which the table you are creating inherits all columns. The newly created table also inherits columns attached to tables higher in the hierarchy.

`ON COMMIT {DELETE | PRESERVE} ROWS`
: Used only with temporary tables. This clause controls the behavior of the temporary table after records are committed to the table. `ON COMMIT DELETE ROWS` clears the temporary table of all rows after each commit. This is the default if the `ON COMMIT` clause is omitted. `ON COMMIT PRESERVE ROWS` saves the rows in the temporary table after the transaction has committed.

`AS` *`select_statement`*
: Enables you to create and populate a table with data from a valid `SELECT` statement. The column names and data types do not need to be defined, since they are inherited from the query. The `CREATE TABLE ... AS` statement has similar functionality to `SELECT ... INTO`, but is more readable.

`ONLY`
: Specifies that only the named table is affected by the `ALTER TABLE` statement, not any parent tables or subtables in the table hierarchy.

`OWNER TO` *`new_owner`*
: Changes the owner of the table to the user identified by *`new_owner`*.

A PostgreSQL table cannot have more than 1,600 columns. However, you should limit the number of columns to well below 1,600, for performance reasons. For example:

```
CREATE TABLE distributors
   (name    VARCHAR(40) DEFAULT 'Thomas Nash Distributors',
    dist_id INTEGER GENERATED BY DEFAULT AS IDENTITY,
    modtime TIMESTAMP TZ DEFAULT CURRENT_TIMESTAMP,
    has_vowel boolean GENERATED ALWAYS AS (name ~* '[aeiou]') STORED
  );
```

Unique to PostgreSQL is the ability to create column-level constraints with multiple columns. Since PostgreSQL also supports standard table-level constraints, the SQL standard approach is still the recommended approach.

PostgreSQL's implementation of `ALTER TABLE` allows the addition of extra columns and generated columns using the `ADD` keyword. Existing columns may have new default values assigned to them using `ALTER COLUMN ... SET DEFAULT`, while `ALTER COLUMN ... DROP DEFAULT` allows the complete erasure of a column-based default. In addition, new defaults may be added to columns using the `ALTER` clause, but only newly inserted rows will be affected by such new default values. `RENAME` allows new names for existing columns and tables.

PostgreSQL follows the SQL specification on how to define generated columns using the `GENERATED ALWAYS AS (`*`expression`*`)` syntax; however, it must be followed by the keyword `STORED`, and the data type specification of the column is not optional. PostgreSQL doesn't currently support virtual columns that are computed at query time, but this is planned to change in the future. Another restriction of generated columns is that the *`expression`* can only use immutable functions and other columns in the table. Expressions cannot use other generated columns or aggregations of the table.

PostgreSQL tables as types. PostgreSQL automatically creates a pseudo-type definition and a companion pseudo-array type definition for tables. One use case for this is to allow a table definition to be used as a column type in another table, similar to Oracle's nested table feature, in which a table is virtually stored within a column of another table. It is also useful as a return type for functions, and is valuable for structured arrays of values in a table.

This example creates a table called *person* and uses it in the definition of another table, *party*, using both the array type definition and the basic type definition:

```
CREATE TABLE person(name varchar(50), phone varchar(20));
CREATE TABLE party
   (id bigint NOT NULL GENERATED ALWAYS AS IDENTITY,
    date_event date,
    party_planner person,
    invited_people person[]);
```

The [] in the definition denotes that we want to store an array where each element has the structure of the *person* table. Specifying the table name *person* without the brackets means we want the column to only store one person.

PostgreSQL typed tables. PostgreSQL tables can also be created from composite types. Here is an example that creates a type and then uses it to define a table:

```
CREATE TYPE inventory_item AS
   (name varchar(50),
    weight_lb numeric(10,2),
    price numeric(10,2));

CREATE TABLE pens OF inventory_item;
```

A table whose definition is derived from a composite type can never have columns added to or removed from it directly. This needs to be done on the type with `CASCADE` to cascade to the related tables, columns, and any other objects that use it. The following is an example of how you would add a new column to all tables that are defined by the *inventory_item* type:

```
ALTER TYPE inventory_item
   ADD ATTRIBUTE upc_code varchar(100)
   CASCADE;
```

PostgreSQL partitioned tables. PostgreSQL allows tables to be partitioned and sub-partitioned. A partitioned table may be broken into distinct parts, possibly placed in separate tablespaces or on separate servers to improve I/O performance (based on three strategies: range, hash, or list). A partitioned table can be further partitioned using the same strategies and need not use the same strategy as its parent. There are two elements to partitioning: the partitioned table that defines the structure but stores no data and the partitions that store the data. Both are detailed in the vendor's documentation.

The partitioned table has this clause:

```
{ PARTITION BY [RANGE | HASH | LIST] (column[, ...]) }
```

And the partition of a table has this clause:

```
{ PARTITION OF partitioned_table [ (
  { column_name [ WITH OPTIONS ] [ column_constraint [ ... ] ]
    | table_constraint }
```

```
        [, ...]
    ) ] { FOR VALUES partition_bound_spec | DEFAULT }
    }
```

Each kind of partition takes a different *partition_bound_spec*:

`RANGE`
    `FOR VALUES FROM (`*`somevalue_1`*`) TO (`*`somevalue_2`*`)`

`LIST`
    `FOR VALUES IN(`*`somevalue_1`*, *`somevalue_2`*`, ...)`

`HASH`
    `VALUES WITH (modulus `*`some_integer_1`*` , remainder `*`some_integer_2`*`)`

Partitions can be added to and removed from a partitioned table using `ALTER TABLE` as well.

The following example code shows the *orders* table partitioned by range:

```
CREATE TABLE orders
  (order_number bigint,
   order_date    DATE,
   cust_nbr      bigint,
   price         numeric(12,2),
   qty           integer,
   cust_shp_id   bigint)
PARTITION BY RANGE(order_date);

CREATE TABLE pre_yr_2000
   PARTITION OF orders FOR VALUES
   FROM (minvalue) TO ('2000-01-01');

ALTER TABLE orders DETACH PARTITION pre_yr_2000;
ALTER TABLE orders ATTACH PARTITION pre_yr_2000
   FOR VALUES FROM (minvalue) TO ('2000-01-01');
```

Primary keys and indexes applied on a partitioned table are automatically applied on all the partitions. One caveat is that primary keys *must* contain the partitioning keys. This often means you'll have to define a compound primary key in cases where you only want one column.

PostgreSQL foreign tables. PostgreSQL offers another kind of table called a `FOREIGN` table, which has a corresponding `SERVER` and users. A foreign table is a table that lives on a different server, database, or filesystem. It uses a connecting mechanism called a *foreign data wrapper* (FDW), installed via the PostgreSQL `CREATE EXTENSION` command.

PostgreSQL's foreign data support follows the SQL for Management of External Data (SQL-MED) standard. For most cases, a foreign table can be queried like any other table, but the performance is often worse than with a local table.

Most PostgreSQL installs (except possibly for DBaaS ones) come packaged with two foreign data wrappers: *postgres_fdw* and *file_fdw*. *postgres_fdw* allows connecting to another Postgres database, which could be on the same PostgreSQL service, another service running on the same server, or a PostgreSQL service running on a different server. *file_fdw* allows for connecting to a delimited text file. These two FDWs provide similar functionality to MySQL's `CSV` and `FEDERATED` and MariaDB's `CONNECT` storage engines, and SQL Server's linked servers.

There are many additional FDWs available, for connecting to web services, different file formats, and different databases. For example, there's an *oracle_fdw* wrapper for connecting to Oracle databases and an *ogr_fdw* wrapper that supports numerous spatial and non-spatial data sources (relational, file, ODBC, and web service). Many of these are provided by PostgreSQL package management systems. Once the binaries are installed, any of these can be installed in a database using the `CREATE EXTENSION` command. A specific FDW can only be installed once in a database but can have many server definitions that use it.

Here is an example for connecting to a CSV file:

```
CREATE EXTENSION file_fdw;
CREATE SERVER svr_files FOREIGN DATA WRAPPER file_fdw;
CREATE FOREIGN TABLE fdt_orders
   (order_number  bigint,
    order_date    DATE,
    cust_nbr      bigint,
    price         numeric(12,2),
    qty           integer,
    cust_shp_id   bigint)
SERVER svr_files
OPTIONS (
   format 'csv', header 'true',
   filename '/external_data/order.psv',
   delimiter '|', null ''
);
```

Some FDWs support a command called `IMPORT FOREIGN SCHEMA` that allows for automatically creating a set of foreign tables without using the `CREATE FOREIGN TABLE` command directly. Many servers also require that a user mapping must exist for a user to connect. The user mapping can be for a particular user role or group role, and a server can have multiple user mappings. Here is an example for connecting to another PostgreSQL database and creating foreign tables for all tables in the remote database's *public* schema in the local *remote_public* schema:

```
CREATE EXTENSION postgres_fdw;
CREATE SERVER svr_pg_remote FOREIGN DATA WRAPPER postgres_fdw
OPTIONS (host 'ip_or_name', port '5432', dbname 'pagila');
CREATE USER MAPPING FOR trusted_users_group SERVER svr_pg_remote
OPTIONS (user 'role_on_foreign', password 'your_password');
CREATE SCHEMA IF NOT EXISTS remote_public;
IMPORT FOREIGN SCHEMA public FROM SERVER svr_pg_remote
INTO remote_public;
```

As mentioned earlier, partitions of a partitioned table can reside on other servers. This is accomplished by making a foreign table with the same structure as the partitioned table and attaching it as a partition. The foreign table need not be a PostgreSQL table.

SQL Server

SQL Server offers a plethora of options when defining or altering a table, its columns, and its table-level constraints. In addition, SQL Server now supports several kinds of tables beyond the standard relational table, including memory-optimized tables, bitemporal tables, XML tables, and JSON tables.

SQL Server does not support the `CREATE TABLE ... AS` *`select_statement`* syntax. Instead, use the `SELECT ... INTO` syntax.

Its `CREATE TABLE` syntax is:

```
CREATE TABLE table_name
[AS FILETABLE]
(
column_name data_type { [DEFAULT default_value]
   | [IDENTITY [(seed,increment) [NOT FOR REPLICATION]]]
     [ROWGUIDCOL] [NULL | NOT NULL]
   | [{PRIMARY KEY | UNIQUE}
     [CLUSTERED | NONCLUSTERED]
     [WITH FILLFACTOR = int] [ON {filegroup | DEFAULT}]]
   | [[FOREIGN KEY]
      REFERENCES reference_table [(reference_column[, ...])]
      [ON {DELETE | UPDATE} {CASCADE | NO ACTION}]
      [NOT FOR REPLICATION]]
   | [CHECK [NOT FOR REPLICATION] (expression)]
   | [COLLATE collation_name]
   | column_name AS computed_column_expression }
[, ...]
| [table_constraint][, ...]
| [table_index]
)
[ON {filegroup | DEFAULT | partition_details}]
[FILESTREAM_ON {filegroup | DEFAULT | partition_details}]
[TEXTIMAGE_ON {filegroup | DEFAULT}]
[WITH ( table_option [, ...] )]
```

And the SQL Server version of `ALTER TABLE` is:

```
ALTER TABLE table_name
[ALTER COLUMN column_name new_data type attributes {ADD | DROP}
   ROWGUIDCOL]
| [ADD [COLUMN] column_name data type attributes][, ...]]
| [WITH CHECK | WITH NOCHECK] ADD table_constraint][, ...]
| [DROP {[CONSTRAINT] constraint_name | COLUMN column_name}][, ...]
| [{CHECK | NOCHECK} CONSTRAINT {ALL | constraint_name[, ...]}]
| [{ENABLE | DISABLE} TRIGGER {ALL | trigger_name[, ...]}]
```

The parameters are as follows:

`*table_name*`
: Specifies the new table's name using either a one-, two-, or three-part naming convention of `[<*database_name*>].[<*schema_name*>].<*table_name*>`.

`AS FILETABLE`
: Specifies an optional table type that supports the Windows file namespace and offers compatibility with Windows applications and SQL Server simultaneously. Commonly used in situations where an application needs direct access to data on the Windows filesystem, but the application designers also want the benefits of ACID transactions and point-in-time recovery offered by a relational database. `FILETABLE` does not allow column definitions since it has a fixed schema. Refer to the vendor documentation on filetables for more information.

`DEFAULT *default_value*`
: Applies to any column except those with a `TIMESTAMP` data type or an `IDENTITY` property. The `*default_value*` must be a constant value such as a character string or a number, a system function such as `GETDATE()`, or `NULL`.

`IDENTITY [(*seed*, *increment*)]`
: Creates and populates the column with a monotonically increasing number, when applied to an integer column. The `IDENTITY` starts counting at the value of `*seed*` and increases by the value of `*increment*`. When either is omitted, the default is 1.

`NOT FOR REPLICATION`
: Specifies that the values of an `IDENTITY` or `FOREIGN KEY` are not replicated to subscribing servers. This helps in situations in which different servers require the same table structures, but not the exact same data.

`ROWGUIDCOL`
: Identifies a column as a globally unique identifier (GUID), which ensures no two values are ever repeated across any number of servers. Only one such column may be identified per table. This clause does not, however, create the unique values itself. They must be inserted using the `NEWID()` function.

`{PRIMARY KEY | UNIQUE}`
: Defines a unique or primary key constraint for the table. The primary key declaration differs from the SQL standard by allowing you to assign the `CLUSTERED` or `NONCLUSTERED` attributes on the primary key index, as well as a starting fill factor. (Refer to the section "PRIMARY KEY Constraints" on page 61 for more information.) The attributes of a unique or primary key include:

    `CLUSTERED | NONCLUSTERED`
    : Declares that the column or columns of the primary key set the physical sort order of the records in the table (`CLUSTERED`), or that the primary key

index maintains pointers to all of the records of the table (NONCLUSTERED). CLUSTERED is the default when this clause is omitted.

WITH FILLFACTOR = *int*
: Declares that a percentage of space (*int*) should remain free on each data page when the table is created. SQL Server does not maintain the fill factor over time, so you should rebuild the index on a regular basis.

ON {*filegroup* | DEFAULT}
: Specifies that the primary key either is located on the preexisting named *filegroup* or is assigned to the DEFAULT filegroup.

FOREIGN KEY
: Checks values as they are inserted into the table against a column in another table in order to maintain referential integrity. Foreign keys are described in detail in Chapter 2. A foreign key can only reference columns that are defined as a PRIMARY KEY or UNIQUE index on the referencing table. A referential action may be specified to take place on the *reference_table* when the record is deleted or updated, according to the following:

ON {DELETE | UPDATE}
: Specifies that an action needs to happen in the local table when either (or both) an UPDATE or DELETE occurs on the referenced table.

CASCADE
: Specifies that any DELETE or UPDATE also takes place on the referring table for any records dependent on the value of the FOREIGN KEY.

NO ACTION
: Specifies that no action occurs in the referring table when a record in the current table is deleted or updated.

NOT FOR REPLICATION
: Specifies that an IDENTITY property should not be enforced when the data is replicated from another database. This ensures that data from the published server is not assigned new identity values.

CHECK
: Ensures that a value inserted into the specified column of the table is a valid value, based on the CHECK expression. For example, the following shows a table with two column-level CHECK constraints:

```
CREATE TABLE people
    (people_id     CHAR(4)
        CONSTRAINT pk_dist_id PRIMARY KEY CLUSTERED
        CONSTRAINT ck_dist_id CHECK (dist_id LIKE '
         [A-Z][A-Z][A-Z][A-Z]'),
     people_name   VARCHAR(40) NULL,
     people_addr1  VARCHAR(40) NULL,
     people_addr2  VARCHAR(40) NULL,
     city          VARCHAR(20) NULL,
     state         CHAR(2)     NULL
        CONSTRAINT def_st DEFAULT ("CA")
        CONSTRAINT chk_st REFERENCES states(state_ID),
     zip           CHAR(5)     NULL
        CONSTRAINT ck_dist_zip
        CHECK(zip LIKE '[0-9][0-9][0-9][0-9][0-9]'),
     phone         CHAR(12)    NULL,
     sales_rep     empid       NOT NULL DEFAULT USER)
GO
```

The `CHECK` constraint on *people_id* ensures an all-alphabetic ID, while the one on *zip* ensures an all-numeric value. The `REFERENCES` constraint on *state* performs a lookup on the *states* table. The `REFERENCES` constraint is essentially the same as a `CHECK` constraint, except that it derives its list of acceptable values from the values stored in another column. This example illustrates how column-level constraints are named using the `CONSTRAINT` *`constraint_name`* syntax.

`COLLATE`
: Allows programmers to change, on a column-by-column basis, the sort order and character set used by the column.

`TEXTIMAGE_ON {`*`filegroup`*` | DEFAULT}`
: Controls the placement of *text*, *ntext*, and *image* columns, allowing you to place `LOB` data on the preexisting *`filegroup`* of your choice. When omitted (or set to `DEFAULT`), these columns are stored in the default filegroup with all other tables and database objects.

`WITH [NO]CHECK`
: Tells SQL Server whether the data in the table should be validated against any newly added constraints or keys. When constraints are added using `WITH NOCHECK`, the query optimizer ignores them until they are enabled via `ALTER TABLE` *`table_name`* `CHECK CONSTRAINT ALL`. When constraints are added using `WITH CHECK`, the constraints are checked immediately against all data already in the table.

`[NO]CHECK CONSTRAINT`
: Enables (`CHECK CONSTRAINT`) or disables (`NOCHECK CONSTRAINT`) an existing constraint.

`{ENABLE | DISABLE} TRIGGER { ALL |` *`trigger_name`*`[, ... ] }`
: Enables or disables the specified trigger or triggers, respectively. You can specify multiple triggers by placing each *`trigger_name`* in a comma-delimited list, or you can enable or disable all triggers on the named table with the keyword `ALL`, as in `ALTER TABLE employee DISABLE TRIGGER ALL`.

SQL Server allows any column-level constraint to be named by specifying `CONSTRAINT` *`constraint_name`* ..., and then the text of the constraint. Several constraints may be applied to a single column, as long as they are not mutually exclusive (for example, `PRIMARY KEY` and `NULL`).

SQL Server also allows a local temporary table to be created, using its own proprietary syntax. A local temporary table, which is stored in the *tempdb* database, requires a prefix of a single pound sign (#) to the name of the table. The local temporary table is usable by the person or process that created it and is deleted when the person logs out or the process terminates. A global temporary table, which is usable by all people and processes that are currently logged in/running, can be established by prefixing two pound signs (##) to the name of the table. The global temporary table is deleted when its process terminates or its creator logs out.

SQL Server also allows the creation of tables with columns that contain computed values. Computed columns can offer a big performance increase in certain circumstances. Such a column does not actually contain data; instead, it is a virtual column containing an expression using other columns already in the table. For example, a computed column could contain an expression such as `order_cost AS (price * qty)`. Computed columns also can contain constants, functions, variables, noncomputed columns, or any of these combined with each other using operators.

Any column-level constraints shown earlier also may be declared at the table level. That is, `PRIMARY KEY` constraints, `FOREIGN KEY` constraints, `CHECK` constraints, and others may be declared after all the columns have been defined in the `CREATE TABLE` statement. This is useful for constraints that cover more than one column. For example, a column-level `UNIQUE` constraint can be applied only to that column. However, declaring the constraint at the table level allows it to span several columns. Here is an example of both column- and table-level constraints:

```
-- Creating a column-level constraint
CREATE TABLE favorite_books
    (isbn          CHAR(100)    PRIMARY KEY NONCLUSTERED,
     book_name     VARCHAR(40)  UNIQUE,
     category      VARCHAR(40)  NULL,
     subcategory   VARCHAR(40)  NULL,
     pub_date      DATETIME     NOT NULL,
     purchase_date DATETIME     NOT NULL)
GO

-- Creating a table-level constraint
CREATE TABLE favorite_books
    (isbn          CHAR(100)    NOT NULL,
     book_name     VARCHAR(40)  NOT NULL,
     category      VARCHAR(40)  NULL,
     subcategory   VARCHAR(40)  NULL,
     pub_date      DATETIME     NOT NULL,
     purchase_date DATETIME     NOT NULL,
        CONSTRAINT pk_book_id   PRIMARY KEY NONCLUSTERED (isbn)
           WITH FILLFACTOR=70,
        CONSTRAINT unq_book UNIQUE CLUSTERED (book_name,pub_date))
GO
```

These two commands provide nearly the same results, except that the table-level `UNIQUE` constraint has two columns, whereas only one column is included in the column-level `UNIQUE` constraint.

The following example adds a new `CHECK` constraint to a table, but does not check to ensure that the existing values in the table pass the constraint:

```
ALTER TABLE favorite_book WITH NOCHECK
ADD CONSTRAINT extra_check CHECK (ISBN > 1)
GO
```

In this example, we further add a new column with an assigned `DEFAULT` value that is placed in each existing record in the table:

```
ALTER TABLE favorite_book ADD reprint_nbr INT NULL
CONSTRAINT add_reprint_nbr DEFAULT 1 WITH VALUES
GO
-- Now, disable the constraint
ALTER TABLE favorite_book NOCHECK CONSTRAINT add_reprint_nbr
GO
```

See also

- `CREATE/ALTER SCHEMA`
- `DROP`

CREATE/ALTER TYPE Statement

The `CREATE TYPE` statement allows you to create a *user-defined type* (UDT), that is, a data type or "class" in object-oriented terms defined by the user. UDTs extend SQL capabilities into the realm of object-oriented programming by allowing inheritance and other object-oriented features. You can also create something called *typed tables* with the `CREATE TABLE` statement using a previously created type made with the `CREATE TYPE` statement. Typed tables are based on UDTs and are equivalent to instantiated classes in object-oriented programming.

Platform	Command
MySQL	Not supported
Oracle	Supported, with limitations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

The `ALTER TYPE` statement is supported with variations by Oracle and PostgreSQL.

SQL standard syntax

```
CREATE TYPE type_name
[UNDER supertype_name]
[AS [new_udt_name] data_type [attribute][, ...]
```

```
      {[REFERENCES ARE [NOT] CHECKED [ON DELETE {NO ACTION |
         CASCADE | RESTRICT | SET NULL | SET DEFAULT}]] |
      [DEFAULT value] |
      [COLLATE collation_name]}]
      [[NOT] INSTANTIABLE]
      [[NOT] FINAL]
   [REF IS SYSTEM GENERATED |
      REF USING data_type
        [CAST {(SOURCE AS REF) | (REF AS SOURCE)} WITH identifier] |
      REF new_udt_name[, ...] ]
   [CAST {(SOURCE AS DISTINCT) | (DISTINCT AS SOURCE)} WITH identifier]
   [method_definition[, ...]]
```

The following syntax alters an existing user-defined data type:

```
   ALTER TYPE type_name {ADD ATTRIBUTE type_definition |
      DROP ATTRIBUTE type_name}
```

Keywords

`{CREATE | ALTER} TYPE` *`type_name`*
: Creates a new type or alters an existing type with the name *`type_name`*.

`UNDER` *`supertype_name`*
: Creates a subtype that is dependent upon a single preexisting named supertype. (A UDT can be a supertype if it is defined as `NOT FINAL`.)

`AS [`*`new_udt_name`*`]`*`data_type`* `[`*`attribute`*`][, ... ]`
: Defines attributes of the type as if they were column declarations in a `CREATE TABLE` statement without constraints. You can define the UDT attribute on an existing data type, such as `VARCHAR(10)`, or on another previously created UDT, or even on a user-defined domain. Defining a UDT using a predefined data type (e.g., `CREATE TYPE` *`my_type`* `AS INT`) creates a *distinct type*, while a UDT defined with an attribute definition is a *structured type*. The allowable attributes for a structured type are:

  `ON DELETE NO ACTION`
  : Produces an error when the foreign key is violated (the default).

  `ON DELETE RESTRICT`
  : Synonym for `NO ACTION`.

  `ON DELETE CASCADE`
  : Sets the value of the referencing column to the value of the referenced column.

  `ON DELETE SET NULL`
  : Sets the value of the referencing column to NULL.

`ON DELETE SET DEFAULT` *`value`*
: Defines a default value for the UDT for when the user does not supply a value.

`COLLATE` *`collation_name`*
: Assigns a collation—that is, a sort order—for the UDT. When omitted, the collation of the database where the UDT was created applies.

`[NOT] INSTANTIABLE`
: Defines the UDT such that it can (or cannot) be instantiated. `INSTANTIABLE` is required for typed tables, but not for standard UDTs.

`[NOT] FINAL`
: Required for all UDTs. `FINAL` means the UDT may have no subtypes. `NOT FINAL` means the UDT may have subtypes.

`REF`
: Defines either a system-generated or user-generated reference specification; i.e., a sort of unique identifier that acts as a pointer that another type may reference. By referencing a preexisting type using its reference specification, you can have a new type inherit properties of a preexisting type. There are three ways to tell the DBMS how the typed table's reference column gets its values (i.e., its reference specification):

`new_udt_name``[, ... ]`
: Declares that the reference specification is provided by another preexisting UDT called *`new_udt_name`*.

`IS SYSTEM GENERATED`
: Declares that the reference specification is system generated (think of an automatically incrementing column). This is the default when the `REF` clause is omitted.

`USING` *`data_type`* `[CAST {(SOURCE AS REF) | (REF AS SOURCE)} WITH` *`identifier`*`]`
: Declares that the user defines the reference specification. You do this by using a predefined data type and optionally casting the value. You can use `CAST (SOURCE AS REF) WITH` *`identifier`* to cast the value with the specified *`data_type`* to the reference type of the structured type, or use `CAST (REF AS SOURCE) WITH` *`identifier`* to cast the value for the structured type to the *`data_type`*. The `WITH` clause allows you to declare an additional identifier for the cast data type.

`CAST {(SOURCE AS DISTINCT) | (DISTINCT AS SOURCE)} WITH` *`identifier`*
`method_definition``[, ... ]`
: Defines one or more preexisting methods for the UDT. A *method* is merely a specialized user-defined function and is created using the `CREATE METHOD` statement (see Chapter 9). The *`method_definition`* clause is not needed for

structured types since their method(s) are implicitly created. The default characteristics of a method are `LANGUAGE SQL`, `PARAMETER STYLE SQL`, `NOT DETERMINISTIC`, `CONTAINS SQL`, and `RETURN NULL ON NULL INPUT`.

`ADD ATTRIBUTE` *`type_definition`*
: Adds an additional attribute to an existing UDT, using the format described earlier under the `AS` clause. Available via the `ALTER TYPE` statement.

`DROP ATTRIBUTE` *`type_name`*
: Drops an attribute from an existing UDT. Available via the `ALTER TYPE` statement.

Rules at a glance

You can create user-defined types as a way to further ensure data integrity in your database and to ease the work involved in doing so. An important concept of UDTs is that they allow you to easily create *subtypes*, which are UDTs built upon other UDTs. The UDT that subtypes depend on is called a *parent type* or *supertype*. Subtypes inherit the characteristics of their supertypes.

Assume, for example, that you want to define a general UDT for phone numbers called *phone_nbr*. You could then easily build new subtypes of *phone_nbr* called *home_phone*, *work_phone*, *cell_phone*, *pager_phone*, etc. Each of the subtypes could inherit the general characteristics of the parent type but also have characteristics of its own.

In this example, we create a general root UDT called *money* and then several subtypes:

```
CREATE TYPE money (phone_number DECIMAL (10,2) )
   NOT FINAL;
CREATE TYPE dollar UNDER money AS DECIMAL(10,2)
   (conversion_rate DECIMAL(10,2) ) NOT FINAL;
CREATE TYPE euro   UNDER money AS DECIMAL(10,2)
   (dollar_conversion_rate DECIMAL(10,2) ) NOT FINAL;
CREATE TYPE pound UNDER euro
   (euro_conversion_rate DECIMAL(10,2) ) FINAL;
```

Programming tips and gotchas

The biggest programming gotcha for user-defined types is that they are seldom used and not well understood by most database developers and database administrators. Consequently, they can be problematic due to simple ignorance. They offer, however, a consistent and labor-saving approach for representing commonly reused conceptual elements in a database, such as an address (e.g., *street1*, *street2*, *city*, *state*, *postal code*).

MySQL

Not supported. To achieve similar functionality, you may use a JSON data type. Although not identical to a user-defined data type, it can provide similar behavior and has been supported by MySQL since version 5.7.8.

Oracle

Oracle has CREATE TYPE and ALTER TYPE statements, but they are nonstandard. Instead of a single CREATE TYPE statement, Oracle uses CREATE TYPE BODY to define the code that makes up the UDT, while CREATE TYPE defines the argument specification for the type. The syntax for CREATE TYPE is:

```
CREATE [OR REPLACE] {[EDITIONABLE | NONEDITIONABLE]}
TYPE type_name
{ [OID 'object_identifier'] [AUTHID {DEFINER | CURRENT_USER}]
   { {AS | IS} OBJECT | [UNDER supertype_name] |
      {OBJECT | TABLE OF data_type | VARRAY (limit)
       OF data_type} }
   USING data_definition
   { [ (attribute data_type[, ...]) |
      [[NOT] FINAL] [[NOT] INSTANTIABLE]
      [{ {MEMBER | STATIC}
         {function_based | procedure_based} |
          constructor_clause | map_clause } [...]]
      [pragma_clause] ] } }
```

Once the type has been declared, you encapsulate all of the UDT logic in the type body declaration. The *type_name* for both CREATE TYPE and CREATE TYPE BODY should be identical. The syntax for CREATE TYPE BODY is shown here:

```
CREATE [OR REPLACE] TYPE BODY type_name
{AS | IS}
{{MEMBER | STATIC}
{function_based | procedure_based | constructor_clause}}[...]
[map_clause]
```

Oracle's implementation of ALTER TYPE enables you to drop attributes and methods from or add them to the type:

```
ALTER TYPE type_name
  { COMPILE [DEBUG] [{SPECIFICATION | BODY}]
     [compiler_directives] [REUSE SETTINGS] |
   REPLACE [AUTHID {DEFINER | CURRENT_USER}] AS OBJECT
      (attribute data_type[, ...] [element_definition[, ...]]) |
   [[NOT] OVERRIDING] [[NOT] FINAL] [[NOT] INSTANTIABLE]
  { {ADD | DROP} { {MAP | ORDER} MEMBER FUNCTION function_name
      (parameter data_type[, ...]) } |
    { {MEMBER | STATIC} {function_based | procedure_based} |
      constructor_clause | map_clause [pragma_clause] } [...] |
    {ADD | DROP | MODIFY} ATTRIBUTE (attribute [data_type][, ...]) |
    MODIFY {LIMIT int | ELEMENT TYPE data_type} }
   [ {INVALIDATE |
   CASCADE [{ [NOT] INCLUDING TABLE DATA | CONVERT TO SUBSTITUTABLE }]
      [FORCE] [EXCEPTIONS INTO table_name]} ] }
```

Parameters for the three statements are as follows:

`OR REPLACE`
: Re-creates the UDT if it already exists. Objects that depend on the type are marked as `DISABLED` after you re-create the type.

`EDITIONABLE | NONEDITIONABLE`
: Specifies whether the type is an editioned or noneditioned object if editioning is enabled for the schema object `TYPE` in the declared schema. The default is `EDITIONABLE`.

`AUTHID {DEFINER | CURRENT_USER}`
: Determines what user permissions any member functions or procedures are executed under and how external name references are resolved. (Note that subtypes inherit the permission styles of their supertypes.) This clause can be used only with an `OBJECT` type, not with a `VARRAY` type or a nested table type.

  `DEFINER`
  : Executes functions or procedures under the privileges of the user who created the UDT. Also specifies that unqualified object names (object names without a schema definition) in SQL statements are resolved to the schema where the member functions or procedures reside.

  `CURRENT_USER`
  : Executes functions or procedures under the privileges of the user who invoked the UDT. Also specifies that unqualified object names in SQL statements are resolved to the schema of the user who invoked the UDT.

`UNDER` *`supertype_name`*
: Declares that the UDT is a subtype of another preexisting UDT. The supertype UDT must be created with the `AS OBJECT` clause. A subtype will inherit the properties of the supertype, though you should override some of those or add new properties to differentiate it from the supertype.

`OID '`*`object_identifier`*`'`
: Declares an equivalent identical object, of the name `'`*`object_identifier`*`'`, in more than one database. This clause is most commonly used by those developing Oracle Data Cartridges and is seldom used in standard SQL statement development.

`AS OBJECT`
: Creates the UDT as a root object type (the top-level object in a UDT hierarchy of objects).

AS TABLE OF *data_type*
: Creates a named nested table type of a UDT called *data_type*. The data type cannot be an NCLOB, but CLOB and BLOB are acceptable. If the data type is an object type, the columns of the nested table must match the name and attributes of the object type.

AS VARRAY (*limit*) OF *data_type*
: Creates the UDT as an ordered set of elements, all of the same data type. The *limit* is an integer of zero or more. The type name must be a built-in data type, a REF, or an object type. The VARRAY cannot contain LOB or XMLType data types. VARRAY may be substituted with VARYING ARRAY.

data_type
: Declares the attributes and data types used by the UDT. Oracle does not allow ROWID, LONG, LONG ROW, or UROWID. Nested tables and VARRAYs do not allow attributes of AnyType, AnyData, or AnyDataSet.

MEMBER | STATIC
: Describes the way in which subprograms are associated with the UDT as attributes. MEMBER has an implicit first argument referenced as SELF, as in object_expression.method(). STATIC has no implicit arguments, as in type_name.method(). The following bases are allowed to call subprograms:

  function_based
  : Declares a subprogram that is function-based using the syntax:

```
FUNCTION function_name (parameter data_type[, ...])
return_clause | java_object_clause
```

  This clause allows you to define the PL/SQL function-based UDT body without resorting to the CREATE TYPE BODY statement. The *function_name* cannot be the name of any existing attribute, including those inherited from supertypes. The *return_clause* and *java_object_clause* are defined later in this list.

  procedure_based
  : Declares a subprogram that is function-based using the syntax:

```
PROCEDURE procedure_name (parameter data_type[, ...])
{AS | IS} LANGUAGE {java_call_spec | c_call_spec}
```

  This clause allows you to define the PL/SQL procedure-based UDT body without resorting to the CREATE TYPE BODY statement. The *procedure_name* cannot be the name of any existing attribute, including those inherited from supertypes. Refer to the entries on *java_call_spec* and *c_call_spec* later in this list for details on those clauses.

constructor_clause
: Declares one or more constructor specifications, using the following syntax:

```
[FINAL] [INSTANTIABLE] CONSTRUCTOR FUNCTION data_type
   [ ( [SELF IN OUT data_type,] parameter data_type[, ...] ) ]
   RETURN SELF AS RESULT

   [ {AS | IS} LANGUAGE {java_call_spec | c_call_spec} ]
```

A constructor specification is a function that returns an initialized instance of a UDT. Constructor specifications are always `FINAL`, `INSTANTIABLE`, and `SELF IN OUT`, so these keywords are not required. The *`java_call_spec`* and *`c_call_spec`* subclauses may be replaced with a PL/SQL code block in the `CREATE TYPE BODY` statement. (Refer to the entries on *`java_call_spec`* and *`c_call_spec`* later in this list for details.)

`map_clause`
: Declares the mapping or ordering of a supertype, using the following syntax:

```
{MAP | ORDER} MEMBER function_based
```

`MAP` uses more efficient algorithms for object comparison and is best in situations where you're performing extensive sorting or hash joins. `MAP MEMBER` specifies the relative position of a given instance in the ordering of all instances of the UDT. `ORDER MEMBER` specifies the explicit position of an instance and references a *`function_based`* subprogram that returns a `NUMBER` data type value. Refer to the entry on *`function_based`* earlier in this list for details.

`return_clause`
: Declares the data type return format of the SQL UDT using the syntax:

```
RETURN data_type [ {AS | IS} LANGUAGE {java_call_spec |
   c_call_spec} ]
```

`java_object_clause`
: Declares the return format of the Java UDT using the syntax:

```
RETURN {data_type | SELF AS RESULT} EXTERNAL [VARIABLE] NAME
   'java_name'
```

If you use the `EXTERNAL` clause, the value of the public Java method must be compatible with the SQL returned value.

`pragma_clause`
: Declares a *pragma restriction* (that is, an Oracle precompiler directive) for the type using the syntax:

```
PRAGMA RESTRICT REFERENCES ( {DEFAULT | method_name},
{RNDS | WNDS |RNPS | WNPS | TRUST}[, ...] )
```

This feature is deprecated and should be avoided. It is intended to control how UDTs read and write database tables and variables.

DEFAULT
: Applies the pragma to all methods in the type that don't have another pragma in place.

method_name
: Identifies the exact method to which to apply the pragma.

RNDS
: Reads no database state—no database reads allowed.

WNDS
: Writes no database state—no database writes allowed.

RNPS
: Reads no package state—no package reads allowed.

WNPS
: Writes no package state—no package writes allowed.

TRUST
: States that the restrictions of the pragma are assumed but not enforced.

java_call_spec
Identifies the Java implementation of a method using the syntax `JAVA NAME '`*`string`*`'`. This clause allows you to define the Java UDT body without resorting to the `CREATE TYPE BODY` statement.

c_call_spec
Declares a C language call specification using the syntax:

```
C [NAME name] LIBRARY lib_name [AGENT IN (argument)]
[WITH CONTEXT] [PARAMETERS (parameter[, ...])]
```

This clause allows you to define the C UDT body without resorting to the `CREATE TYPE BODY` statement.

COMPILE
Compiles the object type specification and body. This is the default when neither a `SPECIFICATION` clause nor a `BODY` clause is defined.

DEBUG
Generates and stores additional codes for the PL/SQL debugger. Do not specify both `DEBUG` and the *`compiler_directive`* `PLSQL_DEBUG`.

SPECIFICATION | BODY
Indicates whether to recompile the `SPECIFICATION` of the object type (created by the `CREATE TYPE` statement) or the `BODY` (created by the `CREATE TYPE BODY` statement).

compiler_directives
: Defines one or more special values for the PL/SQL compiler in the format *directive* = '*value*'. The directives are: PLSQL_OPTIMIZE_LEVEL, PLSQL_CODE_TYPE, PLSQL_WARNINGS, and NLS_LENGTH_SEMANTICS. They may each specify a value once in the statement. The directive is valid only for the unit being compiled.

REUSE SETTINGS
: Retains the original values for the *compiler_directives*.

REPLACE AS OBJECT
: Adds new member subtypes to the specification. This clause is valid only for object types.

[NOT] OVERRIDING
: Indicates whether or not the method overrides a MEMBER method defined in the supertype. This clause is valid only with MEMBER methods and is required for methods that define (or redefine, using ALTER) a supertype method. NOT OVERRIDING is the default if this clause is omitted.

ADD
: Adds a new MEMBER function, function- or procedure-based subprogram, or attribute to the UDT.

DROP
: Drops an existing MEMBER function, function- or procedure-based subprogram, or attribute from the UDT.

MODIFY
: Alters the properties of an existing attribute of the UDT.

MODIFY LIMIT *int*
: Increases the number of elements in a VARRAY collection type up to *int*, as long as *int* is greater than the current number of elements in the VARRAY. Not valid for nested tables.

MODIFY ELEMENT TYPE *data_type*
: Increases the precision, size, or length of a scalar data type of a VARRAY or nested table. This clause is valid for any nonobject collection type. If the collection is a NUMBER, you may increase its precision or scale. If the collection is a RAW, you may increase its maximum size. If the collection is a VARCHAR2 or NVARCHAR2, you may increase its maximum length.

INVALIDATE
: Invalidates all dependent objects without checks.

CASCADE
: Cascades the change to all subtypes and tables. By default, the action will be rolled back if any errors are encountered in the dependent types or tables.

`[NOT] INCLUDING TABLE DATA`
: Converts data stored in the UDT columns to the most recent version of the column's type (`INCLUDING TABLE DATA`, the default), or not (`NOT INCLUDING TABLE DATA`). When `NOT`, Oracle checks the metadata but does not check or update the dependent table data.

`CONVERT TO SUBSTITUTABLE`
: Used when changing a type from `FINAL` to `NOT FINAL`. The altered type then can be used in substitutable tables and columns, as well as in subtypes, instances of dependent tables, and columns.

`FORCE`
: Causes the `CASCADE` operation to go forward, ignoring any errors found in dependent subtypes and tables. All errors are logged to a previously created `EXCEPTIONS` table.

`EXCEPTIONS INTO` *`table_name`*
: Logs all error data to a table previously created using the system package `DBMS_UTILITY.CREATE_ALTER_TYPE_ERROR_TABLE`.

In this example, we create a Java SQLJ object type called `type`:

```
CREATE TYPE address_type AS OBJECT
   EXTERNAL NAME 'scott.address' LANGUAGE JAVA
   USING SQLDATA ( street1 VARCHAR(30) EXTERNAL NAME 'str1',
      street2              VARCHAR(30) EXTERNAL NAME 'str2',
      city                 VARCHAR(30) EXTERNAL NAME 'city',
      state                CHAR(2)     EXTERNAL NAME 'st',
      locality_code        CHAR(15)    EXTERNAL NAME 'lc',
      STATIC FUNCTION square_feet RETURN NUMBER
         EXTERNAL VARIABLE NAME 'square_feet',
      STATIC FUNCTION create_addr (str VARCHAR,
         City VARCHAR, state VARCHAR, zip NUMBER)
         RETURN address_type
         EXTERNAL NAME 'create (java.lang.String,
            java.lang.String, java.lang.String, int)
            return scott.address',
      MEMBER FUNCTION rtrims RETURN SELF AS RESULT
         EXTERNAL NAME 'rtrim_spaces () return scott.address' )
NOT FINAL;
```

We could create a UDT using a `VARRAY` type with four elements:

```
CREATE TYPE employee_phone_numbers AS VARRAY(4) OF CHAR(14);
```

In the following example, we alter the `address_type` that we created earlier by adding a `VARRAY` called `phone_varray`:

```
ALTER TYPE address_type
   ADD ATTRIBUTE (phone phone_varray) CASCADE;
```

In this last example, we'll create a supertype and a subtype called `menu_item_type` and `entry_type`, respectively:

```
CREATE OR REPLACE TYPE menu_item_type AS OBJECT
(id INTEGER, title VARCHAR2(500),
   NOT INSTANTIABLE
   MEMBER FUNCTION fresh_today
   RETURN BOOLEAN)
NOT INSTANTIABLE
NOT FINAL;
```

In the preceding example, we created a type specification (but not the type body) that defines items that may appear on a menu at a café. Included with the type specification is a subprogram method called *fresh_today*, a Boolean indicator that tells whether the menu item is made fresh that day. The `NOT FINAL` clause that appears at the end of the code tells Oracle that this type may serve as the supertype (or base type) to other subtypes that we might derive from it. So now, let's create the *entree_type*:

```
CREATE OR REPLACE TYPE entree_type UNDER menu_item_type
(entree_id INTEGER, desc_of_entree VARCHAR2(500),
   OVERRIDING MEMBER FUNCTION fresh_today
   RETURN BOOLEAN)
NOT FINAL;
```

PostgreSQL

PostgreSQL supports both an `ALTER TYPE` statement and a `CREATE TYPE` statement used to create a new data type. PostgreSQL's implementation of the `CREATE TYPE` statement is nonstandard and can take on any of the following four forms:

For composite types, such as types that can be used to define a table:

```
CREATE TYPE name AS
   ( [attribute_name data_type
     [COLLATE collation][, ...]] )
```

For enum types the label is a list of named values allowed for this type.

```
CREATE TYPE name AS ENUM
   ( ['label'[, ... ]] )
```

For range types which define a start and end value:

```
CREATE TYPE name AS RANGE (
   SUBTYPE = subtype
   [, SUBTYPE_OPCLASS = subtype_operator_class]
   [, COLLATION = collation]
   [, CANONICAL = canonical_function]
   [, SUBTYPE_DIFF = subtype_diff_function]
)
```

For base types that internally define their own storage characteristics and indexing support. These often require programming in C to make and thus are the hardest to create:

```
CREATE TYPE type_name
  ( INPUT = input_function_name,
    OUTPUT = output_function_name
   [, INTERNALLENGTH = {int | VARIABLE}]
   [, DEFAULT = value]
   [, ELEMENT = array_element_data_type]
   [, DELIMITER = delimiter_character]
   [, CATEGORY = category]
   [, COLLATABLE = collatable]
   [, PASSEDBYVALUE]

   [, ALIGNMENT = {CHAR | INT2 | INT4 | DOUBLE}]

   [, STORAGE = {PLAIN | EXTERNAL | EXTENDED | MAIN}]

   [, RECEIVE = receive_function]
   [, SEND = send_function]
   [, ANALYZE = analyze_function]
   [, TYPMOD_IN = type_modifier_input_function]
   [, TYPMOD_OUT = type_modifier_output_function] )
```

PostgreSQL allows you to change the schema or owner of an existing type using the `ALTER TYPE` statement:

```
ALTER TYPE type_name [OWNER TO new_owner_name]
[SET SCHEMA new_schema_name]
```

The parameters are as follows:

`CREATE TYPE` *`type_name`*
: Creates a new user-defined data type called *`type_name`*. The name may not exceed 30 characters in length, nor may it begin with an underscore.

`INPUT =` *`input_function_name`*
: Declares the name of a previously created function that converts external argument values into a form usable by the type's internal form.

`OUTPUT =` *`output_function_name`*
: Declares the name of a previously created function that converts internal output values to a display format.

`INTERNALLENGTH = {` *`int`* `| VARIABLE }`
: Specifies a numeric value, *`int`*, for the internal length of the new type, if the data type is fixed-length. The keyword `VARIABLE` (the default) declares that the internal length is variable.

`DEFAULT =` *`value`*
: Defines a value for *`type`* when it defaults.

`ELEMENT =` *`array_element_data_type`*
: Declares that the data type is an array and that *`array_element_data_type`* is the data type of the array elements. For example, an array containing integer values would be `ELEMENT = INT4`. In general, you should allow the *`array_element_data_type`* value to default. The only time you might want to override the default is when creating a fixed-length UDT composed of an array of multiple identical elements that need to be directly accessible by subscripting.

`DELIMITER =` *`delimiter_character`*
: Declares a character to be used as a delimiter between output values of an array produced by the type. Only used with the `ELEMENT` clause. The default is a comma.

`PASSEDBYVALUE`
: Specifies that the values of the data type are passed by value and not by reference. This optional clause cannot be used for types whose value is longer than the `DATUM` data type (4 bytes on most operating systems, 8 bytes on a few others).

`ALIGNMENT = {CHAR | INT2 | INT4 | DOUBLE}`
: Defines a storage alignment for the type. Four data types are allowed, with each equating to a specific boundary: `CHAR` equals a 1-byte boundary, `INT2` equals a 2-byte boundary, `INT4` equals a 4-byte boundary (the requirement for a variable-length UDT on PostgreSQL), and `DOUBLE` equals an 8-byte boundary.

`STORAGE = {PLAIN | EXTERNAL | EXTENDED | MAIN}`
: Defines a storage technique for variable-length UDTs. (`PLAIN` is required for fixed-length UDTs.) Four types are allowed:

  `PLAIN`
  : Stores the UDT inline, when declared as the data type of a column in a table, and uncompressed.

  `EXTERNAL`
  : Stores the UDT outside of the table without trying to compress it first.

  `EXTENDED`
  : Stores the UDT as a compressed value if it fits inside the table. If it is too long, PostgreSQL will save the UDT outside of the table.

  `MAIN`
  : Stores the UDT as a compressed value within the table. Bear in mind, however, that there are situations where PostgreSQL cannot save the UDT within the table because it is just too large. The `MAIN` storage parameter puts the highest emphasis on storing UDTs with all other table data.

`SEND =` *`send_function`*
: Converts the internal representation of the type to the external binary representation. Usually coded in C or another low-level language.

`RECEIVE = receive_function`
: Converts the text's external binary representation to the internal representation. Usually coded in C or another low-level language.

`ANALYZE = analyze_function`
: Performs type-specific statistical collection for columns of the type.

More details on the `SEND`, `RECEIVE`, and `ANALYZE` functions are available in the PostgreSQL documentation.

When you create a new data type in PostgreSQL, it is available *only* in the current database. The user who created the data type is the owner. When you create a new type, the parameters may appear in any order and are largely optional, except for the first two (the `INPUT` and `OUTPUT` functions). You must create at least these two functions before defining the type (see "CREATE/ALTER FUNCTION/PROCEDURE Statement" on page 661 for details). The `INPUT` function provides the type with external values that can be used by the operators and functions defined for the type, and the `OUTPUT` function renders a usable external representation of the data type. There are some additional requirements when creating the input and output functions:

- The `INPUT` function should either take one argument of type `OPAQUE` or take three arguments of type `OPAQUE`, `OID`, and `INT4`. In the latter case, `OPAQUE` is the input text of a C string, `OID` is the element type for array types, and `INT4` (if known) is the typmod of the destination column.
- The `OUTPUT` function should either take one argument of type `OPAQUE` or take two arguments of type `OPAQUE` and `OID`. In the latter case, `OPAQUE` is the data type itself and `OID` is the element type for array types, if needed.

For example, we can create a UDT called *floorplan* and use it to define a column in two tables, one called *house* and one called *condo*:

```
CREATE TYPE floorplan
   (INTERNALLENGTH=12, INPUT=squarefoot_calc_proc,
    OUTPUT=out_floorplan_proc);
CREATE TABLE house
   (house_plan_id  int4,
    size           floorplan,
    descrip        varchar(30));
CREATE TABLE condo
   (condo_plan_id  int4,
    size           floorplan,
    descrip        varchar(30)
    location_id    varchar(7));
```

SQL Server

SQL Server supports the CREATE TYPE statement, but not the ALTER TYPE statement. New data types can also be added to SQL Server using the non-SQL system stored procedure *sp_addtype*. Beginning in SQL Server 2014 and applicable to Azure SQL Database, you may also process data in a table type using memory-optimized tables. The syntax for SQL Server's implementation of CREATE TYPE follows:

```
CREATE TYPE type_name
{ FROM base_type [ ( precision[, scale] ) ] [[NOT] NULL] |
   AS TABLE table_definition |
   CLR_definition }
```

where:

FROM *base_type*
: Supplies the data type upon which the data type alias is based. The data type may be one of the following: BIGINT, BINARY, BIT, CHAR, DATE, DATE TIME, DATETIME2, DATETIMEOFFSET, DECIMAL, FLOAT, IMAGE, INT, MONEY, NCHAR, NTEXT, NUMERIC, NVARCHAR, REAL, SMALLDATETIME, SMALLINT, SMALLMONEY, SQL_VARIANT, TEXT, TIME, TINYINT, UNIQUEIDENTIFIER, VARBINARY, or VARCHAR. Where appropriate to the data type, a precision and scale may be defined.

[NOT] NULL
: Specifies whether the type can hold a NULL value. When omitted, NULL is the default.

AS TABLE *table_definition*
: Specifies a user-defined table type with columns, data types, keys, constraints (such as CHECK, UNIQUE, and PRIMARY KEY), and properties (such as CLUSTERED and NONCLUSTERED), just like a regular table.

SQL Server supports the creation of types written in Microsoft .NET Framework common language runtime (CLR) methods that can take and return user-supplied parameters. These types have similar CREATE and ALTER declarations to regular SQL types; however, the code bodies are external assemblies. Refer to the SQL Server documentation if you want to learn more about programming routines using the CLR.

User-defined types created with *sp_addtype* are accessible by the PUBLIC database role. However, permission to access user-defined types created with CREATE TYPE must be granted explicitly, including to PUBLIC.

See also

- CREATE/ALTER FUNCTION/PROCEDURE in Chapter 9
- DROP

CREATE/ALTER VIEW Statement

This statement creates a view (also known as a *virtual table*). A view acts just like a table but is actually defined with a query. When a view is referenced in a statement, the result set of the query becomes the content of the view for the duration of that statement. Almost any valid `SELECT` statement can define the contents of a view, though some platforms restrict certain clauses of the `SELECT` statement and certain set operators. Tables and views may not have the same names within a schema, because they share the same namespace.

In some cases, views can be updated, causing the changes to be translated to the underlying data in the base tables. Some database platforms support a *materialized view*, also known as an *indexed view*, which is a physically created table that is defined with a query just like a view.

`ALTER VIEW` is not part of the SQL standard but is implemented (with variations) by all of the database platforms discussed here.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
CREATE [RECURSIVE] VIEW view_name {[(column[, ...])] |
[OF udt_name [UNDER supertype_name
   [REF IS column_name {SYSTEM GENERATED | USER GENERATED | DERIVED}]
   [column_name WITH OPTIONS SCOPE table_name]]]}
AS select_statement [WITH [CASCADED | LOCAL] CHECK OPTION]
```

Keywords

`CREATE VIEW` *`view_name`*
: Creates a new view using the supplied name.

`RECURSIVE`
: Creates a view that derives values from itself. It must have a *`column`* clause and may not use the `WITH` clause.

`[(`*`column`*`[, ... ])]`
: Names all of the columns in the view. The number of columns declared here must match the number of columns generated by the *`select_statement`*.

When omitted, the columns in the view derive their names from the columns in the table. This clause is required when one or more of the columns is derived and does not have a base table column to reference.

`OF` *`udt_name`* `[UNDER` *`supertype_name`*`]`
: Defines the view based on a UDT rather than on the *`column`* clause. The typed view is created using each attribute of the type as a column in the view. Use the `UNDER` clause to define a view on a subtype.

`REF IS` *`column_name`* `{SYSTEM GENERATED | USER GENERATED | DERIVED}`
: Defines the OID column for the view.

`column_name` `WITH OPTIONS SCOPE` *`table_name`*
: Provides scoping for a reference column in the view. (Since the columns are derived from the type, there is no column list. Therefore, to specify column options, you must use *`column_name`* `WITH OPTIONS ...` .)

`AS` *`select_statement`*
: Defines the exact `SELECT` statement that provides the data of the view.

`WITH [CASCADED | LOCAL] CHECK OPTION`
: Used *only* on views that allow updates to their base tables. Ensures that only data that may be read by the view may be inserted, updated, or deleted by the view. For example, if a view of *employees* showed salaried employees but not hourly employees, it would be impossible to insert, update, or delete hourly employee records through that view. The `CASCADED` and `LOCAL` options of the `CHECK OPTION` clause are used for nested views. `CASCADED` performs the check option for the current view and all views upon which it is built; `LOCAL` performs the check option only for the current view, even when it is built upon other views.

Rules at a glance

Views are usually only as effective as the queries upon which they are based. That is why it is important to be sure that the defining `SELECT` statement is speedy and well written. The simplest view is based on the entire contents of a single table:

```
CREATE VIEW employees
AS
SELECT *
FROM employee_tbl;
```

A column list also may be specified after the view name. The optional column list contains aliases serving as names for each element in the result set of the `SELECT` statement. If you use a column list, you must provide a name for every column returned by the `SELECT` statement. If you don't use a column list, the columns of the view will be named whatever the columns in the `SELECT` statement are called. You will sometimes see complex `SELECT` statements within a view that make heavy use of AS clauses for all columns, because that allows the developer of the view to put meaningful names on the columns without including a column list.

The SQL standard specifies that you must use a column list or an AS clause. However, some vendors allow more flexibility, so follow these rules for when to use an AS clause:

- When the SELECT statement contains calculated columns, such as *(salary * 1.04)*
- When the SELECT statement contains fully qualified column names, such as *pubs.scott.employee*
- When the SELECT statement contains more than one column of the same name (though with separate schema or database prefixes)

For example, the following two view declarations have the same functional result:

```
-- Using a column list
CREATE VIEW title_and_authors
   (title, author_order, author, price, avg_monthly_sales,
    publisher)
AS
SELECT t.title, ta.au_ord, a.au_lname, t.price, (t.ytd_sales / 12),
   t.pub_id
FROM authors AS a
JOIN titleauthor AS ta ON a.au_id = ta.au_id
JOIN titles AS t ON t.title_id = ta.title_id
WHERE t.advance > 0;

-- Using the AS clause with each column
CREATE VIEW title_and_authors
AS
SELECT t.title AS title, ta.au_ord AS author_order,
   a.au_lname AS author, t.price AS price,
   (t.ytd_sales / 12) AS avg_monthly_sales, t.pub_id AS publisher
FROM authors AS a
JOIN titleauthor AS ta ON a.au_id = ta.au_id
JOIN titles AS t ON t.title_id = ta.title_id
WHERE t.advance > 0
```

You can also change the titles of columns using the column list. In this case, we'll change *avg_monthly_sales* to *avg_sales*. Note that the code overrides the default column names provided by the AS clauses (in bold):

```
CREATE VIEW title_and_authors
   (title, author_order, author, price, avg_sales, publisher)
AS
SELECT t.title AS title, ta.au_ord AS author_order,
   a.au_lname AS author, t.price AS price,
   (t.ytd_sales / 12) AS avg_monthly_sales, t.pub_id AS publisher
FROM authors AS a
```

```
JOIN titleauthor AS ta ON a.au_id = ta.au_id
JOIN titles AS t ON t.title_id = ta.title_id
WHERE t.advance > 0;
```

A SQL-standard view can update the base table(s) it is based upon if it meets the following conditions:

- The view does not have `UNION`, `EXCEPT`, or `INTERSECT` operators.
- The defining `SELECT` statement does not contain `GROUP BY` or `HAVING` clauses.
- The defining `SELECT` statement does not contain any references to non-SQL pseudocolumns such as `ROWNUM` or `ROWGUIDCOL`.
- The defining `SELECT` statement does not contain the `DISTINCT` clause.
- The view is not materialized.

This example shows a view named *california_authors* that allows data modifications to apply only to authors within the state of California:

```
CREATE VIEW california_authors
AS
SELECT au_lname, au_fname, city, state
FROM authors
WHERE state = 'CA'
WITH LOCAL CHECK OPTION
```

The view shown in this example would accept `INSERT`, `DELETE`, and `UPDATE` statements against the base table but guarantee that all inserted, updated, or deleted records contain a *state* of `'CA'` using the `WITH ... CHECK` clause.

The most important rule to remember when updating a base table through a view is that all columns in a table that are defined as `NOT NULL` must receive a not-NULL value when receiving a new or changed value. You can do this explicitly by directly inserting or updating a not-NULL value into the column, or by relying on a default value. In addition, views do not lift constraints on the base table. Thus, the values being inserted into or updated in the base table must meet all the constraints originally placed on the table through unique indexes, primary keys, `CHECK` constraints, etc.

Programming tips and gotchas

Views also can be built upon other views, but this is inadvisable and usually considered bad practice. Depending on the platform, such a view may take longer to compile, but may offer the same performance as a transaction against the base table(s). On other platforms, where each view is dynamically created as it is invoked, nested views may take a long time to return a result set because each level of nesting means that another query must be processed before a result set is returned to the user. In this worst-case scenario, a three-level nested view must make three correlated query calls before it can return results to the user.

Although materialized views are defined like views, they take up space more like tables. Ensure that you have enough space available for the creation of materialized views.

MySQL

MySQL supports a `CREATE [OR REPLACE] VIEW` and an `ALTER VIEW` statement. It does not support SQL recursive views, UDT and supertyped views, or views using `REF`. The syntax for both statements follows:

```
{ALTER | CREATE [OR REPLACE]}
[ALGORITHM = {UNDEFINED | MERGE | TEMPTABLE}]
[DEFINER = {user_name | CURRENT_USER}]
[SQL SECURITY {DEFINER | INVOKER}]
VIEW view_name [(column[, ...])]
AS select_statement
[WITH [CASCADED | LOCAL] CHECK OPTION]
```

where:

`ALTER | CREATE [OR REPLACE]`
: Alters an existing view or creates (or replaces) a view. You can use the replace form if you want to completely replace the definition of a view, even if such a replace would delete or change the data types of existing columns of the view.

`ALGORITHM = {UNDEFINED | MERGE | TEMPTABLE}`
: Specifies how MySQL should process the view. `MERGE` tells MySQL to merge the query plans of the query referencing the view and the underlying view itself to achieve optimal performance. `TEMPTABLE` tells MySQL to first retrieve the results of the view into a temporary table, then use the temporary table in the query where the view is referenced. `UNDEFINED` tells MySQL to choose the best algorithm to process the view. When this clause is omitted, `UNDEFINED` is the default.

`DEFINER = {`*`user_name`*` | CURRENT_USER}`
: Specifies the user account to use when checking privileges. You may specify either a preexisting user or the user who issued the `CREATE VIEW` statement (i.e., the `CURRENT_USER`). `CURRENT_USER` is the default when this clause is omitted.

`SQL SECURITY {DEFINER|INVOKER}`
: Specifies the security context under which the view runs: either that of the user that created the view (`DEFINER`, the default when this clause is omitted) or the user running the view (`INVOKER`).

In this example we create a view listing just authors in California. It will allow only insertion of authors in California, and only users who have permission to query the underlying table can query this view:

```
CREATE OR REPLACE SQL SECURITY INVOKER VIEW california_authors
AS
SELECT au_lname, au_fname, city, state
FROM authors
WHERE state = 'CA'
WITH CHECK OPTION;
```

Oracle

Oracle supports extensions to the SQL standard to create object-oriented views, XMLType views, and views that support LOB and object types:

```
CREATE [OR REPLACE] [[NO] FORCE][EDITIONING]
 [EDITIONABLE | NONEDITIONABLE ]
 [MATERIALIZED] VIEW view_name
   {[ (column[, ...]) [constraint_clause] ] |
    [OF type_name {UNDER parent_view |
       WITH OBJECT IDENTIFIER {DEFAULT | (attribute[, ...])}
       [(constraint_clause)]}] |
    [OF XMLTYPE [ [XMLSCHEMA xml_schema_url] ELEMENT
       {element | xml_schema_url # element} ]
       WITH OBJECT IDENTIFIER {DEFAULT | (attribute[, ...])}] ]}
  [FOR UPDATE]
AS
(select_statement)
[WITH [READ ONLY | CHECK OPTION [CONSTRAINT constraint_name]]]
```

Oracle's implementation of the ALTER VIEW statement supports added capabilities, such as adding, dropping, or modifying constraints associated with the view. In addition, the ALTER VIEW statement will explicitly recompile a view that is invalid, enabling you to locate recompilation errors before runtime. This recompiling feature enables you to determine whether a change in a base table negatively impacts any dependent views:

```
ALTER [MATERIALIZED] VIEW view_name
  {ADD constraint_clause |
   MODIFY CONSTRAINT constraint_clause [NO]RELY]] |
   DROP {PRIMARY KEY | CONSTRAINT constraint_clause |
   UNIQUE (column[, ...])}}
COMPILE
```

The parameters are:

OR REPLACE
: Replaces any existing view of the same *view_name* with the new view. It maintains the original view's permissions but for regular views will drop any INSTEAD OF triggers.

[NO] FORCE
: Specifies whether or not to force creation of the view regardless of whether the base tables exist or the user creating the view has privileges to read from or write to the base tables, views, or functions defined in the view. The FORCE

clause also creates the view regardless of any errors that occur during view creation. The NO FORCE clause creates the view only if the base tables and proper privileges are in place.

EDITIONING
: Creates an editioning view. Editioning views are single table–based views that select all rows but only a subset of the columns from the base table. Within any edition, there can be only one editioning view of a given base table. The base table must be in the same schema as the view that's being created. In addition to selecting all rows and a subset of columns, editioning views differ from other views in that they can have DML triggers directly on them; these triggers fire only when DML operations are performed on the views themselves, not when data is inserted/updated in the base table. This allows for editions to be used to shield applications from database structural changes. Editioning views cannot have INSTEAD OF triggers. They cannot be created if their underlying table does not exist (even if the FORCE clause is used), and they cannot be object- or XML-based.

MATERIALIZED
: Creates a materialized view, which stores the results of a query. This is used mostly for performance reasons, in cases where querying the underlying tables would be significantly slower than querying a cached set of the data. Materialized views are also used to store local read-only copies of data on remote servers. A materialized view can be read-only or updatable; the default is read-only. For changes to replicate to the underlying tables, the view should be part of a materialized view group. Refresh behavior for the view is configurable: options include FAST, COMPLETE, FORCE, ON COMMIT, and ON DEMAND. Refer to the vendor documentation for additional details on materialized views.

constraint_clause
: Allows you to specify constraints when creating a view (see the section on CREATE/ALTER TABLE for details). With ALTER VIEW, this clause can be used to add, modify, or drop a named preexisting constraint. You can define a constraint at the view level, similar to a table-level view, or at the column or attribute level. Note that although Oracle allows you to define constraints on a view, it doesn't yet enforce them. Oracle supports constraints on a view in DISABLE and NOVALIDATE modes.

OF *type_name*
: Declares that the view is an object view of type *type_name*. The columns of the view correspond directly to the attributes returned by *type_name*, where *type_name* is a previously declared type (see the section on CREATE/ALTER TYPE). You do not specify column names for object and XMLType views.

`UNDER` *`parent_view`*

Specifies a subview based on a preexisting *`parent_view`*. The subview must be in the same schema as the parent view, the *`type_name`* must be an immediate subtype of the *`parent_view`*, and only one subview is allowed.

`WITH OBJECT IDENTIFIER {DEFAULT | (`*`attribute`*`[, ... ])}`

Defines the root object view as well as any *`attribute`*s of the object type used to identify each row of the object view. The attributes usually correspond to the primary key columns of the base table and must uniquely identify each row of the view. This clause is incompatible with subviews and dereferenced or pinned `REF` keys. The `DEFAULT` keyword uses the implicit object identifier of the base object table or view.

`OF XMLTYPE [ [XMLSCHEMA` *`xml_schema_url`*`] ELEMENT {`*`element`*` |`
`xml_schema_url # element`` } ] WITH OBJECT IDENTIFIER {DEFAULT |`
`(`*`attribute`*`[, ... ])}`

Specifies that the view will return XMLType instances. Specifying the optional *`xml_schema_url`* as a preregistered XML schema and element name further constrains the returned XML as an element in that XML schema. The `WITH OBJECT IDENTIFIER` clause specifies the identifier that uniquely identifies each row of the XMLType view. One or more attributes may use non-aggregate functions like `EXTRACTVALUE` to obtain the identifiers from the resultant XMLType.

`WITH READ ONLY`

Ensures that the view is used only to retrieve data, not to modify it.

`WITH CHECK OPTION [CONSTRAINT` *`constraint_name`*`]`

Forces the view to accept only inserted and updated data that can be returned by the view's `SELECT` statement. Alternatively, you can specify a single `CHECK OPTION` *`constraint_name`* that exists on the base table that you want to enforce. If the constraint is not named, Oracle names the constraint `SYS_C`*`n`*, where *`n`* is an integer.

`ADD` *`constraint_clause`*

Adds a new constraint to the view. Oracle supports constraints only in `DISABLE` and `NOVALIDATE` modes.

`MODIFY CONSTRAINT` *`constraint_clause`* `[NO]RELY`

Changes the `RELY` or `NORELY` setting of an existing view constraint. (`RELY` and `NORELY` are explained in the section on `CREATE/ALTER TABLE`.)

`DROP {PRIMARY KEY | CONSTRAINT` *`constraint_clause`* `| UNIQUE`
`(`*`column`*`[, ... ])}`

Drops an existing constraint on a view.

`COMPILE`

Recompiles the view.

Any dblinks in the view's SELECT statement must be declared using the CREATE DATABASE LINK ... CONNECT TO statement. Any view containing flashback queries will have its AS OF clause evaluated at each invocation of the view, not when the view is compiled.

In this example, we create a view that has an added constraint:

```
CREATE VIEW california_authors (last_name, first_name,
   author_ID UNIQUE RELY DISABLE NOVALIDATE,
   CONSTRAINT id_pk PRIMARY KEY (au_id) RELY DISABLE NOVALIDATE)
AS
SELECT au_lname, au_fname, au_id
FROM authors
WHERE state = 'CA';
```

We might also wish to create an object view on an Oracle database and schema. This example creates the type and the object view:

```
CREATE TYPE inventory_type AS OBJECT
( title_id NUM(6),
  warehouse wrhs_typ,
  qty NUM(8) );
CREATE VIEW inventories OF inventory_type
WITH OBJECT IDENTIFIER (title_id)
AS
SELECT i.title_id, wrhs_typ(w.wrhs_id, w.wrhs_name,
   w.location_id), i.qty
FROM inventories i
JOIN warehouses w ON i.wrhs_id = w.wrhs_id;
```

We could recompile the *inventory_type* view like this:

```
ALTER VIEW inventory_type COMPILE:
```

An updatable view in Oracle cannot contain any of the following:

- The DISTINCT clause
- UNION, INTERSECT, or MINUS clauses
- Joins that cause inserted or updated data to affect more than one table
- Aggregate or analytic functions
- GROUP BY, ORDER BY, CONNECT BY, or START WITH clauses
- Subqueries or collection expressions in the SELECT item list (subqueries are acceptable in the SELECT statement's WHERE clause)
- Update pseudocolumns or expressions

There are some restrictions on how subviews and materialized views can be defined in Oracle:

- The subview must use aliases for `ROWID`, `ROWNUM`, or `LEVEL` pseudocolumns.
- The subview cannot query `CURRVAL` or `NEXTVAL` pseudocolumns.
- The subview cannot contain the `SAMPLE` clause.
- The subview evaluates all columns of a `SELECT * FROM ...` statement at compile time. Thus, any new columns added to the base table will not be retrieved by the subview until the view is recompiled.

Note that while older versions of Oracle supported partitioned views, this feature has been deprecated. You should use explicitly declared partitions instead.

PostgreSQL

PostgreSQL supports the SQL standard for `CREATE VIEW` with some variations, including an extended `CREATE OR REPLACE VIEW` syntax. A view column name list must be specified for a RECURSIVE view. The PostgreSQL syntax for `CREATE VIEW` is as follows:

```
CREATE [OR REPLACE] [TEMP[ORARY]][MATERIALIZED]
[RECURSIVE] VIEW view_name [ (column[, ...]) ]
 [ USING method ]
WITH ( view_option_name [= view_option_value] [, ... ] ) ]
AS select_statement
[WITH [CASCADED | LOCAL] CHECK OPTION
 [ [NO] DATA] ]
]
```

`[TEMP]ORARY`
: Creates the view as a temporary view. Temporary views are automatically dropped at the end of the current session.

`MATERIALIZED`
: Stores the results of the query defined by the view. Materialized views are used mostly for performance, where querying the underlying tables would be significantly slower than querying a cached set of the data.

`USING` *`method`*
: Only used with materialized views. Denotes the table access method.

`WITH`
: Allows setting one or more view options, which are as follows:

  `check_option (enum)`
  : This parameter may be either *local* or *cascaded*, and is equivalent to specifying `WITH [ CASCADED | LOCAL ] CHECK OPTION` (see below).

security_barrier (true | false)
: This should be used if the view is intended to provide row-level security. Refer to the documentation for details.

<storage_parameter> = <value>
: There are quite a few storage parameters, which can be set only for materialized views. Refer to the documentation for details.

`WITH [CASCADED | LOCAL] CHECK OPTION`
: Forces the view to accept only inserted and updated data that can be returned by the view's `SELECT` statement.

`WITH [NO] DATA`
: Only used with materialized views. Specifies whether or not the view should be populated at the time it's created. `WITH NO DATA` allows for fast creation of the view since the view query is not executed; however, the view cannot be queried until the first `REFRESH MATERIALIZED VIEW` *name*. If not specified, the default is `DATA`.

PostgreSQL's `ALTER VIEW` command can be used to set certain properties of a view, change the ownership or name of a view, move a view to a different schema, or rename columns. The `ALTER VIEW` command takes the following forms:

```
ALTER VIEW [ IF EXISTS ] name ALTER [ COLUMN ]

   column_name SET DEFAULT expression

ALTER VIEW [ IF EXISTS ] name ALTER [ COLUMN ]

   column_name DROP DEFAULT

ALTER VIEW [ IF EXISTS ] name OWNER TO

   { new_owner | CURRENT_USER | SESSION_USER }

ALTER VIEW [ IF EXISTS ] name RENAME [ COLUMN ]

   column_name TO new_column_name

ALTER VIEW [ IF EXISTS ] name RENAME TO new_name

ALTER VIEW [ IF EXISTS ] name SET SCHEMA new_schema

ALTER VIEW [ IF EXISTS ] name SET

   ( view_option_name [= view_option_value] [, ... ] )

ALTER VIEW [ IF EXISTS ] name RESET

   ( view_option_name [, ... ] )
```

The view options are the same as those that can be used in `CREATE VIEW`.

You cannot use `ALTER VIEW` to replace the definition of a view. However, you can use `CREATE OR REPLACE` VIEW *`view_name`* to substitute the definition of an old view with the definition of a new view. A `CREATE OR REPLACE VIEW` command can only be used if the new view definition adds new columns, not if the new definition changes the data types of existing columns, deletes columns, or changes the order of columns.

PostgreSQL allows views to be built on tables, other views, and other defined class objects. Views based on single tables that don't involve aggregation, like with `GROUP BY`, are updatable by default. For views involving more than one table or aggregation, `INSTEAD OF` triggers can be created to control how data is updated in the underlying tables. You can use functions in views and still have them be automatically updatable as long as updates do not try to update these columns. Here is an example of a view definition that allows updating of *au_lname*, *au_fname*, and even *au_id* but will prevent changing the state because that would cause the updated record to no longer satisfy the filter of the view. It will also prevent updating *current_age* because that is a column that is not part of the base table:

```
CREATE OR REPLACE VIEW california_authors
AS
   SELECT au_lname, au_fname, au_id,
       au_fname || ' '  || au_lname AS au_full_name,
        age(au_birthdate) AS current_age
   FROM authors
   WHERE state = 'CA'
WITH CHECK OPTION;
```

PostgreSQL views are always schema-bound, meaning no objects referenced in the views (such as tables, other views, or functions) can be altered in such a way that they would affect the output definitions of the columns of the view. This means you can't drop tables or views used in a view, and you can't alter the data types of columns of a table used in a view. However, you can change the names of objects (tables, views, columns) referenced by the view. This catches many off guard, because it's different from how most other databases work. PostgreSQL internally tracks all tables and columns in views by their internal identifiers. When you rename an object referenced in a view, such as the name of a column, the view automatically changes. Let's say you decide to rename the *au_lname* column in the *authors* table to *last_name*. If you then look at the definition of *california_authors*, you will see that it has changed *au_lname* to *authors.last_name AS au_lname*. Also note that all column names have been changed to be fully qualified.

PostgreSQL's `CREATE RECURSIVE VIEW` construct is equivalent to writing `CREATE VIEW ... AS WITH RECURSIVE`. PostgreSQL also supports an extended `CREATE MATERIALIZED VIEW` construct that creates a view that caches the result of the query that defines the view. Materialized views, unlike other views, can have indexes defined on them using the `CREATE INDEX` construct. Materialized views are never updatable. Queries on a materialized view are applied to the cached data rather than the underlying tables. To refresh data in a materialized view, you would use `REFRESH MATERIALIZED VIEW` *`view_name`* or `REFRESH MATERIALIZED VIEW CONCURRENTLY` *`view_name`*.

`REFRESH MATERIALIZED VIEW` without the `CONCURRENTLY` keyword is a blocking operation that prevents querying of the view. Using `CONCURRENTLY` allows a materialized view to be queried while it is being refreshed, but can only be used with materialized views that have a unique index. PostgreSQL has no automatic means of refreshing a materialized view. Many users employ a cronjob, triggers, or some other job scheduling tool like *pgAgent* or *pgSchedule* to refresh materialized views.

Here, we define a PostgreSQL materialized view with a unique index:

```
CREATE MATERIALIZED VIEW vw_mat_authors AS
   SELECT au_lname, au_fname, au_id
   FROM authors;
CREATE UNIQUE INDEX ux_vw_mat_authors USING btree(au_id);
```

SQL Server

SQL Server offers some extensions to the SQL standard but does not support object views, subviews, or recursive views. SQL Server 2014 and later provide a `CREATE OR ALTER` construct that is equivalent to the `CREATE OR REPLACE` supported by the other databases described here. Its implementation of `ALTER VIEW` allows you to change an existing view without affecting the permissions or dependent objects of the view. The syntax for both statements follows:

```
CREATE [OR ALTER] VIEW view_name [(column[, ...])]
[WITH {ENCRYPTION | SCHEMABINDING | VIEW_METADATA} [, ...]]
AS select_statement
[WITH CHECK OPTION]
;
```

where:

`WITH ENCRYPTION`
: Encrypts the text of the view in the *sys.comments* table. This option is usually invoked by software vendors who want to protect their intellectual capital.

`WITH SCHEMABINDING`
: Binds the view to the definitions of the underlying objects, meaning the referenced tables and views cannot be changed in a way that would affect the definition of the output columns of the view. The tables and views referenced in the view must also be qualified with at least the schema name (e.g., *dbo.authors* or *nutshell.dbo.authors*, not simply *authors*). This also means any referenced tables and views cannot be dropped or renamed without first dropping the view or dropping the schema binding via `ALTER VIEW`.

`WITH VIEW_METADATA`
: Specifies that SQL Server return metadata about the view (rather than the base table) to calls made from DBLIB or OLEDB APIs. Views created or altered

with VIEW_METADATA enable their columns to be updated by INSERT and UPDATE INSTEAD OF triggers.

WITH CHECK OPTION
: Forces the view to accept only inserted and updated data that can be returned by the view's SELECT statement.

The SELECT clause of a SQL Server view cannot:

- Have COMPUTE, COMPUTE BY, INTO, or ORDER BY clauses (ORDER BY is allowed if you use SELECT TOP)
- Reference a temporary table
- Reference a table variable
- Reference more than 1,024 columns, including those referenced by subqueries

Here, we define a SQL Server view with both ENCRYPTION and CHECK OPTION clauses:

```
CREATE VIEW california_authors (last_name, first_name, author_id)
WITH ENCRYPTION
AS
   SELECT au_lname, au_fname, au_id
   FROM authors
   WHERE state = 'CA'
WITH CHECK OPTION
GO
```

SQL Server allows multiple SELECT statements in a view, as long as they are linked with UNION or UNION ALL clauses. It also allows functions and hints in a view's SELECT statement. A SQL Server view is updatable if all of the conditions in the following list are true:

- The SELECT statement has no aggregate functions.
- The SELECT statement does not contain TOP, GROUP BY, DISTINCT, or UNION clauses.
- The SELECT statement has no derived columns (see "SUBQUERY Substatement" on page 337.
- The FROM clause of the SELECT statement references at least one table.

SQL Server allows indexes to be created on views (see CREATE/ALTER INDEX). By creating a unique, clustered index on a view, you cause SQL Server to store a physical copy of the view on the database. Changes to the base table are automatically updated in the indexed view. Indexed views consume extra disk space but provide a boost in performance. These views must be built using the SCHEMABINDING clause.

SQL Server also allows the creation of local and distributed partitioned views. A *local partitioned view* is a partitioned view where all views are present on the same

SQL server. A *distributed partitioned view* is a partitioned view where one or more views are located on distinct remote servers.

Partitioned views must very clearly derive their data from different sources, with each distinct data source joined to the next with a UNION ALL statement. Partitioned views are updatable. Furthermore, all columns of the partitioned views should be selected and identical, including the collation. It is not sufficient for data types to be coercible, as it normally is for UNION ALL queries. (The idea is that you have split the data out logically by means of a frontend application; SQL Server then recombines the data through the partitioned view.) This example shows how the data in the view comes from three separate SQL servers:

```
CREATE VIEW customers
AS
--Select from a local table on server New_York
SELECT *
FROM sales_archive.dbo.customers_A
UNION ALL
SELECT *
FROM houston.sales_archive.dbo.customers_K
UNION ALL
SELECT *
FROM los_angeles.sales_archive.dbo.customers_S
```

Note that each remote server (*New_York*, *houston*, and *los_angeles*) has to be defined as a remote server on all of the SQL servers using the distributed partitioned view.

Partitioned views can greatly boost performance because they can split I/O and user loads across many machines. However, they are difficult to plan, create, and maintain. Be sure to read the vendor documentation for complete details about all the permutations available with partitioned views.

To create a materialized view on SQL Server, first use the CREATE VIEW ... WITH SCHEMABINDING option, then create a unique clustered index on the view using CREATE INDEX. Refer to the vendor documentation to see the various rules and requirements you must meet to create a materialized view.

When altering an existing view, SQL Server acquires and holds an exclusive schema lock on the view until the alteration is finished. ALTER VIEW drops any indexes that might be associated with a view; you must manually re-create them using CREATE INDEX.

INSTEAD OF triggers can be created on views to control how data is updated in the underlying tables.

See also

- CREATE/ALTER TABLE
- DROP

- SELECT in Chapter 4
- SUBQUERY in Chapter 4
- CREATE/ALTER/DROP TRIGGER in Chapter 9

DROP Statements

All of the database objects created with CREATE statements may be destroyed using complementary DROP statements. On some platforms, a ROLLBACK statement after a DROP statement will recover the dropped object. However, on other database platforms the DROP statement is irreversible and permanent, so it is advisable to use the command with care.

In general, vendor support for dropping different object types lags behind that provided by the SQL standard. However, the SQL standard does not support the DROP DATABASE and DROP INDEX commands, even though every vendor covered in this book (and just about everyone else in the market) does. The exact syntax for each of these commands is covered in the platform-specific sections that follow. Refer to Table 3-1 for an overview of vendor support for the different DROP statements, including those not provided by the SQL standard.

SQL standard syntax

```
DROP [object_type] object_name {RESTRICT | CASCADE}
```

Keywords

DROP [*object_type*] *object_name*

Irreversibly and permanently destroys the object of type *object_type* called *object_name*. The *object_name* does not need a schema identifier; if none is provided the current schema is assumed. SQL supports dropping a long list of object types, each created with its own corresponding CREATE statement. CREATE statements covered in this chapter with corresponding DROP statements include:

- DATABASE
- DOMAIN
- INDEX
- SCHEMA
- TABLE
- TYPE
- VIEW

`RESTRICT | CASCADE`

Prevents the `DROP` from taking place if any dependent objects exist (`RESTRICT`), or causes all dependent objects to also be dropped (`CASCADE`). This clause is not allowed with some forms of `DROP`, such as `DROP TRIGGER`, but is mandatory for others, such as `DROP SCHEMA`. To further explain, `DROP SCHEMA RESTRICT` will only drop an empty schema. Otherwise (i.e., if the schema contains objects), the operation will be prevented. In contrast, `DROP SCHEMA CASCADE` will drop a schema and all objects contained therein.

Rules at a glance

For rules about the creation or modification of each of the object types, refer to the sections on the corresponding `CREATE`/`ALTER` statements.

The `DROP` statement destroys a preexisting object. The object is permanently destroyed, and all users who had permission to access the object immediately lose the ability to access it.

The object may be qualified—that is, you may fully specify the schema where the dropped object is located. For example:

```
DROP TABLE scott.sales_2008 CASCADE;
```

This statement will drop not only the table *scott.sales_2014*, but also any views, triggers, or constraints built on it. A `DROP` statement may also include an unqualified object name, in which case the current schema context is assumed. For example:

```
DROP TRIGGER before_ins_emp;
DROP ROLE sales_mgr;
```

Although not required by the SQL standard, most implementations cause the `DROP` command to fail if the database object is in use by another user.

Programming tips and gotchas

`DROP` will only work when it is issued against a preexisting object of the appropriate type and when the user has appropriate permissions (usually the `DROP TABLE` permission—refer to "GRANT Statement" on page 451 for more information). The SQL standard requires only that the owner of an object be able to drop it, but most database platforms allow variations on that requirement. For example, the database superuser/superadmin can usually drop any object on a database server.

With some vendors, the `DROP` command fails if the database object has extended properties. For example, SQL Server will not drop a table that is replicated unless you first remove the table from replication. PostgreSQL will not allow dropping anything that has dependencies without the `CASCADE` clause.

It is important to be aware that most vendors don't notify you if the DROP command creates a dependency problem. So if a table that is used by a few views and stored procedures elsewhere in the database is dropped, no warning is issued; those other objects simply fail when they are accessed. To prevent this problem, you may use the RESTRICT syntax where it's available, or check for dependencies before invoking the DROP statement.

MySQL / MariaDB

MySQL and MariaDB support the DROP statement for the following SQL objects:

```
DROP { {DATABASE | SCHEMA} | FUNCTION |
   PROCEDURE | [TEMPORARY] TABLE | TRIGGER | VIEW }
[IF EXISTS] object_name[, ...]
[RESTRICT |CASCADE]
```

The supported SQL syntax elements are:

`{DATABASE | SCHEMA}` *`database_name`*
: Drops the named database, including all the objects it contains (such as tables and indexes). DROP SCHEMA is a synonym for DROP DATABASE in MySQL. The DROP DATABASE command removes all database and table files from the filesystem, as well as two-digit subdirectories. MySQL will return a message showing how many files were erased from the database directory. (Files with these extensions are erased: *.bak*, *.dat*, *.frm*, *.hsh*, *.isd*, *.ism*, *.mrg*, *.myd*, *.myi*, *.dm*, and *.fm*.) If the database is linked, both the link and the database are erased. You may drop only one database at a time.

`FUNCTION` *`routine_name`*
: Drops the named routine from the database. You can use the IF EXISTS clause with a DROP FUNCTION statement.

`INDEX` *`index_name`* `ON` *`table_name`*
: Drops the named index from the named table. To drop a primary key, use the index name PRIMARY. This statement is mapped to an ALTER TABLE statement to drop the index.

`PROCEDURE` *`routine_name`*
: Drops the named routine from a MySQL v5.1 or greater database. You can use the IF EXISTS clause with a DROP PROCEDURE statement.

`[TEMPORARY] TABLE` *`table_name`*`[, ... ]`
: Drops one or more named tables, with table names separated from each other by commas. MySQL erases each table's definition and deletes the three table files (*.frm*, *.myd*, and *.myi*) from the filesystem. Issuing this command causes MySQL to commit all active transactions. The TEMPORARY keyword drops only temporary tables without committing running transactions or checking access rights.

`TRIGGER [schema_name.]trigger_name`
: Drops a named trigger from a MySQL v5.0.2 or greater database. You can use the `IF EXISTS` clause with a `DROP TRIGGER` statement to ensure that you only drop a trigger that actually exists within the database.

`VIEW view_name`
: Drops the named view for the MySQL database. You can use the `IF EXISTS` clause with a `DROP VIEW` statement.

`IF EXISTS`
: Prevents an error message when you attempt to drop an object that does not exist.

`RESTRICT | CASCADE`
: Noise words. These keywords do not generate an error, nor do they have any other effect.

MySQL supports the ability to drop a database, a table (or tables), or an index from a table. You can use the `IF EXISTS` clause to prevent MySQL from returning an error message if you try to delete an object that doesn't exist.

Other objects that MySQL allows you to drop using similar syntax include:

```
DROP { EVENT | LOGFILE GROUP |
   SERVER | SPATIAL REFERENCE SYSTEM | TABLESPACE  } object_name
```

MariaDB in addition to the preceding supports:

```
DROP { PACKAGE | PACKAGE BODY  } object_name
```

These variations of the `DROP` statement are beyond the scope of this book. Check the MySQL and MariaDB documentation for more details.

Oracle

Oracle supports the `DROP` statement for the following SQL objects, as well as numerous Oracle-specific objects:

```
DROP { DATABASE | FUNCTION | INDEX | PROCEDURE | ROLE |
   TABLE | TRIGGER | TYPE [BODY] | [MATERIALIZED] VIEW }
object_name
```

The rules for Oracle `DROP` statements are less consistent than the SQL standard's rules, so the full syntax of each `DROP` variant is shown in the following list:

`DATABASE database_name`
: Drops the named database from the Oracle server.

`FUNCTION function_name`
: Drops the named function, as long as it is not a component of a package. (If you want to drop a function from a package, use the `CREATE PACKAGE ... OR REPLACE` statement to redefine the package without that function.) Any local

objects that depend on or call the function are invalidated, and any statistical types associated with the function are disassociated.

`INDEX` *`index_name`* `[FORCE]`
Drops a named index or domain index from the database. Dropping an index invalidates all objects that depend on the parent table, including views, packages, functions, and stored procedures. Dropping an index also invalidates cursors and execution plans that use the index and will force a hard parse of the affected SQL statements when they are next executed.

Non-IOT indexes are secondary objects and can be dropped and re-created without any loss of user data. IOTs, because they combine both table and index data in the same structure, cannot be dropped and re-created in this manner. IOTs should be dropped using the `DROP TABLE` syntax.

When you drop a partitioned index, all partitions are dropped. When you drop a composite partitioned index, all index partitions and subpartitions are dropped. When you drop a domain index, any statistics associated with the domain index are removed and any statistics types are disassociated. The optional keyword `FORCE` applies only when dropping domain indexes. `FORCE` allows you to drop a domain index marked `IN PROGRESS`, or to drop a domain index when its indextype routine invocation returns an error. For example:

```
DROP INDEX ndx_sales_salesperson_quota;
```

`PROCEDURE` *`procedure_name`*
Drops the named stored procedure. Any dependent objects are invalidated when you drop a stored procedure, and attempts to access them before you re-create the stored procedure will fail with an error. If you re-create the stored procedure and then access a dependent object, the dependent object will be recompiled.

`ROLE` *`role_name`*
Drops the named role, removes it from the database, and revokes it from all users and roles to whom it has been granted. No new sessions can use the role, but sessions that are currently running under the role are not affected. For example, the following statement drops the *sales_mgr* role:

```
DROP ROLE sales_mgr:
```

`TABLE` *`table_name`* `[CASCADE CONSTRAINTS] [PURGE]`
Drops the named table, erases all of its data, drops all indexes and triggers built from the table (even those in other schemas), and invalidates all permissions and all dependent objects (views, stored procedures, etc.). On partitioned tables, Oracle drops all partitions (and subpartitions). On index-organized tables, Oracle drops all dependent mapping tables. Statistics types associated with a dropped table are disassociated. Materialized view logs built on a table are also dropped when the table is dropped.

The `DROP TABLE` statement is effective for standard tables, index-organized tables, and object tables. The table being dropped is only moved to the recycling bin, unless you add the optional keyword `PURGE`, which tells Oracle to immediately free all space consumed by the table. (Oracle also supports a non-standard SQL command called `PURGE` that lets you remove tables from the recycling bin outside of the `DROP TABLE` statement.) `DROP TABLE` erases only the metadata of an external table. You must use an external operating system command to drop the file associated with an external table and reclaim its space.

Use the optional `CASCADE CONSTRAINTS` clause to drop all referential integrity constraints elsewhere in the database that depend on the primary or unique key of the dropped table. You cannot drop a table with dependent referential integrity constraints without using the `CASCADE CONSTRAINTS` clause. The following example drops the *job_desc* table in the *emp* schema, then drops the *job* table and all referential integrity constraints that depend on the primary key and unique key of the *job* table:

```
DROP TABLE emp.job_desc;
DROP TABLE job CASCADE CONSTRAINTS;
```

`TRIGGER` *`trigger_name`*
: Drops the named trigger from the database.

`TYPE [BODY]` *`type_name`* `[ {FORCE | VALIDATE} ]`
: Drops the specification and body of the named object type, nested table type, or `VARRAY`, as long as they have no type or table dependencies. You must use the optional `FORCE` keyword to drop a supertype, a type with an associated statistics type, or a type with any sort of dependencies. All subtypes and statistics types are then invalidated. Oracle will also drop any public synonyms associated with a dropped type. The optional `BODY` keyword tells Oracle to drop only the body of the type while keeping its specification intact. `BODY` cannot be used in conjunction with the `FORCE` or `VALIDATE` keywords. Use the optional `VALIDATE` keyword when dropping subtypes to check for stored instances of the named type in any of its supertypes. Oracle performs the drop only if no stored instances are found. For example:

```
DROP TYPE salesperson_type;
```

`VIEW` *`view_name`* `[CASCADE CONSTRAINTS]`
: Drops the named view and marks as invalid any views, subviews, synonyms, or materialized views that refer to the dropped view. Use the optional clause `CASCADE CONSTRAINTS` to drop all referential integrity constraints that depend on the view. Otherwise, the `DROP` statement will fail if dependent referential integrity constraints exist. For example, the following statement drops the *active_employees* view in the *hr* schema:

```
DROP VIEW hr.active_employees;
```

In the DROP syntax, *object_name* can be replaced with [*schema_name.*] *object_name*. If you omit the schema name, the default schema of the user session is assumed. Thus, the following DROP statement drops the specified view from the *sales_archive* schema:

```
DROP VIEW sales_archive.sales_2014;
```

However, if your personal schema is *scott*, the following command is assumed to be against *scott.sales_2014*:

```
DROP VIEW sales_2014;
```

Oracle also supports the DROP statement for a large number of objects that aren't part of SQL, including:

```
DROP { ANALYTIC VIEW | ATTRIBUTE | AUDIT POLICY | CLUSTER |
CONTEXT | DATABASE LINK | DIMENSION | EDITION |
   DIRECTORY | DISKGROUP | FLASHBACK ARCHIVE | HIERARCHY |
   INDEXTYPE | INMEMORY JOIN GROUP |
   JAVA | LIBRARY | MATERIALIZED VIEW | MATERIALIZED VIEW
   LOG | MATERIALIZED ZONEMAP | OPERATOR | OUTLINE | PACKAGE | PROFILE |
   PLUGGABLE DATABASE |RESTORE POINT | ROLLBACK SEGMENT |
   SEQUENCE | SYNONYM |
   TABLESPACE | TABLESPACE SET | TYPE BODY | USER } object_name
```

These variations are beyond the scope of this book. Refer to the Oracle documentation if you want to drop an object of one of these types (although the basic syntax is the same for almost all variations of the DROP statement).

PostgreSQL

PostgreSQL supports both the RESTRICT and CASCADE optional keywords from the SQL standard. RESTRICT is assumed when CASCADE is not specified. It also allows dropping and creating objects in a transaction; as such, you can roll back a sequence of drops and recover everything.

PostgreSQL supports a wide variety of DROP variants, including for PostgreSQL-specific objects. The SQL objects covered are as follows:

```
DROP { DATABASE | DOMAIN | FUNCTION | INDEX | ROLE |
   PROCEDURE | SCHEMA | TABLE | TRIGGER | TYPE |
   [MATERIALIZED] VIEW }
[IF EXISTS]object_name
[ CASCADE | RESTRICT ]
```

Following is the full SQL-supported syntax for each variant:

DATABASE *database_name*
: Drops the named database and erases the operating system directory containing all of the database's data. This command can only be executed by the database owner, while that user is connected to a database other than the target database.

`DOMAIN` *`domain_name`*`[, ... ] [ CASCADE | RESTRICT ]`
: Drops one or more named domains owned by the session user. `CASCADE` automatically drops objects that depend on the domain, while `RESTRICT` prevents the action from occurring if any objects depend on the domain. When omitted, `RESTRICT` is the default behavior.

`FUNCTION` *`function_name`* `( [`*`data_type1`*`[, ... ] ) [ CASCADE | RESTRICT ]`
: Drops the named user-defined function. Since PostgreSQL allows multiple functions of the same name, distinguished only by the various input parameters they require, you must specify one or more data types to uniquely identify the UDF you wish to drop. For example:

```
DROP FUNCTION median_distribution (int, int, int, int);
```

`INDEX` *`index_name`*`[, ... ] [ CASCADE | RESTRICT ]`
: Drops one or more named indexes that you own. For example:

```
DROP INDEX ndx_titles, ndx_authors;
```

`PROCEDURE` *`procedure_name`* `[ ( [`*`data_type1`*`[, ... ]) ] [, ... ] [CASCADE | RESTRICT]`
: Drops one or more named procedures that you own. Since PostgreSQL allows multiple procedures of the same name, distinguished only by the various input parameters they require, you typically must specify one or more data types to uniquely identify the procedure.

`ROLE` *`rule_name`*`[, ... ]`
: Drops one or more named database roles. In PostgreSQL, a role cannot be dropped when it is referenced in any database. That means you'll need to drop or reassign ownership of any objects owned by the role, using the `REASSIGN OWNED` and `DROP OWNED` statements, before dropping it, and then revoke any privileges the role has been granted.

`SCHEMA` *`schema_name`*`[, ... ] [CASCADE | RESTRICT]`
: Drops one or more named schemas from the current database. A schema can only be dropped by a superuser or the owner of the schema (even when the owner does not explicitly own all of the objects in the schema).

`TABLE` *`table_name`*`[, ... ] [CASCADE | RESTRICT]`
: Drops one or more existing tables from the database, as well as any indexes or triggers specified for the tables. For example:

```
DROP TABLE authors, titles;
```

`TRIGGER` *`trigger_name`* `ON` *`table_name`* `[CASCADE | RESTRICT]`
: Drops the named trigger from the database. You must specify the *`table_name`* because PostgreSQL requires that trigger names be unique only for the tables to which they are attached. This means it is possible to have many triggers called, say, *insert_trigger* or *delete_trigger*, each on a different table. For example:

```
DROP TRIGGER insert_trigger ON authors;
```

`TYPE` *`type_name`*`[, ... ] [CASCADE | RESTRICT]`
: Drops one or more preexisting user-defined types from the database. PostgreSQL does not check to see what impact the `DROP TYPE` command might have on any dependent objects, such as functions, aggregates, or tables; you must check the dependent objects manually. (Do *not* remove any of the built-in types that ship with PostgreSQL!) Note that PostgreSQL's implementation of types differs from the SQL standard. Refer to the section on the `CREATE/ALTER TYPE` statement for more information.

`[MATERIALIZED] VIEW` *`view_name`*`[, ... ] [CASCADE | RESTRICT]`
: Drops one or more preexisting views from the database. If a view is materialized, the keyword `MATERIALIZED` needs to be included.

`CASCADE | RESTRICT`
: `CASCADE` automatically drops objects that depend on the object being dropped, while `RESTRICT` prevents the action from occurring if any objects depend on the object being dropped. When omitted, `RESTRICT` is the default behavior.

`IF EXISTS`
: Suspends the creation of an error message if the object to be dropped does not exist. This subclause is usable for most variations of the `DROP` statement.

Note that PostgreSQL drop operations do not allow you to specify the target database where the operation will take place (except for `DROP DATABASE`). Therefore, you should execute any drop operation from the database where the object you want to drop is located.

PostgreSQL supports variations of the `DROP` statement for several objects that are extensions to the SQL standard. The key ones are shown here:

```
DROP { AGGREGATE | CAST | CONVERSION | EXTENSION |
   FOREIGN DATA WRAPPER| FOREIGN TABLE | GROUP | LANGUAGE |
   OPERATOR [CLASS] |
   RULE | SEQUENCE | TABLESPACE | USER } object_name
```

These variations are beyond the scope of this book. Refer to the PostgreSQL documentation if you want to drop an object of one of these types (although the basic syntax is the same for almost all variations of the `DROP` statement).

SQL Server

SQL Server supports the `DROP` statement for the following SQL objects:

```
DROP { DATABASE | FUNCTION | INDEX | PROC[EDURE] | ROLE |
   SCHEMA | TABLE | TRIGGER | TYPE | VIEW }
[IF EXISTS] object_name
```

Following is the full syntax for each variant:

`DATABASE` *`database_name`*`[, ... ]`

Drops the named database(s) and erases all disk files used by the database(s). This command may only be issued from the *master* database. Replicated databases must be removed from their replication schemes before they can be dropped, as must log shipping databases. You cannot drop a database while it is in use, nor can you drop system databases (*master*, *model*, *msdb*, or *tempdb*). For example, we can drop the *northwind* and *pubs* databases with one command:

```
DROP DATABASE northwind, pubs
GO
```

`FUNCTION [`*`schema.`*`]`*`function_name`*`[, ... ]`

Drops one or more user-defined functions from the current database.

`INDEX` *`index_name`* `ON` *`table_or_view_name`*`[, ... ] [WITH { MAXDOP =` *`int`* `| ONLINE = {ON | OFF} | MOVE TO` *`location`* `[FILESTREAM_ON` *`location`*`] }]`

Drops one or more indexes from tables or indexed views in the current database and returns the freed space to the database. This statement should not be used to drop a `PRIMARY KEY` or `UNIQUE` constraint. Instead, drop these constraints using the `ALTER TABLE ... DROP CONSTRAINT` statement. When dropping a clustered index from a table, all non-clustered indexes are rebuilt. When dropping a clustered index from a view, all non-clustered indexes are dropped. The `WITH` subclause may only be used when dropping a clustered index. `MAXDOP` specifies the maximum degrees of parallelism that SQL Server may use to drop the clustered index. Values for `MAXDOP` may be 1 (suppresses parallelism), 0 (the default, using all or fewer processors on the system), or a value greater than 1 (restricts parallelism to the value of *`int`*). `ONLINE` specifies that queries or updates may continue on the underlying tables (with `ON`), or that table locks are applied and the table is unavailable for the duration of the process (with `OFF`). `MOVE TO` specifies a preexisting filegroup or partition, or the default location for data within the database to which the clustered index will be moved. The clustered index is moved to the new location in the form of a heap.

`PROC[EDURE]` *`procedure_name`*`[, ... ]`

Drops one or more stored procedures from the current database. SQL Server allows multiple versions of a single procedure via version numbers, but these versions cannot be dropped individually; you must drop all versions of a stored procedure at once. System procedures (those with an *sp_* prefix) are dropped from the *master* database if they are not found in the current user database. For example:

```
DROP PROCEDURE calc_sales_quota
GO
```

`ROLE` *`rule_name`*`[, ... ]`
: Drops one or more roles from the current database. The role must not own any objects, or else the statement will fail. You must first drop owned objects or change their ownership before dropping a role that owns any objects.

`SCHEMA` *`schema_name`*
: Drops a schema that does not own any objects. To drop a schema that owns objects, first drop the dependent objects or assign them to a different schema.

`TABLE [`*`database_name`*`.][`*`schema_name`*`.]`*`table_name`*`[, ... ]`
: Drops a named table and all data, permissions, indexes, triggers, and constraints specific to that table. (The *`table_name`* may be a fully qualified table name like *pubs.dbo.sales* or a simple table name like *sales*, if the current database and owner are correct.) Views, functions, and stored procedures that reference the table are not dropped or marked as invalid, but will return an error when their procedural code encounters the missing table. Be sure to drop these yourself! You cannot drop a table referenced by a `FOREIGN KEY` constraint without first dropping the constraint. Similarly, you cannot drop a table used in replication without first removing it from the replication scheme. Any user-defined rules or defaults are unbound when the table is dropped. They must be rebound if the table is re-created.

`TRIGGER` *`trigger_name`*`[, ... ] [ON {DATABASE | ALL SERVER}]`
: Drops one or more triggers from the current database. The subclause `[ON {DATABASE | ALL SERVER}]` is available when dropping DDL triggers, while the subclause `[ON ALL SERVER]` is also available to `LOGON` event triggers. `ON DATABASE` indicates the scope of the `DDL` trigger applied to the current database and is required if the subclause was used when the trigger was created. `ON ALL SERVER` indicates the scope of the `DDL` or `LOGON` trigger applied to the current server and is required if the subclause was used when the trigger was created.

`TYPE [`*`schema_name`*`.]`*`type_name`*`[, ... ]`
: Drops one or more user-defined types from the current database.

`VIEW [`*`schema_name`*`.]`*`view_name`*`[, ... ]`
: Drops one or more views from the database, including indexed views, and returns all space to the database.

`IF EXISTS`
: Conditionally drops an object only if it already exists, starting in SQL Server 2016 and Azure SQL Database.

SQL Server also has a large number of objects that extend the SQL standard and that are removed using the more-or-less standardized syntax of the `DROP` statement. The key ones are:

```
DROP { AGGREGATE | APPLICATION ROLE | ASSEMBLY | ASYMMETRIC KEY |
   BROKER PRIORITY | CERTIFICATE | CONTRACT | CREDENTIAL |
   CRYPTOGRAPHIC PROVIDER | DATABASE AUDIT SPECIFICATION |
   DATABASE ENCRYPTION KEY | DEFAULT | ENDPOINT | EVENT NOTIFICATION |
   EVENT SESSION | FULLTEXT CATALOG | FULLTEXT INDEX | FULLTEXT
   STOPLIST | LOGIN | MASTER KEY | MESSAGE TYPE | PARTITION FUNCTION |
   PARTITION SCHEME | QUEUE | REMOTE SERVICE BINDING | RESOURCE POOL |
   ROUTE | SECURITY POLICY | SEQUENCE | SERVER AUDIT |
   SERVER AUDIT SPECIFICATION | SERVER ROLE | SERVICE | SIGNATURE |
   STATISTICS | SYMMETRIC KEY | SYNONYM | USER | WORKLOAD GROUP |
   XML SCHEMA COLLECTION } object_name
```

These variations are beyond the scope of this book. Refer to the SQL Server documentation to drop an object of one of these types (although the basic syntax is the same for almost all variations of the `DROP` statement).

See also

- `CREATE/ALTER SCHEMA`
- `CREATE/ALTER TABLE`
- `CREATE/ALTER VIEW`
- `DELETE` in Chapter 5
- `GRANT` in Chapter 6
- `INSERT` in Chapter 5
- `RETURN` in Chapter 9
- `SELECT` in Chapter 4
- `SET CONSTRAINTS` in Chapter 6
- `SUBQUERY` in Chapter 4
- `UPDATE` in Chapter 5

4

Reading Your Data

In this chapter, we will explore the key SQL statements and clauses needed to extract information from your database. You will learn about the fundamental `SELECT` statement and the various subclauses you can use within it to select data and aggregate data into subtotals. By the end of this chapter, you will understand the concepts of `JOIN` operations, `SET` operations, aggregation, window operations, common table expressions, and subqueries. You will also know how to combine these effectively to query any data in the core database platforms.

How to Use This Chapter

When researching a command in this chapter:

1. Read "SQL Platform Support" on page 250.
2. Check Table 4-1.
3. Look up the specific SQL statement, check the syntax, and read the "Keywords," "Rules at a glance," and "Programming tips and gotchas" sections and read the section on the standard for SQL syntax and description. Do this even if you are looking for a specific platform implementation.
4. Finally, read the platform-specific implementation information.

You will note that the entry for a given platform implementation does *not* duplicate information on any clauses that do not differ from the standard. So, it is possible that you will need to flip between the descriptions for a vendor variation and the SQL standard to cover all possible details of that command.

In our discussions of MySQL, we will also include MariaDB, a fork of MySQL. For the most part, MySQL and MariaDB provide fully code-compatible syntax. In these cases we will refer to them collectively as MySQL. We will explicitly mention MariaDB only in situations where it deviates from MySQL in an important way.

SQL Platform Support

Table 4-1 provides a listing of the SQL statements covered in this chapter, the platforms that support them, and the degree to which they support them. The following list offers useful tips for reading Table 4-1, as well as an explanation of what each abbreviation stands for:

1. The first column contains the SQL commands, in alphabetical order.
2. The SQL statement class for each command is indicated in the second column.
3. The subsequent columns list the level of support for each vendor:

   Supported (S)
   : The platform supports the SQL standard for the particular command.

   Supported, with variations (SWV)
   : The platform supports the SQL standard for the particular command, using vendor-specific code or syntax.

   Supported, with limitations (SWL)
   : The platform supports some but not all of the functions specified by the SQL standard for the particular command.

   Not supported (NS)
   : The platform does not support the particular command according to the SQL standard.

The sections that follow the table describe the commands in detail.

Remember that even if a specific SQL command is listed in the table as "Not supported," the platform usually has alternative coding or syntax to enact the same command or function. Therefore, be sure to read the discussion and examples for each command later in this chapter.

Table 4-1. Alphabetical quick SQL command reference

SQL command	SQL class	MySQL/MariaDB	Oracle	PostgreSQL	SQL Server
`ALL/ANY/SOME`	SQL-data	S	SWV	SWV	SWV
`BETWEEN`	SQL-data	S	S	S	S
`EXCEPT`	SQL-data	NS/SWL	SWL	SWL	SWL
`EXISTS`	SQL-data	S	S	S	S
`FILTER`	SQL-data	NS	NS	S	NS
`GROUP BY`	SQL-data	SWV	SWV	SWV	SWV
`IN`	SQL-data	S	S	S	S

SQL command	SQL class	MySQL/MariaDB	Oracle	PostgreSQL	SQL Server
INTERSECT	SQL-data	NS/SWL	SWL	SWL	SWL
IS	SQL-data	S	S	S	S
JOIN	SQL-data	SWV	SWV	SWV	SWL
LIKE	SQL-data	S	S	SWV	SWV
ORDER BY	SQL-data	SWL	SWV	SWV	SWL
OVER	SQL-data	SWL	SWV	SWV	SWL
SELECT	SQL-data	SWV	SWV	SWV	SWV
SUBQUERY	SQL-data	SWL	S	S	S
UNION	SQL-data	S	SWL	SWL	SWL
VALUES	SQL-data	SWL	NS	S	SWL
WHERE	SQL-data	S	S	S	S
WITH	SQL-data	S	SWV	SWV	SWV
WITH ORDINALITY	SQL-data	NS	NS	S	NS

SQL Command Reference

ALL/ANY/SOME Operators

The ALL operator performs a Boolean test of a subquery for the existence of a value in all rows. The ANY operator and its synonym SOME perform a Boolean test of a subquery for the existence of a value in any of the rows tested.

You will also find the ALL keyword used in conjunction with UNION. This will be covered in "UNION Set Operator" on page 343.

Platform	Command
MySQL	Supported
Oracle	Supported with variations
PostgreSQL	Supported with variations
SQL Server	Supported with variations

SQL standard syntax

```
SELECT ...
WHERE expression comparison {ALL | ANY | SOME} ( subquery )
```

Keywords

WHERE *expression*
: Tests a scalar expression (such as a column) against every value in the *subquery* for ALL and against every value until a match is found for ANY and

SOME. All rows must match the expression to return a Boolean TRUE value for the ALL operator, while one or more rows must match the expression to return a Boolean TRUE value for the ANY and SOME operators.

comparison
Compares the *expression* to the *subquery*. The *comparison* must be a standard comparison operator like =, <>, !=, >, >=, <, or <=.

Rules at a glance

The ALL operator returns a Boolean TRUE value when one of two things happens: either the subquery returns an empty set (i.e., no records match), or every record in the set meets the comparison. ALL returns FALSE when any record in the set does not match the value comparison. The ANY and SOME operators return a Boolean TRUE when at least one record in the subquery matches the comparison operation, and FALSE when no record matches the comparison operation (or when a subquery returns an empty result set). If even one return value of the subquery is NULL, the operation evaluates as NULL, not as TRUE.

Do not include special clauses like ORDER BY, GROUP BY, CUBE, ROLLUP, WITH, etc. in your subquery.

For example, this query returns authors who currently have no titles:

```
SELECT au_id
FROM authors
WHERE au_id <> ALL(SELECT titleauthor.au_id FROM titleauthor);
```

You can use ANY or SOME to perform filtering checks of different kinds. For example, the following query will retrieve from the *employee* table any records that exist in the *jobs* table where the employee has the same *job_lvl* as the minimum required level of a job:

```
SELECT *
FROM employee
WHERE job_lvl = ANY(SELECT min_lvl FROM jobs);
```

Programming tips and gotchas

The ALL and ANY/SOME operators are somewhat difficult to get used to. Most developers find it easier to use similar functions like IN and EXISTS.

EXISTS is semantically equivalent to the ANY/SOME construct

MySQL

MySQL supports the SQL standard versions of ALL and ANY/SOME.

Oracle

Oracle supports the SQL standard versions of ALL and ANY/SOME with one minor variation, which is that you can supply a list of values instead of a subquery. For example, to find all employees who have a *job_lvl* value equal to 9 or 14:

```
SELECT * FROM employee
WHERE job_lvl = ALL(9, 14);
```

PostgreSQL

PostgreSQL supports the SQL standard versions of ALL and ANY/SOME. In addition, it supports their use with arrays. For example, to find all employees who have a *job_lvl* value equal to 9 or 14:

```
SELECT * FROM employee
WHERE job_lvl = ANY(ARRAY[9, 14]);
```

PostgreSQL also supports the use of these terms in conjunction with LIKE and the case-insensitive ILIKE. A common use is to provide a shorthand for multiple LIKE/ILIKE clauses. For example, this:

```
SELECT * FROM employee
WHERE name_last ILIKE ANY(ARRAY['smith', 'paris%', '%chin%']);
```

is equivalent to:

```
SELECT * FROM employee
WHERE name_last ILIKE 'smith'
  OR name_last ILIKE 'paris%'
  OR name_last ILIKE '%chin%';
```

SQL Server

SQL Server supports the SQL standard versions of ALL and ANY/SOME. It also supports some additional comparison operators: not greater than (!>) and not less than (!<).

See also

- BETWEEN
- EXISTS
- IN
- LIKE
- SELECT
- UNION
- WHERE

BETWEEN Operator

The BETWEEN operator performs a Boolean test of a value against a range of values. It returns TRUE when the value is included in the range and FALSE when the value falls outside of the range. The result is NULL (unknown) if any of the range values are NULL.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

```
SELECT ...
WHERE expression [NOT] BETWEEN lower_range AND upper_range
```

Keywords

WHERE *expression*
: Compares a scalar expression, such as a column, to the range of values bounded by *upper_range* and *lower_range*.

[NOT] BETWEEN *lower_range* AND *upper_range*
: Compares the *expression* to the *lower_range* and *upper_range*. The comparison is inclusive, meaning that it is equivalent to saying "where *expression* is [not] greater than or equal to *lower_range* and less than or equal to *upper_range*."

Rules at a glance

The BETWEEN operator is used to test an expression against a range of values. It may be used with any data type except BLOB, CLOB, NCLOB, REF, or ARRAY.

For example, this query returns *title_id*s that have year-to-date sales of between 10,000 and 20,000:

```
SELECT title_id
FROM titles
WHERE ytd_sales BETWEEN 10000 AND 20000
```

`BETWEEN` is inclusive of the range of values listed, so it includes the values 10,000 and 20,000 in the search. If you want an exclusive search, you must use the greater than (>) and less than (<) symbols:

```
SELECT title_id
FROM titles
WHERE ytd_sales > 10000
  AND ytd_sales < 20000
```

The `NOT` operator allows you to search for values outside of the `BETWEEN` range. For example, you can find all the *title_id*s that were not published during 2021:

```
SELECT title_id
FROM titles
WHERE pub_date NOT BETWEEN '01-JAN-2021'
  AND '31-DEC-2021'
```

Programming tips and gotchas

Some coders are very particular about how the keyword `AND` is used in `WHERE` clauses. To prevent a casual reviewer from thinking that the `AND` used in a `BETWEEN` operation is a logical `AND` operator, you might want to use parentheses to encapsulate the entire `BETWEEN` clause:

```
SELECT title_id
FROM titles
WHERE (ytd_sales BETWEEN 10000 AND 20000)
  AND pubdate >= '2021-06-12 00:00:00.000'
```

PostgreSQL also supports @> (the contains operator) and *&&* (the overlaps operator), which serve the same purpose as `BETWEEN` but for array types, range types, and multi-range types.

See also

- `ALL/ANY/SOME`
- `EXISTS`
- `SELECT`
- `WHERE`

EXCEPT Set Operator

The `EXCEPT` set operator retrieves the result sets of two or more queries, including all the records retrieved by the first query that are not also found in subsequent queries. Whereas `JOIN` clauses are used to return the rows of two or more queries that are in common, `EXCEPT` is used to filter out the records that are present in only one of multiple similar tables.

EXCEPT is in a class of keywords called *set operators*. Other set operators include INTERSECT and UNION. (MINUS is a synonym of the EXCEPT keyword; EXCEPT is the SQL standard.) All set operators are used to simultaneously manipulate the result sets of two or more queries, hence the term "set operators."

Platform	Command
MySQL	Not supported
MariaDB	Supported, with limitations
Oracle	Supported, with limitations (as MINUS)
PostgreSQL	Supported, with limitations
SQL Server	Supported, with limitations

SQL standard syntax

There is technically no limit to the number of queries that you may combine with the EXCEPT operator. The general syntax is:

```
{SELECT statement1 | VALUES (expr1[, ...])}
EXCEPT [ALL | DISTINCT]
[CORRESPONDING [BY (column1, column2, ...)]]
{SELECT statement2 | VALUES (expr2[, ...])}
EXCEPT [ALL | DISTINCT]
[CORRESPONDING [BY (column1, column2, ...)]]
...
```

Keywords

VALUES (*expr1*[, ...])
: Generates a derived result set with explicitly declared values as *expr1*, *expr2*, etc.—it's essentially a SELECT statement result set without the *SELECT ... FROM* syntax. This is known as a *row constructor*, since the rows of the result set are manually constructed. According to the SQL standard, multiple handcoded rows in a row constructor must be enclosed in parentheses and separated by commas.

EXCEPT
: Determines which rows will be excluded from the final result set.

ALL | DISTINCT
: ALL considers duplicate rows from all result sets in the EXCEPT comparison. DISTINCT drops duplicate rows from all result sets prior to the EXCEPT comparison. Any columns containing a NULL value are considered duplicates. (If neither ALL nor DISTINCT is used, the DISTINCT behavior is the default.)

`CORRESPONDING`
: Specifies that only columns with the same name in both queries are returned, even if both queries use the asterisk (*) shortcut.

`BY (`*`column1, column2, ...`*` )`
: Specifies that only the named columns are returned, even if more columns with corresponding names exist in the queries. Must be used with the `CORRESPONDING` keyword.

Rules at a glance

There is only one significant rule to remember when using `EXCEPT`: the number and order of the columns should be the same in all queries, and the data types should be of the same category.

The data types do not have to be identical, but they must be compatible. For example, `CHAR` and `VARCHAR` are compatible data types. By default, the result set will default to the largest data type size of each column in each ordinal position. For example, a query retrieving rows from `VARCHAR(10)` and `VARCHAR(15)` columns will use the `VARCHAR(15)` data type and size.

Programming tips and gotchas

None of the platforms supports the `CORRESPONDING [BY (`*`column1, column2, ...`*` )]` clause.

According to the SQL standard, the `UNION` and `EXCEPT` set operators evaluate with equal precedence. However, the `INTERSECT` set operator evaluates before the other set operators. We recommend that you explicitly control the precedence of the set operators using parentheses as a general best practice.

According to the SQL standard, only one `ORDER BY` clause is allowed in the entire query. Include it at the end of the last `SELECT` statement. To avoid column and table ambiguity, be sure to alias each column for each table with the same respective alias. For example:

```
SELECT au_lname AS lastname, au_fname AS firstname
FROM authors
EXCEPT
SELECT emp_lname AS lastname, emp_fname AS firstname
FROM employees
ORDER BY lastname, firstname
```

While each of the column lists may list columns with correspondingly compatible data types, there may be variation in behavior across the DBMS platforms with regard to the length of the columns. For example, if the *au_lname* column in the previous example's first query is markedly longer than the *emp_lname* column in the second query, the platforms may apply different rules as to which length is used for the final result. In general, though, the platforms will choose the longer (and less restrictive) column size for use in the result set.

Each DBMS may apply its own rules as to which column name is used if the names vary across column lists. In general, the column names of the first query are used.

On platforms that do not support `EXCEPT`, you can substitute a `LEFT JOIN`, `NOT IN`, or `NOT EXISTS.` The following queries are examples of how you can achieve `EXCEPT` functionality using `NOT EXISTS` and `NOT IN`:

```
SELECT DISTINCT a.city
FROM authors AS a
WHERE NOT EXISTS
   (SELECT *
    FROM publishers AS p
    WHERE a.city = p.city)

SELECT DISTINCT a.city
FROM authors AS a
WHERE a.city NOT IN
   (SELECT p.city
    FROM pubs.publishers AS p
    WHERE p.city IS NOT NULL)
```

In general, `NOT EXISTS` is faster than `NOT IN`. In addition, there is a subtle issue with NULLs that differentiates the `IN` and `NOT IN` operators and the `EXISTS` and `NOT EXISTS` set operators. To get around this different handling of NULLs, simply add the `IS NOT NULL` clause to the `WHERE` clause, as shown in the preceding example.

The following example illustrates the use of `LEFT JOIN`:

```
SELECT DISTINCT a.city
FROM authors AS a
 LEFT JOIN (SELECT city
  FROM publishers
  WHERE city IS NOT NULL) AS p ON a.city = p.city
WHERE p.city IS NULL;
```

MySQL and MariaDB

MySQL does not support `EXCEPT`. MariaDB 10.3 and later support the `EXCEPT`, `EXCEPT ALL`, and `EXCEPT DISTINCT` set operators using the SQL standard syntax. For MySQL, you can use the `NOT IN` or `NOT EXISTS` operations as alternatives to `EXCEPT`, as detailed in the previous section.

Oracle

Oracle versions below Oracle 21c do not support the `EXCEPT` set operator. However, they have an alternative set operator, `MINUS`, with identical functionality to `EXCEPT`. Its syntax is as follows:

```
<SELECT statement1>
MINUS
<SELECT statement2>
MINUS
...
```

MINUS is the functional equivalent of MINUS DISTINCT; the ALL clause is not implemented.

Oracle does not support MINUS on queries containing:

- Columns whose data types are LONG, BLOB, CLOB, BFILE, or VARRAY
- A FOR UPDATE clause
- TABLE collection expressions

If the first query in a set operation contains any expressions in the SELECTitem list, you must include AS clauses to associate aliases with those expressions. Also, only the last query in the set operation may contain an ORDER BY clause.

For example, you could generate a list of all store IDs that do not have any records in the *sales* table as follows:

```
SELECT stor_id FROM stores
MINUS
SELECT stor_id FROM sales
```

The MINUS command is functionally similar to a NOT IN query. This query retrieves the same results:

```
SELECT stor_id FROM stores
WHERE stor_id NOT IN
   (SELECT stor_id FROM sales)
```

PostgreSQL

PostgreSQL supports the EXCEPT and EXCEPT ALL set operators using the basic SQL standard syntax:

```
<SELECT statement1>
EXCEPT [ALL]
<SELECT statement2>
EXCEPT [ALL]
...
```

EXCEPT DISTINCT is not supported, but EXCEPT is the functional equivalent. EXCEPT or EXCEPT ALL are not supported on queries with a FOR UPDATE clause.

The first query in the set operation may not contain an ORDER BY clause or a LIMIT clause, although you can define a subquery for the SELECT statement that does include these. Subsequent queries in the EXCEPT or EXCEPT ALL set operation may contain these clauses, but such queries must be enclosed in parentheses. Otherwise, the last occurrence of `ORDER BY` or `LIMIT` will be applied to the entire set operation.

PostgreSQL evaluates `SELECT` statements in a multi-`EXCEPT` statement from top to bottom, unless you use parentheses to change the evaluation hierarchy of the statements.

Normally, duplicate rows are eliminated from the two result sets, unless you add the `ALL` keyword. For example, you could find all titles in the *authors* table that have no records in the *sales* table using this query:

```
SELECT title_id
FROM   authors
EXCEPT ALL
SELECT title_id
FROM   sales;
```

SQL Server

SQL Server supports `EXCEPT`, but none of its subclauses. For comparison purposes, SQL Server considers NULL values equal when evaluating an `EXCEPT` result set. If using the `SELECT ... INTO` statement, only the first query may contain the `INTO` clause. `ORDER BY` is only allowed at the end of the statement and is not allowed with each individual query. Conversely, `GROUP BY` and `HAVING` clauses can only be used within individual queries and may not be used to affect the final result set. The `FOR BROWSE` clause may not be used with statements that include `EXCEPT`.

See also

- `INTERSECT`
- `SELECT`
- `UNION`

EXISTS Operator

The `EXISTS` operator tests a subquery for the existence of rows. All the platforms support the SQL standard syntax.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

```
SELECT ...
WHERE [NOT] EXISTS (subquery)
```

Keywords

`WHERE [NOT] EXISTS`
: Tests the subquery for the existence of one or more rows. If even one row satisfies the subquery clause, it returns a Boolean `TRUE` value. The optional `NOT` keyword returns a Boolean `TRUE` value when the subquery returns no matching rows.

`subquery`
: Retrieves a result set based on a fully formed subquery.

Rules at a glance

The `EXISTS` operator checks a subquery for the existence of one or more records against the records in the parent query.

For example, if we want to see whether there are any jobs where no employee is filling the position:

```
SELECT *
FROM jobs
WHERE NOT EXISTS
   (SELECT * FROM employee
    WHERE jobs.job_id = employee.job_id)
```

This example tests for the absence of records in the subquery using the optional `NOT` keyword. The next example looks for specific records in the subquery to retrieve the main result set:

```
SELECT au_lname
FROM authors
WHERE EXISTS
   (SELECT *
    FROM publishers
    WHERE authors.city = publishers.city)
```

This query returns the last names of authors who live in the same city as their publishers. Note that the asterisk in the subquery is acceptable, since the subquery only needs to return a single record to provide a Boolean `TRUE` value. Columns are irrelevant in these cases.

Programming tips and gotchas

`EXISTS`, in many queries, does the same thing as `ANY` (in fact, it is semantically equivalent to the `ANY` operator). `EXISTS` is usually most effective with correlated subqueries.

The `EXISTS` subquery usually searches for only one of two things. Your first option is to use the asterisk wildcard (e.g., `SELECT * FROM ...`) so that you are not retrieving any specific column or value. In this case, the asterisk means "any column." The second option is to select only a single column in the subquery (e.g., `SELECT au_id FROM ...`). The third option is to select a constant, such as (`SELECT 1 FROM ...`).

`EXISTS` can be rewritten using an `IN` clause. Here is an example written with `EXISTS`:

```
SELECT au_id
FROM authors
WHERE EXISTS(SELECT au_id
  FROM titleauthor AS ta WHERE ta.au_id = authors.au_id)
```

and its equivalent using `IN`:

```
SELECT au_id
FROM authors
WHERE au_id IN(SELECT ta.au_id
  FROM titleauthor AS ta
  WHERE ta.au_id = authors.au_id)
```

See also

- `ALL/ANY/SOME`
- `IN`
- `SELECT`
- `WHERE`

FILTER Clause

The `FILTER` clause is used in conjunction with aggregate functions, except when they are used as window aggregates. PostgreSQL supports the SQL standard syntax for this clause; the other platforms do not support it.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

The `FILTER` clause is part of a `SELECT` statement and qualifies an aggregate function call:

```
[aggregate_function(input_args) FILTER
   (WHERE search_condition)
input_args := value[,..]
```

In databases where the `FILTER` clause is not supported, the functionality can be simulated for aggregates that ignore NULLs with a `CASE` statement, as follows:

```
[aggregate_function(input_args)
input_args := CASE WHEN search_condition THEN value
   ELSE NULL END[,...]
```

Keywords

aggregate_function
: An aggregate function such as `AVG`, `COUNT`, `COUNT DISTINCT`, `MAX`, `MIN`, or `SUM`.

`WHERE` *search_condition*
: Any condition allowed in a `WHERE` clause is allowed.

Rules at a glance

The `FILTER` clause is allowed only in queries that utilize aggregate functions. Here is an example that uses the `FILTER` clause to count books by price in PostgreSQL:

```
SELECT SUM(ytd_sales) AS total_sales
   , SUM(ytd_sales) FILTER(WHERE price < '$20.00')
   AS sales_book_lt_20
FROM titles;
```

And here is an alternative using `CASE`:

```
SELECT SUM(ytd_sales) AS total_sales
   , SUM(CASE WHEN price < '$20.00' THEN ytd_sales
   ELSE NULL END) AS sales_book_lt_20
FROM titles;
```

The results are:

```
total_sales  sales_book_lt_20
-----------  -----------------------
97446        83821
```

See also

- `CASE` in Chapter 7
- `GROUP BY`
- `SELECT`
- `WHERE`

GROUP BY Clause

The `GROUP BY` clause is used to aggregate or dedupe data. It is often paired with aggregate functions and the `HAVING` clause.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
[GROUP BY group_by_expression
   [HAVING search_condition]]

group_by_expression ::= { (grouping_column[, ...]) |
   ROLLUP (grouping_column[, ...]) |
   CUBE (grouping_column[, ...]) |
   GROUPING SETS (grouping_set_list) | () |
   grouping_set, grouping_set_list }
```

Keywords

`GROUP BY` *`group_by_expression`*
: Groups result sets into the categories defined in the *`group_by_expression`*. Used in queries that utilize aggregate functions such as `AVG`, `COUNT`, `COUNT DISTINCT`, `MAX`, `MIN`, and `SUM`. The *`group_by_expression`* of the `GROUP BY` clause has an elaborate syntax of its own; refer to the following section for examples and more information on `ROLLUP`, `CUBE`, and `GROUPING SETS`.

`HAVING` *`search_condition`*
: Adds search conditions on the results of the `GROUP BY` clause in a manner similar to the `WHERE` clause. `HAVING` does not affect the rows used to calculate the aggregates. `HAVING` clauses may contain subqueries.

Rules at a glance

The `GROUP BY` clause is needed only in queries that utilize aggregate functions. The `HAVING` clause is almost always accompanied by a `GROUP BY` clause, but a `GROUP BY` clause is often used without a `HAVING` clause.

The GROUP BY clause. The `GROUP BY` clause is used to report an aggregated value for one or more rows returned by a `SELECT` statement based on one or more non-aggregated columns called *grouping columns*. For example, here is a query that counts up how many people were hired each year during the years 2016 through 2021:

```
SELECT hire_year, COUNT(emp_id) AS nbr_emps
FROM employee
WHERE status = 'ACTIVE'
```

```
  AND hire_year BETWEEN 2016 AND 2021
GROUP BY hire_year;
```

The results are:

```
hire_year nbr_emps
--------- --------
2016      27
2017      17
2018      13
2019      19
2020      20
2021      32
```

Queries using aggregate functions provide many types of summary information. The most common aggregate functions include:

`AVG`
: Returns the average of all non-NULL values in the specified column(s)

`AVG DISTINCT`
: Returns the average of all unique non-NULL values in the specified column(s)

`COUNT`
: Counts the occurrences of all non-NULL values in the specified column(s)

`COUNT DISTINCT`
: Counts the occurrences of all unique non-NULL values in the specified column(s)

`COUNT(*)`
: Counts every record in the table

`MAX`
: Returns the highest non-NULL value in the specified column(s)

`MIN`
: Returns the lowest non-NULL value in the specified column(s)

`SUM`
: Totals all non-NULL values in the specified column(s)

`SUM DISTINCT`
: Totals all unique non-NULL values in the specified column(s)

Some queries that use aggregates return a single row and are used to aggregate the whole table. Single-value aggregates are known as *scalar aggregates*. Scalar aggregates do not need a `GROUP BY` clause. For example:

```
-- Query
SELECT AVG(price)
FROM titles
```

```
-- Results
14.77
```

Queries in which all returned columns are aggregates also do not need a GROUP BY clause.

Queries that return both regular column values and aggregate function values are commonly called *vector aggregates*. Vector aggregates use the GROUP BY clause and return one or many rows.

There are a few rules to follow when using GROUP BY:

- Place GROUP BY in the proper clause order—after the WHERE clause and before the ORDER BY clause.
- Include all non-aggregate columns in the GROUP BY clause.
- Do not use column aliases in the GROUP BY clause (though table aliases are acceptable).

For example, let's suppose we need to get the total purchase amount of several purchases from an *Order_Details* table that looks like this:

```
OrderID      ProductID    UnitPrice            Quantity
-----------  -----------  -------------------  --------
10248        11           14.0000              12
10248        42           9.8000               10
10248        72           34.8000              5
10249        14           18.6000              9
10249        51           42.4000              40
10250        41           7.7000               10
10250        51           42.4000              35
10250        65           16.8000              15
...
```

We can do this with a query like the following:

```
SELECT OrderID, SUM(UnitPrice * Quantity) AS Order_Amt
FROM order_details
WHERE orderid IN (10248, 10249, 10250)
GROUP BY OrderID
```

The results are:

```
OrderID      Order_Amt
-----------  ----------------
10248        440.0000
10249        1863.4000
10250        1813.0000
```

We could further refine the aggregations by using more than one grouping column. Consider the following query, which retrieves the average price of our products, grouped first by name and then by size:

```
SELECT name, size, AVG(unit_price) AS avg
FROM product
GROUP BY name, size
```

The results are:

```
name                 size    avg
------------         ------  ----------------------
Flux Capacitor       small   900
P32 Space Modulator  small   1400
Transmogrifier      medium  1400
Acme Rocket          large   600
Land Speeder         large   6500
```

In addition, the `GROUP BY` clause supports a few very important subclauses:

`{ROLLUP | CUBE} ([`*`grouping_column`*`[, ... ]])[, `*`grouping_set_list`*`]`
: Groups the aggregate values of the result set by one or more grouping columns. (Without `ROLLUP` or `CUBE`, the `GROUP BY (`*`grouping_column`*`[, ... ])` clause is the simplest and most common form of the `GROUP BY` clause.)

`ROLLUP`
: Produces subtotals for each set of grouping columns as a hierarchical result set, adding subtotal and grand total rows into the result set in a hierarchical fashion. `ROLLUP` operations return one row per grouping column, with NULL appearing in the grouping column to show the subtotaled or totaled aggregate value.

`CUBE`
: Produces subtotals and cross-tabulated totals for all grouping columns. In a sense, the `CUBE` clause enables you to quickly return multidimensional result sets from standard relational tables without a lot of programmatic work. `CUBE` is especially useful when working with large amounts of data. Like `ROLLUP`, `CUBE` provides subtotals of the grouping columns, but it also includes subtotal rows for all possible combinations of the grouping columns specified in the query.

`GROUPING SETS [{ROLLUP | CUBE}] ([`*`grouping_column`*`[, ... ]])`
`[, `*`grouping_set_list`*`]`
: Enables aggregated groups on several different sets of grouping columns within the same query. This is especially useful when you want to return only a portion of an aggregated result set. The `GROUPING SETS` clause also lets you select which grouping columns to compare, whereas `CUBE` returns all of the grouping columns and `ROLLUP` returns a hierarchical subset of the grouping columns. As the syntax shows, the SQL standard also allows `GROUPING SETS` to be paired with `ROLLUP` or `CUBE`.

Table 4-2 illustrates the differences between the result sets returned by `GROUP BY` on its own and with each of these subclauses.

Table 4-2. `GROUP BY` syntax variations

GROUP BY syntax	Returns the following sets
`GROUP BY (col_A, col_B, col_C)`	`(col_A, col_B, col_C)`

`GROUP BY ROLLUP (col_A, col_B, col_C)`	`(col_A, col_B, col_C)`
	`(col_A, col_B)`
	`(col_A)`
	`()`

`GROUP BY CUBE (col_A, col_B, col_C)`	`(col_A, col_B, col_C)`
	`(col_A, col_B)`
	`(col_A)`
	`(col_B, col_C)`
	`(col_B)`
	`(col_C)`
	`()`

Each type of `GROUP BY` clause returns a different set of aggregated values and, in the case of `ROLLUP` and `CUBE`, totals and subtotals.

The concepts of `ROLLUP`, `CUBE`, and `GROUPING SETS` are much more intuitive when explained by example. In the following example, we query for data summarizing the number of *sales_orders* by *order_year* and by *order_quarter*:

```
SELECT order_year AS year, order_quarter AS quarter,
    COUNT (*) AS orders
FROM order_details
WHERE order_year IN (2020, 2021)
GROUP BY ROLLUP (order_year, order_quarter)
ORDER BY order_year, order_quarter;
```

The results are:

```
year quarter orders
---- ------- ------
NULL NULL    648     -- grand total
2020 NULL    380     -- total for year 2020
2020 1       87
2020 2       77
2020 3       91
2020 4       125
2021 NULL    268     -- total for year 2021
2021 1       139
2021 2       119
2021 3       10
```

Adding grouping columns to the query provides more details (and more subtotaling) in the result set. Now let's modify the previous example by adding a *region* to the query (but since the number of rows increases, we'll only look at the first and second quarters):

```
SELECT order_year AS year, order_quarter AS quarter, region,
   COUNT (*) AS orders
FROM order_details
```

```
WHERE order_year IN (2020, 2021)
  AND order_quarter IN (1,2)
  AND region IN ('USA', 'CANADA')
GROUP BY ROLLUP (order_year, order_quarter,region)
ORDER BY order_year, order_quarter, region;
```

The results are:

```
year quarter region  orders
---- ------- ------  ------
NULL NULL    NULL    183     -- grand total
2020 NULL    NULL    68      -- subtotal for year 2020
2020 1       NULL    36      -- subtotal for all regions in q1 of 2020
2020 1       CANADA  3
2020 1       USA     33
2020 2       NULL    32      -- subtotal for all regions in q2 of 2021
2020 2       CANADA  3
2020 2       USA     29
2021 NULL    NULL    115     -- subtotal for year 2021
2021 1       NULL    57      -- subtotal for all regions in q1 of 2021
2021 1       CANADA  11
2021 1       USA     46
2021 2       NULL    58      -- subtotal for all regions in q2 of 2021
2021 2       CANADA  4
2021 2       USA     54
```

The GROUP BY CUBE clause is useful for performing multidimensional analyses on aggregated data. Like GROUP BY ROLLUP, it returns subtotals, but unlike GROUP BY ROLLUP, it returns subtotals combining all of the grouping columns named in the query. (As you will see, it also has the potential to increase the number of rows returned in the result set.)

In the following example, we query for data summarizing the number of *sales_orders* by *order_year* and by *order_quarter*:

```
SELECT order_year AS year, order_quarter AS quarter,
     COUNT (*) AS orders
FROM order_details
WHERE order_year IN (2020, 2021)
GROUP BY CUBE (order_year, order_quarter)
ORDER BY order_year, order_quarter;
```

The results are:

```
year quarter orders
---- ------- ------
NULL NULL    648     -- grand total
NULL 1       226     -- subtotal for q1 of both years
NULL 2       196     -- subtotal for q2 of both years
NULL 3       101     -- subtotal for q3 of both years
NULL 4       125     -- subtotal for q4 of both years
2020 NULL    380     -- total for year 2020
2020 1       87
```

```
2020 2       77
2020 3       91
2020 4       125
2021 NULL    268     -- total for year 2021
2021 1       139
2021 2       119
2021 3       10
```

The GROUP BY GROUPING SETS clause lets you aggregate on more than one group in a single query. For each group set, the query returns subtotals with the grouping column marked as NULL. While the CUBE and ROLLUP clauses place predefined subtotals into the result set, the GROUPING SETS clause allows you to control what subtotals to add to the query. The GROUPING SETS clause will also return a grand total if you include a set with no columns, such as ().

Using a similar example query to the ones shown with ROLLUP and CUBE, this time we'll subtotal by *year* and *quarter* and separately by *year*:

```
SELECT order_year AS year, order_quarter AS quarter, COUNT (*)
AS orders
FROM order_details
WHERE order_year IN (2020, 2021)
GROUP BY GROUPING SETS ((order_year, order_quarter), (order_year))
ORDER BY order_year, order_quarter;
```

The results are:

```
year quarter orders
---- ------- ------
2020 NULL    380     -- total for year 2020
2020 1       87
2020 2       77
2020 3       91
2020 4       125
2021 NULL    268     -- total for year 2021
2021 1       139
2021 2       119
2021 3       10
```

Another way to think of GROUPING SETS is to consider it to be like a UNION ALL of more than one GROUP BY query that references different parts of the same data. You can tell the database to add subtotals to a GROUPING SET by simply adding in the ROLLUP or CUBE clause according to how you would like subtotaling to occur.

GROUPING SETS can also be concatenated to concisely generate large combinations of groupings. *Concatenated* GROUPING SETS yield the cross product of groupings from each of the sets within a GROUPING SETS list. Concatenated GROUPING SETS are compatible with CUBE and ROLLUP, but since they perform a cross product of all GROUPING SETS, they will generate a very large number of final groupings from even a small number of concatenated groupings. This is demonstrated in the example in Table 4-3.

Table 4-3. `GROUP BY GOUPING SETS` syntax

GROUP BY syntax	Returns the following sets
`GROUP BY (col_A, col_B, col_C)`	`(col_A, col_B, col_C)`
`...`	`...`
`GROUP BY GROUPING SETS (col_A, col_B) (col_Y, col_Z)`	`(col_A, col_Y)` `(col_A, col_Z)` `(col_B, col_Y)` `(col_B, col_Z)`

You can imagine how large the result set would be if the concatenated `GROUPING SETS` contained a large number of groupings! However, the information returned can be very valuable and hard to reproduce.

The HAVING clause. The `HAVING` clause adds search conditions on the result of the `GROUP BY` clause. The `HAVING` clause works very much like the `WHERE` clause, but it applies to the `GROUP BY` clause. The `HAVING` clause supports all the same search conditions as the `WHERE` clause shown earlier. For example, using the same query as at the beginning of the previous section, say we now want to find only those jobs that are performed by more than three people:

```
-- Query
SELECT   j.job_desc "Job Description",
         COUNT(e.job_id) "Nbr in Job"
FROM     employee e
JOIN     jobs j ON e.job_id = j.job_id
GROUP BY j.job_desc
HAVING   COUNT(e.job_id) > 3

-- Results
Job Description                                   Nbr in Job
-------------------------------------------------- -----------
Acquisitions Manager                              4
Managing Editor                                   4
Marketing Manager                                 4
Operations Manager                                4
Productions Manager                               4
Public Relations Manager                          4
Publisher                                         7
```

Note that the SQL standard does not *require* that an explicit `GROUP BY` clause appear with a `HAVING` clause. For example, the following query against the *employee* table is valid because it has an implied `GROUP BY` clause:

```
SELECT COUNT(dept_nbr)
FROM employee
HAVING COUNT(dept_nbr) > 30;
```

Although it's valid, this application of the `HAVING` clause is rather rare.

IN Operator

The `IN` operator provides a way to delineate a list of values, either explicitly listed or from a subquery, and compare a value against that list in a `WHERE` or `HAVING` clause. In other words, it gives you a way to say "Is value A *in* this list of values?" All the platforms support the SQL standard syntax.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

```
{WHERE | HAVING | {AND | OR}}
   value [NOT] IN ({comp_value1, comp_value2[, ...] | subquery})
```

Keywords

`{WHERE | HAVING | {AND | OR}}` *`value`*
: `IN` is permitted in either the `WHERE` or the `HAVING` clause. The `IN` comparison may also be a part of an `AND` or `OR` clause in a multicondition `WHERE` or `HAVING` clause. *`value`* may be of any data type, but is usually the name of a column of the table referenced by the transaction, or perhaps a host variable when used programmatically.

`NOT`
: Optionally tells the database to look for a result set that contains values that are not in the list.

`IN ({`*`comp_value1, comp_value2`*`[, ... ] |`*`subquery`*`})`
: Defines the list of comparative values (hence, *`comp_value`*) to compare against. Each *`comp_value`* must be of the same or a compatible data type as the initial *`value`*. They are also governed by standard data type rules. For example, string values must be delimited by quotes, while integer values need no delimiters. As an alternative to listing specific values, you may use parentheses to enclose a subquery that returns one or more values of a compatible data type.

Rules at a glance

In the following example, generated on SQL Server, we look for all employees in the *employee* table of the *hr* database who have a home state of Georgia, Tennessee, Alabama, or Kentucky:

```
SELECT *
FROM hr..employee
WHERE home_state IN ('AL','GA','TN','KY')
```

Similarly, we can look for all *employee*s in the *hr* database who are authors in the *pubs* database:

```
SELECT *
FROM hr..employee
WHERE emp_id IN (SELECT au_id FROM pubs..authors)
```

We can also use the NOT keyword to return a result set based upon the absence of a value. In the following case, the company headquarters is located in New York, and many workers commute in from neighboring states. We want to see all such workers:

```
SELECT *
FROM hr..employee
WHERE home_state
   NOT IN ('NY','NJ','MA','CT','RI','DE','NH')
```

Note that Oracle, while fully supporting the SQL standard functionality, extends the functionality of the IN operator by allowing multiple argument matches. For example, the following SELECT ... WHERE ... IN statement is acceptable on Oracle:

```
SELECT *
FROM hr..employee e
WHERE (e.emp_id, e.emp_dept)
   IN ( (242, 'sales'), (442, 'mfg'), (747, 'mkt) )
```

See also

- ALL/ANY/SOME
- BETWEEN
- EXISTS
- LIKE
- SELECT

INTERSECT Set Operator

The INTERSECT set operator retrieves the result sets of two or more queries, including only the records retrieved by the first query that are also found in all subsequent queries (that is, it includes only those rows that appear in all the result sets). In some ways, INTERSECT is similar to an INNER JOIN operation (see "JOIN Subclause" on page 278 for details).

INTERSECT is in a class of keywords called set operators. Other set operators include EXCEPT and UNION. All set operators are used to simultaneously manipulate the result sets of two or more queries; hence the term "set operators."

Platform	Command
MySQL	Not supported
MariaDB	Supported, with limitations
Oracle	Supported, with limitations
PostgreSQL	Supported, with limitations
SQL Server	Supported, with limitations

SQL standard syntax

There is technically no limit to the number of queries that you may combine with the `INTERSECT` set operator. The general syntax is:

```
<SELECT statement1>
INTERSECT [ALL | DISTINCT]
[CORRESPONDING [BY (column1, column2, ...)]]
<SELECT statement2>
INTERSECT [ALL | DISTINCT]
[CORRESPONDING [BY (column1, column2, ...)]]
...
```

Keywords

`INTERSECT`
: Determines which rows will be included in the final single result set.

`ALL | DISTINCT`
: `ALL` includes duplicate rows from all result sets in the `INTERSECT` comparison. `DISTINCT` drops duplicate rows from all result sets prior to the `INTERSECT` comparison. Any columns containing a NULL value are considered duplicates. (If neither `ALL` nor `DISTINCT` is used, the `DISTINCT` behavior is the default.)

`CORRESPONDING`
: Specifies that only columns with the same name in both queries are returned, even if both queries use the asterisk (*) shortcut.

`BY (`*`column1, column2, ...`*` )`
: Specifies that only the named columns are returned, even if more columns with corresponding names exist in the queries. Must be used with the `CORRESPONDING` keyword.

Rules at a glance

There is only one significant rule to remember when using `INTERSECT`: the order and number of columns must be the same in all of the queries.

Also, while the data types of the corresponding columns do not have to be identical, they must be compatible (for example, `CHAR` and `VARCHAR` are compatible data types).

By default, the result set will default to the largest of the columns in each ordinal position.

Programming tips and gotchas

None of the platforms support the SQL standard `CORRESPONDING [BY (`*`column1, column2, ...`*` )]` clause.

The SQL standard evaluates `INTERSECT` as higher priority than other set operators, but not all platforms evaluate set operator precedence the same way. You can explicitly control the precedence of set operators using parentheses. Otherwise, the DBMS might evaluate the expressions either from leftmost to rightmost or from first to last.

According to the standard, only one `ORDER BY` clause is allowed in the entire query. It should be included at the end of the last `SELECT` statement. To avoid column and table ambiguity, be sure to alias each column of each table with the same respective alias. For example:

```
SELECT a.au_lname AS last_name, a.au_fname AS first_name
FROM authors AS a
INTERSECT
SELECT e.emp_lname AS last_name, e.emp_fname AS last_name
FROM employees AS e
ORDER BY last_name, first_name
```

Also, be aware that while your column data types may be compatible throughout the queries in the `INTERSECT`, there may be some variation in behavior across the DBMS platforms with regard to varying length of the columns. For example, if the *au_lname* column in the first query is markedly longer than the *emp_lname* column in the second query, different platforms may apply different rules as to which length is used for the final result. In general, though, the platforms will choose the longer (and less restrictive) column size for use in the result set.

Each DBMS may apply its own rules as to which column name is used if the columns across the tables have different names. In general, the column names from the first query are used.

On platforms that do not support `INTERSECT`, substitute a query using `INNER JOIN`.

Here is the earlier example rewritten as an `INNER JOIN`:

```
SELECT DISTINCT a.au_lname AS last_name, a.au_fname AS first_name
FROM authors AS a
   INNER JOIN employees AS e
```

```
      ON (a.au_lname = e.emp_lname AND a.au_fname = e.emp_fname)
   ORDER BY last_name, first_name
```

MySQL and MariaDB

MySQL does not support INTERSECT. MariaDB 10.3 and later support the INTERSECT, INTERSECT ALL, and INTERSECT DISTINCT set operators using the SQL standard syntax.

Oracle

Oracle supports the INTERSECT and INTERSECT ALL set operators using the basic SQL standard syntax. INTERSECT DISTINCT is not supported, but INTERSECT is the functional equivalent.

For example, you could find all store IDs that also have sales using this query:

```
SELECT stor_id FROM stores
INTERSECT
SELECT stor_id FROM sales
```

Oracle does not support INTERSECT on the following types of queries:

- Queries containing columns with LONG, BLOB, CLOB, BFILE, or VARRAY data types
- Queries containing a FOR UPDATE clause or a TABLE collection expression

If the first query in the set operation contains any expressions in the SELECT item list, you should include the AS keyword to associate an alias with the column resulting from the expression. Also, only the first query in the set operation may contain an ORDER BY clause.

PostgreSQL

PostgreSQL supports the INTERSECT and INTERSECT ALL set operators using the basic SQL standard syntax, but not on queries with a FOR UPDATE clause. INTERSECT DISTINCT is not supported, but INTERSECT is the functional equivalent.

For example, you can find all authors who are also employees and whose last last names start with "P" as follows:

```
SELECT a.au_lname
FROM   authors AS a
WHERE  a.au_lname LIKE 'P%'
INTERSECT
SELECT e.lname
FROM   employee AS e
WHERE  e.lname LIKE 'W%';
```

The first query in the set operation may not contain an ORDER BY clause or a LIMIT clause. Subsequent queries in the INTERSECT [ALL] set operation may contain these clauses, but such queries must be enclosed in parentheses. Otherwise, the rightmost occurrence of ORDER BY or LIMIT will be assumed to apply to the entire set operation.

SQL Server

SQL Server supports INTERSECT, but not its subclauses. The column names of the result set are those returned by the first query. Any column names or aliases referenced in an ORDER BY clause must appear in the first query. When using INTERSECT (or EXCEPT) to compare more than two result sets, each pair of result sets (i.e., each pair of queries) is compared before moving to the next pair in the order of expressions in parentheses first, INTERSECT set operators second, and EXCEPT and UNION last in order of appearance.

Also note that you can use NOT IN or NOT EXISTS operations in conjunction with a correlated subquery, as alternatives. Refer to the sections on IN and EXISTS for examples.

See also

- EXCEPT
- EXISTS
- IN
- SELECT
- UNION

IS Operator

The IS operator determines whether a value is NULL or not. All the platforms support the SQL standard syntax.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

```
{WHERE | {AND | OR}} expression IS [NOT] NULL
```

Keywords

{WHERE | {AND | OR}} *expression* IS NULL
: Returns a Boolean value of TRUE if the *expression* is NULL, and FALSE if the *expression* is not NULL. The *expression* evaluated for NULL can be preceded by the WHERE keyword or the AND or OR keywords.

`NOT`
: Inverses the predicate: the statement will instead return a Boolean `TRUE` if the value of *`expression`* is not NULL, and `FALSE` if the value of *`expression`* is NULL.

Rules at a glance

Because the value of NULL is unknown, you cannot use comparison expressions to determine whether a value is NULL. For example, the expressions `X = NULL` and `X <> NULL` cannot be resolved because no value can equal, or not equal, an unknown.

Instead, you must use the `IS NULL` operator. Be sure that you do not put the word NULL within quotation marks, because if you do that, the DBMS will interpret the value as the word "NULL" and not the special value NULL.

Programming tips and gotchas

Some platforms support the use of a comparison operator to determine whether an expression is NULL. However, all platforms covered by this book now support the SQL standard `IS [NOT] NULL` syntax.

Sometimes, checking for NULL will make your `WHERE` clause only slightly more complex. For example, rather than a simple predicate to test the value of *stor_id*, as shown here:

```
SELECT stor_id, ord_date
FROM sales
WHERE stor_id IN (6630, 7708)
```

you can add a second predicate to accommodate the possibility that *stor_id* might be NULL:

```
SELECT stor_id, ord_date
FROM sales
WHERE stor_id IN (6630, 7708)
   OR stor_id IS NULL
```

See also

- `SELECT`
- `WHERE`

JOIN Subclause

The `JOIN` subclause enables you to retrieve rows from two or more logically related tables. You can define many different join conditions and types of joins, though the types of joins supported by the different platforms vary greatly.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
FROM table [AS alias] { [join_type] JOIN [LATERAL] joined_table
[[AS] alias]
   { ON join_condition1 [{AND | OR} join_condition2] [...] |
   USING (column1[, ...]) }} |
 [ PARTITION BY (column1[, ...])]
[...]
```

Keywords

`FROM` *`table`*
: Defines the first table or view in the join.

`[`*`join_type`*`] JOIN [LATERAL]` *`joined_table`*
: Specifies the type of `JOIN` and the second (and any subsequent) table(s) in the join. You may also define an *`alias`* on any of the *`joined_table`*s. The join types are:

  `CROSS JOIN`
  : Specifies the complete cross product of two tables. For each record in the first table, all the records in the second table are joined, creating a *huge* result set. This command has the same effect as leaving off the join condition, and its result set is also known as a *Cartesian product*.

  Cross joins are not advisable or recommended.

  `[INNER] JOIN`
  : Specifies that unmatched rows in either table of the join should be discarded. If no join type is explicitly defined, this is the default.

  `LEFT [OUTER] JOIN`
  : Specifies that all records be returned from the table on the left side of the join statement. If a record returned from the left table has no matching record in the table on the right side of the join, it is still returned. Columns from the right table return NULL values when there is no matching row.

It is a good idea to configure all your outer joins as left outer joins (rather than mixing left and right outer joins) wherever possible, for consistency.

`RIGHT [OUTER] JOIN`
: Specifies that all records be returned from the table on the right side of the join statement, even if the table on the left has no matching record. Columns from the left table return NULL values when there is no matching row.

`FULL [OUTER] JOIN`
: Specifies that all rows from both tables be returned, regardless of whether a row from one table matches a row in the other table. Any columns that have no value in the corresponding joined table are assigned a NULL value.

`NATURAL`
: Specifies that the join (either inner or outer) should be performed on all columns of identical name shared between the two tables. Consequently, you should *not* specify join conditions using the `ON` or `USING` clauses. The query will fail if you issue it on two tables that do not contain any columns with the same name(s).

`LATERAL`
: The `LATERAL` keyword can be used with a `LEFT JOIN` or `CROSS JOIN`. It denotes a correlated subquery or function call where elements from previously specified tables are used in the subquery or as arguments to the function. The function used can return more than one row.

`[AS]` *`alias`*
: Specifies an alias or shorthand for the joined table. The `AS` keyword is optional when specifying an alias.

`ON` *`join_condition`*
: Joins together the rows of the table shown in the `FROM` clause and the rows of the table declared in the `JOIN` clause. You may have multiple `JOIN` statements, all based on a common set of values. These values are usually contained in columns of the same name and data type appearing in both of the tables being joined. These columns, or possibly a single column from each table, are called the *join key* or *common key*. Most (but not all) of the time, the join key is the primary key of one table and a foreign key in the other table. As long as the values in the columns match, the join can be performed.

*`join_condition`*s are syntactically depicted in the following form (note that join types are intentionally excluded in this example):

```
FROM table_name1
JOIN table_name2
   ON table_name1.column1 = table_name2.column2
      [{AND|OR} table_name1.column3 = table_name2.column4]
```

```
        [...]
   JOIN table_name3
      ON table_name1.columnA = table_name3.columnA
         [{AND|OR} table_name1.column3 = table_name2.column4]
         [...]
   [JOIN...]
```

Use the AND operator and the OR operator to issue a JOIN with multiple conditions. It is also a good idea to use brackets around each pair of joined tables if more than two tables are involved, as this makes reading the query much easier.

`USING (column[, ... ])`
: Assumes an equality condition on one or more named *column*s that appear in both tables. The column (or columns) must exist, as named, in both tables. Writing a USING clause is a little quicker than writing `... ON table1.columnA = table2.columnA`, but the results are functionally equivalent.

`PARTITION BY (column1[, ... ])`
: Useful for filling gaps in result sets. Only Oracle supports this clause. Refer to the Oracle section for an example.

Rules at a glance

Joins enable you to retrieve records from two (or more) logically related tables in a single result set. You can use a SQL standard JOIN (detailed here) to perform this operation, or something called a *theta join*. Theta joins, which use a WHERE clause to establish the filtering criteria, are the "old" way to do join operations.

For example, you might have a table called *employee* that tracks information about everyone employed in your company. The *employee* table, however, doesn't contain extensive information about the job an employee holds; instead, it holds only *job_id*s. All information about the job, such as its *description* and *title*, are stored in a table called *job*. Using a join, you can easily return columns from both tables in a single set of records. The following sample queries illustrate the difference between a theta join and a SQL standard JOIN:

```
/* Theta join */
SELECT emp_lname, emp_fname, job_title
FROM employee, jobs
WHERE employee.job_id = jobs.job_id;

/* SQL standard join */
SELECT emp_lname, emp_fname, job_title
FROM employee
JOIN jobs ON employee.job_id = jobs.job_id;
```

Whenever you reference multiple columns in a single query, the columns must be unambiguous. In other words, the columns must either be unique to each table or be referenced with a table identifier, as is done for the *job_id* column in the preceding example (any columns in the query that don't exist in both tables don't need to be qualified by table identifiers). However, queries like this are often hard to read. The following variation of the previous SQL standard `JOIN` is in better form, because it uses the short, easy-to-read aliases *e* and *j* to refer to the *employee* and *jobs* tables:

```
SELECT e.emp_lname, e.emp_fname, j.job_title
FROM employee AS e
JOIN jobs AS j ON e.job_id = j.job_id;
```

The previous examples were limited to *equi-joins*, or joins based on equality using an equals sign (=). However, most other comparison operators are also allowed: you can perform joins with >, <, >=, <=, <>, and so forth.

You cannot join on binary large object data types (e.g., `BLOB`) or any other large object data types (e.g., `CLOB`, `NLOB`, etc.). Other data types are usually allowed in a join comparison.

Following are examples of each type of join:

`CROSS JOIN`

Here are some cross join examples. The first is a theta join that simply leaves off the join conditions, the second is written using the `CROSS JOIN` clause, and the final query is similar in concept to the first, with a `JOIN` clause that omits the join conditions:

```
SELECT *
FROM employee, jobs;

SELECT *
FROM employee
CROSS JOIN jobs;

SELECT *
FROM employee
JOIN jobs;
```

As mentioned earlier, cross joins—joins between two or more tables that return all the data for all the rows in all possible variations (i.e., the Cartesian product of the tables—are a *really bad idea*. Take a careful look at these examples so you know what they look like, and then avoid them!

`INNER JOIN`

Following is an inner join written using the SQL standard syntax:

```
SELECT a.au_lname AS 'last name',
   a.au_fname AS 'first name',
   p.pub_name AS 'publisher'
FROM authors AS a
INNER JOIN publishers AS p ON a.city = p.city
ORDER BY a.au_lname DESC
```

There are lots of authors in the *authors* table, but very few of them have cities that match their publishers' cities in the *publishers* table. For example, the preceding query executed in the *pubs* database on SQL Server produces results like the following:

```
last name      first name            publisher
-------------- -------------------  -----------------
Carson          Cheryl               Algodata Infosystems
Bennet          Abraham              Algodata Infosystems
```

The join is called an *inner join* because only those records that meet the join condition in both tables are said to be "inside" the join. You could also issue the same query, on platforms that support it, by substituting the USING clause for the ON clause:

```
SELECT a.au_lname AS 'last name',
   a.au_fname AS 'first name',
   p.pub_name AS 'publisher'
FROM authors AS a
INNER JOIN publishers AS p USING (city)
ORDER BY a.au_lname DESC
```

The results for this query would be the same.

LEFT [OUTER] JOIN

Following is an example of a left outer join, where we ask for the publisher for each author (we could also substitute the USING clause for the ON clause, as shown in the previous inner join example):

```
SELECT a.au_lname AS "last name",
   a.au_fname AS "first name",
   p.pub_name AS "publisher"
FROM authors AS a
LEFT OUTER JOIN publishers AS p ON a.city = p.city
ORDER BY a.au_lname DESC
```

In this example every author from the left (*authors*) table will be returned, along with the publisher's name where there is a match, or a NULL value where there is no match. For example, in the SQL Server *pubs* database, the query returns:

```
last name     first name           publisher
-------------- ------------------- ---------------
Yokomoto       Akiko               NULL
White          Johnson             NULL
Stringer       Dirk                NULL
Straight       Dean                NULL
...
```

As mentioned earlier, it's best to avoid mixing left and right outer joins, for greater consistency. Left joins are the more common choice.

`RIGHT [OUTER] JOIN`

A right outer join is essentially the same as a left outer join, except it returns all the records from the table on the right side of the query. For example, the following query executed in the *pubs* database on SQL Server:

```
SELECT a.au_lname AS "last name",
   a.au_fname AS "first name",
   p.pub_name AS "publisher"
FROM authors AS a
RIGHT OUTER JOIN publishers AS p ON a.city = p.city
ORDER BY a.au_lname DESC
```

returns the following result set:

```
last name       first name       publisher
--------------- --------------- -----------------------
Carson           Cheryl          Algodata Infosystems
Bennet           Abraham         Algodata Infosystems
NULL             NULL            New Moon Books
NULL             NULL            Binnet & Hardley
...
```

Every publisher from the right (*publishers*) table is returned, along with the authors' names where there is a match, or a NULL value where there is no match. Again, it's best to avoid mixing right and left outer joins.

`NATURAL [INNER | {LEFT | RIGHT} [OUTER]] JOIN`

Natural joins are a substitute for the `ON` or `USING` clause, so do not use `NATURAL` with those clauses. For example:

```
SELECT a.au_lname AS "first name",
   a.au_fname AS "last name",
   p.pub_name AS "publisher"
FROM authors AS a
NATURAL RIGHT OUTER JOIN publishers AS p
ORDER BY a.au_lname DESC
```

The preceding query will work the same as the earlier examples, but only if both tables possess a column called *city* and that is the only column that they hold in common. You could similarly perform any of the other types of joins (`INNER`, `FULL`, `OUTER`) using the `NATURAL` prefix.

We suggest you avoid natural joins. They save a couple of keystrokes, but at the expense of possible breakage of your code in the future. For example, suppose you have a *date_add* column in your *authors* table but not in your *publishers* table, but you later decide to add that column to the *publishers* table. Natural join queries you wrote previously will suddenly start giving very unexpected results because they will now also be joining by *date_add*.

`FULL [OUTER] JOIN`

If we take our previous example query and render it as a `FULL JOIN`, it looks like this (note that the `OUTER` keyword is optional):

```
SELECT a.au_lname AS "last name",
   a.au_fname AS "first name",
   p.pub_name AS "publisher"
FROM authors AS a
FULL JOIN publishers AS p ON a.city = p.city
ORDER BY a.au_lname DESC;
```

The result set returned by the query is actually the accumulation of the result sets of issuing separate `LEFT` and `RIGHT` join queries (some records have been excluded for brevity):

```
last name           first name           publisher
------------------- ------------------- -------------------
Yokomoto             Akiko               NULL
White                Johnson             NULL
Stringer             Dirk                NULL
...
Dull                 Ann                 NULL
del Castillo         Innes               NULL
DeFrance             Michel              NULL
Carson               Cheryl              Algodata Infosystems
Blotchet-Halls       Reginald            NULL
Bennet               Abraham             Algodata Infosystems
NULL                 NULL                Binnet & Hardley
NULL                 NULL                Five Lakes Publishing
NULL                 NULL                New Moon Books
...
NULL                 NULL                Scootney Books
NULL                 NULL                Ramona Publishers
NULL                 NULL                GGG&G
```

As you can see, with a `FULL JOIN` you get some records with all of the data (`LEFT` and `RIGHT JOIN`s), some with the NULLs on the right and data on the left (`LEFT JOIN`), and some with NULLs on the left and data on the right (`RIGHT JOIN`).

`LATERAL {`*`query`*` | `*`function`*`}`

This example uses SQL standard syntax to return the three top-priced books by each author and will only include authors who have at least one title published. You can achieve the same results in MySQL and older versions of PostgreSQL by replacing the `FETCH FIRST 3 ROWS ONLY` with `LIMIT 3`:

```
SELECT a.au_lname AS "first name",
   a.au_fname AS "last name",
   topt.title, topt.pubdate
FROM authors AS a
  CROSS JOIN LATERAL
  (SELECT t.title, t.pubdate
  FROM titles AS t
```

```
       INNER JOIN titleauthor AS ta ON
            t.title_id = ta.title_id
  WHERE ta.au_id = a.au_id
  ORDER BY t.pubdate DESC
  FETCH FIRST 3 ROWS ONLY
  ) AS topt
ORDER BY a.au_lname ASC, topt.pubdate DESC;
```

If you wanted to list all authors even if they have no published titles, you would use a left join as follows:

```
SELECT a.au_lname AS "first name",
   a.au_fname AS "last name",
   topt.title, topt.pubdate
FROM authors AS a
  LEFT JOIN LATERAL
  (SELECT t.title, t.pubdate
  FROM titles AS t
       INNER JOIN titleauthor AS ta ON
            t.title_id = ta.title_id
  WHERE ta.au_id = a.au_id
  ORDER BY t.pubdate DESC
  LIMIT 3
  ) AS topt ON (1=1)
ORDER BY a.au_lname ASC, topt.pubdate DESC;
```

The `LATERAL` keyword can be used only with `CROSS JOIN` or `LEFT JOIN`.

Programming tips and gotchas

As described in the preceding section, there are many types of joins, each with their own rules and behaviors. If an explicit `join_type` is omitted, an `INNER JOIN` is assumed.

In general, you should favor the `JOIN` clause over the `WHERE` clause for describing join expressions. This not only keeps your code cleaner, making it easy to differentiate join conditions from search conditions, but also avoids the possibility of buggy behavior resulting from some platform-specific implementations of outer joins specified using the `WHERE` clause.

In general, we do not recommend the use of labor-saving keywords like `NATURAL`, since the subclause will not automatically update itself when the structures of the underlying tables change. Consequently, statements using these constructs may fail when a table change is introduced without also changing the query.

Not all join types are supported by all platforms, so refer to the following sections for full details on platform-specific join support.

Joins involving more than two tables can be difficult. When joins involve three or more tables, it is a good idea to think of the query as a series of two table joins.

MySQL

MySQL supports most SQL standard syntax, except that natural joins are supported only on outer joins, not on inner joins. MySQL also does not support the PARTITION BY clause. The JOIN syntax is:

```
FROM table [AS alias]
{[STRAIGHT_JOIN joined_table] |
{ {[INNER] | [CROSS] |
    [NATURAL] [ {LEFT | RIGHT | FULL} [OUTER] ]}
   JOIN [LATERAL] joined_table [AS alias]
   { ON join_condition1 [{AND|OR} join_condition2] [...] } |
     USING (column1[, ...]) }}
[...]
```

where:

`STRAIGHT_JOIN`
: Forces the optimizer to join tables in the exact order in which they appear in the FROM clause. The STRAIGHT_JOIN keyword is functionally equivalent to JOIN, except that it forces the join order from left to right. This option was supplied because MySQL might, rarely, join the tables in the wrong order.

  Refer to "Rules at a glance" on page 281 for examples.

MySQL is very fluid in the way it supports joins. You can use several different syntaxes to perform a join; for example, you can explicitly declare a join in a query using the JOIN clause, but then show the join condition in the WHERE clause. The other platforms force you to pick one method or the other and do not allow you to mix them in a single query. However, we think it's bad practice to mix methods, so our examples use SQL standard JOIN syntax.

Oracle

Oracle fully supports the SQL standard JOIN syntax. There's also an older syntax for outer theta joins that involves adding "(+)" to the column names on the opposite side of the direction of the join (this comes from the fact that the table supplying the NULL value rows in effect has NULL value rows added to it). However, this syntax should be avoided because it doesn't support some of the features of SQL standard joins, such as FULL JOIN. Oracle also supports CROSS APPLY and OUTER APPLY clauses (also found in SQL Server), which are equivalent to the SQL standard's LATERAL clause.

For example, the following query does a RIGHT OUTER JOIN on the *authors* and *publishers* tables:

```
SELECT a.au_lname AS 'first name',
   a.au_fname AS 'last name',
   p.pub_name AS 'publisher'
FROM authors AS a
```

```
RIGHT OUTER JOIN publishers AS p ON a.city = p.city
ORDER BY a.au_lname DESC
```

The old Oracle syntax looks like this:

```
SELECT a.au_lname AS 'first name',
   a.au_fname AS 'last name',
   p.pub_name AS 'publisher'
FROM authors a, publishers p
WHERE a.city(+) = p.city
ORDER BY a.au_lname DESC
```

Refer to "Rules at a glance" on page 281 for more `JOIN` examples.

Oracle is unique in offering partitioned outer joins, which are useful for filling gaps in result sets due to sparse data storage. For example, assume we store production records in a *manufacturing* table keyed on day and product ID. The table holds a row showing the quantity of each product produced during any day on which it is made, but there are no rows for the days it is not produced. This is considered sparse data, since a list of all rows will not show every day for every product. For calculation and reporting purposes, it's very useful to be able to create result sets where each product has a row for every day, regardless of whether or not it was manufactured on that day. A partitioned outer join makes it simple to do that, since it lets you define a logical partition and apply an outer join to each partition value. The following example does a partitioned outer join with a *times* table to make sure each *product_id* has the full set of dates in a specified time range:

```
SELECT times.time_id AS time, product_id AS id, quantity AS qty
FROM manufacturing
PARTITION BY (product_id)
RIGHT OUTER JOIN times
ON (manufacturing.time_id = times.time_id)
WHERE manufacturing.time_id
BETWEEN TO_DATE('01/10/05', 'DD/MM/YY')
    AND TO_DATE('06/10/05', 'DD/MM/YY')
ORDER BY 2, 1;
```

Here is the output from this query:

```
time            id        qty
--------- ------          ---
01-OCT-05    101           10
02-OCT-05    101
03-OCT-05    101
04-OCT-05    101           17
05-OCT-05    101           23
06-OCT-05    101
01-OCT-05    102
02-OCT-05    102
03-OCT-05    102           43
04-OCT-05    102           99
05-OCT-05    102
06-OCT-05    102           87
```

Getting these results without using a partitioned outer join would require much more complex and less efficient SQL.

PostgreSQL

PostgreSQL fully supports the SQL standard syntax, except for the PARTITION BY clause. Refer to "Rules at a glance" on page 281 for examples. When using functions in a LATERAL construct, the LATERAL keyword is optional.

For example, if you wanted to create a set of dates from publication date to present date for each title, you could write your LATERAL query as follows:

```
SELECT title_id, i AS cal_date
FROM titles CROSS JOIN
   generate_series(titles.pubdate, CURRENT_DATE, interval '1 day')
   AS i
ORDER BY title_id, cal_date
```

Or with the LATERAL keyword:

```
SELECT title_id, i AS cal_date
FROM titles CROSS JOIN
   LATERAL generate_series(titles.pubdate, CURRENT_DATE,
      interval '1 day')
   AS i
ORDER BY title_id, cal_date
```

SQL Server

SQL Server supports INNER, OUTER, and CROSS joins using the ON clause. It does not support NATURAL join syntax, nor PARTITION BY or the USING clause. SQL Server also does not support the LATERAL clause, though it does support CROSS APPLY, which is equivalent to CROSS JOIN LATERAL, and OUTER APPLY, which is equivalent to LEFT JOIN LATERAL. SQL Server's JOIN syntax is:

```
FROM table [AS alias]
{ {[INNER] | [CROSS] | [ {LEFT | RIGHT | FULL} [OUTER] ]}
   [JOIN | APPLY]  joined_table [AS alias]
      { ON join_condition1 [{AND|OR}
       join_condition2] [...] } }
[...]
```

Refer to "Rules at a glance" on page 281 for examples.

The equivalent SQL Server query for the LATERAL example is:

```
SELECT a.au_lname AS "first name",
   a.au_fname AS "last name",
   topt.title, topt.pubdate
FROM authors AS a
  CROSS APPLY
  (SELECT TOP 3 t.title, t.pubdate
  FROM titles AS t
```

```
        INNER JOIN titleauthor AS ta ON
             t.title_id = ta.title_id
   WHERE ta.au_id = a.au_id
   ORDER BY t.pubdate DESC
   ) AS topt
 ORDER BY a.au_lname ASC, topt.pubdate DESC;
```

If you wanted to make sure all authors are listed even if they have no published titles, you would use the `OUTER APPLY` clause, as follows:

```
 SELECT a.au_lname AS "first name",
    a.au_fname AS "last name",
    topt.title, topt.pubdate
 FROM authors AS a
   OUTER APPLY
   (SELECT TOP 3 t.title, t.pubdate
   FROM titles AS t
        INNER JOIN titleauthor AS ta ON
             t.title_id = ta.title_id
   WHERE ta.au_id = a.au_id
   ORDER BY t.pubdate DESC
   ) AS topt
 ORDER BY a.au_lname ASC, topt.pubdate DESC;
```

See also

- `SELECT`
- `ORDER BY`
- `WHERE`

LIKE Operator

The `LIKE` operator enables specified string patterns in `SELECT`, `INSERT`, `UPDATE`, and `DELETE` statements to be matched, specifically in the `WHERE` clause. A specified pattern may include special wildcard characters. The specific wildcards supported vary from platform to platform.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
 WHERE expression [NOT] LIKE string_pattern
    [ESCAPE escape_sequence]
```

Keywords

`WHERE` *`expression`* `[NOT] LIKE`
: Returns a Boolean `TRUE` when the value of *`expression`* matches the *`string_pattern`*. The expression may be a column, a constant, a host variable, a scalar function, or a concatenation of any of these. It should not be a user-defined type, nor should it be certain `LOB` types.

`NOT`
: Inverses the predicate, so the statement returns a Boolean `TRUE` if the value of *`expression`* does not contain the *`string_pattern`* and returns `FALSE` if the value of *`expression`* contains the *`string_pattern`*.

`ESCAPE` *`escape_sequence`*
: Allows you to search for the presence of characters that would normally be interpreted as wildcards.

Rules at a glance

Matching string patterns is easy with `LIKE`, but there are a couple of rules to remember:

- All characters, including trailing and leading spaces, are important.
- Differing data types may be compared using `LIKE`, but they store string patterns differently. In particular, be aware of the differences between the `CHAR`, `VARCHAR`, and `DATE` data types.
- Using `LIKE` may negate indexes or force the DBMS to use alternative, less optimal indexes than a straight comparison operation.

The SQL standard standard currently supports two wildcard operators that are supported by all of the platforms covered in this book:

`%`
: Matches any string

_ *(underscore)*
: Matches any single character

The first query in the following example retrieves any city record with “ville” in its name. The second query returns authors with a first name *not* like Sheryl or Cheryl (or Aheryl, Bheryl, Dheryl, 2heryl, and so forth):

```
SELECT * FROM authors
WHERE city LIKE '%ville%';
SELECT * FROM authors
WHERE au_fname NOT LIKE '_heryl';
```

Some of the platforms support additional wildcard symbols. These are described in the platform-specific sections that follow.

Use of the ESCAPE clause allows you to look for wildcard characters in the strings stored in your database. Using this mechanism, you designate a character—typically a character that does not otherwise appear in the pattern string—as your escape character. For example, you might designate the tilde (~) because you know it never appears in the pattern string. Any wildcard character preceded by the escape sequence is then treated not as a wildcard, but rather as the character itself. For example, we can look through the *comments* column of the *sales_detail* table (on SQL Server) to see whether any customers have mentioned a newly introduced discount using this query:

```
SELECT ord_id, comment
FROM sales_detail
WHERE comment LIKE '%~%%' ESCAPE '~'
```

In this case, the first and last %s are interpreted as wildcards, but the second % character is interpreted as just that (a % character), because it is preceded by the designated escape sequence.

Programming tips and gotchas

The usefulness of LIKE is based on the wildcard operators that it supports. LIKE returns a Boolean TRUE value when the comparison finds one or more matching values.

The default case sensitivity of the DBMS is very important to the behavior of LIKE. For example, SQL Server is not case-sensitive by default (though it can be configured that way), so it will evaluate the strings 'DAD' and 'dad' to be equal. MySQL is also case-insensitive by default but has a LIKE BINARY operator to force case sensitivity. Oracle and PostgreSQL, on the other hand, are case-sensitive. Thus, on those platforms a comparison of 'DAD' and 'dad' would show them to be unequal. PostgreSQL (but not Oracle) has an ILIKE operator for case-insensitive matching. Here's an example query to better illustrate this point:

```
SELECT *
FROM authors
WHERE lname LIKE 'LARS%'
```

This query on MySQL and SQL Server would find authors whose last names are stored as 'Larson' or 'Lars', even though the search was for the uppercase 'LARS%'. Oracle and PostgreSQL, however, would not find 'Larson' or 'Lars', because they perform case-sensitive comparisons by default.

MySQL

MySQL supports the SQL standard syntax for LIKE. Additionally, it supports the special functions REGEXP, RLIKE, NOT REGEXP, and NOT RLIKE for the evaluation of regular expressions.

Oracle

Oracle supports the SQL standard syntax for `LIKE`. Its `LIKE` syntax is as follows:

```
WHERE expression [NOT] {LIKE | LIKEC | LIKE2 |
   LIKE4} string_pattern
[ESCAPE escape_sequence]
```

The Oracle-specific syntax elements have the following meanings:

`LIKEC`
: Uses Unicode complete characters

`LIKE2`
: Uses Unicode USC2 code points

`LIKE4`
: Uses Unicode UCS4 code points

Since Oracle is case-sensitive, you should enclose the *`expression`*, the *`string_pattern`*, or both with the `UPPER` function. That way, you are always comparing apples to apples.

PostgreSQL

PostgreSQL supports the SQL standard syntax for `LIKE`. It's case-sensitive by default but provides the keyword `ILIKE` for case-insensitive pattern matching. You can also use the operators `~~` as an equivalent to `LIKE`, `~~*` for `ILIKE`, and `!~~` and `!~~*` for `NOT LIKE` and `NOT ILIKE`, respectively. These are all extensions to the SQL standard syntax.

For example, the following queries are functionally the same:

```
SELECT * FROM authors
WHERE city LIKE '%ville';
SELECT * FROM authors
WHERE city ~~ '%ville';
```

Since these queries are in lowercase, you might run into a case-sensitivity problem. That is, the queries are looking for a lowercase `'%ville'`, but the table might contain uppercase (and unequal) values such as `'BROWNSVILLE'`, `'NASHVILLE'`, and `'HUNTSVILLE'`. You can get around this as follows:

```
-- Convert the values to uppercase
SELECT * FROM authors
WHERE city LIKE UPPER('%ville');

-- Perform the pattern match using case insensitivity
SELECT * FROM authors
WHERE city ~~* '%ville';
SELECT * FROM authors
WHERE city ILIKE '%ville';
```

Although beyond the scope of this text, you should be aware that PostgreSQL also supports POSIX regular expressions. See the platform documentation for details.

SQL Server

SQL Server supports the SQL standard syntax for `LIKE`, and the following additional wildcard operators:

`[ ]`
: Matches any value in the specified set, as in *[abc]*, or range, as in *[k–n]*

`[^ ]`
: Matches any characters not in the specified set or range

Using SQL Server's additional wildcard operators, you have some added capabilities. For example, you can retrieve any author with a last name like Carson, Carsen, Karson, or Karsen:

```
SELECT * FROM authors
WHERE au_lname LIKE '[CK]ars[eo]n'
```

or you can retrieve any author with a last name that ends in "arson" or "arsen," *but is not* Larsen or Larson:

```
SELECT * FROM authors
WHERE au_lname LIKE '[A-Z^L]ars[eo]n'
```

Remember that when you're performing string comparisons with `LIKE`, all characters in the pattern string are significant, including all leading and trailing blank spaces.

See also

- `DELETE` in Chapter 5
- `SELECT`
- `UPDATE` in Chapter 5
- `WHERE`

ORDER BY Clause

The `ORDER BY` clause specifies the sort order of the result set retrieved by a `SELECT` statement.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
ORDER BY { sort_expression [COLLATE collation_name]
   [ASC | DESC] [NULLS {FIRST | LAST}] }[, ...]
[ OFFSET int {ROW | ROWS} ]
[ FETCH {FIRST | NEXT} numeric {ROW | ROWS | PERCENT}
   {ONLY | WITH TIES} ]
```

Keywords

`ORDER BY`
: Specifies the order in which rows should be returned by a query. You should not anticipate a specific ordering if you exclude the `ORDER BY` clause, even if you specify a `GROUP BY` clause and it appears that a sort has been done.

`sort_expression`
: Specifies an item in the query that will help determine the order of the result set. You can have multiple sort expressions. They are usually column names or column aliases from the query; however, they may also be expressions like `(salary * 1.02)`.

`COLLATE` *`collation_name`*
: Overrides the default collation of the *`sort_expression`* and applies the *`collation_name`* to the expression for the purposes of the `ORDER BY` clause.

`ASC | DESC`
: Specifies that the result set should be returned in either ascending order (`ASC`) or descending order (`DESC`).

`NULLS {FIRST | LAST}`
: `NULLS FIRST` and `NULLS LAST` specify that the records containing NULLs should appear either first or last, respectively. By default, Oracle and PostgreSQL place NULLs last for ascending-order sorts and first for descending-order sorts.

`OFFSET` *`int`* `{ROW | ROWS}`
: Specifies the number of rows to skip from the start of the `ORDER BY` set.

`FETCH {FIRST | NEXT}` *`numeric`* `{ROW | ROWS | PERCENT}`
: Returns the first or next (from `OFFSET`) *`numeric`* rows or `PERCENT` of records. If `ROW` or `ROWS` is used, the value must be an integer. When using `FIRST`, there should be no `OFFSET` clause. `PERCENT` is any number from 0 to 100 and can include fractional values.

`ONLY | WITH TIES`
: `ONLY` returns at most the specified number or percentage of rows. `WITH TIES` returns additional rows if, based on the `ORDER BY` clause, records within that count are tied. In other words, rather than returning one or more of the tied records at random, up to the *`numeric`* specified, all of the tied records that

are within the count are returned even if the total count exceeds the *numeric* specified.

Rules at a glance

The ORDER BY clause should reference columns as they appear in the item list of the SELECT statement, preferably using their aliases (if aliases exist). For example:

```
SELECT au_fname AS first_name, au_lname AS last_name
FROM authors
ORDER BY first_name, last_name
```

The ORDER BY clause uses a major-to-minor sort ordering. This means that the result set is ordered by the first column referenced; equal values in the first column are then ordered by the second column, equal values in the second column are ordered by the third column, and so forth.

The individual aspects of a column's ordering—COLLATE and ASC/DESC—are independent of the other columns in the ORDER BY clause. Thus, you could order a result set in ascending order by one column, and then flip the next column and order it in descending order:

```
SELECT au_fname AS first_name, au_lname AS last_name
FROM authors
ORDER BY au_lname ASC, au_fname DESC
```

NULLs are always grouped together (i.e., considered equal) for the purposes of sorting. Depending on your platform, NULLs will be clumped together at the top or at the bottom of the result set. The following query on SQL Server:

```
SELECT title, price
FROM titles
ORDER BY price, title
```

provides this result set:

```
title                                                price
---------------------------------------------------- -------
Net Etiquette                                        NULL
The Psychology of Computer Cooking                   NULL
The Gourmet Microwave                                2.9900
You Can Combat Computer Stress!                      2.9900
Life Without Fear                                    7.0000
Onions, Leeks, and Garlic: Cooking Secrets of the Me 20.9500
Computer Phobic AND Non-Phobic Individuals: Behavior 21.5900
But Is It User Friendly?                             22.9500
...
```

You can force NULLs to appear at the top or bottom of the result set using ASC or DESC. Of course, all the non-NULL rows of the result set are also ordered in ascending or descending order.

Some platforms support specification of NULL sorting. In Oracle and PostgreSQL by default NULLs are sorted to the end, but you can change the behavior as follows to yield the previous result by doing:

```
SELECT title, price
FROM titles
ORDER BY price NULLS FIRST, title NULLS LAST
```

The SQL standard also supports for the *`sort_expression`* the use of columns that are not referenced in the `SELECT` item list. For example, the following query is valid:

```
SELECT title, price
FROM titles
ORDER BY title_id
```

Looking at this example, you can see that although the query does not select *title_id*, that column is the primary *`sort_expression`*. The result set is returned in *title_id* order even though that column is not selected.

You can limit the number of records returned using the `[OFFSET] FETCH {FIRST | NEXT}` subclauses. For example, the following query will skip the first 10 titles and return the next 10:

```
SELECT title, price
FROM titles
ORDER BY title
OFFSET 10 ROWS
FETCH NEXT 10 ROWS ONLY
```

Programming tips and gotchas

When using set operators (`EXCEPT`, `INTERSECT`, `UNION`), only the last query may have an `ORDER BY` clause.

A number of behaviors that were supported in SQL92 are deprecated in more recent SQL standards. You should avoid these usages although all the databases covered here still support them:

References to table aliases
: For example, `ORDER BY e.emp_id` should be changed to `ORDER BY emp_id`. If there is an ambiguous column name, use an alias to compensate.

References to ordinal position
: Use explicitly defined column aliases to compensate.

You may sort not only on columns, but also on expressions involving columns, or even literals:

```
SELECT SUBSTRING(title,1,55) AS title, (price * 1.15) as price
FROM titles
WHERE price BETWEEN 2 and 19
ORDER BY price, title
```

When sorting on expressions from the SELECT item list, you should use aliases to make the ORDER BY *sort_expression* column references easier to read.

MySQL

MySQL supports the SQL standard, except for the COLLATE option, FETCH PERCENT, and NULLS {FIRST | LAST}. In addition to the SQL standard OFFSET FETCH, it also supports a LIMIT OFFSET subclause that is equivalent in purpose and predates the SQL standard's subclause. MySQL's ORDER BY syntax is:

```
ORDER BY {sort_expression [ASC | DESC]}[, ...]
[ OFFSET int {ROW | ROWS} ]
[ FETCH {FIRST | NEXT} numeric {ROW | ROWS} {ONLY | WITH TIES} ]
[ LIMIT int OFFSET int ]
```

where:

LIMIT *int*
: Specifies the maximum number of records to return

OFFSET *int*
: Specifies how many records to skip

You cannot use the LIMIT OFFSET construct in conjunction with the OFFSET FETCH construct.

You should not attempt to ORDER BY columns of the BLOB data type, because only the first bytes, defined by the MAX_SORT_LENGTH setting, will be used in the sort. By default, MySQL sorts NULL values lowest (first) for ASC order and highest (last) for DESC order.

Oracle

Oracle supports the SQL standard, except for the COLLATE option. It also supports a SIBLINGS option. Oracle's ORDER BY syntax is:

```
ORDER [SIBLINGS] BY {sort_expression
   [ASC | DESC] [NULLS {FIRST | LAST}]}[, ...]
[ OFFSET int {ROW | ROWS} ]
[ FETCH {FIRST | NEXT} numeric {ROW | ROWS | PERCENT}
   {ONLY | WITH TIES} ]
```

where:

ORDER [SIBLINGS] BY *sort_expression*
: Sorts the result set of the query in order of the *sort_expression*(s). A *sort_expression* may be a column name, an alias, an integer indicating a column's ordinal position, or another expression (e.g., *salary * 1.02*). The ORDER SIBLINGS BY clause tells Oracle to preserve any ordering specified by a hierarchical query clause (CONNECT BY), and to use the sort expression order for ordering of siblings in the hierarchy.

You can emulate the behavior of the `COLLATE` option for a single session by using the `NLSSORT` function with the `NLS_SORT` parameter. You can also emulate the behavior of the `COLLATE` option for all sessions on the server either explicitly, by using the `NLS_SORT` initialization parameter, or implicitly, with the `NLS_LANGUAGE` initialization parameter.

You should *not* perform an `ORDER BY` on any `LOB` column, nested table, or `VARRAY`.

PostgreSQL

PostgreSQL supports the SQL standard, with the exception of the `COLLATE` and `FETCH PERCENT` options. It also supports a `LIMIT OFFSET` subclause similar to MySQL's, and a `USING` subclause. Support for `OFFSET FETCH` was introduced in PostgreSQL 13. PostgreSQL's `ORDER BY` syntax is:

```
ORDER BY {sort_expression [ASC | DESC] [USING operator]
   [NULLS {FIRST | LAST}]}[, ...]
[ OFFSET int {ROW | ROWS} ]
[ FETCH {FIRST | NEXT} int {ROW | ROWS} {ONLY | WITH TIES} ]
[ LIMIT int OFFSET int ]
```

where:

`USING` *`operator`*
: Specifies a specific comparison operator. Thus, you may sort by `>`, `<`, `=`, `>=`, `<=`, and so forth. Ascending order is the same as specifying `USING <`, while descending order is the same as `USING >`.

`LIMIT` *`int`*
: Specifies the maximum number of records to return.

`OFFSET` *`int`*
: Specifies how many records to skip.

`ASC` and `DESC` are SQL standards. If not specified, `ASC` is the default. PostgreSQL sorts NULL values as higher than any other value by default, causing NULL values to appear at the end of `ASC` sorts and at the beginning of `DESC` sorts. You can use the `NULLS {FIRST | LAST}` clause to change this behavior. For example:

```
SELECT stor_id, ord_date, qty AS quantity
FROM sales
ORDER BY stor_id, ord_date DESC, qty ASC NULLS FIRST;
```

You cannot use both `OFFSET FETCH` and `LIMIT OFFSET`, as they achieve equivalent goals. Although `LIMIT OFFSET` is faster to type, the `OFFSET FETCH` construct is SQL standard–compliant and allows for specifying how ties are treated in the result set. For example:

```
SELECT stor_id, ord_date, qty
FROM sales
ORDER BY qty
```

```
FETCH FIRST 3 ROWS WITH TIES;
stor_id |        ord_date        | qty
--------+------------------------+-----
 6380    | 1994-09-13 00:00:00-04 |   3
 6380    | 1994-09-14 00:00:00-04 |   5
 7896    | 1993-12-12 00:00:00-05 |  10
 7067    | 1994-09-14 00:00:00-04 |  10
 8042    | 1994-09-14 00:00:00-04 |  10
(5 rows)
```

Note that the output has five rows instead of three because the last three are tied for third place.

In `SELECT` statements that involve single tables or use `JOIN`s, but not set operations (`UNION`, for example), you may also order by columns of the table that do not appear in the `select_item` list. For example:

```
SELECT stor_name
FROM sales
ORDER BY stor_id, qty;
```

SQL Server

SQL Server supports the SQL standard, except for the `FETCH PERCENT` and `NULLS {FIRST | LAST}` options. `PERCENT` can be used with `TOP` to simulate `FETCH PERCENT`. For example, the following query retrieves the authors' first names from the *authors* table in the `SQL_Latin1` collation:

```
SELECT au_fname
FROM authors
ORDER BY au_fname
COLLATE SQL_Latin1_general_cp1_ci_as
```

By default, SQL Server sorts NULL values higher than all other values.

SQL Server allows a variety of collations that can affect how the result set is evaluated. Thus, under certain collations "SMITH" and "smith" might evaluate and sort differently. You should not use `TEXT`, `IMAGE`, or `NTEXT` columns as *`sort_expression`*s on SQL Server.

See also

- `SELECT`

OVER Clause

The `OVER` clause appears in the `SELECT` clause as a function qualifier for window function–based columns and when aggregates are used in a window construct. The `WINDOW` clause often accompanies one or more `OVER` clauses and appears after the whole SELECT statement. It is used to name a window specification that is then used by name in the OVER clause(s).

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
FUNCTION_NAME(expr) OVER {window_name | (window_specification)}
window_specification ::= [window_name] [partitioning]
      [ordering] [framing]
   partitioning ::= PARTITION BY value[, value...]
         [COLLATE collation_name]
   ordering ::= ORDER [SIBLINGS] BY rule[, rule...]
      rule ::= {value | position | alias} [ASC | DESC]
         [NULLS {FIRST | LAST}]
   framing ::= {ROWS | RANGE | GROUPS} {start | between}
         [exclusion]
      start ::= {UNBOUNDED PRECEDING | unsigned-integer
            PRECEDING | CURRENT ROW}
      between ::= BETWEEN bound AND bound
         bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer
            FOLLOWING}
      exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP |
         EXCLUDE TIES | EXCLUDE NO OTHERS}
```

In addition to the OVER clause, you can have a WINDOW clause before the ORDER BY clause and after the WHERE clause in a SELECT statement. It is followed by one or more definitions of named windows. The syntax is as follows:

```
WINDOW {window_name AS (window_specification)[, ...]}
```

Keywords

`OVER {`*`window_name`*` | (`*`window_specification`*`)}`
: The OVER clause may reference a predefined window (defined in a WINDOW clause) that can be used across multiple columns or can provide a window specification consisting of ORDER BY and PARTITION BY clauses. A window of data consists of a subset of rows relative to the current row.

`partitioning`
: Defines the group of rows that a row is a member of. The *value*s are column names or expressions that include column names. All records with these expressions in common belong to the same partition. If there is no partitioning clause, then all rows belong to the same partition.

ordering
: Specifies the order in which rows should be sorted in the window.

framing
: Denotes which rows are considered to be in the window (a subset of rows relative to the current row). The syntax of the *framing* subclause is as follows:

```
{ROWS | RANGE} {start | between} [exclusion]
start ::= {UNBOUNDED PRECEDING | unsigned-integer PRECEDING |
   CURRENT ROW}
between ::= BETWEEN bound AND bound
bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer
   FOLLOWING}
exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP |
   EXCLUDE TIES | EXCLUDE NO OTHERS}
```

`ASC | DESC`
: Specifies that the result set should be returned in either ascending order (`ASC`) or descending order (`DESC`) based on the *value* | *position*.

`NULLS {FIRST | LAST}`
: Specifies that the records containing NULLs should appear either first or last in the result set, respectively.

`WINDOW {`*window_name* `AS (`*window_specification*`)[, ... ]}`
: Defines one or more named windows, providing a specification for each.

Rules at a glance

Each `SELECT` statement may have zero or more `OVER` clauses. Here are a few examples. The following query ranks each title across all titles (*dr*) and then within the group that has the same publisher:

```
SELECT   t.title_id,
   DENSE_RANK() OVER(ORDER BY price) AS dr,
   DENSE_RANK() OVER(PARTITION BY pub_id ORDER BY price) AS dr_pub
FROM     titles AS t
ORDER BY title_id;
```

The next query uses the `SUM` aggregate function to produce a running total and an overall total for price. Note that the `ORDER BY` clause used in an `OVER` clause does not need to be the same as the `SELECT ... ORDER BY`, but it does make it easier to debug:

```
SELECT   t.title_id,
   SUM(price) OVER() AS overall_total,
   SUM(price) OVER(ORDER BY price) AS running_total
FROM     titles AS t
ORDER BY title_id;
```

Finally, here's an example of a query that uses named windows:

```
SELECT   t.title_id,
   DENSE_RANK() OVER wprice AS dr,
   SUM(price) OVER(wpub) AS wpub_total
FROM     titles AS t
WINDOW wprice AS (ORDER BY price),
   wpub AS (PARTITION BY pub_id)
ORDER BY title_id;
```

MySQL

MySQL supports a subset of the SQL standard syntax for the `OVER` and *`window_specification`* clauses, as shown here:

```
FUNCTION_NAME(expr) OVER {window_name | (window_specification)}
window_specification ::= [window_name] [partitioning]
      [ordering] [framing]
   partitioning ::= PARTITION BY value[, value...]
   ordering ::= ORDER BY rule[, rule...]
      rule ::= {value | position | alias} [ASC | DESC] ]
   framing ::= {ROWS | RANGE} {start | between} [exclusion]
      start ::= {UNBOUNDED PRECEDING | unsigned-integer
            PRECEDING | CURRENT ROW}
      between ::= BETWEEN bound AND bound
         bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer
                                    FOLLOWING}
```

It also supports the `WINDOW` clause, and has the same options for the *`window_specification`* clause.

Oracle

Oracle fully supports the SQL standard `OVER` and *`window_specification`* clauses, except for the `COLLATE` clause. Its syntax is as follows:

```
FUNCTION_NAME(expr) OVER {window_name | (window_specification)}
window_specification ::= [window_name] [partitioning]
      [ordering] [framing]
   partitioning ::= PARTITION BY value[, value...]
   ordering ::= ORDER [SIBLINGS] BY rule[, rule...]
      rule ::= {value | position | alias} [ASC | DESC]
            [NULLS {FIRST | LAST}]
   framing ::= {ROWS | RANGE | GROUPS} {start | between}
         [exclusion]
      start ::= {UNBOUNDED PRECEDING | unsigned-integer
            PRECEDING | CURRENT ROW}
      between ::= BETWEEN bound AND bound
         bound ::= {start | UNBOUNDED FOLLOWING |
               unsigned-integer FOLLOWING}
      exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP |
            EXCLUDE TIES | EXCLUDE NO OTHERS}
```

The `WINDOW` clause was introduced in Oracle 21c. It allows anything that is also allowed in the *`window_specification`* of the `OVER` clause.

PostgreSQL

PostgreSQL supports all the SQL standard syntax for the `OVER` and *`window_specification`* clauses, except for the `SIBLINGS` keyword and `COLLATE` clause. It allows all aggregate functions, including user-defined ones, to be used as window aggregates. Aggregates can be created in nearly any PostgreSQL-supported language, but the PL/pgSQL and SQL built-in languages do not support the creation of window functions (window functions can be created in C, PL/V8, and PL/R).

The PostgreSQL `OVER` syntax is as follows:

```
FUNCTION_NAME(expr) OVER {window_name | (window_specification)}
window_specification ::= [window_name] [partitioning]
      [ordering] [framing]
   partitioning ::= PARTITION BY value[, value...]
   ordering ::= ORDER BY rule[, rule...]
      rule ::= {value | position | alias} [ASC | DESC]
            [NULLS {FIRST | LAST}]
   framing ::= {ROWS | RANGE | GROUPS} {start | between}
         [exclusion]
      start ::= {UNBOUNDED PRECEDING | unsigned-integer
            PRECEDING | CURRENT ROW}
      between ::= BETWEEN bound AND bound
         bound ::= {start | UNBOUNDED FOLLOWING |
               unsigned-integer FOLLOWING}
      exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP |
            EXCLUDE TIES | EXCLUDE NO OTHERS}
```

It also supports the `WINDOW` clause, with the same options for the *`window_specification`* clause.

SQL Server

SQL Server supports a subset of the SQL standard syntax for the `OVER` clause. It does not support named windows or the `WINDOW` clause. SQL Server's `OVER` syntax is as follows:

```
FUNCTION_NAME(expr) OVER {(window_specification)}
window_specification ::= [partitioning] [ordering] [framing]
   partitioning ::= PARTITION BY value[, value...]
         [COLLATE collation_name]
   ordering ::= ORDER BY rule[, rule...]
      rule ::= {value | position | alias} [ASC | DESC]
   framing ::= {ROWS | RANGE} {start | between}
      start ::= {UNBOUNDED PRECEDING | unsigned-integer
            PRECEDING | CURRENT ROW}
```

```
        between ::= BETWEEN bound AND bound
           bound ::= {start | UNBOUNDED FOLLOWING |
                 unsigned-integer FOLLOWING}
```

See also

- SELECT
- "SQL Window Functions" on page 625

SELECT Statement

The SELECT statement retrieves rows, columns, and derived values from one or many tables of a database.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

The full syntax of the SELECT statement is powerful and complex, but it can be broken down into these main clauses:

```
SELECT [{ALL | DISTINCT}] select_item [AS alias][, ...]
FROM [ONLY | OUTER]
   {table_name [[AS] alias] | view_name [[AS] alias]}[, ...]
[ [join_type] JOIN join_condition ]
[WHERE search_condition] [ {AND | OR | NOT} search_condition[...] ]

group_by_clause

order_by_clause
```

Keywords

`[{ALL | DISTINCT}] select_item`

Retrieves values that compose the query result set. Each *select_item* may be a literal, an aggregate or scalar function, a mathematical calculation, a parameter or variable, or a subquery, but a *select_item* is most commonly a column from a table or view. A comma must separate each item in a list of such items.

The schema or owner name should be prefixed to a column's name when it's extracted from a context outside of the current user's. If another user owns the table, that user must be included in the column reference. For example, if the user *jake* needed to access data in the schema *katie* he would use:

```
SELECT emp_id
FROM katie.employee;
```

You can use the asterisk (*) shorthand to retrieve all columns in every table or view listed in the `FROM` clause. It's a good idea to use this shortcut on single-table queries only.

`ALL`, the default behavior, returns all records that meet the selection criteria. `DISTINCT` tells the database to filter out any duplicate records, thus retrieving only one instance of many identical records.

`AS` *`alias`*
: Replaces a column heading (when in the *`select_item`* clause) or a table name or view name (when in the `FROM` clause) with a shorter heading or name. This clause is especially useful for replacing cryptic or lengthy names with short, easy-to-understand names or mnemonics, and for when the column contains only derived data, so you don't end up with a column called something like *ORA000189x7/0.02*. It is also very useful in self-joins and correlated subqueries where a single query references the same table more than once. When multiple items appear in the *`select_item`* clause or `FROM` clause, make sure to place the commas *after* the `AS` *`alias`* clauses. Also, be careful to always use an alias uniformly once you introduce it into the query.

`FROM [ONLY | OUTER] {`*`table_name`*` | `*`view_name`*`}[, ... ]`
: Lists all of the tables and/or views from which the query retrieves data. Separate table and view names using commas. The `FROM` clause also allows you to assign aliases to long table/or view names or subqueries using the `AS` clause. Using shorter aliases instead of longer table or view names simplifies coding. (Of course, this might thwart the DBA's carefully planned naming conventions, but the alias only lasts for the duration of the query. Refer to "Rules at a glance" on page 308 for more information on aliases.) A `FROM` clause may contain a subquery (refer to "SUBQUERY Substatement" on page 337 for details).

`ONLY`
: Specifies that only the rows of the named table or view (and no rows in subtables or subviews) will be retrieved in the result set. When using `ONLY`, be sure to enclose the *`table_name`* or *`view_name`* within parentheses. `ONLY` is ignored if the table or view has no subtables or subviews.

`OUTER`
: Specifies that the rows of the named table or view, along with the rows and columns of any and all subtables or subviews, will be retrieved in the result set. Columns of the subtables (or subviews) will be appended to the right, in subtable hierarchy order according to the depth of the subtable. In extensive hierarchies, subtables with common parents are appended in the creation order of their types. When using `OUTER`, be sure to enclose the *`table_name`* or *`view_name`* within parentheses. `OUTER` is ignored if the table or view has no subtables or subviews.

`[*join_type*] JOIN *join_condition*`

Joins together the result set of the table shown in the `FROM` clause to another table that shares a meaningful relationship based on a common set of values. These values are usually contained in columns of the same name and data type that appear in both tables being joined. These columns, or possibly a single column from each table, are called the *join key* or *common key*. Most—but not all—of the time, the join key is the primary key of one table and a foreign key in the other table. As long as the data in the columns matches, the join can be performed. (Note that joins can also be performed using the `WHERE` clause. This technique is sometimes called a *theta join*.)

Refer to "JOIN Subclause" on page 278 for details of different kinds of joins.

Join conditions are most commonly depicted in the form:

```
JOIN table_name2 ON table_name1.column1 comparison_operator
   table_name2.column1
JOIN table_name3 ON table_name1.columnA comparison_operator
   table_name3.columnA
[...]
```

When the *`comparison_operator`* is the equals sign (=), a join is said to be an *equi-join*. However, the comparison operator may be <, >, <=, >=, or even <>.

Use the `AND` operator to issue a `JOIN` with multiple conditions. You can also use the `OR` operator to specify alternative join conditions.

If an explicit *`join_type`* is omitted, an `INNER JOIN` is assumed. Note that there are many types of joins, each with its own rules and behaviors. Also be aware that an alternative approach to the join condition, via the `USING` clause, exists:

`USING (*column_name*[, ... ])`

Acts as an alternative to the `ON` clause. With this clause, instead of describing the conditions of the join, you simply provide one or more column names (separated by commas) that appear in both tables. The database then evaluates the join based on those columns (the column names must be identical in both tables). In the following example, the two queries produce identical results:

```
SELECT emp_id
FROM employee
LEFT JOIN sales USING (emp_id, region_id);

SELECT emp_id
FROM employee AS e
LEFT JOIN sales AS s
   ON e.emp_id     = s.emp_id
   AND e.region_id = s.region_id;
```

`WHERE *search_condition*`

Filters unwanted data from the result set of the query, returning only those records that satisfy the search conditions. A poorly written `WHERE` clause can ruin the performance of an otherwise useful SELECT statement, so mastering the nuances of the WHERE clause is of paramount importance. Search conditions are syntactically depicted in the form WHERE [*schema*.[*table_name*.]]*column operator value*.

WHERE clauses usually compare the values contained in a *column* of the table. The values of the column are compared using an *operator* of some type (refer to Chapter 2 for more details). For example, a column might equal (=) a given *value*, be greater than (>) a given *value*, or be BETWEEN a range of *values*.

WHERE clauses may contain many search conditions concatenated together using the AND or OR Boolean operators, and parentheses can be used to impact the order of precedence of the search conditions. WHERE clauses can also contain subqueries (refer to "WHERE Clause" on page 349 for details).

group_by_clause
Refer to "GROUP BY Clause" on page 263 for details.

order_by_clause
Refer to "ORDER BY Clause" on page 294 for details.

Rules at a glance

Each clause of the SELECT statement has a specific use. Thus, it is possible to speak individually of the FROM clause, the WHERE clause, the GROUP BY clause, and so forth. You can get more details and examples of SELECT statements by looking up the entries for each clause of the statement elsewhere in this chapter. Not every query needs every clause, but at a minimum a query needs a *select_item* list.

Because the SELECT clause is so important and offers so many options, we've divided this "Rules at a glance" section into the following detailed subsections:

- Aliases and WHERE clause joins
- The JOIN clause
- The WHERE clause
- The ORDER BY clause

All of these clauses, as well as the GROUP BY clause, are discussed at greater length in their respective sections in this chapter.

Aliases and WHERE clause joins. Column names may need to be prefixed with their database, schema, and table names, particularly when the same column name may appear in more than one table in the query. For example, on an Oracle database, both the *jobs* table and *scott*'s *employee* table may contain *job_id* columns. The following example joins the *employee* and *jobs* tables using the WHERE clause. This is an old-style join syntax:

```
SELECT   scott.employee.emp_id,
         scott.employee.fname,
         scott.employee.lname,
         jobs.job_desc

FROM     scott.employee,
         jobs
WHERE    scott.employee.job_id = jobs.job_id
ORDER BY scott.employee.fname,
         scott.employee.lname
```

You can also use aliases to write such a query more simply and clearly:

```
SELECT   e.emp_id,
         e.fname,
         e.lname,
         j.job_desc
FROM     scott.employee AS e,
         jobs AS j
WHERE    e.job_id = j.job_id
ORDER BY e.fname,
         e.lname
```

These two queries illustrate the following important rules about `WHERE` clause joins:

- Use commas to separate multiple elements in the *`select_item`* list, tables in the `FROM` clause, and items in the *`order_expression`*.
- Use the `AS` clause to define aliases.
- Use aliases consistently throughout the `SELECT` statement once you define them.

In general, you should favor the `JOIN` clause (explained next) over the `WHERE` clause for describing join expressions. This not only keeps your code cleaner, making it easy to differentiate join conditions from search conditions, but also allows you to avoid the counterintuitive behavior that may result from using the `WHERE` clause for outer joins in some implementations.

The JOIN clause. To perform the same query as in the previous example using a SQL standard join, list the first table and the keyword `JOIN`, followed by the name of the table to be joined, the keyword `ON`, and the join condition that would have been used in the old-style query. The next example shows the preceding query using the SQL standard `JOIN` clause:

```
SELECT   e.emp_id, e.fname, e.lname, j.job_desc
FROM     scott.employee AS e
JOIN     jobs AS j ON e.job_id = j.job_id
ORDER BY e.fname, e.lname;
```

Alternatively, you could use the `USING` clause. Instead of describing the conditions of the join, simply provide one or more *`column_name`*s (separated by commas) that appear in both of the joined tables. The database then evaluates the join based on those columns (the column names must be identical in both tables). In the following example, the two queries (one using the ON clause and one using the USING clause) produce identical results:

```
SELECT emp_id
FROM employee LEFT JOIN sales USING (emp_id, region_id);

SELECT emp_id
FROM employee   AS e
LEFT JOIN sales AS s
   ON  e.emp_id    = s.emp_id
   AND e.region_id = s.region_id;
```

Refer to "JOIN Subclause" on page 278 for details on different types of joins.

The WHERE clause. A poorly written WHERE clause can ruin an otherwise beautiful SELECT statement, so it's important that you master the nuances of the WHERE clause (discussed in more detail later in this chapter). Here is an example of a typical query with a multipart WHERE clause:

```
SELECT   a.au_lname,
         a.au_fname,
         t2.title,
         t2.pubdate
FROM     authors a
JOIN     titleauthor t1 ON a.au_id = t1.au_id
JOIN     titles t2 ON t1.title_id = t2.title_id
WHERE    (t2.type = 'business' OR t2.type = 'popular_comp')
  AND    t2.advance > 5500
ORDER BY t2.title
```

In examining this query, note that the parentheses impact the order of processing for the search conditions. You can use parentheses to move search conditions up or down in precedence, just like you would in an algebra equation.

On some platforms, the database's default collation (also known as the *sort order*) impacts how the WHERE clause filters results for a query. For example, SQL Server is (by default) *dictionary-order* and *case-insensitive*, making no differentiation between "Smith," "smith," and "SMITH." Oracle, however, is *dictionary-order* and *case-sensitive*, finding the values "Smith," "smith," and "SMITH" to be unequal.

The WHERE clause offers many more specific capabilities than the preceding example illustrates. The following list references some of the more common capabilities of the WHERE clause:

`NOT`
: Inverts a comparison operation using the syntax `WHERE NOT` *`expression`*. Thus, you might use `WHERE NOT LIKE ...` or `WHERE NOT IN ...` in a query.

Comparison operators
: Compares any set of values, using the operations <, >, <>, >=, <=, and =. For example:

```
WHERE emp_id = '54123'
```

`IS NULL` *or* `IS NOT NULL` *conditions*
: Search for any `NULL` or `NOT NULL` values, respectively, using the syntax `WHERE` *`expression`* `IS [NOT] NULL`.

`AND`
: Merges multiple conditions, returning only those records that meet all conditions. The maximum number of multiple conditions is platform-dependent. For example:

```
WHERE job_id = '12' AND job_status = 'active'
```

`OR`
: Merges alternative conditions, returning records that meet any of the conditions. For example:

```
WHERE job_id = '13' OR job_status = 'active'
```

`LIKE`
: Tells the query to use a pattern-matching string contained within quotation marks. The wildcard symbols supported by each platform are detailed in their individual sections. All platforms support the percent sign (%) for a wildcard symbol. For example, to find any phone number starting with the 415 area code:

```
WHERE phone LIKE '415%'
```

`EXISTS`
: Used only with subqueries, `EXISTS` tests to see whether the subquery data exists. It is typically much faster than a `WHERE IN` subquery. For example, the following query finds all authors who are also employees:

```
SELECT au_lname FROM authors WHERE EXISTS
   (SELECT last_name FROM employees)
```

`BETWEEN`
: Performs a range check to see whether a value is in between two values (inclusive of those two values). For example:

```
WHERE ytd_sales BETWEEN 4000 AND 9000.
```

`IN`

Performs a test to see whether an expression matches any one value out of a list of values. The list may be literal, as in `WHERE state IN ('or', 'il', 'tn', 'ak')`, or it may be derived using a subquery:

```
WHERE state IN (SELECT state_abbr FROM territories)
```

`SOME | ANY`

Functions the same as the `EXISTS` operation, though with slightly different syntax. For example, the following query finds all authors who are also employees:

```
SELECT au_lname FROM authors WHERE
   au_lname = SOME(SELECT last_name FROM employees)
```

`ALL`

Performs a check to see whether all records in the subquery match the evaluation criteria, and returns `TRUE` when the subquery returns zero rows. For example:

```
WHERE city = ALL
   (SELECT city FROM employees WHERE emp_id = 54123)
```

Refer to "WHERE Clause" on page 349 for additional details.

The ORDER BY clause. A result set can be sorted through the `ORDER BY` clause, in accordance with the database's sort order. Each column of the result set may be sorted in either ascending (`ASC`) or descending (`DESC`) order. (Ascending order is the default.) If no `ORDER BY` clause is specified, most implementations return the data either according to the physical order of the data within the table or according to the order of an index utilized by the query. However, when no `ORDER BY` clause is specified, there is no guarantee as to the order of the result set. Following is an example of a `SELECT` statement with an `ORDER BY` clause on SQL Server:

```
SELECT   e.emp_id "Emp ID",
         e.fname "First",
         e.lname "Last",
         j.job_desc "Job Desc"
FROM     employee e,
         jobs j

WHERE    e.job_id = j.job_id
  AND    j.job_desc = 'Acquisitions Manager'
ORDER BY e.fname DESC,
         e.lname ASC
```

The results are:

```
Emp ID    First           Last            Job Desc
--------- --------------- --------------- --------------------
MIR38834F Margaret        Rancé          Acquisitions Manager
MAS70474F Margaret        Smith          Acquisitions Manager
```

```
KJJ92907F Karla          Jablonski     Acquisitions Manager
GHT50241M Gary           Thomas        Acquisitions Manager
```

After the result set is pared down to meet the search conditions, it is sorted by the authors' first names in descending order. Where the authors' first names are equal, the results are sorted in ascending order by last name. Refer to "ORDER BY Clause" on page 294 for more details.

You may write an ORDER BY clause using columns in the table that do not appear in the *select_item* list. For example, you might query all *emp_id*s from the *employee* table, yet ORDER BY the employees' first and last names.

Programming tips and gotchas

Once you've assigned an alias to a table or view in the FROM clause, use it exclusively for all other references to that table or view within the query (in the WHERE clause, for example). Do *not* mix references to the full table name and the alias within a single query. You should avoid mixed references for a couple of reasons. First, it is simply inconsistent and makes code maintenance more difficult. Second, some database platforms return errors on SELECT statements containing mixed references. (Refer to "SUBQUERY Substatement" on page 337 for special instructions on aliasing within a subquery.)

MySQL, PostgreSQL, and SQL Server support certain types of queries that do not need a FROM clause. Use these types of queries with caution, since the SQL standard requires a FROM clause. Queries without a FROM clause must be manually migrated either to the SQL standard form or to a form that also works on the target database. Refer to the entry for each clause to fully investigate the varying degrees of support offered by the different database vendors for the various options of the SELECT command.

MySQL

MySQL's implementation of SELECT includes support for JOIN (with some variations, as detailed in "JOIN Subclause" on page 278), the INTO clause, the LIMIT clause, and the PROCEDURE clause. Its syntax follows:

```
SELECT [DISTINCT | DISTINCTROW | ALL] [HIGH_PRIORITY] [STRAIGHT_JOIN]
   [ {SQL_SMALL_RESULT | SQL_BIG_RESULT} ] [SQL_BUFFER_RESULT]
   [SQL_CALC_FOUND_ROWS] select_item[, ...]
[INTO {OUTFILE 'filename' options | DUMPFILE 'filename' |
   variable[, ...]}]
[FROM table_name[, ...]

join_clause

[WHERE search_condition]
```

```
    group_by_clause

    order_by_clause

    [PROCEDURE procedure_name (param[, ...])]
    [FOR {UPDATE | SHARE} [OF table_name[, ...]] [NOWAIT | SKIP LOCKED] |
       LOCK IN SHARE MODE]
```

where:

`DISTINCT | DISTINCTROW | ALL`
: `DISTINCTROW` is a synonym for `DISTINCT`. `ALL` is assumed if `DISTINCT` or `DISTINCTROW` is not specified.

`HIGH_PRIORITY`
: Gives the query a higher priority than statements that modify data within the table. This should be used only for special, high-speed queries.

`STRAIGHT_JOIN`
: Similar to `JOIN`, except that the left table is always read before the right table. This is a join optimization feature. It should be avoided unless you are getting bad query plans with the standard `JOIN` syntax.

`SQL_SMALL_RESULT | SQL_BIG_RESULT`
: Tells the optimizer to expect a small or large result set, respectively, for a `GROUP BY` or `DISTINCT` clause. MySQL builds a temporary table when a query has a `DISTINCT` or `GROUP BY` clause, and these optional keywords tell MySQL whether to build a fast temporary table in memory (for `SQL_SMALL_RESULT`) or a slower, disk-based temporary table (for `SQL_BIG_RESULT`) to process the worktable.

`SQL_BUFFER_RESULT`
: Forces the result set into a temporary table so that MySQL can free table locks earlier and get the result set to the client faster.

`SQL_CALC_FOUND_ROWS`
: Calculates how many rows are in the result set (regardless of a `LIMIT` clause), which can then be retrieved using `SELECT FOUND_ROWS()`.

`select_item`
: Retrieves the expressions or columns listed. Columns may be listed in the format `[`*`database_name`*`.[`*`table_name`*`.]]`*`column_name`*. If the database and/or table names are left out, MySQL assumes the current database and table.

`INTO {OUTFILE '`*`filename`*`'` *`options`* `| DUMPFILE '`*`filename`*`' |` *`variable`*`[, ... ]}`
: Writes the result set of the query to a file named *`'filename'`* on the host filesystem with the `OUTFILE` option. The named file must not already exist on the filesystem. The `DUMPFILE` option writes a single continuous line of data without column terminations, line terminations, or escape characters. This

option is used mostly for `BLOB` files. Specific rules for using this clause are detailed following this list. The `INTO` *`variable`* clause allows you to list one or more variables (one for each column returned). If using `INTO` *`variable`*, do not also specify a filename.

`FROM ...`
: Indicates the table from which rows will be retrieved. The table may be described as `[`*`database_name`*`.]`*`table_name`*. MySQL will treat the query as a join if more than one table appears in the `FROM` clause.

`PROCEDURE` *`procedure_name`* `(`*`param`*`[, ... ])`
: Names a procedure that processes the data in the result set. The procedure is an external procedure (usually C++), not an internal database stored procedure.

`FOR {UPDATE | SHARE} [OF` *`table_name`*`[, ... ]] [NOWAIT | SKIP LOCKED] | LOCK IN SHARE MODE`
: Issues a write lock on the rows returned by the query (`UPDATE`) for its exclusive use (provided the table is of InnoDB or BDB type), or issues read locks on the rows returned by the query (`SHARE` and `LOCK IN SHARE MODE`), such that other users may see the rows but may not modify them. `NOWAIT` and `SKIP LOCKED` cause a `FOR UPDATE` or `FOR SHARE` query to execute immediately. `NOWAIT` returns an error if a row lock cannot be obtained, while `SKIP LOCKED` excludes rows from the result set that are locked by another transaction.

Keep a couple of rules in mind when using the `INTO` clause. First, the output file cannot already exist, since overwrite functionality is not supported. Second, any file created by the query will be readable by everyone that can connect to the server. (When using `SELECT ... INTO OUTFILE`, you can then turn around and use the MySQL command `LOAD DATA INFILE` to quickly load the data.)

You can use the following options to better control the content of the output file when using `SELECT ... INTO OUTFILE`:

- `ESCAPED BY`
- `FIELDS TERMINATED BY`
- `LINES TERMINATED BY`
- `OPTIONALLY ENCLOSED BY`

The following example illustrates the use of these optional commands via a MySQL query that returns a result set in a comma-delimited output file:

```
SELECT job_id, emp_id, lname+fname
INTO OUTFILE "/tmp/employees.text"
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"'
LINES TERMINATED BY "\;n"
FROM employee;
```

MySQL also allows SELECT statements without a FROM clause when performing simple arithmetic. For example, the following queries are valid in MySQL:

```
SELECT 2 + 2;
SELECT 565 - 200;
SELECT (365 * 2) * 52;
```

For interoperability with Oracle, MySQL also supports selection from the pseudo-table called *dual*:

```
SELECT 565 - 200 FROM DUAL;
```

MySQL offers an interesting alternative to the SQL standard for querying tables—the HANDLER statement. The HANDLER statement works a lot like SELECT, except that HANDLER provides very rapid data reads that circumvent the SQL query engine in MySQL. However, since the HANDLER statement is not a SQL statement, we'll refer you to the MySQL documentation for more information.

Oracle

Oracle allows a very large number of extensions to the SQL standard SELECT statement. For example, since both nested tables and partitioned tables are allowed in Oracle (see "CREATE/ALTER TABLE Statement" on page 140), the SELECT statement allows queries to those types of structures. Oracle's SELECT syntax is as follows:

```
SELECT ( {[ALL | DISTINCT]} | [UNIQUE] ) [optimizer_hints]
select_item [AS alias][, ...]
[INTO {variable[, ...] | record}]
FROM {[ONLY] {[[schema.][table_name | view_name |
   materialized_view_name]} [@database_link]
      [AS [OF] {SCN | TIMESTAMP} expression] |
   subquery [WITH {READ ONLY | CHECK OPTION [CONSTRAINT
      constraint_name]}] |
   [[VERSIONS BETWEEN {SCN | TIMESTAMP} {exp | MINVALUE} AND
      {exp | MAXVALUE}] AS OF {SCN | TIMESTAMP} expression] |
   TABLE (nested_table_column) [(+)]
      {[PARTITION (partition_name) |
        SUBPARTITION (subpartition_name)]}
   [SAMPLE [BLOCK] [sample_percentage] [SEED (seed_value)]]}
   [AS alias][, ...]

join_clause
[WHERE search_condition [{AND | OR} search_condition[, ...]]
   [[START WITH value] CONNECT BY [PRIOR] condition]]
group_by_clause

[MODEL model_clause]
order_by_clause

[FOR UPDATE [OF [schema.][table.]column][, ...]
   {[NOWAIT | WAIT (int)]}]
```

Unless otherwise noted, the clauses shown here follow the SQL standard. Similarly, elements of the clauses are identical to those in the SQL standard unless otherwise noted. For example, Oracle's `GROUP BY` clause is nearly identical to the SQL standard, including its component elements, such as `ROLLUP`, `CUBE`, `GROUPING SETS`, concatenated `GROUPING SETS`, and the `HAVING` clause.

The parameters are:

`{ALL | DISTINCT} | UNIQUE`
: `UNIQUE` is a synonym for `DISTINCT`. In Oracle, `DISTINCT` and `UNIQUE` cannot be used on `LOB` columns.

`optimizer_hints`
: Overrides the default behavior of the query optimizer with user-specified behaviors. For example, hints can force Oracle to use an index that it might not otherwise use or to avoid an index that it might otherwise use. Refer to the vendor documentation for more information about optimizer hints.

`select_item`
: Retrieves the expressions or columns listed. Columns can be from a named query, table, view, or materialized view and can be listed in the format `[`*`schema`*`.[`*`table_name`*`.]]`*`column_name`*. If you omit the schema, Oracle assumes the context of the current schema. Oracle also allows for *named queries* that may be referenced much like nested table subqueries (discussed in "SUBQUERY Substatement" on page 337); it refers to using named queries as *subquery factoring*. In addition to named queries, Oracle supports subqueries and the asterisk (*), shorthand for all columns, in the *`select_item`* list.

`INTO {`*`variable`*`[, ... ] | `*`record`*`}`
: Retrieves the result set values into PL/SQL variables or into a PL/SQL record.

`FROM [ONLY]`
: Identifies the table, view, materialized view, partition, or subquery from which the result set is retrieved. The `ONLY` keyword is optional and applies only to views belonging to a hierarchy. Use `ONLY` when you want to retrieve records from a named view only, and not from any of its subviews.

`AS [OF] {SCN | TIMESTAMP}` *`expression`*
: Implements SQL-driven flashback, whereby system change numbers (SCNs) or timestamps are applied to each object in the *`select_item`* list. Records retrieved by the query are only those that existed at the specified SCN or time. (This feature can also be implemented at the session level using the `DBMS_FLASHBACK` built-in package.) `SCN` *`expression`* must equal a number, while `TIMESTAMP` *`expression`* must equal a timestamp value. Flashback queries cannot be used on linked servers.

`*subquery*` `[WITH {READ ONLY | CHECK OPTION [CONSTRAINT` `*constraint_name*` `]}]`
: Mentioned separately because Oracle allows you extra ways to control a subquery. `WITH READ ONLY` indicates that the target of the subquery cannot be updated. `WITH CHECK OPTION` indicates that any update to the target of the subquery must produce rows that would be included in the subquery. `WITH CONSTRAINT` creates a `CHECK OPTION` constraint of `*constraint_name*` on the table. Note that `WITH CHECK OPTION` and `WITH CONSTRAINT` are usually used in `INSERT ... SELECT` statements.

`[VERSIONS BETWEEN {SCN | TIMESTAMP} {`*`exp`*` | MINVALUE} AND {`*`exp`*` | MAXVALUE}] AS OF {SCN | TIMESTAMP}` *`expression`*
: Specifies a special kind of query to retrieve the history of changes made to data from a table, view, or materialized view. The `VERSIONS_XID` pseudocolumn shows the identifier corresponding to the transaction that made the change. This kind of query is referred to as a *flashback query*; it requires that you specify an `SCN` or `TIMESTAMP` value for each object in the *`select_item`* list. (You can implement SQL-driven session-level flashback using the Oracle `DBMS_FLASHBACK` package.)

The optional subclause `VERSIONS BETWEEN` is used to retrieve multiple versions of the data specified, either using an upper and lower boundary of an `SCN` (a number) or `TIMESTAMP` (a timestamp value), or using the `MINVALUE` and `MAXVALUE` keywords. Without this clause, only one past version of the data is returned. (Oracle also provides several version query pseudocolumns for additional versioning information.)

The `AS OF` clause, discussed earlier in this list, determines the SCN or moment in time from which the database issues the query when used with the `VERSIONS` clause.

You cannot use flashback queries with the `VERSIONS` clause against temporary tables, external tables, tables in a cluster, or views.

`TABLE`
: Required when querying a hierarchically declared nested table.

`PARTITION | SUBPARTITION`
: Restricts a query to the specified partition or subpartition of the table. Rows are retrieved only from the named partition or subpartition, not from the entire table, reducing I/O.

`SAMPLE [BLOCK] [`*`sampling_percentage`*`] [SEED (`*`seed_value`*`)]`
: Tells Oracle to select records from a random sampling of rows within the result set, as a percentage of rows or blocks, rather than from the entire table. `BLOCK` tells Oracle to use block sampling rather than row sampling. The *`sampling_percentage`*, telling Oracle the total block or row percentage to be included in the sample, may be anywhere between .000001 and 99. The optional `SEED` clause is used to provide limited repeatability. If you specify a seed value, Oracle will attempt to return the same sample from one execution of the query

to the next. The seed value can be between 0 and 4,294,967,295. When `SEED` is omitted, the resulting sample will change from one execution of the query to the next. Sampling may be used only on single-table queries.

`join_clause`
: Merges the result sets of two or more tables in a single query. See the description following this list for more information.

`WHERE ... [[START WITH` *`value`*`] CONNECT BY [PRIOR]` *`condition`*`]`
: Filters records returned in the result set. Oracle allows the use of hierarchical information within tables, whose filtering can be controlled with the `START WITH` clause. `START WITH` identifies the rows that will serve as the parent rows in the result set. `CONNECT BY` identifies the relationship *`condition`* between the parent rows and their child rows. The `PRIOR` keyword is used to identify the parent rows instead of the child rows.

  Hierarchical queries use the `LEVEL` pseudocolumn to identify (1) the root node, (2) the child nodes, (3) the grandchild nodes, and so forth. Other pseudocolumns available in hierarchical queries are `CONNECT_BY_ISCYCLE` and `CONNECT_BY_ISLEAF`. Hierarchical queries are mutually exclusive of the `ORDER BY` and `GROUP BY` clauses. Do not use those clauses in a query containing `START WITH` or `CONNECT BY`. You can order records from siblings of the same parent table by using the `ORDER SIBLINGS BY` clause.

`MODEL` *`model_clause`*
: Allows you to create a multidimensional array from query results and then apply formulas (called rules) to this array to calculate new values. See "The MODEL clause" on page 325 for details.

`FOR UPDATE [OF [`*`schema.`*`][`*`table.`*`]`*`column`*`[, ... ] {[NOWAIT | WAIT (`*`int`*`)]}`
: Locks the rows of the result set so that other users cannot lock or update them until you're finished with your transaction. `FOR UPDATE` cannot be used in a subquery, in queries using `DISTINCT` or `GROUP BY`, or in queries with set operators or aggregate functions. Child rows in a hierarchical table are not locked when this clause is issued against the parent rows. The `OF` keyword is used to lock only the selected table or view. Otherwise, Oracle locks all the tables or views referenced in the `FROM` clause. When using `OF`, the columns are not significant, though real column names (not aliases) must be used. The `NOWAIT` and `WAIT` keywords tell Oracle either to return control immediately if a lock already exists or to wait *`int`* seconds before returning control to you, respectively. If neither `NOWAIT` nor `WAIT` is specified, Oracle waits until the rows become available.

Unlike some other database platforms, Oracle does not allow a `SELECT` statement without a `FROM` clause. The following query, for example, is invalid:

```
SELECT 2 + 2;
```

As a workaround, Oracle has provided a special-purpose table called *DUAL*. Any time you want to write a query that does not retrieve data from a user-created table, such as to perform a calculation, use FROM DUAL. Both of the following queries are valid:

```
SELECT 2 + 2
FROM DUAL;
SELECT (((52-4) * 5) * 8)
FROM DUAL;
```

Oracle's implementation of SELECT is quite straightforward if you want to retrieve data from a table. As mentioned previously, Oracle allows the use of named queries. A named query is, in a sense, an alias to an entire query that can save you time when you're writing a complex multi-subquery SELECT statement. For example:

```
WITH pub_costs AS
   (SELECT pub_id, SUM(job_lvl) dept_total
    FROM employees e
    GROUP BY pub_id),
avg_costs AS
   (SELECT SUM(dept_total)/COUNT(*) avg
    FROM employee)
SELECT * FROM pub_costs
WHERE dept_total > (SELECT avg FROM avg_cost)
ORDER BY department_name;
```

Here we create two named subqueries—*pub_costs* and *avg_costs*—which are later referenced in the main query. The named queries are effectively the same as subqueries; however, subqueries must be written out in their entirety each time they're used, while named queries need not be.

Oracle allows you to select rows from a single partition of a partitioned table using the PARTITION clause, or to retrieve only a statistical sampling of the rows (as a percentage of rows or blocks) of a result set using SAMPLE. For example:

```
SELECT *
FROM sales PARTITION (sales_2021_q3) sales
WHERE sales.qty > 1000;
SELECT *
FROM sales SAMPLE (12);
```

Flashback queries are a feature of Oracle that enable retrieval of point-in-time result sets. For example, you could find out what everyone's salary was yesterday before a big change was applied to the database:

```
SELECT job_lvl, lname, fname
FROM employee
   AS OF TIMESTAMP (SYSTIMESTAMP - INTERVAL '1' DAY);
```

Another interesting Oracle extension of the standard query format is the *hierarchical* query. Hierarchical queries return the results of queries against hierarchically designed tables in the order you define. For example, the following query returns the names of the employees and their positions in the hierarchy (represented by the position in the *org_char* column), employee IDs, manager IDs, and job IDs:

```
-- Query
SELECT LPAD(' ',2*(LEVEL-1)) || lname AS org_chart,
   emp_id, mgr_id, job_id
FROM employee
START WITH job_id = 'Chief Executive Officer'
CONNECT BY PRIOR emp_id = mgr_id;

-- Results
ORG_CHART      EMPLOYEE_ID MANAGER_ID JOB_ID
-------------- ----------- ---------- -----------------------
Cramer             101        100 Chief Executive Officer
Devon              108        101 Business Operations Mgr
Thomas             109        108 Acquisitions Manager
Koskitalo          110        108 Productions Manager
Tonini             111        108 Operations Manager
Whalen             200        101 Admin Assistant
Chang              203        101 Chief Financial Officer
Gietz              206        203 Comptroller
Buchanan           102        101 VP Sales
Callahan           103        102 Marketing Manager
```

In the previous query, the `CONNECT BY` clause defines the hierarchical relationship of the *emp_id* value as the parent row equal to the *mgr_id* value in the child row, while the `START WITH` clause specifies where in the hierarchy the result set should begin.

Oracle supports the following types of `JOIN` syntax (refer to "JOIN Subclause" on page 278 for more details):

```
FROM table1 {
   CROSS JOIN table2 |
   INNER JOIN table2 [ {ON join_condition |
      USING (column_list)} ] |
   NATURAL [LEFT [OUTER]] JOIN table2 |
   LEFT [OUTER] JOIN table2 [ {ON join_condition
    | USING (column_list)} ] |
   RIGHT [OUTER] JOIN table2 [ {ON join_condition
    | USING (column_list)} ]|
   NATURAL [RIGHT [OUTER]] JOIN table2
   FULL [OUTER] JOIN table2 }
```

`[CROSS] JOIN`
: Retrieves all records of both *`table1`* and *`table2`*. This is syntactically the same as `FROM` *`table1, table2`* with no join conditions in the `WHERE` clause.

`INNER JOIN`
: Retrieves those records of both *`table1`* and *`table2`* where there are matching values in both tables according to the join condition. Note that the syntax `FROM` *`table1, table2`* with join conditions in the `WHERE` clause is semantically equivalent to an inner join.

`NATURAL`
: Shortcuts the need to declare a join condition by assuming a `USING` clause containing all columns that are in common between the two joined tables. (Be careful if columns have the same names but not the same data types or the same sort of values!) `LOB` columns cannot be referenced in a natural join. Referencing a `LOB` or collection column in a `NATURAL JOIN` clause will return an error.

`LEFT [OUTER] JOIN`
: Retrieves all records in the leftmost table (i.e., *`table1`*) and matching records in the rightmost table (i.e., *`table2`*). If there isn't a matching record in *`table2`*, NULL values are substituted for that table's columns. You can use this type of join to retrieve all the records in a table, even when there are no counterparts in the joined table. For example:

```
SELECT j.job_id, e.lname
FROM jobs j
LEFT OUTER JOIN employee e ON j.job_id = e.job_id
ORDER BY d.job_id
```

`RIGHT [OUTER] JOIN`
: Retrieves all records in the rightmost table, regardless of whether there is a matching record in the leftmost table. A right join is the same as a left join, except that the optional table is on the left.

`FULL [OUTER] JOIN`
: Specifies that all rows from both tables be returned, regardless of whether a row from one table matches a row in the other table. Any columns that have no value in the corresponding joined table are assigned a NULL value.

`ON` *`join_condition`*
: Declares the condition(s) that join the result sets of two tables together. This takes the form of declaring the columns in *`table1`* and *`table2`* that must match the join condition. When multiple columns must be compared, use the `AND` clause.

`USING (`*`column_list`*`)`
: Acts as an alternative to the `ON` clause. Instead of describing the conditions of the join, simply provide a column name (or columns separated by commas) that appears in both tables. The column name(s) must be identical in both tables and cannot be prefixed with a table name or alias. `USING` cannot be used on `LOB` columns of any type. The following two queries produce identical results. One is written with a `USING` clause and the other specifies join conditions using SQL standard syntax:

```
SELECT column1
FROM foo
LEFT JOIN poo USING (column1, column2);

SELECT column1
```

```
    FROM foo
    LEFT JOIN poo ON foo.column1 = poo.column1
    AND foo.column2 = poo.column2;
```

Partitioned outer joins. Oracle supports the `PARTITION BY` subclause of the SQL standard's `JOIN` clause, which defines a special kind of query called a partitioned outer join that extends the conventional outer join syntax by applying a right or left outer join to a partition of one or more rows. This is especially useful for querying sparse data along a particular dimension of data, thereby returning rows that otherwise would be omitted from the result set. The `PARTITION BY` clause can be used on either side of an outer join, resulting in a `UNION` of the outer joins of each of the partitions in the partitioned result set and the table on the other side of the join. (When this clause is omitted, Oracle treats the entire result set as a single partition.) `PARTITION BY` is not allowed with a `FULL OUTER JOIN`.

For example, our *product* table keeps track of all products we produce, while the *manufacturing* table shows when we produce them. Since we're not continuously making every product at all times, the joined data between the two tables may be sparse at times. Thus, the following query:

```
SELECT manufacturing.time_id AS time, product_name AS name,
     quantity AS qty
FROM product
PARTITION BY (product_name)
RIGHT OUTER JOIN times ON (manufacturing.time_id =
     product.time_id)
WHERE manufacturing.time_id
   BETWEEN TO_DATE('01/10/05', 'DD/MM/YY')
       AND TO_DATE('06/10/05', 'DD/MM/YY')
ORDER BY 2, 1;
```

returns this result:

```
time      name            qty

--------- ---------      ---------

01-OCT-05 flux capacitor  10
02-OCT-05 flux capacitor

03-OCT-05 flux capacitor
04-OCT-05 flux capacitor
05-OCT-05 flux capacitor
06-OCT-05 flux capacitor  10
06-OCT-05 flux capacitor  8
01-OCT-05 transmogrifier 10
01-OCT-05 transmogrifier 15
02-OCT-05 transmogrifier
03-OCT-05 transmogrifier
04-OCT-05 transmogrifier 10
04-OCT-05 transmogrifier 11
```

```
05-OCT-05 transmogrifier
06-OCT-05 transmogrifier
```

Flashback queries. Oracle also supports flashback queries, which keep track of previous values of the results returned for a `SELECT` statement. In the following set of example code, we'll issue a regular query on a table, change the values in the table with an `UPDATE` statement, and then query the flashback version of the data. First, the regular query:

```
SELECT salary FROM employees
WHERE last_name = 'McCreary';
```

The results are:

```
SALARY
----------
3800
```

Now, we'll change the value in the *employees* table and query the table to confirm the current value:

```
UPDATE employees SET salary = 4000
WHERE last_name = 'McCreary ';
SELECT salary FROM employees
WHERE last_name = 'McCreary ';
```

The results are:

```
SALARY
----------
4000
```

Finally, we'll perform a flashback query to see what the *salary* value was in the past:

```
SELECT salary FROM employees
AS OF TIMESTAMP (SYSTIMESTAMP - INTERVAL '1' DAY)
WHERE last_name = 'McCreary';
```

The results are:

```
SALARY
----------
3800
```

If we wanted to be more elaborate, we could find out all of the values of *salary* for a given time period, say, the last two days:

```
SELECT salary FROM employees
VERSIONS BETWEEN TIMESTAMP
   SYSTIMESTAMP - INTERVAL '1' MINUTE AND
   SYSTIMESTAMP - INTERVAL '2' DAY
WHERE last_name = 'McCreary';
```

The results are:

```
SALARY
----------
4000
3800
```

The MODEL clause. Oracle supports a MODEL clause that enables spreadsheet-like result sets to be returned from a SELECT statement. The MODEL clause is designed to alleviate the need for developers to extract data from the database and put it into a spreadsheet, like Microsoft Excel, for further manipulation. It creates a multidimensional array in which cells can be referenced by dimension values. For instance, you might dimension an array on product and time, specifying column values that you wish to access via combinations of those two dimensions. You can then write rules that are similar in concept to spreadsheet formulas, that are executed in order to change values in your model, or that create new values, and perhaps even new rows, in your model.

Syntactically, the MODEL clause appears after the GROUP BY clause and before the ORDER BY clause. The earlier syntax diagram for Oracle's SELECT statement shows the position of the clause, and the syntax details are presented here:

```
MODEL
   [{IGNORE | KEEP} NAV]
      [UNIQUE {DIMENSION | SINGLE REFERENCE}]
   [ RETURN {UPDATED | ALL} ROWS ]
   [REFERENCE reference_model_name ON (subquery)
      [PARTITION BY (column [AS alias][, ...])]
         DIMENSION BY (column [AS alias][, ...])
         MEASURES (column [AS alias][, ...])
      [{IGNORE | KEEP} NAV]
      [UNIQUE {DIMENSION | SINGLE REFERENCE}]]
[MAIN main_model_name]
   [PARTITION BY (column [AS alias][, ...])]
      DIMENSION BY (column [AS alias][, ...])
      MEASURES (column [AS alias][, ...])
   [{IGNORE | KEEP} NAV]
      [UNIQUE {DIMENSION | SINGLE REFERENCE}]]
   model_rules_clause
[RULES [UPSERT [ALL] | UPDATE]
      [{AUTOMATIC | SEQUENTIAL} ORDER]]
   [ITERATE (int) [UNTIL (ending_condition)]]
   ( [ {UPSERT [ALL] | UPDATE } ]   measure [...]
   [FOR { dimension | ( dimension[, ...] ) }
   { [IN ({subquery | literal[, ...]})] |
      [LIKE pattern] FROM start_literal TO end_literal
         {INCREMENT | DECREMENT} diff_literal }[, ...]
   [ORDER [SIBLINGS] BY (order_column [ASC | DESC]
      [NULLS FIRST | NULLS LAST][, ...])]]
   = expr[, ...] )
```

The parameters of the `MODEL` clause are as follows:

`{IGNORE | KEEP} NAV`
: Specifies whether NULL or absent values (`NAV`) are retained as NULLs (`KEEP`), or whether they are replaced with suitable defaults (`IGNORE`): zero for numeric types, 1-Jan-2000 for date types, an empty string for character types, and NULL for anything else.

`UNIQUE {DIMENSION | SINGLE REFERENCE}`
: Specifies the scope within which the database ensures that a given cell reference points to a unique data value. Use `DIMENSION` to require that each *possible* cell reference, whether on the left or right side of a rule, represents a single value. Use `SINGLE REFERENCE` to perform that check only for those cell references that appear on the righthand side of a rule.

`RETURN {UPDATED | ALL} ROWS`
: Specifies whether all rows are returned from model processing, or whether only updated rows are returned.

`*reference_model_name* ON (*subquery*)`
: Specifies the name and rowsource for a reference model. This is a model on which you cannot perform calculations, but which contains values that you can reference from within your main query.

`PARTITION BY (*column*[, ... ])`
: Splits a model into independent partitions based on the columns given. You cannot partition reference models.

`DIMENSION BY (*column*[, ... ])`
: Specifies the dimensions for a model. Values from these columns represent the set of index values that are used to identify cells in the multidimensional addressing space.

`MEASURES (*column*[, ... ])`
: Specifies the values associated with each unique combination of dimensions (e.g., with each cell of the model).

`alias`
: Specifies an alias for a column.

`MAIN *model_name*`
: Begins the definition of the main model, and also gives that model a name. The main model represents the model on which you perform work. Rows from your containing `SELECT` feed into this model, rules are applied, and the resulting rows are returned.

`RULES [UPSERT [ALL] | UPDATE]`
: Specifies whether rules may both create new cells and update existing cells (`UPSERT`), or whether they must only update existing cells (`UPDATE`). If you want

your model to be able to create new rows in your result set, specify `UPSERT`. The default is `UPSERT`. You can also control this behavior on a rule-by-rule basis; see *`rule`* in the syntax.

`{AUTOMATIC | SEQUENTIAL} ORDER`
: Specifies whether the optimizer determines the order in which rules are evaluated (`AUTOMATIC`), or whether rules are evaluated in the order in which you list them (`SEQUENTIAL`). The default is `SEQUENTIAL`.

`ITERATE (`*`int`*`)`
: Requests that entire set of rules be evaluated repeatedly, *`int`* times. The default is to evaluate the set of rules just once.

`UNTIL(`*`ending_condition`*`)`
: Specifies a condition that, when met, causes iteration to end. You must still specify an *`int`*, which serves as a safeguard against infinite loops.

`measure``[ ... ]`
: A reference to one of the measures listed in the `MEASURES` clause. When you reference a measure, the square brackets are part of the syntax. You must specify all dimensions, either via a subquery or by listing them, and the specific value of the measure associated with those dimensions will be returned, or referenced.

`FOR ...`
: A `FOR` loop iterating over one or many dimensions. The multi-iterating `FOR` loop is much like a subquery where each row of the result set represents a specific combination of dimensions.

`{` *`dimension`* `| (` *`dimension`*`[, ... ]) }`
: A list of values, whether from columns or expressions, that collectively identify a unique cell in the model.

`IN ({`*`subquery`* `|` *`literal`*`[, ... ]})`
: The source of values for a `FOR` loop may be a subquery, or it may be a specific list of literal values.

`LIKE` *`pattern`*
: Allows you to insert dimension values into a pattern. Use a percent-sign to mark the location at which you want dimension values to be inserted. For example, use `FOR x LIKE 'A%B' FROM 1 TO 3 INCREMENT 1` to generate values such as `'A1B', 'A2B', 'A3B'`.

`FROM` *`start_literal`* `TO` *`end_literal`* `{INCREMENT | DECREMENT}` *`diff_literal`*
: Defines the starting and ending `FOR` loop values, and also the difference between each subsequent value as the loop iterates from start to end.

`ORDER [SIBLINGS] BY (`*`order_column`*` [ASC | DESC] [NULLS FIRST | NULLS LAST][, ... ])`
: Imposes an order of evaluation with respect to the cells referenced from the left side of a rule. Use this clause if you want a rule to be applied to cells in order. Otherwise, you have no guarantee as to the order in which the rule is applied to the cells that it affects. You can order records from siblings of the same parent table by using the `ORDER SIBLINGS BY` clause.

Following is a list of functions that have been designed specifically for use in the `MODEL` clause:

`CV() or CV(`*`dimension_column`*`)`
: Returns the current value of a dimension column. May be used only on the righthand side of an expression in a rule. When the `CV()` form is used, the dimension column is determined implicitly based on the function call's position in a list of dimension values.

`PRESENTNNV(`*`measure`*`[`*`dimension`*`[, ... ], `*`not_null, was_null`*`)`
: Returns either *`not_null`* or *`was_null`*, depending on whether the specified measure was NULL when model processing began. This function may be used only from the righthand side of a rule expression.

`PRESENTV(`*`measure`*`[`*`dimension`*`[, ... ], `*`did_exist, didnt_exist`*`)`
: Returns either *`did_exist`* or *`didnt_exist`*, depending on whether the specified measure existed when model processing began. This function may be used only from the righthand side of a rule expression. Be aware that whether a measure existed is a completely separate question from whether that measure was NULL.

`ITERATION_NUMBER`
: Returns 0 on the first iteration through the rules, 1 on the second iteration, and so forth. This is useful when you want to base rule calculations on the number of iterations.

The following example demonstrates that the `MODEL` clause gives a normal `SELECT` statement the ability to construct a multidimensional array as a result set and calculate inter-row and inter-array values interdependently. The newly calculated values are returned as part of the `SELECT` statement's result set:

```
SELECT SUBSTR(region,1,20) country, SUBSTR(product,1,15)
   product, year, sales
FROM sales_view
WHERE region IN ('USA','UK')
MODEL RETURN UPDATED ROWS
   PARTITION BY (region)
   DIMENSION BY (product, year)
   MEASURES (sale sales)
   RULES (
      sales['Bounce',2006] = sales['Bounce',2005]
         + sales['Bounce',2004],
      sales['Y Box', 2006] = sales['Y Box', 2005],
      sales['2_Products',2006] = sales['Bounce',2006]
         + sales['Y Box',2006] )
ORDER BY region, product, year;
```

In this example, a query against the *sales_view* materialized view returns the sum of sales over the course of a few years for the regions 'USA' and 'UK'. The MODEL clause then falls between the WHERE clause and the ORDER BY clause. Since *sales_view* currently holds data for the years 2004 and 2005, we provide it with rules to calculate figures for the year 2006.

The subclause RETURN UPDATED ROWS limits the result set to the rows that were created or updated by the query. Next, the example defines the logical divisions of the data using data elements from the materialized view and using the PARTITION BY, DIMENSION BY, and MEASURES subclauses. The RULES subclause then references individual measures of the model by referring to combinations of different dimension values, much like a spreadsheet macro references worksheet cells with specific lookups and references to ranges of values.

Oracle (and SQL Server, using a somewhat different technique) supports a non-SQL standard query type known as a *pivot* query. Although you should refer to the vendor documentation for exactly how to write a pivot (or unpivot) query, an example here will help you take advantage of this useful technique. A pivot query turns the result set on its side, enabling you to extract more value from the data. In Oracle, you must first create your pivot table. By using a pivot table, you can then turn the result "on its side" so that the *order_type* column becomes the column headings:

```
CREATE TABLE pivot_table AS
SELECT * FROM (SELECT year, order_type, amt FROM sales)
PIVOT SUM(amt) FOR order_type IN ('retail', 'web');

SELECT * FROM pivot_table ORDER BY YEAR;
```

The results are:

```
YEAR     RETAIL    WEB
---- ----------- ------
2004     7014.54
2005     9745.12
2006    16717.88 10056.6
2007    28833.34 39334.9
2008    66165.77 127109.4
```

PostgreSQL

PostgreSQL supports a straightforward implementation of the SELECT statement. It supports JOIN and subquery applications. PostgreSQL also allows the creation of new temporary or permanent tables using the SELECT ... INTO syntax or the CREATE TABLE AS SELECT construct. Its SELECT syntax is as follows:

```
SELECT [ALL | DISTINCT [ON (select_item[, ...])]]
[AS alias [(alias_list)]][, ...]
[INTO [LOGGED | UNLOGGED] [[TEMP]ORARY] [TABLE] new_table]
[FROM [ONLY] table1[.*] [AS alias][, ...]]
[[join_type] JOIN table2 {[ON join_condition] |
   [USING (column_list)]}]
[WHERE search_condition]
[group_by_clause]
[order_by_clause]
[for_update_clause]

for_update_clause ::= [FOR {UPDATE | NO KEY UPDATE | SHARE | KEY SHARE}
   [OF table_name[, ...]] [NOWAIT | SKIP LOCKED] [...]]
```

where:

`ALL | DISTINCT [ON (`*`select_item`*`[, ... ]]`
: Supports the `ALL` and `DISTINCT` keywords of the SQL standard, where `ALL` (the default) returns all rows (including duplicates) and `DISTINCT` eliminates duplicate rows. In addition, `DISTINCT ON` eliminates duplicates on only the specified *`select_item`*s, not on all of the *`select_item`*s in the query (example follows).

`select_item`
: Includes the standard elements of a *`select_item`* list supported by the SQL standard. In addition to the asterisk (`*`) shorthand to retrieve all rows, you can use *`table_name`*`.*` to retrieve all rows from an individual table.

`AS` *`alias`* `[(`*`alias_list`*`)]`
: Creates an alias or a list of aliases for one or more columns (or tables in the `FROM` clause). `AS` is required for *`select_item`* aliases, but not for `FROM` table aliases. (Some other database platforms treat the `AS` as an option when declaring an alias.)

`INTO [UNLOGGED | LOGGED] [[TEMP]ORARY] [TABLE]` *`new_table`*
: Creates a new table from the result set of the query. Both `TEMP` and `TEMPORARY` are acceptable usages to create a temporary table that is automatically dropped at the end of the session. Otherwise, the command creates a permanent table. Permanent tables created with this statement must have new, unique names, but temporary tables may have the same name as an existing table. If you create a temporary table with the same name as an existing permanent table, the temporary table is used to resolve all operations against that table name while in the same session as the one that created it. Other sessions will continue to see the existing permanent table. The `UNLOGGED` table creates a table where only the creation of the table structure is written to the transaction logs. Creating unlogged tables is generally faster than logged ones and could be as much as 5 times faster. However, because `UNLOGGED` table data writing is not logged, data inserted can not be replicated. They are also truncated during database restarts or crashes. That said, you should only use unlogged tables for data you do

not need to read on replicas and data that can be easier recreated. When the logging option is not specified, a LOGGED table is created.

FROM [ONLY]*table1*[, ...]

Specifies one or more source tables where the data resides. (Be sure to specify a join condition or a theta WHERE clause so that you don't get a Cartesian product of all records in all tables.) PostgreSQL allows inheritance in child tables of declared parent tables. The ONLY keyword is not supported for partitioned tables because the parent never has data. Use the ONLY keyword to suppress rows from the child tables of your source table. (You can turn off this default inheritance globally with the command SET SQL_Inheritance TO OFF.) PostgreSQL also supports nested table subqueries (see the section on SUBQUERY later in this chapter). The FROM clause is not needed when used for computation:

```
SELECT 8 * 40;
```

PostgreSQL will also include an implicit FROM on SELECT statements that include schema-identified columns. For example, the following query is acceptable (though not recommended):

```
SELECT sales.stor_id WHERE sales.stor_id = '6380';
```

for_update_clause

If FOR UPDATE, FOR NO KEY UPDATE, FOR SHARE, or FOR KEY SHARE is specified, the SELECT statement locks the selected rows against concurrent updates. SKIP LOCKS allows records already locked to not be updated. This is suitable if you are updating records in batches and can always revisit records that haven't been updated in a secondary batch.

PostgreSQL supports a handy variation of the DISTINCT clause, DISTINCT ON (*select_item*[, ...]). This variation allows you to pick and choose the exact columns that are considered for elimination of duplicates. PostgreSQL chooses the result set in a manner much like it does for ORDER BY. You should include an ORDER BY clause so that there's no unpredictability as to which record is returned. For example, this query retrieves the most recent sales report for each store based on the most recent order date:

```
SELECT DISTINCT ON (stor_id), ord_date, qty
FROM sales
ORDER BY stor_id, ord_date DESC;
```

However, there would be no way to predict what single record would have been returned without the ORDER BY clause.

PostgreSQL also allows retrieving a whole row as a column, as follows:

```
SELECT DISTINCT ON (stor_id) stor_id, s AS sale_row
FROM sales AS s
ORDER BY stor_id, ord_date DESC;
```

This query retrieves the most recent sales report for each store based on the most recent order date, but instead of returning individual columns, it returns the whole row as a column value. This is done simply by specifying the name of the table or table alias. If a table alias is specified, then the table name cannot be used; you must use the alias. The output of the preceding query looks like this:

```
6380  (6380,6871,"1994-09-14 00:00:00-04",5,"Net 60",BU1032)
7066  (7066,QA7442.3,"1994-09-13 00:00:00-04",75,"ON invoice",PS2091)
7067  (7067,D4482,"1994-09-14 00:00:00-04",10,"Net 60",PS2091)
7131  (7131,N914008,"1994-09-14 00:00:00-04",20,"Net 30",PS2091)
7896  (7896,TQ456,"1993-12-12 00:00:00-05",10,"Net 60",MC2222)
8042  (8042,423LL922,"1994-09-14 00:00:00-04",15,"ON invoice",MC3021)
```

This feature is particularly useful for outputting data to applications by combining it with a function such as *jsonb_agg* or *json_agg*, as follows, and using `ORDER BY` aggregation syntax (a feature supported for all PostgreSQL aggregate functions, including user-defined ones):

```
SELECT json_agg(s ORDER BY stor_id, ord_date) AS sale_rows
FROM sales AS s;
```

Refer to "JOIN Subclause" on page 278 for information on the supported join types.

SQL Server

SQL Server supports most of the basic elements of the SQL standard `SELECT` statement, including all of the various join types. It also offers several variations on the `SELECT` statement, including optimizer hints, the `INTO` clause, the `TOP` clause, `GROUP BY` variations, `COMPUTE`, and `WITH OPTIONS`. The SQL Server `SELECT` syntax is:

```
SELECT {[ALL | DISTINCT] | [TOP number [PERCENT] [WITH TIES]]}
   select_item [AS alias]
[INTO new_table_name]
[FROM {[rowset_function | table1[, ...]]} [AS alias]]
[[join_type] JOIN table2 [ON join_condition]]
[WHERE search_condition]
group_by_clause
order_by_clause

[COMPUTE {aggregation (expression)}[, ...]
   [BY expression[, ...]]]
[FOR {BROWSE | XML | JSON}]
[OPTION (hint[, ...])]
```

where:

`TOP` *`number`* `[PERCENT] [WITH TIES]`
: Indicates that only the specified *`number`* of rows should be retrieved in the query result set. If `PERCENT` is specified, only the first *`number`* percent of the rows are retrieved. `WITH TIES` is used only for queries with an `ORDER BY` clause. This variation specifies that additional rows are returned from the base result

set using the same value in the `ORDER BY` clause, appearing as the last of the `TOP` rows.

`INTO` *`new_table_name`*
: Creates a new table from the result set of the query. You can use this command to create temporary or permanent tables. (Refer to SQL Server's rules for creating temporary or permanent tables in "CREATE/ALTER TABLE Statement" on page 140.) The `SELECT ... INTO` command quickly copies the rows and columns queried from other table(s) into a new table using a non-logged operation. Since it is not logged, `COMMIT` and `ROLLBACK` statements do not affect it.

`FROM {[`*`rowset_function`*` | `*`table1`*`[, ... ]]}`
: Supports the standard behavior of the SQL standard `FROM` clause, including nested table subqueries. In addition, SQL Server supports a set of extensions called *rowset functions*. Rowset functions allow SQL Server to source data from special or external data sources such as XML streams, full-text search file structures (a special structure in SQL Server used to store things like MS Word documents and MS PowerPoint slide shows within the database), or external data sources (like an MS Excel spreadsheet).

See the SQL Server documentation for the full description of the available `FROM {[`*`rowset_function`*` | `*`table1`*`[, ... ]]}` options. Among the many possibilities, SQL Server currently supports the following functions:

`CONTAINSTABLE`
: Returns a table derived from a specified table that contains at least one full-text index `TEXT` or `NTEXT` column. The records derived are based upon either a precise, fuzzy, weighted-match, or proximity-match search. The derived table is then treated like any other `FROM` data source.

`FREETEXTTABLE`
: Similar to `CONTAINSTABLE`, except that records are derived based upon a meaning search of *`'freetext_string'`*. `FREETEXTTABLE` is useful for ad hoc queries against full-text tables, but less accurate than `CONTAINSTABLE`.

`OPENDATASOURCE`
: Provides a means of sourcing data external to SQL Server via OLEDB without declaring a linked server, such as an MS Excel spreadsheet or a Sybase Adaptive Server database table. This is intended for the occasional ad hoc query; if you frequently retrieve result sets from external data sources, you should declare a linked server.

`OPENQUERY`
: Executes a pass-through query against a linked server. This is an effective means of performing a nested table subquery against a data source that is external to SQL Server. The data source must first be declared as a linked server.

`OPENROWSET`
: Executes a pass-through query against an external data source. This is similar to `OPENDATASOURCE`, except that `OPENDATASOURCE` only opens the data source; it does not actually pass through a `SELECT` statement. `OPENROWSET` is intended for occasional, ad hoc usage only.

`OPENXML`
: Provides a queryable, table-like view to an XML document using a file handle. This is covered in "SQL Server XML keywords, functions, procedures, and methods" on page 787.

`COMPUTE {`*`aggregation`*` (`*`expression`*`)}[, ... ] [BY `*`expression`*`[, ... ]]`
: Generates additional aggregations—usually totals—that appear at the end of the result set. `BY` *`expression`* adds subtotals and control breaks to the result set. `COMPUTE` and `COMPUTE BY` can be used simultaneously in the same query. `COMPUTE BY` must be coupled with an `ORDER BY` clause, though the *`expression`* used by `COMPUTE BY` can be a subset of the *`order_by_expression`*. The aggregation may be any of these function calls: `AVG`, `COUNT`, `MAX`, `MIN`, `STDEV`, `STDEVP`, `VAR`, `VARP`, or `SUM`. Examples are shown later in this section.

  `COMPUTE`, in any form, does not work with the `DISTINCT` keyword or with `TEXT`, `NTEXT`, or `IMAGE` data types.

`FOR {BROWSE | XML | JSON}`
: `FOR BROWSE` is used to allow updates to data retrieved in a DB-Library browse mode cursor. (DB-Library is the original access methodology for SQL Server and has since been supplanted by OLE DB in most applications.) `FOR BROWSE` can only be used against tables with a unique index and a column with the `TIMESTAMP` data type; it cannot be used in `UNION` statements or when a `HOLDLOCK` hint is active.

  `FOR XML` and `FOR JSON` are used to extract the result set as an XML document or as JSON, respectively. See Chapter 10 for details on working with these formats.

`OPTION (`*`hint`*`[, ... ])`
: Replaces elements of the default query plan with your own. Because the optimizer usually picks the best query plan for any query, you are strongly discouraged from placing optimizer hints into your queries. Refer to the SQL Server documentation for more information on hints.

Here's an example of SQL Server's `SELECT ... INTO` capability. This example creates a table called *non_mgr_employees* using `SELECT ... INTO`. The table contains the *emp_id*, first name, and last name of each non-manager from the *employee* table, joined with their job descriptions (taken from the *jobs* table):

```
SELECT   e.emp_id, e.fname, e.lname,
   SUBSTRING(j.job_desc,1,30) AS job_desc
INTO non_mgr_employee
```

```
FROM     employee e
JOIN     jobs AS j ON e.job_id = j.job_id
WHERE    j.job_desc NOT LIKE '%MANAG%'
ORDER BY 2,3,1
```

The newly created and loaded table *non_mgr_employee* now can be queried like any other table.

`SELECT ... INTO` is not logged or recoverable and so should only be used for operations that can be restarted from the beginning.

`COMPUTE` has a number of permutations that can impact the result set retrieved by the query. The following example shows the sum of book prices broken out by type of book and sorted by type and then price:

```
-- Query
SELECT type, price
FROM titles
WHERE type IN ('business','psychology')
  AND price > 10
ORDER BY type, price
COMPUTE SUM(price) BY type

-- Results
type         price
------------ --------------------
business     11.9500
business     19.9900
business     19.9900
             sum
             ====================
             51.9300
type         price
------------ --------------------
psychology   10.9500
psychology   19.9900
psychology   21.5900
             sum
             ====================
             52.5300
```

The `COMPUTE` clause behaves differently if you do not include `BY`. The following query retrieves the grand total of prices and advances for books with prices over $16.00:

```
-- Query
SELECT type, price, advance
FROM titles
```

```
WHERE price > $16
COMPUTE SUM(price), SUM(advance)

-- Results
type         price                advance
------------ -------------------- --------------------
business     19.9900              5000.0000
business     19.9900              5000.0000
mod_cook     19.9900              .0000
popular_comp 22.9500              7000.0000
popular_comp 20.0000              8000.0000
psychology   21.5900              7000.0000
psychology   19.9900              2000.0000
trad_cook    20.9500              7000.0000
             sum
             =====================
             165.4500
                                  sum
                                  =====================
                                  41000.0000
```

You can even use COMPUTE BY and COMPUTE in the same query to produce subtotals and grand totals. (For the sake of brevity, we'll show an example query, but not the result set.) In this example, we find the sum of prices and advances by type for business and psychology books that cost over $16.00:

```
SELECT type, price, advance
FROM titles
WHERE price > $16
  AND type IN ('business','psychology')
ORDER BY type, price
COMPUTE SUM(price), SUM(advance) BY type
COMPUTE SUM(price), SUM(advance)
```

Don't forget that you must include the ORDER BY clause with a COMPUTE BY clause! (You do not need an ORDER BY clause with a simple COMPUTE clause without the BY keyword.) There are many permutations that you can perform in a single query —multiple COMPUTE and COMPUTE BY clauses, GROUP BY with a COMPUTE clause, and even COMPUTE with an ORDER BY statement. It's actually fun to tinker around with the different ways you can build queries using COMPUTE and COMPUTE BY. It's not theme park fun, but whaddya want? This is a programming book!

SQL Server (and Oracle, using a somewhat different technique) also supports a non-SQL standard query known as a *pivot query*. Although you should refer to the vendor documentation for details on exactly how to write a pivot (or unpivot) query, an example here will help you take advantage of this useful technique. A pivot query turns the result set on its side, enabling you to extract more value from the data. For example, the following query produces a two-column, four-row result set:

```
-- Query
SELECT days_to_make, AVG(manufacturing_cost) AS Avg_Cost
FROM manufacturing.products
GROUP BY days_to_make;

-- Results
days_to_make  Avg_Cost
0             5
1             225
2             350
4             950
```

By using a pivot query, you can then turn the result "on its side" so that the *days_to_make* column values become the column headings and the query returns one row with five columns:

```
-- Query
SELECT 'Avg_Cost' As Cost_by_Days, [0], [1], [2], [3], [4]
FROM
   (SELECT days_to_make, manufacturing_cost
    FROM manufacturing.products)
AS source
PIVOT
   (AVG(manufacturing_cost)
    FOR days_to_make IN ([0], [1], [2], [3], [4]))
 AS pivottable;

-- Results
Cost_by_Days  0    1    2    3    4
Avg_Cost      5    225  350  NULL 950
```

See also

- JOIN
- GROUP BY
- ORDER BY
- WHERE
- WITH

SUBQUERY Substatement

A subquery is a nested query. Subqueries may appear in various places within a SQL statement.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

The different types of subqueries the SQL standard supports are described "Rules at a glance" on page 338. Scalar, table, and nested table subqueries are represented by the following generalized syntax:

```
SELECT column1, column2, ... (scalar_subquery)
FROM table1, ... (nested_table_subquery)
   AS subquery_table_name]
WHERE foo = (scalar_subquery)
   OR foo IN (table_subquery)
```

Correlated subqueries are more complex because the values of such subqueries are dependent on values retrieved in their main queries. For example:

```
SELECT column1
FROM   table1 AS t1
WHERE  foo IN
   (SELECT value1
    FROM table2 AS t2
    WHERE t2.pk_identifier = t1.fk_identifier)
```

Note that the `IN` clause is for example purposes only. Any comparison operator may be used.

Keywords

scalar_subquery
: Includes a scalar subquery in the `SELECT` item list or in the `WHERE` or `HAVING` clause of a query.

table_subquery
: Includes a table subquery only in the `WHERE` clause, with operators such as `IN`, `ANY`, `SOME`, `EXISTS`, or `ALL` that act upon multiple values. Table subqueries return one or more rows containing a single value each.

nested_table_subquery
: Includes a nested table subquery only in the `FROM` clause, in conjunction with the `AS` clause.

Rules at a glance

Subqueries allow you to return one or more values and nest them inside a `SELECT`, `INSERT`, `UPDATE`, or `DELETE` statement, or inside another subquery. Subqueries can be used wherever expressions are allowed. Subqueries also can often be replaced with a `JOIN` statement. Depending on the DBMS, subqueries may perform less quickly than joins.

Subqueries are always enclosed in parentheses.

SQL supports the following types of subquery:

Scalar subqueries
: Subqueries that retrieve a single value. These are the most widely supported type of subquery among the various database platforms.

Vector subqueries
: Subqueries that retrieve a single row which has more than one column.

Table subqueries
: Subqueries that retrieve more than one value or row of values.

Scalar and vector subqueries can, on some platforms, appear as part of the expression in a `SELECT` list of items, a `WHERE` clause, or a `HAVING` clause. Nested table subqueries tend to appear in the `FROM` clauses of `SELECT` statements.

A *correlated subquery* is a subquery that is dependent upon a value in an outer query. Consequently, the inner query is executed once for every record retrieved in the outer query. Since subqueries can be nested many layers deep, a correlated subquery may reference any level in the main query higher than its own level.

Different rules govern the behavior of a subquery, depending on the clause in which it appears. The level of support amongst the database platforms also varies: some platforms support subqueries in all clauses mentioned earlier (`SELECT`, `FROM`, `WHERE`, and `HAVING`), while others support subqueries in only one or two of the clauses.

Subqueries are usually associated with the `SELECT` statement. Since subqueries may appear in the `WHERE` clause, they can be used in any SQL statement that supports a `WHERE` clause, including `SELECT`, `INSERT ... SELECT`, `DELETE`, and `UPDATE` statements.

Certain operators in a `WHERE` clause, such as `=`, `<`, `>`, `>=`, `<=`, and `<>` (or `!=`), expect only one value. If a subquery returns more than one value but the operator expects a single value, the entire query will fail. Scalar subqueries should be used in these cases because they can return only a single value. On the other hand, table subqueries may return multiple values, but they are usable only with multivalue expressions like `[NOT] IN`, `ANY`, `ALL`, `SOME`, or `[NOT] EXISTS`.

Table subqueries may appear in the `FROM` clause and should be aliased by the `AS` clause. The result set returned by a table subquery, sometimes called a *derived table*, offers similar functionality to a view (see "CREATE/ALTER VIEW Statement" on page 221 for more on views). Every column returned in the derived table need not be used in the query, though they can all be acted upon by the outer query.

Correlated subqueries typically appear as a component of a WHERE or HAVING clause in the outer query (and, less commonly, in the SELECT item list) and are correlated through the WHERE clause of the inner query (that is, the subquery). Correlated subqueries can also be used as table subqueries, though this is less common. Be sure to include in such a subquery a WHERE clause that evaluates based on a correlating value from the outer query; the example for a correlated query in the earlier SQL standard syntax diagram illustrates this requirement.

It is also important to specify a table alias, called a *correlation name*, using the AS clause or other alias shortcut for every table referenced in a correlated query, in both the outer and inner queries. Correlation names avoid ambiguity and help the DBMS quickly resolve the tables involved in the query.

All SQL standard–compliant subqueries comply with the following short list of rules:

- A subquery cannot include an ORDER BY clause.
- A subquery cannot be enclosed in an aggregate function. For example, the following query is invalid:

```
SELECT foo FROM table1
WHERE sales >= AVG(SELECT column1 FROM sales_table ...)
```

You can get around this limitation by performing the aggregation in the subquery rather than in the outer query.

Programming tips and gotchas

For most vendor platforms, subqueries should not reference large object data types (e.g., CLOB or BLOB on Oracle and IMAGE or TEXT on SQL Server) or array data types (such as TABLE or CURSOR on SQL Server).

The platforms all support subqueries, but not every vendor supports every type of subquery. Table 4-4 summarizes vendor support at the time of writing.

Table 4-4. Platform-specific subquery support

Platform	MySQL	Oracle	PostgreSQL	SQL Server
Scalar subquery in SELECT item list	✓	✓	✓	✓
Scalar subquery in WHERE/HAVING clause	✓	✓	✓	✓
Vector subquery in WHERE/HAVING clause	✓	✓	✓	✓
Table subquery in FROM clause	✓	✓	✓	✓
Correlated subquery in WHERE/HAVING clause	✓	✓	✓	✓

Aside from SELECT statements, subqueries may also be used in INSERT, UPDATE, and DELETE statements that include a WHERE clause. Subqueries are often used for the following purposes:

- To identify the rows inserted into the target table using an `INSERT ... SELECT` statement, a `CREATE TABLE ... SELECT` statement, or a `SELECT ... INTO` statement
- To identify the rows of a view or materialized view in a `CREATE VIEW` statement
- To identify value(s) assigned to existing rows using an `UPDATE` statement
- To identify values for conditions in the `WHERE` and `HAVING` clauses of `SELECT`, `UPDATE`, and `DELETE` statements
- To build a view of a table(s) on the fly (i.e., nested table subqueries)

Examples. This section shows subquery examples that are equally valid on MySQL, Oracle, PostgreSQL, and SQL Server.

A simple scalar subquery is shown in the `SELECT` item list of the following query:

```
SELECT job, (SELECT AVG(salary) FROM employee) AS "Avg Sal"
FROM   employee
```

Table subqueries are functionally equivalent to querying a view. In the following, we query the education level and salary in a table subquery, and then perform aggregations on the values in the derived table in the outer query:

```
SELECT AVG(edlevel), AVG(salary)
FROM
   (SELECT edlevel, salary
    FROM employee) AS emprand
GROUP BY edlevel
```

Remember that this query may fail, depending on the platform, without the `AS` clause to associate a name with the derived table.

The following query shows a standard table subquery in the `WHERE` clause expression. In this case, we want all project numbers for employees in the department `'A00'`:

```
SELECT projno
FROM   emp_act
WHERE  empno IN
   (SELECT empno
    FROM   employee
    WHERE  workdept ='A00')
```

The subquery is executed only once for the outer query.

In the next example, we want to know the names of employees and their level of seniority. We get this result set through a correlated subquery:

```
SELECT firstname, lastname,
   (SELECT COUNT(*)
    FROM employee, senior
    WHERE employee.hiredate > senior.hiredate) as senioritype
FROM employee
```

Unlike the previous subquery, this subquery is executed one time for every row retrieved by the outer query. In a query like this, the total processing time could be very long, since the inner query may potentially execute many times for a single result set.

Correlated subqueries depend on values retrieved by the outer query to complete the processing of the inner query. They are tricky to master, but they offer unique programmatic capabilities. The following example returns information about orders where the quantity sold in each order is less than the average quantity in other sales for that title:

```
SELECT s1.ord_num, s1.title_id, s1.qty
FROM sales AS s1
WHERE s1.qty <
   (SELECT AVG(s2.qty)
    FROM sales AS s2
    WHERE s2.title_id = s1.title_id)
```

For this example, you can accomplish the same functionality using a self-join. However, there are situations in which a correlated subquery may be the only easy way to do what you need.

The next example shows how a correlated subquery might be used to update values in a table:

```
UPDATE course SET ends =
   (SELECT min(c.begins) FROM course AS c
    WHERE c.begins BETWEEN course.begins AND course.ends)
WHERE EXISTS
   (SELECT * FROM course AS c
    WHERE c.begins BETWEEN course.begins AND course.ends)
```

Similarly, you can use a subquery to determine which rows to delete. This example uses a correlated subquery to delete rows from one table based on related rows in another table:

```
DELETE FROM course
WHERE EXISTS
   (SELECT * FROM course AS c
    WHERE course.id > c.id
    AND (course.begins BETWEEN c.begins
      AND c.ends OR course.ends BETWEEN c.begins AND c.ends))
```

MySQL

MySQL supports subqueries in the `FROM` clause and the `WHERE` clause. It supports scalar subqueries in the `SELECT` item list.

Oracle

Oracle supports SQL-standard subqueries, though it uses a different nomenclature. In Oracle, a table subquery that appears in the FROM clause is called an *inline view*. That makes sense because table subqueries are basically views built on the fly. Oracle calls a subquery that appears in the WHERE clause or the HAVING clause of a query a *nested subquery*. It allows correlated subqueries in the SELECT item list and in the WHERE and HAVING clauses.

PostgreSQL

PostgreSQL supports SQL-standard subqueries in the FROM, WHERE, and HAVING clauses and also allows them to have ORDER BY clauses. However, subqueries appearing in a HAVING clause cannot include ORDER BY, FOR UPDATE, or LIMIT clauses. It supports scalar and vector subqueries in the SELECT item list.

SQL Server

SQL Server supports SQL-standard subqueries. Scalar subqueries can be used almost anywhere a standard expression is allowed. Subqueries in SQL Server cannot include the COMPUTE or FOR BROWSE clauses. They can include the ORDER BY clause if the TOP clause is also used.

See also

- DELETE in Chapter 5
- INSERT in Chapter 5
- ORDER BY
- SELECT
- UPDATE in Chapter 5
- WHERE

UNION Set Operator

The UNION set operator combines the result sets of two or more queries, showing all the rows returned by each of the queries as a single result set.

UNION is in a class of keywords known as set operators. Other set operators include INTERSECT and EXCEPT. All set operators are used to simultaneously manipulate the result sets of two or more queries; hence the term "set operators."

Platform	Command
MySQL	Supported
Oracle	Supported, with limitations
PostgreSQL	Supported, with limitations
SQL Server	Supported, with limitations

SQL standard syntax

There are technically no limits to the number of queries that you may combine with the `UNION` statement. The general syntax is:

```
<SELECT statement1>
UNION [ALL | DISTINCT]
<SELECT statement2>
UNION [ALL | DISTINCT]
...
```

Keywords

`UNION`
: Determines which result sets will be combined into a single result set. Duplicate rows are, by default, excluded.

`ALL | DISTINCT`
: Combines duplicate rows from all result sets (`ALL`) or eliminates duplicate rows from the final result set (`DISTINCT`). Columns containing a NULL value are considered duplicates. If neither `ALL` nor `DISTINCT` is used, `DISTINCT` behavior is the default.

Rules at a glance

There is only one significant rule to remember when using `UNION`: the order, number, and data types of the columns should be the same in all queries.

The data types do not have to be identical, but they should be compatible. For example, `CHAR` and `VARCHAR` are compatible data types. By default, the result set will default to the largest of two (or more) compatible data types, so a query that unions three `CHAR` columns—`CHAR(5)`, `CHAR(10)`, and `CHAR(12)`—will display the results in the `CHAR(12)` format with extra space padded onto the smaller column results.

Programming tips and gotchas

Even though the SQL standard calls for `INTERSECT` to take precedence over other set operators in a single statement, many platforms evaluate all set operators with equal precedence. You can explicitly control the precedence of set operators using parentheses. Otherwise, the DBMS is likely to evaluate them in order from the leftmost to the rightmost expression.

Depending on the platform, specifying `DISTINCT` can incur a significant performance cost, since it often involves a second pass through the results to winnow out duplicate records. `ALL` can be specified in any instance where no duplicate records are expected (or where duplicate records are OK) for faster results.

According to the SQL standard, only one `ORDER BY` clause is allowed in the entire query. Include it at the end of the last `SELECT` statement. To avoid column and table ambiguity, be sure to alias matching columns in each table with the same respective aliases. However, for column-naming purposes, only the aliases in the first query are used for each column in the SELECT ... UNION query. For example:

```
SELECT au_lname AS "lastname", au_fname AS "firstname"
FROM authors
UNION
SELECT emp_lname AS "lastname", emp_fname AS "firstname"
FROM employees
ORDER BY lastname, firstname
```

Also be aware that even if the queries in your UNION have compatible data-typed columns, there may be some variation in behavior across the DBMS platforms, especially with regard to the length of the columns. For example, if the *au_lname* column in the first query is markedly longer than the *emp_lname* column in the second query, different platforms may apply different rules as to which length is used. In general, though, the platforms will choose the longer (and less restrictive) column size for use in the result set.

Each DBMS may apply its own rules as to which column name is used if the columns across the tables have different names. In general, the column names of the first query are used.

MySQL

MySQL fully supports the SQL standard syntax.

Oracle

Oracle supports the UNION and UNION ALL set operators using the basic SQL standard syntax. UNION DISTINCT is not supported, but UNION is the functional equivalent.

For example, you could find out all unique store IDs without duplicates using this query:

```
SELECT stor_id FROM stores
UNION
SELECT stor_id FROM sales;
```

Oracle does not support UNION [ALL] on the following types of queries:

- Queries containing columns with LONG, BLOB, CLOB, BFILE, or VARRAY data types
- Queries containing a FOR UPDATE clause or a TABLE collection expression

If the first query in the set operation contains any expressions in the SELECT item list, include the AS keyword to associate an alias with the column resulting from the expression. Also, only the last query in the set operation may contain an ORDER BY clause.

PostgreSQL

PostgreSQL supports the UNION and UNION ALL set operators using the basic SQL standard syntax, but not on queries with a FOR UPDATE clause UNION DISTINCT is not supported, but UNION is the functional equivalent.

The first query in the set operation may not contain an ORDER BY clause or a LIMIT clause. Subsequent queries in the UNION [ALL] set operation may contain these clauses, but such queries must be enclosed in parentheses. Otherwise, the rightmost occurrence of ORDER BY or LIMIT will be assumed to apply to the entire set operation.

For example, we could find all authors and all employees whose last names start with “P” with the following query:

```
SELECT a.au_lname
FROM   authors AS a
WHERE  a.au_lname LIKE 'P%'
UNION
SELECT e.lname
FROM   employee AS e
WHERE  e.lname LIKE 'W%';
```

SQL Server

SQL Server supports the UNION and UNION ALL set operators using the basic SQL standard syntax. UNION DISTINCT is not supported, but UNION is the functional equivalent.

You can use SELECT ... INTO with UNION or UNION ALL, but INTO may appear only in the first query of the union. Special keywords, such as SELECT TOP and GROUP BY ... WITH CUBE, are usable with all queries in a union, but if you use them in one query you must use them with all of the queries. If you use SELECT TOP or GROUP BY ... WITH CUBE in only one query in a union, the operation will fail.

Each query in a union must contain the same number of columns. The data types of the columns do not have to be identical, but they must implicitly convert. For example, mixing VARCHAR and CHAR columns is acceptable. SQL Server uses the larger of the two columns when evaluating the size of the columns returned in the result set. Thus, if a SELECT ... UNION statement has a CHAR(5) column and a CHAR(10) column, it will display the data of both columns as a CHAR(10) column. Numeric columns are converted to and displayed as the most precise data type in the union.

For example, the following query unions the results of two independent queries that use GROUP BY ... WITH CUBE:

```
SELECT ta.au_id, COUNT(ta.au_id)
FROM   pubs..titleauthor AS ta
JOIN   pubs..authors     AS a ON a.au_id = ta.au_id
WHERE  ta.au_id >= '722-51-5454'
```

```
GROUP  BY ta.au_id WITH CUBE
UNION
SELECT ta.au_id, COUNT(ta.au_id)
FROM   pubs..titleauthor AS ta
JOIN   pubs..authors     AS a ON a.au_id = ta.au_id
WHERE  ta.au_id < '722-51-5454'
GROUP  BY ta.au_id WITH CUBE
```

See also

- `EXCEPT`
- `INTERSECT`
- `SELECT`

VALUES Clause

The `VALUES` multi-row constructor is a constructor often found in `INSERT` statements, but it can also be used in `FROM` statements or anywhere you can have a table expression to create an inline table. When used in a `FROM` statement, the column names and table name must be aliased.

Platform	Command
MySQL/MariaDB	Supported, with limitations
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Supported, with limitations

SQL standard syntax

```
( VALUES [ROW](<row1 columns>), [ROW](<row2 columns>), ...
   [ROW](<rown columns>) )
[AS <table_alias>(column1, column2[,... columnn])]
```

Keywords

`(VALUES [ROW](<row1 columns>), [ROW](<row2 columns>), ... [ROW](<rown columns>) )`
: Defines a set of rows. Each row is enclosed in parentheses, and column values are separated by commas. Each row must have the same number of columns.

`ROW`
: Optional keyword to denote the beginning of a row. Some databases do not support this keyword and others require it.

`AS <table_alias>(column1, column2[, ... columnn])`
: Specifies names for the table and columns. When not specified, the default names for columns are *column1*, *column2*, … *column*.

Rules at a glance

VALUES clauses can stand alone or be included in SELECT statements, JOIN clauses, IN clauses, NOT IN clauses, DELETE statements, INSERT ... SELECT statements, UPDATE statements, and any statement that might have a query or subquery (such as DECLARE, CREATE TABLE, CREATE VIEW, and so forth). The following example defines a virtual table consisting of two rows with two named columns:

```
SELECT *
FROM
(VALUES ('ABC1', 'Title 1'),
   ('DCF1', 'Title 2')
) AS t(title_id, title);
```

VALUES can also be used in a common table expression (WITH clause) as follows:

```
WITH t(title_id, title) AS (
   VALUES
      ('ABC1', 'Title 1'),
      ('DCF1', 'Title 2')
)
SELECT * FROM t;
```

And it can be used standalone without aliasing, as follows:

```
VALUES ('ABC1', 'Title 1'),
   ('DCF1', 'Title 2');
```

The output of the preceding queries is:

```
ABC1    | Title 1
DCF1    | Title 2
```

MySQL and MariaDB

MySQL 8 and later support the VALUES multi-row constructor, which can be used standalone or within a SELECT, INSERT, or UPDATE statement. When used as table output the ROW keyword is not optional for MySQL. For example:

```
SELECT *
FROM
(VALUES ROW('ABC1', 'Title 1'),
  ROW('DCF1', 'Title 2')
) AS t(title_id, title);
```

When used in an INSERT statement, the ROW keyword can be left out.

MariaDB also supports the VALUES multi-row constructor, which can be used standalone, in a WITH clause, or within an INSERT statement. The ROW keyword is not supported. MariaDB allows aliasing in a WITH clause, but not when VALUES is used standalone.

Oracle

Oracle does not support the VALUES multi-row constructor.

PostgreSQL

PostgreSQL fully supports the VALUES constructor, except for the ROW keyword.

SQL Server

SQL Server supports the multi-row VALUES constructor and allows its use in SELECT ... FROM and INSERT statements. It does not support its use in WITH or IN clauses or standalone, and it does not support the optional ROW keyword. When used in the FROM clause, renaming of columns is required.

See also

- IN
- INSERT
- JOIN
- SELECT
- WITH

WHERE Clause

The WHERE clause sets the search criteria for an operation such as SELECT, UPDATE, or DELETE. Any records in the target table(s) that do not meet the search criteria are excluded from the operation. The search conditions may include many variations, such as calculations, Boolean operators, and SQL predicates (for example, LIKE or BETWEEN). All the platforms support the SQL standard syntax.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported

SQL standard syntax

```
{ WHERE search_criteria | WHERE CURRENT OF cursor_name }
```

Keywords

WHERE *search_criteria*
: Defines search criteria for the statement to ensure that only the target rows are affected.

`WHERE CURRENT OF` *`cursor_name`*
: Restricts the operation of the statement to the current row of a defined and opened cursor called *`cursor_name`*.

Rules at a glance

`WHERE` clauses are found in `SELECT` statements, `DELETE` statements, `INSERT ... SELECT` statements, `UPDATE` statements, and any statement that might have a query or subquery (such as `DECLARE`, `CREATE TABLE`, `CREATE VIEW`, and so forth).

The search conditions, all of which are described in their own entries elsewhere in this book, can include:

All records (`=ALL`*,* `>ALL`*,* `<= ALL`*,* `SOME/ANY`*)*
: For example, to see publishers who live in the same city as their authors:

```
SELECT pub_name
FROM   publishers
WHERE city = SOME (SELECT city FROM authors);
```

Combinations(`AND`*,* `OR`*, and* `NOT`*) and evaluation hierarchy*
: For example, to see all authors with sales in quantities greater than or equal to 75 units, or coauthors with a royalty of greater than or equal to 60:

```
SELECT a.au_id
FROM   authors AS a
JOIN titleauthor AS ta ON a.au_id = ta.au_id
WHERE  ta.title_id IN (SELECT title_id FROM sales
                       WHERE qty >= 75)
   OR  (a.au_id IN (SELECT au_id FROM titleauthor
                    WHERE royaltyper >= 60)
  AND  a.au_id IN (SELECT au_id FROM titleauthor
                   WHERE au_ord = 2));
```

Comparison operators (such as `=, < >, <, >, <=,` *and* `>=`*)*
: For example, to see the last and first names of authors who don't have a contract (i.e., authors with *contract* value of 0):

```
SELECT au_lname, au_fname
FROM   authors
WHERE  contract = 0;
```

Lists (`IN` *and* `NOT IN`*)*
: For example, to see all authors who do not yet have a title in the *titleauthor* table:

```
SELECT au_fname, au_lname
FROM   authors
WHERE au_id NOT IN (SELECT au_id FROM titleauthor);
```

NULL comparisons (`IS NULL` *and* `IS NOT NULL`*)*
: For example, to see titles that have NULL year-to-date sales:

```
SELECT title_id, SUBSTRING(title, 1, 25) AS title
FROM   titles
WHERE ytd_sales IS NULL;
```

Be sure *not* to specify `= NULL` in a query. `NULL` is unknown and can never be equal to anything. Using `= NULL` is not the same as specifying the `IS NULL` operator.

Pattern matches (`LIKE` *and* `NOT LIKE`*)*
: For example, to see authors whose last names start with a "C":

```
SELECT au_id
FROM   authors
WHERE au_lname LIKE 'C%';
```

Range operations (`BETWEEN` *and* `NOT BETWEEN`*)*
: For example, to see authors with last names that fall alphabetically between "Smith" and "White":

```
SELECT au_lname, au_fname
FROM   authors
WHERE  au_lname BETWEEN 'smith' AND 'white';
```

Programming tips and gotchas

The `WHERE` clause may require special handling when dealing with certain data types, such as `LOB`s, or certain character sets, including Unicode.

Parentheses are used to control evaluation hierarchy within a `WHERE` clause. Encapsulating a clause within parentheses tells the DBMS to evaluate that clause before others. Parentheses can be nested to create a hierarchy of evaluations. The innermost parenthetical clause will be evaluated first. You should watch parentheses very carefully, for two reasons:

- You must always have an equal number of opening and closing parentheses. Any imbalance in the number of opening and closing parentheses will cause an error.
- You should be careful where you place parentheses, since misplacing a parenthesis can dramatically change the result set of your query.

For example, consider again the following query, which returns six rows in the *pubs* database on the SQL Server platform:

```
SELECT DISTINCT a.au_id
FROM   authors AS a
JOIN   titleauthor AS ta ON a.au_id = ta.au_id
WHERE  ta.title_id IN (SELECT title_id FROM sales
                       WHERE qty >= 75)
```

```
   OR  (a.au_id  IN (SELECT au_id FROM titleauthor
                     WHERE royaltyper >= 60)
  AND   a.au_id  IN (SELECT au_id FROM titleauthor
                     WHERE au_ord = 2))
```

The output from this query is as follows:

```
au_id
-----------
213-46-8915
724-80-9391
899-46-2035
998-72-3567
```

Changing just one set of parentheses produces different results:

```
SELECT DISTINCT a.au_id
FROM   authors AS a
JOIN titleauthor AS ta ON a.au_id = ta.au_id
WHERE  (ta.title_id IN (SELECT title_id FROM sales
                      WHERE qty >= 75)
   OR  a.au_id  IN (SELECT au_id FROM titleauthor
                    WHERE royaltyper >= 60))
 AND  a.au_id  IN (SELECT au_id FROM titleauthor
                   WHERE au_ord = 2)
```

This time, the output will look like this:

```
au_id
-----------
213-46-8915
724-80-9391
899-46-2035
```

See also

- `ALL/ANY/SOME`
- `BETWEEN`
- `DECLARE CURSOR` in Chapter 9
- `DELETE` in Chapter 5
- `EXISTS`
- `IN`
- `LIKE`
- `SELECT`
- `UPDATE`

WITH Clause

The `WITH` clause defines a short-term view that is instantiated for the duration of a parent query. It may or may not have an alias associated with it in order to ease referencing from the parent query (or subqueries) later. The temporary named result set created by a `WITH` clause is called a *common table expression* (CTE), and this is also known as *subquery factoring*. CTEs are not stored in the database schema like standard views, but they behave in essentially the same way. In fact, when CTEs were added to the SQL:1999 standard, they were simply referred to as *statement-scoped views*. All the platforms support the SQL standard syntax for the `WITH` clause, some with extensions.

Platform	Command
MySQL	Supported
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
WITH [RECURSIVE] with_query[, ...]
SELECT...
```

Keywords

`with_query`
: Defines a query with a name that takes the form *`some_name`* `AS (`*`query_definition`*`)` or *`some_name`*`(`*`col1,col2,col3`* `...) AS (`*`query_definition`*`)`. There can be one or more *`with_query`*s before the final query. Each *`with_query`* must be separated by a comma.

`RECURSIVE`
: Denotes that the CTE batch may contain queries that call themselves, generally using tail recursion. This keyword is syntactic sugar providing a hint to the query planner that a `WITH` clause has recursive elements.

Rules at a glance

`WITH` clauses are used to make complex SQL queries easier to read and debug by dividing them into subsets. They are also used to compartmentalize a subquery that is reused in multiple parts of a parent query (each CTE is associated with an anchoring parent query, which may in turn have multiple CTEs), to write recursive queries, and to improve performance.

Some databases allow for writable CTEs, which have elements that update data and return the changed data.

Programming tips and gotchas

The `WITH` clause can have implications for query performance. Depending on the database vendor and version, a query written with `WITH` may perform better or worse than a similar query utilizing nested `SELECT` statements. When in doubt, experiment with writing your query using `WITH` and without `WITH`.

Here's an example of a non-recursive CTE:

```
WITH au AS (SELECT au_state AS state, COUNT(*) AS au_count
   FROM authors
   GROUP BY au_state
   ),
   pu AS (SELECT pub_state AS state, COUNT(*) AS pub_count
      FROM publishers
   GROUP BY pub_state
   )
SELECT au.state, au.au_count, pu.pub_count
FROM au INNER JOIN pu ON au.state = pu.state;
```

A completely SQL standard–compliant recursive CTE that counts from 1 to 20 might look like this:

```
WITH RECURSIVE numbers AS (
   SELECT 1 AS n
   UNION ALL
   SELECT n + 1
      FROM numbers
   WHERE n+1 <= 20
)
SELECT *
FROM numbers;
```

There is no physical *numbers* table; *numbers* is a CTE expression that builds on itself. If you did have a *numbers* table in your database, however, the CTE version would still be used; this is because in the case of name clashes CTEs take precedence.

Recursive CTEs cannot include `DISTINCT`. Some databases, like PostgreSQL, will error if you prefix a *`with_query`* with `RECURSIVE` and it has no recursive elements. SQL Server, although it supports recursive queries, does not allow the `RECURSIVE` keyword.

MySQL and MariaDB

MySQL fully supports the `WITH` clause as of version 8.0. MariaDB introduced support in version 10.2.

Oracle

Oracle supports the SQL standard `WITH` as well as a `MATERIALIZE` Hint that forces a CTE to be materialized for better performance. To force materialization you would write something like:

```
WITH au AS (SELECT /*+ MATERIALIZE */ au_state, COUNT(*) AS au_count
   FROM authors
   GROUP BY au_state
   ),
   pu AS (SELECT /*+ MATERIALIZE */ pub_state, COUNT(*) AS pub_count
      FROM publishers
   GROUP BY pub_state
   )
SELECT au.state, au.au_count, pu.pub_count
FROM au INNER JOIN pu ON au.state = pu.state;
```

PostgreSQL

PostgreSQL fully supports the SQL standard `WITH` clause and some extensions to it. PostgreSQL allows CTEs to contain one or more `INSERT`/`UPDATE`/`DELETE` statements if they are followed with a `RETURNING` clause. The final query can also be an `INSERT`/`UPDATE`/`DELETE` but need not have a `RETURNING` clause. This is useful, for example, to move deleted records to another table, as follows:

```
WITH del AS (DELETE
   FROM authors
   WHERE au_state = 'CA' RETURNING *)
INSERT INTO deleted_authors(au_id)
SELECT del.au_id
FROM del;
```

PostgreSQL also supports a `MATERIALIZED`/`NOT MATERIALIZED` extension to the standard. To force materialization of a CTE you would prefix it with `MATERIALIZED`, and if you wanted to discourage materialization you could similarly prefix it with `NOT MATERIALIZED`, as follows:

```
WITH au AS MATERIALIZED
(SELECT au_state AS state, COUNT(*) AS au_count
   FROM authors
   GROUP BY au_state
),
pu AS NOT MATERIALIZED
(SELECT pub_state AS state, COUNT(*) AS pub_count
   FROM publishers
   GROUP BY pub_state
)
SELECT au.state, au.au_count, pu.pub_count
FROM au INNER JOIN pu ON au.state = pu.state;
```

`WITH RECURSIVE` is also supported in the definition of views, which allows for writing recursive views. PostgreSQL will complain if you use `WITH RECURSIVE` and have no recursive elements in your view.

SQL Server

SQL Server supports `WITH` but does not allow the `RECURSIVE` keyword; it internally determines whether a `WITH` clause is recursive or not. SQL Server does not allow `ORDER BY` clauses in CTEs unless they are used in conjunction with `TOP`. It also does not allow `INTO` or `OPTION` clauses with query hints. Unlike other statements where the `;` is optional, CTEs must start with a `;` if they are part of a set of query statements.

The earlier recursive CTE would be written without the `RECURSIVE` keyword as follows:

```
WITH numbers AS (
   SELECT 1 AS n
   UNION ALL
   SELECT n + 1
      FROM numbers
   WHERE n+1 <= 20
)
SELECT *
FROM numbers;
```

See also

- `ALTER/CREATE VIEW`
- `RETURNING` in Chapter 5
- `SELECT`
- `SUBQUERY`

WITH ORDINALITY Clause

The `WITH ORDINALITY` clause adds an incrementing integer column to the result of a set-returning function. The name of the column is *ordinality* unless it is renamed. It is generally used in the `FROM` or `JOIN` clause and is commonly used in conjunction with the `UNNEST` function to expand and number array data.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
set_returning_function_call WITH ORDINALITY [AS ..]
```

Keywords

`set_returning_function_call`
Defines a function call, for example `UNNEST(`*`somevalue`*`)`.

Rules at a glance

`WITH ORDINALITY` is used to number the results of a set-returning function. For regular `SELECT` queries, you would use `ROW_NUMBER() OVER()` instead for numbering.

Programming tips and gotchas

Here is a PostgreSQL example of using `WITH ORDINALITY` to number an array of values:

```
SELECT *
FROM unnest(ARRAY['PC8888','BU1032',
                 'PS7777','PS3333','BU1111']
            ) WITH ORDINALITY AS title_id;
```

The output of this query is:

```
title_id | ordinality
----------------------
PC8888   |  1
BU1032   |  2
PS7777   |  3
PS3333   |  4
BU1111   |  5
```

You can also rename the output of the columns using aliases, as follows:

```
SELECT *
FROM unnest(ARRAY['PC8888','BU1032',
   'PS7777','PS3333','BU1111']
) WITH ORDINALITY AS title_id(id, ord);
```

`WITH ORDINALITY` is often used in a `JOIN` clause or a `LATERAL JOIN` clause.

See also

- `JOIN`
- `SELECT`

5

Manipulating Your Data

In this chapter, we will explore the key SQL statements and clauses needed to update information in your database. You will learn about the fundamental `UPDATE`, `INSERT`, and `DELETE` statements and the various subclauses you can use within them to select data you need to update.

How to Use This Chapter

When researching a command in this chapter:

1. Read "SQL Platform Support" on page 360.
2. Check Table 5-1.
3. Look up the specific SQL statement, check the syntax, and read the "Keywords," "Rules at a glance," and "Programming tips and gotchas" sections. Do this even if you are looking for a specific platform implementation.
4. Finally, read the platform-specific implementation information.

You will note that the entry for a given platform implementation does *not* duplicate information on any clauses that do not differ from the standard. So, it is possible that you will need to flip between the descriptions for a vendor variation and the SQL standard to cover all possible details of that command.

In our discussions of MySQL, we will also include MariaDB, a fork of MySQL. For the most part, MySQL and MariaDB provide fully code-compatible syntax. In these cases we will refer to them collectively as MySQL. We will explicitly mention MariaDB only in situations where it deviates from MySQL in an important way.

SQL Platform Support

Table 5-1 provides a listing of the SQL statements covered in this chapter, the platforms that support them, and the degree to which they support them. The following list offers useful tips for reading Table 5-1, as well as an explanation of what each abbreviation stands for:

1. The first column contains the SQL commands, in alphabetical order.
2. The SQL statement class for each command is indicated in the second column.
3. The subsequent columns list the level of support for each vendor:

   Supported (S)
   The platform supports the SQL standard for the particular command.

   Supported, with variations (SWV)
   The platform supports the SQL standard for the particular command, using vendor-specific code or syntax.

   Supported, with limitations (SWL)
   The platform supports some but not all of the functions specified by the SQL standard for the particular command.

   Not supported (NS)
   The platform does not support the particular command according to the SQL standard.

The sections that follow the table describe the commands in detail. Remember that even if a specific SQL command is listed in the table as "Not supported," the platform usually has alternative coding or syntax to enact the same command or function. Therefore, be sure to read the discussion and examples for each command later in this chapter. Likewise, one command in Table 5-1 is not found in the SQL standard; this is indicated with the term "Non-standard" in the "SQL class" column of the table.

Table 5-1. Alphabetical quick SQL command reference

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`COMMIT`	SQL-transaction	SWV	SWV	SWV	SWV
`DELETE`	SQL-data	SWV	SWV	SWV	SWV
`INSERT`	SQL-data	SWV	SWV	SWV	SWV
`MERGE`	SQL-data	NS	SWV	NS	SWV
`RELEASE SAVEPOINT`	SQL-transaction	S	NS	S	NS
`RETURNING`	Non-standard	NS/SWL	SWV	S	NS
`ROLLBACK`	SQL-transaction	SWL	SWV	S	SWV
`SAVEPOINT`	SQL-transaction	S	S	S	SWL

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
SET TRANSACTION	SQL-transaction	SWV	SWL	SWV	SWL
START TRANSACTION	SQL-transaction	SWL	NS	SWV	NS
TRUNCATE TABLE	SQL-data	SWL	SWV	SWV	SWL
UPDATE	SQL-data	SWV	SWV	SWV	SWV

SQL Command Reference

COMMIT Statement

The COMMIT statement explicitly ends an open transaction and makes the changes permanent in the database. Transactions can be opened implicitly as part of an INSERT, UPDATE, or DELETE statement, or opened explicitly with a START statement. In either case, an explicitly issued COMMIT statement will end the open transaction.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
COMMIT [WORK] [AND [NO] CHAIN]
```

Keywords

COMMIT [WORK]
: Ends the current open transaction and writes any data manipulated by the transaction to the database. The optional keyword WORK is noise and has no effect.

AND [NO] CHAIN
: AND CHAIN directs the DBMS to initiate (or start) a new transaction with the same characteristics as the preceding transaction. In effect, the two transactions are separate units of work, but they share a common transaction environment (such as transaction isolation level). Including the optional NO keyword directs the DBMS to explicitly use the SQL standard default behavior. The COMMIT keyword by itself is functionally equivalent to the statement COMMIT WORK AND NO CHAIN.

Rules at a glance

For simple operations, you will execute transactions (that is, SQL code that manipulates or changes data and objects in a database) without explicitly declaring a transaction. However, all transactions are best managed by explicitly closing them with a `COMMIT` statement. Because records and even entire tables can be locked for the duration of a transaction, it is extremely important that transactions are completed as quickly as possible. Manually issuing a `COMMIT` statement with a transaction can help control user concurrency issues and locking problems on the database.

Programming tips and gotchas

The most important gotcha to consider is that some database platforms perform automatic and *implicit* transactions, while others require *explicit* transactions. If you assume a platform uses one method of transactions and not the other, you may get bitten. Thus, when moving between database platforms you should follow a standard, preset way of addressing transactions. We recommend always using explicit transactions with `START TRANSACTION`, on database platforms that support it, to begin a transaction, and `COMMIT` or `ROLLBACK` to end a transaction.

In addition to finalizing a single or group of data manipulation operation(s), `COMMIT` has some interesting effects on other aspects of a transaction. First, it closes any associated open cursors. Second, any temporary table(s) specified with `ON COMMIT DELETE ROWS` (an optional clause of the `CREATE TABLE` statement, discussed in Chapter 3) are cleared of data. Third, all deferred constraints are checked. If any deferred constraints are violated, the transaction is rolled back. Finally, all locks opened by the transaction are released. The SQL standard dictates that transactions are *implicitly opened* when one of the following statements is executed:

- `ALTER`
- `CLOSE`
- `COMMIT AND CHAIN`
- `CREATE`
- `DELETE`
- `DROP`
- `FETCH`
- `FREE LOCATOR`
- `GRANT`
- `HOLD LOCATOR`
- `INSERT`
- `OPEN`
- `RETURN`

- `REVOKE`
- `ROLLBACK AND CHAIN`
- `SELECT`
- `START TRANSACTION`
- `UPDATE`

So, even if you did not explicitly open a transaction when you issued one of the commands listed here, the standard dictates that the DBMS platform opens a transaction for you.

MySQL

MySQL supports `COMMIT` and two transaction-safe engines, InnoDB and NDB Cluster, using this syntax:

```
COMMIT [WORK] [AND [NO] CHAIN] [[NO] RELEASE]
```

The `RELEASE` keyword directs MySQL to close the current client connection once the current transaction is complete. `NO CHAIN` and `NO RELEASE` are the default behavior.

Oracle

Oracle supports the standard, but not the `AND [NO] CHAIN` clause. It also provides some extensions to the standard clause. Oracle's `COMMIT` syntax is:

```
COMMIT [WORK] [ {COMMENT 'text' | FORCE 'text'[, int]} ]
```

where:

`COMMENT '`*`text`*`'`
: Associates a comment with the current transaction. `'`*`text`*`'` is a literal string up to 255 characters long. The text string is stored in the Oracle data dictionary view *DBA_2PC_PENDING* with the transaction ID, in case the transaction rolls back.

`FORCE '`*`text`*`' [, `*`int`*`]`
: Allows an in-doubt distributed transaction to be manually committed. `'`*`text`*`'` is a literal string that identifies the local or global transaction ID, which can be found by querying the Oracle data dictionary view *DBA_2PC_PENDING*. The optional *`int`* parameter is an integer that explicitly assigns a system change number (SCN) to the transaction. Without *`int`*, the transaction commits using the current SCN.

  Issuing a `COMMIT` statement with the `FORCE` clause will commit only the transaction explicitly identified in the `FORCE` clause. It will not affect the current transaction unless it is explicitly identified. The `FORCE` clause is not usable in PL/SQL statements.

The following example commits a transaction while associating a comment with the transaction:

```
COMMIT WORK COMMENT 'In-doubt transaction, Call (949) 555-1234';
```

PostgreSQL

PostgreSQL implements the following syntax:

```
COMMIT [WORK | TRANSACTION] [AND [NO] CHAIN]
```

In PostgreSQL, both the `WORK` and `TRANSACTION` keywords are optional. When you issue a `COMMIT`, all open transactions are written to disk and the results of those transactions then become visible to other users. For example:

```
INSERT INTO sales VALUES('7896','JR3435','Oct 28 1997',25,
   'Net 60','BU7832');
COMMIT WORK;
```

SQL Server

SQL Server does not support the `AND [NO] CHAIN` clause. It supports the keyword `TRANSACTION` as an equivalent to `WORK`, and it supports a `DELAYED_DURABILTY` setting. The syntax is as follows:

```
COMMIT { [TRAN[SACTION] [transaction_name]] | [WORK]
   [ WITH ( DELAYED_DURABILITY = { OFF | ON } ) ] }
```

SQL Server allows the creation of a specific, named transaction using the `START TRANSACTION` statement (discussed later in this chapter). The `COMMIT TRANSACTION` syntax allows you to specify an explicit named transaction to close, or to store a transaction name in a variable. Curiously, SQL Server ignores *`transaction_name`* when doing a commit. The *`transaction_name`* is only useful as a programming documentation tool to clarify which `COMMIT` goes with which `BEGIN`.

The `COMMIT WORK` statement causes SQL Server to terminate all open transactions and write their changes to the database. You *may not* specify a transaction name when using `COMMIT WORK`.

When you set `DELAYED_DURABILITY` to `ON`, SQL Server runs the transaction commits asynchronously, reporting success before the logs are written to disk. The `DELAYED_DURABILITY` transaction setting is ignored when this setting is `DISABLED` or `FORCED` at the database or system level, (using the following syntax):

```
ALTER DATABASE ... SET DELAYED_DURABILITY = { DISABLED | ALLOWED |
   FORCED }
```

`FORCED` means `DELAYED_DURABILITY` is set to `ON` and `DISABLED` means `DELAYED_DURABILITY` is set to `OFF`. The default behavior when this is not set is `OFF`.

See also

- ROLLBACK
- START TRANSACTION

DELETE Statement

The DELETE statement erases records from a specified table or tables. DELETE statements acting against tables are sometimes called *search deletes*. The DELETE statement may also be used in conjunction with a cursor. DELETE statements acting upon the rows of a cursor are also called *positional deletes*.

Platform	Command
MySQL/MariaDB	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
DELETE FROM { table_name | ONLY (table_name) }
[FOR PORTION OF application_time_period_name
   FROM point_in_time_1 TO point_in_time_2]
[ [AS] correlation_name ]
[{ WHERE search_condition | WHERE CURRENT OF cursor_name }]
```

Keywords

FROM { *table_name* | ONLY (*table_name*) }
: Identifies the table (called *table_name*) from which rows will be deleted. The current schema is assumed if one is not specified. You may alternatively specify a single table view name. FROM is mandatory, except in the DELETE ... WHERE CURRENT OF statement. When not using the ONLY clause, do not enclose the *table_name* in parentheses. ONLY restricts cascading of the deleted records to any subtables of the target table or view. This clause affects only typed (object-oriented) tables and views. If used with a non-typed table or view, it is ignored and does not cause an error.

FOR PORTION OF *application_time_period_name* FROM *point_in_time_1* TO *point_in_time_2*
: This clause can only be used for system-versioned tables with time periods defined. *application_time_period_name* identifies the time period that will be used for filtering. *point_in_time_1* defines the beginning of the time period and *point_in_time_2* defines the end.

[AS] *correlation_name*
: An alias for the *table_name* that should be used in the *search_condition*.

`WHERE` *`search_condition`*

Defines search criteria for the `DELETE` statement, using one or more *`search_condition`* clauses to ensure that only the target rows are deleted. Any legal `WHERE` clause is acceptable. Typically, these criteria are evaluated against each row of the table before the deletion occurs. In the case of versioned tables and in the absence of a `FOR PORTION OF` clause, there is an implicit `AND` *`endcol`* `=` *`endval`* clause added, where *`endcol`* refers to the name of the period end column and *`endval`* is the highest allowed value of a table. This ensures that only current state data is deleted and not prior history data.

`WHERE CURRENT OF` *`cursor_name`*

Restricts the `DELETE` statement to the current row of a defined and open cursor called *`cursor_name`*.

Rules at a glance

The `DELETE` statement erases rows from a table or view. The space released will be returned to the database where the table is located, though this may not happen immediately. Keep in mind, however, that the SQL standard is mute about releasing space—that's an implementation detail.

A simple `DELETE` statement that erases all records in a given table has no `WHERE` clause, as in the following:

```
DELETE FROM sales;
```

You can use any valid `WHERE` clause to filter records that you do not want to delete. All three of the following examples are valid `DELETE` statements, and since all are search deletes, they all include the `FROM` clause:

```
DELETE FROM sales
WHERE qty IS NULL;

DELETE FROM suppliers
WHERE supplierid = 17
   OR companyname = 'Tokyo Traders';

DELETE FROM distributors
WHERE postalcode IN
   (SELECT territorydescription FROM territories);
```

Note that in a positional delete, the `FROM` clause is not required.

In some cases, you may wish to delete a specific row that is being processed by a declared and open cursor:

```
DELETE titles WHERE CURRENT OF title_cursor;
```

This query assumes that you have declared and opened a cursor named *title_cursor*; whichever row the cursor is on will be deleted when the command is executed.

MariaDB, Oracle, and SQL Server support system-versioned tables, but only MariaDB supports defining application time periods.

Programming tips and gotchas

It is rare to issue a DELETE statement without a WHERE clause because this results in *all* rows being deleted from the affected table. You should first issue a SELECT statement with the same WHERE clause you intend to use in the DELETE statement. That way, you can be sure exactly which records will be deleted.

If it becomes necessary to remove all the rows in a table, you should consider using the nonstandard though very common TRUNCATE TABLE statement (described later in this chapter). In those databases that support the command, TRUNCATE TABLE is usually a faster method to physically remove all rows because the deletion of individual records is not logged. The reduction of logging overhead saves considerable time when erasing a large number of records, but on some platforms this makes rollback of a TRUNCATE statement impossible. Furthermore, on some database platforms all foreign keys on the table must be dropped before issuing a TRUNCATE statement. TRUNCATE does not fire triggers.

MySQL and MariaDB

MySQL's DELETE syntax provides a number of extensions to the SQL standard, but it does not support the WHERE CURRENT OF clause. The syntax is shown here:

```
DELETE [LOW_PRIORITY] [QUICK][IGNORE] [table_name[.*][, ...]]
{FROM table_name[.*][, ...] | [USING table_name[.*][, ...]]}
[PARTITION (partition_name[, ...])]
[WHERE search_condition]
[ORDER BY clause]
[LIMIT nbr_of_rows]
```

MariaDB supports all the syntax of MySQL plus a returning clause, which is detailed in "RETURNING Clause" on page 403:

```
DELETE [LOW_PRIORITY] [QUICK][IGNORE] [table_name[.*][, ...]]
{FROM table_name[.*][, ...] | [USING table_name[.*][, ...]]}
[PARTITION (partition_name[, ...] )]
[FOR PORTION OF application_time_period_name
   FROM point_in_time_1 TO point_in_time_2]
[WHERE search_condition]
[order_by_clause]
[LIMIT nbr_of_rows]
[returning_clause]
```

MariaDB also provides the following syntax for deleting periods of time from a system-versioned table:

```
DELETE HISTORY
FROM table_name
```

```
    [PARTITION (partition_name[, ...])]
    [BEFORE SYSTEM_TIME [TIMESTAMP | TRANSACTION] expression]
```

The parameters are:

`LOW_PRIORITY`
: Delays the execution of `DELETE` until no other clients are reading from the table. This is useful for storage engines that employ table locking for deletes, such as MyISAM and Aria.

`QUICK`
: Prevents the storage engine from merging index leaves during the `DELETE` operation.

`IGNORE`
: Signals to continue with the operation even if noncritical errors arise. For example, if you have referential integrity in place between two tables and you try to delete records from the primary table, `IGNORE` will cause the `DELETE` operation to skip over records in the primary table that have related records in another table. If `IGNORE` is not specified, then the whole `DELETE` transaction fails.

`DELETE` *`table_name`*`[.*][, ... ]`
: Enables you to delete from more than one table at a time. Tables listed before the `FROM` clause, assuming one or more tables appear in the `FROM` clause, will be the target of the `DELETE` operation. That is, if more than one table appears before the `FROM` clause, all matching records in all of the tables will be deleted. (The `.*` clause is an option to improve compatibility with MS Access.)

`FROM` *`table_name`*`[.*]`
: Specifies the table or tables from which records will be deleted. If tables are listed before the `FROM` clause, the table or tables in the `FROM` clause are assumed to be used to support a join or lookup operation.

`USING` *`table_name`*`[.*][, ... ]`
: Substitutes the table or tables before the `FROM` clause with those after the `FROM` clause.

`order_by_clause`
: Specifies the order in which rows will be deleted. This is useful only in conjunction with `LIMIT`.

`LIMIT` *`nbr_of_rows`*
: Places an arbitrary cap on the number of records deleted before control is passed back to the client.

MySQL allows deletion from more than one table at a time. For example, the following two `DELETE` statements are functionally equivalent:

```
DELETE orders FROM customers, orders
WHERE customers.customerid = orders.customerid
   AND orders.orderdate BETWEEN '20150101' AND '20151231';

DELETE FROM orders USING customers, orders
WHERE customers.customerid = orders.customerid
   AND orders.orderdate BETWEEN '20150101' AND '20151231';
```

In the preceding examples, we delete all orders made by customers during the year 2015. Note that you cannot use `ORDER BY` or `LIMIT` clauses in a multi-table `DELETE` like those just shown.

You can also delete records in orderly batches using the `ORDER BY` clause in conjunction with the `LIMIT` clause:

```
DELETE FROM sales
WHERE customerid = 'TORTU'
ORDER BY customerid
LIMIT 5
```

MySQL exhibits several behaviors that speed up `DELETE` operations. For example, it normally returns the number of records deleted when it completes the operation, but it will return zero as the number of deleted records when you delete all records from a table because it is faster to do so than to count the actual number of rows deleted. In `AUTOCOMMIT` mode, MySQL will even substitute a `TRUNCATE` statement for a `DELETE` statement without a `WHERE` clause because `TRUNCATE` is faster.

Note that the speed of a MySQL `DELETE` operation is directly related to the number of indexes on the table and the available index cache. You can speed up `DELETE` operations by executing the command against tables with few or no indexes or by increasing the size of the index cache.

Oracle

Oracle allows you to delete rows from tables, views, materialized views, nested subqueries, partitioned views, and tables. Its `DELETE` syntax is as follows:

```
DELETE [FROM]
   {table_name | ONLY (table_name)} [alias]
      [{PARTITION (partition_name) |
       SUBPARTITION (subpartition_name)}] |
   (subquery [WITH {READ ONLY |
      CHECK OPTION [CONSTRAINT constraint_name]}]) |
   TABLE (collection_expression) [ (+) ]}[hint]
[WHERE search_condition]
[RETURNING expression[, ...] INTO variable[, ...]]
[LOG ERRORS [INTO [schema.]table_name] [(simple_expression)]
[REJECT LIMIT {UNLIMITED |int}]]
```

The parameters are:

`table_name [alias]`
: Specifies the table, view, materialized view, or partitioned table or view from which the records will be deleted. You may optionally prepend a schema identifier to the *table_name* or append a database link. Otherwise, Oracle will assume the user's default schema and the local database server. You may also optionally apply an *alias* to the *table_name*. The alias is required if the target table references an object type attribute or method.

`PARTITION partition_name`
: Applies the `DELETE` operation to the named partition, rather than to the entire table. You are not required to name a partition when deleting from a partitioned table, but it can, in many cases, help reduce the complexity of the `WHERE` clause.

`SUBPARTITION subpartition_name`
: Applies the operation to a named subpartition, rather than to the entire table.

`(subquery [WITH {READ ONLY | CHECK OPTION [CONSTRAINT constraint_name]}])`
: Specifies that the target for deletion is a nested subquery, not a table, view, or other database object. The parameters of this clause are:

    `subquery`
    : Describes the `SELECT` statement that makes up the subquery. The subquery can be any standard subquery, though it may not contain an `ORDER BY` clause.

    `WITH READ ONLY`
    : Specifies that the *subquery* cannot be updated.

    `WITH CHECK OPTION [CONSTRAINT constraint_name]`
    : Tells Oracle to abort any changes to the deleted table that would not appear in the result set of the subquery. `[CONSTRAINT constraint_name>]` directs Oracle to further restrict changes based upon a specific constraint identified by *constraint_name*.

`TABLE (collection_expression) [ (+) ]`
: Informs Oracle that the *collection_expression* should be treated like a table even though it may, in fact, be a subquery, a function, or some other collection constructor. In any case, the value returned by the *collection_expression* must be a nested table or `VARRAY`.

`hint`
: Instructs the database to use specific optimizer instructions other than those it might choose for itself; for example, to use or ignore a specific index. Refer to the vendor documentation for a full discussion of hints.

`RETURNING` *`expression`*
: Retrieves the rows affected by the command (`DELETE` normally only shows the number of rows deleted). The `RETURNING` clause can be used when the target is a table, a materialized view, or a view with a single base table. When used for single-row deletes, the `RETURNING` clause stores values from the row deleted by the statement, defined by *`expression`*, into PL/SQL variables and bind variables. When used for a multi-row delete, the `RETURNING` clause stores the values of the deleted rows, defined by *`expression`*, into bind arrays.

`INTO` *`variable`*
: Specifies the variables into which the values returned as a result of the `RETURNING` clause are stored. There must be a corresponding *`variable`* for every *`expression`* in the `RETURNING` clause.

`LOG ERRORS [INTO [`*`schema.`*`]`*`table_name`*`] [(`*`simple_expression`*`)] [REJECT LIMIT {UNLIMITED |`*`int`*`}]`
: Captures DML errors and log column values of affected rows, saving them in an error-logging table. Constraint violations will always cause the statement to fail and roll back, regardless of whether you specify a `LOG ERRORS` clause. The `LOG ERRORS` clause also cannot track errors in the error-logging table for columns with `LONG`, `LOG`, or object-type columns, though the table that is the target of the DML operation may have columns of these data types. The parameters of this clause are:

  `INTO [`*`schema.`*`]`*`table_name`*
  : Specifies the error-logging table. When omitted, the default is *ERR$_xxx*, where *xxx* is the first 25 characters of the name of the table from which the records are being deleted.

  `(simple_expression)`
  : Specifies a value that tags each error in the logging table so that you can differentiate errors from many DML statements.

  `REJECT LIMIT {UNLIMITED |` *`int`*`}`
  : Specifies an upper limit for the number of errors to be logged (*`int`*) before terminating the `DELETE` and rolling back any changes. The default is 0. The `UNLIMITED` keyword allows error logging with no upper limit.

When you execute a `DELETE` statement, Oracle releases space from the target table (or the base table of a target view) back to the table or index that owned the data.

When deleting from a view, the view cannot contain a set operator, the `DISTINCT` keyword, joins, an aggregate function, an analytic function, a subquery in the `SELECT` list, a collection expression in the `SELECT` list, a `GROUP BY` clause, an `ORDER BY` clause, a `CONNECT BY` clause, or a `START WITH` clause.

Here's an example where we delete records from a remote server:

```
DELETE FROM scott.sales@chicago;
```

In the following query, we delete from a derived table that is a collection expression:

```
DELETE TABLE(SELECT contactname FROM customers
   c WHERE c.customerid = 'BOTTM') s
WHERE s.region IS NULL OR s.country = 'MEXICO';
```

Here's an example where we delete from a partition:

```
DELETE FROM sales PARTITION (sales_q3_1997)
WHERE qty > 10000;
```

Finally, in the next example, we use the `RETURNING` clause to look at the values that are deleted:

```
DELETE FROM employee
WHERE job_id = 13
  AND hire_date + TO_YMINTERVAL('01-06') =< SYSDATE;
RETURNING job_lvl
INTO :int01;
```

This example deletes records from the *employee* table and returns the *job_lvl* values into the predefined *:into1* variable.

For more information on the `RETURNING` clause, see "RETURNING Clause" on page 403.

PostgreSQL

PostgreSQL uses the `DELETE` command to remove rows and any defined subclasses from the table. Its implementation is otherwise identical to the SQL standard, with a few extensions:

```
[WITH [RECURSIVE] cte_expression[, ...]]
DELETE [FROM] [ONLY] [schema.]table_name
[ USING usinglist ]
[ WHERE search_condition | WHERE CURRENT OF cursor_name ]
[ RETURNING { * | expression [AS alias][, ...] } ]
```

When deleting rows from only the table specified, use the optional `ONLY` clause. Otherwise, PostgreSQL will also delete records from any explicitly defined subtable. PostgreSQL supports a few other important subclauses:

`WITH [RECURSIVE] cte_expression[, ... ]]`
: Defines the temporary named result set of a common table expression, derived from `SELECT/DELETE/INSERT/UPDATE` statements, for the `DELETE` statement. If the CTEs have `INSERT/DELETE/UPDATE` clauses, these need to also have `RETURNING` clauses.

`USING` *`usinglist`*

Specifies a list of table expressions, thereby allowing columns from other tables to appear in the `WHERE` clause. This has the same effect as specifying multiple tables in the `FROM` clause of a `SELECT` statement.

`RETURNING { * |` *`expression`* `[AS` *`alias`*`][, ... ] }`

Specifies an expression to be returned by the `DELETE` statement after each row is deleted. The *`expression`* can return all columns (using the `*` wildcard) or any columns you specify that are in *`table_name`* or in the *`usinglist`*.

The following statement deletes all records in the *authors* table where the *royaltyper* value in *titleauthor* is `40` and returns the deleted rows, including the *title_id* from *titleauthor* of related records that were deleted. This example also demonstrates aliasing the table names:

```
DELETE FROM authors AS au
USING titleauthor AS ta
WHERE au.au_id = ta.au_id AND ta.royaltyper = 40
RETURNING au.*, ta.title_id;
```

This example deletes all records in one table based on the results of a subquery against another table (in this case, erasing from the *titleauthor* table the records that have a match concerning "computers" in the *titles* table):

```
DELETE FROM titleauthor
WHERE title_id IN
  (SELECT title_id
  FROM titles
  WHERE title LIKE '%computers%')
```

And here we delete all records in a table and return the full details of the deleted rows:

```
DELETE FROM titles WHERE ytd_sales IS NULL RETURNING *;
```

SQL Server

SQL Server allows records to be deleted both from tables and from views that describe a single table. SQL Server also allows a second `FROM` clause to allow `JOIN` constructs, as in the following example:

```
[WITH cte_expression[, ...]]
DELETE [TOP ( number ) [PERCENT]] [FROM] table_name [[AS] alias]
[WITH ( hint [...] )]
[OUTPUT expression INTO {@table_variable | output_table}
 [ (column_list[, ...]) ]]
[FROM table_source[, ...]]
[ [{INNER | CROSS | [LEFT | RIGHT | FULL] OUTER}]
   JOIN joined_table ON condition][, ...] ]
[WHERE search_condition | WHERE CURRENT OF [GLOBAL] cursor_name]
[OPTION ( hint[, ...n] )]
```

The syntax elements are as follows:

`WITH` *`cte_expression`*
: Defines the temporary named result set of a common table expression, derived from a `SELECT` statement, for the `DELETE` statement.

`DELETE` *`table_name`*
: Allows the deletion of records from the named table or view filtered by the `WHERE` clause. You can delete records from a view, provided the view is based on one table and contains no aggregate functions and no derived columns. If you omit the server name, database name, or schema name when naming the table or view, SQL Server assumes the current context. An `OPENDATASOURCE` or `OPENQUERY` function, as described in "SELECT Statement" on page 305, may be referenced instead of a table or view.

`TOP (` *`number`* `) [PERCENT]`
: Indicates that the statement should delete only the specified *`number`* of rows. If `PERCENT` is specified, only the first *`number`* percent of the rows are retrieved. If *`number`* is an expression, such as a variable, it must be enclosed in parentheses. The expression should be of the `FLOAT` data type with a range of 0 to 100 when using `PERCENT`. When not using `PERCENT`, the *`number`* should be of the `BIGINT` data type.

`WITH (` *`hint`* `)`
: Instructs the database to use specific optimizer instructions other than those it might choose for itself; for example, to use or ignore a specific index. The `WITH (` *`hint`* `)` clause specifies one or more table hints that are allowed for the target table. Refer to the vendor documentation for a full discussion of hints.

`OUTPUT` *`expression`* `INTO {@`*`table_variable`* `|` *`output_table`*`} [ (`*`column_list`*`[, ... ]) ]`
: Retrieves the rows affected by the command, whereas `DELETE` normally only shows the number of rows deleted, placing the rows you specify in *`expression`* into either a given *`table_variable`* or *`output_table`*. If the *`column_list`* is omitted for the *`output_table`*, the *`output_table`* must have the same number of columns as the number of columns in the `OUTPUT` expression. The *`output_table`* cannot have triggers, participate in a foreign key, or have any `CHECK` constraints.

`FROM` *`table_source`*
: Names an additional `FROM` clause that correlates records from the table in the first `FROM` clause using a `JOIN` rather than forcing you to use a correlated subquery. One or more tables may be listed in the second `FROM` clause.

`[{INNER | CROSS | [LEFT | RIGHT | FULL] OUTER}] JOIN` *`joined_table`* `ON` *`condition`*`][, ... ]`
: Specifies one or more `JOIN` clauses, in conjunction with the second `FROM` clause. You may use any of the join types that SQL Server supports. Refer to "JOIN Subclause" on page 278 for more information.

`GLOBAL` *`cursor_name`*
: Specifies that the `DELETE` operation should occur on the current row of an open global cursor. This clause is otherwise the same as the standard `WHERE CURRENT OF`.

`OPTION (` *`hint`*`[, ... ] )`
: Replaces elements of the default query plan with your own. Because the optimizer usually picks the best query plan for any query, we strongly discourage you from placing optimizer hints into your queries.

A significant extension in SQL Server's implementation of the `DELETE` statement is the addition of a second `FROM` clause. The second `FROM` allows the use of the `JOIN` statement and makes it quite easy to delete rows from the table specified in the first `FROM` by correlating rows of a table declared in the second `FROM`. For example, you could use a rather complex subquery to erase all the *sales* records of computer books with this command:

```
DELETE sales
WHERE title_id IN
   (SELECT title_id
    FROM titles
    WHERE type = 'computer')
```

But SQL Server allows a more elegant construction using a second `FROM` clause and a `JOIN` clause:

```
DELETE s
FROM sales AS s
INNER JOIN titles AS t ON s.title_id = t.title_id
   AND type = 'computer'
```

The following example deletes all rows with an *order_date* of 2012 or earlier, in batches of 2,500:

```
WHILE 1 = 1
BEGIN
  DELETE TOP (2500)
  FROM sales_history WHERE order_date <= '20120101'
  IF @@rowcount < 2500 BREAK
END
```

Common table expressions may be used with SELECT, INSERT, UPDATE, and DELETE statements as well as the CREATE VIEW statement. These expressions are a means of naming and defining a temporary result set from a SELECT statement, even allowing recursive behaviors. When defining a CTE, you may not use COMPUTE, COMPUTE BY, FOR XML, FOR BROWSE, INTO, OPTION, or ORDER BY clauses (see "WITH Clause" on page 352 for further details). Multiple SELECT statements are allowed in a WITH clause only if they are combined with set operators such as UNION, UNION ALL, EXCEPT, or INTERSECT. The following is a simple DELETE statement using a common table expression:

```
WITH direct_reports (Manager_ID, DirectReports) AS
( SELECT manager_ID, COUNT(*)
   FROM hr.employee AS e
   WHERE manager_id IS NOT NULL
   GROUP BY manager_id )
DELETE FROM direct_reports
WHERE DirectReports <= 1;
```

The OUTPUT clause allows you to see all of the rows that are being deleted:

```
DELETE TOP 10 error_log WITH (READPAST)
OUTPUT deleted.*
WHERE error_log_id = '28-OCT-2008';
```

See also

- INSERT
- RETURNING
- SELECT in Chapter 4
- TRUNCATE TABLE
- UPDATE
- VALUES in Chapter 4
- WHERE in Chapter 4
- WITH in Chapter 4

INSERT Statement

The INSERT statement adds rows of data to a table or view through one of several methods:

- One or more rows can be inserted using the DEFAULT values specified for a column via the CREATE TABLE or ALTER TABLE statements.
- The actual values to be inserted into each column of the record can be declared (this is the most common method).
- The result set of a SELECT statement can be inserted into a table or view, populating it with many records simultaneously.

All the databases we discuss also allow bulk loading data from a file, but each does it with vendor-specific syntax. We will include these bulk loading statements in this section even though they are not SQL-standard.

Platform	Command
MySQL/MariaDB	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
INSERT INTO {table_name | view_name} [(column1[, ...])]
[OVERRIDING {SYSTEM | USER} VALUE]
{DEFAULT VALUES | VALUES [ROW]
   ({value1 | DEFAULT}[, ...])[, [ROW] (value1[, ...])] |
   select_statement}
```

Keywords

`{table_name | view_name} [(column1[, ... ])]`
: Declares the updatable target table or view into which the records will be inserted. You must have `INSERT` privileges on the table or, at a minimum, on the columns that will receive the inserted values. If no schema information is included, as in *scott.employee*, the current schema and user context are assumed. You may optionally include a list of the columns in the target table or view that will receive data.

`OVERRIDING {SYSTEM | USER} VALUE`
: `OVERRIDING SYSTEM VALUE` requires the `SYSTEM` keyword when inserting a literal *`value`* into a column that would otherwise be given a system-generated value, such as an autogenerated sequence number. The `OVERRIDING USER VALUE` clause does the converse, by inserting system-supplied values even if a user has provided literal values to insert.

`DEFAULT VALUES`
: Inserts all values declared via the `DEFAULT` column characteristic on the target table where they exist, and NULLs where they do not exist. (Of course, the `DEFAULT` column characteristic can specify NULL as a value, too.) This operation inserts a single record. It might encounter an error, depending on how the `PRIMARY KEY` constraint or `UNIQUE` constraint is constructed on the target table (assuming such constraints exist).

`VALUES [ROW] ({value1| DEFAULT}[, ... ]) [, ... ]`
: Specifies the actual value(s) to be inserted into the target table. The number of values must match the exact number of columns in the column list, if one is provided. Furthermore, the data types and sizes of the values must be compatible with the columns of the target table. Each value in the value list corresponds to the column with the same ordinal number in the column list. Thus, the first column will get its data from the first value, the second column from the second value, and so on until all columns are satisfied. In the case

of a multivalue constructor, each value set must be separated by commas and enclosed in parentheses. You may also optionally use the keywords `DEFAULT` to insert a column's default value and `NULL` to insert a NULL value. `ROW` is noise but is required by some databases.

`select_statement`
: Inserts rows retrieved via the specified `SELECT` statement into the target table or view. The values retrieved by the fully formed `SELECT` statement's item list correspond directly to the columns of the column list. The target table or view may not be referenced in the `SELECT` statement's `FROM` or `JOIN` clauses.

Rules at a glance

You may insert values into tables, and into views built upon a single source table. The `INSERT ... VALUES` statement adds one or more rows of data to a table, using literal values supplied in the statement. In the following example, a new row in the *authors* table is inserted for the author *Jessica Rabbit*:

```
INSERT INTO authors (au_id, au_lname, au_fname, phone,
   address, city, state, zip, contract)
VALUES ('111-11-1111', 'Rabbit', 'Jessica', DEFAULT,
   '1717 Main St', NULL, 'CA', '90675', 1)
```

Every column in the table is assigned a specific, literal value except the *phone* column, which is assigned the default value (as defined in the `CREATE TABLE` or `ALTER TABLE` statement), and the *city* column, which is set to NULL.

You can use a multivalue constructor to insert more than one row as follows:

```
INSERT INTO authors (au_id, au_lname, au_fname, phone,
   address, city, state, zip, contract)
VALUES ('111-11-1111', 'Rabbit', 'Jessica', DEFAULT,
    '1717 Main St', NULL, 'CA', '90675', 1),
   ('211-11-1111', 'Jones', 'James', DEFAULT,
    '1717 Mission St', NULL, 'CA', '90674', 1)
```

It's important to remember that you may skip columns in the table and set them to NULL, assuming they allow NULL values. Inserts that leave some columns NULL are called *partial `INSERT`s*. Here is a partial `INSERT` that performs the same work as the preceding example:

```
INSERT INTO authors (au_id, au_lname, au_fname, phone, contract)
VALUES ('111-11-1111', 'Rabbit', 'Jessica', DEFAULT, 1)
```

The `INSERT` statement, combined with a nested `SELECT` statement, allows a table to be quickly populated with one or more rows from the result set of the `SELECT` statement. For example, to load data from the *sales_new* table into the *sales* table:

```
INSERT INTO sales (stor_id, ord_num, ord_date, qty,
   payterms, title_id)
SELECT
   CAST(store_nbr AS CHAR(4)),
   CAST(order_nbr AS VARCHAR(20)),
   order_date,
   quantity,
   SUBSTRING(payment_terms,1,12),
   CAST(title_nbr AS CHAR(1))
FROM new_sales
WHERE order_date >= '01-JAN-2022'
-- Retrieve only the newer records
```

You must specify the columns in the table that will receive data by enclosing their names in parentheses, in a comma-delimited list. This *`column_list`* can be omitted, but all columns that are defined for the table are then assumed, in their ordinal positions. Any column with an omitted value will be assigned its default value (according to any `DEFAULT` column setting on the table) or, if no `DEFAULT` column setting exists, NULL. The columns in the column list may be in any order, but you may not repeat any column in the list. Furthermore, the columns and their corresponding *`value`* entries must agree in terms of data type and size.

The first of the following two examples leaves off the column list, while the second uses only `DEFAULT` values:

```
INSERT INTO authors
VALUES ('111-11-1111', 'Rabbit', 'Jessica', DEFAULT,
   '1717 Main St', NULL, 'CA', '90675', 1);

INSERT INTO temp_details
DEFAULT VALUES
```

The first statement will succeed only if all the values in the value list correspond correctly with the data types and size limitations of the columns of the target table. Any inconsistencies will generate an error. The second statement will succeed only as long as defaults have been declared for the columns of the target table, or those columns allow NULL values.

Executing an `INSERT` statement without a column list is a "worst practice," since the statement may fail if the target table ever changes.

Programming tips and gotchas

`INSERT` statements will *always* fail under the following circumstances:

- When a data type mismatch occurs between a column and its value
- When a column is defined as `NOT NULL` and the insertion value is `NULL`
- When a duplicate value is inserted into a `UNIQUE` or `PRIMARY KEY` constraint
- When the inserted values do not meet the requirements of a `CHECK` constraint

- When an inserted value is constrained by a FOREIGN KEY constraint because the value is not derived from the declared primary key of another table

The most common error encountered when executing INSERT statements is a mismatch between the number of columns and the number of values. If you accidentally leave out a value that corresponds to a column, you are likely to encounter an error that will cause the statement to fail.

INSERT statements also fail when an inserted value is of a data type that is a mismatch with the column of the target table. For example, an attempt to insert a string like '*Hello World*' into an integer column would fail. On the other hand, some database platforms automatically and implicitly convert certain data types. For example, SQL Server will automatically convert a date value to a character string for insertion into a VARCHAR column.

Another common problem encountered with the INSERT statement is a size mismatch between a value and its target column. For example, inserting a long string into a CHAR(5) target column or inserting a very large integer into a TINYINT column can cause problems. Depending on the platform you are using, the size mismatch may cause an outright error and rollback of the transaction, or the database server may simply trim the extra data. Either result is undesirable. Similarly, a problem can arise when an INSERT statement attempts to insert a NULL value into a target column that does not accept NULLs.

Most problems with INSERT statements occur because the programmer does not know the target table very well. Make sure you understand the target table or view before writing elaborate INSERT statements.

MySQL and MariaDB

MySQL supports several INSERT syntax options that have helped to foster this platform's reputation for high speed. The value list ROW keyword is optional:

```
INSERT [LOW_PRIORITY | DELAYED | HIGH_PRIORITY] [IGNORE]
[INTO] [[database_name.]owner.]table_name
   [(column1[, ...])]
[PARTITION (partition_name[, partition_name] ...)]
{VALUES | VALUE ( [ROW] {value1 | DEFAULT}[, ...] )
   [, [ROW](,...)] |
   select_statement SET [ON DUPLICATE KEY UPDATE]
      column1=value1, column2=value2[, ...]}
```

MariaDB 10.5 and later support a RETURNING clause, which MySQL does not (described in "RETURNING Clause" on page 403). The syntax for MariaDB is as follows:

```
INSERT [LOW_PRIORITY | DELAYED | HIGH_PRIORITY] [IGNORE]
[INTO] [[database_name.]owner.]table_name
```

```
      [(column1[, ...])]
   [PARTITION (partition_name[, partition_name] ...)]
   {VALUES | VALUE ( [ROW] {value1 | DEFAULT}[, ...] )
      [, [ROW](,...)] |
      select_statement SET [ON DUPLICATE KEY UPDATE]
         column1=value1, column2=value2[, ...]}
   [RETURNING select_expr[, select_expr ...]]
```

where:

`LOW_PRIORITY | DELAYED | HIGH_PRIORITY`
: Defers the execution of `INSERT` until no other clients are reading from the table, for `LOW_PRIORITY`. This may result in a long wait. `LOW_PRIORITY` should not be used with MyISAM tables because it disables concurrent inserts. The `DELAYED` keyword allows the client to continue immediately, even if the `INSERT` has not yet completed. `DELAYED` is ignored with `INSERT ... SELECT` and `INSERT ... ON DUPLICATE`. `HIGH_PRIORITY` merely overrides the effect of servers running in `LOW_PRIORITY` mode; it does not otherwise boost priority (or processing speed) for queries running normally.

`IGNORE`
: Directs MySQL not to attempt to insert records that would duplicate a value in a primary key or unique index; without this clause, the `INSERT` will fail if such duplication occurs. If a duplicate is encountered while the `IGNORE` clause is in use, the duplicate records are ignored while all the other records are inserted.

`PARTITION (partition_name[, ... ])]`
: Only relevant for partitioned tables, this clause is used to explicitly specify what partitions can be inserted into. This reduces the work of the planner as it means it doesn't need to consider all partitions of a table for insert.

`SET column=value`
: An alternate syntax that allows you to specify values for target columns by name.

`ON DUPLICATE KEY UPDATE`
: Causes an `INSERT` operation that would create a duplicate value in a primary key or unique index to update the value of the existing row.

Additionally, for loading data from a delimited file, MySQL offers a `LOAD DATA` statement:

```
LOAD DATA
   [LOW_PRIORITY | CONCURRENT] [LOCAL]
   INFILE 'file_name'
   [REPLACE | IGNORE]
   INTO TABLE table_name
   [PARTITION (partition_name [, partition_name] ...)]
   [CHARACTER SET charset_name]
   [{FIELDS | COLUMNS}
      [TERMINATED BY 'delimiter_character']
```

```
         [[OPTIONALLY] ENCLOSED BY 'quote_character']
         [ESCAPED BY 'char']
      ]
      [LINES
         [STARTING BY 'delimiter_character']
         [TERMINATED BY 'delimiter_character']
      ]
      [IGNORE int {LINES | ROWS}]
      [(col_name_or_user_var[, col_name_or_user_var] ...)]
      [SET column1=value1, column2=value2[, ...]]
```

The MariaDB variant of `LOAD DATA` is the same as MySQL's, but lacks the `PARTITION` clause:

```
   LOAD DATA
      [LOW_PRIORITY | CONCURRENT] [LOCAL]
      INFILE 'file_name'
      [REPLACE | IGNORE]
      INTO TABLE table_name
      [CHARACTER SET charset_name]
      [{FIELDS | COLUMNS}
         [TERMINATED BY 'delimiter_character']
         [[OPTIONALLY] ENCLOSED BY 'quote_character']
         [ESCAPED BY 'char']
      ]
      [LINES
         [STARTING BY 'delimiter_character']
         [TERMINATED BY 'delimiter_character']
      ]
      [IGNORE int {LINES | ROWS}]
      [(col_name_or_user_var[, col_name_or_user_var] ...)]
      [SET column1=value1, column2=value2[, ...]]
```

where:

`LOW_PRIORITY | CONCURRENT`
: Only relevant for storage engines that perform table locking (MyISAM, MEMORY, and MERGE). `LOW_PRIORITY` waits until no clients are connected to the table before performing the insert. `CONCURRENT` does inserts concurrently with other connections and can only be used with MyISAM. These terms are mutually exclusive.

`LOCAL`
: Loads the data from the client's filesystem instead of the server's, which is the default behavior for MySQL and MariaDB.

`INFILE '`*`file_name`*`'`
: Specifies the name of the input file to load.

`[REPLACE | IGNORE]`
: In the event of a duplicate key violation, indicates whether to replace the existing record or skip the row to be inserted.

`CHARACTER SET '`*`charset_name`*`'`
: Specifies the encoding of the data in the data file.

`TERMINATED BY = '`*`delimiter_character`*`'`
: Specifies the delimiter character for each column in a line of text. The default is the tab (*t*) character.

`[OPTIONALLY] ENCLOSED BY = '`*`quote_character`*`'`
: Defines the character to use for quoting column data. The `OPTIONALLY` allows for the data to be unquoted.

`ESCAPED BY '`*`char`*`'`
: Defines the character to use to escape the `ENCLOSED BY` or `TERMINATED BY` characters.

`IGNORE `*`int`*` [LINES|ROWS]`
: Declares the number of rows to skip before inserting. For data with a header row, *`int`* should be 1 or higher.

MySQL does *not* support the SQL-standard `OVERRIDING` clause.

MySQL additionally supports a statement called `REPLACE` with similar syntax to `INSERT` that overwrites existing values rather than discarding rows that are duplicates.

Oracle

Oracle's implementation of the `INSERT` statement allows data insertion into a given table, view, partition, subpartition, or object table. It also supports additional extensions such as inserting records into many tables at once and conditional inserts. The syntax is:

```
-- Standard INSERT statement
INSERT [INTO] {table_name
   [ [SUB]PARTITION { (prtn_name) | (key_value) } ] |
   (subquery) [WITH {READ ONLY | CHECK OPTION
      [CONSTRAINT constr_name]}] |
   TABLE (collection) [ (+) ] } [alias]
   [(column1[, ...])]
{VALUES (value1[, ...]) [RETURNING expression1[, ...]
   INTO variable1[, ...]] |
   select_statement [WITH {READ ONLY |
      CHECK OPTION [CONSTRAINT constr_name]}]}
-- Conditional INSERT statement
INSERT {[ALL | FIRST]} WHEN condition
   THEN standard_insert_statement
```

```
ELSE standard_insert_statement
[LOG ERRORS [INTO [schema.]table_name] [( expression )]
   [REJECT LIMIT {int | UNLIMITED}]]
```

where:

`INSERT [INTO]`
: Inserts one or more rows into a single table, view, materialized view, or subquery. The `INTO` keyword is optional. You insert a single row using the `VALUES` clause and many rows using a *`subquery`*.

`table_name` `[ [SUB]PARTITION { (`*`prtn_name`*`) | (`*`key_value`*`) } ]`
: Identifies the target into which you will insert data. The target may be a table, view, materialized view, or subquery. To enable you to fully qualify the target, *`table_name`* can expand to `[`*`schema`*`.]`*`table_name`*`[@`*`db_link`*`]`. You may optionally identify the schema and remote address (via `@`*`db_link`*) of the target, but the current schema and local database are assumed if you do not otherwise specify them. You may also optionally identify the `PARTITION` or `SUBPARTITION` (through the *`prtn_name`* parameter or a *`key_value`* for a hash partition or subpartition) into which the record(s) will be inserted, as long as the target is not an object table or object view.

`subquery`
: Instructs Oracle to insert records into the base table or tables of the *`subquery`*, where the *`subquery`* is a normally formed `SELECT` statement. Essentially, you're using a subquery to construct a view on the fly, and the effect is the same as inserting into a view. This is the primary means for inserting values into multiple tables at one time. All of the columns defined by the subquery, across all tables, must have a corresponding value to insert, or a failure will occur. Multi-table inserts must use the subquery format. The following options apply when using subqueries:

  `WITH READ ONLY`
  : Indicates that the subqueried table or view cannot be updated until the statement completes.

  `WITH CHECK OPTION [CONSTRAINT `*`constr_name`*`]`
  : Indicates that you cannot insert into the table or view rows that would not pass the *`constr_name`* check constraint.

  `TABLE (`*`collection`*`) [ (+) ] } [`*`alias`*`]`
  : Directs Oracle that the *`collection`* should be treated like a standard target (i.e., a table or view), whether it be a subquery, a column, a function, or a collection constructor. In any event, the table collection must return a nested table or `VARRAY` set of values. Since constructions can be very long, you can provide an optional *`alias`*. Aliases are not allowed in multi-table insert operations.

`(`*`column1`*`[, ... ])`
: Specifies the target column(s) into which data will be inserted. If you leave off the list of columns, Oracle assumes that the `VALUES` clause or columns of the subquery will perfectly match the columns of the target. Oracle will return an error if you do not insert a value for any columns marked as `NOT NULL` that do not have defined default values.

`VALUES (`*`value1`*`[, ... ]) [RETURNING `*`expression1`*`[, ... ] INTO` *`variable1`*`[, ... ]]`
: Inserts values into the target table or tables. As with the SQL standard, there must be a matching value for every column, though the value can be `DEFAULT` or, if the column accepts NULLs, the literal `NULL`. `DEFAULT` is not allowed when inserting into a view. On multi-table insert operations, the `VALUES` clause must return a corresponding value for every item in the `SELECT` list of the subquery. The syntax is as follows:

  `RETURNING` *`expression1`*
  : Retrieves the rows inserted by the operation. The *`expression`* returned by the statement is often a value being inserted, but it may be another value. For example, you might use the `RETURNING` clause to find the value of an automatically generated primary key. Single-row operations store the results into host variables or PL/SQL variables, while multi-row operations store them in bind arrays. You can use `RETURNING` against tables, views with a single base table, and materialized views. The `RETURNING` clause is not allowed with multi-table insert operations.

  `INTO` *`variable1`*
  : Specifies the variables that will hold the values returned as a result of the `RETURNING` clause. You must declare a corresponding host variable or PL/SQL variable for each expression in the `RETURNING` clause. You cannot use the `INTO` clause to hold a `LONG` data type, with remote objects, on views that have `INSTEAD OF` triggers, or with parallel `INSERT`, `UPDATE`, or `DELETE` statements.

`ALL`
: Performs a multi-table `INSERT`. `ALL` is used only with the *`subquery`* format. Without a `WHEN` clause, `ALL` unconditionally inserts all the data retrieved by the subquery into the tables defined. With a `WHEN` clause, `ALL` performs conditional insert operations that tell Oracle to evaluate all `WHEN` clauses regardless of the results of any other `WHEN` operation. Each time a `WHEN` clause evaluates as `TRUE`, Oracle executes the corresponding `INTO` clause. Multi-table inserts are not parallelized on index-organized tables or bitmap-indexed tables. They are not allowed at all when:

  - The target is a view or materialized view.
  - The target is a remote table.

- The `INSERT` command uses a `TABLE` collection expression.
- The table needs more than 999 total target columns.
- The subquery uses a sequence.

`FIRST`
: Tells Oracle to evaluate the `WHEN` clauses in order and, when it finds the first `TRUE` expression, to execute the corresponding `INTO` clause and skip all other `WHEN` clauses.

`WHEN` *`condition`* `THEN` *`standard_insert_statement`*
: Sets a *`condition`* and, when the condition is `TRUE`, executes the `THEN` insert clause. The value of *`condition`* is evaluated for each column returned in the result set of the subquery. Up to 127 `WHEN` clauses are allowed.

`ELSE` *`standard_insert_statement`*
: Executes when no `WHEN` clause evaluates as `TRUE`.

`LOG ERRORS [INTO [`*`schema.`*`]`*`table_name`*`] [(` *`expression`* `)] [REJECT LIMIT {`*`int`* `| UNLIMITED}]`
: Captures DML errors and logs column values of the affected rows into an error-logging table. `INTO` specifies the name of the error-logging table. When omitted, Oracle inserts the affected rows into a table with a name of *ERR$_* prepended to the first 25 characters of the table name. *`expression`* is a literal string or general SQL expression (such as `TO_CHAR(SYSDATE)`) that you want inserted into the error-logging table. `REJECT LIMIT` allows an upper limit for the total number of errors allowed before terminating the DML operation and rolling back the transaction. (Note that you cannot track errors for `LONG`, `LOB`, or object type columns.)

Oracle allows the standard `INSERT` operations as described in the SQL implementation section, such as `INSERT ... SELECT` and `INSERT ... VALUES`. However, it has a great many special variations.

When inserting into tables that have assigned sequences, be sure to use the *`<sequence_name>.nextval`* function call to insert the next logical number in the sequence. For example, assume you want to use the *authors_seq* sequence to set the value of *au_id* when inserting a new row into the *authors* table. You can do this as follows:

```
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES (authors_seq.nextval, 'Rabbit', 'Jessica', 1)
```

When retrieving values during an `INSERT` operation, check for a one-to-one match between the expressions in the `RETURNING` clause and the variables of the `INTO` clause. The expressions returned by the clause do not necessarily have to be those mentioned in the `VALUES` clause. For example, the following `INSERT` statement places a record into the *sales* table, but places a completely distinct value into a bind variable:

```
INSERT authors (au_id, au_lname, au_fname, contract )
VALUES ('111-11-1111', 'Rabbit', 'Jessica', 1)
RETURNING hire_date INTO :temp_hr_dt;
```

Notice that the `RETURNING` clause returns the *hire_date* even though *hire_date* is not one of the values listed in the `VALUES` clause. (In this example, it is reasonable to assume a default value was established for the *hire_date* column.)

An unconditional multi-table `INSERT` statement into a lookup table that contains a list of all the approved *jobs* in the company looks like this:

```
INSERT ALL
   INTO jobs(job_id, job_desc, min_lvl, max_lvl)
   VALUES(job_id, job_desc, min_lvl, max_lvl)
   INTO jobs(job_id+1, job_desc, min_lvl, max_lvl)
   VALUES(job_id, job_desc, min_lvl, max_lvl)
   INTO jobs(job_id+2, job_desc, min_lvl, max_lvl)
   VALUES(job_id, job_desc, min_lvl, max_lvl)
   INTO jobs(job_id+3, job_desc, min_lvl, max_lvl)
   VALUES(job_id, job_desc, min_lvl, max_lvl)
SELECT job_identifier, job_title, base_pay, max_pay
FROM   job_descriptions
WHERE  job_status = 'Active';
```

And just to make things more complex, Oracle allows multi-table `INSERT` statements that are conditional:

```
INSERT ALL
   WHEN job_status = 'Active'     INTO jobs
   WHEN job_status = 'Inactive'   INTO jobs_old
   WHEN job_status = 'Terminated' INTO jobs_canceled
   ELSE INTO jobs
SELECT job_identifier, job_title, base_pay, max_pay
FROM   job_descriptions;
```

Note that in the preceding example, you would have to follow each `INTO` clause with a `VALUES` clause if you were skipping `NOT NULL` columns in the target table. The following example shows this syntax:

```
INSERT FIRST
   WHEN job_status = 'Active'
      INTO jobs
      VALUES(job_id, job_desc, min_lvl, max_lvl)
   WHEN job_status = 'Inactive'
      INTO jobs_old
      VALUES(job_id, job_desc, min_lvl, max_lvl)
   WHEN job_status = 'Terminated'
      INTO jobs_canceled
      VALUES(job_id, job_desc, min_lvl, max_lvl)
   WHEN job_status = 'Terminated'
```

```
      INTO jobs_outsourced
      VALUES(job_id, job_desc, min_lvl, max_lvl)
   ELSE INTO jobs
      VALUES(job_id, job_desc, min_lvl, max_lvl)
SELECT job_identifier, job_title, base_pay, max_pay
FROM   job_descriptions;
```

Notice that in this example, the `FIRST` clause also directs Oracle to execute the first occurrence of *`job_status = 'Terminated'`* by inserting the records into the *jobs_canceled* table and skipping the *jobs_outsourced* `INSERT` operation.

Oracle allows you to insert data into a table, partition, or view (also known as the *target*) using either a regular or a *direct-path `INSERT`* statement. In a regular insert, Oracle maintains referential integrity and reuses free space in the target. In a direct-path insert, Oracle appends data at the end of the target table without filling in any free space gaps elsewhere in the table. This method bypasses the buffer cache and writes directly to the datafiles; hence the term "direct path."

Oracle allows the use of hints to circumvent default query optimization for `INSERT` statements. For example, you can use the `APPEND` hint to ensure that an `INSERT` uses a direct-path approach. Refer to the platform documentation for more details on hints that are usable with `INSERT`.

The direct-path approach enhances performance on long, multi-record insert operations. However, if any of the following are true, Oracle will perform a regular `INSERT` instead of a direct-path `INSERT`:

- The data in the target is altered with an `UPDATE` or `DELETE` statement before the `INSERT` statement, in a single transaction. (`UPDATE` and `DELETE` are allowed after the direct-path `INSERT` statement.)
- The `INSERT` statement is or may become distributed.
- The target contains a `LOB` or object data type column.
- The target has a clustered index or index-organized table.
- The target has triggers or referential integrity constraints.
- The target is replicated.
- The `ROW_LOCKING` initialization parameter is set to `INTENT`.

In addition, Oracle will not allow you to query (e.g., using `SELECT`) a table later in the same transaction after you perform a direct-path `INSERT` into that table until a `COMMIT` has been performed.

Oracle allows you to use parallel direct-path inserts into multiple tables, but you may only use subqueries to insert the data into the tables, not a standard `VALUES` clause.

Inserting LOBs and BFILEs is tricky. You should initialize such values to NULL before inserting. RAW columns are also tricky. If you insert a regular string into a RAW column, all future queries against the column will be forced to use a table scan.

Oracle has no SQL construct specifically for loading data from delimited files; however, you can create an external table that links to a file on the filesystem, and then use the standard INSERT statement from the SELECT of the external table.

PostgreSQL

PostgreSQL supports the SQL standard for the INSERT statement, except for the OVERRIDING clause. It also has added support for a RETURNING clause and WITH clause (common table expressions):

```
[WITH cte_expression[, ...]]
INSERT INTO table_name [(column1[, ...])]
{[DEFAULT] VALUES | VALUES {(value1[, ...]) | DEFAULT} |
   select_statement}
[ ON CONFLICT
   [ ( { index_column_name | ( index_expression ) }
      [ COLLATE collation ] [ opclass ][, ...] )
      [ WHERE index_predicate ]
      ON CONSTRAINT constraint_name ]
   DO NOTHING
   DO UPDATE SET { column_name = { expression | DEFAULT } |
      ( column_name[, ...] ) =
         [ ROW ] ( { expression | DEFAULT } [, ...] ) |
      ( column_name[, ...] ) = ( select_statement )
[ON ALL SERVER]  }[, ...]
    WHERE condition ]
]
[RETURNING { * | column_value [AS output_name][, ...] }]
```

where:

`(column1>[, ... ])`
: Identifies one or more columns in the target table. The list must be enclosed in parentheses, and commas must separate each item in the list. SQL Server automatically provides values for IDENTITY columns, TIMESTAMP columns, and columns with DEFAULT constraints.

`DEFAULT`
: Tells the INSERT statement simply to create a new record using all of the default values specified for the target table.

`ON CONFLICT ...`
: ON CONFLICT is an optional clause that specifies an alternative action to raising a unique violation or exclusion constraint violation error. For each individual

row for insertion, either the insertion happens or, in the event of a primary key or unique key violation, the alternative `DO NOTHING` OR `DO UPDATE` action is taken. `ON CONFLICT DO NOTHING` skips insertion of the row. `ON CONFLICT DO UPDATE` updates the existing row that conflicts with the row proposed for insertion.

`RETURNING { * | `*`column_value`*` [AS `*`output_name`*`][, ... ] }`
: Retrieves the rows inserted by the operation. You may return all columns using an asterisk (`*`), or one or more specific columns of the table with the heading *`output_name`*. For example, you might use the `RETURNING` clause to find the value of an automatically generated primary key.

For copying from delimited files and outputs of programs to a table, PostgreSQL offers a `COPY FROM` statement:

```
COPY table_name [ ( column_name[, ...] ) ]
   FROM { 'filename' | PROGRAM 'command' | STDIN }
   [ [ WITH ] ( option[, ...] ) ]
   [ WHERE condition ]
```

where:

`WITH `*`option`*`[, ... ]`
: Allows for controlling the behavior of reads. Valid options are:

  `FORMAT `*`format_name`*
  : Specifies the format of data to be read. *`format_name`* options are *text*, *csv*, or *binary*, with *text* being the default if not specified.

  `FREEZE [ `*`boolean`*` ]`
  : Indicates whether to copy the data with rows frozen. `COPY FREEZE` cannot be performed on a partitioned table.

  `DELIMITER '`*`delimiter_character`*`'`
  : Specifies the delimiter character for columns in a line of text. When not specified, it defaults to the tab character for text format and a comma for CSV.

  `NULL '`*`null_string`*`'`
  : Specifies a string that denotes a NULL value. Only one is allowed, and it will be converted to NULL on insert.

  `HEADER [ `*`boolean`*` ]`
  : Indicates whether the first line of the file or program output is a header and should be skipped for insertion. The default is `TRUE`.

  `QUOTE '`*`quote_character`*`'`
  : Defines the character to use for quoting. When not specified, it defaults to the double quote.

`ESCAPE '`*`escape_character`*`'`
: Specifies the character that should appear before the *`quote_character`* when that character appears in a data value, so that it displays correctly.

`FORCE_QUOTE { (` *`column_name`*`[, ... ] ) | * }`
: Forces quoting of non-NULL column values for certain columns.

`FORCE_NOT_NULL (` *`column_name`*`[, ... ] )`
: Prevents matching of certain columns' values against NULL.

`FORCE_NULL (` *`column_name`*`[, ... ] )`
: Matches certain columns' values against NULL, even when quoted.

`ENCODING '`*`encoding_name`*`'`
: Specifies the encoding of the file. When not specified it defaults to the encoding of the database.

There is also a companion `COPY TO` for exporting data to a flat file, which we will not cover but has a similar syntax. An alternative way to load data from a flat file is to use the *file_fdw* foreign data wrapper extension and create a foreign table that points to the file. The foreign table convention for *file_fdw* is very similar in options to `COPY FROM`, with the added benefit of being able to query the file like any other table.

PostgreSQL attempts to perform automatic data type coercion when the expressions in the `VALUE` clause or the `SELECT` item list of a subquery do not match the data types defined for the target table or view.

Here is an example that attempts to add a new row and does nothing in the event of failure:

```
INSERT INTO titleauthor(au_id, title_id, au_ord, royaltyper)
VALUES('409-56-7008','BU1032', 1, 60 )
ON CONFLICT DO NOTHING;
```

Here is the same insert that on key violation updates all the values except the keys:

```
INSERT INTO titleauthor(au_id, title_id, au_ord, royaltyper)
VALUES('409-56-7008','BU1032', 1, 60 )
ON CONFLICT (au_id, title_id) DO UPDATE
   SET au_ord = EXCLUDED.au_ord,
      royaltyper = EXCLUDED.royaltyper;
```

Finally, this version does the same but also returns the changed values:

```
INSERT INTO titleauthor(au_id, title_id, au_ord, royaltyper)
VALUES('409-56-7008','BU1032', 1, 60 )
ON CONFLICT (au_id, title_id) DO UPDATE
   SET au_ord = EXCLUDED.au_ord,
       royaltyper = EXCLUDED.royaltyper
RETURNING *;
```

SQL Server

SQL Server supports a few extensions to the SQL standard for INSERT. Specifically, it supports several rowset functions (explained later), as well as the capability to insert the results from stored procedures and extended procedures directly into the target table. SQL Server's syntax is:

```
[WITH cte_expression[, ...]]
INSERT [TOP ( number ) [PERCENT]]
[INTO] table_name [(column1[, ...])]
[OUTPUT expression INTO {@table_variable | output_table}
   [ (column_list[, ...]) ]]
{[DEFAULT] VALUES | VALUES (value1[, ...]) | select_statement |
   EXEC[UTE] proc_name [[@param =] value] [OUTPUT] [, ...]]}
```

SQL Server also supports a variant for copying from files, BULK INSERT:

```
BULK INSERT table_name FROM 'data_file'
[ WITH (
   [ [ , ] BATCHSIZE = batch_size ]
   [ [ , ] CHECK_CONSTRAINTS ]
   [ [ , ] CODEPAGE = { 'ACP' | 'OEM' | 'RAW' | 'code_page' } ]
   [ [ , ] DATAFILETYPE =
      { 'char' | 'native'| 'widechar' | 'widenative' } ]
   [ [ , ] DATA_SOURCE = 'data_source_name' ]
   [ [ , ] ERRORFILE = 'file_name' ]
   [ [ , ] ERRORFILE_DATA_SOURCE = 'data_source_name' ]
   [ [ , ] FIRSTROW = first_row ]
   [ [ , ] FIRE_TRIGGERS ]
   [ [ , ] FORMATFILE_DATA_SOURCE = 'data_source_name' ]
   [ [ , ] KEEPIDENTITY ]
   [ [ , ] KEEPNULLS ]
   [ [ , ] KILOBYTES_PER_BATCH = kilobytes_per_batch ]
   [ [ , ] LASTROW = last_row ]
   [ [ , ] MAXERRORS = max_errors ]
   [ [ , ] ORDER ( { column [ ASC | DESC ] }[, ...n] ) ]
   [ [ , ] ROWS_PER_BATCH = rows_per_batch ]
   [ [ , ] ROWTERMINATOR = 'row_terminator' ]
   [ [ , ] TABLOCK ]

   -- input file format options
   [ [ , ] FORMAT = 'CSV' ]
   [ [ , ] FIELDQUOTE = 'quote_characters']
   [ [ , ] FORMATFILE = 'format_file_path' ]
   [ [ , ] FIELDTERMINATOR = 'field_terminator' ]
   [ [ , ] ROWTERMINATOR = 'row_terminator' ]
)]
```

For BULK INSERT, the number of columns and order of data in the file must match the database table structure.

Options for both types of INSERT are as follows:

`WITH` *`cte_expression`*
: Defines the temporary named result set of a common table expression, derived from a `SELECT` statement, for the `INSERT` statement.

`WITH` *`bulk_insert_options`*
: Itemizes options for bulk insert behavior. Most commonly used are:

  `FORMAT 'CSV'`
  : Specifies that the input file is a CSV file.

  `FIELDQUOTE = '`*`quote_character`*`'`
  : Defines the character to use for quoting character.

  `FORMATFILE ='`*`format_file_path`*`'`
  : Provides the path to a format file usually generated by using the *bcp* utility on the table or view. Allows for skipping columns or having a different column order in the file than in the table.

  `FIELDTERMINATOR = '`*`delimiter_character`*`'`
  : Specifies the delimiter character for each column in a line of text. The default is the tab (`\t`) character.

  `ROWTERMINATOR = '`*`delimiter_character`*`'`
  : Specifies the delimiter character for each row. The default is the newline (*\r\n*) character.

  `FIRSTROW =` *`int`*
  : Indicates the number of the first row of data to load. For files with headers, you should set this to 2 or higher.

  `CODEPAGE = '`*`codepage_value`*`'`
  : Specifies the code page of the data in the data file.

`[BULK] INSERT [INTO]` *`table_name`*
: Identifies the insertion target (a table, view, or rowset function). When inserting into a view, an `INSERT` cannot affect more than one of the base tables in the view, if there are more than one. Rowset functions allow SQL Server to source data from special or external data sources such as XML streams, full-text search file structures (a special structure in SQL Server used to store things like MS Word documents and MS PowerPoint slideshows within the database), or external data sources (such as an MS Excel spreadsheet). Examples are shown later in this section. Rowset functions SQL Server supports for the `INSERT` statement include:

  `OPENQUERY`
  : Executes a pass-through `INSERT` against a linked server. This is an effective means of performing a nested `INSERT` against a data source that is external to SQL Server. The data source must first be declared as a linked server.

OPENROWSET
: Executes a pass-through INSERT statement against an external data source. This is similar to OPENDATASOURCE, except that OPENDATASOURCE only opens the data source; it does not actually pass through an INSERT statement. OPENROWSET is intended for occasional, ad hoc usage only.

TOP (*number*) [PERCENT]
: Indicates that the statement should insert only the specified *number* of rows. If PERCENT is specified, only the first *number* percent of the rows are inserted. If *number* is an expression, such as a variable, it must be enclosed in parentheses. The expression should be of the FLOAT data type with a range of 0 to 100 when using PERCENT. When not using PERCENT, the value of *number* should conform to the rules for the BIGINT data type.

(*column1*[, ...])
: Identifies one or more columns in the target table. The list must be enclosed in parentheses, and commas must separate each item in the list. SQL Server automatically provides values for IDENTITY columns, TIMESTAMP columns, and columns with DEFAULT constraints.

OUTPUT *expression* INTO {@*table_variable* | *output_table*} [(*column _list*[, ...])]
: Retrieves the rows affected by the command (whereas INSERT normally only shows the number of rows affected), placing the rows you specify in *expression* into either a given *table_variable* or *output_table*. If the *column_list* is omitted for the *output_table*, the *output_table* must have the same number of columns as the target table. The *output_table* cannot have triggers, participate in a foreign key constraint, or have any CHECK constraints.

DEFAULT
: Tells the INSERT statement simply to create a new record using all of the default values specified for the target table.

EXEC[UTE] *proc_name* [[@*param* =] *value*] [OUTPUT][, ...]]
: Directs SQL Server to execute a dynamic Transact-SQL statement, a stored procedure, a remote procedure call (RPC), or an extended stored procedure and store the results in a local table. *proc_name* is the name of the stored procedure you wish to execute. You may optionally include any of the parameters of the stored procedure, as identified by @*param* (the at sign is required), assign a *value* to the parameter, and optionally designate the parameter as an OUTPUT parameter. The columns returned by the result set must match the data types of the columns in the target table.

Although SQL Server automatically assigns values to IDENTITY columns and TIMESTAMP columns, it does not do so for UNIQUEIDENTIFIER columns. Columns of either of the former data types can simply be skipped in the *column* and *value* lists. However, you cannot do that with a UNIQUEIDENTIFIER column. Instead, you must use the NEWID() function to obtain and insert a globally unique ID (GUID):

```
INSERT INTO guid_sample (global_ID, sample_text,
   sample_int)
VALUES (NEWID(), 'insert first record','10000')
GO
```

When migrating between platforms, remember that inserting an empty string ('') into a SQL Server TEXT or VARCHAR column results in a zero-length string being stored. This is not the same as a NULL value, as some platforms interpret it. When inserting into a table using the INSERT ... SELECT variant, WITH hints are allowed on the subquery as long as you do not use READPAST, NOLOCK, and READUNCOMMITTED.

The following example illustrates the INSERT ... EXEC statement. It first creates a temporary table called *#ins_exec_container*. Then, the first INSERT operation retrieves a listing of the *c:\temp* directory and stores it in the temporary table, while the second INSERT executes a dynamic SELECT statement:

```
CREATE TABLE #ins_exec_container (result_text
   VARCHAR(300) NULL)
GO
INSERT INTO #ins_exec_container
EXEC master..xp_cmdshell "dir c:\temp"
GO
INSERT INTO sales
EXECUTE ('SELECT * FROM sales_2002_Q4')
GO
```

This functionality can be very useful when you want to build business logic using Transact-SQL stored procedures; for example, to determine the state of objects in or outside of the database and then act on those results using Transact-SQL.

SQL Server allows the use of hints to circumvent default query optimization for INSERT statements. However, this type of tuning is recommended only for the most advanced users. Refer to the vendor documentation for more details on hints that are usable with INSERT.

Common table expressions may be used with SELECT, INSERT, UPDATE, and DELETE statements, as well as the CREATE VIEW statement. CTEs offer a means of naming and defining a temporary result set from a SELECT statement, even allowing recursive behaviors (see "WITH Clause" on page 352 for details). When defining a CTE, you may not use the COMPUTE, COMPUTE BY, FOR XML, FOR BROWSE, INTO, OPTION, or ORDER BY clauses. Multiple SELECT statements are allowed in a CTE only if they are combined with set operators such as UNION, UNION ALL, EXCEPT, or INTERSECT.

The following is a simple DELETE statement using a common table expression:

```
WITH direct_reports (Manager_ID, DirectReports) AS
( SELECT manager_ID, COUNT(*)
   FROM hr.employee AS e
   WHERE manager_id IS NOT NULL
   GROUP BY manager_id )
DELETE FROM direct_reports
WHERE DirectReports <= 1;
```

Performing an INSERT that shows what records and column values were inserted is easy using the OUTPUT clause:

```
INSERT hr.employee
   OUTPUT INSERTED.employee_id, INSERTED.employee_lname,
   INSERTED.employee_fname
   INTO @my_temporary_table_variable
VALUES ('Insert Error', GETDATE() );
```

See also

- DELETE
- MERGE
- RETURNING
- SELECT in Chapter 4
- UPDATE
- WITH in Chapter 4

MERGE Statement

The MERGE statement is sort of like a CASE statement for DML operations. It combines UPDATE and INSERT statements into a single atomic statement with either/or functionality. MERGE examines the records of a source table and a target table. If the records exist in both tables, the records in the target table are updated with the values of the records in the source table, based upon predefined conditions. Records that exist in the source table but not the target table are inserted into the target table.

Platform	Command
MySQL	Not supported
Oracle	Supported, with variations
PostgreSQL	Not supported
SQL Server	Supported, with variations

SQL standard syntax

```
MERGE INTO {object_name | subquery} [ [AS] alias ]
USING table_reference [ [AS] alias ]
ON search_condition
WHEN MATCHED
```

```
      THEN {UPDATE SET column = {expression | DEFAULT}
         [, ...] | DELETE}
   WHEN NOT MATCHED
      THEN INSERT [(column[, ...])]
         VALUES (expression[, ...])
```

Keywords

`MERGE INTO {object_name | subquery}`
: Declares the target object of the merge operation. The target object may be a table or updatable view of *`object_name`*, or it may be a nested table subquery.

`[AS] alias`
: Provides an optional alias for the target table.

`USING table_reference`
: Declares the source table, view, or subquery of the merge operation.

`ON search_condition`
: Specifies the condition (or conditions) on which a match between the source and target table is evaluated. The syntax is essentially the same as for the `ON` subclause of the `JOIN` clause (discussed in Chapter 4). For example, when merging records from the *new_hire_emp* table into the *emp* table, the clause might look like `ON emp.emp_id = new_hire_emp.emp_id`.

`WHEN MATCHED THEN UPDATE SET column = {expression | DEFAULT}[, ... ] | DELETE`
: Declares that if a record from the source table has a matching record in the target table (based on the *`search_condition`*), one or more specified columns of the target table should be updated with the indicated value of *`expression`* or deleted.

`WHEN NOT MATCHED THEN INSERT [(column[, ... ])] VALUES (expression[, ... ])`
: Declares that if a record from the source table does not have a matching record in the target table (based on the *`search_condition`*), a new record should be inserted into the target table using one or more specified columns with the value of *`expression`*.

Rules at a glance

The rules for using `MERGE` are straightforward:

- The `WHEN MATCHED` and `WHEN NOT MATCHED` clauses are required, but may not be specified more than once.
- The target table can be a standard updatable table, an updatable view, or an updatable subquery.
- If the *`table_reference`* is a subquery, enclose it in parentheses.

- The *search_condition* clause should not contain any references to stored procedures or user-defined functions.
- The *search_condition* clause may contain multiple elements using the AND or OR operators.
- If the column list is omitted from the WHEN NOT MATCHED clause, a column list of all the columns in the target table, in ordinal position, is assumed.

Other important rules used by the MERGE statement are self-evident. For example, the columns referenced in the WHEN MATCHED clause must be updatable.

Programming tips and gotchas

The MERGE statement is sometimes nicknamed the "upsert" statement. This is because it allows, in a single operation, a set of records to be either inserted into a table or, if they already exist, updated with new values. The only tricky aspect of the MERGE statement is getting used to the idea of the either/or processing of the INSERT and UPDATE statements.

Assume that we have two tables, *EMP* and *NEW_HIRE*. The *EMP* table contains all employees of the company who have successfully completed the mandatory 90-day probationary period at the start of their employment. Employees in the *EMP* table can also have several statuses, such as *active*, *inactive*, and *terminated*. Any new hire to the company is recorded in the *NEW_HIRE* table. After 90 days, they are moved into the *EMP* table like all other regular employees. However, since our company hires college interns every summer, it's very likely that some of our new hires will actually have a record in the *EMP* table from last year with a status of *inactive*. Using pseudocode, the business problem is summarized as:

```
For each record in the NEW_HIRE table
   Find the corresponding record in the EMP table
   If the record exists in the EMP table
      Update existing data in the EMP table
   Else
      Insert this record into the EMP table
   End If
End For
```

We could write a rather lengthy stored procedure that would examine all the records in the *NEW_HIRE* table and then conditionally perform INSERT statements for the entirely new employees or UPDATE statements for the returning college interns. However, the following MERGE statement makes this process much easier:

```
MERGE INTO emp AS e
   USING (SELECT * FROM new_hire) AS n
   ON e.empno = n.empno
WHEN MATCHED THEN
   UPDATE SET
      e.ename  = n.ename,
      e.sal    = n.sal,
      e.mgr    = n.mgr,
      e.deptno = n.deptno
WHEN NOT MATCHED THEN
   INSERT ( e.empno, e.ename, e.sal, e.mgr, e.deptno )
   VALUES ( n.empno, n.ename, n.sal, n.mgr, n.deptno );
```

As you can see, the `MERGE` statement is very useful for data loading operations.

MySQL

MySQL does not support the `MERGE` statement. However, you may use the syntactically and functionally similar `REPLACE` statement to do the same thing as `MERGE`. MySQL also supports `ON DUPLICATE KEY UPDATE` for inserts, which achieves a similar purpose (see the discussion of this platform in "INSERT Statement" on page 376 for details).

Oracle

Oracle supports the `MERGE` statement with only the tiniest variations. Its syntax is as follows:

```
MERGE INTO [schema.]{object_name | subquery} [alias]
USING [schema.]table_reference [alias]
ON ( search_condition )
WHEN MATCHED THEN
  { UPDATE SET column = { expression | DEFAULT }[, ...] |
    DELETE [ search_condition ] }
WHEN NOT MATCHED THEN
   INSERT ( column[, ...] ) VALUES ( expression[, ...]
[LOG ERRORS [INTO [schema.]table_name] [( expression )]
   [REJECT LIMIT { int | UNLIMITED}]]
```

The differences between the SQL standard and Oracle's implementation include:

- The Oracle implementation does not allow the `AS` keyword when assigning an alias to the target or source table.
- Oracle requires parentheses around the *`search_condition`* clause.
- In Oracle the `WHEN NOT MATCHED` clause requires an `INSERT` column list, while the SQL standard makes this optional.

Oracle supports error logging on the `MERGE` statement, following the syntax `LOG ERRORS [INTO [`*`schema`*`.]`*`table_name`*`] [(`*`expression`*` )] [REJECT LIMIT { `*`int`*` | UNLIMITED }]`. This clause captures DML errors and logs column values of the affected rows into an error-logging table. `INTO` specifies the name of that table. When omitted, Oracle inserts the affected rows into a table with a name of *ERR$_* prepended to the first 25 characters of the table name. *`expression`* is a literal string or general SQL expression (such as `TO_CHAR(SYSDATE)`) that you want inserted into the error-logging table. `REJECT LIMIT` allows an upper limit for the total number of errors allowed before terminating the DML operation and rolling back the transaction. (Note that you cannot track errors for LONG, LOB, or object type columns.)

Refer to the examples in the earlier "Rules at a glance" and "Programming tips and gotchas" sections for more information.

PostgreSQL

PostgreSQL does not support the MERGE statement. However, it does support an INSERT ON CONFLICT clause that achieves a similar purpose (see the discussion of this platform in "INSERT Statement" on page 376 for details).

SQL Server

SQL Server supports its own distinctive variant of the MERGE statement. The syntax follows:

```
[WITH common_table_expression[, ...]]
MERGE [TOP ( number ) [PERCENT]]
[INTO] {object_name | subquery} [ [AS] alias ]
USING ( table_reference ) [ [AS] alias ]
ON search_condition
WHEN MATCHED
   THEN { UPDATE SET column = { expression | DEFAULT }
      [, ...] | DELETE }
WHEN NOT MATCHED [BY {[TARGET] | SOURCE}]
   THEN INSERT [(column[, ...])]
   [DEFAULT] VALUES ( expression[, ...] )
[OUTPUT expression [ INTO {@table_variable | output_table}
   [(column_list[, ...])] ]]
[OPTION (query_hint[,...])]
```

where:

`WITH` *`cte_expression`*
: Defines the temporary named result set of a common table expression, derived from a SELECT statement, for the DELETE statement.

`TOP (` *`number`* `) [PERCENT]`
: Indicates that the statement should insert only the specified *number* of rows. If PERCENT is specified, only the first *number* percent of the rows are inserted. If *number* is an expression, such as a variable, it must be enclosed in parentheses. The expression should be of the FLOAT data type with a range of 0 to 100 when using PERCENT. When not using PERCENT, the value of *number* should conform to the rules for the BIGINT data type.

`WHEN {[TARGET] | SOURCE} NOT MATCHED`
: Specifies the behavior of the transaction when a matching value is not discovered between the source and target tables. When neither keyword is specified, the TARGET behavior is assumed, so WHEN NOT MATCHED is equivalent to WHEN

TARGET NOT MATCHED. The WHEN SOURCE NOT MATCHED clause is for use with additional search conditions, all of which must be matched for the condition to be considered satisfied. Otherwise, you should use WHEN [TARGET] NOT MATCHED. You may have two WHEN SOURCE NOT MATCHED clauses that specify different conditions for a DELETE operation and an UPDATE operation.

OUTPUT *expression* INTO {@*table_variable* | *output_table*} [(*column_list*[, ...])]
: Retrieves the rows affected by the command (whereas MERGE normally only shows the number of rows affected), placing the rows you specify in *expression* into either a given *table_variable* or *output_table*. If the *column_list* is omitted for the *output_table*, the *output_table* must have the same number of columns as the target table. The *output_table* cannot have triggers, participate in a foreign key constraint, or have any CHECK constraints.

OPTION (*query_hint*[, ...])
: Specifies that optimizer hints are used to customize the way the SQL Server Database Engine processes the statement. Refer to the documentation for details.

The MERGE statement allows a few variations on simply specifying a column name to update or insert values into. The column may be {DELETED | INSERTED | *from_table_name*}.{* | *column_name*} or $ACTION ($ACTION is a keyword that outputs the actual INSERT, UPDATE, or DELETE statement used by the MERGE statement, depending on the action(s) it performs). SQL Server maintains the same *inserted* and *deleted* pseudotables that are used in triggers to maintain transactional consistency within the MERGE statement. Therefore, a column may be referenced in the OUTPUT clause using the *inserted* or *deleted* pseudotables. In addition, any AFTER triggers declared on the target table may fire according to the INSERT, UPDATE, or DELETE triggers defined upon it and the INSERT, UPDATE, or DELETE transaction initiated by the MERGE statement.

See also

- DELETE
- INSERT
- JOIN in Chapter 4
- SELECT in Chapter 4
- SUBQUERY in Chapter 4
- UPDATE

RELEASE SAVEPOINT Statement

The RELEASE SAVEPOINT statement removes the specified savepoint and any more recent savepoints in the current transaction.

Platform	Command
MySQL	Supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
RELEASE SAVEPOINT savepoint_name
```

Keywords

savepoint_name
: Represents a named savepoint (or target specification) created earlier in the transaction with the `SAVEPOINT` statement. The *savepoint_name* must be unique within the transaction.

Rules at a glance

Use the `RELEASE SAVEPOINT` statement within a transaction to destroy a named savepoint. Any savepoints that were created after the named savepoint will also be destroyed.

To illustrate the behavior of savepoints, the following example code inserts a few records, creates a savepoint named *first_savepoint*, and then releases it:

```
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('111-11-1111', 'Rabbit', 'Jessica', 1);
SAVEPOINT first_savepoint;
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('277-27-2777', 'Fudd', 'E.P.', 1);
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('366-36-3636', 'Duck', 'P.J.', 1);
RELEASE SAVEPOINT first_savepoint;
COMMIT;
```

In this example, the *first_savepoint* savepoint is destroyed and then all three records are inserted into the *authors* table.

In the next example, we perform the same action but with more savepoints:

```
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('111-11-1111', 'Rabbit', 'Jessica', 1);
SAVEPOINT first_savepoint;
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('277-27-2777', 'Fudd', 'E.P.', 1);
SAVEPOINT second_savepoint;
INSERT authors (au_id, au_lname, au_fname, contract)
VALUES ('366-36-3636', 'Duck', 'P.J.', 1);
SAVEPOINT third_savepoint;
```

```
RELEASE SAVEPOINT second_savepoint;
COMMIT;
```

Here, when we release the savepoint called *second_savepoint*, the database actually releases *second_savepoint* and *third_savepoint* since *third_savepoint* was created after *second_savepoint*.

Once released, a savepoint name can be reused.

Programming tips and gotchas

Issuing either a `COMMIT` or a full `ROLLBACK` statement will destroy all open savepoints in a transaction. Issuing a `ROLLBACK TO SAVEPOINT` statement returns the transaction to its state at the specified savepoint; any savepoints declared afterward are nullified.

MySQL

MySQL supports the SQL standard syntax.

Oracle

Oracle does not support the `RELEASE SAVEPOINT` statement.

PostgreSQL

PostgreSQL supports the SQL standard syntax, although the keyword `SAVEPOINT` is optional:

```
RELEASE [SAVEPOINT] savepoint_name
```

SQL Server

SQL Server does not support the `RELEASE SAVEPOINT` statement.

See also

- `ROLLBACK`
- `SAVEPOINT`

RETURNING Clause

The `RETURNING` clause can appear in an `INSERT`, `UPDATE`, or `DELETE` statement and is used to return a set of rows consisting of changed values or deleted values. Although it does not appear in the SQL standard, it is supported by many relational databases, so it can be considered a de facto standard.

Platform	Command
MySQL	Not supported
MariaDB	Supported, with limitations

Platform	Command
Oracle	Supported, with variations
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
RETURNING {* | column_name[,...]}
```

Keywords

`RETURNING {* | column_name[, ... ]}`
: Returns all columns (with `*`) or a specific set of columns (with *`column_name`*`[, ... ]`) of all records inserted, deleted, or updated, depending on whether the `RETURNING` clause appears in an `INSERT`, `DELETE`, or `UPDATE` statement.

Rules at a glance

`RETURNING` is used to return all or a subset of columns from inserted, updated, or deleted rows. The clause immediately follows other clauses in the `INSERT`, `UPDATE`, or `DELETE` statement.

MySQL and MariaDB

MySQL does not support the `RETURNING` clause. MariaDB supports it for `INSERT` (since version 10.5) and `DELETE` (since v10.1). It does not support `RETURNING` for the `UPDATE` clause, but does support it for the `REPLACE` clause (described in the discussion of this platform in "INSERT Statement" on page 376).

Oracle

Oracle supports the `RETURNING` clause with `INSERT`, `UPDATE`, and `DELETE`, but requires an `INTO` part. It also allows for returning aggregate values such as `SUM(`*`column_name`*`)`. Oracle's syntax is as follows:

```
RETURNING {* | column_name[,...]
[BULK COLLECT] INTO [row_variable | table_variable]
```

PostgreSQL

PostgreSQL supports the `RETURNING` clause with `INSERT`, `UPDATE`, and `DELETE`. In addition to returning changed columns of the changed table, it allows returning other columns from joined tables. Its syntax is as follows:

```
RETURNING {* | column_name| table_name.column_name[,...]
```

`RETURNING { * | expression [AS alias][, ... ] }`

Specifies an expression to be returned by the `DELETE/INSERT/UPDATE` statement after each row is actioned. The *`expression`* can return all columns (using the * wildcard) or any columns you specify that are present in the designated *`table_name`* or `DELETE` *`usinglist`*.

SQL Server

SQL Server does not support the `RETURNING` clause, but does support an `OUTPUT` clause. The syntax of `OUTPUT` allows for returning both original values and changed values instead of just changed values.

See also

- `DELETE`
- `INSERT`
- `UPDATE`

ROLLBACK Statement

The `ROLLBACK` statement undoes a transaction to its beginning or to a previously declared savepoint. `ROLLBACK` also closes any open cursors.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported
SQL Server	Supported, with variations

SQL standard syntax

```
ROLLBACK [WORK]
[AND [NO] CHAIN]
[TO SAVEPOINT savepoint_name]
```

Keywords

`WORK`

An optional keyword, but basically just noise.

`AND [NO] CHAIN`

Directs the DBMS to end the current transaction and to start a new transaction with the same characteristics as the previous transaction, such as transaction isolation level (`AND CHAIN`), or ends the transaction (`AND NO CHAIN`). Effectively, using `AND NO CHAIN` is the same as not including the clause at all.

`TO SAVEPOINT` *`savepoint_name`*

Allows the transaction to be rolled back to a named savepoint (that is, a partial rollback) rather than rolling back the entire transaction. The *`savepoint_name`* may be a literal expression or a variable. If there is no savepoint of *`save point_name`* active, the statement will return an error. When the `TO SAVEPOINT` clause is omitted, all cursors are closed. When the `TO SAVEPOINT` clause is included, only the cursors that were open within the savepoint are closed.

In addition to undoing a single data manipulation operation such as an `INSERT`, `UPDATE`, or `DELETE` statement (or a batch of them), the `ROLLBACK` statement undoes transactions up to the last issued `START TRANSACTION`, `SET TRANSACTION`, or `SAVEPOINT` statement.

Rules at a glance

`ROLLBACK` is used to undo a transaction. It can be used to undo explicitly declared transactions that are started with a `START TRANSACTION` statement or a transaction-initiating statement. It can also be used to undo implicit transactions that are started without a `START TRANSACTION` statement. `ROLLBACK` is mutually exclusive of the `COMMIT` statement.

Most people associate commands like `INSERT`, `UPDATE`, and `DELETE` with the term "transaction." However, transactions encompass a wide variety of commands. The list varies from platform to platform but generally includes any command that alters data or database structures and is logged to the database logging mechanism. According to the standard, all SQL statements can be undone with `ROLLBACK`.

Programming tips and gotchas

The most important gotcha to consider is that some database platforms perform automatic and *implicit* transactions, while others require *explicit* transactions. If you assume a platform uses one method instead of the other, you may get bitten. Thus, when moving between database platforms, you should follow a standard, preset way of addressing transactions. We recommend an explicit approach, using `SET TRANSACTION` or `START TRANSACTION` to begin a transaction and `COMMIT` or `ROLLBACK` to end a transaction.

MySQL

MySQL supports a simple and direct rollback mechanism, as well as the SQL standard `CHAIN` keyword:

```
ROLLBACK [WORK] [AND [NO] CHAIN]
[[NO] RELEASE] TO [SAVEPOINT] savepoint_name
```

The optional `RELEASE` clause allows you to specify that MySQL should automatically terminate the client connection when the current transaction has completed.

When creating a table in MySQL, beware that if you might issue a ROLLBACK against it, it must be *transaction-safe*. (A transaction-safe table is one declared with the InnoDB or NDB Cluster property. Refer to "CREATE/ALTER TABLE Statement" on page 140 for more information.) MySQL allows you to issue transaction-control statements like COMMIT and ROLLBACK against non-transaction-safe tables, but it will simply ignore them and autocommit as usual. In the case of a ROLLBACK against a non-transaction-safe table, the changes will not be rolled back.

MySQL, by default, runs in AUTOCOMMIT mode, causing all data modifications to automatically be written to disk. You can turn AUTOCOMMIT off by issuing the command SET AUTOCOMMIT=0. You can also control the autocommit behavior on a statement-by-statement basis using the BEGIN or BEGIN WORK command:

```
BEGIN;
SELECT @A:=SUM(salary) FROM employee WHERE job_type=1;
BEGIN WORK;
UPDATE jobs SET summmary=@A WHERE job_type=1;
COMMIT;
```

MySQL automatically issues an implicit COMMIT upon the completion of any of these statements: ALTER TABLE, BEGIN, CREATE INDEX, DROP DATABASE, DROP TABLE, RENAME TABLE, and TRUNCATE.

Oracle

Oracle supports the SQL-standard form of the ROLLBACK statement with the addition of the FORCE clause:

```
ROLLBACK [WORK] {[TO [SAVEPOINT] savepoint_name] | [FORCE 'text']};
```

ROLLBACK clears all data modifications made to the current open transaction (or to a specific, existing savepoint). It also releases all locks held by the transaction, erases all savepoints, undoes all the changes made by the current transaction, and ends the current transaction.

ROLLBACK ... TO SAVEPOINT rolls back just the portion of the transaction after the savepoint, erases all savepoints that followed, and releases all table- and row-level locks acquired after the savepoint. Refer to the upcoming section on the SAVEPOINT statement for more information.

Oracle's implementation closely follows the SQL standard, with the exception of the FORCE option. ROLLBACK FORCE rolls back an in-doubt, distributed transaction. You must have the FORCE TRANSACTION privilege to issue a ROLLBACK ... FORCE statement. FORCE cannot be used with TO [SAVEPOINT]. ROLLBACK ... FORCE affects not the current transaction but the transaction named in '*text*', where '*text*' must be equal to the local or global transaction ID of the transaction you want to roll back. (The transactions and their ID names are detailed in the Oracle system view *DBA_2PC_PENDING*.)

For example, you might want to roll back your current transaction to the *salary_adjustment* savepoint. These two commands are equivalent:

```
ROLLBACK WORK TO SAVEPOINT salary_adjustment;
ROLLBACK TO salary_adjustment;
```

In the following example, you roll back an in-doubt distributed transaction:

```
ROLLBACK FORCE '45.52.67'
```

PostgreSQL

PostgreSQL supports the basic form of ROLLBACK, with savepoints:

```
ROLLBACK { [WORK] | [TRANSACTION] }
[ AND [ NO ] CHAIN ]
[TO [SAVEPOINT] savepoint_name ]
```

where:

WORK | TRANSACTION
: Optional keywords that are not required.

TO [SAVEPOINT] *savepoint_name*
: Rolls back all commands that were executed after the savepoint was established. The savepoint stays active and can be reused later, if needed.

ROLLBACK clears all data modifications made to the current open transaction. It will return an error if no transaction is currently open. For example, to roll back all open changes, use:

```
ROLLBACK;
```

Be careful with cursors and rolling back to savepoints. For example, a cursor that is opened within a savepoint will be closed if the transaction is rolled back to that savepoint. If a cursor is open but has a savepoint midway through its FETCH processes, the cursor position will remain at the position that FETCH left it at (meaning that it won't be rolled back). A cursor will remain closed even if rolling back to a savepoint takes you back before the CLOSE CURSOR command was issued. Generally, it's a good idea not to mix cursors and savepoints.

Remember that only the command RELEASE SAVEPOINT permanently destroys a savepoint; otherwise, it remains active and reusable.

PostgreSQL supports ABORT as a synonym of ROLLBACK, in the form ABORT [WORK] or ABORT [TRANSACTION].

SQL Server

SQL Server supports both the WORK and TRANSACTION keywords. The only difference between them is that the ROLLBACK WORK statement doesn't allow rolling back of a named transaction or to a specific savepoint. Its syntax is as follows:

```
ROLLBACK [ [WORK] | {TRAN | TRANSACTION}
   [transaction_name | savepoint_name] ]
```

If ROLLBACK is issued alone without the WORK or TRAN[SACTION] keywords, it rolls back all current open transactions. ROLLBACK normally frees locks, but it does not free locks when rolling back to a savepoint.

SQL Server allows you to name a specific *transaction_name* in addition to a specific *savepoint_name*. You may reference them explicitly, or you may use variables within Transact-SQL.

SQL Server does not allow rolling back transactions to a savepoint with a two-phase commit (i.e., a distributed transaction on SQL Server).

ROLLBACK TRAN[SACTION], when issued in a trigger, undoes all data modifications, including those performed by the trigger, up to the point of the ROLLBACK statement. Nested triggers are not executed if they follow a ROLLBACK within a trigger; however, any statements within the trigger that follow the rollback are not impacted by the rollback. ROLLBACK behaves similarly to COMMIT with regard to nesting, resetting the @@TRANCOUNT system variable to zero. (Refer to "COMMIT Statement" on page 361 for more information on transaction control within a SQL Server nested trigger.)

Following is a Transact-SQL batch using COMMIT and ROLLBACK in SQL Server. In this example, the code inserts a record into the *sales* table. If the insertion fails the transaction is rolled back, but if the insertion succeeds the transaction is committed:

```
BEGIN TRANSACTION -- Initializes a transaction
-- The transaction itself
INSERT INTO sales

VALUES('7896','JR3435','Oct 28 1997',25,'Net 60','BU7832')
-- Some error handling in the event of a failure
IF @@ERROR <> 0
BEGIN
    -- Raises an error in the event log and skips to the end
    RAISERROR 50000 'Insert of sales record failed'
    ROLLBACK WORK
    GOTO end_of_batch
END
-- The transaction is committed if no errors are detected
COMMIT TRAN
-- The GOTO label that enables the batch to skip to
-- the end without committing
end_of_batch:
GO
SAVEPOINT sales1
```

See also

- COMMIT
- RELEASE SAVEPOINT

- SAVEPOINT

SAVEPOINT Statement

This command breaks up a transaction at logical breakpoints. Multiple savepoints may be specified within a single transaction. The main benefit of the SAVEPOINT command is that transactions may be partially rolled back to a savepoint marker using the ROLLBACK command (discussed in the previous section).

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported, with limitations

SQL standard syntax

```
SAVEPOINT savepoint_name
```

Keywords

SAVEPOINT *savepoint_name*
: Establishes a savepoint named *savepoint_name* within the current transaction.

Rules at a glance

Savepoints are established within the scope of the entire transaction in which they are defined, and savepoint names should be unique within their scope. Always make sure to provide easy-to-understand names for your savepoints, because you'll be referencing them later in your programs. Furthermore, make sure you use BEGIN and COMMIT statements prudently, because accidentally placing a BEGIN statement too early or a COMMIT statement too late can have a dramatic impact on the way transactions are written to the database.

The SQL standard supports the statement RELEASE SAVEPOINT *savepoint_name*, enabling an existing savepoint to be eliminated. Refer to "RELEASE SAVEPOINT Statement" on page 401 for more information about eliminating an existing savepoint.

Programming tips and gotchas

Some vendors allow duplicate savepoint names within a transaction, but this is not recommended by the SQL standard. Generally, reusing a savepoint name won't produce an error or warning, but a duplicate savepoint name will render the previous savepoint with the same name useless. So, be careful when naming savepoints!

When a transaction is initiated, resources (namely, locks) are expended to ensure transactional consistency. Make sure that your transaction runs to completion as quickly as possible so that the locks are released for others to use.

The following example performs several data modifications and then rolls back to a savepoint:

```
INSERT INTO sales
VALUES('7896','JR3435','Oct 28 1997',25,'Net 60','BU7832');
SAVEPOINT after_insert;
UPDATE sales SET terms = 'Net 90'
WHERE sales_id = '7896';
SAVEPOINT after_update;
DELETE sales;
ROLLBACK TO after_insert;
```

MySQL

MySQL fully supports the SQL standard implementation.

Oracle

Oracle fully supports the SQL standard implementation.

PostgreSQL

PostgreSQL fully supports the SQL standard implementation.

SQL Server

SQL Server does not support the `SAVEPOINT` command. Instead, it uses the `SAVE` command:

```
SAVE TRAN[SACTION] savepoint_name
```

In addition, rather than declaring the literal name of the savepoint, you can optionally reference a variable containing the name of the savepoint. If you use a variable, it must be of the `CHAR`, `VARCHAR`, `NCHAR`, or `NVARCHAR` data type.

SQL Server allows you to have many different named savepoints in a single transaction. However, be careful—since SQL Server supports multiple savepoints in a single transaction, it might appear that the platform fully supports nested savepoints, but in fact *it does not*. Any time you issue a commit or savepoint in SQL Server, it only commits or rolls back to the last open savepoint.

When the `ROLLBACK TRAN[SACTION]` *`savepoint_name`* command is executed, SQL Server rolls the transaction back to the specified savepoint, then continues processing with the next valid Transact-SQL command following the `ROLLBACK` statement. The transaction must ultimately be concluded with a `COMMIT` or a final `ROLLBACK` statement.

See also

- `COMMIT`
- `ROLLBACK`
- `RELEASE SAVEPOINT`

SET TRANSACTION Statement

The `SET TRANSACTION` statement controls many characteristics of data modification, primarily the read/write characteristics and isolation level of a transaction.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with limitations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
SET [LOCAL] TRANSACTION  [READ ONLY | READ WRITE]
   [ISOLATION LEVEL {READ COMMITTED | READ UNCOMMITTED |
      REPEATABLE READ | SERIALIZABLE}]
   [DIAGNOSTIC SIZE int]
```

Keywords

`LOCAL`
: Changes transaction settings for the current session on the local server only. If this keyword is not specified, the transaction settings for the next transaction are changed, even if the transaction runs on a remote server.

`READ ONLY`
: Sets the next upcoming transaction as a read-only transaction. Once the next transaction is complete, transaction behavior reverts to the default settings.

`READ WRITE`
: Sets the next upcoming transaction so it may perform transactions that read and write data.

`ISOLATION LEVEL`
: Sets the isolation level for the next transaction in the session. Options are:

  `READ COMMITTED`
  : Allows a transaction to read rows written by other transactions only when they have been committed.

`READ UNCOMMITTED`
: Allows a transaction to read rows that have been written, but not committed, by other transactions.

`REPEATABLE READ`
: All sessions can see records that are committed before their first transactions were begun. Other open sessions can see or change only committed rows in the user's current session. Consequently, later transactions can add records that might then be visible to the transactions of earlier sessions, but the other sessions must requery to see those records.

`SERIALIZABLE`
: All sessions can see records that are committed before their first transactions were begun. Before that point, open sessions can see records within other user sessions but cannot insert or update until those sessions' transactions are completed. This is the most restrictive isolation level and the default for the SQL standard.

`DIAGNOSTIC SIZE` *`int`*
: Designates the specific number of error messages (*`int`*) to capture for a transaction. The `GET DIAGNOSTICS` statement retrieves these error messages.

Rules at a glance

When issued, `SET TRANSACTION` sets the properties of the next upcoming transaction. Because of this, `SET TRANSACTION` is an interim statement that should be issued after one transaction completes and before the next transaction starts. (To begin a transaction and set its characteristics at the same time, use `START TRANSACTION`.) More than one option may be applied with this command, but only one access mode, isolation level, and diagnostic size may be specified at a time.

The *isolation level* of a transaction specifies the degree of isolation a transaction has from other concurrently running sessions. The isolation level controls:

- Whether rows read and updated by your database session are available to other concurrently running database sessions.
- Whether the update, read, and write activity of other database sessions can affect your database session.

If you are unfamiliar with isolation levels, be sure to read your platform's vendor documentation.

Programming tips and gotchas

The `ISOLATION LEVEL` clause controls a number of behaviors and anomalies in a transaction concerning concurrent transactions, including the following:

Dirty reads
: Occur when a transaction reads the altered records of another transaction before the other transaction has completed. This allows a data modification to occur on a record that might not be committed to the database.

Nonrepeatable reads
: Occur when one transaction reads a record while another modifies it. If the first transaction then attempts to reread the record, it won't be able to find it.

Phantom records
: Occur when Transaction A reads a group of records, but Transaction B adds or changes the data so that more records satisfy the query issued by Transaction A. Thus, Transaction A may read in the records of Transaction B as if they were committed to the database, when in fact the records from Transaction B may still be rolled back. Since Transaction A is reading records that are not yet permanent, these are called *phantom records*.

Table 5-2 shows the impact of various isolation level settings on the anomalies just listed.

Table 5-2. Isolation level and anomaly impact

Isolation level	Dirty reads	Nonrepeatable reads	Phantom records
`READ UNCOMMITTED`	Allowed	Allowed	Allowed
`READ COMMITTED`	Not allowed	Allowed	Allowed
`REPEATABLE READ`	Not allowed	Not allowed	Allowed
`SERIALIZABLE`	Not allowed	Not allowed	Not allowed

None of the platforms support *DIAGNOSTIC SIZE*.

MySQL

MySQL allows you to set the transaction isolation level for the next individual transaction, the whole session, or globally across the server, as follows:

```
SET [GLOBAL | SESSION] TRANSACTION ISOLATION LEVEL
   {READ UNCOMMITTED |READ COMMITTED | REPEATABLE READ |
   SERIALIZABLE} | {READ WRITE | READ ONLY}
```

By default, MySQL sets the isolation level for the transaction that immediately follows the statement. The keywords are:

`GLOBAL`
: Sets the transaction isolation level for all subsequent transactions across all user sessions or system threads.

`SESSION`
: Sets the transaction isolation level for all subsequent transactions of the current session.

`TRANSACTION ISOLATION LEVEL`
: Sets a specific transaction isolation level, as described earlier in the section "Keywords" on page 361.

If no transaction isolation level is specified, MySQL defaults to `REPEATABLE READ`.

The `SUPER` privilege is required to set a `GLOBAL` transaction isolation level. You can also set the default isolation level via the `MYSQL` command-line executable using the *–transaction-isolation* switch. Following is an example that sets all subsequent threads (both user and system threads) to the `SERIALIZABLE` transaction isolation level:

```
SET GLOBAL TRANSACTION ISOLATION LEVEL SERIALIZABLE;
```

Oracle

Oracle allows you to set a transaction as read-only or read/write, set the transaction isolation level, and specify a specific rollback segment for your transactions:

```
SET TRANSACTION { [ READ ONLY | READ WRITE ]
| [ ISOLATION LEVEL { READ COMMITTED | SERIALIZABLE } ]
| [ USE ROLLBACK SEGMENT segment_name ]
| NAME 'transaction_name' };
```

where:

`READ ONLY`
: Sets the next transaction as read-only and serializable. This option is not available to the user `SYS`. The only statements permitted in read-only sessions are `SELECT`, `ALTER SESSION`, `ALTER SYSTEM`, `LOCK TABLE`, and `SET ROLE`.

`USE ROLLBACK SEGMENT` *`segment_name`*
: Sets the next read/write transaction to be written to a specific Oracle rollback segment identified by *`segment_name`*. Because it applies only to the current transaction, `USE ROLLBACK SEGMENT` should be the first statement in the transaction. This option is not compatible with the `READ ONLY` option. The rollback segment must already exist, or this statement will fail.

`NAME '`*`transaction_name`*`'`
: Assigns a name of 255 characters or less to the current transaction. This option is useful in distributed transaction processing environments for two-phase commits because it lets you easily identify which local transactions belong to a single distributed transaction.

The `USE ROLLBACK SEGMENT` variant can be useful for performance tuning, as it allows you to direct long-running transactions to rollback segments large enough to hold them, while small transactions can be directed to rollback segments that might be small enough to be retained in the cache.

Oracle only supports the READ COMMITTED and SERIALIZABLE transaction isolation levels. The default transaction isolation level in Oracle is READ COMMITTED, and the default transaction style is READ WRITE.

The SET TRANSACTION statement should be the first statement in any SQL batch, but Oracle treats it virtually the same as the START TRANSACTION statement, so one could be substituted for the other.

In the following example, the query reports from a biweekly process on the *chicago* server while avoiding any impact from other users who might be updating or inserting records:

```
SET TRANSACTION READ ONLY NAME 'chicago';
SELECT prod_id, ord_qty
FROM   sales
WHERE  stor_id = 5;
```

In another case, late-night batch processing might create a huge transaction that would overflow all but the rollback segment created to support that one transaction:

```
SET TRANSACTION USE ROLLBACK SEGMENT huge_tran_01;
```

PostgreSQL

SET TRANSACTION in PostgreSQL impacts only the new transaction you are beginning. Consequently, you may have to issue this statement before each new transaction. PostgreSQL adds two enhancements to the SET TRANSACTION statement, DEFERRABLE and SNAPSHOT. The syntax is:

```
SET TRANSACTION ISOLATION LEVEL { SERIALIZABLE |
   REPEATABLE READ | READ COMMITTED | READ UNCOMMITTED }
   { READ WRITE | READ ONLY }
   [ NOT ] DEFERRABLE
```

or:

```
SET TRANSACTION SNAPSHOT snapshot_id
```

where:

[NOT] DEFERRABLE
: Allows a transaction to block when acquiring its snapshot, then run without the overhead of a SERIALIZABLE transaction (well suited to backups and long-running reports). The DEFERRABLE property has no effect unless the transaction is also SERIALIZABLE and READ ONLY.

SET TRANSACTION SNAPSHOT *snapshot_id*
: Allows a new transaction to run with the same *snapshot_id* as an existing transaction. The preexisting transaction must have exported its snapshot with the *pg_export_snapshot* function. Refer to the documentation for details.

By default, PostgreSQL uses the `READ COMMITTED` transaction isolation level. You can set the default transaction isolation level for all transactions in the session by using either of the following commands:

```
SET SESSION CHARACTERISTICS AS TRANSACTION ISOLATION LEVEL
   { READ COMMITTED | SERIALIZABLE };

SET default_transaction_isolation =
   { 'read committed' | 'serializable' }
```

Of course, you can then override the isolation level of any subsequent transaction using the `SET TRANSACTION` statement.

For example, you can set the next transaction to the `SERIALIZABLE` transaction isolation level:

```
SET TRANSACTION ISOLATION LEVEL SERIALIZABLE;
```

Or you could set all the transactions in an entire session to `SERIALIZABLE`:

```
SET SESSION CHARACTERISTICS AS TRANSACTION
   ISOLATION LEVEL SERIALIZABLE;
```

SQL Server

The `SET TRANSACTION ISOLATION LEVEL` command in SQL Server sets the isolation level for an entire session. All queries that follow this statement run under the designated isolation level until it is changed. The syntax is:

```
SET TRANSACTION ISOLATION LEVEL {READ COMMITTED |
   READ UNCOMMITTED | REPEATABLE READ |
   SNAPSHOT | SERIALIZABLE}
```

where:

`SNAPSHOT`
: Specifies that data read by any statement in a transaction will be the transactionally consistent version of the data that existed at the start of the transaction. Statements in the transaction effectively get a snapshot of the committed data as it existed at the start of the transaction.

For example, the following command lowers the transaction isolation level for all `SELECT` statements during the session from `READ COMMITTED` to `REPEATABLE READ`:

```
SET TRANSACTION ISOLATION LEVEL REPEATABLE READ
GO
```

`READ COMMITTED` is the default isolation level in SQL Server. Setting the transaction isolation level to `READ UNCOMMITTED` or `SERIALIZABLE` has the same effect as using the `NOLOCK` or `HOLDLOCK` optimizer hints, respectively. Refer to the vendor documentation for more details.

See also

- `COMMIT`
- `ROLLBACK`

START TRANSACTION Statement

The `START TRANSACTION` statement allows you to perform all the functions of `SET TRANSACTION` while also initiating a new transaction.

Platform	Command
MySQL	Supported, with limitations
Oracle	Not supported
PostgreSQL	Supported, with variations
SQL Server	Not supported; use `BEGIN TRANSACTION` instead

SQL standard syntax

```
START TRANSACTION [READ ONLY | READ WRITE]
   [ISOLATION LEVEL {READ COMMITTED | READ UNCOMMITTED |
   REPEATABLE READ | SERIALIZABLE}]
[DIAGNOSTIC SIZE int]
```

Keywords

`READ ONLY`
: Sets the next upcoming transaction as a read-only transaction. Once the next transaction is complete, transaction behavior reverts to the default settings.

`READ WRITE`
: Sets the next upcoming transaction so it may perform transactions that read and write data.

`ISOLATION LEVEL`
: Sets the isolation level for the next transaction in the session.

`READ COMMITTED`
: Allows a transaction to read rows written by other transactions only when they have been committed.

`READ UNCOMMITTED`
: Allows a transaction to read rows that have been written, but not committed, by other transactions.

`REPEATABLE READ`
: All sessions can see records that are committed before their first transactions were begun. Other open sessions can see or change only committed rows in the user's current session. Consequently, later transactions can add records

that might then be visible to the transactions of earlier sessions, but the other sessions must requery to see those records.

`SERIALIZABLE`
: All sessions can see records that are committed before their first transactions were begun. Before that point, open sessions can see records within other user sessions but cannot insert or update until those sessions' transactions are completed. This is the most restrictive isolation level and the default for the SQL standard.

`DIAGNOSTIC SIZE` *`int`*
: Designates the specific number of error messages (*`int`*) to capture for a transaction. The `GET DIAGNOSTICS` statement retrieves these error messages.

Rules at a glance

According to the SQL standard, the only difference between `SET` and `START` is that `SET` is considered outside of the current transaction, while `START` is considered the beginning of a new transaction. Thus, `SET TRANSACTION` settings apply to the next transaction, whenever that may be initiated, while `START TRANSACTION` settings apply to the transaction currently being initiated.

While only MySQL and PostgreSQL support the `START TRANSACTION` statement, SQL Server (as well as MySQL and PostgreSQL) supports a similar command, `BEGIN TRAN[SACTION]`, and its synonym, `BEGIN WORK`. `BEGIN TRANSACTION` declares an explicit transaction, but it does not set isolation levels. The only significant rule of the `START TRANSACTION` statement is that it is used to control the access mode, isolation level, and/or diagnostic size of the current transaction only. Once a new transaction starts, you must either issue new values for the setting(s) or rely on the defaults.

Most database platforms allow you to implicitly control transactions, using what is commonly called *autocommit* mode. In autocommit mode, the database treats each statement as a transaction in and of itself, complete with implicit `BEGIN TRANSACTION` and `COMMIT TRANSACTION` statements.

The alternative to autocommit mode is to manually control each transaction. Under explicit transaction control, you declare each new transaction with the `START TRANSACTION` statement. A new transaction may also start implicitly any time a transaction-initiating statement is issued, such as an `INSERT`, `UPDATE`, `DELETE`, or `SELECT`. The transaction is not committed or rolled back until either a `COMMIT` or `ROLLBACK` statement is explicitly issued.

Oracle does not support the explicit declaration of a new transaction using `START TRANSACTION`, but it does support explicitly committing, savepointing, and rolling back a transaction. Other platforms, including MySQL, PostgreSQL, and SQL Server, allow you both to explicitly declare a transaction with `START TRANSACTION` and to explicitly commit, savepoint, and roll back the transaction.

Programming tips and gotchas

Many of the platforms discussed in this book run in autocommit mode by default. Therefore, it is a good rule of thumb to use explicitly declared transactions only if you intend to do so for all transactions in a session. In other words, do not mix implicitly declared transactions and explicitly declared transactions in a single session.

Each transaction that is explicitly declared can only be made permanent with the `COMMIT` statement. Similarly, any transaction that fails or needs to be discarded must be explicitly undone with the `ROLLBACK` statement.

> Be sure to issue `START` in a pair with either `COMMIT` or `ROLLBACK`. Otherwise, the DBMS may not complete the transaction(s) until it encounters a `COMMIT` or `ROLLBACK` statement. Poor planning and omitting timely `COMMIT`s (or `ROLLBACK`s) could potentially lead to huge transactions.

It is a good idea to issue explicit `COMMIT`s or `ROLLBACK`s after one or a few statements because long-running transactions can lock up resources, thus preventing other users from accessing those resources. Long-running or very large transaction batches can fill up the rollback segments or transaction logs of a database, even if those files are small.

MySQL

MySQL normally runs in autocommit mode, meaning changes are automatically saved to disk when completed. If a change fails for any reason, it is automatically rolled back.

MySQL supports `START TRANSACTION` and a synonym, `BEGIN [WORK]`. You can suspend autocommit for one or several statements using the `BEGIN` syntax:

```
START TRANSACTION [{WITH CONSISTENT SNAPSHOT |
   READ WRITE | READ ONLY}]
BEGIN [WORK]
```

where:

`WITH CONSISTENT SNAPSHOT`
: Starts a consistent read of data on engines that support consistency of reads (currently, only InnoDB) when running under a transaction isolation level that supports consistent reads (i.e., `SERIALIZABLE` and `REPEATABLE READ`).

`BEGIN [WORK]`
: Marks the beginning of one or more transactions. `WORK` is an optional keyword with no effect.

Issuing the following command can disable autocommit mode for all sessions and threads:

```
SET AUTOCOMMIT=0
```

Once you have disabled autocommit, the COMMIT statement is required to store any data modification to disk, and the ROLLBACK statement is required to undo changes made during a transaction. Disabling autocommit is only effective with "transaction-safe" tables, such as InnoDB or BDB tables. Disabling autocommit on non-transaction-safe tables has no effect—autocommit will still be enabled.

Earlier versions of MySQL use an update log. However, the update log does not support SQL standard transactions unless the tables are defined as InnoDB or NDB Cluster tables.

Transactions are stored in the binary log in a single write operation when the COMMIT statement is issued. Here's an example:

```
BEGIN;
   SELECT @A := SUM(salary)
   FROM   employee
   WHERE  type=1;
   UPDATE payhistory SET summmary=@A WHERE type=1;
COMMIT;
```

Rollbacks issued against non-transactional tables will fail with the error ER_WARNING_NOT_COMPLETE_ROLLBACK, but transaction-safe tables will be restored as expected.

MySQL's START TRANSACTION command does not allow setting the transaction isolation level. You must first issue a SET TRANSACTION command to set the isolation level.

Oracle

Oracle does not support the START TRANSACTION command. Transactions in Oracle are started implicitly. Refer to the discussion of this platform in the previous section for more information about how Oracle controls individual transactions.

PostgreSQL

PostgreSQL's START TRANSACTION command has the following syntax:

```
START TRANSACTION [ ISOLATION LEVEL {READ COMMITTED |
   READ UNCOMMITTED | REPEATABLE READ | SERIALIZABLE}
   {READ ONLY | READ WRITE}
   [ NOT ] DEFERRABLE ]
```

where:

`[NOT ] DEFERRABLE`
: Allows a transaction to block when acquiring its snapshot, then run without the overhead of a `SERIALIZABLE` transaction (well suited to backups and long-running reports). The `DEFERRABLE` property has no effect unless the transaction is also `SERIALIZABLE` and `READ ONLY`.

PostgreSQL also supports a synonym, `BEGIN [WORK | TRANSACTION]`, which is more commonly used than `START TRANSACTION`.

PostgreSQL normally runs in autocommit mode, where each data modification statement or query is its own transaction. It applies an implicit `COMMIT` for any transaction that completes without an error, and an implicit `ROLLBACK` for any statement that fails. The `BEGIN` statement allows explicit `COMMIT` or `ROLLBACK` of a transaction, which may then consist of multiple statements.

Manually coded transactions are much faster in PostgreSQL than autocommitted transactions. `SET TRANSACTION ISOLATION LEVEL SERIALIZABLE` should be set just after the `BEGIN` statement to bolster the transaction isolation level. PostgreSQL allows many data modification statements (`INSERT`, `UPDATE`, `DELETE`) within a `BEGIN ... COMMIT` block. However, when the `COMMIT` command is issued, either all or none of the transaction is committed, depending on the success or failure of the command.

`BEGIN` has a separate usage on database platforms that support their own procedural languages (namely, Oracle and SQL Server). On these platforms, `BEGIN` (without the keyword `TRANSACTION`), is used to mark a new block of procedural code. For this reason, you are advised to include the `TRANSACTION` keyword for any transactions you write on PostgreSQL. Otherwise, you will face some complicated migration issues should you ever move your code to Oracle or SQL Server.

Following is an example of `BEGIN TRANSACTION` in PostgreSQL:

```
BEGIN TRANSACTION;
   INSERT INTO jobs(job_id, job_desc, min_lvl, max_lvl)
   VALUES(15, 'Chief Operating Officer', 185, 135)
COMMIT;
```

SQL Server

SQL Server supports the `BEGIN TRANSACTION` statement rather than the SQL standard `START TRANSACTION` statement. It also supports extensions to the standard that facilitate transaction backup and recovery, such as the `WITH MARK` clause. The syntax is:

```
BEGIN TRAN[SACTION] [transaction_descriptor
   [WITH MARK [ 'log_descriptor' ]]]
```

where:

`TRAN[SACTION]`
: Marks the beginning of a transaction.

`transaction_descriptor`
: Identifies a transaction. This can be a name or string data type (`CHAR`, `NCHAR`, `VARCHAR`, or `NVARCHAR`) variable of up to 32 characters in size. When working with nested transactions, only name the outermost transaction.

`WITH MARK '`*`log_descriptor`*`'`
: Tells SQL Server to place a mark of name *`log_descriptor`* in the transaction log, allowing it to restore a transaction log up to that point. In a sense, this allows point-in-time recovery based on the name of the mark for databases set to `FULL` recovery mode. `WITH MARK` must be used in conjunction with a named transaction.

When nesting transactions, only the outermost `BEGIN ... COMMIT` or `BEGIN ... ROLLBACK` pair should reference the transaction name (if it has one). In general, we recommend avoiding nested transactions.

Here is a SQL Server set of `INSERT` statements, all performed as a single transaction:

```
BEGIN TRANSACTION
   INSERT INTO sales VALUES('7896','JR3435','Oct 28 2003',25,
      'Net 60','BU7832')
   INSERT INTO sales VALUES('7901','JR3435','Oct 28 2003',17,
      'Net 30','BU7832')
   INSERT INTO sales VALUES('7907','JR3435','Oct 28 2003',6,
     'Net 15','BU7832')
COMMIT
GO
```

If for some reason any one of these `INSERT` statements had to wait for completion, they would all have to wait, since they are treated as a single transaction.

The `BEGIN TRANSACTION` statement does not allow specifying the transaction isolation level; use `SET TRANSACTION` before issuing this command to do this.

See also

- `COMMIT`
- `ROLLBACK`
- `SET TRANSACTION`

TRUNCATE TABLE Statement

The `TRUNCATE TABLE` statement was introduced in the SQL:2008 standard, but all the databases discussed here supported it before it was incorporated into the standard. It irrevocably removes all rows from a table without logging the individual row deletes. It quickly erases all the records in a table without altering the table structure, taking up little or no space in the redo logs or transaction logs. However, since a truncate operation is not logged, the `TRUNCATE TABLE` statement cannot be rolled back once it is issued.

Platform	Command
MySQL/MariaDB	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
TRUNCATE TABLE table_name
[CONTINUE IDENTITY | RESTART IDENTITY]
```

Keywords

`table_name`
: The name of any valid table within the current database or schema context.

`CONTINUE IDENTITY | RESTART IDENTITY`
: If the table has an incrementing identity column, you can optionally specify whether the incrementing should be restarted or should continue from the previous incrementing number. With `CONTINUE`, new IDs will be assigned for new data instead of overlapping with truncated data.

Rules at a glance

The `TRUNCATE TABLE` statement has the same effect on a table as a `DELETE` statement with no `WHERE` clause; both erase all rows in a given table. However, there are some important differences: `TRUNCATE TABLE` is faster and it is not logged, meaning it cannot be rolled back if issued in error, and `TRUNCATE TABLE` does not activate triggers, while the `DELETE` statement does.

This command should be issued manually. We strongly encourage you not to place it into automated scripts or production systems that contain irreplaceable data. It cannot be paired with transaction control statements such as `START TRANSACTION`, `COMMIT`, or `ROLLBACK`.

Programming tips and gotchas

Because the `TRUNCATE TABLE` statement is not logged, it is generally used only in development databases. Use it in production databases with caution!

We strongly advise that you do not write TRUNCATE TABLE statements into the stored procedures or functions of a production application because most platforms do not log the operation and cannot recover from an improperly issued TRUNCATE statement.

The TRUNCATE TABLE command will fail if another user has a lock on the table at the time the statement is issued. TRUNCATE TABLE does not activate triggers but will work when they are present. However, it won't work when foreign key constraints are in place on a given table.

MySQL and MariaDB

MySQL and MariaDB support a basic format of the TRUNCATE TABLE statement. Neither supports the CONTINUE/RESTART IDENTITY clause, but TRUNCATE TABLE in MySQL/MariaDB is equivalent to TRUCATE TABLE RESTART IDENTITY. In both cases, the word TABLE is optional. The MySQL syntax is:

```
TRUNCATE [TABLE] name
```

MariaDB supports an extension to the standard:

```
TRUNCATE [TABLE] name [WAIT n | NOWAIT]
```

Additionally, if SQL_MODE=Oracle is set in MariaDB, it supports the following syntax:

```
TRUNCATE [TABLE] name [ {DROP | REUSE} STORAGE]
[WAIT n | NOWAIT]
```

where:

{DROP | REUSE} STORAGE
: Causes the disk space freed by the deleted rows to be deallocated (DROP), or causes the space allocated to a table to remain allocated to that table, though empty (REUSE).

WAIT *n* | NOWAIT
: Instructs the database to wait *n* seconds for a lock table before canceling. NOWAIT or WAIT 0 cancels immediately if a lock can't be obtained immediately.

For more on the SQL_MODE setting, see the vendor documentation and "Platform-Specific Extensions" on page 538.

MySQL achieves the result of a TRUNCATE TABLE command by dropping and re-creating the affected table. Since MySQL stores each table in a file called

<*table_name*>*.frm*, the <*table_name*>*.frm* file must exist in the directory containing the database files for the command to work properly.

For example, to remove all data from the *publishers* table:

```
TRUNCATE TABLE publishers
```

Oracle

Oracle allows a table or an indexed cluster (but not a hash cluster) to be truncated. Oracle's syntax is:

```
TRUNCATE { CLUSTER [owner.]cluster
   | TABLE [owner.]table [{PRESERVE | PURGE}
   MATERIALIZED VIEW LOG] }
[{DROP | REUSE} STORAGE]
```

`TRUNCATE TABLE` was first introduced by Oracle, and other platforms soon added support for the statement. Oracle has added more features to this statement than are commonly implemented by other vendors. The syntax elements are as follows:

`CLUSTER | TABLE`
: Specifies whether an index cluster or a table will be truncated. An index cluster is a physical construct that stores related rows of two tables next to each other physically on disk to speed up joins by reducing I/O. The `MATERIALIZED VIEW LOG` and `STORAGE` options are not available when truncating an index cluster.

`{PRESERVE | PURGE} MATERIALIZED VIEW LOG`
: Maintains any snapshot logs when a master table is truncated (`PRESERVE`), or clears out any snapshot logs (`PURGE`).

`{DROP | REUSE} STORAGE`
: Causes the disk space freed by the deleted rows to be deallocated (`DROP`), or causes the space allocated to a table to remain allocated to that table, though empty (`REUSE`).

For example, this command erases all records in the table *scott.authors*:

```
TRUNCATE TABLE scott.authors
   PRESERVE MATERIALIZED VIEW LOG REUSE STORAGE
```

It also maintains the existing snapshot log and allows the table to keep and reuse the storage space already allocated to it.

PostgreSQL

PostgreSQL fully supports the standard and adds additional options: a `CASCADE | RESTRICT` clause, an `ONLY` clause, and the ability to specify more than one table to truncate. The `TABLE` keyword is optional. The syntax is as follows:

```
TRUNCATE [TABLE] [ONLY] table_name [*][, ... ]
[CONTINUE IDENTITY | RESTART IDENTITY]
[CASCADE | RESTRICT]
```

where:

`[ONLY] table_name`
: Specifies the name (optionally schema-qualified) of a table to truncate. If `ONLY` is specified before the table name, only that table is truncated. If `ONLY` is not specified, the table and all its descendant tables (if any) are truncated. Optionally, * can be specified after the table name to explicitly indicate that descendant tables are included. One or more table names are allowed as long as they are separated by commas.

`CASCADE`
: Automatically truncates all tables that have foreign key references to any of the named tables, or to any tables added to the group due to `CASCADE`.

`RESTRICT`
: Aborts the command if any of the named tables have foreign key references from tables that are not listed in the command. This is the default if neither `CASCADE` nor `RESTRICT` is specified.

When no `IDENTITY` clause is specified, the default behavior is `CONTINUE IDENTITY`. The `IDENTITY` clause applies to table columns specified using *serial* as well as those defined using the `GENERATED` clause.

The following command erases all the records in the *authors* table on a PostgreSQL database and also truncates all data in tables with a foreign key constraint to *authors*:

```
TRUNCATE authors CASCADE;
```

SQL Server

SQL Server supports the standard except for `CONTINUE IDENTITY | RESTART IDENTITY`. It also adds additional clauses for handling table partitions. The SQL Server `TRUNCATE TABLE` syntax is as follows:

```
TRUNCATE TABLE table_name
[WITH (PARTITIONS ({partition_number_expression | range}
   [, ...n]))]
```

where:

`WITH (PARTITIONS)`
: Specifies the numbered partitions to truncate or range of rows to be removed. Only use this clause if your table is partitioned; otherwise, an error will be generated. If the `WITH PARTITIONS` clause is not provided on a partitioned table, the entire table will be truncated.

See also

- `DELETE`

UPDATE Statement

The `UPDATE` statement changes existing data in a table. Use great caution when issuing an `UPDATE` statement without a `WHERE` clause, since the statement then affects every row in the entire table.

Platform	Command
MySQL/MariaDB	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
UPDATE [ONLY] {table_name | view_name}
[ FOR PORTION OF application_time_period_name
   FROM point_in_time_1  TO point_in_time_2 ]
[ [AS] correlation_name ]
SET { (column_name[, ...]) = [ROW] (val[, ...]) |
      {column_name = { ARRAY [array_val[, ...]] | DEFAULT |
         NULL | scalar_expression }[, ...]} |
      ROW = row_expression }
[ WHERE search_condition | WHERE CURRENT OF cursor_name ]
```

Keywords

`ONLY`
: Restricts cascading of the updated values to any subtables of the target table or view. `ONLY` affects only typed (object-oriented) tables and views. If used with a non-typed table or view, it causes an error.

`table_name | view_name`
: Specifies the target table or view of the `UPDATE` statement. You need appropriate permissions on the target, according to the rules of the platform. Updates against views often have special rules. Generally, it is advisable to perform an `UPDATE` against a view only if the view is representative of a single table.

`FOR PORTION OF` *`application_time_period_name`* `FROM` *`point_in_time_1`* `TO` *`point_in_time_2`*
: This clause can only be used for system-versioned tables with time periods defined. *`application_time_period_name`* identifies the time period that will be used for filtering. *`point_in_time_1`* defines the beginning of the time period and *`point_in_time_2`* defines the end.

`[AS]` *`correlation_name`*
: An alias for the *`table_name`* that should be used in the *`search_condition`*.

`SET`
: Assigns a specific value to a column or row.

`(`*`column_name`*`[, ...]) = [ROW] (`*`val`*`[, ...]) |` *`column_name`* `= {ARRAY [`*`array_val`*`[, ... ] | DEFAULT | NULL |` *`scalar_expression`* `}[, ... ]`
: Allows you to set new values for the specified column(s), as in `SET (column1, column2) = ('foo', 'foo2')`. You can update as many columns as you like in one statement, though you cannot update the same column more than once in a single statement and the order of your column list has to match the order of your value list. There should be exactly the same number of columns specified as there are values. `ARRAY [`*`array_val`*`[, ... ]` assigns the column to an array value or to an empty array (using `ARRAY[]`). This behavior is not widely supported by DBMS platforms. `DEFAULT` sets the column to its default value, as defined by a `DEFAULT` specification. `NULL` sets the column to NULL. *`scalar_expression`* sets the column to any single value expression, such as a literal string or numeric value, a scalar function, or a scalar subquery.

`ROW =` *`row_expression`*
: Used to set a value for each and every column in the table, as in `SET ROW = ROW('foo', 'bar')`. Mutually exclusive with `SET` *`column_name`*. This behavior is not widely supported by DBMS platforms.

`WHERE` *`search_condition`*
: Defines search criteria for the `UPDATE` statement using the *`search_condition`* to ensure that only the target rows are updated. Any legal `WHERE` clause is acceptable. Typically, these criteria are evaluated against each row of the table before the update is applied. If the search condition is a subquery, the subquery is executed on each row, which is potentially a long-running process.

`WHERE CURRENT OF` *`cursor_name`*
: Restricts the `UPDATE` statement to the current row of a defined and opened cursor called *`cursor_name`*.

Rules at a glance

The `UPDATE` statement can be used to modify the values of one or more columns of a table or view at a time. Typically, you will update the values in one or more rows at a time. The new values must be scalar (except in row expressions and arrays). That is, a given field/column must have a single, constant value at the time the transaction is executed, though it can be literal or derived from a function call or subquery.

A basic `UPDATE` statement without a `WHERE` clause looks like this:

```
UPDATE authors
SET contract = 0
```

This example sets the contract status of all authors in the *authors* table to 0 (meaning they don't have contracts anymore). Similarly, values can be adjusted mathematically with an UPDATE statement:

```
UPDATE titles
SET price = price * 1.1
```

This UPDATE statement would increase all book prices by 10%.

You can also set multiple values in one statement, as shown here, where we set all author last names and first names to uppercase letters:

```
UPDATE authors SET au_lname = UPPER(au_lname),
   au_fname = UPPER(au_fname);
```

Adding a WHERE clause to an UPDATE statement allows records in the table to be modified selectively:

```
UPDATE titles
SET    type  = 'pers_comp',
       price = (price * 1.15)
WHERE  type  = 'popular_com';
```

This query makes two changes to any record of the type 'popular_com': it increases the price by 15% and alters the type to 'pers_comp'.

The preceding query can alternatively be written in a *column list* = *value list* format as follows:

```
UPDATE titles
SET   (type, price)  = ('pers_comp', (price * 1.15) )
WHERE  type  = 'popular_com';
```

You can also invoke functions or subqueries to derive the values used in an UPDATE statement. In some cases, you may wish to update the specific row that is being processed by a declared and open cursor. The following example shows both concepts:

```
UPDATE titles SET ytd_sales = (SELECT SUM(qty)
                               FROM sales
                               WHERE title_id = 'TC7777')
WHERE CURRENT OF title_cursor;
```

This query assumes that you have declared and opened a cursor named *title_cursor* and that it is processing titles with IDs of 'TC7777'.

Sometimes you need to update values in a given table based on the values stored in another table. For example, if you need to update the publication date for all the titles written by a certain author, you might find the author and a list of their titles first through subqueries:

```
UPDATE titles
SET    pubdate = 'Jan 01 2022'
WHERE  title_id IN
   (SELECT title_id
    FROM   titleauthor
    WHERE  au_id IN
      (SELECT au_id
       FROM   authors
       WHERE  au_lname = 'White'))
```

Programming tips and gotchas

The UPDATE statement alters values in existing records of a table or view. If you update a view, the view should include all necessary (NOT NULL) columns, or else the statement may fail. Columns with a DEFAULT value can usually be safely omitted.

The SET ROW clause is not widely supported among DBMS platforms and should be avoided. The WHERE CURRENT OF clause is more commonly implemented, but it must be used in conjunction with a cursor. Make sure you understand the use and functionality of cursors before using this clause.

In an interactive user session, it is good practice to issue a SELECT statement using the same WHERE clause before issuing the actual UPDATE statement. This precaution enables you to check all rows in the result set before actually performing the UPDATE, helping ensure that you don't alter anything you don't mean to alter.

MySQL and MariaDB

MySQL supports the SQL standard UPDATE statement with a few variations, including the LOW PRIORITY clause, the IGNORE clause, and the LIMIT clause and the ability to reference multiple tables:

```
UPDATE [LOW PRIORITY] [IGNORE] table_references
SET [table_alias.]column_name = {scalar_expression}
    [, ...]
WHERE search_conditions
[ORDER BY column_name1 [{ASC | DESC}][, ...]]
[LIMIT int]
```

MariaDB supports all of MySQL's syntax plus a partitioning clause and the SQL standard FOR PORTION OF clause. Its UPDATE syntax is as follows:

```
UPDATE [LOW PRIORITY] [IGNORE] table_references
[PARTITION (partition_list)]
[ FOR PORTION OF application_time_period_name
   FROM point_in_time_1  TO point_in_time_2 ]
SET [table_alias.]column_name = {scalar_expression}
    [, ...]
WHERE search_conditions
[ORDER BY column_name1 [{ASC | DESC}][, ...]]
[LIMIT int]
```

The parameters are:

`table_references`
: Lists one or more tables that can be used in the *`search_conditions`* and `SET` operations. It also allows for `JOIN` clauses and subqueries in the table references.

`LOW PRIORITY`
: Tells the database to delay the execution of the `UPDATE` statement until no other client is reading from the table.

`IGNORE`
: Tells the database to ignore any duplicate key errors generated by `PRIMARY KEY` and `UNIQUE` constraints. However, only records that don't generate such errors will be updated.

`ORDER BY`
: Tells the database to update the rows in the specified order (ascending or descending) of the columns specified.

`LIMIT` *`int`*
: Restricts the `UPDATE` action to a specific number of rows, as designated by the *`int`* value.

MySQL and MariaDB support `DEFAULT` value assignment in both the `INSERT` statement and the `UPDATE` statement.

The following `UPDATE` increases all prices in the *titles* table by 1:

```
UPDATE titles SET price = price + 1;
```

The next example limits the `UPDATE` to the first 10 records encountered in the *titles* table, according to *title_id*. Also, the value of *price* is updated twice. Those two updates of *price* are assessed from left to right. First the price is doubled, and then it is increased by 1:

```
UPDATE titles
SET price = price * 2,
    price = price + 1
ORDER BY title_id
LIMIT 10;
```

Oracle

The Oracle implementation of `UPDATE` allows updates against views, materialized views, subqueries, and tables in an allowable schema:

```
UPDATE [ONLY]
 { [schema.]{view_name | materialized_view_name |
    table_name}
      [@database_link] [alias]
      {[PARTITION (partition_name)] |
       [SUBPARTITION (subpartition_name)]}
   | subquery [WITH { [READ ONLY] |
      [CHECK OPTION [CONSTRAINT constraint_name]] }]
   | [TABLE (collection_expression_name) [ ( + ) ]] }
SET {column_name1[, ...]} = {expression[, ...] | subquery} |
      VALUE [(alias)] = {value | (subquery)},
    {column_name2[, ...]} = {expression[, ...] | subquery} |
       VALUE [(alias)] = {value | (subquery)},
    [, ...]
{WHERE search_conditions | CURRENT OF cursor_name}
[RETURNING expression[, ...] INTO variable[, ...]]
[LOG ERRORS
  [ INTO [schema.]table ]
  [ (simple_expression) ]
  [ REJECT LIMIT { int | UNLIMITED } ]]
```

where:

`ONLY`
: Tells Oracle not to update rows from any subviews. Applies only to views that belong to a hierarchy.

`materialized_view_name`
: Applies the `UPDATE` statement to a preexisting snapshot.

`@database_link`
: Applies the `UPDATE` statement to a view or table on a remote server made available through a preexisting database link.

`alias`
: Specifies an alias for the table being updated. Oracle allows table aliases, but it does not support the `AS` keyword with `UPDATE` statements. Aliases can also be supplied for the `VALUE` clause of an `UPDATE` statement.

`PARTITION`
: Applies the update to a named partition, rather than to an entire table. You are not required to name a partition when updating a partitioned table, but doing so can, in many cases, help reduce the complexity of your `WHERE` clause.

`SUBPARTITION`
: Applies the update to a named subpartition, rather than to an entire table.

`WITH READ ONLY`
: Specifies that the *`subquery`* cannot be updated. In some cases, an `UPDATE` transaction may actually alter the records used in a subquery. The `WITH READ ONLY` clause prevents this from happening.

`WITH CHECK OPTION`
: Tells Oracle to abort any changes to the updated table that would not appear in the result set of the subquery.

`CONSTRAINT`
: Tells Oracle to further restrict changes based upon a specific constraint.

`SET VALUE`
: Allows you to set the entire row value for any `TABLE` data type. The `SET VALUE` clause is very similar to the SQL standard `SET ROW` clause. You can also specify a subquery that retrieves all values needed by the `SET VALUE` clause.

`RETURNING`
: Retrieves the rows affected by the command, whereas `UPDATE` normally only shows the number of rows updated. When used for a single-row update, the values of the row can be stored in PL/SQL variables and bind variables. When used for a multi-row delete, the values of the rows are stored in bind arrays.

`INTO`
: Indicates the variables into which the values brought back by the `RETURNING` clause should be stored.

`LOG ERRORS INTO [`*`schema.`*`]`*`table`*
: Specifies the name of the error-logging table.

`REJECT LIMIT {` *`int`* `| UNLIMITED }`
: Specifies the upper limit of errors to log before the statement terminates or rolls back.

Oracle has some important rules about issuing `UPDATE` statements:

- `UPDATE` statements are *not* allowed against tables or the base tables of views containing a domain index with a status of `FAILED` or `IN PROGRESS`. `UPDATE` statements are also not allowed against any table that has an index partition with a status of `UNUSABLE`. (You can avoid the index partition problem by setting the `SKIP_UNUSABLE_INDEXES` session parameter to `TRUE`.)
- Updates against views can be problematic if a view's defining query contains a join, an aggregate function, a set operator, the `DISTINCT` keyword, an `ORDER BY` clause, a `GROUP BY` clause, a `CONNECT BY` clause, a `START WITH` clause, an analytical function, a collection expression, or a subquery. (Under these circumstances, you can use an `INSTEAD OF` trigger to update the tables underlying a view.)

The following code snippets show some examples of the extensions that Oracle offers to the `UPDATE` statement. To begin with, assume that the *sales* table has grown into a large partitioned table. You can update a specific partition using the `PARTITION` clause. For example:

```
UPDATE sales PARTITION (sales_yr_2004) s
   SET s.payterms = 'Net 60'
WHERE qty > 100;
```

You can also use the `SET VALUE` clause to supply a new value for each column in the row identified by the `WHERE` clause:

```
UPDATE big_sales bs
   SET VALUE(bs) = (SELECT VALUE(s) FROM sales s
                    WHERE bs.title_id = s.title_id
                    AND bs.stor_id  = s.stor_id)
WHERE bs.title_id = 'TC7777';
```

You can return values for review after an update by using the RETURNING clause. The following example updates one row, placing the updated values into PL/SQL variables:

```
UPDATE employee
SET job_id = 13, job_level = 140
WHERE last_name = 'Josephs'
RETURNING last_name, job_id
INTO :var1, :var2;
```

You can also log errors to a table:

```
UPDATE employee
SET job_id = 13, job_level = 140
WHERE last_name = 'Josephs'
LOG ERRORS INTO errlog ('job_id job_level failure')
REJECT LIMIT 10;
```

PostgreSQL

PostgreSQL supports the SQL-standard UPDATE syntax with a couple of small variations: it provides an additional FROM clause and RETURNING clause, and although it supports an array functionality, it does not support the ARRAY keyword. PostgreSQL also supports the UPDATE statement within a common table expression. If the UPDATE is not the final query, then it must have a RETURNING clause. PostgreSQL's UPDATE syntax is:

```
[WITH [RECURSIVE] select_clause[, ...] ]
UPDATE [ONLY] table_name [*] [[AS] alias]
SET {{column_name = { ARRAY [array_val[, ...]] | DEFAULT |
      NULL | scalar_expression },
      column_name = { ARRAY | DEFAULT |
      NULL | scalar_expression }
      [, ...]}
   | (column_name[, ...]) = [ROW](val[, ...])
SET { column_name = {expression | DEFAULT} |
     (column_name[, ...]) = [ROW](val[, ...]) |
     {column_name[, ...]) = (subquery) }[, ...])
[FROM expression[, ...])]
[WHERE search_condition | WHERE CURRENT OF cursor_name]
[returning_clause]
```

Most of the syntax elements are the same as in the SQL standard. The only nonstandard elements are:

`FROM`
: Provides the ability to build highly selective join-based criteria when determining which rows to update. `FROM` is not needed when only one table (the target table) is used to determine the rows to be updated.

`returning_clause`
: Provides the ability to return changed values or values from joined tables. Refer to "RETURNING Clause" on page 403 for details.

In the following example, we want to update *job_lvl* for employees who have a *job_id* of 12 and a *min_lvl* of 25. We could do this with a large, complex subquery, or we could use the `FROM` clause to enable us to build a join:

```
UPDATE employee As e
SET job_lvl = 80
FROM jobs As j
WHERE e.job_id = j.job_id
AND j.job_id = 12
AND j.min_lvl = 25;
```

SQL Server

SQL Server supports most of the basic components of the SQL standard `UPDATE` statement, but it does not support the `ONLY` and `ARRAY` keywords, nor does it support an array update functionality. However, SQL Server has extended the capabilities of `UPDATE` by adding table hints using the `WITH` clause, query hints using the `OPTION` clause, as well as more robust variable handling, as follows:

```
[WITH cte_query[,...]]
UPDATE {table_name | view_name | rowset}
[WITH (table_hint1, table_hint2[, ...])]
SET {column_name = {DEFAULT | NULL | scalar_expression}
   | variable_name = scalar_expression
   | variable_name = column_name = scalar_expression}[, ...]
[OUTPUT expression INTO {@table_variable | output_table}
   [ (column_list[, ...]) ]]
[FROM {table1 | view1 | nested_table1 | rowset1}[, ...]]
   [AS alias]
[JOIN {table2[, ...]}]
WHERE {conditions | CURRENT OF [GLOBAL] cursor_name}
[OPTION (hint1, hint2[, ...])]
```

where:

`WITH (`*`table_hint1, table_hint2`*`[, ... ])`
: Allows the use of table hints to override the default behavior of the query optimizer. Since the query optimizer is quite good at choosing query plans, use hints only with a deep understanding of the tables, indexes, and data affected by the operation. Without this understanding, including hints could result in a decrease rather than an increase in performance.

variable_name
: SQL Server variables must be declared prior to the `UPDATE` statement, in the form `DECLARE @variable`. The construct `SET @variable = column1 = expression1` sets a variable to the final value of an updated column, whereas `SET @variable = column1, column1 = expression` sets the variable to the value of the column before execution of the `UPDATE` statement.

`FROM`
: Provides the ability to build highly selective join-based criteria when determining which rows to update. `FROM` is not needed when only one table (the target table) is used to determine the rows to be updated.

`AS alias`
: Allows you to assign an easy-to-use alias to the table, view, nested table subquery, or rowset function.

`JOIN`
: Provides the ability to use SQL standard syntax for joined tables, in conjunction with the `FROM` clause.

`GLOBAL`
: A slight variation on the SQL standard's `WHERE CURRENT OF` clause. The clause `WHERE CURRENT OF cursor_name`, when used in combination with a cursor, directs SQL Server to update only the single record where the cursor is currently positioned. The cursor is assumed to be a local cursor, but it can be designated a global cursor by using the keyword `GLOBAL`.

`OPTION (hint1, hint2[, ... ])`
: Allows the use of query hints to override the default behavior of the query optimizer. As in the `WITH` clause, which uses table hints, use query hints only if you have a deep understanding of the tables, indexes, and data affected by the operation. Without this understanding, including hints could result in a decrease rather than an increase in performance.

The primary extension to the SQL standard that SQL Server offers in an `UPDATE` statement is a `FROM` clause. This `FROM` clause allows the use of the `JOIN` statement to make it especially easy to update rows in the target table by correlating rows declared in the `FROM` clause with the rows updated by the `UPDATE` *table_name* component of the statement. The following example shows an update using the SQL standard style and a rather cumbersome subquery, followed by an update using SQL Server's `FROM` clause extension to update the result of a table join. Both statements accomplish the same work, but in very different ways:

```
-- SQL standard style
UPDATE titles
SET    pubdate = GETDATE()
WHERE  title_id IN
   (SELECT title_id
    FROM   titleauthor
    WHERE  au_id IN
       (SELECT au_id
        FROM   authors
        WHERE  au_lname = 'White'))
-- SQL Server style
UPDATE titles
SET    pubdate = GETDATE()
FROM   authors AS a
JOIN   titleauthor AS t2 ON a.au_id = t2.au_id
WHERE  t2.title_id = titles.title_id
  AND a.au_lname = 'White'
```

Performing this update using the SQL Server style is simply a matter of joining two tables—*authors* and *titleauthor*—to the *titles* table. To perform the same operation using SQL standard–compliant code, the *au_id* in *author* must first be found and passed up to the *titleauthors* table, and then the *title_id* must be identified and passed up to the main `UPDATE` statement.

The following example updates the *state* column for the first 10 authors from the *authors* table:

```
UPDATE authors
SET state = 'ZZ'
FROM (SELECT TOP 10 * FROM authors ORDER BY au_lname) AS t1
WHERE authors.au_id = t1.au_id
```

The important thing to note about this example is that it is normally difficult to update the first `n` records in an `UPDATE` statement, unless there is some explicit row sequence you can identify in the `WHERE` clause. However, the nested table subquery in the `FROM` clause uses a `TOP` keyword to return the first 10 records, thereby saving a lot of added programming that would otherwise be required.

See also

- `DECLARE CURSOR` in Chapter 9
- `JOIN` in Chapter 4
- `RETURNING`
- `SELECT` in Chapter 4
- `WHERE` in Chapter 4
- `WITH` in Chapter 4

6

Securing Your Data

In this chapter, we will discuss the SQL commands that enable DBAs and developers to permit or disable access to data, objects, and execution permissions within the database, as well as several commands that provide a higher level of control over the runtime characteristics of a worker session. These statements, particularly `GRANT` and `REVOKE`, make up the core of the data control language (DCL) category within the SQL standard.

There are some variations between vendors in terms of which statements they classify as DCL statements, and not all of them use that name. For example, SQL Server includes a `DENY` statement that implements a subset of the behavior of the SQL standard's `REVOKE` statement (as explained in "REVOKE Statement" on page 475), and MySQL categorizes `GRANT` and `REVOKE` as database administration statements and does not use the term DCL.

How to Use This Chapter

When researching a command in this chapter:

1. Read "SQL Platform Support" on page 440.
2. Check Table 6-1.
3. Look up the specific SQL statement, check the syntax, and read the "Keywords," "Rules at a glance," and "Programming tips and gotchas" sections. Do this even if you are looking for a specific platform implementation.
4. Finally, read the platform-specific implementation information.

You will note that the entry for a given platform implementation does *not* duplicate information on any clauses that do not differ from the standard. So, it is possible that you will need to flip between the descriptions for a vendor variation and the SQL standard to cover all possible details of that command.

In our discussions of MySQL, we will also include MariaDB, a fork of MySQL. For the most part, MySQL and MariaDB provide fully code-compatible syntax. In these cases we will refer to them collectively as MySQL. We will explicitly mention MariaDB only in situations where it deviates from MySQL in an important way.

SQL Platform Support

Table 6-1 provides a listing of the SQL statements discussed in this chapter, the platforms that support them, and the degree to which they are supported. The following list offers useful tips for reading Table 6-1, as well as an explanation of what each abbreviation stands for:

1. The first column contains the SQL commands, in alphabetical order.
2. The SQL statement class for each command is indicated in the second column.
3. The subsequent columns list the level of support for each vendor:

   Supported (S)
   : The platform supports the SQL standard for the particular command.

   Supported, with variations (SWV)
   : The platform supports the SQL standard for the particular command, using vendor-specific code or syntax.

   Supported, with limitations (SWL)
   : The platform supports some but not all of the functions specified by the SQL standard for the particular command.

   Not supported (NS)
   : The platform does not support the particular command according to the SQL standard.

The sections that follow the table describe the commands in detail. Remember that even if a specific SQL command is listed in the table as "Not supported," the platform usually has alternative coding or syntax to enact the same command or function. Therefore, be sure to read the discussion and examples for each command later in this chapter.

Table 6-1. Alphabetical quick SQL command reference

SQL Statement	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`CONNECT`	SQL-connection	NS	SWL	SWL	SWV
`CREATE ROLE`	SQL-schema	SWL	SWV	SWV	SWL
`GRANT`	SQL-schema	SWV	SWV	SWV	SWV

SQL Statement	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`REVOKE`	SQL-schema	SWV	SWV	SWV	SWV
`SET CONNECTION`	SQL-connection	NS	NS	S	SWL
`SET CONSTRAINTS`	SQL-connection	NS	S	S	NS
`SET PATH`	SQL-session	NS	NS	NS	NS
`SET ROLE`	SQL-session	NS	SWV	SWV	NS
`SET SCHEMA`	SQL-session	NS	NS	S	NS
`SET SESSION AUTHORIZATION`	SQL-session	NS	NS	S	NS
`SET TIME ZONE`	SQL-session	SWL	SWV	SWL	NS
`SET TRANSACTION`	SQL-session	SWV	SWL	S	SWV

SQL Command Reference

CONNECT Statement

The `CONNECT` statement establishes a connection to the DBMS and to a specific database within the DBMS under a predefined user context.

Platform	Command
MySQL	Not supported
Oracle	Supported, with limitations
PostgreSQL	Supported, with limitations
SQL Server	Supported, with variations

SQL standard syntax

```
CONNECT TO [DEFAULT | {[server_name] [AS connection_name]
   [USER user_name]}]
```

Keywords

`DEFAULT`
: Initiates a default session with the server, with the current database and the default user authorization. The standard specifies that `CONNECT TO DEFAULT` is issued implicitly if you start a SQL session without first issuing a `CONNECT` statement.

`server_name`
: An implementation-defined string that points to the database server instance to which the connection will be made. *`server_name`* may be a string literal enclosed in single quotes or a host variable.

`AS` *`connection_name`*
: Establishes a connection with the name *`connection_name`*, which may be a string literal enclosed in single quotes or a host variable. This is optional only for the first connection attached to a server; all subsequent sessions must include the `AS` clause. This is useful for telling user connections apart when many users (or perhaps even a single user) have many open sessions on a given *`server_name`*.

`USER` *`user_name`*
: Specifies the *`user_name`* under which to establish the connection to the named server.

Rules at a glance

Issue the `CONNECT` statement to open an interactive SQL working session with a DBMS. The period between issuing the `CONNECT` and `DISCONNECT` statements is commonly called a *session*. Typically, you will complete all work on a DBMS during an explicitly invoked session.

If you do not specify the server name, the connection name, or the username, the DBMS will provide default values for you. The defaults vary from platform to platform.

To connect to the *houston* server under the user ID *pubs_admin*, you might issue the command:

```
CONNECT TO houston USER pubs_admin
```

If the DBMS requires named connections, you might use the following alternative syntax:

```
CONNECT TO houston USER pubs_admin
   AS pubs_administrative_session;
```

Or if you want just a simple, short-term connection, you might use the default:

```
CONNECT TO DEFAULT;
```

Programming tips and gotchas

If the `CONNECT` statement is invoked before the previous session has been explicitly disconnected, the old session becomes dormant and the new session becomes active. You can then switch between connections using the `SET CONNECTION` statement, described later in this chapter.

MySQL

MySQL does not support the `CONNECT` statement.

Oracle

The `CONNECT` statement in Oracle allows a database connection under a specific username. Alternatively, a connection can be established for special privileges with `AS SYSOPER` or `AS SYSDBA`. The Oracle syntax is:

```
CONN[ECT] [[logon | / | proxy] [AS role]]
```

where:

`CONN[ECT] [`*`logon`*` | / | `*`proxy`*`]`
: Establishes a connection to the database instance using the specified credentials. If you omit the username and/or password or enter a slash (`/`), Oracle prompts you for them. *`proxy`* has the syntax *`proxyuser`*`[`*`username`*`]` `[`*`password`*`]`; the username and the brackets around it are required, but the password is optional (if you do not provide it, you will be prompted for it).

`AS` *`role`*
: Optionally establishes the connection as the specified system role, enabling special privileges. *`role`* can be one of `SYSASM`, `SYSBACKUP`, `SYSDBA`, `SYSDG`, `SYSOPER`, `SYSRAC`, or `SYSKM`.

If another connection is already open, `CONNECT` commits any open transactions, closes the current session, and opens the new one.

> Oracle also allows the `CONNECT` statement in its SQL*Plus and *i*SQL*Plus tools. SQL*Plus uses the `CONNECT` command somewhat differently: to connect a user to a specific schema.

PostgreSQL

PostgreSQL allows the use of the `CONNECT` statement when defining a user connection to a database for embedded SQL only (e.g., inside a C program), using the following syntax:

```
EXEC SQL CONNECT TO target_name [AS connection_name]
USER {login_name[.password] | $integrated}
```

where:

`CONNECT TO` *`target_name`*
: Specifies the server and database to which you want to connect. You may use a variety of expressions to declare the target, such as *`database_name`*`[@`*`host name`*`][:`*`port`*`]` with or without prefixes for TCP (*tcp:postgresql://...*) or Unix (*unix:postgresql://...*), the keyword `DEFAULT` (to connect to the default database under the default username), a variable, or a SQL string literal.

`AS` *`connection_name`*
: Names the connection with an alphanumeric string of up to 30 characters in length. Symbols are allowed, except for hyphens (-), but the first character must be a letter. `CURRENT` and `ALL` are reserved and may not be used for a *`connection_name`*. You need only define connection names when making more than one connection.

`USER {`*`login_name`*`[.`*`password`*`] | $integrated}`
: Connects the session under the *`login_name`* specified using either the *`password`* provided or Windows integrated security. The password is optional when supplying a login name.

When using *psql*, the command-line client shipped with PostgreSQL, use the \c or \connect switch, which has the following syntax:

```
\c or \connect
[ -reuse-previous=on|off ]
[ dbname [ user_name ] [ host ] [ port ] | conninfo ]
```

where:

-reuse-previous
: Denotes whether to use previous connections settings if the setting is not explicitly overwritten by this connections setting. This is set to on by default.

`dbname`
: Specifies the name of the database to connect to on the current connected server if no further arguments are specified.

`user_name`
: Specifies the login role to connect as.

`host`
: Specifies the host server name or IP address. Defaults to *local* when not specified.

`port`
: Specifies the port the service runs under. Defaults to 5432 if there is a host specified and no port.

`conninfo`
: Specifies the connection string used for the connection.

For example, in *psql* you could switch to a different database (here, *nutshell*) under the same logged-in role with the following command:

```
\c nutshell
```

SQL Server

SQL Server supports the basic elements of the `CONNECT` statement within embedded SQL (inside C++ or Visual Basic programs), with the following syntax:

```
CONNECT TO [server_name.]database_name [AS connection_name]
USER {login_name[.password] | $integrated}
```

where:

`CONNECT TO [`*`server_name`*`.]`*`database_name`*
: Specifies the server and database to which you want to connect. You may leave off the *`server_name`* if you wish to default to the local server.

`AS` *`connection_name`*
: Names the connection with an alphanumeric string of up to 30 characters in length. Symbols are allowed, except for hyphens (`-`), but the first character must be a letter. `CURRENT` and `ALL` are reserved and may not be used for a *`connection_name`*. You need only define connection names when making more than one connection.

`USER {`*`login_name`*`[.`*`password`*`] | $integrated}`
: Connects the session under the *`login_name`* specified using either the *`password`* provided or Windows integrated security. The password is optional when supplying a login name.

For example, we can connect to the server named *new_york* as the Windows user *pubs_admin* as follows:

```
CONNECT TO new_york.pubs USER pubs_admin
```

To issue the same command under SQL Server standard security:

```
EXEC SQL CONNECT TO new_york.pubs USER pubs_admin
```

To issue the same command under Windows integrated security:

```
EXEC SQL CONNECT TO new_york.pubs USER $integrated
```

To switch to a different connection, use the `SET CONNECTION` statement.

See also

- `SET CONNECTION`

CREATE ROLE Statement

`CREATE ROLE` allows the creation of a named set of privileges that may be assigned to users of a database. When a role is granted to a user, that user gets all the privileges and permissions of that role at the database level. Roles are generally accepted as one of the best means for maintaining security and controlling privileges within a database.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL standard syntax

```
CREATE ROLE role_name [WITH ADMIN {CURRENT_USER | CURRENT_ROLE}]
```

Keywords

`CREATE ROLE` *`role_name`*
: Creates a new role and differentiates that role from a host DBMS user and other roles. A role can be assigned any permission that a user can be assigned. The important difference is that a role can then be assigned to one or more users, thus giving them all the permissions of that role.

`WITH ADMIN {CURRENT_USER | CURRENT_ROLE}`
: Assigns a role immediately to the currently active user or currently active role along with the privilege to pass the use of the role on to other users. The statement defaults to `WITH ADMIN CURRENT_USER`.

Rules at a glance

Using roles for database security can greatly ease administration and user maintenance. The general steps for using roles in database security are:

1. Assess the needs for roles and pick the role names (e.g., *administrator*, *manager*, *data_entry*, *report_writer*, etc.).
2. Assign permissions to each role as if it were a standard database user, using the `GRANT` statement. For example, the *manager* role might have permission to read from and write to all user tables in a database, while the *report_writer* role might only have permission to execute read-only reports against certain reporting tables in the database.
3. Use the `GRANT` statement to grant roles to users of the system according to the types of work they will perform.

Permissions can be disabled using the `REVOKE` command.

Programming tips and gotchas

The main problem with roles is that occasionally a database administrator will provide redundant permissions to a role and separately to a user. If you ever need to prevent a user's access to a resource in situations like this, you usually will need to

REVOKE the permissions twice: the role must be revoked from the user, and then the specific user-level privilege must also be revoked from the user.

MySQL

MySQL supports a variation of the CREATE ROLE statement. It does not support the WITH ADMIN clause but does offer an IF NOT EXISTS extension that causes the statement to produce a warning (instead of raising an error and rolling the statement back) if you try to create a role that already exists. Its syntax is as follows:

```
CREATE ROLE [IF NOT EXISTS] role_name[, role_name2, ..]|
```

For example:

```
CREATE ROLE IF NOT EXISTS 'admins', 'read_only';
```

You can also specify a hostname, for example if you want the role to apply only to users connecting from the local server:

```
CREATE ROLE 'admins'@'localhost';
```

When the hostname is omitted it defaults to @'%', which means connection from anywhere.

Additionally, MySQL provides a SET DEFAULT ROLE statement that defines which roles become active for a given user when they connect to the server:

```
SET DEFAULT ROLE role_name[, role_name2, ...] TO user_name
```

Oracle

Oracle supports the concept of roles, though its implementation is very different from the SQL standard's. It also offers an ALTER ROLE statement that is not currently supported by the SQL standard. The syntax is as follows:

```
{CREATE | ALTER} ROLE role_name
   [NOT IDENTIFIED |
    IDENTIFIED {BY password | EXTERNALLY | GLOBALLY |
       USING package_name}]
```

where:

`{CREATE | ALTER} ROLE` *`role_name`*
: Identifies the name of the new role being created or the preexisting role being modified.

`NOT IDENTIFIED`
: Declares that no password is needed for the role to receive authorization to the database. This is the default.

`IDENTIFIED`
: Declares that the users of the role must authenticate themselves by the method indicated before the role is enabled via the SET ROLE command, where:

`BY` *`password`*
: Creates a local role authenticated by the string value of *`password`*. Only single-byte characters are allowed in the password, even when using a multibyte character set.

`EXTERNALLY`
: Creates an external role that is authenticated by the operating system or a third-party provider. In either case, the external authentication service will likely require a password.

`GLOBALLY`
: Creates a global role that is authenticated by an enterprise directory service, such as an LDAP directory.

`USING` *`package_name`*
: Creates an application role that enables a role only through an application that uses a PL/SQL package of *`package_name`*. If you omit the schema, Oracle assumes that the package is in your schema.

In Oracle, the role is created first, then granted privileges and permissions as if it were a user via the `GRANT` command. When users want to get access to the permissions of a role protected by a password, they use the `SET ROLE` command. If a password is placed on the role, any user wishing to access it must provide the password with the `SET ROLE` command.

Oracle ships with several preconfigured roles. `CONNECT`, `DBA`, and `RESOURCE` are available in all versions of Oracle. `EXP_FULL_DATABASE` and `IMP_FULL_DATABASE` are newer roles used for import and export operations. See the discussion of Oracle in "GRANT Statement" on page 451 for further details on the preconfigured roles available in Oracle.

The following example uses `CREATE` to specify a new role in Oracle, grants it privileges, assigns it a password with `ALTER ROLE`, and grants the new role to a couple of users:

```
CREATE ROLE boss;
GRANT ALL ON employee TO boss;
GRANT CREATE SESSION, CREATE DATABASE LINK TO boss;
ALTER ROLE boss IDENTIFIED BY le_grand_fromage;
GRANT boss TO emily, jake;
```

PostgreSQL

PostgreSQL supports both the `ALTER` and `CREATE ROLE` statements, and it offers a nearly identical extension of its own called `ALTER/CREATE GROUP`. The `CREATE ROLE WITH LOGIN` statement is equivalent to the PostgreSQL-specific `CREATE USER` and is the recommended way of creating new users. The PostgreSQL syntax for `CREATE/ALTER ROLE` follows:

```
{CREATE | ALTER} ROLE name
[ [WITH] [[NO]SUPERUSER] [[NO]CREATEDB] [[NO]CREATEUSER] [[NO]INHERIT]
[ [NO]LOGIN]
   [CONNECTION LIMIT int]
   [ {ENCRYPTED | UNENCRYPTED} PASSWORD 'password' ]
   [VALID UNTIL 'date_and_time'] [IN ROLE rolename[, ...]]
   [IN GROUP groupname[, ...]] [ROLE rolename[, ...]]
   [ADMIN rolename[, ...]] [USER rolename[, ...]] [...] ]
[RENAME TO new_name]
[SET parameter {TO | =} {value | DEFAULT}]
[RESET parameter]
```

where:

`{CREATE | ALTER} ROLE` *`name`*
: Specifies the new role to create or the existing role to modify, where *`name`* is the name of the role to create or modify.

`[NO]SUPERUSER`
: Specifies whether the role is a superuser or not. The superuser may override all access restrictions within the database. `NOSUPERUSER` is the default.

`[NO]CREATEDB`
: Specifies whether the role may create databases or not. `NOCREATEDB` is the default.

`[NO]CREATEROLE`
: Specifies whether the role may create new roles and alter or drop other roles. `NOCREATEROLE` is the default.

`[NO]CREATEUSER`
: Specifies whether the role may create a superuser. This clause is deprecated in favor of `[NO]SUPERUSER`.

`[NO]INHERIT`
: Specifies whether the role inherits the privileges of the roles of which it is a member. A role with `INHERIT` automatically may use the privileges that are granted to the roles of which it is (directly or indirectly) a member. `INHERIT` is the default.

`[NO]LOGIN`
: Specifies whether the role may log in. With `LOGIN`, a role is essentially a user. With `NOLOGIN`, a role provides a mapping to specific database privileges but is not an actual user. The default is `NOLOGIN`.

`CONNECTION LIMIT` *`int`*
: Specifies how many concurrent connections a role can make, if it has `LOGIN` privileges. The default is –1; that is, unlimited.

`{ENCRYPTED | UNENCRYPTED} PASSWORD '`*`password`*`'`
: Sets a password for the role, if it has `LOGIN` privileges. The password may be stored in plain text (`UNENCRYPTED`) or encrypted in MD5-format in the system catalogs (`ENCRYPTED`). Older clients may not support MD5 authentication, so be careful.

`VALID UNTIL '`*`date_and_time`*`'`
: Sets a date and time when the role's password will expire, if it has `LOGIN` privileges. When omitted, the default is no time limit.

`IN ROLE, IN GROUP`
: Specifies one or more existing roles (or groups, though this clause is deprecated) of which the role is a member.

`ROLE, GROUP`
: Specifies one or more existing roles (or groups, though this clause is deprecated) that are automatically added as members of the new or modified role.

`ADMIN `*`rolename`*
: Similar to the `ROLE` clause, except new roles are given the right to grant membership in this role to others.

`USER `*`username`*
: Equivalent to the `ROLE` clause `WITH LOGIN`. This is a deprecated clause that is still accepted for backward compatibility.

`[RENAME TO `*`new_name`*`]`
: Renames an existing role to a new name.

`[SET `*`parameter`*` {TO | =} {`*`value`*` | DEFAULT}], [RESET `*`parameter`*`]`
: Sets a configuration parameter, or resets a configuration parameter to the default value. Configuration parameters are fully detailed within PostgreSQL's documentation.

Use the `DROP ROLE` clause to drop a role you no longer want.

SQL Server

SQL Server supports `ALTER` and `CREATE ROLE` statements, as well as equivalent capabilities via the system stored procedure *sp_add_role*. It does not support the `WITH ADMIN` clause. SQL Server's syntax is as follows:

```
CREATE ROLE role_name [AUTHORIZATION owner_name]

ALTER ROLE existing_role_name
   { WITH NAME = role_name_new | ADD MEMBER role_name |
     DROP MEMBER role_name }
```

where:

`AUTHORIZATION` *`owner_name`*
: Specifies the database user or role that owns the newly created role. The newly created role may also be assigned to system roles, such as *db_securityadmin*. When omitted, the role is owned by the user that created it.

`WITH NAME =` *`role_name_new`*
: Specifies the new name of the role, where the role is a database user or user-defined database role. Changing the name of a role does not change any other aspect of the role, such as permissions granted to the role, the owner, or the internal ID number.

`ADD MEMBER =` *`role_name`*
: Adds a newly created user role or user-defined database role to an existing role, where the role is a database user or user-defined database role.

`DROP MEMBER =` *`role_name`*
: Drops an existing user or user-defined database role from a previously created role, where the role is a database user or user-defined database role.

See also

- `GRANT`
- `REVOKE`
- `SET ROLE`

GRANT Statement

The `GRANT` statement assigns privileges to users and roles, allowing them to access and use database objects as well as a variety of powerful system privileges. In addition, most database platforms use the `GRANT` statement to authorize users and roles to create new database objects and execute stored procedures, functions, and so forth.

Object privileges are quite standard, both within the SQL standard and across the various database platforms. However, *system privileges* per se are not a part of the SQL standard. System privileges, even within a given database platform, can vary quite a lot (say, between SQL Server and Azure SQL Database). Consequently, these are beyond the scope of our discussion.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
GRANT { {object privilege[, ...] | role[, ...]} }
[ON database_object_name]
[TO grantee[, ...]]
[WITH HIERARCHY OPTION] [WITH GRANT OPTION] [WITH ADMIN OPTION]
[FROM {CURRENT_USER | CURRENT_ROLE}]
[GRANTED BY grantor ]
```

Keywords

`GRANT` *`object privilege`*`[, ... ]`
: Grants privileges to issue one or more SQL statements. Multiple privileges may be granted at one time, separated by commas. You should not combine `ALL PRIVILEGES` with other privileges, but the remainder may be combined in any order. Valid privileges are:

  `ALL PRIVILEGES`
  : Grants all privileges currently assigned to the grantor to the named user(s) and/or for the specified database objects. This is generally not a recommended approach, since it can encourage sloppy permissioning.

  `EXECUTE`
  : Grants the privilege to execute any SQL standard routine (stored procedure, user-defined function, or user-defined method).

  `SELECT | INSERT | UPDATE | DELETE`
  : Grants the specified privilege for a given user on the specified database object, such as a table or view. You may add a parenthetical list of the columns of the table or view on which the privilege will be granted (except for the `DELETE` statement).

  `REFERENCES`
  : Grants the privilege to use the column(s) in any constraint or assertion, not just a foreign key. The `REFERENCES` clause also allows you to define column-specific details (by including a parenthetical, comma-delimited list) for statements such as `INSERT`, `SELECT`, and so on. Finally, `REFERENCES` grants the privilege to create or drop foreign key constraints referencing the database object as a parent object.

  `TRIGGER`
  : Grants the privilege to create a trigger to operate on a specific table and its columns.

  `UNDER`
  : Grants the privilege to create subtypes or typed tables.

  `USAGE`
  : Grants privileges to use a domain, user-defined type, character set, collation, sequence, or translation.

`GRANT` *`role`*`[, ... ]`

Grants a specific, predefined role to the grantee; this role must be available to the user or role identified in the `FROM` clause. For example, the database administrator might want to create a role called *Reporter* that has read-only access to several tables. Subsequently granting this role to a user would bestow upon that user all of the read-only permissions granted to the *Reporter* role. That is, users can have roles assigned to them and receive all of the permissions already assigned to those roles.

`ON` *`database_object_name`*

Grants privileges on the specified, predefined database object identified by *`database_object_name`*, which may be one of the following:

```
{[TABLE] object_name | DOMAIN object_name |
 COLLATION object_name | CHARACTER SET object_name |
 TRANSLATION object_name | SPECIFIC ROUTINE routine_name}
```

`TO` *`grantee`*

Assigns the privilege(s) to the named user(s) or role(s), designated as *`grantee`*. You can assign privileges to multiple users and/or roles, as long as commas separate them. Alternatively, privileges may be granted to `PUBLIC`, meaning that all users (including those that will be created in the future) have the specified privileges.

`WITH HIERARCHY OPTION`

Bestows the `WITH HIERARCHY OPTION` privilege, enabling the grantee to `SELECT` not only from the named table, but also from all of its subtables. This applies to privilege grants only.

`WITH GRANT OPTION`

Enables the grantee to further grant the privileges to other users. This applies to privilege grants only.

`WITH ADMIN OPTION`

Bestows the ability to assign a role. The ability to assign role responsibilities is separate from the ability to grant privileges to other users or roles.

`FROM {CURRENT_USER | CURRENT_ROLE}`

Names the user who is granting the specified privilege(s), either the `CURRENT_USER` or the `CURRENT_ROLE`. This clause is optional and assumes the current user context.

`GRANTED BY` *`grantor`*

Names the user who is granting the specified privilege(s). If specified, the *`grantor`* must be `CURRENT_ROLE` or `CURRENT_USER`. This clause is currently present in this form only for SQL compatibility.

Rules at a glance

Although it may be tempting to `GRANT ALL PRIVILEGES` to the users of your database and application, long experience has taught us that this is a recipe for disaster. You are strongly encouraged to use the principle of "least privileges," meaning that you should only grant permissions to users that are essential for them to perform their designated work. Applying this principle usually results in the need to create many users with varying levels of privileges. For example, instead of allowing a user to connect with admin privileges, you might need several types of users, some who can read only specific tables and views of the database, others who can read tables and views as well as execute certain stored procedures, and yet another who can read and write data, execute stored procedures, and take backups and bulk-copy data.

> Don't be a lazy SQL developer! Always apply the principle of least privileges when granting permissions. That is, never grant more permissions than those essential to the user or role in question. Giving every user system admin privileges is simply inexcusable in this era of constant hacks and significant compliance regulation. If you take the lazy way out, you may subject your organization to data breaches, hacks, and possible failure of very important compliance audits.

Hackers have stepped up the sophistication of their attacks over the decades, frequently causing enormous damage and costing organizations untold millions simply because the databases they target have only one or two users, each equipped with full permissions throughout the database. Don't make that same mistake.

You may grant many privileges on a single object with one statement, but do not mix the `ALL PRIVILEGES` privilege with the individual SQL statement keywords in a single `GRANT` statement. You can grant a specific privilege on a specific database object to a single user using the syntax:

```
GRANT privilege_name ON object_name TO grantee
```

For example:

```
GRANT SELECT ON employee TO dylan;
```

You can grant a specific privilege on a specific object to all users via the `PUBLIC` user. When a grant is issued to `PUBLIC`, that means everyone has that permission on that object, without the need for a specific grant. For example:

```
GRANT SELECT ON employee TO PUBLIC;
```

When granting privileges to multiple grantees, simply place a comma between each:

```
GRANT SELECT ON employee TO dylan, ava, PUBLIC
```

The previous example shows that you may grant privileges to multiple users—in this case, *dylan*, *ava*, and the `PUBLIC` role—in a single `GRANT` statement. When granting privileges on a table, you may extend or restrict the privileges to the column level by providing a list of columns enclosed in parentheses after the table name. For example:

```
GRANT SELECT ON employee(emp_id, emp_fname, emp_lname, job_id)
TO dylan, jake
```

This example shows that *dylan* and *jake* now have `SELECT` privileges on several columns of the *employee* table.

Programming tips and gotchas

Depending on the specific database implementation, views may or may not have access privileges independent from their base tables.

Note that all of the optional `WITH` clauses control extensions to the base privilege(s) granted in the statement. Thus, the following command grants *dylan* the privilege to `SELECT` records from the *employee* table:

```
GRANT SELECT ON employee TO dylan;
```

but the following command grants the privilege to `SELECT` records from the *employee* table *and* to grant that `SELECT` privilege to other users:

```
GRANT SELECT ON employee TO dylan
WITH GRANT OPTION;
```

Similarly, you can use the `REVOKE` statement to revoke only the `WITH GRANT OPTION`, the individual `SELECT` privilege, or both.

Most of the platforms isolate privileges at the user and role level. Thus, an individual user who is a member of two roles may be granted an individual permission four times—once for their primary role, once for `PUBLIC`, and once via each of the roles of which the user is a member. In this situation, you must be very careful. To remove the privilege completely, you'll have to remove the user from each role that has the permission and then revoke the user's privileges directly in both of the other roles. As a general rule, you should limit permissions granted to a role that all users belong to. For example, some databases have a built-in `PUBLIC` role of which all users are members of.

MySQL and MariaDB

MySQL and MariaDB provide additional access privileges, primarily relating to object manipulation within a database. Details on the supported privilege types are available in the MySQL and MariaDB documentation. The MySQL syntax (which is shared by MariaDB) is as follows:

```
GRANT [ { ALL [PRIVILEGES] |
   {SELECT | INSERT | UPDATE} [ (column_name[, ...]) ] | DELETE |
   REFERENCES [ (column_name[, ...]) ] } |
   {[{ALTER | CREATE | DROP} [dml_option]] | [EVENT] | [EXECUTE] |
   [FILE] | [INDEX] | [LOCK TABLES] | [PROCESS] | [RELOAD] |
   [REPLICATION {CLIENT | SLAVE}] | [SHOW DATABASES] | [SHOW VIEW] |
   [SHUTDOWN] | [SUPER] | [TRIGGER] | [USAGE]}[, ...]
ON [ {TABLE | FUNCTION | PROCEDURE} ]
   { [database_name.]table_name | * | *.* | database_name.* }
[PROXY ON user_name TO user_name[, ...]]
TO grantee_name [IDENTIFIED BY [PASSWORD] 'password'][, ...]
[AS user_name
   [WITH ROLE {DEFAULT | NONE | ALL | ALL EXCEPT [role_name[, ...]] } ]
[REQUIRE security_options]
[WITH with_option[...]]
```

Where keywords not covered by or that deviate from the standard are:

`REFERENCES`
: The `REFERENCES` clause is ignored but allowed.

`{ALTER | CREATE | DROP} [`*`dml_option`*`]`
: Grants the ability to alter, drop, or create tables and other database objects. When using the `CREATE` syntax, you are not required to specify an `ON` clause to identify a specific table. When you specify `ALTER`, `CREATE`, or `DROP` and an object name, it is assumed the object is a table. You can further refine this subclause with these *`dml_option`*s:

`{CREATE | ALTER | DROP} ROUTINE`
: Grants the privilege to create, alter, or drop procedures and functions.

`CREATE TEMPORARY TABLE`
: Grants the ability to use the `CREATE TEMPORARY TABLE` statement, for use with `GRANT CREATE` only.

`CREATE USER`
: Grants the privilege to create, drop, and rename users as well as to use the statement `REVOKE ALL PRIVILEGES`.

`CREATE VIEW`
: Grants the ability to use the `CREATE VIEW` statement.

`EVENT`
: Grants the privilege to create events for the event scheduler.

`FILE`
: Grants the ability to load data from, or write data to, files using the `SELECT INTO` and `LOAD DATA` commands.

`INDEX`
: Grants the ability to create or drop indexes.

`LOCK TABLES`
: Grants the privilege to execute the MySQL command `LOCK TABLES` on tables where the user has `SELECT` privileges.

PROCESS
: Grants the ability to view running processes using SHOW PROCESSLIST.

RELOAD
: Grants the ability to invoke the FLUSH and RESET commands.

REPLICATION {CLIENT | SLAVE}
: Grants a user the privilege to see metadata about replication slaves and masters (CLIENT), or grants a replication slave the right to read binlogs from a replication master (SLAVE).

SHOW DATABASES
: Grants the privilege to execute the MySQL command SHOW DATABASES.

SHOW VIEW
: Grants the ability to use the SHOW CREATE VIEW command.

SHUTDOWN
: Grants the privilege to use the MYSQLADMIN SHUTDOWN command to kill the server process.

SUPER
: Grants the user the privilege of one connection even if the MAX_CONNECTIONS threshold is reached. Users with SUPER privileges can also execute important MySQL commands such as CHANGE MASTER, KILL, MYSQLADMIN DEBUG, PURGE [MASTER] LOGS, and SET GLOBAL.

TRIGGER
: Grants the ability to create and drop triggers on a specific table.

USAGE
: Creates a "no privilege" user account (i.e., a user that has no privileges).

PROXY ON *user_name* TO *user_name*[, ...]
: Allows the named user to impersonate another user—i.e., to assume all of the previously granted rights and privileges of that user. Note that the other user may also be a role. The PROXY privilege must be granted alone and cannot be specified with other privileges.

ON {[*database_name*.]*table_name* | * | *.* | *database_name*.*}
: Grants privileges on the specified *table_name*, on all tables within the current database using an asterisk (*), on all tables in all databases with *.*, or on all tables in the specified *database_name* with *database_name*.*.

TO *grantee_name* [IDENTIFIED BY [PASSWORD] '*password*'][, ...]
: Names the user or users who will gain the specified privilege(s). The PASSWORD keyword is entirely optional. You may enter multiple users separated by commas. When granting privileges to a new user, you may also optionally set the

new password for the new named user at the same time using the `IDENTIFIED BY` clause.

`AS` *`user_name`* `[WITH ROLE {DEFAULT | NONE | ALL | ALL EXCEPT [`*`role_name`*`[, ... ] ] }`
: The `AS` clause, added in MySQL 8.0.16, provides additional context for statement execution. Its primary use is to grant the privileges of another role, but to restrict certain privileges already specified for that role. The `AS` clause may not be used in combination with the `PROXY` subclause and currently supports granting global privileges only (e.g., `ON *.*`). It cannot be used to grant privileges greater than those held by the granting user. In other words, this clause can only restrict privileges and not escalate them.

`REQUIRE` *`security_options`*`= {NONE | {SSL | X509} [CIPHER '`*`cipher_name`*`' [AND]] [ISSUER '`*`issuer_name`*`' [AND]] [SUBJECT '`*`subject_name`*`'] }`
: Specifies whether the user must connect with a secured connection or not, according to these security options:

    `REQUIRE NONE`
    : The account has no special SSL or X509 requirements. This is the default if no `REQUIRE` subclause is specified.

    `REQUIRE SSL`
    : Allows only SSL-encrypted connections for the account.

    `REQUIRE X509`
    : Specifies that the client must have a valid certificate, though the certificate, issuer, and subject do not matter. You can specify *X509* to also include one or more specific `SUBJECT`s, `ISSUER`s, and `CIPHER`s. The `AND` keyword is optional between the *`security_option`*s.

    `REQUIRE CIPHER '`*`cipher_name`*`'`
    : Ensures that a specific cipher method and ciphers and key lengths of sufficient length are used.

    `REQUIRE ISSUER '`*`issuer_name`*`'`
    : Ensures that a valid X509 certificate containing a specific certificate authority (CA) issuer is used.

    `REQUIRE SUBJECT '`*`subject_name`*`'`
    : Ensures that a valid X509 certificate containing a specific subject is used.

`WITH` *`with_option`*
: Allows you to set one or more optional privileges:

    `GRANT OPTION`
    : Entitles the grantee to assign the granted privilege (in fact, any privilege that that user/role possesses) to other users.

`MAX_QUERIES_PER_HOUR` *`count`*
: Limits the number of queries not served from the cache that may be performed by the user per hour. Queries served from the cache do not count against the limit. The default value of 0 means unlimited queries per hour.

`MAX_UPDATES_PER_HOUR` *`count`*
: Limits the number of `UPDATE` statements that may be performed by the user per hour. The default value of 0 means unlimited updates per hour.

`MAX_CONNECTIONS_PER_HOUR` *`count`*
: Limits the maximum number of simultaneously open connections that the user may hold per hour. The default value of 0 means the maximum number of simultaneous connections is determined by the `MAX_USER_CONNECTION` system variable.

Since MySQL is focused on speed, you can implement server-wide features that provide high-speed performance. For example, you can enable the `SKIP_GRANT_TABLES` startup option to disable checks for privileges. This can speed up queries, but obviously no permission checking is done, which means that all users have full access to all resources in the database.

The following are access privileges that are usable with tables: `SELECT`, `INSERT`, `UPDATE`, `DELETE`, `CREATE`, `DROP`, `GRANT`, `WITH GRANT OPTION`, `CREATE VIEW`, `SHOW VIEW`, `INDEX`, `TRIGGER`, and `ALTER`. `INSERT`, `UPDATE`, and `SELECT` permissions are also grantable or revocable at the column level of a table. Thus, for example, you can grant `SELECT` permissions on a specific column of a specific table. In any situation, table, database, and column names may each be up to 64 characters in length.

For routines (i.e., procedures and functions), you can specify `ALTER ROUTINE`, `EXECUTE`, and `WITH GRANT OPTION` permissions. `CREATE ROUTINE` is not actually a routine-level privilege because a user must have this privilege in the first place to create a routine.

Several privileges can be granted only globally, using `ON *.*` syntax, including `FILE`, `PROCESS`, `RELOAD`, `REPLICATION CLIENT`, `REPLICATION SLAVE`, `SHOW DATABASES`, `SHUTDOWN`, `SUPER`, and `CREATE USER`.

When specifying the user, password protection may be enforced by including the `IDENTIFIED BY` clause. The following example grants read permissions on the *employee* table to three users with passwords:

```
GRANT SELECT ON employee TO dylan IDENTIFIED BY 'porsche',
  kelly IDENTIFIED BY 'mercedes',
  emily IDENTIFIED BY 'saab';
```

MySQL also supports the possibility of granting rights to a specific user on a specific host if the *`grantee_name`* is in the form `USER@HOST`. The username may be up to 16 characters long (this same restriction applies to the *`grantee_name`* when the `@HOST` portion is not included), and the hostname may be up to 60 characters long.

Wildcards can be included in the hostname of a `grantee_name` to provide the access privilege to a large number of users at one time. A missing hostname is considered the same as the `%` wildcard. For example, consider this `GRANT` statement:

```
GRANT SELECT ON employee TO katie@% IDENTIFIED BY 'audi',
   annalynn IDENTIFIED BY 'cadillac',
   cody@us% IDENTIFIED BY 'bmw';
```

It grants read privileges on the *employee* table to the user *katie* explicitly at any hostname. Similarly, it grants read privileges to the user *annalynn* implicitly at any hostname. Finally, this statement grants read privileges to the user *cody* explicitly at any hostname starting with "US." MySQL allows you to issue grants on remote hosts as well. For example, the following `GRANT` statement provides all permissions on all tables of the current database across all hosts in the *notforprofit.org* domain to the user *annalynn*:

```
GRANT ALL ON * TO annalynn@'%.notforprofit.org';
```

If you grant permissions to a user that doesn't exist in MySQL, MySQL creates that user. The two statements that follow create a user and password with global privileges and another user that has no privileges (the `USAGE` privilege):

```
GRANT SELECT ON *.* TO tony IDENTIFIED BY 'humbolt';
GRANT USAGE ON sales.* TO alicia IDENTIFIED BY 'dakota';
```

Failing to include the `IDENTIFIED BY` clause in a `GRANT` statement that creates a new user will create a user without a password. This practice is insecure and dangerous.

If you ever create a new user using the `GRANT` command and forget to specify a password, you can and should subsequently set a password using the `SET PASSWORD` command.

Privileges are written directly to system tables at four different levels:

Global level
: Global privileges apply to all databases on a given server and are stored in the *mysql.user* system table.

Database level
: Database privileges apply to all tables in a given database and are stored in the *mysql.db* system table.

Table level
: Table privileges apply to all columns in a given table and are stored in the *mysql.tables_priv* system table.

Column level
: Column privileges apply to single columns in a given table and are stored in the *mysql.columns_priv* system table.

Because of the way permissions are granted and the system tables involved, you may grant redundant permissions at different levels. For example, you could grant a user SELECT privileges on a specific table, and then grant global SELECT privileges on that same table to all users of the database. To ensure that particular user no longer had the privilege of SELECTing from the table, you would then have to revoke both of those privileges. Bear in mind that MySQL does not automatically revoke any privileges when dropping a table or database, though it will drop routine privileges when dropping a procedure or function.

System tables in MySQL are unprotected, so it is also possible to change permissions by issuing INSERT, UPDATE, and DELETE statements against those tables rather than by using GRANT or REVOKE. Normally, all privileges are read into memory when MySQL starts. Database, table, and column privileges issued by a GRANT statement are available immediately and take effect right away. User privileges issued by a GRANT statement are noticed immediately and take effect the next time the user connects. If you directly modify permissions in the system tables, none of the changes will be noticed until you restart MySQL or issue a FLUSH PRIVILEGES command.

On MySQL, system privileges are known as *dynamic privileges*. Examples of MySQL system privileges include options like *audit admin*, *firewall admin*, *show routine*, and many more. Refer to the vendor documentation for more details about the variety and meaning of dynamic privileges.

If high-level, certificate-based security is important, you should consider using the REQUIRE clause. You do not have to specify all elements of the REQUIRE clause if you simply want the user to have a valid SSL or X509 certificate. However, you may add more specifications if they're required to meet your needs. Here, for example, we grant privileges to the user *tony* on the *localhost* MySQL server and require an X509 subject, issuer, and cipher:

```
GRANT SELECT ON *.* TO 'tony'@'localhost'
   IDENTIFIED BY 'humbolt'
   REQUIRE SUBJECT '/C=EE/ST=CA/L=Frisco/O=MySQL demo client
      certificate/CN=Tony Tubs/Email=tont@myorg.com'
   AND ISSUER '/C=FI/ST=CA/L=UC/O=MySQL/CN=Tony
      Tubs/Email=tont@myorg.com'
   AND CIPHER 'EDH-RSA-DES-CBC3-SHA';
```

Oracle

Oracle's implementation of the GRANT statement supports an enormous number of variations and permutations. The syntax is as follows:

```
GRANT { [object_privilege][, ...] | [system_privilege][, ...] |
   [role][, ...] }
[ ON { [schema_name.][object][, ...] |
   [DIRECTORY directory_object_name] |
   [JAVA [ { SOURCE | RESOURCE } ] [schema_name.][object]] } ]
TO {grantee_name[, ...] | role_name[, ...] | PUBLIC}
   [WITH { GRANT | HIERARCHY } OPTION]
[IDENTIFIED BY password] [WITH ADMIN OPTION]
```

You can grant multiple privileges with a single invocation of the command, but they must all be of the same type (object, system, or role).

For example, you could grant a user three object privileges on a single table in one `GRANT` statement, and then issue a separate grant of two system privileges to a role, and yet a third grant of several roles to a user, but you could not do all of this in one `GRANT` statement.

Following are the parameters to Oracle's `GRANT` statement:

`GRANT` *`object_privilege`*
: Grants the specified privilege(s) to the specified *`grantee_name`* or *`role_name`* on the named schema object (for example, a table or view). You may combine several object privileges, schema objects, and grantees in a single statement. However, you may *not* grant system privileges or roles in the same statement as object privileges. The object privileges are:

  `ALL [PRIVILEGES]`
  : Grants all available privileges on a named schema object. Available for use on tables.

  `ALTER`
  : Grants the privilege to change an existing table using the `ALTER TABLE` statement. Available for use on tables and sequences.

  `DEBUG`
  : Grants access to a table through a debugger. The access granted applies to any triggers on the table and to information in SQL that directly references the table. Available for use on tables, views, procedures, functions, packages, Java objects, and types.

  `EXECUTE`
  : Grants the privilege to execute a stored procedure, user-defined function, index type, library, or package. Available for use on procedures, functions, packages, Java objects, libraries, types, index types, and user-defined operators.

  `INDEX`
  : Grants the privilege to create indexes on a table.

  `{ ON COMMIT REFRESH | QUERY REWRITE }`
  : Grants the privilege to create a refresh-on-commit materialized view or to create a materialized view for query rewrite on the specified table. Available for materialized views only.

`QUERY REWRITE`
: Grants the privilege to create a materialized view for query rewriting on a specific table. Available for materialized views only.

`{ READ | WRITE }`
: Grants the privilege to read and write files in a named directory, including the full pathname of the operating system directory. Since Oracle has the ability to store files outside of the database, the Oracle server process must run under a user context with privileges on the applicable directories. You can enable Oracle to enforce security on individual users via this security mechanism. Note that `WRITE` is only useful in connection with an external table, such as a logfile or an error file.

`GRANT` *`system_privilege`*
: Grants the specified Oracle system privilege to one or more users or roles. For example, you could grant the `CREATE TRIGGER` privilege or the `ALTER USER` privilege; in each case, issuing a grant for a system privilege empowers the user or role to execute the command of the same name. Refer to Table 6-2 later in this section for a list of common system privileges.

`role`
: Grants a role to the specified user or to another role. In addition to user-defined roles, there are a number of system roles that come predefined with Oracle:

`CONNECT`, `RESOURCE`, *and* `DBA`
: Provided for backward compatibility with older versions of Oracle. Do not use these roles in current or newer versions of Oracle, since they may be dropped in the future. It's highly recommended for security that these roles are either disabled or, better yet, dropped.

`DELETE_CATALOG_ROLE`, `EXECUTE_CATALOG_ROLE`, *and* `SELECT_CATALOG_ROLE`
: Grant members of these roles the privilege to delete, execute, and select from data dictionary views and packages.

`EXP_FULL_DATABASE` *and* `IMP_FULL_DATABASE`
: Grant members of these roles the privilege to execute the import and export utilities.

`AQ_USER_ROLE` *and* `AC_ADMINISTRATOR_ROLE`
: Grant members of these roles the privilege to use or administrate Oracle's Advanced Queuing functionality.

`SNMPAGENT`
: Assigned only to Oracle Enterprise Manager and Intelligent Agent.

`RECOVERY_CATALOG_OWNER`
: Grants the privilege to create users who own their own recovery catalogs.

`HS_ADMIN_ROLE`
: Grants the privilege to access areas of the data dictionary used to support Oracle's heterogeneous services feature.

`ON` *`schema_name`*
: Grants a user or role the named privilege(s) on an object in the schema. Database objects include tables, views, sequences, stored procedures, user-defined functions, packages, materialized views, user-defined types, libraries, index types, user-defined operators, and any synonyms for any of these. If you do not include the schema name, Oracle assumes the schema of the current user.

  Oracle also supports two additional keywords for special cases:

  `DIRECTORY`
  : Grants privileges on a directory object, which is an Oracle object corresponding to a filesystem directory.

  `JAVA`
  : Grants privileges on a Java `SOURCE` or a `RESOURCE` schema object.

`TO {`*`grantee_name`*` | `*`role_name`*` | PUBLIC} [ WITH { GRANT | HIERARCHY } OPTION ]`
: Names the user or role that will get the specified privilege(s). `PUBLIC` may also be used to revoke privileges granted to the `PUBLIC` role. Multiple grantees can be listed with a comma between each.

`WITH GRANT OPTION`
: Enables the grantee to grant the specific privilege(s) to other users or to `PUBLIC`, but not to roles.

`WITH HIERARCHY OPTION`
: Enables the grantee to receive privileges on all subobjects when granted privileges on a parent object. This includes subobjects created in the future. You can use this option only when granting the `SELECT` object privilege.

`IDENTIFIED BY` *`password`*
: Establishes or changes a password that the grantee must use to enable a role being granted.

Grants to users take effect right away. Grants to roles also take effect right away, assuming the roles are enabled. Otherwise, a grant to a role takes effect when the role is enabled. Note that you can grant roles to users and to other roles (including `PUBLIC`). For example:

```
GRANT sales_reader TO sales_manager;
```

To grant privileges on a view, you must have the specific privilege and the `WITH GRANT OPTION` privilege on all of the base tables for the view.

Any time you want a privilege to be available to all users, simply grant it to `PUBLIC`:

```
GRANT SELECT ON work_schedule TO public;
```

However, there are some restrictions when granting system privileges and roles:

- A privilege or role should not appear more than once in the `GRANT` statement.
- Roles cannot be granted to themselves.
- Roles cannot be granted recursively. That is, you can't grant the role *sales_reader* to *sales_manager* and then grant the role *sales_manager* to *sales_reader*.

You can grant multiple privileges of the same type in a single statement. However, the grants must be on the same type of object:

```
GRANT UPDATE (emp_id, job_id), REFERENCES (emp_id),
ON employees
TO sales_manager;
```

As an aside, granting any of the object permissions on a table allows the user (or role) to lock the table in any lock mode using Oracle's `LOCK TABLE` statement.

Recent versions of Oracle have added a number of business intelligence objects. Although the business intelligence features are beyond the scope of this book, granting privileges to them works in essentially the same way as granting privileges to any other object. The business intelligence objects include `MINING MODEL`, `CUBE`, `CUBE MEASURE FOLDER`, `CUBE DIMENSIONS`, and `CUBE BUILD PROCESS`. Oracle also includes some additional advanced queuing features in other add-on components. The privilege syntax for these add-ons' objects is similar to that for objects such as `AQ_USER_ROLE` and `AQ_ADMINISTRATOR_ROLE`. Refer to Oracle's documentation for more information on business intelligence and advanced queuing features and privileges.

Oracle has a massive number of system privileges and system roles, covering the spectrum of all available feature sets as well as a variety of specialized system roles. Refer to the vendor documentation to explore the wide variety of system privileges and roles.

Nearly every supported Oracle object or command is assignable with a `GRANT` command (as shown in Table 6-2). Privileges can be granted not only on database objects (such as tables and views) and system commands (such as `CREATE ANY TABLE`), but also on schema objects (such as `DIRECTORY`, `JAVA SOURCE`, and `RESOURCE`). The `ANY` option grants the privilege to execute a given statement against objects of a specific type owned by any user within the schema. Without the `ANY` option, the user can only execute the statement against objects in their own schema.

Table 6-2. Oracle system privileges

Options	Description
**`CREATE	ALTER	DROP`**	
`CREATE CLUSTER`	Grants the privilege to create a cluster in the grantee's own schema.
`{CREATE	ALTER	DROP} ANY CLUSTER`	Grants the privilege to create, alter, or drop (respectively) a cluster in any schema.
`{CREATE	DROP} ANY CONTEXT`	Grants the privilege to create or drop (respectively) any context namespace.
`CREATE DIMENSION`	Grants the privilege to create dimensions in the grantee's own schema.
`{CREATE	ALTER	DROP} ANY DIMENSION`	Grants the privilege to create, alter, or drop dimensions in any schema.
`{CREATE	DROP} ANY DIRECTORY`	Grants the privilege to create or drop directory database objects.
`{CREATE	ALTER	DROP	EXECUTE} [ANY] INDEX`	Grants the privilege to create, alter, drop, or execute a specific index in one or (using the ANY keyword) all schemas.
`CREATE INDEXTYPE`	Grants the privilege to create an index type in the grantee's own schema.
`{CREATE	DROP	EXECUTE} ANY INDEXTYPE`	Grants the privilege to create, drop, or execute an index type in any schema.
`CREATE DATABASE LINK`	Grants the privilege to create private database links in the grantee's own schema.
`CREATE EXTERNAL JOB`	Allows the grantee to create an executable scheduler job that runs on the OS within the grantee's schema.
`CREATE [ANY] JOB`	Grants the privilege to create, alter, or drop jobs, schedules, or programs in any schema or, without ANY, a single specific schema. Grant this with caution, because it allows the user to execute any code as if they were another user.
`{CREATE	DROP} [ANY] LIBRARY`	Grants the privilege to create or drop external procedure/function libraries in any or, without ANY, a single specific schema.
`{CREATE	ALTER	DROP} [ANY] MATERIALIZED VIEW`	Grants the privilege to create, alter, or drop materialized views in any or, without ANY, a single specific schema.
`CREATE OPERATOR`	Grants the privilege to create an operator and its bindings in the grantee's own schema.
`{CREATE	ALTER	DROP	EXECUTE} ANY OPERATOR`	Grants the privilege to create, alter, drop, or execute an operator and its bindings in any schema.
`{CREATE	ALTER	DROP } ANY OUTLINE`	Grants the privilege to create, alter, or drop outlines that can be used in any schema that uses outlines.
`SELECT ANY OUTLINE`	Grants the privilege to clone private outlines from public ones.

Options	Description
{CREATE | ALTER | DROP | EXECUTE} [ANY] PROCEDURE	Grants the privilege to create, alter, drop, or execute stored procedures, functions, and packages in any schema, or, without ANY, in the current schema.
{CREATE | ALTER | DROP} PROFILE	Grants the privilege to create, alter, or drop profiles.
CREATE PUBLIC DATABASE LINK	Grants the privilege to create public database links.
{CREATE | DROP} PUBLIC SYNONYM	Grants the privilege to create or drop public synonyms.
ALTER RESOURCE COST	Allows the grantee to set costs for session resources.
{CREATE | ALTER | DROP} [ANY] ROLE	Grants the privilege to create a database role (do not use ANY with the CREATE keyword), as well as to alter or drop any existing role.
{CREATE | ALTER | DROP | GRANT} ANY ROLE	Grants the privilege to create, alter, drop, or grant roles in the database.
{CREATE | ALTER | DROP} ROLLBACK SEGMENT	Grants the privilege to create, alter, or drop rollback segments.
{CREATE | ALTER | DROP | SELECT} [ANY] SEQUENCE	Grants the privilege to create, alter, drop, or select sequences in any schema in the database or, without ANY, to create, alter, drop, or select a sequence in the current schema.
CREATE SNAPSHOT	Grants the privilege to create snapshots (aka materialized views) in the grantee's own schema.
{CREATE | ALTER | DROP} ANY SNAPSHOT	Grants the privilege to create, alter, or drop snapshots in any schema.
CREATE SYNONYM	Grants the privilege to create synonyms in the grantee's own schema.
{CREATE | DROP} ANY SYNONYM	Grants the privilege to create or drop private synonyms in any schema.
EXECUTE	
EXECUTE ANY CLASS	Grants the privilege to run any job class in a job in the grantee's schema.
EXECUTE ANY PROGRAM	Grants the privilege to run any program in a job within the grantee's schema.
SESSION	
ALTER SESSION	Grants the privilege to issue ALTER SESSION statements.
CREATE SESSION	Grants the privilege to connect to the database.
DEBUG ANY PROCEDURE	Grants the privilege to debug all PL/SQL objects in the database. Similar to granting DEBUG privileges on all procedures, functions, and packages.
DEBUG CONNECT SESSION	Grants the privilege to connect the current session to the Java Debug Wire Protocol (JDWP) debugger.

Options	Description
`DROP PUBLIC DATABASE LINK`	Grants the privilege to drop public database links.
`FLASHBACK ARCHIVE ADMINISTRATOR`	Grants the privilege to create, alter, or drop any flashback data archive.
`GRANT ANY ROLE`	Grants the privilege to grant a role to other users.
`MANAGE SCHEDULER`	Grants full privileges for jobs (i.e., privileges to drop, create, or alter any job class, window, or window group).
`ON COMMIT REFRESH`	Grants privileges to create a refresh-on-commit materialized view on any table in the database or alter any refresh-on-demand materialized view into a refresh-on-commit materialized view.
`RESTRICTED SESSION`	Enforces that the grantee logs on after the instance is started using the SQL*Plus `STARTUP RESTRICT` statement.
`TABLE/TABLESPACE`	
`ALTER ANY TABLE`	Grants the privilege to alter any table or view in the schema.
`BACKUP ANY TABLE`	Enables the use of the export utility to incrementally export objects from the schemas of other users.
`CREATE ANY TABLE`	Grants the privilege to create tables in any schema. The owner of the schema containing the table must have enough free space in the tablespace to contain the table.
`DELETE ANY TABLE`	Allows the deletion of rows from tables, table partitions, or views in any schema.
`DROP ANY TABLE`	Grants the privilege to drop or truncate tables or table partitions in any schema.
`FLASHBACK ANY TABLE`	Grants the privilege to issue a SQL flashback query on any table, view, or materialized view in any schema. This privilege is not required for `DBMS_FLASHBACK` procedures.
`INSERT ANY TABLE`	Grants the privilege to insert rows into tables and views in any schema.
`LOCK ANY TABLE`	Grants the privilege to lock tables and views in any schema.
`SELECT ANY TABLE`	Grants the privilege to query tables, views, or snapshots in any schema.
`UPDATE ANY TABLE`	Grants the privilege to update rows in tables and views in any schema.
`{CREATE | ALTER | DROP} TABLESPACE`	Grants the privilege to create, alter, or drop tablespaces.
`MANAGE TABLESPACE`	Grants the privilege to take tablespaces offline and online and begin and end tablespace backups.
`UNLIMITED TABLESPACE`	Grants the privilege to use an unlimited amount of any tablespace. This privilege overrides any specific quotas assigned. If you revoke this privilege from a user, the user's schema objects remain, but further tablespace allocation is denied unless authorized by specific tablespace quotas. You cannot grant this system privilege to roles.
`TRIGGER`	

Options	Description
`ADMINISTER DATABASE TRIGGER`	Grants the privilege to create a trigger on `DATABASE`. (The user/role must also have the `CREATE TRIGGER` or `CREATE ANY TRIGGER` privilege.)
`{CREATE | ALTER | DROP} [ANY] TRIGGER`	Grants the privilege to create, alter, or drop database triggers in any schema or, without `ANY`, to create, alter, or drop a trigger in the current schema.
TYPE	
`{CREATE | ALTER | DROP} [ANY] TYPE`	Grants the privilege to create, alter, or drop object types and object-type bodies in any schema or, without `ANY`, to create, alter, or drop a type in the current schema.
`EXECUTE ANY TYPE`	If granted to a specific user, allows that user to use and reference object types and collection types in any schema and to invoke methods of an object type in any schema. If granted to a role, individual members of that role will *not* be able to invoke methods of an object type in any schema.
USER	
`ALTER USER`	Grants the privilege to alter any user. The privilege authorizes the grantee to: • Change another user's password or authentication method. • Assign quotas on *any* tablespace. • Set default and temporary tablespaces. • Assign a profile and default roles.
`BECOME USER`	Grants the privilege to become another user (required by any user performing a full database import).
`CREATE USER`	Grants the privilege to create users. The privilege also allows the grantee to: • Assign quotas on any tablespace. • Set default and temporary tablespaces. • Assign a profile as part of a `CREATE USER` statement.
`DROP USER`	Grants the privilege to drop users.
`UNDER ANY TYPE`	Allows the creation of subtypes under any parent object type, such as a table or view.
VIEW	
`{CREATE | DROP} [ANY] VIEW`	Grants the privilege to create or drop views in any schema or, without `ANY`, to create a view in the current schema.

Options	Description
`MERGE ANY VIEW`	Grants the privilege to the optimizer to use view merging on behalf of the user to speed up query performance.
`UNDER ANY VIEW`	Grants the privilege to create a subview under any parent view.

As this table shows, the `ANY` keyword has a special meaning. In effect, `ANY` gives a user the privilege to execute the specified command or operation in any schema. If you want to include all user schemas but exclude the *SYS* system schema, keep the `O7_DICTIONARY_ ACCESSIBILITY` initialization parameter at its default value of `FALSE`.

PostgreSQL

PostgreSQL supports most of the SQL standard syntax for `GRANT` as well as some additional features. PostgreSQL's `GRANT` syntax has a couple of variants. Note that not all of the privileges are available on all the types of objects, and there are some additional options that are not shown here (see the following list and the documentation for details):

```
GRANT { { ALL [PRIVILEGES] | { SELECT | INSERT | UPDATE | DELETE |
   TRUNCATE | REFERENCES | TRIGGER | USAGE | CREATE |
   CONNECT | TEMP[ORARY] | EXECUTE }[, ...] } }
ON { TABLE | SEQUENCE | DATABASE | DOMAIN | FUNCTION |
   FOREIGN DATA WRAPPER | FOREIGN SERVER | PROCEDURE | ROUTINE |
   LANGUAGE | LARGE OBJECT | SCHEMA | TABLESPACE | TYPE }
   object_name[, ...]
TO grantee[, ...]
[ WITH GRANT OPTION ]
[ GRANTED BY grantor ]

GRANT role_name[, ...]
TO grantee[, ...]
[ WITH ADMIN OPTION ]
[ GRANTED BY grantor ]
```

where:

`ALL [PRIVILEGES]`
: Grants all privileges the grantor has available to grant. The `PRIVILEGES` keyword is optional. Using `ALL` is generally not a recommended approach, since it can encourage sloppy permissioning.

`TRUNCATE`
: Grants the privilege to use `TRUNCATE` on a table.

`REFERENCES`
: Grants the privilege to create or drop foreign key constraints referencing the database object as a parent object.

`USAGE`
: Grants privileges to use sequences, domains, foreign data wrappers, foreign servers, languages, schemas, or types.

`CREATE`
: Grants the privilege to create objects of the specified type. Usable with `ON DATABASE`, `ON SCHEMA`, and `ON TABLESPACE`. On databases, this privilege allows the creation of new schemas within the database. On schemas, it allows the creation of new objects and the renaming of existing objects in the schema. On tablespaces, this privilege allows the creation of tables and indexes within the tablespace.

`CONNECT`
: Grants the privilege to connect to a specific database.

`TEMP[ORARY]`
: Grants permission to create temporary tables when using the named database.

`EXECUTE`
: Grants permission to call a function or procedure.

`TO` *`grantee`*
: Names the user or role that will be granted the specified privilege (multiple users or roles can be listed with a comma between each). Options are `[GROUP]` *`role_name`*, `PUBLIC`, `CURRENT_ROLE`, `CURRENT_USER`, and `SESSION_USER`. `PUBLIC` is a synonym for all users.

Multiple privileges may be granted at one time, in a comma-separated list. However, when granting privileges, they should be of a related type. You should not combine `ALL [PRIVILEGES]` with other privileges, but many of the remaining privileges may be combined in any order.

The owner of an object may revoke most of their own privileges on that object, but the privilege for the creator of an object to assign privileges on that object cannot be revoked. Similarly, the right to drop an object is permanently assigned to the creator of the object and cannot be revoked. Users other than the creator of an object or a superuser do not have permissions on an object until they are specifically granted.

Certain privileges are allowed only for certain objects, as shown here:

`TABLE`
: May be granted `SELECT`, `INSERT`, `UPDATE`, `DELETE`, `TRUNCATE`, `REFERENCES`, `TRIGGER`, and `ALL [PRIVILEGES]`.

`SEQUENCE`
: May be granted `USAGE`, `SELECT`, `UPDATE`, and `ALL [PRIVILEGES]`.

`DATABASE`
: May be granted `CONNECT`, `CREATE`, `TEMP[ORARY]`, and `ALL [PRIVILEGES]`.

`DOMAIN`, `FOREIGN DATA WRAPPER`, `FOREIGN SERVER`, `LANGUAGE`, `TYPE`
: May be granted `USAGE` and `ALL [PRIVILEGES]`.

`FUNCTION`, `PROCEDURE`, `ROUTINE`
: May be granted `EXECUTE` and `ALL [PRIVILEGES]`.

`LARGE OBJECT`
: May be granted `SELECT`, `UPDATE`, and `ALL [PRIVILEGES]`.

`SCHEMA`
: May be granted `CREATE`, `USAGE`, and `ALL [PRIVILEGES]`.

`TABLESPACE`
: May be granted `CREATE` and `ALL [PRIVILEGES]`.

In the following examples, `INSERT` privileges are granted on the *publishers* table to the `PUBLIC` role and `SELECT` and `UPDATE` privileges are granted on the *sales* table to the users *emily* and *dylan*:

```
GRANT INSERT ON TABLE publishers TO PUBLIC;
GRANT SELECT, UPDATE ON sales TO emily, dylan;
```

The following example grants database control privileges to the user *katie* and then assigns the users *katie* and *anna* to a new group:

```
GRANT ALL ON DATABASE publishing TO katie;
GRANT manager_role ON katie, anna WITH ADMIN OPTION;
```

SQL Server

SQL Server's implementation of `GRANT` offers few variations from the SQL standard. SQL Server does not support the SQL standard's `FROM` clause or the `HIERARCHY` or `ADMIN` options, but it does offer the ability to grant specific system privileges and to grant them under another user's security context. The syntax is as follows:

```
GRANT { [object_privilege][, ...] | [execute_privilege] }
[ON { [definition_scope::[[schema_name.]object_name]
   [(column[, ...])] }]
TO { grantee[, ...] | role[, ...] | PUBLIC | GUEST }
[WITH GRANT OPTION]
[AS {group | role}]
```

where:

`GRANT` *`object_privilege`*
: Grants privileges for a variety of objects, which may be combined in any order (with the exception of the `ALL [PRIVILEGES]` privilege). Object privileges may be granted for tables, views, functions (table-valued, scalar, and aggregate), procedures (stored and extended), service queues, and synonyms. `ALL` can only be used by members of the `SYSADMIN` and `DB_OWNER` system roles, or by the object owner. It was deprecated in SQL Server 2008 and is only included

for backward compatibility. `GRANT ALL` is now shorthand for the following privileges:

`GRANT ALL` *on databases*
: Grants the privileges `BACKUP DATABASE`, `BACKUP LOG`, `CREATE DATABASE`, `CREATE DEFAULT`, `CREATE FUNCTION`, `CREATE PROCEDURE`, `CREATE RULE`, `CREATE TABLE`, and `CREATE VIEW`.

`GRANT ALL` *on functions*
: Grants the privileges `EXECUTE` and `REFERENCES` for scalar functions and `DELETE`, `INSERT`, `REFERENCES`, `SELECT`, and `UPDATE` for table-valued functions.

`GRANT ALL` *on procedures (includes both stored procedures and extended stored procedures)*
: Grants the `EXECUTE` privilege.

`GRANT ALL` *on tables and views*
: Grants the privileges `DELETE`, `INSERT`, `REFERENCES`, `SELECT`, and `UPDATE`.

`GRANT` ***`execute_privilege`***
: Grants the privilege to execute one of the corresponding statements (`EXECUTE`) or to select against one (or more) of the views in the `SYS` schema (`SELECT`). Refer to the vendor's documentation for more details.

The privilege to issue a `CREATE` statement also implies the privilege to issue the equivalent `ALTER` or `DROP` statement. However, granting a single granular permission does not ensure that all required permissions have been granted—for example, granting `EXECUTE` permission on *sp_addlinkedserver* doesn't allow a user to create a linked server unless that user has also been added as a member to the *sysadmin* role.

`ON [`*`definition_scope`*`::][[`*`schema_name`*`.]`*`object_name`*`] [(`*`column`*`[, ... ])]`
: Specifies the object for which the privilege is granted. This clause is not required when granting system privileges. The *`definition_scope`* is required and indicates the type of object to which you will be granting privileges. *`definition_scope`*s must always include the assignment symbols (`::`). Allowable values for definition scope include `LOGIN::`, `DATABASE::`, `OBJECT::`, `ROLE::`, `SCHEMA::`, and `USER::`.

The definition scope `OBJECT::` is for tables, views, and other database objects. Other *`definition_scope`*s are applicable to objects of the same name: see the documentation for details.

`TO {`*`grantee`*`[, ... ] |` *`role`*`[, ... ] | PUBLIC | GUEST}`
: Names the user or role that will gain the privilege being granted. Multiple grantees can be listed in a comma-separated list. Use the keyword `PUBLIC` to grant privileges to the `PUBLIC` role, a role that implicitly includes all users. SQL Server also supports a `GUEST` role, which is the role used by all users who

do not have any other roles in the database. Because SQL Server allows two different security models (one based on the database and one based on the Windows operating system), you may be granting privileges to a SQL Server user, a Windows user, a Windows group, or a SQL Server database role.

`AS {`*`group`*` | `*`role`*`}`
: Specifies an alternative user or group that has the authority in the current database to execute the `GRANT` command. You can use the `AS` clause to grant privileges as if the granting session is part of a different group or role context from the current one.

Privileges may not be granted in any database other than the current database, nor may privileges be granted in more than one database at a time.

SQL Server has a somewhat different security model than the other platforms described here (and the SQL standard). Like the standard, SQL Server uses the `GRANT` command to assign specific privileges to a user or role and the `REVOKE` command to remove those permissions. However, SQL Server augments these commands with the `DENY` command, using essentially the same syntax as `REVOKE`.

`DENY`, under SQL Server, allows DBAs to declare certain privileges as strictly off-limits to a user or role. Any privileges that have been denied must be revoked before they can be granted. As such, `DENY` takes precedence over `GRANT` and `REVOKE`. `DENY` can be used to effectively restrict any permission from an individual who might otherwise inherit permissions from membership in Windows groups or SQL Server database roles.

SQL Server applies precedence to permissions. Thus, if a user has a privilege granted at the user level, but the permission is revoked at the group level (when the user is a member of a group), the permission is revoked at both levels.

SQL Server, much like Oracle, has a very large number of system privileges and roles. They span a variety of scenarios, like `ALTER ANY CERTIFICATE` and `RECEIVE` *`service_broker_queue`*. Refer to the vendor documentation for more details about the variety and meaning of SQL Server's system privilege and roles.

Privileges to `CREATE` or `ALTER` an object also imply the privilege to `DROP` the object. Privileges to `CREATE` an object additionally imply the privilege to `ALTER` the object.

In the following example, the `CREATE DATABASE` and `CREATE TABLE` privileges are granted to the users *emily* and *sarah*. Next, numerous permissions on the *titles* table are granted to the *editors* group. The editors are then able to grant permissions to others:

```
GRANT CREATE DATABASE, CREATE TABLE TO emily, sarah;
GO
GRANT SELECT, INSERT, UPDATE, DELETE ON titles
TO editors
WITH GRANT OPTION;
GO
```

The following example grants permissions to the database user *sam* and the Windows user *jacob*:

```
GRANT CREATE TABLE TO sam, [corporate\jacob];
GO
```

Finally, the following example shows how to grant permissions using the optional `AS` keyword. In this example, the user *emily* owns the *sales_detail* table, and she grants `SELECT` privileges to the *sales_manager* role. The user *sumit*, who is a member of the *sales_manager* role, wants to grant `SELECT` privileges to *sam*, but he cannot because the permissions were granted to the *sales_manager* role and not to him explicitly. *sumit* can use the `AS` clause to get around this hurdle:

```
-- Initial grant
GRANT SELECT ON sales_detail TO sales_manager
WITH GRANT OPTION;
GO
-- Sumit passes the privilege to Sam as a member of the
-- sales_manager role
GRANT SELECT ON sales_detail TO sam AS sales_manager;
GO
```

See also

- `REVOKE`

REVOKE Statement

The `REVOKE` statement takes two main forms. The first form of the statement removes specific statement permissions from a user, group, or role. The second form removes access permissions to specific database objects or resources.

Platform	Command
MySQL	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
REVOKE { [special_options] | {privilege[, ...] | role[, ...]} }
ON database_object_name
```

```
FROM grantee[, ...]
[GRANTED BY {CURRENT_USER | CURRENT_ROLE}]
{CASCADE | RESTRICT}
```

Keywords

special_options
: Allows the use of one of three optional special options:

  `GRANT OPTION FOR`
  : Undoes the `WITH GRANT OPTION` privilege assigned to a user, meaning that the user can no longer grant privileges to other users on the object. That user's own privileges on the object remain intact. (This clause is valid to revoke a privilege, but not to revoke a role.)

  `HIERARCHY OPTION FOR`
  : Undoes the `WITH HIERARCHY OPTION` privilege that allows a user to `SELECT` not only from the named table, but also all of its subtables. (This clause is valid to revoke a privilege, but not to revoke a role.)

  `ADMIN OPTION FOR`
  : Undoes the ability to grant a role to other users. (This clause is valid to revoke a privilege, but not to revoke a role.)

privilege
: Revokes privileges for a variety of statements, which may all be combined in any order:

  `ALL PRIVILEGES`
  : Revokes all privileges currently assigned to the named user(s) and/or for the specified database object(s). Generally not a recommended approach, since it can encourage sloppy coding.

  `EXECUTE`
  : Revokes the privileges to execute a routine (i.e., a stored procedure, user-defined function, or method).

  `SELECT | INSERT | UPDATE | DELETE`
  : Revokes the specific privilege for a given user on the specified database object, such as a table or view. You may add a parenthetical list of the columns on a given table where the privilege will be revoked for `SELECT`, `INSERT`, and `UPDATE` privileges, to limit the action to those columns.

  `REFERENCES`
  : Revokes the user's privilege to create any constraints or assertions referencing the database object as a parent object. You may add a parenthetical list of the columns on a given table where the privilege will be revoked, to limit the action to those columns.

`TRIGGER`
: Revokes the user's ability to create triggers on the specified tables. As a side effect of the `REVOKE`, any triggers that depend on the privilege are also dropped.

`UNDER`
: Revokes the privilege to create subtypes or typed tables.

`USAGE`
: Revokes the privilege to use a domain, user-defined type, character set, collation, or translation.

`role`
: Revokes a specific, predefined role from the grantee identified in the `FROM` clause.

`ON` *`database_object_name`*
: Revokes privileges on a specific, predefined database object. SQL does not include support for system privileges, but many implementations provide a variation of this clause to revoke such privileges. (The `ON` subclause is not used at all when revoking system privileges or roles.) The *`database_object_name`* may be one of the following:

```
{ [TABLE] object_name | DOMAIN object_name |
   COLLATION object_name | CHARACTER SET object_name |
   TRANSLATION object_name | TYPE object_name |
   [SPECIFIC] {ROUTINE | FUNCTION | PROCEDURE | METHOD}
   object_name }
```

`FROM` *`grantee`*
: Names the user(s) or role(s) who will lose the specified privilege(s). The `PUBLIC` keyword may be used to revoke privileges granted to the `PUBLIC` global user list. Multiple grantees can be listed with a comma between each.

`FROM { CURRENT_USER | CURRENT_ROLE }`
: Optionally used to specify who granted the privilege to the user in the first place. For example, when using `FROM CURRENT_USER`, the privilege is revoked only if the current user granted the privilege. Otherwise, the statement will fail. When this clause is omitted, `CURRENT_USER` is the default.

`RESTRICT | CASCADE`
: Limits a `REVOKE` operation to only the specified privilege (`RESTRICT`), or causes the specified privilege and all dependent privileges to be revoked (`CASCADE`) and possibly causes objects that depend on the privilege to be dropped. Note that `REVOKE ... RESTRICT` will fail if dependent privileges exist. The dependent privileges must be revoked first.

Rules at a glance

A specific privilege on a specific database object can be revoked for a single user using `REVOKE` *`privilege_name`* `ON` *`object_name`* `FROM` *`grantee`* `RESTRICT`. A specific privilege on a specific object may be revoked from all users via the `PUBLIC` global user list.

When revoking privileges from multiple grantees, simply place a comma between each. You may also revoke privileges from one or more grantees and the `PUBLIC` role in a single `REVOKE` statement. (`PUBLIC` is described in detail in the section on the `GRANT` statement. When a `GRANT` is issued to `PUBLIC`, that means everyone has the specified permissions.)

When revoking privileges on a table, the operation may be restricted to the column level by including a list of columns enclosed in parentheses after the table name.

Programming tips and gotchas

Most of the platforms isolate privileges at the user and role level. (Remember, a *role* is a group of privileges.) Thus, it's possible for an individual user who is assigned two roles to be granted the same permission three times. In this situation, to revoke that permission you would have to revoke the user's privilege directly and remove the user from both roles.

An important aspect of `REVOKE` (and its sister command `GRANT`) is that certain elements of the command are geared toward object-level permissions, while other options of the command are more oriented toward roles or administrative privileges. Generally, these operations are never combined. (The differences in object-level permissions and administrative privileges are fully explained in the database platform sections that follow.) For example, you might want to revoke certain object-level privileges for a given role (*salespeople*) or for individual users (*e_fudd* and *prince_edward*). You could do this with the following commands:

```
REVOKE SELECT ON TABLE authors FROM salespeople RESTRICT;
REVOKE ALL PRIVILEGES ON TABLE sales FROM e_fudd,
   prince_edward CASCADE;
```

A lot of table-level privileges can even be assigned down to the column level. Those privileges can be revoked as follows:

```
REVOKE INSERT(au_id, au_fname, au_lname)
   ON authors FROM e_fudd;
```

The special option clauses (`GRANT OPTION`, `HIERARCHY OPTION`, and `ADMIN OPTION`) all exist to allow you to revoke the ability of users to pass privileges or roles on to other users. However, these clauses do not prevent the first group of users themselves from exercising those privileges. For example, we can issue this command if we no longer want anyone in the role *manager* to grant their `UPDATE` privileges to other users:

```
REVOKE GRANT OPTION FOR UPDATE ON sales FROM manager CASCADE;
```

You can also remove role privileges from a user with the REVOKE command:

```
REVOKE manager FROM e_fudd CASCADE;
```

A common best practice is to keep REVOKE and GRANT statements as self-contained and logical as possible. Under this practice, you should avoid using the CASCADE and ALL PRIVILEGES clauses because they perform work for you that may not be immediately evident within the scope of the command.

MySQL

MySQL supports the SQL standard keywords, with the exception of UNDER. It also has a shortcut to allow global assignment or revocation of privileges. The complete MySQL REVOKE syntax is as follows (full details on the supported privilege types are available in the MySQL and MariaDB documentation):

```
REVOKE [ { ALL [PRIVILEGES] | [, GRANT OPTION]
   {SELECT | INSERT | UPDATE} [ (column_name[, ...]) ] |
   DELETE | REFERENCES [ (column_name[, ...]) ] } |
{ [ USAGE ] | [{ALTER | CREATE | DROP}] | [FILE] |
   [INDEX] | [PROCESS] | [RELOAD] | [SHUTDOWN] |
   [CREATE TEMPORARY TABLES] | [LOCK TABLES] |
   [REPLICATION CLIENT] | [REPLICATION SLAVE] |
   [SHOW DATABASES] | [SUPER] }[, ...] |
[PROXY]
ON [object_type] {table_name | * | *.* | database_name.*}
FROM user_name[, ...]
```

where:

ALL [PRIVILEGES]
: Covers all privileges that apply at the level indicated by the ON clause, except GRANT OPTION, which must be revoked through its own subclause. (This includes privileges like SELECT, INSERT, UPDATE, DELETE, and others that are applicable to the object.) The PRIVILEGES keyword is optional.

REFERENCES
: Unimplemented.

USAGE
: Revokes all of a user's privileges.

{ALTER | CREATE | DROP}
: Revokes the ability to alter, create, or drop tables and other database objects.

FILE
: Revokes the ability to load data from or write data to files using the SELECT INTO and LOAD DATA commands.

INDEX
: Revokes the ability to create or drop indexes.

`PROCESS`
: Revokes the ability to view running processes using `SHOW FULL PROCESSLIST`.

`RELOAD`
: Revokes the ability to invoke the `FLUSH` command.

`SHUTDOWN`
: Revokes the ability to use the `MYSQLADMIN SHUTDOWN` command to kill the server process.

`CREATE TEMPORARY TABLES`
: Revokes the ability to create temporary tables.

`LOCK TABLES`
: Revokes the ability to use the MySQL command `LOCK TABLES` on tables where the user has `SELECT` privileges.

`REPLICATION CLIENT`
: Revokes the privilege to see metadata about replication slaves and masters.

`REPLICATION SLAVE`
: Revokes the right to read binlogs of a replication master from a replication slave.

`SHOW DATABASES`
: Revokes the privilege to execute the MySQL command `SHOW DATABASES`.

`SUPER`
: Revokes the user privilege of opening one connection even if the `MAX_CON`` NECTIONS` threshold has been reached. Also revokes the privileges to execute the MySQL commands `CHANGE MASTER`, `KILL`, `MYSQLADMIN DEBUG`, `PURGE [MASTER] LOGS`, and `SET GLOBAL`.

`PROXY`
: Revokes a proxy for the given user, in which the user impersonates or becomes known as another user to the MySQL system.

`ON [`*`object_type`*`] {`*`table_name`*` | * | *.* `*`database_name`*`.*}`
: Removes privileges from the specified *`table_name`*, from all tables within the current database with `*`, from all tables in the specified *`database_name`* with *`database_name`*.*, or from all tables in all databases with *.*. The optional *`object_type`* may be used to revoke privileges on specific objects (namely, the `TABLE`, `FUNCTION`, or `PROCEDURE` object types).

`FROM`
: Removes the privileges of one or more users, separated by commas. Usernames may also include an `@`*`host_name`* suffix, if you wish to restrict the revocation to a specific host computer.

REVOKE has size limitations: usernames cannot be longer than 16 characters, while host, database, and database object names can be up to 60 characters long. Usernames may also be linked to a specific host. Refer to the discussion of MySQL in "GRANT Statement" on page 451 for more details.

MySQL's implementation of REVOKE does not explicitly roll back permissions on objects that are dropped. Thus, it is necessary to explicitly REVOKE permissions on a table, even if the table is dropped. For example, let's say you drop a table without issuing a REVOKE on the existing permissions. If you later re-create the table, all of the old permissions will still be in place. Similarly, a user's privileges persist in the database even after the user has been dropped.

It is also important to note that MySQL allows multiple levels of permissions. Thus, a user might have access to a table from a table-level grant, and have an additional set of permissions to the same table because they have been given global database or server-wide permissions. Thus, you need to be careful when revoking permissions, because global-level permissions might continue to provide to a user permissions you thought you had revoked!

The first of the following commands revokes all privileges on the *sales* table for users *emily* and *dylan*, while the second command revokes SELECT privileges for the user *kelly* in the current database:

```
REVOKE ALL PRIVILEGES ON sales FROM emily, dylan;
REVOKE SELECT ON * FROM kelly;
```

The first of the next two commands removes *kelly*'s ability to grant privileges to other users on the *sales* table, while the second command removes privileges that the user *sam* has on the *pubs* database:

```
REVOKE GRANT OPTION ON sales FROM kelly;
REVOKE ALL ON pubs.* FROM sam;
```

Oracle

The REVOKE command can be used not only to immediately revoke object and system privileges, but also to revoke a role from a user (or a role from another role). Refer to the section on the GRANT statement for more information on the specific object and system privileges supported by the REVOKE command.

The two forms of the REVOKE command, REVOKE *object_privilege* and REVOKE *system_privilege*, are mutually exclusive. Do not attempt to do both operations in a single statement. Since the complete syntax for both forms of the command is extremely long, refer to the section on Oracle in "GRANT Statement" on page 451 for more details on the different *object_privilege*s available in Oracle. Note that Oracle's *system_privilege*s number in the hundreds; refer to the vendor documentation for documentation on all the options.

Oracle provides an interesting twist on privileges. While other database platforms typically allow a user to have more than one context for a set of privileges (based on the individual user, and any groups or roles to which that user belongs), Oracle takes this one step further. More than one grantor may have given a user a particular privilege on a specific object. When this is the case, *all* grantors must revoke that privilege to effectively rid the user of the privilege. If even one grantor doesn't do this, the user still has the privilege.

In Oracle, use the following syntax with REVOKE:

```
REVOKE { [object_privilege][, ...] |
   [system_privilege] |
   [role] }
[ON { [schema_name.][object] |
   [DIRECTORY directory_object_name] |
   [JAVA [ { SOURCE | RESOURCE } ] [schema_name.][object]] }]
FROM {grantee_name[, ...] | role_name[, ...] | PUBLIC}
[CASCADE [CONSTRAINTS]] [FORCE]
```

where:

object_privilege
: Revokes the specified privilege(s) for the given user(s) or role(s) on the named schema object (for example, a table or view). The available privileges include:

ALL [PRIVILEGES]
: Revokes all granted privileges on the named schema object. Since ALL also includes the REFERENCES privilege, you must include the CASCADE clause (see REFERENCES below). The PRIVILEGES keyword is optional.

ALTER
: Revokes the privilege to change an existing table using the ALTER TABLE statement.

EXECUTE
: Revokes the privilege to execute a stored procedure, user-defined function, or package.

`INDEX`
: Revokes the privilege to create indexes on a table.

`REFERENCES`
: Revokes the privilege to define referential integrity constraints. Requires that the `CASCADE CONSTRAINTS` clause also be used.

`SELECT | INSERT | DELETE | UPDATE`
: Revokes the privilege to execute each of the respective SQL commands against the named schema object. Note that `DELETE` privileges are dependent on `SELECT` privileges.

`system_privilege`
: Revokes the specified Oracle system privilege(s), such as `CREATE TRIGGER` or `ALTER USER`, for the given user(s) or role(s). Do not use the `ON` clause with the `REVOKE` *`system_privilege`* variation of the statement. Because there are so many system privileges, we won't list them again here. Please refer to the section on Oracle's implementation of the `GRANT` statement for a full list of system privileges.

`role`
: Revokes a user's or role's membership in the named role.

`ON`
: Revokes the named privilege for the given user(s) or role(s) from the named object. Objects include tables, views, sequences, stored procedures, user-defined functions, packages, materialized views, user-defined types, libraries, index types, user-defined operators, and synonyms for any of these. For example, you could revoke `SELECT` privileges for a given user on the *scott.authors* table. If you do not include the schema name, Oracle assumes the schema of the current user. Oracle also supports two additional keywords for special cases:

  `DIRECTORY` *`directory_object_name`*
  : Identifies a directory object from which the privileges are revoked.

  `JAVA [ { SOURCE | RESOURCE } ] [`*`schema_name`*`.][`*`object`*`]`
  : Identifies a Java source or a resource schema object from which the privileges are revoked.

`FROM {`*`grantee_name`*` | `*`role_name`*` | PUBLIC}`
: Names the user or role that will lose the specified privilege. `PUBLIC` may also be used to revoke privileges granted to the `PUBLIC` role. Multiple grantees can be listed with a comma between each.

`CASCADE [CONSTRAINTS]`
: Drops any referential integrity constraints that depend on the privilege being revoked. This clause is needed only when the `REFERENCES` or `ALL [PRIVILEGES]` clauses are used.

`FORCE`
: Required to revoke `EXECUTE` object privileges on user-defined type objects with type or table dependencies.

Oracle automatically cascades the revocation from the defined *`grantee_name`* to all users that received their privileges from the grantee. In addition, any objects created by the grantee that depend on the privilege (such as stored procedures, triggers, views, and packages that depend on a `SELECT` privilege against a certain table) will become invalid.

Users who are granted the `GRANT ANY ROLE` system privilege may revoke any role. The `REVOKE` command can only revoke privileges specifically granted with the `GRANT` command, not privileges available through roles or the operating system. In those cases, you must use the `REVOKE` command to drop the privilege from the role. All users assigned to the role will then lose the privilege.

The following are examples of revoking a role from specific grantee and revoking a system privilege from a role:

```
REVOKE read_only FROM sarah;
REVOKE CREATE ANY SEQUENCE,
   CREATE ANY DIRECTORY FROM read_only;
```

Here's an example that revokes a `REFERENCES` privilege and cascades the revoked privileges:

```
REVOKE REFERENCES
ON pubs_new_york.emp
FROM dylan
CASCADE CONSTRAINTS;
```

Finally, the following example grants all privileges on a specific table, and then revokes a privilege:

```
GRANT ALL PRIVILEGES ON emp TO dylan;
REVOKE DELETE, UPDATE ON emp FROM dylan;
```

PostgreSQL

PostgreSQL supports most of the SQL standard syntax for `REVOKE` as well as some additional features. It does not offer the SQL-standard special option `HIERARCHY OPTION FOR`. PostgreSQL's `REVOKE` syntax has a couple of variants. Note that not all of the privileges are available on all the types of objects, and there are some additional options that are not shown here (see the following list and the documentation for details):

```
REVOKE [ GRANT OPTION FOR ]
{ ALL [PRIVILEGES] | {SELECT | INSERT |
   UPDATE | DELETE | TRUNCATE | REFERENCES | TRIGGER |
   USAGE | CREATE | CONNECT | TEMP[ORARY] | EXECUTE }[, ...] }
ON { {[TABLE] | ALL TABLES IN SCHEMA} | {SEQUENCE |
   ALL SEQUENCES IN SCHEMA} | DATABASE | DOMAIN |
   FOREIGN DATA WRAPPER | FOREIGN SERVER |
   { {FUNCTION | PROCEDURE | ROUTINE} |
   ALL {FUNCTIONS | PROCEDURES | ROUTINES} IN SCHEMA } | LANGUAGE |
   LARGE OBJECT | SCHEMA | TABLESPACE | TYPE} object_name[, ...] }
FROM grantee[, ...]
[ GRANTED BY grantor ]
[ CASCADE | RESTRICT ]

REVOKE [ ADMIN OPTION FOR ]
    role_name[, ...] FROM grantee[, ...]
    [ GRANTED BY grantor ]
    [ CASCADE | RESTRICT ]
```

where:

`ALL [PRIVILEGES]`
: Shorthand for every privilege the grantor has available to grant. Revokes all privileges currently assigned to the named user(s) and/or group(s) for the specified database object(s). Generally not a recommended approach, since it can encourage sloppy coding. The `PRIVILEGES` keyword is optional.

`TRUNCATE`
: Revokes the user or group's privilege to use `TRUNCATE` on a table.

`REFERENCES`
: Revokes the privilege to create or drop foreign key constraints that reference the database object as a parent object. You may add a parenthetical list of the columns in a given table where the privilege will be revoked.

`TRIGGER`
: Revokes the privilege to create or drop triggers on a table.

`USAGE`
: Revokes the privilege to use a sequence, domain, foreign data wrapper, foreign server, language, schema, or user-defined type.

`CREATE`
: Revokes the privilege to create objects.

`CONNECT`
: Revokes the privilege to connect to a specific database.

`TEMP[ORARY]`
: Revokes permission to create temporary tables when using the named database.

`EXECUTE`
: Revokes permission to call a function or procedure.

`FROM` *`grantee`*

Names the user or role that will lose the specified privilege (multiple users or roles can be listed with a comma between each). Options are `[GROUP]` *`role_name`*, `PUBLIC`, `CURRENT_ROLE`, and `CURRENT_USER`.

`CASCADE | RESTRICT`

Limits a `REVOKE` operation to only the specified privilege (`RESTRICT`), or causes the specified privilege and all dependent privileges to be revoked (`CASCADE`). Only used with the `GRANT OPTION FOR` clause. When omitted, PostgreSQL assumes `RESTRICT` by default.

Refer to the section detailing PostgreSQL's implementation of the `GRANT` statement to see a full list of privileges allowed for each object type. You may, in turn, revoke any of these privileges that have been assigned to a user or role.

PostgreSQL's implementation of `REVOKE` is relatively straightforward. The only issue to be aware of is that PostgreSQL treats the term `GROUP` as a synonym for `ROLE`. For example, the following commands remove some privileges from the `PUBLIC` group and from the `READ_ONLY` group:

```
REVOKE ALL PRIVILEGES ON employee FROM public;
REVOKE SELECT ON jobs FROM read_only;
```

When revoking the `GRANT OPTION FOR` clause, you should pay extra attention to dependencies. If you revoke a user's privilege with the `RESTRICT` keyword, the statement will fail if other users depend on the revokee. If you revoke a user's privilege with the `CASCADE` keyword, the statement will revoke privileges not only for the revokee, but for all users that depend on the revokee.

SQL Server

SQL Server implements the `REVOKE` statement as a means to undo any permission settings for a given user or role. This is significant because SQL Server also supports an extension statement called `DENY`, which explicitly disallows a user from a specific resource. In SQL Server, `REVOKE` can be used to undo permissions granted to a user with `GRANT`, but if you want to explicitly prevent a user from having a certain privilege, you must use the `DENY` statement.

SQL Server does not support the `HIERARCHY OPTION FOR` and `ADMIN OPTION FOR` clauses of the SQL standard, but it does allow revocation of a couple of administrative privileges (`CREATE` and `BACKUP`). The syntax is as follows:

```
REVOKE [GRANT OPTION FOR]
{ [object_privilege][, ...] | [system_privilege] }
[ON [class::][object] [(column[, ...])]] |
{TO | FROM} {grantee_name[, ...] | role[, ...] |
   PUBLIC | GUEST)}
[CASCADE]
[AS {group_name | role_name}]
```

where:

`REVOKE` *`object_privilege`*
: Revokes privileges for a variety of statements, which may be combined in any order. Refer to the discussion of SQL Server's implementation of the `GRANT` statement for a full list of object privileges.

`REVOKE` *`system_privilege`*
: Revokes privileges to execute commands and perform certain functions. Refer to the SQL Server documentation for a full list of system privileges, permissions, and roles.

`ON` *`object`* `[(`*`column`*`[, ... ])]`
: Identifies the object from which privileges will be removed. If the object is a table or view, you may optionally revoke privileges on specific columns. You may revoke `SELECT`, `INSERT`, `UPDATE`, `DELETE`, and `REFERENCES` privileges on a table or view, but only `SELECT` and `UPDATE` privileges on the columns of a table or view. You may revoke `EXECUTE` privileges on a stored procedure, user-defined function, or extended stored procedure.

`{TO | FROM} {`*`grantee_name`*` | `*`role`*` | PUBLIC | GUEST}`
: Names the user(s) or role(s) that will lose the specified privilege. `PUBLIC` may be used to revoke privileges granted to the `PUBLIC` role (a role that implicitly includes all users), and `GUEST` can be used to revoke privileges granted to SQL Server's `GUEST` role (an account used by all users who do not have a user account in the database). Multiple grantees can be listed with a comma between each.

`CASCADE`
: Revokes privileges from users who received their permissions under the `WITH GRANT OPTION` clause. Required when using the `GRANT OPTION FOR` clause.

`AS {`*`group_name`*` | `*`role_name`*`}`
: Defines the authority by which the privilege is revoked. In certain circumstances, a user may need to temporarily assume the privileges of a group to revoke the specified privileges. To accommodate this scenario, you can use the `AS` clause to assume the authority of a given group.

The two forms of the `REVOKE` command, `REVOKE` *`object_privilege`* and `REVOKE` *`system_privilege`*, are mutually exclusive. *Do not* attempt to do both operations in a single statement. The key syntactical difference between the two versions is that you should not include the `ON` clause when revoking system privileges. For example, to drop a system privilege, you might use:

```
REVOKE CREATE DATABASE, BACKUP DATABASE FROM dylan, katie
```

Privileges granted to a user with `WITH GRANT OPTION` should be revoked using both `GRANT OPTION FOR` and `CASCADE`. For example:

```
REVOKE GRANT OPTION FOR
SELECT, INSERT, UPDATE, DELETE ON titles
TO editors
CASCADE
GO
```

REVOKE can be used only in the current database. Consequently, the CURRENT_USER and CURRENT_ROLE options in the SQL standard are always implied. REVOKE is also used to disable any DENY settings.

SQL Server's DENY statement is syntactically the same as REVOKE. However, it is conceptually different in that REVOKE neutralizes a user's privileges, while DENY explicitly prohibits a user from having certain privileges. You can use the DENY statement to keep a user or role from accessing a privilege, even if it is granted through a role or an explicit GRANT statement.

You must use REVOKE to remove previously granted *or* denied privileges. For example, say the user *sumit* took an extended leave of absence for parental care. During that time, his permissions on the *employee* table were denied. Upon his return, you'll want to lift (REVOKE) the denied privileges:

```
DENY ALL ON employee TO sumit;
GO
REVOKE ALL ON employee TO sumit;
GO
```

In this example, the REVOKE command does not remove *sumit*'s privileges; rather, it neutralizes the DENY statement.

See also

- GRANT

SET CONNECTION Statement

The SET CONNECTION statement allows users to switch between several open connections on one or more database servers.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Supported, with limitations

SQL standard syntax

```
SET CONNECTION {DEFAULT | connection_name}
```

Keywords

`connection_name`
: Names the connection of the current session. If the *`connection_name`* is different from the current session's connection name, the connection context is switched to the *`connection_name`*.

`DEFAULT`
: Switches to the default connection from any other connection. This enables rapid switching to the default connection without knowing its name.

Description

This command does not end a connection. Instead, it switches from the current connection to the connection named (making it the current connection), or from the current connection to the default connection. When switching between connections, the old connection becomes dormant (without committing any changes), while the new connection becomes active.

Rules at a glance

`SET CONNECTION` does not create a connection; it merely switches your connection context. Use the `CONNECT` command to create a new connection, and use `DISCONNECT` to terminate a connection.

Programming tips and gotchas

The `SET CONNECTION` command is not frequently used, since many users connect programmatically via ODBC, JDBC, or some other connectivity method. However, on those platforms that support `SET CONNECTION`, the command can be very useful for rapidly changing connection properties without terminating any existing connections.

MySQL

Not supported.

Oracle

Not supported.

PostgreSQL

PostgreSQL supports the SQL standard syntax for `SET CONNECTION`, but only in embedded SQL, not within its ad hoc querying tool, *psql*, or *pgAdmin*. For *psql* and *libpq* you can use *\connect*.

The value for *`connection_name`* must reference a connection named in a previous `CONNECT` statement, either as a literal or as a variable.

Here is a full SQL program in PostgreSQL that shows `CONNECT`, `DISCONNECT`, and `SET CONNECTION`:

```
EXEC SQL CONNECT TO nutshell AS nutshell_1 USER postgres;
EXEC SQL SET CONNECTION nutshell_1;
EXEC SQL SELECT name FROM employee INTO :name;
EXEC SQL DISCONNECT ALL;
-- Terminates all sessions. You could alternatively use two
-- DISCONNECT commands, one for each named connection.
```

SQL Server

SQL Server supports the `SET CONNECTION` command, but only in embedded SQL (for example, in a C++ program), not within its ad hoc querying tool, SQL Query Analyzer. The syntax is the same as the SQL standard command, except that it does not support the `DEFAULT` keyword:

```
SET CONNECTION connection_name
```

The value for *`connection_name`* must reference a connection named in a previous `CONNECT` statement, either as a literal or as a variable. Though it is supported, this command is not used very often; most prefer the SQL Server–specific command `USE` instead.

Here is a full Transact-SQL program in SQL Server that shows `CONNECT`, `DISCONNECT`, and `SET CONNECTION`:

```
EXEC SQL CONNECT TO chicago.pubs AS chicago1 USER sa;
EXEC SQL CONNECT TO new_york.pubs AS new_york1 USER read-only;
-- Opens connections to the servers named "chicago" and
   "new_york"
EXEC SQL SET CONNECTION chicago1;
EXEC SQL SELECT name FROM employee INTO :name;
-- Sets the chicago1 connection as active and performs work
   within that session
EXEC SQL SET CONNECTION new_york1;
EXEC SQL SELECT name FROM employee INTO :name;
-- Sets the new_york1 connection as active and performs work
   within that session
EXEC SQL DISCONNECT ALL;
-- Terminates all sessions. You could alternately use two
-- DISCONNECT commands, one for each named connection.
```

See also

- CONNECT

SET CONSTRAINTS Statement

The SET CONSTRAINTS statement defines, for the current transaction, whether a deferrable constraint is checked after each DML statement or when the transaction is finally committed. If the session is not currently in an open transaction, the setting applies to the next transaction.

Platform	Command
MySQL	Not supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
SET CONSTRAINTS {constraint_name[, ...] | ALL} {DEFERRED | IMMEDIATE}
```

Keywords

constraint_name[, ...] | ALL
: Names one or more deferrable constraints to which the setting will apply. The keyword ALL sets the constraint mode for all deferrable constraints of the current transaction.

DEFERRED
: Checks the conditions specified by the deferrable constraint when the transaction is committed, rather than when the DML statements are issued.

IMMEDIATE
: Checks the conditions specified by the deferrable constraint immediately after each DML statement is issued, rather than when the transaction is committed.

Rules at a glance

SET CONSTRAINTS ALL defines a value for the constraint mode of all deferrable constraints of the current transaction. If the session is not currently in a transaction, the SET CONSTRAINTS statement applies to the next transaction issued during the session.

The following example sets all deferrable constraints to be checked immediately following the issuance of each DML statement:

```
SET CONSTRAINTS ALL IMMEDIATE;
```

The next example sets two constraints to defer their data modifications until the transaction is committed:

```
SET CONSTRAINTS scott.hr_job_title, scott.emp_bonus DEFERRED:
```

Programming tips and gotchas

PostgreSQL fully supports the SQL standard syntax. Older versions allowed the synonym NOT DEFERRABLE in place of IMMEDIATE.

MySQL

Not supported.

Oracle

Oracle fully supports the SQL standard syntax as well as the alias SET CONSTRAINT.

PostgreSQL

PostgreSQL fully supports the SQL standard syntax, but it currently allows SET CONSTRAINTS to affect only foreign key, primary key, unique key, and exclusion constraints. Check constraints and not null constraints are not affected and are always considered IMMEDIATE.

SQL Server

Not supported.

SET PATH Statement

The SET PATH statement changes the value of the CURRENT PATH setting to one or more schemas. The PATH is used for searching for SQL-invoked routines.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Not supported
SQL Server	Not supported

SQL standard syntax

```
SET PATH schema_name[, ...]
```

Keywords

schema_name[, ...]
Defines one or more schemas as the current path.

Rules at a glance

`SET PATH` defines one or more schemas used to qualify an unqualified routine name (that is, the name of any function, procedure, or method).

The following example sets the current path (i.e., schema name) for unqualified routines to *scott*:

```
SET PATH scott;
```

Then, whenever a routine is referenced during the current session, the *scott* schema will be used if no schema is identified.

Programming tips and gotchas

When referencing multiple schema names, all the schemas must belong to the current database. (The schemas cannot be on a remote database.)

`SET PATH` does not apply the schema to unqualified objects like tables or views; it only applies to routines.

`SET PATH` is not supported by any of the platforms discussed in this book. PostgreSQL does support a `SET` ***`search_path`*** which achieves the same purpose, but is not limited to routines; it applies to all unqualified objects.

See also

- `SET SCHEMA`

SET ROLE Statement

The `SET ROLE` statement enables and disables specific roles for the current session.

Platform	Command
MySQL	Not supported
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Not supported

SQL standard syntax

```
SET ROLE {NONE | role_name}
```

Keywords

`NONE`
: Assigns the `CURRENT_ROLE` role to the current session.

role_name
: Associates the set of privileges associated with the named role with the current session.

Rules at a glance

When a user session is opened using the `CONNECT` statement, issuing the `SET ROLE` statement grants that session the privileges associated with a role. The `SET ROLE` command can be issued only outside of a transaction.

The value for *`role_name`* must reference a valid user role existing on the server. You may specify the role name either as a literal or through a variable.

Programming tips and gotchas

Most database platforms offer some method of setting or changing the role used during a user session. `SET ROLE` is the SQL-standard approach, but it is not widely supported by the different database platforms. The following sections detail the analogous commands supported by the platforms discussed in this book; check your platform's documentation for more information.

MySQL

MySQL does not support the `SET ROLE` command, but it provides an analogous method to control connection settings in the `[`*`client`*`]` section of the *.my.cnf* configuration file in the home directory. For example:

```
[client]
host=server_name
user=user_name
password=client_password
```

To rapidly change between user roles, you can reassign host, user, and password connection properties, respectively, by assigning new values to `MYSQL_HOST`, `USER` (for Windows only), and `MYSQL_PWD` (though `MYSQL_PWD` is insecure in that other users can view this file).

Oracle

When a user initiates a connection, Oracle explicitly assigns roles to that user. The role(s) under which the session is operating can be changed with the `SET ROLE` command, assuming the user is a member of the assigned role. Oracle uses the `MAX_ENABLED_ROLES` initialization parameter (in the *init.ora* file) to control the maximum number of roles that can be enabled concurrently. The Oracle syntax for the `SET ROLE` command is:

```
SET ROLE { role_name [IDENTIFIED BY password][, ...]
   | [ALL [EXCEPT role_name[, ...]]
   | NONE }
```

where:

role_name
: Declares a valid role name (or names) already created within Oracle, of which the user must already be a member. Any roles not specified here are unavailable throughout the current session. You can enable multiple roles by providing a list, placing a comma between each role listed.

IDENTIFIED BY *password*
: If the *role_name* has a password, that password must be specified using this clause.

ALL
: Enables all roles that are granted to the current user, including roles that are granted through other roles. Cannot be used with the IDENTIFIED BY clause.

EXCEPT
: Specifies a list of roles to exclude from a SET ROLE ALL command.

NONE
: Disables all roles, including the default role.

Roles with passwords may be accessed only through the statement SET ROLE *role_name* IDENTIFIED BY *password*. For example, we can use this statement to enable the specific roles *read_only* and *updater*—identified by the passwords *editor* and *red_marker*, respectively—for the current session:

```
SET ROLE
   read_only IDENTIFIED BY editor,
   updater   IDENTIFIED BY red_marker;
```

To enable all roles except the *read_write* role, we can issue this command:

```
SET ROLE ALL EXCEPT read_write;
```

PostgreSQL

PostgreSQL supports the SQL standard SET ROLE command, with some extensions. Its syntax is as follows:

```
SET [ SESSION | LOCAL ] ROLE {role_name | NONE}
RESET ROLE
```

where:

SESSION | LOCAL
: Specifies whether the role takes effect for the current session (SESSION) or only for the current transaction (LOCAL).

RESET ROLE
: Resets the role to the role used to log in.

SQL Server

Not supported.

See also

- CONNECT
- CREATE ROLE
- SET SESSION AUTHORIZATION

SET SCHEMA Statement

The SET SCHEMA statement changes the value of the CURRENT SCHEMA setting to a user-specified schema.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
SET SCHEMA schema_name[, ...]
```

Keywords

schema_name[, ...]
: Defines one or more schemas as the current path.

Rules at a glance

SET SCHEMA sets the default schema name for unqualified objects in the current SQL session.

The following example sets the current schema for unqualified objects to *scott*:

```
SET SCHEMA scott;
```

Then, whenever an object is referenced during the current session, the *scott* schema will be used if no schema is identified.

Programming tips and gotchas

This command is only supported by PostgreSQL. However, all of the other platforms discussed here have an approximately equivalent command.

MySQL

MySQL does not support the `SET SCHEMA` command. In MySQL the terms database and schema are synonymous; the equivalent command is `USE DATABASE`:

```
USE DATABASE schema_name
```

Oracle

Oracle does not support the `SET SCHEMA` command. IThe equivalent is `ALTER SESSION SET CURRENT_SCHEMA`:

```
ALTER SESSION SET CURRENT_SCHEMA = schema_name
```

PostgreSQL

PostgreSQL supports the `SET SCHEMA` command, which is an alias for its `SET SEARCH_PATH` command. However, `SET SCHEMA` supports only one schema, unlike `SET SEARCH_PATH`, which allows you to specify multiple schemas: the first one listed is where non-schema-qualified objects are created when you issue a `CREATE` statement, and is the first schema searched for non-schema-qualified objects. The schemas are searched in the order they are listed. The PostgreSQL syntax is as follows:

```
SET SCHEMA = schema_name
SET SEARCH_PATH = schema_name[,...]
ALTER [ROLE | DATABASE | SYSTEM] SET SEARCH_PATH = schema_name[,..]
```

Prefixing the `SET SEARCH_PATH` command with `ALTER [ROLE | DATABASE | SYSTEM]` causes the setting to persist across connections; otherwise, it lasts only for the duration of the current connection.

SQL Server

SQL Server does not support the `SET SCHEMA` command. It does allow you to set the default schema for each user with the following command, but does not permit setting the schema for the current session:

```
ALTER USER SET DEFAULT_SCHEMA = schema_name
```

See also

- `SET PATH`
- `SET ROLE`

SET SESSION AUTHORIZATION Statement

The `SET SESSION AUTHORIZATION` statement sets the user identifier for the current session.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported
SQL Server	Not supported

SQL standard syntax

```
SET SESSION AUTHORIZATION username
```

Keywords

`username`
: Sets the session user and the current user of the SQL session to the context of *`username`*, where *`username`* may be a literal, a parameter, or a host variable.

Rules at a glance

This command allows you to switch between users and to run under the corresponding permissions.

Programming tips and gotchas

This command is only supported by PostgreSQL. However, all of the other platforms discussed here provide a way to achieve equivalent functionality.

Some platforms allow you to use special shortcut keywords like `CURRENT_USER` and `SESSION_USER`. These are usually the same thing: the username of the currently active session provided by the client. However, `CURRENT_USER` and `SESSION_USER` can diverge in a session when `SETUID` functions and other similar mechanisms are invoked.

Superuser permissions are required to invoke the `SET SESSION AUTHORIZATION` command, but you will still be able to switch back to the initial user session even if the current user session does not normally have permission to run `SET SESSION AUTHORIZATION`.

You might also wish to check the value of `CURRENT_USER` and `SESSION_USER` before using them. You can do that with this SQL statement:

```
SELECT SESSION_USER, CURRENT_USER;
```

Normally, you should issue `SET SESSION AUTHORIZATION` before any transactions, to set the session and current user values for all transactions that follow. It must be issued as the only command in its transaction batch.

MySQL

Not supported. You must disconnect your session from MySQL and then reconnect to utilize another set of user privileges.

Oracle

Not supported. Similar functionality is achieved using the `CONNECT` statement or by logging off the server and reconnecting.

PostgreSQL

PostgreSQL supports the SQL standard syntax for this command. The only difference, and it is a minor one, is that the SQL standard does not allow this command during a transaction, while PostgreSQL does not care one way or the other.

SQL Server

Not supported. Similar functionality is achieved with the `CONNECT` statement or by logging off the server and reconnecting.

See also

- `CONNECT`
- `GRANT`

SET TIME ZONE Statement

The `SET TIME ZONE` statement changes the current session's time zone if it needs to be different from the default time zone.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with limitations
SQL Server	Not supported

SQL standard syntax

```
SET TIME ZONE {LOCAL | INTERVAL {+ | -}'00:00' [HOUR TO MINUTE]}
```

Keywords

`LOCAL`
: Sets the current session's time zone to that of the local server.

`INTERVAL`
: Specifies the time zone offset from Coordinated Universal Time (UTC) in terms of hours and minutes. The offset can be either an increase (with `+`) or decrease (with `-`) in relation to the default time.

`HOUR TO MINUTE`
: Specifies the data type of the `TIME ZONE` value.

Rules at a glance

This is a relatively simple command that either sets the user session time zone to that of the server (`LOCAL`), or sets the time zone in relation to Coordinated Universal Time (formerly Greenwich Mean Time, or GMT). Thus, an `INTERVAL` of *2* would advance the time zone to two hours after UTC, while an `INTERVAL` of *–6* would reduce the time zone to six hours before UTC (i.e., to the United States Central Standard Time zone).

Programming tips and gotchas

Like most `SET` commands, `SET TIME ZONE` can be executed only outside of an explicit transaction. In other words, you do not need to encapsulate the command within a `START` or `BEGIN TRANSACTION` and a `COMMIT TRANSACTION` statement.

MySQL

MySQL allows you to specify a named time zone set through the system variable time_zone, or to set the time zone to the server's default by using the `LOCAL` or the `DEFAULT` clause:

```
SET TIME ZONE {'time_zone' | LOCAL | DEFAULT }
```

To set the time zone globally and on startup, use:

```
SET GLOBAL TIME ZONE 'time_zone'
```

Oracle

In Oracle, you can use the following `ALTER SESSION` command to set the session time zone:

```
ALTER SESSION
   SET TIME_ZONE = {'[+ | -] hh:mm'
                   | LOCAL
                   | DBTIMEZONE
                   | 'region'}
```

Use `LOCAL` to revert back to your session's original default time zone, use `DBTIMEZONE` to set your session's time zone to the database's time zone, and use `'region'` to specify a time zone region name such as `'EST'` or `'PST'`. Use an offset such as `'-5:00'` to specify your time zone in terms of an hour and minute displacement from UTC. A displacement of `'-5:00'` means that your time is five hours behind UTC time (e.g., 5:00 A.M. your time is 10:00 A.M. UTC time).

To retrieve a list of valid time zone region names, issue the following query:

```
SELECT tzname FROM v$timezone_names;
```

Both of the following commands set the time zone to Eastern Standard Time. The first command does this by specifying the appropriate displacement from UTC, while the second command specifies the time zone region name:

```
ALTER SESSION SET TIME_ZONE = '-5:00';
ALTER SESSION SET TIME_ZONE = 'EST';
```

Oracle's time zone support is complex. Steven Feuerstein and Bill Pribyl's *Oracle PL/SQL Programming*, 6th ed. (O'Reilly) contains a good explanation of it in the chapter on datetime data types.

PostgreSQL

PostgreSQL allows a session's time zone value to be set to a named time zone, or set to the server default by using the `LOCAL` or the `DEFAULT` clause:

```
SET TIME ZONE {'time_zone' | LOCAL | DEFAULT }
```

PostgreSQL also allows the time zone to be set at the database level or system level, using the following syntax:

```
ALTER DATABASE name_of_database SET TIME ZONE
   {'time_zone' | LOCAL | DEFAULT }
```

In order for system-level changes to take effect, the database service needs to be reloaded or a reload configuration needs to be called, as shown here:

```
ALTER SYSTEM SET TIME ZONE 'time_zone';
SELECT pg_reload_conf();
```

There are some variations from the SQL standard:

`time_zone`
: Specifies a time zone by name. The possible values depend on the operating system; for example, the file */usr/share/zoneinfo* contains the database of time zones for Linux servers.

`LOCAL | DEFAULT`
: Sets the current session's time values to those of the default time zone as determined by the local server.

For example, `'PST8PDT'` is a valid time zone for California on Linux systems, while `'Europe/Rome'` is a valid time zone for Italy on Linux and other systems. If you specify an invalid time zone, the command sets the time zone to UTC.

The following example sets the PostgreSQL time zone to Pacific Standard Time:

```
SET TIME ZONE 'PST8PDT';
```

Next, the time for the current session is returned to the server's default time zone:

```
SET TIME ZONE LOCAL;
```

SQL Server

Not supported.

7 SQL Built-in Functions

A function is a special type of command word in the SQL command set, and each SQL dialect varies in its implementation of that command set. The value of a function can be determined by input parameters, as with a function that averages a list of database values. However, many functions do not use any type of input parameter. The function that returns the current system time, `CURRENT_TIME`, is an example of such a function. Functions may also return tables or sets of rows. These types of functions are often referred to as *set-returning* functions.

The SQL standard supports a number of useful functions. This chapter and the next cover those functions, providing detailed descriptions and examples for each platform. We do not cover every function under the sun, but will focus on the most commonly used functions. In addition, each database supports a large set of its own internal functions that are outside the scope of the SQL standard; listings of these functions for each vendor are provided at the end of each chapter.

In the case of MariaDB and MySQL, we will refer only to MySQL except in cases where MariaDB deviates from MySQL behavior.

Most database platforms support the ability to create user-defined functions (UDFs). For more information on UDFs, refer to Chapter 9. JSON and XML functions are covered in Chapter 10 and will not be discussed in this or the next chapter.

How to Use This Chapter

When researching a function in this chapter:

1. Check the SQL syntax and read the description, even if you are looking for a specific platform implementation.
2. Read the platform-specific implementation information.

Elements of the vendors' implementations that do not differ from the standard are not discussed in the individual platform sections; these sections only call out any differences from the standard. For details not provided in a particular platform section, see the section on the SQL syntax.

Types of Functions

There are different ways to categorize functions into groups. The following subsections describe distinctions that are critical to understanding how functions work.

Deterministic and Nondeterministic Functions

Functions can be either deterministic or nondeterministic. A *deterministic function* always returns the same results if given the same input values. A *nondeterministic function* may return different results every time it is called, even when the same input values are provided.

Why is it important that a given input always returns the same output? It has to do with how functions may be used within views and indexes, in user-defined functions, and in stored procedures. Restrictions vary across implementations, but these objects sometimes allow only deterministic functions within their defining code. For example, many databases allow the creation of an index on a column expression, but only if the expression does not contain any nondeterministic functions. Check your platform's documentation for details.

Aggregate Functions

Another way of categorizing functions is in terms of whether they operate on values from just one row at a time, on values from a collection, or on a set of rows. *Aggregate functions* operate on a collection of values and return a single summarizing value. Aggregate functions are also often combined with `GROUP BY` and `HAVING` clauses that determine the number of groups of data. We'll cover aggregates in the next chapter.

Window Functions

Window functions are similar to aggregate functions in that they operate over many rows at one time. The difference lies in how you define those rows. Aggregate functions operate over the sets of rows defined by a query's `GROUP BY` clause. With window functions, you specify the set of rows for each function call, so different invocations of a function within the same query can execute over different sets of rows. A window function also always returns the same number of rows as you started with, whereas the results of a query with an aggregate function collapse the grouped rows into one value. In many cases aggregate functions can be used like window functions. In these cases the aggregate function has an `OVER()` clause just like any other window function call.

SQL Functions

We'll focus on functions that are not aggregate or window functions in this chapter. These functions may be deterministic or nondeterministic, and they may return tables or single values. The SQL standard provides many functions that can be used to manipulate collections, strings, and numbers, as well as to retrieve system information such as the current user or system time. These functions fall into the categories listed in Table 7-1.

Table 7-1. Categories of functions

Function category	Explanation
Variable functions (including date and time functions)	These functions, unlike others, are not followed by `()`; they are called like any other variables and return information such as the current server time or the username of the currently logged-in user. Date and time functions perform operations on temporal data types and return values in a temporal data type format. There is no SQL function that operates on a temporal data type and returns a temporal result; the closest function is `EXTRACT` (covered in "Numeric Functions" on page 511), which operates on temporal values and returns numeric values.
General-purpose functions	This category includes functions that can be used with many kinds of data types, and are often used for conditional logic. For example, `CASE` supplies `IF`/`THEN` logic to SQL statements, and `CAST` can convert values from one data type to another.
Numeric functions	These functions perform operations on numeric values and return numeric values.
String functions and operators	These functions perform operations on character values (e.g., the `CHAR`, `VARCHAR`, `NCHAR`, `NVARCHAR`, and `CLOB` data types) and return string or numeric values.
Collection functions	These functions take a collection object such as a nested table, array, or collection type and expand them into subelements.

Variable Functions

The SQL standard variable functions identify the current user session and its characteristics, such as the current session privileges. Variable functions are always nondeterministic. The `CURRENT_DATE`, `CURRENT_TIME`, and `CURRENT_TIMESTAMP` functions included in Table 7-2 fall into the date-and-time category of functions. Although the four platforms discussed in this book provide many additional functions beyond these SQL built-ins (see "Platform-Specific Extensions" on page 538 for details), the SQL standard defines only those listed in this table.

Table 7-2. SQL standard built-in scalar functions

Function	Usage
CURRENT_DATE	Returns the current date
CURRENT_ROLE	Returns the current active role within a database
CURRENT_TIME	Returns the current time
CURRENT_TIMESTAMP	Returns the current date and time
CURRENT_USER or USER	Returns the username of the currently active user within the database server
CURRENT_USER	Returns the currently active authorization ID, if it differs from the user's ID
SYSTEM_USER	Returns the username of the currently active user within the host operating system

MySQL

MySQL supports all of the functions listed in Table 7-2 with and without (), except for USER, CURRENT_USER, and SYSTEM_USER—so, for example, CURRENT_DATE and CURRENT_DATE() are both allowed. In addition, MySQL supports NOW() as a synonym for the function CURRENT_TIMESTAMP.

Oracle

Oracle supports the USER, CURRENT_DATE, and CURRENT_TIMESTAMP functions.

PostgreSQL

PostgreSQL supports all of the functions listed in Table 7-2. In addition, it supports NOW() as a synonym for the function CURRENT_TIMESTAMP.

SQL Server

SQL Server supports all of the functions listed in Table 7-2 except for CURRENT_DATE and CURRENT_TIME. In addition, it supports GETDATE() as a synonym for CURRENT_TIMESTAMP.

Examples

The following queries retrieve the current date and time. Notice that the various platforms return dates in their native formats:

```
/* On MySQL */
SELECT CURRENT_TIMESTAMP;
2022-0405 14:48:44

/* On Oracle */
SELECT CURRENT_TIMESTAMP FROM DUAL;
05-APR-22 02.48.44.554000 PM -04:00

/* On PostgreSQL */
```

```
SELECT CURRENT_TIMESTAMP;
2022-04-05 14:48:44.84403-04

/* On SQL Server */
SELECT CURRENT_TIMESTAMP;
2022-04-05 14:48:44.060
```

General-Purpose Functions

The SQL standard provides several general-purpose functions that can be used with many kinds of data types. These are often used for conditional logic.

CASE

The `CASE` function provides `IF/THEN/ELSE` functionality within a `SELECT`, `INSERT`, or `UPDATE` statement. It evaluates a list of conditions and returns one value out of several possible values.

`CASE` has two usages: *simple* and *searched*. Simple `CASE` expressions compare one value, the *`input_value`*, with a list of other values and return a result associated with the first matching value. Searched `CASE` expressions allow the analysis of several logical conditions and return a result associated with the first one that is true.

All vendors support the SQL standard syntax for `CASE`.

SQL standard syntax.

```
-- Simple comparison operation
CASE input_value
WHEN value THEN resulting_value
[WHEN value_n THEN resulting_value_n ...]
[ELSE else_result_value]
END

-- Boolean searched operation
CASE
WHEN boolean_condition THEN resulting_value
[WHEN boolean_condition_n THEN resulting_value_n ...]
[ELSE else_result_expression]
END
```

In the simple `CASE` function, the *`input_value`* is evaluated against each `WHEN` clause. The *`resulting_value`* is returned for the first `TRUE` instance of *`input_value`* = *`when_condition`*. If no *`when_condition`* evaluates as `TRUE`, the *`else_result_value`* is returned. If no *`else_result_value`* is specified, NULL is returned.

The structure is essentially the same in the more elaborate Boolean searched operation, except that each `WHEN` clause has its own Boolean comparison operation.

In either usage, multiple `WHEN` clauses are used. If there is more than one `ELSE`, it will cause an error.

Examples. Here is a simple comparison operation where the CASE function alters the display of the *contract* column to make it more understandable:

```
SELECT  au_fname,
        au_lname,
        CASE contract
            WHEN 1 THEN 'Yes'
            ELSE 'No'
        END 'contract'
FROM    authors
WHERE   state = 'CA'
```

Here is an elaborate searched CASE function in a SELECT statement that will report how many titles have been sold in different year-to-date sales ranges:

```
SELECT CASE
           WHEN ytd_sales IS NULL  THEN 'Unknown'
           WHEN ytd_sales <=   200 THEN 'Not more than 200'
           WHEN ytd_sales <=  1000 THEN 'Between  201 and  1000'
           WHEN ytd_sales <=  5000 THEN 'Between 1001 and  5000'
           WHEN ytd_sales <= 10000 THEN 'Between 5001 and 10000'
           ELSE 'Over 10000'
       END 'YTD Sales',
       COUNT(*) 'Number of Titles'
FROM   titles
GROUP BY CASE
           WHEN ytd_sales IS NULL  THEN 'Unknown'
           WHEN ytd_sales <=   200 THEN 'Not more than 200'
           WHEN ytd_sales <=  1000 THEN 'Between  201 and  1000'
           WHEN ytd_sales <=  5000 THEN 'Between 1001 and  5000'
           WHEN ytd_sales <= 10000 THEN 'Between 5001 and 10000'
           ELSE 'Over 10000'
         END
ORDER BY MIN( ytd_sales )
```

The results are:

```
YTD Sales              Number of Titles
---------------------- ----------------
Unknown                2
Not more than 200      1
Between  201 and  1000 2
Between 1001 and  5000 9
Between 5001 and 10000 1
Over 10000             3
```

Next is an UPDATE statement that applies discounts to all of the titles. This more complicated command will discount all popular computing–related titles by 25% and all other titles by 10%, with the exception of titles with year-to-date sales exceeding 10,000 units, which will receive only a 5% discount. This query uses a searched CASE expression to perform the price adjustments:

```
UPDATE  titles
SET     price = price *
        CASE
            WHEN ytd_sales > 10000     THEN 0.95  -- 5% discount
            WHEN type = 'popular_comp' THEN 0.75  -- 25% discount
            ELSE 0.9                              -- 10% discount
        END
WHERE   pub_date IS NOT NULL
```

This example demonstrates completion of three separate `UPDATE` operations in a single statement.

CAST

The `CAST` function explicitly converts an expression of one data type to another. All vendors support the SQL standard syntax for `CAST`, and PostgreSQL and SQL Server also provide some extensions.

SQL standard syntax.

```
CAST(expression AS data_type[(length)])
```

The `CAST` function converts a given *`expression`*, such as a column value or variable, into another defined data type. The length of the data type may optionally be supplied for those data types (such as `CHAR` or `VARCHAR`) that support lengths.

Be aware that some conversions, such as converting `DECIMAL` values to `INTEGER`, will result in rounding operations. Also, some conversion operations may result in an error if the new data type does not have sufficient space to display the converted value.

PostgreSQL. In addition to the standard `CAST` function, PostgreSQL provides a :: operator to achieve the same purpose. You will find this operator used more frequently than `CAST` because it is shorter to type and allows for easy chaining of cast operations. The data type qualifiers can be length, precision, or any custom qualifiers supported for that type:

```
expression::data_type[(data_type_qualifiers)]
```

Here's an example of chaining:

```
SELECT 50::numeric(10,2)::text
'50.00'
```

SQL Server. In addition to `CAST`, SQL Server provides a `TRY_CAST` function that will return NULL instead of an error when it fails to cast. For example:

```
SELECT TRY_CAST('One' AS integer)
NULL
```

Examples. This example retrieves the year-to-date sales figure as a CHAR and concatenates it with a literal string and a portion of the title of the book. It converts *ytd_sales* values to CHAR(5), and it shortens the length of the *title* column to make the results more readable. Note that SQL Server uses + for concatenation instead of the SQL standard ||:

```
SELECT CAST(ytd_sales AS CHAR(5)) || ' Copies sold of ' +
CAST(title AS VARCHAR(30))
FROM titles
WHERE ytd_sales IS NOT NULL
  AND ytd_sales > 10000
ORDER BY ytd_sales DESC;
```

The results are:

```
---------------------------------------------------
22246 Copies sold of The Gourmet Microwave
18722 Copies sold of You Can Combat Computer Stress
15096 Copies sold of Fifty Years in Buckingham Pala
...
```

COALESCE

The COALESCE function returns the first non-NULL value in a list. The values should be coercible to the same data type, or an error might result.

All vendors support the SQL standard syntax for COALESCE.

SQL standard syntax.

```
COALESCE(expression1[,expression2[,...]])
```

Examples.

```
/* Oracle */
SELECT COALESCE(NULL,2,NULL,1) AS n FROM DUAL;
 n
----------
        2

/* MySQL, PostgreSQL, SQL Server */
SELECT COALESCE(NULL,2,NULL,1) AS n;
```

NULLIF

The NULLIF function returns NULL if two values are equivalent and the first value when they are different. All vendors support the SQL standard syntax for NULLIF.

SQL standard syntax.

```
NULLIF(expression1,expression2)
```

NULLIF (*expression1*,*expression2*) is shorthand for:

```
CASE WHEN expression1 = expression2 THEN NULL ELSE expression1 END
```

Examples.

```
/* Oracle */
SELECT NULLIF(1,2) AS n FROM DUAL;
 n
----------
        1

SELECT NULLIF(1,1) AS n FROM DUAL;
 n
----------
        NULL

/* MySQL, PostgreSQL, SQL Server */
SELECT NULLIF(1,2) AS n;
 n
----------
        1

SELECT NULLIF(1,1) AS n;
n
----------
        NULL
```

Numeric Functions

The numeric functions and syntax supported by the SQL standard are listed in Table 7-3. These functions return a numeric value given a value, although the input values are not always numeric. In addition to the functions listed here, the SQL standard also specifies the use of the trigonometric functions ACOS, ASIN, ATAN, COS, COSH, SIN, SINH, TAN, and TANH. Platform support for these functions varies, with individual vendors often providing their own alternatives; refer to the individual sections for details.

Table 7-3. SQL numeric functions

Function	Usage
ABS	Returns the absolute value of a number.
BIT_LENGTH	Returns the number of bits in the value. This function is not in the SQL standard, but most of the databases discussed support it.
CARDINALITY	Returns the number of elements in a collection.
CEIL, CEILING	Rounds a noninteger value upward to the next highest integer. Returns an integer value unchanged.
CHAR_LENGTH, CHARACTER _LENGTH	Returns an integer value representing the number of characters in a string expression.
EXP	Raises a value to the power of the mathematical constant known as *e*.

Function	Usage
`EXTRACT`	Allows the date part (`YEAR`, `MONTH`, `DAY`, `HOUR`, `MINUTE`, `SECOND`, `TIMEZONE_HOUR`, or `TIMEZONE_MINUTE`) to be extracted from a temporal expression.
`FLOOR`	Rounds a noninteger value downward to the next lowest integer. Returns an integer value unchanged.
`LN`	Returns the natural logarithm of a number.
`LOG10`	Returns the base-10 logarithm of a number.
`MOD`	Returns the remainder of one number divided by another.
`OCTET_LENGTH`	Returns an integer value representing the number of octets in another value. This value is the same as `BIT_LENGTH / 8`.
`POSITION`	Returns an integer value representing the starting position of a string within the search string.
`POSITION_REGEX`	Returns an integer value representing the starting position of a string within the search string that fits a regular expression (regex) pattern
`POWER`	Raises a number to the specified power.
`SQRT`	Computes the square root of a number.
`WIDTH_BUCKET`	Deposits a value into the appropriate bucket from a set of buckets covering a given range.

ABS

`ABS` returns the absolute value of the number in *`expression`*. All platforms support the SQL standard `ABS` function.

SQL standard syntax.

```
ABS(expression)
```

Examples. The following examples show how to use the `ABS` function:

```
/* Oracle */
SELECT ABS(-1) FROM DUAL;
1

/* SQL standard and other platforms */
SELECT ABS(-1);
1
```

BIT_LENGTH, CHAR_LENGTH, and OCTET_LENGTH

Many platforms stray from the SQL standard in their support for scalar functions for determining the length of expressions. While the platform support is nonstandard, the equivalent functionality exists under different names.

SQL standard syntax.

```
BIT_LENGTH(expression)
CHAR_LENGTH(expression)
CHARACTER_LENGTH(expression)
OCTET_LENGTH(expression)
```

The SQL standard's scalar functions for getting the length of a value take an *`expression`* to calculate the value and return the length as an integer. The `BIT_LENGTH` function returns the number of bits contained within the value of *`expression`*, `CHAR_LENGTH` (and its synonym `CHARACTER_LENGTH`) returns the number of characters in the string *`expression`*, and `OCTET_LENGTH` returns the number of octets in the string *`expression`*. All of these functions will return NULL if *`expression`* is NULL.

MySQL. MySQL supports `BIT_LENGTH`, `CHAR_LENGTH`, `CHARACTER_LENGTH`, and `OCTET_LENGTH`. It also supports a `LENGTH` function that returns the number of bytes in a string.

PostgreSQL. PostgreSQL supports `BIT_LENGTH`, `CHAR_LENGTH`, `CHARACTER_LENGTH`, and `OCTET_LENGTH`. It also supports `LENGTH`, which is a platform-specific alias for `CHAR_LENGTH.`

Oracle. Oracle supports the `LENGTHB` function, which returns an integer value representing the number of bytes in an expression. For the length of an expression in characters, Oracle provides a `LENGTH` function as a synonym for `CHAR_LENGTH`.

SQL Server. SQL Server provides a `LEN` function that returns the number of characters in a string and a `DATALENGTH` function that returns the number of bytes in a string.

Examples. The following example, shown for different databases, determines the length of a string and a value retrieved from a column:

```
/* On MySQL and PostgreSQL */
SELECT CHAR_LENGTH(title), OCTET_LENGTH(title)
FROM titles;

/* On Oracle */
SELECT LENGTH(title), LENGTHB(title) FROM titles;

/* On SQL Server */
SELECT DATALENGTH(title), LENGTH(title) FROM titles;
```

CARDINALITY

The `CARDINALITY` function returns the number of elements in a collection.

SQL standard syntax.

```
CARDINALITY(expression)
```

MySQL. Does not support the `CARDINALITY` function.

Oracle. Supports the `CARDINALITY` function for sets.

PostgreSQL. Supports the `CARDINALITY` function for arrays and returns the number of elements in the array.

SQL Server. Does not support the `CARDINALITY` function.

Example. The following example uses `CARDINALITY` :

```
/* SQL standard, Oracle, PostgreSQL */
SELECT sometable.id,
   CARDINALITY(sometable.collection_column) AS num_elements
FROM sometable;
id                  num_elements
------------        ------------
         101        5
         102        2
```

CEIL, CEILING

The `CEIL` (or `CEILING`) function returns the smallest integer greater than an input value that you specify.

SQL standard syntax.

```
CEIL(expression)
CEILING(expression)
```

MySQL. Supports both `CEIL` and `CEILING`.

Oracle. Supports only `CEIL`.

PostgreSQL. Supports both `CEIL` and `CEILING`.

SQL Server. Supports only `CEILING`.

Examples. When you pass a positive, non-integer number, the effect of `CEIL` is to round up to the next highest integer:

```
SELECT CEIL(100.1) FROM DUAL;
CEIL(100.1)
-----------
         101
```

Remember, though, that with negative numbers, rounding "up" results in a lower absolute value:

```
SELECT CEIL(–100.1) FROM DUAL;
CEIL(–100.1)
------------
         –100
```

Use FLOOR to get behavior opposite to that of CEIL.

EXP

The EXP function returns the value of the mathematical constant *e* (approximately 2.718281) raised to the power of a specified number. All platforms support the SQL standard syntax.

SQL standard syntax.

```
EXP(expression)
```

Example. The following Oracle-based example uses EXP to return an approximation of *e*:

```
SELECT EXP(1) FROM DUAL;
    EXP(1)
----------
2.71828183
```

Use LN to go in the opposite direction.

EXTRACT

The SQL scalar function for extracting parts from a date is EXTRACT. MySQL, Oracle, and PostgreSQL support the SQL standard syntax.

SQL standard syntax.

```
EXTRACT(date_part FROM expression)
```

The SQL EXTRACT function takes a *date_part* and an *expression* that evaluates to a datetime value.

MySQL. MySQL's implementation extends somewhat beyond the SQL standard, which does not have a provision for returning multiple fields from the same call to EXTRACT (e.g., DAY_HOUR). MySQL supports the *date_part*s listed in Table 7-4.

Table 7-4. MySQL date_parts

Type value	Meaning
MICROSECOND	Microseconds
SECOND	Seconds
MINUTE	Minutes
HOUR	Hours (for MariaDB this is always between 0 and 23; for MySQL it may be higher if the time represents an interval)
DAY	Days
WEEK	Weeks
MONTH	Months

Type value	Meaning
QUARTER	Quarter
YEAR	Years
SECOND_MICROSECOND	Seconds and microseconds
MINUTE_MICROSECOND	Minutes, seconds, and microseconds
MINUTE_SECOND	Minutes and seconds
HOUR_MICROSECOND	Hours, minutes, seconds, and microseconds
HOUR_SECOND	Hours, minutes, and seconds
HOUR_MINUTE	Hours and minutes
DAY_MICROSECOND	Days, hours, minutes, seconds, and microseconds
DAY_SECOND	Days, hours, minutes, and seconds
DAY_MINUTE	Days, hours, and minutes
DAY_HOUR	Days and hours
YEAR_MONTH	Years and months

Oracle. Oracle supports the SQL standard syntax with the *date_parts* listed in Table 7-5. The unit types that have TIMEZONE in the name can only be used with TIMESTAMP WITH TIME ZONE or TIMESTAMP WITH LOCAL TIME ZONE data types. The sub-day units cannot be used with the DATE type.

Table 7-5. Oracle date_parts

Type value	Meaning
DAY	The day of the month field (1–31)
HOUR	The hour field (0–23)
MINUTE	The minutes field (0–59)
MONTH	The month field (1–12)
SECOND	The seconds field (0–59)
TIMEZONE_HOUR	The hour component of the time zone offset
TIMEZONE_MINUTE	The minute component of the time zone offset
TIMEZONE_REGION	The current time zone name
TIMEZONE_ABBR	The abbreviation of the current time zone
YEAR	The year field

PostgreSQL. PostgreSQL supports the SQL standard syntax with a few extra *date_parts* that can be used for TIMESTAMP, TIMESTAMP WITH TIME ZONE, DATE, and INTERVAL data types. The *date_parts* it supports are listed in Table 7-6. In addition, PostgreSQL has an alias, `DATE_PART(`*`text, value`*`)`, which is clearer in purpose.

Table 7-6. PostgreSQL `date_parts`

Type value	Meaning
`CENTURY`	The century. Prior to version 8.0, this returned the year field divided by 100. It now returns the century according to the Gregorian calendar, where the first century starts in the year 0001 and there is no century numbered 0 (zero).
`DAY`	The day of the month field (1–31).
`DECADE`	The year field divided by 10.
`DOW`	The day of the week field (0–6, where Sunday is 0). This type only works for `TIMESTAMP` values.
`DOY`	The day of the year field (1–366). The maximum returned value is only 365 for years that are not leap years. This type can only be used with `TIMESTAMP` values.
`EPOCH`	The number of seconds between the epoch (1970-01-01 00:00:00-00) and the supplied value. The result can be negative for values before the epoch.
`HOUR`	The hour field (0–23).
`ISODOW`	The day of the week as Monday (1) to Sunday (7).
`ISOYEAR`	The ISO 8601 week-numbering year that the date falls in (not applicable to intervals).
`JULIAN`	The Julian date corresponding to the date or timestamp (not applicable to intervals). Timestamps that are not local midnight result in a fractional value.
`MICROSECONDS`	The seconds field (including fractional parts) multiplied by 1,000,000.
`MILLENNIUM`	The millennium. Prior to version 8.0, this returned the year field divided by 1,000. It now returns the millennium according to the Gregorian calendar, where the first millennium starts in 0001 and there is no millennium numbered 0 (zero). The year 1001 is the start of the second millennium, while the year 2001 is the start of the third millennium.
`MILLISECONDS`	The seconds field (including fractional parts) multiplied by 1,000.
`MINUTE`	The minutes field (0–59).
`MONTH`	The month field (1–12) or, for interval values, the number of months modulo 12 (0–11).
`QUARTER`	The quarter of the year (1–4) in which the value occurs. This type can only be used with `TIMESTAMP` values.
`SECOND`	The seconds field (0–59).
`TIMEZONE`	The time zone offset in seconds.
`TIMEZONE_HOUR`	The hour component of the time zone offset.
`TIME ZONE_MINUTE`	The minute component of the time zone offset.
`WEEK`	The number of the week within the year in which the value falls.
`YEAR`	The year field.

SQL Server. SQL Server does not support the SQL standard `EXTRACT` function but provides the function `DATEPART(`*`date_part, expression`*`)` as an equivalent. It supports the *`date_part`*s listed in Table 7-7.

Table 7-7. SQL Server `date_parts`

Type value	Meaning
day	The day of the month for the datetime expression. The abbreviations *d* and *dd* can also be used.
dayofyear	The day of the year for the datetime expression. The abbreviations *y* and *dy* can also be used.
hour	The hour of the day for the datetime expression. The abbreviation *hh* can also be used.
iso_week	The ISO 8601 week number (1–53). The abbreviations *isowk* and *isoww* can also be used.
microsecond	The microseconds (0–999999) for the datetime expression. The abbreviation *mcs* can also be used.
millisecond	The milliseconds for the datetime expression. The abbreviation *ms* can also be used.
minute	The minute of the hour for the datetime expression. The abbreviations *n* and *mi* can also be used.
month	The month (1–12). The abbreviations *m* and *mm* can also be used.
nanosecond	The number of nanoseconds (0–999999999). The abbreviation *ns* can also be used.
quarter	The quarter of the year in which the datetime expression falls. The abbreviations *q* and *qq* can also be used.
second	The second of the minute for the datetime expression. The abbreviations *s* and *ss* can also be used.
TZoffset	The time zone. The abbreviation *tz* can also be used.
week	The week of the year for the datetime expression. The abbreviations *wk* and *ww* can also be used.
weekday	The day of the week for the datetime expression. The abbreviation *dw* can also be used.
year	The year field of the datetime expression. The abbreviations `yy` and `yyyy` can also be used for two-digit and four-digit years, respectively.

Examples. These examples extract date parts from several datetime values:

```
/* On MySQL */
SELECT EXTRACT(YEAR FROM '2013-07-02');
2013
SELECT EXTRACT(YEAR_MONTH FROM '2013-07-02 01:02:03');
201307
SELECT EXTRACT(DAY_MINUTE FROM '2013-07-02 01:02:03');
20102

/* On PostgreSQL */
```

```
SELECT EXTRACT(HOUR FROM TIMESTAMP '2022-02-16 20:38:40');
20
```

FLOOR

The `FLOOR` function returns the largest integer less than an input value that you specify. All platforms support the SQL standard syntax.

SQL standard syntax.

```
FLOOR(expression)
```

Examples. When you pass a positive number, the effect of `FLOOR` is to eliminate anything after the decimal point:

```
SELECT FLOOR(100.1) FROM DUAL;
FLOOR(100.1)
------------
         100
```

Remember, though, that with negative numbers going in the "less-than" direction corresponds to increasingly larger absolute values:

```
SELECT FLOOR(-100.1) FROM DUAL;
FLOOR(-100.1)
-------------
         -101
```

Use `CEIL` to get behavior opposite to `FLOOR`.

LN, LOG, and LOG10

The `LN` function returns the natural logarithm of a number, which is the power to which you would need to raise the mathematical constant *e* (approximately 2.718281) in order to get the number in question as the result. `LOG10` returns the base-10 logarithm of a number. Some databases also include a `LOG` function which may be equivalent to either `LN` or `LOG10`, and so should be used with caution.

SQL standard syntax.

```
LN(expression)
LOG10(expression)
```

MySQL. MySQL supports the SQL standard syntax for the `LN` function. It also supports the use of `LOG` as a synonym for `LN` when no base is provided, and it supports the SQL standard `LOG10` function. The syntax of the MySQL `LOG` function is as follows:

```
LOG(expression[, base])
```

Oracle. Oracle supports the SQL standard syntax for the `LN` and `LOG10` functions.

PostgreSQL. PostgreSQL supports the SQL standard syntax for the `LN` function. It also supports a `LOG` function that can be used as a synonym for `LOG10` when no base is provided or be used for other bases. The syntax of the PostgreSQL `LOG` function is:

```
LOG([base,] expression)
```

SQL Server. SQL Server calls its logarithm function `LOG.` When no base is passed it, it returns the natural log. The syntax is as follows:

```
LOG(expression[, base])
```

Example. The following examples demonstrate finding the natural logarithm of a number closely approximating the mathematical constant *e* and the base-10 log of 100:

```
-- Oracle
SELECT LN(2.718281), LOG10(100) FROM DUAL;
LN(2.718281)    LOG10(100)
------------    —---------
  .999999695     2

-- MySQL
SELECT LN(2.718281), LOG10(100) AS log10,
LOG(2.718281) AS logln, LOG(64,2) AS logb2;
        ln         | log10 | logln             | logb2
-------------------+-------+-------------------+----------
 0.999999695226903 | 2     | 0.999999695226903  | 6

-- PostgreSQL
SELECT LN(2.718281), LOG10(100) AS log10,
LOG(100) AS logb10, LOG(2,64) AS logb2;
       ln           | log10 | logb10 |       logb2
--------------------+-------+--------+-------------------
 0.9999996952269030 |    2  |   2    | 6.0000000000000000

-- SQL Server
SELECT LOG(2.718281) AS ln, LOG10(100) AS log10,
LOG(100,10) AS logb10, LOG(64,2) AS logb2;
        ln          | log10 | logb10 |       logb2
--------------------+-------+--------+-------------------
 0.999999695226903  | 2     |   2    | 6
```

Use the `EXP` function to go in the other direction.

MOD

The `MOD` function returns the remainder of a dividend divided by a divider; it returns a divide by 0 error if the divider is 0. All platforms support the SQL standard syntax for the `MOD` function.

SQL standard syntax.

```
MOD(dividend, divider)
```

Example. The following example shows how to use the `MOD` function from within a `SELECT` statement:

```
SELECT MOD(12, 5) FROM NUMBERS
2
```

POSITION

The `POSITION` function returns an integer that indicates the starting position of a string within the search string.

SQL standard syntax.

```
POSITION(string1 IN string2 [ USING CHARACTERS | OCTETS ])
```

The standard syntax for the `POSITION` function is to return the first location of *`string1`* within *`string2`*. `POSITION` returns 0 if *`string1`* does not occur within *`string2`* and NULL if either argument is NULL. The measurement defaults to characters if `USING` is not specified.

MariaDB and MySQL and MariaDB. MySQL and MariaDB support the SQL standard syntax for the `POSITION` function, with the exception of the `USING` clause. MySQL also provides a `LOCATE` alias function that can take an additional input of *`start_at`* to denote the starting index position of the search. The syntax is as follows:

```
POSITION(string1 IN string2)
LOCATE(string1, string2[, start_at])
```

PostgreSQL. PostgreSQL supports the SQL standard syntax for the `POSITION` function, with the exception of the `USING` clause. Its syntax is as follows:

```
POSITION(string1 IN string2)
```

Oracle. Oracle's equivalent function is called `INSTR`:

```
INSTR(string1, string2[, start_at][, occurrence])
```

It returns the position of *`string2`* within *`string1`*, optionally searching from a starting position of *`start_at`* (an integer) and looking for the specified *`occurrence`* of *`string2`*. For example:

```
SELECT INSTR('foobar', 'o', 1, 1) FROM DUAL;
2
```

Use `INSTRB` for bytes, `INSTRC` for Unicode complete characters, `INSTR2` for Unicode `UCS2` code points, and `INSTR4` for Unicode `UCS4` code points.

SQL Server. Instead of POSITION, SQL Server supports CHARINDEX and PATINDEX functions. CHARINDEX and PATINDEX are very similar, except that PATINDEX allows the use of wildcard characters in the search criteria:

```
CHARINDEX(string1, string2[, start_at])
PATINDEX('%pattern%', expression)
```

Examples.

```
/* SQL standard, MySQL, PostgreSQL */
SELECT POSITION('bar' IN 'foobar');
4

/* MySQL */
SELECT LOCATE('bar', 'foobar');
4

/* MySQL and PostgreSQL */
SELECT POSITION('fu' IN 'snafu');
0

/* Oracle **/
SELECT INSTR('foobar', 'bar', 1, 1) FROM DUAL;
4

/* SQL Server */
SELECT CHARINDEX('bar', 'foobar');
4

SELECT PATINDEX('%fg', 'abcdefg');
6
```

POSITION_REGEX

The POSITION_REGEX function returns an integer that indicates the starting position of a string within the search string that fits a regex pattern. None of the platforms discussed here actually use the function name POSITION_REGEX, but they all support the same capabilities through a different function.

SQL standard syntax.

```
POSITION_REGEX([START | AFTER]
   pattern IN string
   [ FROM start_position]
   [ USING CHARACTERS | OCTETS ]
   [ OCCURRENCE regex_occurrence]
   [ GROUP regex_capture_group]
)
```

The standard syntax for the POSITION_REGEX function is to return the first location of the regular expression *pattern* within a *string*. POSITION_REGEX returns 0 if the *pattern* does not occur within the *string* and NULL if either argument is NULL.

The optional variables *`start_position`*, *`regex_occurrence`*, and *`regex_capture_group`* are all integers. The *`start_position`* is the position to start searching within the string and defaults to 1.

`START | AFTER` defaults to `START` if not specified and determines if the position returned is the beginning of the match or after the match.

`regex_occurrence` is the *n*th occurrence position that should be returned. It defaults to 1 (meaning the first occurrence) if not specified.

MySQL and MariaDB. MySQL and MariaDB do not support `POSITION_REGEX`, but both provide an equivalent function called `REGEXP_INSTR`. In MySQL, it has this syntax:

```
REGEXP_INSTR(string, pattern
   [, start_position]
   [, regex_occurrence]
   [, return_option]
   [, match_type]
)
```

where:

`return_option`
: The type of position to return. If this value is 0, `REGEXP_INSTR` returns the position of the matched substring's first character. If the value is 1, `REGEXP_INSTR` returns the position following the matched substring. If omitted, the default is 0.

`match_type`
: A string that may contain any or all the following characters specifying how to perform matching:

  `'c'`
  : Performs case-sensitive matching.

  `'i'`
  : Performs case-insensitive matching.

  `'m'`
  : Enables multiple-line mode, which recognizes line terminators such as carriage returns and line feeds anywhere in the source string. The default behavior is to match line terminators only at the start and end of the entire source string.

  `'n'`
  : Causes the `.` character to match line terminators. The default is for `.` matching to stop at the end of a line.

`'u'`
: Specifies Unix-only line endings. Only the newline character is recognized as a line ending by the `.`, `^`, and `$` match operators.

In MariaDB, the function has this syntax:

```
REGEXP_INSTR([BINARY] string [COLLATE collation], pattern)
```

If the *`string`* is preceded with `BINARY`, then the position returned is the byte position rather than the character position. If *`collation`* is specified, then the case sensitivity rules of the collation are applied. Case-insensitive matching can be forced using (*?i*) and (*?-i*) in the *`pattern`*.

Oracle. Oracle does not support `POSITION_REGEX`. An equivalent function in Oracle is the `REGEXP_INSTR` function, which has this syntax:

```
REGEXP_INSTR(string, pattern
   [, start_position]
   [, regex_occurrence]
   [, return_option]
   [, match_type]
)
```

where:

`pattern`
: The *`pattern`* is limited to 512 bytes.

`match_type`
: This is a string that can take on one or more of the following values:

  `'i'`
  : Performs case-insensitive matching.

  `'c'`
  : Performs case-sensitive matching.

  `'n'`
  : Indicates that the "match any character" subpattern `(.)` will include the newline character. Otherwise, `(.)` does not match the newline.

  `'m'`
  : Treats the source string as multiple lines. By default Oracle treats a source string as a single line. If present, ^ and *$* are treated as the start and end, respectively, of any line anywhere in the source string, rather than only at the start or end of the entire source string.

  `'x'`
  : Ignores whitespace characters. By default, whitespace characters match themselves.

PostgreSQL. PostgreSQL does not support POSITION_REGEX. An equivalent function in PostgreSQL 15 and later is REGEXP_INSTR, which has this syntax:

```
REGEXP_INSTR(string, pattern
   [, start_position]
   [, regex_occurrence]
   [, end_option]
   [, flags]
   [, subexpr]
)
```

end_option, if specified, must have a value of 0 or 1. If the *end_option* parameter is omitted or specified as 0, the function returns the position of the first character of the match. If *end_option* is 1, then it returns the character following the match. 0 is equivalent to the SQL standard START clause and 1 is equivalent to AFTER.

SQL Server. SQL Server does not support POSITION_REGEX. The closest equivalent is the PATINDEX function, which does not support regular expressions. It therefore supports a more limited set of patterns than POSITION_REGEX or the REGEXP_INSTR functions found in other databases. For regular expression support in SQL Server, many people turn to building user-defined CLR functions that leverage the rich regular expression support in *.NET System.Text.RegularExpressions*. Refer to Chapter 9 for details on building CLR functions.

The syntax of PATINDEX is as follows:

```
PATINDEX(pattern, string)
```

The *pattern* clause usually uses % as a wildcard.

Examples.

```
/* On MySQL and PostgreSQL 15+ */
SELECT REGEXP_INSTR('I have a duck', 'duck')
-----------
       10

/* On Oracle */
SELECT REGEXP_INSTR('I have a duck', 'duck') FROM DUAL;
-----------
       10
```

POWER

The POWER function raises a number to a specific value. All platforms support the SQL standard syntax.

SQL standard syntax.

```
POWER(base, exponent)
```

The result of the POWER function is *base* raised to the *exponent* power, or *baseexponent*. If *base* is negative, *exponent* must be an integer.

Examples. Raising a positive number to an exponent is straightforward:

```
SELECT POWER(10,3) FROM DUAL;
POWER(10,3)
-----------
       1000
```

Anything raised to the 0th power evaluates to 1:

```
SELECT POWER(0,0) FROM DUAL;
POWER(0,0)
----------
         1
```

Negative exponents move the decimal point to the left:

```
SELECT POWER(10,-3) FROM DUAL;
POWER(10,-3)
------------
        .001
```

SQRT

The SQRT function returns the square root of a number. All platforms support the SQL standard syntax.

SQL standard syntax.

```
SQRT(expression)
```

Example.

```
SELECT SQRT(100) FROM DUAL;
 SQRT(100)
----------
        10
```

WIDTH_BUCKET

The WIDTH_BUCKET function assigns values to buckets (individual segments) in an equiwidth histogram.

SQL standard syntax.

```
WIDTH_BUCKET(expression, min, max, buckets)
```

The *expression* argument represents a value to be assigned to a bucket, typically based on one or more columns returned by a query. The *buckets* argument specifies the number of buckets to create over the range defined by *min* through *max*. *min* is inclusive, whereas *max* is not. The value from *expression* is assigned to one of those buckets, and the function then returns the corresponding bucket number.

When *expression* falls outside the range of buckets, the function returns either 0 or *max* + 1, depending on whether *expression* is lower than *min* or greater than or equal to *max*.

MySQL. Does not support WIDTH_BUCKET.

Oracle. Supports the SQL standard syntax.

PostgreSQL. Supports the SQL standard syntax.

SQL Server. Does not support WIDTH_BUCKET.

Examples. The following example divides the integer values 1 through 10 into two buckets:

```
SELECT x, WIDTH_BUCKET(x,1,10,2)FROM pivot;
         X WIDTH_BUCKET(X,1,10,2)
---------- ----------------------
         1                      1
         2                      1
         3                      1
         4                      1
         5                      1
         6                      2
         7                      2
         8                      2
         9                      2
        10                      3
```

This next example is more interesting. It divides 11 values (from 1 through 10) into three buckets and illustrates the distinction between *min* being inclusive and *max* being noninclusive:

```
SELECT x, WIDTH_BUCKET(x,1,10,3)FROM pivot;
         X WIDTH_BUCKET(X,1,10,3)
---------- ----------------------
         1                      1
         2                      1
         3                      1
         4                      2
         5                      2
         6                      2
         7                      3
         8                      3
         9                      3
       9.9                      3
        10                      4
```

Pay particular attention to the results for X=1, X=9.9, and X=10. An input value of *min* (1, in this example) falls into the first bucket, proving that the lower end of the range for bucket 1 is defined as *x* >= *min*. An input value of *max*, however, falls *outside* the highest bucket. In this example, 10 falls into the overflow bucket numbered *max* + 1. The value 9.9, on the other hand, falls into bucket 3, illustrating that the upper end of the range for the highest bucket is defined as $x < max$.

Trigonometric functions

The SQL standard defines the following trigonometric functions, which take as input a radian value in numeric format and compute the radian value of the sine, cosine, tangent, hyperbolic sine, hyperbolic cosine, hyperbolic tangent, arc sine, arc cosine, or arc tangent. The function names are, respectively, `SIN`, `COS`, `TAN`, `SINH`, `COSH`, `TANH`, `ASIN`, `ACOS`, `ATAN`.

The following rules apply:

- In case of NULL inputs the output is NULL.
- For `ASIN` and `ACOS` the values must be between –1 and 1, or an exception should be raised.

Several databases additionally support an `ATAN2` function, which takes as input two arguments expressed in radians and returns the arc tangent of the two.

SQL standard syntax.

```
-- SIN can be replaced with any of the aforementioned
   trigonometric functions
SIN(expression)
```

MySQL. MySQL supports all the SQL standard trigonometric functions, as well as the functions `COT` for cotangent and `ATAN2` for arc tangent. Its `ATAN` and `ATAN2` functions take as input two arguments. MySQL also includes a `RADIANS` function that converts degrees to radians and a `DEGREES` function that converts radians to degrees.

Oracle. Oracle supports all the SQL standard trigonometric functions and `ATAN2`.

PostgreSQL. PostgreSQL supports all the SQL standard trigonometric functions, as well as a `COT` function for cotangent, the `ATAN2` function, a `RADIANS` function that converts degrees to radians, and a `DEGREES` function that converts radians to degrees. In addition, PostgreSQL provides variants of the non-hyperbolic trigonometric functions that take as input and return degrees instead of radians. These variants have names that end in `D`, as follows: `SIND`, `COSD`, `TAND`, `ASIND`, `ACOSD`, `ATAND`, and `ATAN2D`.

SQL Server. SQL Server supports all the SQL standard trigonometric functions, and a `COT` function for cotangent. It also includes a `RADIANS` function that converts degrees to radians and a `DEGREES` function that converts radians to degrees.

Examples.

```
SELECT COSH(180) FROM DUAL -> 7.4469E+77
SELECT ACOS( 0 ) -> 1.570796
SELECT ASIN( 0 ) -> 0.000000
SELECT COS(0) -> 1.000000
SELECT COT( 3.1415 ) -> −10792.88993953
```

String Functions and Operators

Basic string functions and operators offer a number of capabilities and return string values as their results. Some string functions are *dyadic*, indicating that they operate on two strings at once. The SQL standard supports the string functions and operators listed in Table 7-8.

Table 7-8. SQL string functions and operators

Function or operator	Usage
Concatenation operator (||)	Appends two or more literal string expressions, column values, or variables together into one string
CONVERT	Converts a string to a different representation within the same character set
LOWER	Converts a string to all lowercase characters
OVERLAY	Returns the result of replacing a substring of one string with another
SUBSTRING	Returns a portion of a string
TRANSLATE	Converts a string from one character set to another
TRIM	Removes leading characters, trailing characters, or both from a character string
UPPER	Converts a string to all uppercase characters

Concatenation operator

The SQL standard defines a concatenation operator (||), which joins two distinct strings into one string value.

SQL standard syntax.

```
string1 || string2
```

MySQL. MySQL supports CONCAT as a synonym for the SQL concatenation operator and uses the || operator for logical OR. CONCAT can take an arbitrary number of arguments.

Oracle. Oracle supports the SQL concatenation operator and CONCAT as a synonym. However, it only allows CONCAT with two arguments, so it is not a complete SQL standard replacement for the concatenation operator.

PostgreSQL. PostgreSQL supports the SQL concatenation operator and `CONCAT` as a synonym, with an arbitrary number of arguments. It also allows the use of the || operator for other data types; for example, it can be used to concatenate two arrays.

SQL Server. SQL Server does not support || as a concatenation operator, but uses the plus sign (+) as a synonym. It has the system setting `CONCAT_NULL_YIELDS_NULL`, which can be set to alter the behavior when NULL values are used in the concatenation of string values with +. SQL Server also supports a `CONCAT` function which can take an indefinite number of arguments and ignores NULLs.

Examples.

```
/* SQL standard syntax */
'string1' || 'string2' || 'string3'
'string1string2string3'

/* On MySQL, Oracle, PostgreSQL, and SQL Server */
CONCAT('string1', 'string2')
'string1string2'

/* On MySQL, PostgreSQL, and SQL Server */
CONCAT('string1', 'string2', 'string3')
'string1string2string3'
```

If any of the concatenation values are NULL, the entire returned string is NULL. Also, if a numeric value is concatenated, it is implicitly converted to a character string.

```
/* On MySQL, PostgreSQL, and SQL Server */
SELECT CONCAT('My ', 'bologna ', 'has ', 2, ' names');
'My bologna has 2 names'

/* On Oracle */
SELECT CONCAT('My ', NULL) FROM DUAL;
'My '

/* On MySQL and PostgreSQL */
SELECT CONCAT('My ', NULL);
NULL

/* On SQL Server */
SELECT CONCAT('My ', NULL);
'My '
```

CONVERT and TRANSLATE

The `CONVERT` function alters the representation of a character string within its character set and collation. For example, it might be used to alter the number of bits per character.

TRANSLATE alters the character set of a string value from one base character set to another. Thus, TRANSLATE might be used to translate a value from the English character set to a Kanji (Japanese) or Cyrillic (Russian) character set. The translation must already exist, either by default or by virtue of having been created using the CREATE TRANSLATION command.

SQL standard syntax.

```
CONVERT(char_value USING conversion_char_name)

TRANSLATE(char_value USING translation_name)
```

CONVERT converts *char_value* to the character set with the name supplied in *conversion_char_name*. TRANSLATE converts *char_value* to the character set provided in *translation_name*.

MySQL. MySQL supports the SQL standard syntax for CONVERT but does not support TRANSLATE.

Oracle. Oracle supports CONVERT and TRANSLATE with the same meaning as the SQL standard, but with slightly different syntax:

```
CONVERT(char_value, target_char_set, source_char_set)

TRANSLATE(char_value USING {CHAR_CS | NCHAR_CS})
```

Under Oracle's implementation, the CONVERT function returns the text of *char_value* in the target character set. *char_value* is the string to convert, *target_char_set* is the name of the character set into which the string is to be converted, and *source_char_set* is the name of the character set in which *char_value* was originally stored.

Oracle's TRANSLATE function follows the SQL standard syntax, but it supports only two arguments for the character set: you can choose between the database character set (CHAR_CS) and the national character set (NCHAR_CS).

Oracle also supports a different function named TRANSLATE, which omits the USING keyword. That version of TRANSLATE has nothing to do with character set translation.

Both the target and source character set names can be passed either as literal strings, as variables, or as columns from a table. Note that replacement characters might be substituted when converting from or to a character set that does not support a representation of all the characters used in the conversion.

Oracle supports several common character sets, including *US7ASCII*, *WE8DECDEC*, *WE8HP*, *F7DEC*, *WE8EBCDIC500*, *WE8PC850*, and *WE8ISO8859P1*. For example:

```
SELECT CONVERT('Gro2', 'US7ASCII', 'WE8HP') FROM DUAL;
Gross
```

PostgreSQL. PostgreSQL's implementation of the TRANSLATE function can convert any occurrence of one text string to another within a specified string. The CONVERT function is used for converting from a binary string representing specific text encoding to another binary string representation in a different text encoding. Their syntax is as follows:

```
CONVERT(bytea, source_encoding, target_encoding)
TRANSLATE(character_string, from_text, to_text)
```

Here are some examples:

```
SELECT TRANSLATE('12345abcdea', '5a', 'XX');
'1234XXbcdeX'
SELECT TRANSLATE('12345abcdea', '5a', 'XY');
'1234XYbcdeY'
SELECT  TRANSLATE('Straight Talk About Computers', 'Computer', 'PC');
'Saigh Talk AbC PCs'
SELECT CONVERT('Café'::bytea, 'UTF8', 'WIN1252');
\x436166e9
```

SQL Server. SQL Server does not support TRANSLATE. Its implementation of CONVERT is a very rich utility that alters the base data type of an expression but is otherwise quite different from the SQL standard's CONVERT function. It is functionally equivalent to the CAST function, and has the following syntax:

```
CONVERT(data_type[(length) | (precision, scale)],
   expression[, style])
```

The *style* clause is used to define the format of a date conversion; refer to the vendor documentation for more information. Following is an example:

```
SELECT title, CONVERT(char(7), ytd_sales)
FROM titles
ORDER BY title
GO
```

LOWER and UPPER

The functions LOWER and UPPER allow the case of a string to be altered quickly and easily so that all the characters are lower- or uppercase, respectively. These functions are supported in all the database implementations covered in this book. The different database platforms also support a variety of other text formatting functions that are specific to their implementations.

SQL standard syntax.

```
LOWER(string)
UPPER(string)
```

LOWER converts *string* into a lowercase string. UPPER is the uppercase counterpart of LOWER.

MySQL. MySQL additionally supports the synonyms UCASE and LCASE.

Example.

```
SELECT LOWER('You Talkin To ME?'), UPPER('you talking to me?!');
you talkin to me?, YOU TALKING TO ME?!
```

OVERLAY

The OVERLAY function embeds one string into another and returns the result.

SQL standard syntax.

```
OVERLAY(string PLACING embedded_string FROM start
[FOR length])
```

If any of the inputs are NULL, the OVERLAY function returns NULL. The *embedded_string* replaces the *length* characters in *string*, starting at the character position *start*. If the *length* is not specified, the *embedded_string* will replace all the characters in *string* after *start*.

MySQL. MySQL does not support the OVERLAY function, but you can simulate it by using a combination of SUBSTRING and the concatenation operator (discussed elsewhere in this section).

Oracle. Oracle does not support the OVERLAY function. You can simulate it by using a combination of SUBSTRING and the concatenation operator.

PostgreSQL. PostgreSQL supports the OVERLAY function.

SQL Server. SQL Server does not have an OVERLAY function but offers a function called STUFF that is similar in purpose. In the case of STUFF, the length is not optional. The syntax is as follows:

```
STUFF(string, start, length, embedded_string)
```

Examples.

```
/* SQL standard and PostgreSQL */
SELECT OVERLAY('NORTH DAKOTA' PLACING 'CAROLINA' FROM 7);
'NORTH CAROLINA'
SELECT OVERLAY('MINNIE ADORES MICKEY' PLACING 'LOVES' FROM 8 FOR 6);
'MINNIE LOVES MICKEY'

/* SQL Server */
SELECT STUFF('NORTH DAKOTA', 7, 6, 'CAROLINA');
'NORTH CAROLINA'
SELECT STUFF('MINNIE ADORES MICKEY', 8, 6, 'LOVES');
'MINNIE LOVES MICKEY'
```

SUBSTRING

The SUBSTRING function allows one character string to be returned from another.

SQL standard syntax.

```
SUBSTRING(extraction_string FROM starting_position
   [FOR length])
```

If any of the inputs are NULL, the SUBSTRING function returns NULL. The *extraction_string* is the source from which the character value is to be extracted. It may be a literal string, a column in a table with a character data type, or a variable with a character data type. The *starting_position* is an integer value telling the function at which position to begin performing the extraction. The optional *length* is an integer value that tells the function how many characters to extract, starting at the *starting_position*. If this is omitted, the substring starting at *starting_position* and continuing to the end of the *extraction_string* is returned. The *starting_position* should be a positive number that is greater than or equal to 1. If a negative value is passed in for *starting_position*, it is converted to 1.

MySQL. MySQL supports the SQL standard. This platform's implementation assumes that the characters are to be extracted from the starting position and will continue to the end of the character string. The syntax is as follows:

```
SUBSTRING(extraction_string [FROM starting_position]
   [FOR length])
```

Oracle. Oracle's implementation, SUBSTR, largely functions the same way as the SQL standard's SUBSTRING. When the *starting_position* is a negative number, Oracle counts from the end of the *extraction_string*. If *length* is omitted, the remainder of the string (starting at *starting_position*) is returned. The syntax is:

```
SUBSTR(extraction_string, starting_position[, length])
```

PostgreSQL. PostgreSQL supports the SQL standard syntax. It also allows for the alias SUBSTR. The PostgreSQL syntax is:

```
SUBSTRING(extraction_string [FROM starting_position]
   [FOR length])
SUBSTRING(extraction_string, starting_position[, length])
SUBSTR(extraction_string, starting_position[, length])
```

SQL Server. SQL Server supports the SQL standard syntax. It allows the function to be applied to text, image, and binary data types; however, the *starting_position* and *length* represent the number of bytes rather than the number of characters to count. The SQL Server syntax is as follows:

```
SUBSTRING(extraction_string [FROM starting_position]
   [FOR length])
```

Examples. Most of these examples will work on any of the database platforms profiled in this book. Only the second Oracle example, with a negative starting position, fails on the others (assuming, of course, that Oracle's `SUBSTR` is translated into `SUBSTRING`):

```
/* On Oracle, counting from the left */
SELECT SUBSTR('ABCDEFG',3,4) FROM DUAL;
'CDEF'

/* On PostgreSQL, counting from the left */
SELECT SUBSTR('ABCDEFG',3,4);
'CDEF'

/* On Oracle, counting from the right */
SELECT SUBSTR('ABCDEFG',-5,4) FROM DUAL;
'CDEF'

/* On MySQL or PostgreSQL */
SELECT SUBSTRING('Be vewy, vewy quiet' FROM 5);
'ewy, vewy quiet'

/* On PostgreSQL or SQL Server */
SELECT au_lname, SUBSTRING(au_fname, 1, 1)
FROM authors
WHERE au_lname = 'Carson';
Carson      C
```

TRIM

The `TRIM` function removes leading characters, trailing characters, or both from a specified character string or `BLOB` value. This function also removes other types of characters from a specified character string. The default behavior is to trim the specified character from both sides of the character string. If no removal character is specified, `TRIM` removes spaces by default.

SQL standard syntax.

```
TRIM( [ [{LEADING | TRAILING | BOTH}] [removal_char] FROM ]
  target_string )
```

The *`removal_char`* is the character to be stripped out, and the *`target_string`* is the character string from which characters are to be stripped. If no *`removal_char`* is specified, `TRIM` strips out spaces.

MySQL. MySQL supports the `TRIM` function.

Oracle. Oracle supports the `TRIM` function.

PostgreSQL. PostgreSQL supports the `TRIM` function and an alias, `BTRIM`. It also supports `LTRIM` and `RTRIM` functions to trim off leading or trailing characters, respectively. When a character is not specified, the space character is assumed.

SQL Server. SQL Server provides the functions `LTRIM` and `RTRIM` to trim off leading spaces or trailing spaces, respectively. These functions cannot be used to trim other characters. SQL Server 2017 introduced a `TRIM` function, but it does not follow the SQL standard syntax; it only allows removal of whitespace from the front and back. The syntax is:

```
TRIM(target_string)
```

Examples.

```
/* SQL standard and all platforms (add FROM DUAL for Oracle) */
SELECT TRIM('   wamalamadingdong  ');
'wamalamadingdong'

/* PostgreSQL and SQL Server **/
SELECT LTRIM( RTRIM('   wamalamadingdong  ') );
'wamalamadingdong'

/* SQL standard, MySQL, Oracle (add FROM DUAL), and PostgreSQL */
SELECT TRIM(LEADING '19' FROM '1976 AMC GREMLIN');
'76 AMC GREMLIN'

/* SQL standard, MySQL, Oracle (add FROM DUAL), and PostgreSQL */
SELECT TRIM(BOTH 'x' FROM 'xxxWHISKEYxxx');
'WHISKEY'

/* SQL standard, MySQL, Oracle (add FROM DUAL), and PostgreSQL */
SELECT TRIM(TRAILING 'snack' FROM 'scooby snack');
'scooby '
```

Collection Functions

TABLE

The `TABLE` function expands a collection object into a set of rows.

SQL standard syntax.

```
TABLE (collection_value_expression)
```

The *`collection_value_expression`* is a collection object such as a set of a type. It is used to return the results of a set-returning function.

MySQL. MySQL does not support the `TABLE` function.

Oracle. Oracle supports the `TABLE` function and requires its use for all set-returning functions.

PostgreSQL. PostgreSQL does not support the `TABLE` function; however, functions can be defined as `RETURNS TABLE` or `SET OF` and used without wrapping in a `TABLE` construct. In addition, PostgreSQL supports `WITH ORDINALITY` for all `TABLE`/set-returning functions.

SQL Server. SQL Server does not support the `TABLE` function; however, functions can be defined as `RETURNS TABLE` or `SET OF` and used without wrapping in a `TABLE` construct.

Examples.

```
/* SQL standard, Oracle */
SELECT *
FROM TABLE(some_table_function(a,b,c));

/* SQL Server, PostgreSQL */
SELECT *
FROM some_table_function(a,b,c);
```

UNNEST

The `UNNEST` function expands an array or multiset value into a set of rows.

SQL standard syntax.

```
UNNEST (collection_value_expression)
[ WITH ORDINALITY ]
```

The *`collection_value_expression`* is a collection object such as an array. If the `WITH ORDINALITY` clause is included, then an extra column called *ordinality* is added to the output that sequentially numbers the rows.

MySQL. MySQL does not support the `UNNEST` function.

PostgreSQL. PostgreSQL supports the `UNNEST` function.

Oracle. Oracle does not support the `UNNEST` function. You can use the `TABLE` function as an alternative.

SQL Server. SQL Server does not support the `UNNEST` function. You can to some extent replace it with the `STRING_SPLIT` function, which takes a delimited string and returns a set of strings broken by the delimiter.

Examples.

```
/* SQL standard and PostgreSQL */
SELECT f.ord, f.a
FROM UNNEST(ARRAY['wamalamadingdong', 'dong dong'])
   WITH ORDINALITY AS f(a,ord);
ord   a
--- ------
1   wamalamadingdong
2   dong dong
```

Platform-Specific Extensions

The following sections provide comprehensive listings of key vendor-supported functions that are not included in the SQL standard. These functions are platform-specific, so those supported by one vendor may not be supported by another (or not in the same way). This list does not include aggregate functions, window functions, XML functions, or JSON functions, which are covered in 8 and 10, respectively. Functions discussed earlier in the chapter are also not included in these listings.

MySQL-Supported Functions

This section provides an alphabetical listing of MySQL-supported functions that are not part of the SQL standard, with examples and corresponding results for most:

`ADDDATE(`*`date, days`*`)`
: Returns *`date`* with *`days`* added to it. For example:

```
ADDDATE('2022-04-14', 1) -> '2022-04-15'
```

`ADDDATE(`*`date`*`, INTERVAL `*`expr unit`*`)`
: Synonym for `DATE_ADD`. Returns *`date`* with *`expr`* units of *`unit`* added. For example:

```
ADDDATE('2022-04-14', INTERVAL 1 DAY) -> '2022-04-15'
```

`AES_DECRYPT(`*`crypt_str, key_str`*`)`
: Returns *`crypt_str`* decrypted using AES and the key *`key_str`*.

`AES_ENCRYPT(`*`str, key_str`*`)`
: Returns *`str`* encrypted with AES using the key *`key_str`*. For example:

```
AES_DECRYPT(AES_ENCRYPT('secret sauce', 'password'), 'password') ->
'secret sauce'
```

`ASCII(`*`text`*`)`
: Returns the ASCII code of the first character of *`text`*. For example:

```
ASCII('x') -> 120
```

`BENCHMARK(`*`count, expr`*`)`
: Executes the expression *`expr count`* times. The result is always 0. For example:

```
BENCHMARK(1000000,ATAN2(3.1415, 1)) -> 0
```

`BIN(`*`number`*`)`
: Returns a string containing the binary value of *`number`*, where *`number`* is a `BIGINT`.

`BINARY(`*`string`*`)`
: Casts *`string`* to a binary string.

`BIT_COUNT(`*`number`*`)`
: Returns the number of bits that are set in *`number`*. For example:

```
BIT_COUNT(5) -> 2
```

`BIT_LENGTH(`*`string`*`)`
: Returns the length of *`string`* in bits. For example:

```
BIT_LENGTH('abc') -> 24
```

`CHAR(`*`number`*`[, ... ])`
: Returns a string consisting of the characters corresponding to the ASCII code values in the arguments. Any NULL values are ignored. For example:

```
CHAR(120,121,122) -> 'xyz'
```

`CHARSET(`*`str`*`)`
: Returns the character set of the string argument *`str`*. For example:

```
CHARSET('oolong') -> 'latin1'
```

`COERCIBLITY(`*`expr`*`)`
: Returns the collation coercibility value of *`expr`*, which is an integer value between 0 and 5; the lowest values have the highest precedence. For example:

```
COERCIBILITY( 'darjeeling' ) -> 4
```

`COLLATION(`*`str`*`)`
: Returns the collation of *`str`*. For example:

```
COLLATION( _utf8'assam' ) -> 'utf8_general_ci'
```

`COMPRESS(`*`string`*`)`
: Returns a compressed version of *`string`*.

`CONCAT_WS(`*`separator, str1, str2`*`[, ... ])`
: A special form of `CONCAT` that inserts *`separator`* between every pair of string arguments concatenated. If *`separator`* is NULL, the result is NULL. For example:

```
CONCAT_WS(', ', au_lname, au_fname ) -> 'Jefferson, Thomas'
```

`CONNECTION_ID()`
: Returns the connection ID for the connection. Every connection has its own unique ID. For example:

```
CONNECTION_ID() -> 305102
```

`CONV(`*`number, from_base, to_base`*`)`
: Returns a string representation of the number *`number`*, converted from base *`from_base`* to base *`to_base`*. If any argument is `NULL`, the result is `NULL`. For example:

```
CONV(12,10,2) -> 1100
```

`CRC32(`*`expr`*`)`
: Returns the CRC32 checksum of *`expr`*. For example:

```
CRC32('mysql') -> 2501908538
```

`CURDATE()`
: Returns today's date as a value in `YYYY-MM-DD` or `YYYYMMDD` format, depending on whether the function is used in a string or numeric context. For example:

```
CURDATE() -> '2022-0-24'
```

`CURTIME()`
: Returns the current time as a value in HH:MM:SS or HHMMSS format, depending on whether the function is used in a string or numeric context. For example:

```
CURTIME() -> '20:40:20'
```

`DATABASE()`
: Returns the current database name. For example:

```
DATABASE() -> 'PUBS'
```

`DATE_ADD(`*`date`*`, INTERVAL `*`expr unit`*`)`
: Synonym for `ADDDATE`. Returns the result of adding the `INTERVAL` to the *`date`* expression. For example:

```
DATE_ADD('2022-04-15', INTERVAL 1 DAY) -> '2022-04-16'
```

`DATE_ FORMAT(`*`date`*`, `*`format`*`)`
: Formats the *`date`* value according to the *`format`* string. For example:

```
DATE_FORMAT('2022-04-15', '%M-%D-%Y') -> 'April-15th-2022'
```

Table 7-9 lists the available specifiers for *`format`* and their meanings.

Table 7-9. MySQL format specifiers

Format specifier	Meaning
%a	Abbreviation of the day (Sun–Sat)
%b	Abbreviation of the month (Jan–Dec)
%c	Number of the month (1–12)
%D	Day of the month with a suffix (1st, 2nd, 3rd, ...)
%d	Two-digit day of the month (01, 02, ...)
%e	Day of the month (1, 2, 3, ...)
%H	Hour (00–23)
%h	Hour (01–12)
%I	Hour (01–12)
%i	Minute (00–59)
%j	Day of the year (001–366)
%k	Hour (0–23)

Format specifier	Meaning
%l	Hour (1–12)
%M	Full month name (January–December)
%m	Month (01–12)
%p	AM or PM
%r	12-hour time (hh:mm:ss AM or PM)
%S or *%s*	Seconds (00–59)
%T	24-hour time (hh:mm:ss)
%U	Week number (00–53, Sunday being the first day of the week)
%u	Week number (00–53, Monday being the first day of the week)
%V	Week number (01–53, Sunday being the first day of the week)
%v	Week number (01–53, Monday being the first day of the week)
%W	Name of the day (Sunday–Saturday)
%w	Day of the week (0–6, 0 being Sunday and 6 being Saturday)
%X	Four-digit year with Sunday being the first day of the week
%x	Four-digit year with Monday being the first day of the week
%Y	Four-digit year
%y	Two-digit year
%%	Literal "%"

`DATE_SUB(`*`date,`*` INTERVAL `*`expr unit`*`)`

Synonym for `SUBDATE`. Returns the result of subtracting the `INTERVAL` from the *`date`* expression. For example:

```
DATE_SUB('2022-04-15', INTERVAL 1 DAY) -> '2022-04-14'
```

`DAYNAME(`*`date`*`)`

Returns the name of the weekday for *`date`*. For example:

```
DAYNAME('2022-04-15') -> 'Friday'
```

`DAYOFMONTH(`*`date`*`)`

Returns the day of the month for *`date`*, in the range 1 to 31. For example:

```
DAYOFMONTH('2022-04-15') -> 15
```

`DAYOFWEEK(`*`date`*`)`

Returns the weekday index for *`date`* (1 = Sunday, 2 = Monday, ... 7 = Saturday). For example:

```
DAYOFWEEK('2022-04-15') -> 6
```

`DAYOFYEAR(`*`date`*`)`

Returns the day of the year for *`date`*, in the range 1 to 366. For example:

```
DAYOFYEAR('2022-04-15') -> 105
```

`DECODE(`*`crypt_str, pass_str`*`)`
: Decrypts the encrypted string *`crypt_str`* using *`pass_str`* as the password; *`crypt_str`* should be a string returned from `ENCODE`. For example:

```
DECODE(ENCODE('foo','bar'),'bar') -> 'foo'
```

`DEFAULT(`*`column_name`*`)`
: Returns the default value of the column *`column_name`*. For example:

```
SELECT DEFAULT(a_column) FROM a_table -> 0
```

`DEGREES(`*`number`*`)`
: Returns the argument *`number`* converted from radians to degrees. For example:

```
DEGREES(3.1415926) -> 179.99999692953
```

`DES_DECRYPT(`*`crypt_str, key_str`*`)`
: Returns *`crypt_str`* decrypted using DES and the key *`key_str`*.

`DES_ENCRYPT(`*`str, key_str`*`)`
: Returns *`str`* encrypted with DES using the key *`key_str`*. For example:

```
DES_DECRYPT(DES_ENCRYPT('secret sauce', 'password'), 'password') ->
'secret sauce'
```

`ELT(`*`n, str1, str2, str3`*`[, ...`*`n`*`])`
: Returns *`str1`* if *`n`* = 1, *`str2`* if *`n`* = 2, and so on. If *`n`* is less than 1 or greater than the number of arguments, this function returns NULL. `ELT` is the complement of `FIELD`. For example:

```
ELT(1, 'Hi', 'There') -> 'Hi'
ELT(2, 'Hi', 'There') -> 'There'
```

`ENCODE(`*`str, pass_str`*`)`
: Encrypts *`str`* using *`pass_str`* as the password. The result is a binary string the same length as the string; to decrypt it, use `DECODE`. For example:

```
DECODE(ENCODE('foo','bar'),'bar') -> 'foo'
```

`ENCRYPT(`*`str`*`[,`*`salt`*`])`
: Encrypts *`str`* using the Unix *crypt* system call. The optional *`salt`* argument should be a string with two characters. For example:

```
ENCRYPT('password') -> 'ZB7yqPUHvNnmo'
```

`EXPORT_SET(`*`bits, on, off`*`,[ `*`separator`*`,[ `*`number_of_bits`*`]])`
: Returns a string where every bit in *`bits`* that is set gets an *`on`* string and every unset bit gets an *`off`* string. Each string is separated with *`separator`*; the default is a comma (`,`). *`number_of_bits`* is optional; when omitted, the default is 64. For example:

```
EXPORT_SET(4,'T','F') ->
F,F,T,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,
F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F
```

`FIELD(`*`str, str1, str2, str3`*`[, ... ])`

Returns the index of *`str`* in the given string arguments, or 0 if *str* is not found. `FIELD` is the complement of `ELT`. For example:

```
FIELD('GOOSE','DUCK','DUCK','GOOSE','DUCK') -> 3
```

`FIND_IN_SET(`*`str, strlist`*`)`

Returns the index of *`str`* within the *`strlist`*, where *`strlist`* is a list of strings separated by commas. This function is equivalent to calling `FIELD(`*`str`*`, CONCAT_WS(',',` *`str1, str2, str3`*`[, ... ]))`. For example:

```
FIND_IN_SET('b','a,b,c,d') -> 2
```

`FORMAT(`*`number, decimals`*`)`

Formats the number *`number`* to a format like #,###,###.##, rounded to *`decimals`* decimals. If *`decimals`* is 0, the result has no decimal point or fractional part. For example:

```
FORMAT(12345.2132,2) -> 12,345.21
FORMAT(12345.2132,0) -> 12,345
```

`FOUND_ROWS()`

Returns the number of rows that would have been returned by a query that was previously executed with the `LIMIT` clause. The query of `FOUND_ROWS` must be done immediately after the limited query is executed. For example:

```
FOUND_ROWS() -> 31415926
```

`FROM_DAYS(`*`number`*`)`

Given a day *`number`*, returns a `DATE` value. This function should not be used for values that precede the advent of the Gregorian calendar (1582), due to the days lost when the calendar was changed. For example:

```
FROM_DAYS(888888) -> 2433-09-10
```

`FROM_UNIXTIME(`*`unix_timestamp`*`)`

Returns a representation of the *`unix_timestamp`* argument as a value in `YYYY-MM-DD HH:MM:SS` or `YYYYMMDDHHMMSS` format, depending on whether the function is used in a string or numeric context. For example:

```
FROM_UNIXTIME(1647000892) -> 2022-03-11 07:14:52
```

`FROM_UNIXTIME(`*`unix_timestamp, format`*`)`

Returns a string representation of the *`unix_timestamp`*, formatted according to the *`format`* string. *`format`* may contain the same specifiers as those listed in the entry for the `DATE_FORMAT` function (Table 7-9). For example:

```
FROM_UNIXTIME(1647000892,'%Y %D %M') -> '2022 11th March'
```

`GET_LOCK(`*`str, timeout`*`)`

Tries to obtain a lock with a name given by the string *`str`*, with a timeout of *`timeout`* seconds. Returns 1 if the lock is obtained successfully, or NULL if an error occurs or the attempt to acquire the lock times out. For example:

```
GET_LOCK('lochness',10) -> 1
```

`GREATEST(`*`x, y`*`[, ... ])`

Returns the largest argument. For example:

```
GREATEST(8,2,4) -> 8
```

`HEX(`*`number`*`)`

Returns a string representation of the hexadecimal value of *`number`*. This is equivalent to `CONV(`*`number`*`, 10, 16)`. For example:

```
HEX(255) -> FF
```

`HOUR(`*`time`*`)`

Returns the hour for *`time`*, in the range 0 to 23. For example:

```
HOUR('08:20:15') -> 8
```

`IF(`*`expr1, expr2, expr3`*`)`

Returns *`expr2`* if *`expr1`* is `TRUE`; otherwise, returns *`expr3`*. For example:

```
IF(1,'yes','no') -> 'yes'
IF(0,'yes','no') -> 'no'
```

`IFNULL(`*`expr1, expr2`*`)`

Returns *`expr1`* if *`expr1`* is not NULL; otherwise, returns *`expr2`*. For example:

```
IFNULL(0,'NULL') -> 0
IFNULL(NULL,'NULL') -> 'NULL'
```

`INET_ATON(`*`expr`*`)`

Returns a numeric representation of a network IP address found in *`expr`*. For example:

```
INET_ATON('127.0.0.1') -> 2130706433
```

`INET_NTOA(`*`num`*`)`

Returns the network IP address as a string decoded from the numeric value *`num`*. For example:

```
INET_NTOA(2130706433) -> '127.0.0.1'
```

`INSERT(`*`str, pos, len, newstr`*`)`

Returns the string *`str`* with *`newstr`* inserted at character position *`pos`* for length *`len`*. For example:

```
INSERT('paper',2,3,'ea') -> 'pear'
```

`INSTR(str, substr)`

Returns the position of the first occurrence of the substring *substr* in the string *str*. For example:

```
INSTR('ducks','c') -> 3
```

`INTERVAL(num1, num2, num3, num4[, ... n])`

Returns 0 if *num1* < *num2*, 1 if *num1* < *num3*, and so on. It is required that *num2* < *num3* < *num4* < ... < *numN*. For example:

```
INTERVAL(5,1,6) -> 1
INTERVAL(5,2,3,7,9) -> 2
```

`IS_FREE_LOCK(lock)`

Returns 1 if *lock* is free and 0 if the lock is currently in use. The function may return NULL on error conditions. For example:

```
IS_FREE_LOCK('lochness') -> 0
```

`IS_USED_LOCK(lock)`

Returns the connection identifier if the lock with the ID *lock* is taken, and NULL otherwise. For example:

```
IS_USED_LOCK('lochness') -> 0
```

`ISNULL(expr)`

Returns 1 if *expr* is NULL; otherwise, it returns 0. For example:

```
ISNULL(1) -> 0
ISNULL(NULL) -> 1
```

`LAST_DAY(expr)`

Returns the last day in the month for the date found in *expr*. For example:

```
LAST_DAY('2022-01-01') -> '2022-01-31'
```

`LAST_INSERT_ID([expr])`

Returns the last automatically generated value that was inserted into an `AUTO_INCREMENT` column. For example:

```
LAST_INSERT_ID() -> 0
```

`LEAST(X, Y[, ... n])`

With two or more arguments, returns the smallest (minimum-valued) argument. For example:

```
LEAST(10,5,3,7) -> 3
```

`LEFT(str, len)`

Returns the leftmost *len* characters from the string *str*. For example:

```
LEFT('Ducks', 4) -> 'Duck'
```

`LOAD_FILE(`*`file_name`*`)`
: Reads the file identified by *`file_name`* and returns the file contents as a string. The file must be on the server, and the user must specify the full pathname to the file and have permission to access the file.

`LOG2(X)`
: Returns the base-2 logarithm of `X`. For example:

```
LOG2(50) -> 5.64386
```

`LPAD(`*`str, len, padstr`*`)`
: Returns the string *`str`*, left-padded with the string *`padstr`* until *`str`* is *`len`* characters long. For example:

```
LPAD('ucks',6,'d') -> 'dducks'
```

`LTRIM(`*`str`*`)`
: Returns the string *`str`* with leading space characters removed. For example:

```
LTRIM('     Howdy!     ') -> 'Howdy!    '
```

`MAKE_SET(`*`bits, str1, str2`*`[, ... `*`n`*`])`
: Returns a *`set`* (a string containing substrings separated by commas) consisting of the string arguments that have the corresponding bit in *`bits`* set; *`str1`* corresponds to bit 0, *`str2`* to bit 1, etc. NULL strings in *`str1`*, *`str2`*, `...` are not appended to the result. For example:

```
MAKE_SET(1 | 4,'hello','nice','world') -> 'hello,world'
```

`MAKEDATE(`*`y, n`*`)`
: Returns a date corresponding to the year *`y`* and the day number *`n`*. For example:

```
MAKEDATE(2022, 1) -> '2022-01-01'
```

`MAKETIME(`*`hour, minute, second`*`)`
: Returns a time matching *`hour`*:*`minute`*:*`second`*. For example:

```
MAKETIME(2, 30, 0) -> '02:30:00'
```

`MATCH(`*`col1, col2, ...`*` ) AGAINST (`*`expr`*` [`*`search_modifier`*`])`
: Performs a full-text search looking for *`expr`* in the supplied columns. See the MySQL documentation for more information on full-text searching.

`MD5(`*`string`*`)`
: Calculates an MD5 checksum for the *`string`*. The value is returned as a 32-digit hex number. For example:

```
MD5('somestring') -> 1f129c42de5e4f043cbd88ff6360486f
```

`MICROSECOND(`*`time`*`)`
: Returns the microseconds for *`time`*, in the range 0 to 999999. For example:

```
MICROSECOND('08:20:15.000050') -> 50
```

`MID(`*`str, pos, len`*`)`
: Synonym for `SUBSTRING(`*`str, pos, len`*`)`.

`MINUTE(`*`time`*`)`
: Returns the minute for *`time`*, in the range 0 to 59. For example:

```
MINUTE('08:20:15') -> 20
```

`MONTH(`*`date`*`)`
: Returns the month for *`date`*, in the range 1 to 12. For example:

```
MONTH('2022-04-15') -> 4
```

`MONTHNAME(`*`date`*`)`
: Returns the name of the month for *`date`*. For example:

```
MONTHNAME('2022-04-15') -> 'April'
```

`NOW(), SYSDATE()`
: Returns the current date and time as a value in `YYYY-MM-DD HH:MM:SS` or `YYYYMMDDHHMMSS` format, depending on whether the function is used in a string or numeric context. For example:

```
NOW() -> 2022-04-15 20:40:24
SYSDATE() -> 2022-04-15 20:40:24
CURRENT_TIMESTAMP -> 2022-04-15 20:40:24
```

`NULLIF(`*`expr1, expr2`*`)`
: Returns NULL if *`expr1`* is equal to *`expr2`*; otherwise, returns *`expr1`*. For example:

```
NULLIF(2,29) -> 2
NULLIF(29,29) -> NULL
```

`OCT(`*`n`*`)`
: Returns an octal value equivalent of *`n`*, where *`n`* is a number. This is equivalent to `CONV(n,10,8)`. Returns `NULL` if *`n`* is `NULL`. For example:

```
OCT(255) -> 377
```

`ORD(`*`str`*`)`
: Returns the character ordinal of the multibyte character string *`str`*. The value is calculated using the following formula: ((first byte ASCII code) * 256 + (second byte ASCII code) * 256 * 256) (third byte ASCII code) * 256 * 256 * 256[, ...]. If *`str`* isn't a multibyte character, this function returns the same value as the `ASCII` function. For example:

```
ORD('29') -> 50
```

`PASSWORD(`*`str`*`)`
: Calculates a password string from the plain-text password *`str`*. This is the function that is used for encrypting MySQL passwords. For example:

```
PASSWORD('password') -> '5d2e19393cc5ef67'
```

`PERIOD_ADD(`*`period, months`*`)`

Adds the number of months found in *`months`* to the period in *`period`* (in the format `YYMM` or `YYYYMM`). Returns a value in the format `YYYYMM`. For example:

```
PERIOD_ADD(9902,3) -> 199905
```

`PERIOD_DIFF(`*`period1, period2`*`)`

Returns the number of months between *`period1`* and *`period2`*. *`period1`* and *`period2`* should be in the format `YYMM` or `YYYYMM`. Seven digits is default displayed, but full double precision is available For example:

```
PERIOD_DIFF(9902,9905) -> –3
```

`PI()`

Returns the value of π. Seven digits is the default displayed, but adding a higher precision will result in higher-precision value. For example:

```
PI() -> 3.141593
PI() +0.000000000000000000 -> 3.141592653589793116
```

`POW(X, Y), POWER(X, Y)`

Returns the value of `X` raised to the power of `[ON ALL SERVER]`. For example:

```
POW(2, 8) -> 256.000000
```

`QUARTER(`*`date`*`)`

Returns the quarter of the year for *`date`*, in the range 1 to 4. For example:

```
QUARTER('2022-04-15') -> 2
```

`QUOTE(`*`str`*`)`

Returns *`str`* with special characters properly escaped for usage within a SQL statement. For example:

```
QUOTE('\'start and end with quote\") -> '\'start and end
   with quote\"
```

`RADIANS(X)`

Returns the argument `X`, converted from degrees to radians. For example:

```
RADIANS(180) -> 3.1415926535898
```

`RAND(), RAND([ON ALL SERVER])`

Returns a random floating-point value in the range 0 to 1.0. If an integer argument `[ON ALL SERVER]` is specified, it is used as the seed value. For example:

```
RAND() -> 0.29588872501244
```

`expr` `REGEXP` *`pat, expr`* `RLIKE` *`pat`*

Returns 1 if *`expr`* matches the regular expression pattern in *`pat`*; otherwise, returns 0. For example:

```
'oolong' REGEXP '^[a-z]' -> 1
```

`REGEXP_REPLACE(`*`s, pattern, replacement, match_type`*`)`, `REGEXP_REPLACE(`*`s, pattern, replacement`*`)`

Returns *`s`* with all substrings matching the regular expression *`pattern`* replaced with the string found in *`replacement`*. MySQL supports a *`match_type`* option to allow non-default processing by the regular expression matching engine. The options are `'i'` for case-insensitive matching, `'c'` for case-sensitive matching, `'n'` for the "`.`" character also matching newlines, and *'m'* to recognize line terminators within the string.

MariaDB does not support the *`match_type`* argument, but all special processing can be specified as part of the *`pattern`* using standard POSIX regex syntax.

For example:

```
REGEXP_REPLACE('ab1ab2ab3', '[0-9]+', 'X') -> abXabXabX
```

`RELEASE_LOCK(`*`str`*`)`

Releases the lock named by the string *`str`* that was obtained with `GET_LOCK`. Returns 1 if the lock is released, or NULL if the named lock doesn't exist or isn't locked by this thread (in which case the lock is not released). For example:

```
RELEASE_LOCK('lochness') -> 1
```

`REPEAT(`*`str, count`*`)`

Returns a string consisting of the string *`str`* repeated *`count`* times. For example:

```
REPEAT('Duck', 3) -> 'DuckDuckDuck'
```

`REPLACE(`*`str, from_str, to_str`*`)`

Returns the string *`str`* with all occurrences of the string *`from_str`* replaced by the string *`to_str`*. For example:

```
REPLACE('change', 'e', 'ing') -> 'changing'
```

`REVERSE(`*`str`*`)`

Returns the string *`str`* reversed. For example:

```
REVERSE('STOP') -> 'POTS'
```

`RIGHT(`*`str, int`*`)`

Returns the rightmost *`int`* characters of the string *`str`*. For example:

```
RIGHT('Hello, World!', 6) -> 'World!'
```

`ROUND(X[, D])`

Returns the argument `X`, rounded to a number with `D` decimals. If `D` is 0, the result has no decimal point or fractional part. For example:

```
ROUND(12345.6789, 2) -> 12345.68
```

`ROW_COUNT()`

Returns the number of rows updated in the previous statement. For example:

```
ROW_COUNT() -> 4
```

`RPAD(`*`str, len, padstr`*`)`
: Returns the string *`str`*, right-padded with the string *`padstr`* until *`str`* is *`len`* characters long. For example:

```
RPAD('duck',6,'s') -> 'duckss'
```

`RTRIM(`*`str`*`)`
: Returns the string *`str`* with trailing space characters removed. For example:

```
RTRIM('    welcome    ') -> 'welcome   '
```

`SCHEMA()`
: Synonym for `DATABASE`.

`SEC_TO_TIME(`*`seconds`*`)`
: Returns the *`seconds`* argument, converted to hours, minutes, and seconds, as a value in HH:MM:SS or HHMMSS format, depending on whether the function is used in a string or numeric context. For example:

```
SEC_TO_TIME(256) -> 00:04:16
```

`SECOND(`*`time`*`)`
: Returns the seconds for *`time`*, in the range 0 to 59. For example:

```
SECOND('08:20:15') -> 15
```

`SHA(X), SHA1(X)`
: Returns a SHA1 160-bit checksum for `X`. For example:

```
SHA('abc') -> 'a9993e364706816aba3e25717850c26c9cd0d89d'
```

`SIGN(X)`
: Returns the sign of the argument as −1, 0, or 1, depending on whether `X` is negative, zero, or positive. For example:

```
SIGN(−3.1415926) -> −1
```

`SLEEP(`*`s`*`)`
: Sleeps for *`s`* seconds. For example:

```
SLEEP( 60 ) -> 0
```

`SOUNDEX(`*`string`*`)`
: Returns a character string containing the phonetic representation of *`string`*. This function allows words that are spelled differently but sound alike in English to be compared for equality. For example:

```
SOUNDEX('thimble') -> 'T514'
```

`expr1` `SOUNDS LIKE` *`expr2`*
: Synonymous with the expression:

```
SOUNDEX(expr1) = SOUNDEX(expr2)
```

SPACE(*n*)

Returns a string consisting of *n* space characters. For example:

```
SPACE(5) -> '     '
```

STD(*expr*), STDDEV(*expr*)

Returns the standard deviation of *expr*. The STDDEV form of this function is provided for Oracle compatibility. For example:

```
STD(5) -> NULL
```

STR_TO_DATE(*str*, *format*)

Returns a date parsed from *str* using the format specifiers found in the *format* argument. This is the reverse of DATE_FORMAT; see that entry for a list of the supported specifiers (Table 7-9). For example:

```
STR_TO_DATE('28/08/2016', '%d/%m/%Y') -> '2016-08-28'
```

STRCMP(*expr1*, *expr2*)

STRCMP Compares *expr1* and *expr2* and returns 0 if the strings are the same, −1 if the first argument is smaller than the second according to the current sort order, and 1 otherwise. For example:

```
STRCMP('DUCKY', 'DUCK') -> 1STRCMP('DUCK', 'DUCK') -> 0
```

SUBDATE(*date*, INTERVAL *expr unit*)

Synonym for DATE_SUB. Returns the result of subtracting the INTERVAL from the *date* expression. For example:

```
SUBDATE('2022-04-15', INTERVAL 1 DAY) -> '2022-04-14'
```

SUBSTRING(*str*, *pos*), SUBSTRING(*str* FROM *pos*)

Returns a substring from the string *str* starting at the position *pos*. For example:

```
SUBSTRING('Hello, World!', 8) -> 'World!'
SUBSTRING('Hello, World!' FROM 8) -> 'World!'
```

SUBSTRING(*str*, *pos*, *len*)

Returns a substring *len* characters long from the string *str*, starting at the position *pos*. Synonym for MID(*str*, *pos*, *len*) and the SQL standard function SUBSTRING(*str* FROM *pos* FOR *len*). For example:

```
SUBSTRING('Hello, World!', 8, 10) -> 'World!'
SUBSTRING('Hello, World!' FROM 8 FOR 10) -> 'World!'
```

SUBSTRING_INDEX(*str*, *delim*, *count*)

Returns the substring *str* after *count* occurrences of the delimiter *delim*. For example:

```
SUBSTRING_INDEX('www.mysql.com', '.', 2) -> 'www.mysql'
```

SUBTIME(*expr1*, *expr2*)

Returns the result of subtracting *expr2* from *expr1*. For example:

```
SUBTIME('2022-04-15 16:30:00.999999', '0 0:30:0.999996') ->
'2022-04-15 16:00:00.000003'
```

`TIME(`*`expr`*`)`
: Returns the time portion of the value found in *`expr`*. For example:

```
TIME('2016-08-28 08:20:15') -> '08:20:15'
```

`TIME_FORMAT(`*`time, format`*`)`
: Used like `DATE_FORMAT`, but the *`format`* string may contain only those format specifiers that handle hours, minutes, and seconds. Other specifiers produce a NULL value or 0. See `DATE_FORMAT` for a list of the available format specifiers (Table 7-9). For example:

```
TIME_FORMAT('2022-04-15 08:20:15', '%r') -> 08:20:15 AM
```

`TIME_TO_SEC(`*`time`*`)`
: Returns the *`time`* argument, converted to seconds. For example:

```
TIME_TO_SEC('08:20:15') -> 30015
```

`TIMEDIFF(`*`expr1, expr2`*`)`
: Returns the difference between *`expr1`* and *`expr2`*. For example:

```
TIMEDIFF('2016-08-28 08:20:15', '2016-08-28 08:20:16') ->
'00:00:01.000000'
```

`TIMESTAMP(`*`expr1`*`[, `*`expr2`*`])`
: Returns a timestamp value where the date comes from *`expr1`* and the time component comes from *`expr2`*. For example:

```
TIMESTAMP('2016-08-28', '08:20:16') -> '2016-08-28 08:20:16'
```

`TIMESTAMPADD(`*`unit, interval, expr`*`)`
: Returns a timestamp constructed by adding *`interval`* to the date expression *`expr`*. The units for *`interval`* are specified by *`unit`*. For example:

```
TIMESTAMPADD(DAY, 2, '2016-08-28') -> '2016-08-30 00:00:00'
```

`TIMESTAMPDIFF(`*`unit, expr1, expr2`*`)`
: Returns an integer that is the result of subtracting *`expr1`* from *`expr2`*. The units of the result are specified by *`unit`*. For example:

```
TIMESTAMPDIFF(DAY, '2016-08-30', '2016-08-28') -> −2
```

`TO_DAYS(`*`date`*`)`
: Given a *`date`*, returns a day number (the number of days since the year 0). For example:

```
TO_DAYS('2022-03-15') -> 738594
```

`TRUNCATE(X, D)`
: Returns the number `X`, truncated to `D` decimal places. If `D` is 0, the result has no decimal point or fractional part. For example:

```
TRUNCATE('123.456', 2) -> '123.45'
TRUNCATE('123.456', 0) -> '123'
TRUNCATE('123.456', −1) -> '120'
```

`UCASE(`*`str`*`)`
: Synonym for the SQL standard function `UPPER(`*`str`*`)`. For example:

```
UCASE('duck') -> 'DUCK'
```

`UNCOMPRESS(`*`string`*`)`
: Returns an uncompressed version of *`string`*.

`UNCOMPRESS_LENGTH(`*`string`*`)`
: Returns the length of *`string`* in its uncompressed form.

`UNHEX(`*`str`*`)`
: Returns a binary string constructed from hex characters in *`str`*.

`UNIX_TIMESTAMP(), UNIX_TIMESTAMP(`*`date`*`)`
: If called with no argument, returns a Unix timestamp (seconds since 1970-01-01 00:00:00 GMT). If called with a *`date`* argument, returns the value of the argument as seconds since 1970-01-01 00:00:00 GMT. For example:

```
UNIX_TIMESTAMP() -> 1649105629
UNIX_TIMESTAMP('2022-04-04') -> 1649044800
```

`UTC_DATE()`
: Returns the current UTC date. For example:

```
UTC_DATE() -> '2022-04-15'
```

`UTC_TIME()`
: Returns the current UTC time. For example:

```
UTC_TIME() -> '01:01:00'
```

`UTC_TIMESTAMP()`
: Returns the current UTC date and time. For example:

```
UTC_TIMESTAMP() -> '2022-04-15 01:01:00'
```

`UUID()`
: Returns a universal unique identifier. For example:

```
UUID() -> '1ae84bc9-5e4d-8f22-1f2e-123456789abc'
```

`VERSION()`
: Returns a string indicating the MySQL or MariaDB server version. For example:

```
VERSION() -> '10.6.5-MariaDB'
```

`WEEK(`*`date`*`), WEEK(`*`date, first`*`)`
: With a single argument, returns the week for *`date`*, in the range 1 to 53. (The beginning of a week 53 is possible during some years.) The two-argument form

of `WEEK` allows the user to specify whether the week starts on Sunday (0) or Monday (1). For example:

```
WEEK('2022-04-15') -> 15
```

`WEEKDAY(`*`date`*`)`
: Returns the weekday index for *`date`* (0 = Monday, 1 = Tuesday, ... 6 = Sunday). For example:

```
WEEKDAY('2022-04-15') -> 4
```

`WEEKOFYEAR(`*`date`*`)`
: Returns the calendar week for *`date`*, where the calendar week is an integer between 1 and 53, inclusive. For example:

```
WEEKOFYEAR('2022-01-01') -> 1
```

`op1` `XOR` *`op2`*
: Returns the logical `XOR` of *`op1`* and *`op2`*. For example:

```
1 XOR 1, 1 XOR 0 -> 0, 1
```

`YEAR(`*`date`*`)`
: Returns the year for *`date`*, in the range 1000 to 9999. For example:

```
YEAR('2022-04-15') -> 2022
```

`YEARWEEK(`*`date`*`), YEARWEEK(`*`date, first`*`)`
: Returns the year and week for *`date`*. The second argument works exactly like the second argument to `WEEK`. Note that the year may be different from the year in the *`date`* argument for the first and the last week of the year. For example:

```
YEARWEEK('2022-04-15') -> 202215
```

Oracle-Supported Functions

This section provides an alphabetical listing of the SQL functions specific to Oracle, with examples and corresponding results for most of them.

`ADD_MONTHS(`*`date, int`*`)`
: Returns the *`date`* plus *`int`* months. For example:

```
SELECT ADD_MONTHS('15-APR-2022', 3) FROM DUAL -> 15-JUL-22
```

`ASCII(`*`text`*`)`
: Returns the ASCII code of the first character of *`text`*. For example:

```
SELECT ASCII('x') FROM DUAL -> 120
```

`ASCIISTR(`*`text`*`)`
: Converts *`text`* from any character set into an ASCII equivalent. Characters in *`text`* that have no equivalent in ASCII will be replaced with the string *\XXXX*, where `XXXX` represents the UTF-16 code unit. For example:

```
SELECT ASCIISTR('ÄBC') FROM DUAL -> '\00C4BC'
```

`BFILENAME(`*`directory, filename`*`)`
: Returns a `BFILE` locator associated with a physical `LOB` binary file on the server's filesystem in *`directory`* with the name *`filename`*.

`BIN_TO_NUM(`*`expr`*`[, ...`*`n`*`])`
: Returns a decimal number equivalent of the binary bit vector contained in the *`expr`* argument(s). For example:

```
SELECT BIN_TO_NUM(1,0,1) FROM DUAL -> 5
```

`BITAND(`*`integer1, integer2`*`)`
: Returns the bitwise `AND` of the two integer arguments. For example:

```
SELECT BITAND(101, 2) FROM DUAL -> 0
SELECT BITAND(column1, 1) FROM DUAL -> 1
```

`CHARTOROWID(`*`char`*`)`
: Converts a value from a character data type (`CHAR` or `VARCHAR2`) to a `ROWID` data type.

`CHR(`*`number`*` [USING NCHAR_CS])`
: Returns the character having the binary equivalent to *`number`* in either the database character set (if `USING NCHAR_CS` is not included) or the national character set (if `USING NCHAR_CS` is included).

`CLUSTER_ID(), CLUSTER_PROBABILITY(), CLUSTER_SET()`
: Support data mining features. See the documentation for the Oracle Data Mining Java API or the `DBMS_DATA_MINING` package for more details on these functions.

`COMPOSE(`*`string`*`)`
: Returns *`string`* as a fully normalized Unicode string.

`CUBE_TABLE(`*`'expr'`*`)`
: Extracts a two-dimensional relational view from an OLAP cube or dimension. See the Oracle OLAP documentation for more information.

`CV([`*`dimension_column`*`])`
: Relevant only in the inter-row calculations performed within the `MODEL` clause of a `SELECT` statement, this function returns the current value of the *`dimension_column`*. `CV` can only be used in the righthand side of a rule, since it returns the value of the *`dimension_column`* from the lefthand side of the same rule.

`DATAOBJ_TO_PARTITION(`*`table, partition_id`*`)`
: Returns the partition identifier for the system-partitioned table specified by the arguments. See the Oracle documentation for more information on this function.

`DBTIMEZONE`
: Returns the time zone offset from UTC time for the database server. For example:

```
SELECT DBTIMEZONE FROM DUAL -> +00:00
```

`DECODE(`*`expr, search, result`*`[, `*`search, result`*`[, ... `*`n`*`]][, `*`default`*`])`
: Compares *`expr`* to the *`search`* value; if *`expr`* is equal to *`search`*, it returns the result. For example:

```
DECODE('B','A',1,'B',2,...'Z',26,'?') -> 2
```

Without a match, `DECODE` returns *`default`*, or NULL if *`default`* is omitted. Refer to the Oracle documentation for more details. Consider using `CASE` instead, as `CASE` is part of the SQL standard.

`DECOMPOSE(`*`string`*` [{CANONICAL | COMPATIBILITY}])`
: Returns *`string`* decomposed into Unicode code points. The second argument specifies the type of decomposition performed. `CANONICAL`, which specifies the default behavior, allows the original Unicode string to be recomposed.

`DEREF(`*`expression`*`)`
: Returns the object referenced by *`expression`*, where *`expression`* must return a `REF` to an object.

`DUMP(`*`expression`*`[, `*`return_format`*`[, `*`starting_at`*`[, `*`length`*`]]])`
: Returns a `VARCHAR2` value containing a data type code, *`length`* in bytes, and internal representation of *`expression`*. The resulting value is returned in the format of *`return_format`*. For example:

```
SELECT DUMP('abc', 1016) FROM DUAL ->
Typ=96 Len=3 CharacterSet=AL32UTF8: 61,62,63
```

`EMPTY_BLOB(), EMPTY_CLOB()`
: Return an empty `LOB` locator that can be used to initialize a `LOB` variable. These functions can also be used to initialize a `LOB` column or attribute to empty in an `INSERT` or `UPDATE` statement.

`FEATURE _ID(), FEATURE _SET(), FEATURE_VALUE()`
: Support data mining features. See the documentation for the Oracle Data Mining Java API or the `DBMS_DATA_MINING` package for more details on these functions.

`FROM_TZ(`*`timestamp, timezone`*`)`
: Returns *`timestamp`* converted to a `TIMESTAMP WITH TIME ZONE` value, where *`timestamp`* is a `TIMESTAMP` value and *`timezone`* is a string in the TZH:TZM format. For example:

```
SELECT FROM_TZ(TIMESTAMP '2004-04-15 23:59:59', '8:00') FROM DUAL ->
'15-APR-22 11.59.59 PM +08:00'
```

`GREATEST(`*`expression`*`[, ... `*`n`*`])`

Returns the greatest of the list of expressions. All expressions after the first are implicitly converted to the data type of the first expression before the comparison. For example:

```
SELECT GREATEST(8,2,4) FROM DUAL -> 8
```

`HEXTORAW(`*`string`*`)`

Converts a *`string`* containing hexadecimal digits into a raw value. For example:

```
SELECT HEXTORAW('0FE') FROM DUAL -> '00FE'
```

`INITCAP(`*`string`*`)`

Returns *`string`*, with the first letter of each word in uppercase and all other letters in lowercase. For example:

```
SELECT INITCAP('thomas jefferson') FROM DUAL -> 'Thomas Jefferson'
```

`INSERTCHILDXML(`*`xml_fragment, xpath, child_expr, value_expr`*`[, `*`name space`*`])`

Injects the nodes specified by *`child_expr`* within *`value_expr`* into *`xml_fragment`* at the location given by the XPath query *`xpath`*, and returns the result. The optional *`namespace`* argument provides the namespace for the XPath query. For example:

```
SELECT INSERTCHILDXML('<a></a>', '/a', 'b', '<b>B1</b><b>B2</b>')
   FROM DUAL -> '<a><b>B1</b><b>B2</b></a>'
```

`INSERTXMLBEFORE(`*`xml_fragment, xpath, value_expr`*`[, `*`namespace`*`])`

Injects *`value_expr`* into *`xml_fragment`* at the location given by the XPath query *`xpath`* and returns the result. The optional *`namespace`* argument provides the namespace for the XPath query. For example:

```
SELECT INSERTXMLBEFORE('<a><b>B2</b></a>', '/a/b', '<b>B1</b>')
   FROM DUAL -> '<a><b>B1</b><b>B2</b></a>'
```

`ITERATION_NUMBER`

Relevant only in the inter-row calculations performed within the `MODEL` clause of a `SELECT` statement, this function returns the number of times the rules within the `MODEL` clause have been executed while processing the query.

`LAST_DAY(`*`date`*`)`

Returns the date of the last day of the month that contains *`date`*. For example:

```
SELECT LAST_DAY('15-APR-2022') FROM DUAL -> 30-APR-22
```

`LEAST(`*`expression`*`[, ...`*`n`*`])`

Returns the least of the list of expressions. For example:

```
SELECT LEAST(10,5,3,7) FROM DUAL -> 3
```

`LNNVL(`*`condition`*`)`
: Returns `TRUE` if *`condition`* is false or if one of the operands in *`condition`* is NULL; otherwise, returns `FALSE`. For example:

```
SELECT COUNT(*) FROM authors WHERE LNNVL( contract <> 1 ) -> 4
```

`LOCALTIMESTAMP[(`*`precision`*`)]`
: Returns a `TIMESTAMP` value for the current date and time. This function is similar to `CURRENT_TIMESTAMP`, with the exception that this function does not return a `TIME ZONE` value with the `TIMESTAMP`. For example:

```
SELECT LOCALTIMESTAMP FROM DUAL -> '15-APR-22 03.15.00 PM'
```

`LPAD(`*`string1, number`*`[, `*`string2`*`])`
: Returns *`string1`*, left-padded to length *`number`* using characters in *`string2`*; *`string2`* defaults to a single blank. For example:

```
SELECT LPAD('ucks',5,'d') FROM DUAL -> 'ducks'
```

`MAKE_REF({`*`table_name`*` | `*`view_name`*`}, `*`key`*`[, ... `*`n`*`])`
: Creates a reference (`REF`) to a row of an object view or a row in an object table whose object identifier is primary key–based.

`MONTHS_BETWEEN(`*`date1, date2`*`)`
: Returns the number of months between the dates *`date1`* and *`date2`*. When *`date1`* is later than *`date2`*, the result is positive. When it is earlier, the result is negative. For example:

```
SELECT MONTHS_BETWEEN('15-APR-2022', '15-JUL-2021') FROM DUAL -> 9
```

`NANVL(`*`a, b`*`)`
: Returns *`b`* when *`a`* is not a number (*NaN*); returns *`a`* otherwise. The expression *`a`* must evaluate to a `BINARY_FLOAT` or `BINARY_DOUBLE` number, which are the only number types that permit storing *NaN*. For example:

```
SELECT c1, NANVL(c1, 0) FROM NUMS ->
1.0E+000      1.0E+000
2.0E+000      2.0E+000
Nan           0
```

`NCHAR(`*`number`*`)`
: Synonym for `CHR(`*`number`*`) USING NCHAR_CS`.

`NEW_TIME(`*`date, time_zone1, time_zone2`*`)`
: Returns the date and time in *`time_zone2`*, using *`date`* as the input date/time and using *`time_zone1`* as the originating time zone. For example:

```
ALTER SESSION SET NLS_DATE_FORMAT = 'DD-MON-YYYY HH12:MI:SS'
SELECT NEW_TIME(TO_DATE('04-15-99 08:22:31',
   'MM-DD-YY HH12:MI:SS'),'AST', 'PST')
   FROM DUAL ->
15-APR-2022 04:22:31
```

`time_zone1` and `time_zone2` may be any of these text strings:

`'AST', 'ADT'`
: Atlantic Standard or Daylight Time

`'BST', 'BDT'`
: Bering Standard or Daylight Time

`'CST', 'CDT'`
: Central Standard or Daylight Time

`'EST', 'EDT'`
: Eastern Standard or Daylight Time

`'GMT'`
: Greenwich Mean Time

`'HST', 'HDT'`
: Alaska–Hawaii Standard or Daylight Time

`'MST', 'MDT'`
: Mountain Standard or Daylight Time

`'NST'`
: Newfoundland Standard Time

`'PST', 'PDT'`
: Pacific Standard or Daylight Time

`'YST', 'YDT'`
: Yukon Standard or Daylight Time

`NEXT_DAY(`*`date, string`*`)`
: Returns the date of the first weekday named by *`string`* that is later than *`date`*. The argument *`string`* must be either the full name or the abbreviation of a day of the week in the date language of the session. For example:

```
ALTER SESSION SET NLS_DATE_FORMAT = 'DD-MON-YYYY'
SELECT NEXT_DAY('15-APR-2022', 'SUNDAY') FROM DUAL ->
17-APR-2022
```

`NLS_CHARSET_DECL_LEN(`*`bytecnt, csid`*`)`
: Returns the declaration width (*`bytecnt`*) of an `NCHAR` column using the character set ID (*`csid`*) of the column.

`NLS_CHARSET_ID(`*`text`*`)`
: Returns the NLS character set ID number corresponding to *`text`*.

`NLS_CHARSET_NAME(`*`number`*`)`
: Returns the `VARCHAR2` name for the NLS character set corresponding to the ID *`number`*.

`NLS_INITCAP(`*`string`*`[, `*`nlsparameter`*`])`
: Returns *`string`* with the first letter of each word in uppercase and all other letters in lowercase. The *`nlsparameter`* offers special linguistic sorting features.

`NLS_LOWER(`*`string`*`[, `*`nlsparameter`*`])`
: Returns *`string`* with all letters in lowercase. The *`nlsparameter`* offers special linguistic sorting features.

`NLS_UPPER(`*`string`*`[, `*`nlsparameter`*`])`
: Returns *`string`* with all letters in uppercase. The *`nlsparameter`* offers special linguistic sorting features.

`NLSSORT(`*`string`*`[, `*`nlsparameter`*`])`
: Returns the string of bytes used to sort *`string`*. The *`nlsparameter`* offers special linguistic sorting features.

`NUMTODSINTERVAL(`*`number, string`*`)`
: Converts *`number`* to an `INTERVAL DAY TO SECOND` literal, where *`number`* is a number or an expression resolving to a number, such as a numeric data type column. The second argument, *`string`*, specifies how to interpret *`number`*: it can be `'DAY'`, `'HOUR'`, `'MINUTE'`, or `'SECOND'`. For example:

```
SELECT NUMTODSINTERVAL(100, 'DAY') FROM DUAL ->
+000000100 00:00:00.000000000
```

`NUMTOYMINTERVAL(`*`number, string`*`)`
: Converts *`number`* to an `INTERVAL YEAR TO MONTH` literal, where *`number`* is a number or an expression resolving to a number, such as a numeric data type column. The second argument, *`string`*, specifies how to interpret *`number`*: it can be `'YEAR'` or `'MONTH'`. For example:

```
SELECT NUMTOYMINTERVAL(100, 'YEAR') FROM DUAL -> +000000100-00
```

`NVL(`*`expression1, expression2`*`)`
: If *`expression1`* is NULL, *`expression2`* is returned in place of that NULL value. Otherwise, *`expression1`* is returned. *`expression1`* and *`expression2`* may be any data type. For example:

```
SELECT NVL(2,29) FROM DUAL -> 2
```

`NVL2(`*`expression1, expression2, expression3`*`)`
: Similar to `NVL`, except that if *`expression1`* is *not* NULL, *`expression2`* is returned, and if *`expression1`* *is* NULL, *`expression3`* is returned. The expressions may be any data type except `LONG`. For example:

```
SELECT NVL2(1,3,5) FROM DUAL -> 3
```

`ORA_HASH(`*`expression`*`[, `*`buckets`*`[, `*`seed`*`]])`
: Computes a hash value from *`expression`* and returns a bucket number based on the computed hash value. The optional *`buckets`* argument is the maximum bucket number to use, which is one less than the total number of buckets, since

the bucket numbering starts at 0. The default for *buckets* is 4,294,967,295. The optional *seed* value is used to seed the hashing function so that multiple results can be produced from the same data by changing only the *seed* value. The *seed* value defaults to 0. This example pseudorandomly assigns all numbers to one of two buckets and returns those assigned to the first bucket, which will be a sample of roughly half of the values:

```
SELECT C1 FROM FIVE_NUMS WHEREORA_HASH( C1, 1, TO_CHAR(
   SYSTIMESTAMP, 'SSSS.FF' ) ) = 0 ->
1
5
```

PATH(*number*)
Returns the path specified by the UNDER_PATH condition with the correlation variable *number* in an XML query. See the Oracle SQL Reference for more information.

PRESENTNNV(*cell_reference, expr1, expr2*)
Relevant only in the inter-row calculations performed within the MODEL clause of a SELECT statement, this function returns *expr1* when *cell_reference* exists and is not NULL; otherwise, it returns *expr2*.

PRESENTV(*cell_reference, expr1, expr2*)
Relevant only in the inter-row calculations performed within the MODEL clause of a SELECT statement, this function returns *expr1* when *cell_reference* exists; otherwise, it returns *expr2*.

PREVIOUS(*cell_reference*)
Relevant only in the inter-row calculations performed within the ITERATE ... [UNTIL] section of a SELECT statement's MODEL clause, this function returns the value held by *cell_reference* at the beginning of the iteration.

RAWTOHEX(*raw*)
Converts a *raw* value to a string (character data type) of its hexadecimal equivalent. For example:

```
SELECT RAWTOHEX('Hi') FROM DUAL -> 4869
```

RAWTONHEX(*raw*)
Converts a *raw* value to an NVARCHAR2 (character data type) of its hexadecimal equivalent.

REF(*table_alias*)
Takes a table alias associated with a row from an object table or an object view. A special reference value is returned for the object instance that is bound to the variable or row.

REFTOHEX(*expression*)
Converts *expression* to a character value containing its hexadecimal equivalent.

REGEXP_REPLACE(*string*, *pattern*[, *newstr*[, *start_at*[, *occurrence*[, *mparam*]]]])

Searches *string* from a starting position of *start_at* (an integer greater than 0) looking for the specified *occurrence* of the regular expression *pattern*, and returns the result of replacing all occurrences of *pattern* within *string* with another string, *newstr*. Both the *start_at* and *occurrence* parameters default to 1. The *mparam* argument can be used to modify the matching behavior of the function and can be set to one or more of the following characters:

'i'
: Matching is case-insensitive.

'c'
: Matching is case-sensitive.

'n'
: The "." character matches newline characters.

'm'
: Treats the input string as multiple lines; use ^ to match the beginning of a line and $ to match the end of a line.

For example:

```
SELECT REGEXP_REPLACE('Hello, World!', '([^ ]*!)', 'Reader!')
   FROM DUAL -> 'Hello, Reader!'
```

REGEXP_SUBSTR(*string*, *pattern*[, *start_at*[, *occurrence*[, *mparam*]]])

Searches *string* from a starting position of *start_at* (an integer greater than 0) looking for the specified *occurrence* of the regular expression *pattern*, and returns the substring within *string* matching *pattern*. Both the *start_at* and *occurrence* parameters default to 1. The options for *mparam* are the same as for REGEXP_REPLACE. For example:

```
SELECT REGEXP_SUBSTR('Hello, World!', '([^ ]*!)') FROM DUAL ->
'World!'
```

REMAINDER(*m*, *n*)

Returns the remainder of *m* divided by *n*. This return value is equivalent to the expression:

```
m-n*ROUND(m/n)
```

The function MOD uses FLOOR instead of ROUND. For example:

```
SELECT REMAINDER(11, 4), MOD(11, 4) FROM DUAL ->
-1       3
```

REPLACE(*string*, *search_string*[, *replacement_string*])

Returns *string* with every occurrence of *search_string* replaced with *replacement_string*. For example:

```
SELECT REPLACE('change', 'e', 'ing') FROM DUAL -> changing
```

`REVERSE(`*`string`*`)`
: Reverses the characters of *`string`*. For example:

```
SELECT REVERSE( 'hello') FROM DUAL -> olleh
```

`ROUND(`*`date`*`[, `*`format`*`])`
: Returns the *`date`* rounded to the unit specified by the *`format`* model. When *`format`* is omitted, the date is rounded to the nearest day. (For more on valid format specifiers, see Table 7-10 in the description of the `TO_CHAR` function.) For example:

```
SELECT ROUND(TO_DATE('15-APR-2022'), 'MONTH') FROM DUAL -> 01-APR-2022
```

`ROUND(`*`number`*`[, `*`decimal`*`])`
: Returns *`number`* rounded to *`decimal`* places to the right of the decimal point. When *`decimal`* is omitted, *`number`* is rounded to an integer. Note that *`decimal`*, an integer, can be negative to round off digits to the left of the decimal point. For example:

```
SELECT ROUND(12345.6789, 2) FROM DUAL -> 12345.68
```

`ROWIDTOCHAR(`*`rowid`*`), ROWIDTONCHAR(`*`rowid`*`)`
: `ROWIDTOCHAR` converts the *`rowid`* value to an 18-character-long `VARCHAR2` value; `ROWIDTONCHAR` converts *`rowid`* to an 18-character-long `NVARCHAR2` value. For example:

```
SELECT ROWIDTOCHAR(ROWID) FROM NUMS ->
ABAsxDAAKAAAAEqAAA
ABAsxDAAKAAAAEqAAB
ABAsxDAAKAAAAEqAAC
ABAsxDAAKAAAAEqAAD
```

`RPAD(`*`string1`*`, `*`number`*`[, `*`string2`*`])`
: Returns *`string1`*, right-padded to the length *`number`* with the value of *`string2`*, repeated as needed. *`string2`* defaults to a single blank. For example:

```
SELECT RPAD('duck',8,'s') FROM DUAL -> 'duckssss'
```

`SCN_TO_TIMESTAMP(`*`scn`*`)`
: Returns the timestamp associated with the system change number (*`scn`*) argument. For example:

```
SELECT SCN_TO_TIMESTAMP(ORA_ROWSCN) FROM NUMS WHERE c1 = 1 ->
15-APR-22 02.56.05.000000000 PM
```

`SESSIONTIMEZONE`
: Returns the session's time zone offset. For example:

```
SELECT SESSIONTIMEZONE FROM DUAL -> −06:00
```

SET(*nested_table*)
: Returns a nested table of distinct elements from the input *nested_table*. For more information, see the Oracle SQL Reference.

SIGN(*number*)
: Returns –1 when *number* < 0, 0 when *number* = 0, and 1 when *number* > 0. For example:

```
SELECT SIGN(-3.1415926) FROM DUAL -> -1
```

SOUNDEX(*string*)
: Returns a character string containing the phonetic representation of *string*. This function allows words that are spelled differently but sound alike in English to be compared for equality. For example:

```
SELECT SOUNDEX('thimble') FROM DUAL -> 'T514'
```

SYS_CONNECT_BY_PATH(*column, char*)
: For hierarchical queries, SYS_CONNECT_BY_PATH returns the path from the root to the node with the column name specified by the *column* parameter. The *char* parameter specifies the node separator for the return path. For more on Oracle hierarchical queries, refer to the Oracle SQL Reference.

SYS_CONTEXT(*namespace, attribute*[*, length*])
: Returns the value of the *attribute* associated with the context *namespace*, usable in both SQL and PL/SQL statements. The *length* parameter optionally defines the size of the value returned by the function; it defaults to up to 256 bytes, but you may specify a value of between 1 and 4,000 bytes. For example:

```
SELECT SYS_CONTEXT ('USERENV', 'SESSION_USER') FROM DUAL -> 'LOGIN'
```

SYS_DBURIGEN(*column*[*, rowid*][, ...][, 'text()'])
: Returns a URL that can be used as a unique reference to the row specified by the *column* parameter. For columns that don't hold unique values, a *rowid* can be used directly after the column it identifies to guarantee that the URL only points to one row. Use the 'text()' option if you want the URL to point to the text within an XML document, instead of the document itself.

SYS_EXTRACT_UTC(*datetime*)
: Returns the *datetime* argument converted to a UTC datetime value. For example:

```
SELECT SYS_EXTRACT_UTC(TIMESTAMP '2022-04-15 11:59:59.00 -08:00')
   FROM DUAL -> '15-APR-22 07.59.59.000000000 PM'
```

SYS_GUID()
: Generates and returns a globally unique identifier (RAW value) made up of 16 bytes. For example:

```
SELECT SYS_QUID() FROM DUAL -> C0FD3FDC30148EAEE030440A49096A41
```

`SYS_TYPEID(`*`object_value`*`)`
: Returns the type ID of the *`object_value`* parameter.

`SYSDATE`
: Returns the current date and time on the system in which the database is hosted. The value returned is of type `DATE`. For example:

```
SELECT SYSDATE FROM DUAL -> 15-APR-2022
```

`SYSTIMESTAMP`
: Returns the current date and time on the system in which the database is hosted. The value returned is of type `TIMESTAMP`. For example:

```
SELECT SYSTIMESTAMP FROM DUAL -> 15-APR-2022 11.15.00.000000 PM –06:00
```

`TIMESTAMP_TO_SCN(`*`timestamp_value`*`)`
: Returns the approximate system change number (SCN) associated with the *`timestamp_value`*. The return value is of type `NUMBER`.

`TO_BINARY_DOUBLE(`*`expr`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts *`expr`* to a `BINARY_DOUBLE`, optionally in the format specified by the *`format`* parameter. If *`expr`* is a character expression, the *`format`* and *`nls_parameter`* options have equivalent meanings, as they do in the `TO_CHAR` function. If *`expr`* is a numeric expression, *`format`* and *`nls_parameter`* must be omitted. For example:

```
SELECT c1, TO_BINARY_DOUBLE(c1) FROM NUMS ->
1            1.0E+000
2            2.0E+000
3            3.0E+000
```

`TO_BINARY_FLOAT(`*`expr`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts *`expr`* to a `BINARY_FLOAT`, optionally in the format specified by the *`format`* parameter. If *`expr`* is a character expression, the *`format`* and *`nls_parameter`* options have equivalent meanings, as they do in the `TO_CHAR` function. If *`expr`* is a numeric expression, *`format`* and *`nls_parameter`* must be omitted. For example:

```
SELECT c1, TO_BINARY_FLOAT(c1) FROM NUMS ->
1            1.0E+000
2            2.0E+000
3            3.0E+000
```

`TO_CHAR(`*`character_expr`*`)`
: Converts *`character_expr`* to the database character set. For example:

```
SELECT TO_CHAR('Howdy') FROM DUAL -> Howdy
```

`TO_CHAR(`*`date`*` | `*`interval`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts *`date`* or *`interval`* to a `VARCHAR2` in the format specified by *`format`*. When *`format`* is omitted, *`date`* is converted to the default date format. The *`nls_parameter`* option offers additional control over formatting. For example:

```
SELECT TO_CHAR(TO_DATE('15-APR-2022'), 'MON-DD-YYYY') FROM DUAL ->
APR-15-2022
```

Table 7-10 lists the available specifiers for *format* and their meanings.

Table 7-10. Oracle format specifiers

Format specifier	Meaning
AD or A.D.	AD indicator
AM or A.M.	Meridian indicator
BC or B.C.	BC indicator
D	Day of week (1–7)
DAY	Name of day
DD	Day of month (1–31)
DDD	Day of year (1–366)
DL	Long date format
DS	Short date format
DY	Abbreviated name of day
FF	Fractional seconds; to specify the precision, include a number (1–9) after the FF specifier
HH or HH12	Hour (1–12)
HH24	Hour (0–23)
J	Julian day; the number of days since January 1, 4713 BC
MI	Minute (0–59)
MM	Month (01–12)
MON	Abbreviated name of month
RM	Roman numeral month (I–XII)
SS	Second (0–59)
SSSSS	Seconds past midnight (0–86,399)
SYYY	Four-digit year; BC dates are prefixed with a minus sign
TS	Short time format
TZD	Daylight savings information (example: PST versus PDT)
TZH	Time zone hour
TZM	Time zone minute
TZR	Time zone region
X	Local radix character
Y, YY, or YYY	One-, two-, or three-digit year
Y,YYY	Year with comma
YYYY	Four-digit year

`TO_CHAR(`*`number`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts *`number`* to a `VARCHAR2` in the *`format`* specified. When *`format`* is omitted, *`number`* is converted to a string long enough to hold the number. The *`nls_parameter`* option offers additional control over formatting options. For example:

```
SELECT TO_CHAR(123.45, '$999.99') FROM DUAL -> $123.45
```

`TO_CLOB(`*`expr`*`)`
: Converts the character expression given by *`expr`* to the `CLOB` data type. For example:

```
SELECT LENGTH(TO_CLOB('I am a SQL nut!')) FROM DUAL -> 15
```

`TO_DATE(`*`string`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts *`string`* (a `CHAR` or `VARCHAR2`) to the `DATE` data type. The *`nls_parameter`* option offers additional control over formatting options. For example:

```
SELECT TO_DATE('15/04/2022', 'DD/MM/YYYY') FROM DUAL
-> 15-APR-2022
```

`TO_DSINTERVAL(`*`string`*`[, `*`nls_parameter`*`])`
: Converts the character expression given by *`string`* to the `INTERVAL DAY TO SECOND` data type. The *`nls_parameter`* option offers additional control over formatting options. For example:

```
SELECT CURRENT_DATE, CURRENT_DATE-TO_DSINTERVAL('14 00:00:00')FROM DUAL ->
15-APR-2022     01-APR-2022
```

`TO_LOB(`*`long_column`*`)`
: Converts `LONG` or `LONG RAW` values in the column *`long_column`* to `LOB` values. Usable only by `LONG` or `LONG RAW` expressions and only in the `SELECT` list of a subquery in an `INSERT` statement.

`TO_MULTI_BYTE(`*`string`*`)`
: Returns *`string`* with all of its single-byte characters converted to their corresponding multibyte characters.

`TO_NCHAR(`*`expr`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Synonymous with the `TO_CHAR` function, except the return data type is `NCHAR`. For more on valid format specifiers, see the `TO_CHAR` function.

`TO_NCLOB(`*`expr`*`)`
: Converts the character expression given by *`expr`* to the `NCLOB` data type. For example:

```
SELECT LENGTH(TO_NCLOB('I am a SQL nut!')) FROM DUAL -> 15
```

`TO_NUMBER(`*`string`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
: Converts a numeric *`string`* (a `CHAR` or `VARCHAR2`) to the `NUMBER` data type, optionally in the format specified by the *`format`* parameter. The *`nls_parameter`*

option offers additional control over formatting options. (For more on valid format specifiers, see the `TO_CHAR` function.) For example:

```
SELECT TO_NUMBER('12345') FROM DUAL -> 12345
```

`TO_SINGLE_BYTE(`*`string`*`)`
Returns *`string`* with all of its multibyte characters converted to their corresponding single-byte characters.

`TO_TIMESTAMP(`*`string`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
Converts the character expression provided by *`string`* to the `TIMESTAMP` data type, optionally in the format specified by the *`format`* parameter. The *`nls_parameter`* option offers additional control over formatting options. (For more on valid format specifiers, see the `TO_CHAR` function.) For example:

```
SELECT TO_TIMESTAMP(CURRENT_DATE) FROM DUAL -> 15-APR-22 12.00.00 AM
```

`TO_TIMESTAMP_TZ(`*`string`*`[, `*`format`*`[, `*`nls_parameter`*`]])`
Converts the character expression provided by *`string`* to the `TIMESTAMP WITH TIME ZONE` data type, optionally in the format specified by the *`format`* parameter. The *`nls_parameter`* option offers additional control over formatting options. (For more on valid format specifiers, see the `TO_CHAR` function.) For example:

```
SELECT TO_TIMESTAMP_TZ('15-04-2022', 'DD-MM-YYYY') FROM DUAL ->
15-APR-22 12.00.00.000000000 AM −07:00
```

`TO_YMINTERVAL(`*`string`*`)`
Converts the character expression provided by *`string`* to the `INTERVAL YEAR TO MONTH` data type. For example:

```
SELECT TO_DATE('29-FEB-2020')+TO_YMINTERVAL('04-00') FROM DUAL ->
29-FEB-24
```

`TREAT(`*`expr`*` AS [REF] [`*`schema.`*`]`*`type`*`)`
Converts *`expr`* from its declared type to the type specified by the *`type`* parameter. For more information on the usage of this function, refer to the Oracle SQL Reference.

`TRUNC(`*`base`*`[, `*`number`*`])`
Returns *`base`* truncated to *`number`* decimal places. When *`number`* is omitted, *`base`* is truncated to an integer. *`number`* can be negative to truncate all digits to the left of the decimal point. For example:

```
SELECT TRUNC('123.456', 2) FROM DUAL -> 123.45
```

`TRUNC(`*`date`*`[, `*`format`*`])`
Returns *`date`* truncated to the unit specified by *`format`*. When *`format`* is omitted, *`date`* is truncated to the nearest whole day. (For more on valid format specifiers, see the `TO_CHAR` function.) For example:

```
SELECT TRUNC(TO_DATE('15/04/2022', 'MM/DD/YYYY'), 'YYYY')
   FROM DUAL -> 2022
```

`TZ_OFFSET({expr| SESSIONTIMEZONE | DBTIMEZONE})`
: Returns the time zone offset corresponding to the argument. The character expression *`expr`* can either be the name of the time zone or a time zone offset. The `SESSIONTIMEZONE` and `DBTIMEZONE` arguments provide the time zone for the session or database, respectively. For example:

```
SELECT TZ_OFFSET('+08:00'), TZ_OFFSET(SESSIONTIMEZONE) FROM DUAL ->
+08:00      -07:00
```

`UID`
: Returns an integer that uniquely identifies the currently logged-on session user. No parameters are needed. For example:

```
SELECT UID FROM DUAL -> 47
```

`UNISTR(string)`
: Converts *`string`* to the `NCHAR` data type, while converting any Unicode-encoded values within *`string`*. For example:

```
SELECT UNISTR('El Ni\00F1o') FROM DUAL -> 'El Niño'
```

`UPDATEXML(instance, xpath, expr[, namespace])`
: Updates the values held by nodes within *`instance`* to the new value in *`expr`*. Only those nodes returned by the XPath query contained in the *`xpath`* parameter are updated. The optional *`namespace`* parameter specifies the XML namespace in the query. For more information on XML queries, refer to the Oracle SQL Reference. For example:

```
SELECT UPDATEXML( XMLTYPE('<foo><bar>Hello, World!</bar></foo>'),
   '/foo/bar', '<bar>Bye, World!</bar>' ) from DUAL -> Bye, World!
```

`VALUE(table_alias)`
: Takes a *`table_alias`* associated with a row in an object table and returns the object instance stored within the object table for that row.

`VSIZE(expression)`
: Returns the number of bytes in the internal representation of *`expression`*. When *`expression`* is `NULL`, returns `NULL`. For example:

```
SELECT vsize(1) FROM DUAL -> 2
```

PostgreSQL-Supported Functions

This section lists the scalar and set-returning functions specific to PostgreSQL, with examples and corresponding results for most of them. The more esoteric functions have been left out because they are not widely used:

`AGE(`*`timestamp`*`[, `*`timestamp`*`])`

Returns the time between the two *`timestamp`* values. If only one *`timestamp`* value is provided, the second is assumed to be the current time. For example:

```
AGE( '2021-12-31', CURRENT_TIMESTAMP ) ->
3 mons 15 days 00:34:41.658325
```

`ARRAY_APPEND(`*`array, element`*`)`

Returns the result of appending *`element`* to *`array`*. For example:

```
ARRAY_APPEND(ARRAY[1,2], 3) -> {1,2,3}
```

`ARRAY_CAT(`*`array1, array2`*`)`

Returns the result of appending *`array2`* to *`array1`*. For example:

```
ARRAY_CAT(ARRAY[1,2], ARRAY[3,4]) -> {1,2,3,4}
```

`ARRAY_DIMS(`*`array`*`)`

Returns the text representation of *`array`* dimensions. For example:

```
ARRAY_DIMS(ARRAY[1,2]) -> '[1:2]'
```

`ARRAY_FILL(`*`anyelement, integer`*`[][, `*`integer`*`[]])`

Returns a dimensional array filled with the *`anyelement`* value. The *`integer`*`[]` integer array determines the dimensions. The optional integer array supplies lower bound values. For example:

```
ARRAY_FILL(true, ARRAY[2,3]) -> {{t,t,t},{t,t,t}}
ARRAY_FILL(true, ARRAY[3], ARRAY[2]) -> [2:4]={t,t,t}
```

`ARRAY_LENGTH(`*`array, i`*`)`

Returns the length of a requested array dimension. For example:

```
ARRAY_LENGTH(ARRAY[[1,2],[2,3],[4,5]], 1) -> 3
```

`ARRAY_LOWER(`*`array, i`*`)`

Returns the lower bound of the dimension *`i`* of *`array`*. For example:

```
ARRAY_LOWER(ARRAY[[1,2],[2,3],[4,5]], 1) -> 1
```

`ARRAY_NDIMS(`*`array`*`)`

Returns the number of dimensions of *`array`*. For example:

```
ARRAY_NDIMS(ARRAY[1,2]) -> 1
```

`ARRAY_POSITION(`*`array, anyelement`*`)`

Returns the position number of an element in a one-dimensional array, or NULL if the element is not present. For example:

```
ARRAY_POSITION(ARRAY[1,2,-1,2],-1) -> 3
```

`ARRAY_POSITIONS(`*`array, anyelement`*`)`

Returns an integer array that specifies the positions of an element in a one-dimensional array, or NULL if the element is not present. For example:

```
ARRAY_POSITIONS(ARRAY[1,2,-1,2],2) -> {2,4}
```

`ARRAY_PREPEND(`*`i, array`*`)`
: Returns the result of prepending *`i`* to *`array`*. For example:

```
ARRAY_PREPEND(0, ARRAY[1,2]) -> {0,1,2}
```

`ARRAY_REMOVE(`*`array, anyelement`*`)`
: Returns an array with any occurrences of the specified element removed from the input array. For example:

```
ARRAY_REMOVE(ARRAY[1,2,-1,2],2) -> {1,-1}
```

`ARRAY_REPLACE(`*`array, anyelement`*`)`
: Returns an array with any occurrences of the specified element in the input array replaced with another element. For example:

```
ARRAY_REPLACE(ARRAY[1,2,-1,2],2,3) -> {1,3,-1,3}
```

`ARRAY_TO_STRING(`*`array, delimiter`*`)`
: Returns a string that is constructed by concatenating the elements of *`array`*, with *`delimiter`* used as a delimiter between each element. For example:

```
ARRAY_TO_STRING(ARRAY[1,2,3], ';') -> '1;2;3'
```

`ARRAY_TO_TSVECTOR(`*`text`*`[])`
: Converts an array of text to full-text *tsvector* type. For example:

```
ARRAY_TO_TSVECTOR(ARRAY['Johnny smokes', 'weed', 'weed']) ->
'Johnny smokes' 'weed'
```

`ARRAY_UPPER(`*`array, i`*`)`
: Returns the upper bound of the dimension *`i`* of *`array`*. For example:

```
ARRAY_UPPER(ARRAY[1,2], 1) -> 2
```

`ASCII(`*`text`*`)`
: Returns the ASCII code of the first character of *`text`*. For example:

```
ASCII('x') -> 120
```

`BROADCAST(`*`inet`*`)`
: Constructs a broadcast address as text. For example:

```
BROADCAST('192.168.1.5/24') -> '192.168.1.255/24'
```

`BTRIM(`*`s, c`*`)`
: Return *`s`* without the characters found in *`c`*. For example:

```
BTRIM('<<<trim_me>>>', '><') -> 'trim_me'
```

`CBRT(`*`float8`*`)`
: Returns the cube root of *`float8`*. For example:

```
CBRT(8) -> 2
```

`CHAR(`*`text`*`)`
: Converts *`text`* to the `CHAR` type.

`CHR(`*`integer`*`)`
: Returns the character with the given code. In UTF8 encoding the argument is treated as a Unicode code point. In other multibyte encodings the argument must designate an ASCII character. `CHR(0)` is disallowed because text data types cannot store that character. For example:

```
CHR(64) -> @
```

`CLOCK_TIMESTAMP()`
: Returns the current date and time, which can change within a single SQL statement execution.

`CONCAT_WS(`*`separator, str1, str2`*`[, ... ])`
: A special form of `CONCAT` that inserts *`separator`* between every pair of string arguments concatenated. If *`separator`* is NULL, the result is NULL. For example:

```
CONCAT_WS(', ', au_lname, au_fname ) -> 'Jefferson, Thomas'
```

`CURRVAL(`*`s`*`)`
: Returns the current value of the sequence named *`s`*. For example:

```
CURRVAL( 'myseq' ) -> 99
```

`DATE_TRUNC(`*`precision, timestamp`*`)`
: Truncates *`timestamp`* to the specified *`precision`*. For example:

```
DATE_TRUNC('hour', TIMESTAMP '2022-04-15 23:58:30') ->
2022-04-15 23:00:00
```

`DECODE(`*`s, type`*`)`
: Decodes an encoded string *`s`*. The *`type`* can be `'base64'`, `'hex'`, or `'escape'`. For example:

```
DECODE( ENCODE('darjeeling', 'base64'), 'base64' ) ->
'darjeeling'
```

`DEGREES(`*`float8`*`)`
: Converts radians to degrees. For example:

```
DEGREES( 3.1415926 ) -> 179.999996929531
```

`ENCODE(`*`s, type`*`)`
: Encodes a string *`s`*. The *`type`* can be `'base64'`, `'hex'`, or `'escape'`. For example:

```
DECODE( ENCODE('darjeeling', 'base64'), 'base64' ) ->
'darjeeling'
```

`FLOAT(`*`int`*`), FLOAT4(`*`int`*`)`
: Converts *`int`* to a floating point.

`FORMAT(`*`string, replace1`*`[, `*`replace2, ...`*` ])`
: Formats arguments according to a format string;

```
format('Hello %s %L you owe me %I', 'Donald', 'Duck',
   'mucho money') -> Hello Donald 'Duck' you owe me "mucho money"
```

`GET_CURRENT_TS_CONFIG()`
: Gets the default full text configuration. For example:

```
GET_CURRENT_TS_CONFIG() -> english
```

`HOST(`*`inet`*`)`
: Extracts the host address as text. For example:

```
HOST('192.168.1.5/24') -> '192.168.1.5'
```

`INITCAP(`*`text`*`)`
: Converts the first letter of each word to uppercase. For example:

```
INITCAP( 'my name is inigo montoya.' ) -> 'My Name Is Inigo Montoya.'
```

`INTEGER(`*`float`*`)`
: Converts a *`float`* to an integer.

`ISFINITE(`*`interval`*`)`
: Returns `'f'` if *`interval`* is open, and `'t'` otherwise. For example:

```
ISFINITE(INTERVAL '4 hours') -> 't'
```

`ISFINITE(`*`timestamp`*`)`
: Returns `'f'` if *`timestamp`* is either invalid or infinite, and `'t'` otherwise. For example:

```
ISFINITE(TIMESTAMP '2022-02-16 21:28:30') -> 't'
```

`JUSTIFY_DAYS(`*`interval`*`)`
: Returns the number of 30-day time periods within *`interval`*. For example:

```
JUSTIFY_DAYS(INTERVAL '90 days') -> 3
```

`JUSTIFY_HOURS(`*`interval`*`)`
: Returns the number of 24-hour time periods within *`interval`*. For example:

```
JUSTIFY_HOURS(INTERVAL '48 hours') -> 2 days
```

`JUSTIFY_INTERVAL(`*`interval`*`)`
: Returns the number of 30-day time periods and remaining 24-hour time periods within *`interval`*. For example:

```
JUSTIFY_INTERVAL(INTERVAL '2 mon - 12 hour') ->
'2 mons -12:00:00'
```

`LEFT(`*`string, n`*`)`
: Returns the leftmost *`n`* characters of *`string`*. For example:

```
LEFT('hello', 3 ) -> hel
```

`LPAD(`*`text, int[, char`*`])`
: Returns the string *`text`*, left-padded to the specified (*`int`*) length with the specified fill character (if not specified, defaults to a space). For example:

```
LPAD('Duck', 10, 's') -> 'ssssssDuck'
```

`LTRIM(`*`text`*`)`
: Returns *`text`* with all leading whitespace removed. For example:

```
LTRIM('    Howdy!    ') -> 'Howdy!    '
```

`MASKLEN(`*`cidr`*`)`
: Returns the netmask length of *`cidr`*. For example:

```
MASKLEN('192.168.1.5/24') -> 24
```

`MD5(`*`s`*`)`
: Returns the MD5 hash of *`s`*.

`NETMASK(`*`inet`*`)`
: Returns the netmask for *`inet`*. For example:

```
NETMASK('192.168.1.5/24') -> '255.255.255.0'
```

`NETWORK(`*`inet`*`)`
: Returns the network part of *`inet`*. For example:

```
NETWORK('192.168.1.5/24') -> '192.168.1.0/24'
```

`NEXTVAL(`*`s`*`)`
: Returns the next number in the sequence named *`s`*. For example:

```
NEXTVAL('myseq') -> 100
```

`NORMALIZE(`*`text`*`[, `*`form`*`])`
: Converts the string *`text`* to the specified Unicode normalization form. The optional *`form`* keyword specifies the form: `NFC` (the default), `NFD`, `NFKC`, or `NFKD`. This function can only be used when the server encoding is UTF8. For example:

```
NORMALIZE(U&'\0061\0308bc',NFC) -> U&'\00E4bc'
```

`NUMNODE(`*`tsquery`*`)`
: Returns the number of lexemes plus operators in a *`tsquery`*. For example:

```
NUMNODE('happy & fat & elephant'::tsquery) -> 5
```

`PARSE_IDENT(`*`string`*`[, boolean DEFAULT true ] )`
: Returns an array from a string that represents an identifier, such as *<schema>.<table>*. *boolean* denotes strict mode and defaults to *true* if not specified. For example:

```
PARSE_IDENT('"Nutshell".orders') -> {Nutshell,orders}
PARSE_IDENT('Nutshell.orders') -> {nutshell,orders}
```

`PG_CLIENT_ENCODING()`
: Returns the name of the current client encoding in use. For example:

```
PG_CLIENT_ENCODING() -> UTF8
```

`PI()`
: Returns the constant π.

`PHRASETO_TSQUERY([regconfig, ]text)`
: Converts the *text* to the specified full-text query and includes distance operators. If the full-text *regconfig* is not provided, then uses the default database one. For example:

```
PHRASETO_TSQUERY('happy fat elephant') ->
'happi' <-> 'fat' <-> 'eleph'
PHRASETO_TSQUERY('simple','happy fat elephant') ->
'happy' <-> 'fat' <-> 'elephant'
```

`PLAINTO_TSQUERY([regconfig,] text)`
: Converts the *text* to the specified full-text query. If the full-text *regconfig* is not provided, then uses the default database one. For example:

```
PLAINTO_TSQUERY('happy fat elephant') ->
'happi' & 'fat' & 'eleph'
PLAINTO_TSQUERY('simple','happy fat elephant') ->
'happy' & 'fat' & 'elephant'
```

`POW(number, exponent)`
: Raises *number* to the specified *exponent*. For example:

```
POW( 2, 3 ) -> 8
```

`QUOTE_IDENT(s)`
: Returns *s* properly escaped so that it can be used as an identifier in a SQL statement. For example:

```
QUOTE_IDENT( 'tea' ) -> "tea"
```

`QUOTE_LITERAL(anyelement)`
: Returns *anyelement* properly escaped so that it can be used as a string literal in a SQL statement. If it's NULL, returns NULL. For example:

```
QUOTE_LITERAL( 'you''re here' ) -> 'you''re here'
```

`QUOTE_NULLABLE(anyelement)`
: Converts *anyelement* to a string literal. If it's NULL, returns NULL as an unquoted string. For example:

```
QUOTE_NULLABLE( 'you''re here' ) -> 'you''re here'
QUOTE_NULLABLE( null) -> NULL
```

`RADIANS(float8)`
: Converts degrees to radians. For example:

```
RADIANS( 180 ) -> 3.14159265358979
```

RADIUS(*circle*)

Returns the radius of *circle*. For example:

```
RADIUS( CIRCLE '((0,0), 2.0)' ) -> 2
```

RANDOM()

Returns a random value between 0.0 and 1.0. For example:

```
RANDOM() -> 0.785398163397448
```

REGEXP_MATCH(*s*, *pattern*[, *flags*])

Returns captured substrings as an array resulting from the first match within *s* of the regular expression *pattern*. The optional *flags* argument can specify non-default processing by the regular expression matching engine. The most common options for *flags* are `'i'` for case-insensitive matching and `'n'` for newline-sensitive matching. `'g'` for global matching is not supported by this function. For example:

```
REGEXP_MATCH('catfish cowfish dogcat', 'c[a-z]+') -> {catfish}
```

REGEXP_MATCHES(*s*, *pattern*[, *flags*])

Returns a set of rows of arrays within *s* matching the regular expression *pattern*. The optional *flags* argument can specify non-default processing by the regular expression matching engine. The most common options for *flags* are `'i'` for case-insensitive matching, `'n'` for newline-sensitive matching, and `'g'` for global matching. For example:

```
REGEXP_MATCHES('catfish cowfish dogcat', 'c[a-z]+', 'g') ->
{catfish}
{cowfish}
{cat}
```

REGEXP_REPLACE(*s*, *pattern*, *replacement*[, *flags*])

Returns *s* with all substrings matching the regular expression *pattern* replaced with the string found in *replacement*. The optional *flags* argument can select non-default processing by the regular expression matching engine. The most common options for *flags* are `'i'` for case-insensitive matching, `'n'` for newline-sensitive matching, and `'g'` for global matching. For example:

```
REGEXP_REPLACE('ab1ab2ab3', '[0-9]+', 'X') -> abXab2ab3
REGEXP_REPLACE('ab1ab2ab3', '[0-9]+', 'X', 'g') -> abXabXabX
```

REGEXP_SPLIT_TO_ARRAY(*s*, *pattern*[, *flags*])

Returns *s* split into an array using the regular expression *pattern* as the delimiter for array elements. The optional *flags* argument can specify non-default processing by the regular expression matching engine. The most common options for *flags* are `'i'` for case-insensitive matching, `'n'` for newline-sensitive matching, and `'g'` for global matching. For example:

```
REGEXP_SPLIT_TO_ARRAY('a b c', E'\\s+') -> {a,b,c}
```

`REGEXP_SPLIT_TO_TABLE(`*`s, pattern`*`[, `*`flags`*`])`

Returns *`s`* split into a table using the regular expression *`pattern`* as the delimiter for rows. The optional *`flags`* argument can select non-default processing by the regular expression matching engine. The most common options for *`flags`* are `'i'` for case-insensitive matching, `'n'` for newline-sensitive matching, and `'g'` for global matching. For example:

```
REGEXP_SPLIT_TO_TABLE('a b c', E'\\s+') ->
'a'
'b'
'c'
```

`REPEAT(`*`string, n`*`)`

Repeats *`string`* the number of times designated by *`n`*. For example:

```
REPEAT( 'hello ', 3 ) -> hello hello hello
```

`REPLACE(`*`string, search_string`*`[, `*`replacement_string`*`])`

Returns *`string`* with every occurrence of *`search_string`* replaced with *`replacement_string`*. For example:

```
REPLACE('change', 'e', 'ing') -> changing
```

`REVERSE(`*`string`*`)`

Reverses the characters of *`string`*. For example:

```
REVERSE( 'hello' ) -> olleh
```

`RIGHT(`*`string, n`*`)`

Returns the rightmost *`n`* characters of *`string`*. For example:

```
RIGHT('hello', 3 ) -> llo
```

`ROUND(`*`number`*`[, `*`p`*`])`

Rounds *`number`* to *`p`* decimal places. The optional *`p`* argument defaults to 0 for classic rounding of integers. For example:

```
ROUND( 5.5 ) -> 6
ROUND( 5.5555, 2 ) -> 5.56
```

`RPAD(`*`text, int`*`[, `*`char`*`])`

Pads *`text`* to the specified length (*`int`*) using *`char`* (defaults to a space). For example:

```
RPAD('Duck', 10, 's') -> 'Ducksssss'
```

`RTRIM(`*`text`*`)`

Returns *`text`* with all trailing whitespace removed. For example:

```
RTRIM('    St. Lucia    ') -> '    St. Lucia'
```

`SET_MASKLEN(`*`inet, size`*`)`

Sets the netmask length for *`inet`* to *`size`*. For example:

```
SET_MASKLEN('192.168.1.5/24',16) -> '192.168.1.5/16'
```

SETSEED(*i*)
Seeds the random number generator with *i*.

SETVAL(*s*, *i*)
Sets the next number in the sequence named *s* to *i*. For example:

```
SETVAL('myseq', 0)
```

SETWEIGHT(*tsvector*, *weight*[, *lexemes*])
Sets the full-text weight of elements in a full-text vector. The *weight* is a letter between A and D. *lexemes* is an optional array of text; if not provided, all elements in the vector are assigned the *weight*. For example:

```
SETWEIGHT('johnny:1 smokes:2 weed:3,4'::tsvector, 'A') ->
'johnny':1A 'smokes':2A 'weed':3A,4A

SETWEIGHT('johnny:1 smokes:2 weed:3,4'::tsvector, 'A',
   ARRAY['smokes', 'weed']) -> 'johnny':1 'smokes':2A 'weed':3A,4A
```

SIGN(*number*)
Returns the sign of *number*. For example:

```
SIGN( –69 ), SIGN(69) -> -1,1
```

SPLIT_PART(*s*, *delimiter*, *nth*)
Returns the *nth* substring of *s* using *delimiter* as a delimiter. For example:

```
SPLIT_PART('Donald~@~Mickey~@~Minnie', '~@~', 2) -> Mickey
```

STARTS_WITH(*s*, *substring*)
Returns a Boolean indicating whether the string *s* starts with *substring*. For example:

```
STARTS_WITH('Donald Duck', 'Donald') -> TRUE
```

STATEMENT_TIMESTAMP()
Returns the date and time at which the SQL statement began execution.

STRING_TO_ ARRAY(*str1*, *delimiter*)
Returns an array that is constructed by extracting the elements of *str1* using *delimiter* as a delimiter between each element. For example:

```
STRING_TO_ARRAY('1;2;3', ';') -> {1,2,3}
```

STRING_TO_ TABLE(*str1*, *delimiter*)
Returns the set of rows that is constructed by extracting the elements of *str1* using *delimiter* as a delimiter between each element. Note that all set-returning functions in PostgreSQL support the WITH ORDINALITY clause. For example:

```
SELECT v.ord, v.val
FROM STRING_TO_TABLE('Donald~@~Mickey~@~Minnie', '~@~')
   WITH ORDINALITY AS v(val, ord) ->
 ord |  val
```

```
-----+--------
    1 | Donald
    2 | Mickey
    3 | Minnie
```

`STRIP(`*`tsvector`*`)`
: Strips weights and positions from a *`tsvector`*. For example:

```
STRIP('johnny:1A smokes:2 weed:3,4'::tsvector) ->
'johnny' 'smokes' 'weed'
```

`STRPOS(`*`s, substring`*`)`
: Returns the starting index of *`substring`* in the string *s*. For example:

```
STRPOS('Donald Duck', 'Duck') -> 8
```

`SUBSTR(`*`s, start`*`[, `*`count`*`])`
: Returns the substring of *`s`* starting at *`start`* with *`count`* characters. If *`count`* is omitted, it returns the substring from *`start`* to the end of the string. For example:

```
SUBSTR('Donald Duck', 8) -> Duck
```

`TIMEOFDAY()`
: Returns the current timestamp (using `CLOCK_TIMESTAMP`) as a string.

`TIMESTAMP(`*`date`*`[, `*`time`*`])`
: Converts *`date`* to a timestamp.

`TO_ASCII(`*`string`*`), TO_ASCII(`*`string, encodingname`*`)`
: Converts *`string`* to ASCII from another encoding, which may be identified by name or number. If *`encoding`* is omitted the database encoding is assumed (which in practice is the only useful case). The conversion consists primarily of dropping accents. Conversion is only supported from LATIN1, LATIN2, LATIN9, and WIN1250 encodings. (See the PostgreSQL *unaccent* module for another, more flexible solution.) For example:

```
TO_ASCII('Café') -> Cafe
```

`TO_CHAR(`*`expression, format`*`)`
: Converts *`expression`* to a formatted string. For example:

```
TO_CHAR(NUMERIC '-125.8', '999D99S') -> 125.80-
TO_CHAR(INTERVAL '15h 2m 12s', 'HH24:MI:SS') -> 15:02:12
```

`TO_DATE(`*`string, format`*`)`
: Converts *`string`* to a date using the second argument for the input format. For example:

```
TO_DATE('05 Dec 2020', 'DD Mon YYYY') -> 2020-12-05
```

Table 7-11 lists the available specifiers for *`format`* and their meanings.

Table 7-11. PostgreSQL format specifiers

Format specifier	Meaning
AD or A.D.	AD indicator
AM or A.M.	Meridian indicator
BC or B.C.	BC indicator
CC	Two-digit century
D	Day of week (1–7)
DAY	Full uppercase day name
Day	Full CamelCase day name
day	Full lowercase day name
DD	Day of month (01–31)
DDD	Day of year (001–366)
DY	Abbreviated day name
Dy	Abbreviated camel-case day name
dy	Abbreviated lowercase day name
HH or HH12	Hour (01–12)
HH24	Hour (00–23)
I	Last digits of ISO year
IW	ISO week number of year
IY, IYY, IYYY	Last two digits, three digits, or all digits of ISO year, respectively
J	Julian day number (days since January 1, 4713 BC)
MI	Minute (00–59)
MM	Month (01–12)
MON	Abbreviated month name
Mon	Abbreviated camel-case month name
mon	Abbreviated lowercase month name
MONTH	Full uppercase month name
Month	Full camel-case month name
month	Full lowercase month name
MS	Milliseconds (000–999)
PM or P.M.	Meridian indicator
Q	Quarter of the year
RM	Roman numeral month (I–XII)
rm	Lowercase Roman numeral month (i–xii)
SS	Second (00–59)
SSSS	Seconds past midnight (0–86,399)

Format specifier	Meaning
`SYYY`	Four-digit year; BC dates are prefixed with a minus sign
`TS`	Short time format
`TZ`	Uppercase time zone name
`tz`	Lowercase time zone name
`US`	Microseconds (000000–999999)
`W`	Week of month (1–5)
`WW`	Week of year (1–53)
`Y, YY, YYY, YYYY`	One-, two-, three-, or four-digit year, respectively
`Y,YYY`	Year with comma

`TO_HEX(`*`integer`*`)`
: Converts *`integer`* to its hexadecimal representation. For example:

```
to_hex(50000000) -> 2faf080
```

`TO_NUMBER(`*`string, format`*`)`
: Converts *`string`* to a numeric value using the second argument for the input format. For example:

```
TO_NUMBER('12,454.8-', '99G999D9S') -> -12454.8
```

`TO_TIMESTAMP(`*`text, format`*`)`
: Converts *`text`* to a timestamp value using the second argument for the input format. (For more on valid format specifiers, see the `TO_DATE` function.) For example:

```
TO_TIMESTAMP('05 Dec 2020', 'DD Mon YYYY') -> 2020-12-05 00:00:00-08
```

`TO_TSQUERY([`*`config,`*`]`*`string`*`)`
: Normalizes words in a query *`string`* and converts it to a full-text query. If the full-text configuration is not specified then it uses the default configuration for the database. For example:

```
TO_TSQUERY('like & swimming') -> 'like' & 'swim'
TO_TSQUERY('simple','like & swimming') -> 'like' & 'swimming'
```

`TRANSACTION_TIMESTAMP()`
: Returns the date and time at which the current transaction was started.

`TRUNC(`*`float8`*`)`
: Truncates (toward zero). For example:

```
TRUNC( PI() ) -> 3
```

`VARCHAR(`*`string`*`)`
: Converts *`string`* to a `VARCHAR`.

WEBSEARCH_TO_TSQUERY([*regconfig*,] *text*)

Converts the *text* to the specified full-text query and converts words like "and" and "or" to their equivalent query operators. If the full-text *regconfig* is not provided, uses the default database configuration. For example:

```
WEBSEARCH_TO_TSQUERY('happy fat elephant or dog') ->
'happi' & 'fat' & 'eleph' | 'dog'
WEBSEARCH_TO_TSQUERY('simple','happy fat elephant or dog') ->
'happy' & 'fat' & 'elephant' | 'dog'
```

SQL Server–Supported Functions

This section provides an alphabetical listing of SQL Server–supported functions, with examples and corresponding results for most.

APP_NAME()

Returns the application name for the current session, set by the application. For example:

```
APP_NAME() -> 'SQL Enterprise Manager'
```

ASCII(*text*)

Returns the ASCII code of the first character of *text*. For example:

```
ASCII('x') -> 120
```

BINARY_CHECKSUM(* | *expression*[, ... *n*])

Returns the binary checksum for a list of expressions or for a row of a table. This example returns a list of user IDs where the stored password's checksum doesn't match the current password's checksum:

```
SELECT userid AS 'Changed' FROM users
WHERE NOT password_chksum = BINARY_CHECKSUM( password )
```

CHAR(*integer_expression*)

Converts a numeric ASCII code to a character. For example:

```
CHAR( 78 ) -> 'N'
```

CHARINDEX(*substring*, *string*[, *start_location*])

Returns the position of the first occurrence of *substring* in *string*, optionally from the given *start_location*. For example:

```
CHARINDEX( 'he', 'Howdy, there!' ) -> 9
```

CHECKSUM(* | *expression*[, ... *n*])

Returns a checksum (computed over the row values or expressions provided). The following example returns a list of user IDs for which the stored password's checksum doesn't match the current password's checksum (there is also an aggregate form of this function called CHECKSUM_AGG):

```
SELECT userid AS 'Changed' FROM users
WHERE NOT password_chksum = CHECKSUM( password )
```

`COL_LENGTH(`*`table, column`*`)`
: Returns the length of *`column`* in bytes. For example:

```
COL_LENGTH('authors', 'au_fname') -> 50
```

`COL_NAME(`*`table_id, column_id`*`)`
: Returns the column name, given *`table_id`* and *`column_id`*. For example:

```
COL_NAME( OBJECT_ID('authors'), 1 )
```

`CONTAINS({`*`column`*` | *}, `*`contains_search_condition`*`)`
: Searches *`column`* for exact or "fuzzy" matches of the *`contains_seach_condition`*. `CONTAINS` is an elaborate function used to perform full-text searches; refer to the vendor documentation for more information. This example returns all product IDs from the *products* table that contain the words "peanut" and "butter" in close proximity to each other.

```
SELECT productid FROM products
WHERE CONTAINS(productname, ' "peanut" NEAR "butter" ' )
```

`CONTAINSTABLE(`*`table, column, contains_search_condition`*`)`
: Returns a *`table`* with exact and "fuzzy" matches of the *`contains_search_condition`*. `CONTAINSTABLE` is an elaborate function used to perform full-text searches. The following example returns all product IDs from the *products* table that contain the words "peanut" and "butter" in close proximity to each other:

```
SELECT products.productid, products.productname, ct.rank
FROM products
 INNER JOIN CONTAINSTABLE(products, productname,
  ' "peanut" NEAR "butter" ')
 AS ct ON products.productid = ct.key
```

`DATABASEPROPERTYEX(`*`database, property`*`)`
: Returns a database option or property. For example:

```
DATABASEPROPERTYEX('pubs', 'Version') -> 539
```

`DATA_LENGTH(`*`expression`*`)`
: Returns the number of bytes in a character or binary string. For example:

```
SELECT MAX( DATA_LENGTH( au_fname ) ) FROM authors -> 11
```

`DATEADD(`*`date_part, number, date`*`)`
: Adds a number of *`date_parts`* (e.g., days) to a datetime value. For example:

```
DATEADD(Year, 10, CURRENT_TIMESTAMP) -> 2032-04-15 01:46:21.707
```

`DATEDIFF(`*`date_part, start_date,end_date`*`)`
: Calculates the difference between two datetime values expressed in the specified *`date_part`*. For example:

```
DATEDIFF( Day, CURRENT_TIMESTAMP, DATEADD( Year, 1,
   CURRENT_TIMESTAMP )) -> 366
```

DATENAME(*date_part, date*)
: Returns the name of a *date_part* (e.g., month) of a datetime argument. For example:

```
DATENAME(month, GETDATE()) -> 'April'
```

DATEPART(*date_part, date*)
: Returns the value of a *date_part* (e.g., year) of a datetime argument. For example:

```
DATEPART(year, GETDATE()) -> 2022
```

DAY(*date*)
: Returns an integer value representing the day of the *date* provided as a parameter. For example:

```
DAY('04/15/2022') -> 15
```

DB_ID([*database_name*])
: Returns the database ID when provided with a *database_name*. For example:

```
DB_ID() -> 5
```

DB_NAME(*database_id*)
: Returns the database name when provided with a *database_id*. For example:

```
DB_NAME( 5 ) -> 'pubs'
```

DEGREES(*numeric_expression*)
: Converts radians to degrees. For example:

```
DEGREES( PI() ) -> 180
```

DIFFERENCE(*character_expression, character_expression*)
: Compares how two arguments sound and returns a number from 0 to 4, with a higher result indicating a better phonetic match. For example:

```
DIFFERENCE( 'moe', 'low' ) -> 3
```

FILE_ID(*file_name*)
: Returns the file ID for the logical *file_name*. For example:

```
FILE_ID( 'master' ) -> 1
```

FILE_NAME(*file_id*)
: Returns the logical filename for the *file_id*. For example:

```
FILE_NAME( 1 ) -> 'master'
```

FILEGROUP_ID(*filegroup_name*)
: Returns the filegroup ID for the logical *filegroup_name*. For example:

```
FILEGROUP_ID( 'PRIMARY' ) -> 1
```

`FILEGROUP_NAME(`*`filegroup_id`*`)`
: Returns the logical filegroup name for *`filegroup_id`*. For example:

```
FILEGROUP_NAME( 1 ) -> 'PRIMARY'
```

`FILEGROUPPROPERTY(`*`filegroup_name, property`*`)`
: Returns the filegroup property value for the specified *`property`*. For example:

```
FILEGROUPPROPERTY( 'PRIMARY', 'IsReadOnly' ) -> 0
```

`FILEPROPERTY(`*`file_name, property`*`)`
: Returns the file property value for the specified *`property`*. For example:

```
FILEPROPERTY( 'pubs', 'SpaceUsed' ) -> 160
```

`FORMATMESSAGE(`*`msg_number, param_value n`*`])`
: Constructs a message from an existing message in the `SYSMESSAGES` table (similar to `RAISEERROR`). For example:

```
sp_addmessage 50001, 1, 'Table %s has %s rows.'
SELECT FORMATMESSAGE(50001, 'AUTHORS', (SELECT COUNT(*)
   FROM AUTHORS)) -> 'Table AUTHORS has 23 rows.'
```

`FREETEXT({`*`column`*` | *}, `*`freetext_string`*`)`
: Used for full-text searches. Returns rows with *`column`* values that match the meaning, but not exactly the value, of *`freetext_string`*. For example:

```
SELECT * FROM authors WHERE FREETEXT (*, 'kev')
```

`FREETEXTTABLE(`*`table`*`, {`*`column`*` | *}, `*`freetext_string`*`[, `*`top_n_by_rank`*`])`
: Used for full-text searches. Returns rows from *`table`* with *`column`* values that match the meaning, but not exactly the value, of *`freetext_string`*. For example:

```
SELECT * FROM FREETEXTTABLE (authors, *, 'kev')
```

`FULLTEXTCATALOGPROPERTY(`*`catalog_name, property`*`)`
: Returns the full-text catalog properties. For example:

```
FULLTEXTCATALOGPROPERTY( 'Cat_Desc', 'LogSize' )
```

`FULLTEXTSERVICEPROPERTY(`*`property`*`)`
: Returns the full-text service-level properties. For example:

```
FULLTEXTSERVICEPROPERTY('IsFulltextInstalled') -> 1
```

`GETANSINULL([`*`database`*`])`
: Returns the default nullability setting for new columns. For example:

```
GETANSINULL() -> 1
```

`GETDATE()`
: Returns the current date and time. For example:

```
GETDATE() -> 2022-04-1519:26:59.893
```

`GETUTCDATE()`
: Returns the current date as a Coordinated Universal Time (UTC) date. For example:

```
GETUTCDATE() -> 2022-04-15 02:26:46.720
```

`HOST_ID()`
: Returns the workstation ID. For example:

```
HOST_ID() -> 216
```

`HOST_NAME()`
: Returns the process hostname. For example:

```
HOST_NAME() -> 'PLATO'
```

`IDENT_CURRENT(`*`table_name`*`)`
: Returns the last identity value generated for the specified table. For example:

```
IDENT_CURRENT('jobs') -> 876
```

`IDENT_INCR(`*`table_or_view`*`)`
: Returns an identity column increment value. For example:

```
IDENT_INCR('jobs') -> 1
```

`IDENT_SEED(`*`table_or_view`*`)`
: Returns an identity seed value. For example:

```
IDENT_SEED('jobs') -> 1
```

`IDENTITY(`*`data_type`*`[, `*`seed, increment`*`]) AS `*`column_name`*
: Used in a `SELECT INTO` statement to insert an identity column into the destination table. For example:

```
SELECT IDENTITY(int, 1,1) AS ID INTO NewTable FROM OldTable
```

`INDEX_COL(`*`table, index_id, key_id`*`)`
: Returns an index column name given a table name, an index ID, and the sequential number of the column in the index key. For example:

```
INDEX_COL(OBJECT_ID('authors'), 1, 1) -> NULL
```

`INDEXPROPERTY(`*`table_id, index, property`*`)`
: Returns an index property (such as `FILLFACTOR`). For example:

```
INDEXPROPERTY(OBJECT_ID('authors'), 'UPKCL_auidind',
   'IsPadIndex') -> 0
```

`IS_MEMBER({`*`group`*` | `*`role`*`})`
: Returns true or false (1 or 0) depending on whether or not the user is a member of the specified Windows NT *group* or SQL Server *role*. For example:

```
IS_MEMBER( 'db_owner' ) -> 0
```

`IS_SRVROLEMEMBER(`*`role`*`[, `*`login`*`])`

Returns true or false (1 or 0) depending on whether or not the user is a member of the specified server *`role`*. For example:

```
IS_SRVROLEMEMBER( 'sysadmin' ) -> 0
```

`ISDATE(`*`expression`*`)`

Validates whether a character string can be converted to `DATETIME`. For example:

```
ISDATE(NULL), ISDATE(GETDATE()) -> 0      1
```

`ISNULL(`*`check_expression, replacement_value`*`)`

Returns the first argument if it is not NULL; otherwise, returns the second argument. For example:

```
ISNULL( NULL, 'NULL' ) -> 'NULL'
```

You should use `COALESCE` instead of `ISNULL` because `COALESCE` is a SQL standard function, is more versatile, and achieves the same goal as `ISNULL`.

`ISNUMERIC(`*`expression`*`)`

Validates whether a character string can be converted to `NUMERIC`. For example:

```
ISNUMERIC('3.1415'), ISNUMERIC('IRK') -> 1     0
```

`LEFT(`*`character_expression, integer_expression`*`)`

Returns the leftmost *`integer_expression`* characters of *`character_expression`*. For example:

```
LEFT( 'Wet Paint', 3 ) -> 'Wet'
```

`LTRIM(`*`character_expression`*`)`

Trims leading space characters. For example:

```
LTRIM('    beaucoup    ') -> 'beaucoup    '
```

`MONTH(`*`date`*`)`

Returns the month part of the date provided. For example:

```
MONTH( GETDATE() ) -> 4
```

`NCHAR(`*`integer_expression`*`)`

Returns the Unicode character with the given integer code. For example:

```
NCHAR(120) -> 'x'
```

`NEWID()`

Creates a new unique identifier of type `UNIQUEIDENTIFIER`. For example:

```
NEWID() -> '32B35185-F55E-4FE0-B2C8-B57B35815C12'
```

`OBJECT_ID(`*`object`*`)`

Returns the object ID of *`object`*. For example:

```
OBJECT_ID('authors') -> 8
```

`OBJECT_NAME(`*`object_id`*`)`
: Returns the object name of the object with the given *`object_id`*. For example:

```
OBJECT_NAME( OBJECT_ID('authors') ) -> 'authors'
```

`OBJECTPROPERTY(`*`id, property`*`)`
: Returns the properties of objects in the current database. For example:

```
OBJECTPROPERTY(object_id('authors'),'ISTABLE') -> 1
```

`OPEN {{[GLOBAL]` *`cursor_name`*`} |` *`cursor_variable_name`*`}`
: Opens a local or global cursor.

`OPENDATASOURCE(`*`provider_name, init_string`*`)`
: Makes a connection to a data source without using a linked server name. For examples, refer to the documentation.

`OPENQUERY(`*`linked_server, query`*`)`
: Queries a remote data source previously configured as a linked server. For examples, refer to the documentation.

`OPENROWSET(`*`provider_name`*`, {`*`datasource, user_id, password`*` |`
`provider_string``}, {[`*`catalog.`*`][`*`schema.`*`]`*`object`*` | `*`query`*`})`
: Queries a remote data source without setting it up as a linked server. For examples, refer to the documentation.

`PARSENAME(`*`object_name, object_piece`*`)`
: Returns the database name, owner name, server name, or object name for the object specified. *`object_piece`* is an integer between 1 and 4. For example:

```
PARSENAME('pubs..authors', 1) -> 'authors'
PARSENAME('pubs..authors', 2) -> NULL
PARSENAME('pubs..authors', 3) -> 'pubs'
PARSENAME('pubs..authors', 4) -> NULL
```

`PATINDEX('%`*`pattern`*`%',` *`expression`*`)`
: Returns the position of the first occurrence of a pattern in a string. For example:

```
PATINDEX('%Du%', 'Donald Duck') -> 8
```

`PERMISSIONS([`*`object_id`*`[,` *`column`*`]])`
: Returns a numeric value representing a bitmap with the current user's permissions on the specified object or column. For example:

```
PERMISSIONS(OBJECT_ID('authors'))&8 -> 8
```

`PI()`
: Returns the constant *pi*. For example:

```
2*PI() -> 6.2831853071795862
```

`RADIANS(`*`numeric_expression`*`)`
: Converts degrees to radians. For example:

```
RADIANS( 90.0 ) -> 1.570796326794896600
```

`RAND([seed])`
: Returns a pseudorandom `FLOAT` type value between *`seed`* and 1. For example:

```
RAND(PI()) -> 0.71362925915543995
```

`REPLICATE(character_expression, integer_expression)`
: Repeats a string a number of times. For example:

```
REPLICATE( 'FOOBAR', 3 ) -> 'FOOBARFOOBARFOOBAR'
```

`REPLACE(string_expression1, string_expression2, string_expression3)`
: Performs a search and replace on *`string_expression1`*, replacing each occurrence of *`string_expression2`* with *`string_expression3`*. For example:

```
REPLACE('North Dakota', 'Dakota', 'Carolina') -> 'North Carolina'
```

`REVERSE(character_expression)`
: Reverses the characters of a string. For example:

```
REVERSE( 'Donald Duck' ) -> 'kcuD dlanoD'
```

`RIGHT(character_expression, integer_expression)`
: Returns the rightmost *`integer_expression`* characters of *`character_expression`*. For example:

```
RIGHT( 'Donald Duck', 4 ) -> 'Duck'
```

`ROUND(number, decimal[, function])`
: Returns *`number`* rounded to *`decimal`* places to the right of the decimal point. Note that *`decimal`*, an integer, can be negative to round off digits to the left of the decimal point. If a nonzero integer is provided for *`function`*, the return value will be truncated; otherwise, the value is rounded. For example:

```
ROUND(PI(), 2) -> 3.1400000000000001
```

`ROWCOUNT_BIG()`
: Returns the number of rows affected by the most recent query. (Same as `@@ROWCOUNT`, but returns a `BIGINT` type.) For example:

```
ROWCOUNT_BIG() -> 1
```

`RTRIM(character_expression)`
: Trims trailing space characters from the expression. For example:

```
RTRIM('   beaucoup   ') -> '   beaucoup'
```

`SIGN(numeric_expression)`
: Returns –1 if the argument is negative, 0 if it is zero, and 1 if the argument is positive. For example:

```
SIGN(-PI()) -> –1.0
```

SOUNDEX(*character_expression*)

Returns a four-character code based on how the argument string sounds. This function allows words that are spelled differently but sound alike in English to be compared for equality. For example:

```
SOUNDEX('char') -> 'C600'
SOUNDEX('care') -> 'C600'
```

SPACE(*integer_expression*)

Returns a string consisting of a given number of space characters. For example:

```
SPACE(5) -> '     '
```

STATS_DATE(*table_id, index_id*)

Returns the date and time that index statistics were last updated. For example:

```
SELECT i.name, STATS_DATE(i.id, i.indid)
FROM sysobjects o, sysindexes i
WHERE o.name = 'authors' AND o.id = i.id ->
UPKCL_auidind   2022-01-06 01:34:00.153
aunmind         2022-01-06 01:34:00.170
```

STR(*number*[, *int*[, *decimal*]])

Converts *number* to a character string with length *int* and *decimal* decimal places.

STRING_ESCAPE(*string, escape_type*)

Returns *string* with special characters escaped. The only supported *escape_type* is 'json'. For example:

```
STRING_ESCAPE('"Hello"', 'json') -> \"Hello\"
```

STRING_SPLIT(*string, delimiter*)

Returns a table with a column named *value* derived from a delimited string. This is often used with the CROSS APPLY and OUTER APPLY constructs. For example:

```
SELECT value
FROM string_split('Donald Duck', ' ') ->
value
-------
Donald
Duck
```

STUFF(*string1, start, length, string2*)

Replaces *length* characters within *string1*, starting with the character in the *start* position, with those in *string2*. For example:

```
STUFF('North Dakota', 7, 6, 'Carolina') -> 'North Carolina'
```

`SUBSTRING(`*`string,start, length`*`)`
: Extracts *`length`* characters from *`string`*, starting at the character in the *`start`* position. For example:

```
SUBSTRING( 'North Dakota', 7, 6 ) -> 'Dakota'
```

`SUSER_ID([`*`login`*`])`
: Returns the system user ID of the current user, or for the specified *`login`*.

`SUSER_SID([`*`login`*`])`
: Returns the security ID (SID) for the current user, or for the specified *`login`*. The SID is returned in binary format. For example:

```
SUSER_SID('montoyai') -> 0x68FC17A71010DE40B005BCF2E443B377
```

`SUSER_SNAME([`*`server_user_sid`*`])`
: Returns the login name for the current user, or for the specified SID. For example:

```
SUSER_SNAME() -> 'montoyai'
```

`TEXTPTR(`*`column`*`)`
: Returns a pointer to a `TEXT`, `NTEXT`, or `IMAGE` column in `VARBINARY` format. For example:

```
SELECT TEXTPTR(pr_info)
FROM pub_info WHERE pub_id = '0736'
ORDER BY pub_id ->
0xFEFF6F00000000005C00000001000100
```

`TEXTVALID(`*`table.column, text_ptr`*`)`
: Returns true or false (1 or 0), depending on whether or not the provided pointer to a `TEXT`, `NTEXT`, or `IMAGE` column is valid. For example:

```
SELECT pub_id, 'Valid (if 1) Text data'
   = TEXTVALID('pub_info.logo', TEXTPTR(logo))
FROM pub_info
ORDER BY pub_id ->
0736        1
0877        1
1389        1
1622        1
1756        1
9901        1
9952        1
9999        1
```

`TYPEPROPERTY(`*`data_type, property`*`)`
: Returns information about data type properties. The *`data_type`* argument can contain the name of any data type, and *`property`* can be a string containing one of the following:

Precision
: The number of digits or characters the data type can store.

Scale
: The number of decimal places, for a numeric data type. A NULL value will be returned if *`data_type`* is not a numeric data type.

For example:

```
TYPEPROPERTY('decimal', 'PRECISION') -> 38
```

`UNICODE(`*`ncharacter_expression`*`)`
: Returns the Unicode code point for the first character of the input parameter. For example:

```
UNICODE('Hello!') -> 72
```

`USER_ID([`*`user`*`])`
: Returns the user ID for *`user`* in the current database. If *`user`* is omitted, the current user's ID will be returned. For example:

```
USER_ID() -> 2
```

`USER_NAME([`*`id`*`])`
: Returns the username of the user identified by *`id`* or, if no ID is provided, of the current user. For example:

```
USER_NAME() -> 'montoyai'
```

`YEAR(`*`date`*`)`
: Returns an integer that is the `YEAR` part of the specified date. For example:

```
YEAR( CURRENT_TIMESTAMP ) -> 2022
```

8

SQL Built-in Aggregate and Window Functions

In the previous chapter we discussed the different kinds of functions that exist in a database and focused our attention on scalar and set-returning (table) functions. In this chapter we will delve into the use of aggregate and window functions and detail which ones are defined in the SQL standard, providing detailed descriptions and examples for each platform. In addition, each database supports a long set of its own internal window and aggregate functions that are outside the scope of the SQL standard; listings of these functions for each vendor are provided at the end of each chapter.

In the case of MariaDB and MySQL, we will refer only to MySQL except in cases where MariaDB deviates from MySQL behavior.

Many database platforms also support the ability to create user-defined aggregate and window functions (UDFs). For more information on UDFs, refer to Chapter 9. JSON and XML functions are covered in Chapter 10 and will not be discussed in this chapter.

How to Use This Chapter

When researching a function in this chapter:

1. Check the SQL syntax and read the description, even if you are looking for a specific platform implementation.
2. Read the platform-specific implementation information.

Elements of the vendors' implementations that do not differ from the standard are not discussed in the individual platform sections; these sections only call out any differences from the standard. For details not provided in a particular platform section, see the section on the SQL syntax.

SQL Aggregate Functions

Aggregate functions return a single value based upon a set of other values. If used among other expressions in the item list of a `SELECT` statement, the `SELECT` statement must have a `GROUP BY` or `HAVING` clause. No `GROUP BY` or `HAVING` clause is required if the aggregate function is the only value retrieved by the `SELECT` statement. The aggregate functions supported by the SQL standard and their syntax are listed in Table 8-1.

Table 8-1. SQL aggregate functions

Function	Usage
`ARRAY_AGG(`*`expression`*`)`	Returns an array of a set of values
`AVG(`*`expression`*`)`	Computes the average value of a column given by *`expression`*
`CORR(`*`dependent, independent`*`)`	Computes a correlation coefficient
`COUNT(`*`expression`*`)`	Counts the rows defined by *`expression`*
`COUNT(*)`	Counts all rows in the specified table or view
`COVAR_POP(`*`dependent, independent`*`)`	Computes population covariance
`COVAR_SAMP(`*`dependent, independent`*`)`	Computes sample covariance
`CUME_DIST(`*`value_list`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Computes the relative percent position of a hypothetical row within a group of rows. The values returned are always between 0 and 1.
`DENSE_RANK(`*`value_list`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Generates a dense rank (no ranks are skipped) for a hypothetical row (*`value_list`*) in a group of rows generated by `GROUP BY`
`LISTAGG(`*`expression, separator`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Orders data within each group specified in the `ORDER BY` clause and then concatenates the values
`MAX(`*`expression`*`)`	Finds the maximum value in a column given by *`expression`*
`MIN(`*`expression`*`)`	Finds the minimum value in a column given by *`expression`*
`PERCENT_RANK(`*`value_list`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Generates a relative rank for a hypothetical row (*`value_list`*) in a group of rows generated by `GROUP BY` by dividing that row's rank less 1 by the number of rows in the group

Function	Usage
`PERCENTILE_CONT(`*`percentile`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Generates an interpolated value that, if added to the group, would correspond to the *`percentile`* given
`PERCENTILE_DISC(`*`percentile`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Returns the value with the smallest cumulative distribution value greater than or equal to *`percentile`*
`RANK(`*`value_list`*`) WITHIN GROUP (ORDER BY `*`sort_list`*`)`	Generates a rank for a hypothetical row (*`value_list`*) in a group of rows generated by `GROUP BY`
`REGR_AVGX(`*`dependent, independent`*`)`	Computes the average of the independent variable
`REGR_AVGY(`*`dependent, independent`*`)`	Computes the average of the dependent variable
`REGR_COUNT(`*`dependent, independent`*`)`	Counts the number of pairs remaining in the group after any pair with one or more NULL values has been eliminated
`REGR_INTERCEPT(`*`dependent, independent`*`)`	Computes the y-intercept of the least-squares-fit linear equation
`REGR_R2(`*`dependent, independent`*`)`	Computes the coefficient of determination
`REGR_SLOPE(`*`dependent, independent`*`)`	Determines the slope of the least-squares-fit linear equation
`REGR_SXX(`*`dependent, independent`*`)`	Sums the squares of the independent variables
`REGR_SXY(`*`dependent, independent`*`)`	Sums the products of each pair of variables
`REGR_SYY(`*`dependent, independent`*`)`	Sums the squares of the dependent variables
`STDDEV_POP(`*`expression`*`)`	Computes the population standard deviation of all *`expression`* values in a group
`STDDEV_SAMP(`*`expression`*`)`	Computes the sample standard deviation of all *`expression`* values in a group
`SUM(`*`expression`*`)`	Computes the sum of the column values given by *`expression`*
`VAR_POP(`*`expression`*`)`	Computes the population variance of all *`expression`* values in a group
`VAR_SAMP(expression)`	Computes the sample standard deviation of all *`expression`* values in a group

Technically speaking, `ALL`, `ANY`, and `SOME` are considered aggregate functions. However, they have been discussed as range search criteria since they are most often used that way. Refer to "ALL/ANY/SOME Operators" on page 251 for more information on these functions.

The number of values processed by an aggregate function varies depending on the number of rows queried from the table. This behavior differentiates aggregate functions from scalar functions, which can only operate on the values of a single row per invocation.

SQL Aggregate Syntax

The general syntax of an aggregate function is:

```
aggregate_function_name( [ALL | DISTINCT] expression )
[within_group_specification] [filter_clause]
   [ OVER window_clause ]

filter_clause ::= FILTER (search_specification)
within_group_specification ::= WITHIN GROUP
   (sort_specification)
```

The *aggregate_function_name* may be any function listed in Table 8-1. The `ALL` keyword, which specifies the default behavior, evaluates all rows when aggregating the value of the function. The `DISTINCT` keyword uses only distinct values when evaluating the function.

All aggregate functions except `COUNT(*)` and `ARRAY_AGG(*)` will ignore NULL values when computing their results.

For an explanation of *sort_specification*, see "ORDER BY Clause" on page 294.

For an explanation of *search_specification*, see "WHERE Clause" on page 349.

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

For an explanation of *filter_clause*, see "FILTER Clause" on page 262.

MySQL aggregate syntax

MySQL supports the standard syntax except for the *filter_clause* clause.

Oracle aggregate syntax

Oracle supports the standard syntax except for the *filter_clause* clause.

PostgreSQL aggregate syntax

PostgreSQL deviates from the standard in that it allows for sorting to be applied to any aggregate, so it has two allowed forms:

```
AGG_FUNCTION_NAME(expr) [within_group_specification]
   [filter_clause] [ OVER window_clause ]
```

```
AGG_FUNCTION_NAME(expr [sort_specification] ) [filter_clause]
   [ OVER window_clause ]
```

The *`within_group_specification`* syntax is mandatory for the `PERCENTILE_CONT` and `PERCENTILE_DIST` functions; these are inverse distribution functions, where order is absolutely required. PostgreSQL doesn't allow the use of *`within_group_specification`* for other functions.

The SQL standard allows *`sort_specification`* to be used after the expression in the `ARRAY_AGG` function.

SQL Server aggregate syntax

SQL Server supports the standard syntax except for the *`filter_clause`* clause.

Examples

The following query computes average year-to-date sales for each type of book:

```
SELECT type, AVG( ytd_sales ) AS avg_ytd_sales
FROM titles GROUP BY type;
```

This query returns the sum of year-to-date sales for each type of book:

```
SELECT type, SUM( ytd_sales ) FROM titles GROUP BY type;
```

The following query returns a running total number of books sold by store sorted in order of sale date. Note that the number of records will be the same as in the table:

```
SELECT stor_id, ord_date, SUM( qty )
OVER (PARTITION BY stor_id ORDER BY ord_date) AS num_sold
FROM sales
ORDER BY stor_id, ord_date;
```

See also

- "SQL Window Functions" on page 625
- `FILTER` in Chapter 4
- `GROUP BY` in Chapter 4
- `SELECT` in Chapter 4

ARRAY_AGG

The `ARRAY_AGG` function aggregates a set of values into a single array. The values can be composite objects. Use the `DISTINCT` keyword to include each distinct value only once in an array.

SQL standard syntax

```
sort_specification ::= expression1 [ASC | DESC]
   [NULLS FIRST | NULLS LAST][, ...]
ARRAY_AGG( [ALL | DISTINCT] expression
   [ORDER BY sort_specification] ) [filter_clause]
   [ OVER (window_clause) ]
```

MySQL

MySQL does not support the ARRAY_AGG function. GROUP_CONCAT (discussed in "LISTAGG" on page 608) achieves similar behavior, but only returns strings; MySQL does not support the concept of arrays.

Oracle

Oracle does not support the ARRAY_AGG function. On Oracle you can use LISTAGG, which concatenates values as a string.

PostgreSQL

PostgreSQL supports the SQL standard syntax for the ARRAY_AGG function.

SQL Server

SQL Server does not support the ARRAY_AGG function. You can instead use STRING_AGG (discussed in "LISTAGG" on page 608), which concatenates values as a string. SQL Server does not support arrays.

Example

The following query returns a distinct array of types from the *titles* table for each *pub_id* and also alphabetically orders the types:

```
/** PostgreSQL **/
SELECT pub_id, ARRAY_AGG(DISTINCT type ORDER BY type) AS atypes
FROM titles
GROUP BY pub_id
ORDER BY pub_id;
```

See also

- COLLECT
- LISTAGG

AVG and SUM

The AVG function computes the average of values in a column or an expression, and SUM computes the sum. Both functions work with numeric values and ignore NULL values. Use the DISTINCT keyword to compute the average or sum of all distinct values in a column or expression. All the platforms discussed here support the SQL standard syntax for this function.

SQL standard syntax

```
AVG( [ALL | DISTINCT] expression ) [OVER (window_clause)]
SUM( [ALL | DISTINCT] expression ) [OVER (window_clause)]
```

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

Examples

The following query computes average year-to-date sales for each type of book:

```
SELECT type, AVG( ytd_sales ) AS "average_ytd_sales" FROM titles
GROUP BY type;
```

This query returns the sum of year-to-date sales for each type of book:

```
SELECT type, SUM( ytd_sales ) FROM titles GROUP BY type;
```

The following query returns a running total of the number of books sold by each store, sorted in order of sale date. Note that the number of records will be the same as in the table:

```
SELECT stor_id, ord_date, SUM( qty )
OVER (PARTITION BY stor_id ORDER BY ord_date) AS num_sold
FROM sales
ORDER BY stor_id, ord_date;
```

COLLECT

The `COLLECT` function aggregates a set of objects into a single collection (a nested table). The values can be composite objects. Use the `DISTINCT` keyword to include each distinct value only once in a collection.

SQL standard syntax

```
sort_specification ::= expression1 [ASC | DESC]
   [NULLS FIRST | NULLS LAST][, ...]
COLLECT( [ALL | DISTINCT] expression
   [ORDER BY sort_specification] ) [filter_clause]
   [ OVER (window_clause) ]
```

MySQL

MySQL does not support the `COLLECT` function. `GROUP_CONCAT` (discussed in "LISTAGG" on page 608) achieves similar behavior but only returns strings. MySQL does not support the concept of arrays.

Oracle

Oracle supports the SQL standard syntax for the `COLLECT` function.

PostgreSQL

PostgreSQL does not support the COLLECT function. Use ARRAY_AGG instead.

SQL Server

SQL Server does not support the COLLECT function. You can instead use STRING_AGG (discussed in "LISTAGG" on page 608), which concatenates values as a string. SQL Server does not support arrays.

Example

The following query returns a distinct array of types from the *titles* table for each *pub_id* and also alphabetically orders the types:

```
/** Oracle **/
SELECT pub_id, COLLECT(DISTINCT type ORDER BY type) AS atypes
FROM titles
GROUP BY pub_id
ORDER BY pub_id;
PUB_
----
ATYPES
-------------------------------------------------------------------
1389
ST00001ITPYYoQQ9irKWp9GZU3dg=('popular_comp')
```

See also

- ARRAY_AGG
- LISTAGG

CORR

The CORR function returns the correlation coefficient between a set of dependent and independent variables.

SQL standard syntax

```
CORR(dependent, independent) [OVER (window_clause)]
```

Any pair in which either the dependent variable, the independent variable, or both are NULL is ignored. The result of the function is NULL when none of the input pairs consists of two non-NULL values.

To use CORR as a window aggregate, include the OVER clause. For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

MySQL

Does not support the CORR function.

Oracle

Supports the CORR function both in aggregate form and window form.

PostgreSQL

Supports the CORR function both in aggregate form and window form.

SQL Server

Does not support the CORR function.

Examples

The following CORR example uses the data retrieved by the first SELECT:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test2;
         y          x
---------- ----------
         1          3
         2          2
         3          1
SELECT CORR(y,x) FROM test2;
CORR(Y,X)
---------
       -1
```

The following CORR example uses the window aggregate form:

```
/** On Oracle and PostgreSQL **/
SELECT y, x, CORR(y,x) OVER () AS corr FROM test2;
         y          x        corr
---------- ---------------------
         1          3        -1
         2          2        -1
         3          1        -1
```

COUNT

The COUNT function is used to compute the number of rows in an expression. All the platforms support the SQL standard syntax.

SQL standard syntax

```
COUNT(*) [OVER (window_clause)]
COUNT( [ALL | DISTINCT] expression ) [OVER (window_clause)]
```

where:

COUNT(*)
: Counts all the rows in the target table, regardless of whether they include NULLs.

`COUNT( [ALL | DISTINCT] *expression*)`
: Computes the number of rows with non-NULL values in a specific column or expression. When the keyword `DISTINCT` is used, duplicate values are ignored and a count of the distinct values is returned. `ALL` returns the number of non-NULL values in the expression and is implicit when `DISTINCT` is not used.

For an explanation of *`window_clause`*, see "SQL Window Functions" on page 625.

Examples

This query counts all the rows in a table:

```
SELECT COUNT(*) FROM publishers;
```

The following query finds the number of different countries where publishers are located:

```
SELECT COUNT(DISTINCT country) "Count of Countries"
FROM   publishers
```

This query provides a running count of titles published by date:

```
SELECT title_id, pubdate, count(*) OVER (ORDER BY pubdate)
FROM titles
ORDER BY pubdate, title_id;
```

COVAR_POP

The `COVAR_POP` function returns the population covariance of a set of dependent and independent variables.

SQL standard syntax

```
COVAR_POP(dependent, independent) [OVER (window_clause)]
```

The function disregards any pair in which either the dependent variable, the independent variable, or both are NULL. If no rows remain in the group after NULL elimination, the result of the function is NULL.

For an explanation of *`window_clause`*, see "SQL Window Functions" on page 625.

MySQL

Does not support the `COVAR_POP` function.

Oracle

Supports the SQL standard syntax of the `COVAR_POP` function.

PostgreSQL

Supports the SQL standard syntax of the `COVAR_POP` function.

SQL Server

Does not support the COVAR_POP function.

Example

The following COVAR_POP example uses the data retrieved by the first SELECT:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test2;
         Y          X
---------- ----------
         1          3
         2          2
         3          1

SELECT COVAR_POP(y,x) FROM test2;
COVAR_POP(Y,X)
--------------
    -.66666667
```

COVAR_SAMP

The COVAR_SAMP function returns the sample covariance of a set of dependent and independent variables.

SQL standard syntax

```
COVAR_SAMP(dependent, independent) [OVER (window_clause)]
```

The function disregards any pair in which either the dependent variable, the independent variable, or both are NULL. The result of the function is NULL when none of the input pairs consists of two non-NULL values.

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

MySQL

Does not support the COVAR_SAMP function.

Oracle

Supports the SQL standard syntax of the COVAR_SAMP function.

PostgreSQL

Supports the SQL standard syntax of the COVAR_SAMP function.

SQL Server

Does not support the COVAR_SAMP function.

Example

The following COVAR_SAMP example uses the data retrieved by the first SELECT:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test2;
         Y          X
---------- ----------
         1          3
         2          2
         3          1

SELECT COVAR_SAMP(y,x) FROM test2;
COVAR_SAMP(Y,X)
---------------
             -1
```

CUME_DIST

The CUME_DIST function computes the relative rank of a hypothetical row within a group of rows, using the following equation:

```
(rows_preceding_hypothetical + rows_peered_with_hypothetical) /
   rows_in_group
```

Bear in mind that the *rows_in_group* value includes the hypothetical row that you are proposing when you call the function.

SQL standard syntax

```
CUME_DIST(value_list) WITHIN GROUP (ORDER BY sort_list)
value_list ::= expression[, expression...]
sort_list ::= sort_item[, sort_item...]
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

Items in the *value_list* correspond by position to items in the *sort_list*. Therefore, both lists must have the same number of expressions.

MySQL

MySQL does not support the CUME_DIST aggregate function.

Oracle

Oracle supports the SQL standard aggregate syntax for CUME_DIST and also supports it as a window function. See the subsection on this function in "SQL Window Functions" on page 625.

PostgreSQL

PostgreSQL supports the SQL standard aggregate syntax for `CUME_DIST` and also supports it as a window function. See the subsection on this function in "SQL Window Functions" on page 625.

SQL Server

SQL Server does not support the `CUME_DIST` aggregate function.

Example

The following example determines the relative rank of the hypothetical new row (*num=4*, *odd=1*) within each group of rows from *test4*, where groups are distinguished by the values in the *odd* column:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test4;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
         3          1
         4          0
         5          1

SELECT odd, CUME_DIST(4,1) WITHIN GROUP (ORDER BY num, odd)
FROM test4 GROUP BY odd;
       ODD CUME_DIST(4,1)WITHINGROUP(ORDERBY NUM,ODD)
---------- ----------------------------------------
         0                                        1
         1                                       .8
```

In the group *odd=0*, the new row comes after the three rows (*0,0*), (*2,0*), and (*4,0*). It will peer with itself. The total number of rows in the group, including the hypothetical row, will be four. The relative rank, therefore, is computed as follows:

```
(3 rows preceding + 1 peering) / (3 in group + 1 hypothetical)
= 4 / 4 = 1
```

In the group *odd=1*, the new row follows the three rows (*1,1*), (*3,1*), and a duplicate (*3,1*). Again, there is one peer: the hypothetical row itself. The number of rows in the group is five, which includes the hypothetical row. The relative rank is thus:

```
(3 rows preceding + 1 peering) / (4 in group + 1 hypothetical)
 = 4 / 5 = .8
```

DENSE_RANK

The DENSE_RANK function computes a rank in a group for a hypothetical row that you supply. This is a *dense rank*, which means rankings are never skipped, even when a group contains rows that rank identically.

SQL standard syntax

```
DENSE_RANK(value_list) WITHIN GROUP (ORDER BY sort_list)
value_list ::= expression[, expression...]
sort_list ::= sort_item[, sort_item...]
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

Items in the *value_list* correspond by position to items in the *sort_list*. Therefore, both lists must have the same number of expressions.

MySQL

Does not support the DENSE_RANK aggregate function.

Oracle

Supports the DENSE_RANK aggregate function.

PostgreSQL

Supports the DENSE_RANK aggregate function.

SQL Server

Supports the DENSE_RANK aggregate function.

Example

The following example determines the dense rank of the hypothetical new row (*num=4*, *odd=1*) within each group of rows from *test4*, where groups are distinguished by the values in the *odd* column:

```
/** On Oracle, PostgreSQL, or SQL Server **/
SELECT * FROM test4;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
         3          1
         4          0
         5          1

SELECT odd,
   DENSE_RANK(4,1)
```

```
      WITHIN GROUP (ORDER BY num, odd) AS dr
FROM test4
GROUP BY odd;
       ODD DR
---------- ----------------------------------------
         0                                        3
         1                                        3
```

In the group *odd=0*, the new row comes after (*0,0*), (*2,0*), and (*4,0*), and thus it is in position 4. In the group *odd=1*, the new row follows (*1,1*), (*3,1*), and a duplicate (*3,1*). In that case, the duplicate occurrences of (*3,1*) both rank 2, so the new row is ranked 3. Compare this behavior with RANK, discussed later in this section, which gives a different result.

EVERY

The EVERY function returns true if all items in the set return true and false if any items in the set return false.

SQL standard syntax

```
EVERY( boolean_expression ) [filter_clause]
```

MySQL

Supports the EVERY aggregate function.

Oracle

Does not support the EVERY aggregate function.

PostgreSQL

Supports the EVERY aggregate function and provides an alias, BOOL_AND.

SQL Server

Does not support the EVERY aggregate function.

Example

The following query returns a list by type indicating whether it has titles and if royalties are greater than 10 in the set. *t* is for true and the *f* is for false:

```
/** On MySQL and PostgreSQL **/
SELECT type, EVERY(title > '') AS have_titles,
   EVERY(royalty > 10) AS all_royalty_gt10
FROM titles
WHERE royalty IS NOT NULL
GROUP BY type
ORDER BY type;
```

```
    type      | have_titles | all_royalty_gt10
--------------+-------------+------------------
business      | t           | f
mod_cook      | t           | t
popular_comp  | t           | f
psychology    | t           | f
trad_cook     | t           | f
```

LISTAGG

The `LISTAGG` function aggregates a set of values into a single string separated by some separator. Although `LISTAGG` is the SQL standard name, some platforms provide equivalent functionality by another name.

SQL standard syntax

```
LISTAGG ( [ALL | DISTINCT] string_expression
   [WITHIN GROUP (ORDER BY sort_list)], separator
   [overflow_clause] )
   [ OVER (window_clause) ]
sort_list ::= sort_item[, sort_item...]
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
overflow_clause ::= ON OVERFLOW overflow_behavior
overflow_behavior ::= ERROR | TRUNCATE [string_literal]
   count_indication
count_indication ::= WITH COUNT | WITHOUT COUNT
```

MySQL

For MySQL, `GROUP_CONCAT` achieves the same purpose as `LISTAGG`. The output of the function is a `VARCHAR` or `VARBINARY` if the length is under 512 characters and a `BLOB` if it's greater than or equal to 512 characters. The input expression need not be a string. The syntax of the MySQL `GROUP_CONCAT` function is as follows:

```
GROUP_CONCAT( [ALL | DISTINCT] expression [ORDER BY sort_list]
   SEPARATOR separator )
```

Oracle

Oracle fully supports the SQL standard syntax for the `LISTAGG` function.

PostgreSQL

PostgreSQL does not support `LISTAGG` but supports the analogous `STRING_AGG` function as both a regular aggregate and a window aggregate. The syntax is as follows:

```
STRING_AGG( [ALL | DISTINCT] expression
   [ORDER BY sort_list], separator ) [filter_clause]
   [ OVER window_clause ]
```

SQL Server

SQL Server does not support LISTAGG but supports the analogous STRING_AGG function. It does not support DISTINCT in conjunction with this function. Its syntax is as follows:

```
STRING_AGG( expression, separator )
[WITHIN GROUP (ORDER BY sort_list)]
sort_list ::= sort_item[, sort_item...]
sort_item ::= expression [ASC | DESC]
```

Example

The following examples list authors who have more than one title and list the titles separated by &:

```
/** MySQL **/
SELECT ta.au_id,
   GROUP_CONCAT(t.title
      SEPARATOR ' & ' ORDER BY t.title) AS titles
FROM titleauthor AS ta
   INNER JOIN titles AS t ON ta.title_id = t.title_id
GROUP BY ta.au_id
HAVING COUNT(*) > 1
ORDER BY ta.au_id;

/** Oracle **/
SELECT ta.au_id,
   LISTAGG(t.title,
      ' & ') WITHIN GROUP (ORDER BY t.title) AS titles
FROM titleauthor AS ta
   INNER JOIN titles AS t ON ta.title_id = t.title_id
GROUP BY ta.au_id
HAVING COUNT(*) > 1
ORDER BY ta.au_id;

/** PostgreSQL **/
SELECT ta.au_id,
   STRING_AGG(t.title,
      ' & ' ORDER BY t.title) AS titles
FROM titleauthor AS ta
   INNER JOIN titles AS t ON ta.title_id = t.title_id
GROUP BY ta.au_id
HAVING COUNT(*) > 1
ORDER BY ta.au_id;

/** SQL Server **/
SELECT ta.au_id,
   STRING_AGG(t.title,
      ' & ' ) WITHIN GROUP (ORDER BY t.title) AS titles
FROM titleauthor AS ta
   INNER JOIN titles AS t ON ta.title_id = t.title_id
```

```
GROUP BY ta.au_id
HAVING COUNT(*) > 1
ORDER BY ta.au_id;

/** Results **/
    au_id    | titles
-------------+---------------------------------------------------------
 213-46-8915 | The Busy Executive's Database Guide
                  & You Can Combat Computer Stress!
 267-41-2394 | Cooking with Computers: Surreptitious Balance Sheets
                  & Sushi, Anyone?
 486-29-1786 | Emotional Security: A New Algorithm & Net Etiquette
 724-80-9391 | Computer Phobic AND Non-Phobic...
                  & Cooking with Computers: Surreptitious Balance Sheets
 899-46-2035 | Is Anger the Enemy?
                  & The Gourmet Microwave
 998-72-3567 | Is Anger the Enemy?
                  & Life Without Fear
```

MIN and MAX

MIN(*expression*) and MAX(*expression*) find the minimum and maximum values of *expression* (string, datetime, or numeric) in a set of rows. Either DISTINCT or ALL may be used with these functions, but they do not affect the result. All the platforms support the SQL standard syntax for these functions.

SQL standard syntax

```
MIN( [ALL | DISTINCT] expression ) [OVER (window_clause)]
MAX( [ALL | DISTINCT] expression ) [OVER (window_clause)]
```

Examples

The following query finds the best and worst sales for any title on record:

```
SELECT MIN(ytd_sales), MAX(ytd_sales)
FROM   titles;
```

Aggregate functions are used often in the HAVING clauses of queries with GROUP BY. The following query selects all categories (types) of books that have an average price for all books in the category higher than $15.00:

```
SELECT type AS "Category", AVG( price ) AS "Average Price"
FROM   titles
GROUP BY type
HAVING AVG(price) > 15
```

PERCENT_RANK

The PERCENT_RANK function generates a relative rank for a hypothetical row by dividing that row’s rank less 1 by the number of rows in the group.

SQL standard syntax

```
PERCENT_RANK(value_list) WITHIN GROUP (ORDER BY sort_list)
value_list ::= expression[, expression...]
sort_list ::= sort_item[, sort_item ...]
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

Items in the `value_list` correspond by position to items in the `sort_list`. Therefore, both lists must have the same number of expressions.

MySQL

Does not support the `PERCENT_RANK` aggregate function.

Oracle

Supports the SQL standard syntax for the `PERCENT_RANK` aggregate function.

PostgreSQL

Supports the SQL standard syntax for the `PERCENT_RANK` aggregate function.

SQL Server

Does not support the `PERCENT_RANK` aggregate function.

Example

The following example determines the percentage rank of the hypothetical new row (*num=4*, *odd=1*) within each group of rows from *test4*, where groups are distinguished by the values in the *odd* column:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test4;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
         3          1
         4          0
         5          1

SELECT odd, PERCENT_RANK(4,1)
   WITHIN GROUP (ORDER BY num, odd) AS pr
FROM test4 GROUP BY odd;
       ODD PR
---------- --------------------------------------------
         0                                            1
         1                                          .75
```

In the group *odd=0*, the new row comes after (*0,0*), (*2,0*), and (*4,0*), and thus it is in position 4. The rank computation is (4th rank – 1) / 3 rows = 100%. In the group *odd=1*, the new row follows (*1,1*), (*3,1*), and a duplicate (*3,1*), and is again ranked at 4. The rank computation for *odd=1* is (4th rank – 1) / 4 rows = 3/4 = 75%.

PERCENTILE_CONT

The `PERCENTILE_CONT` function generates an interpolated value corresponding to a percentile that you specify and the value from the `ORDER BY` clause that falls at that percentile.

SQL standard syntax

```
PERCENTILE_CONT(percentile) WITHIN GROUP (ORDER BY sort_item)
percentile::= value between 0 and 1
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

The `ORDER BY` *`sort_item`* must be a numeric value, and only one column/expression is allowed.

MySQL and MariaDB

MySQL does not support the `PERCENTILE_CONT` function in any form. MariaDB supports `PERCENTILE_CONT` as a window function but not as an aggregate function. The syntax is as follows:

```
PERCENTILE_CONT(percentile) WITHIN GROUP
(ORDER BY sort_item) OVER (partitioning)
```

MariaDB also supports a window function called `MEDIAN` which is shorthand for `PERCENTILE_CONT(0.5)`. It has the following syntax:

```
MEDIAN(column_name) OVER (partitioning)
```

See "SQL Window Functions" on page 625 for a description of partitioning.

Oracle

Oracle supports the SQL standard syntax for the `PERCENTILE_CONT` aggregate function. It also allows use of windowing syntax:

```
PERCENTILE_CONT(percentile) WITHIN GROUP
(ORDER BY sort_list) OVER (partitioning)
```

PostgreSQL

PostgreSQL supports the SQL standard syntax for the PERCENTILE_CONT aggregate function. It also supports an ARRAY form that allows for specifying multiple *percentiles* and returning an array of values:

```
PERCENTILE_CONT(ARRAY[percentiles]) WITHIN GROUP (ORDER BY sort_item)
percentiles ::= percentile[, percentile...]
```

SQL Server

SQL Server only supports PERCENTILE_CONT as a window function, not as an aggregate function. The syntax is as follows:

```
PERCENTILE_CONT(percentile) WITHIN GROUP
(ORDER BY sort_item) OVER (partitioning)
```

Examples

The following example groups the data in *test2* by the column named *x* and invokes PERCENTILE_CONT to return a 50th-percentile value:

```
SELECT Y, X FROM test2;
       Y         X
---------- ----------
         1          3
         2          2
         3          1
         4          4

/** Returns median value (SQL standard, Oracle, and PostgreSQL) **/
SELECT PERCENTILE_CONT(0.50) WITHIN GROUP (ORDER BY X) AS median
FROM test2;
 median
--------------------------------------------
 2.5

/** Returns median value for window (Oracle, MariaDB, SQL Server) **/
SELECT Y,
   PERCENTILE_CONT(0.50)
   WITHIN GROUP (ORDER BY X) OVER () AS median
FROM test2;
       Y        median
---------- ----------
         1         2.5
         2         2.5
         3         2.5
         4         2.5

/** PostgreSQL array form **/
SELECT Y,
   PERCENTILE_CONT(ARRAY[0.25, 0.5,1])
   WITHIN GROUP (ORDER BY X) OVER () AS median
FROM test2;
 median
--------------------------------------------
 {1.75,2.5,4}
```

PERCENTILE_DISC

The `PERCENTILE_DISC` function determines the value in a group with the smallest cumulative distribution greater than or equal to a percentile that you specify.

SQL standard syntax

```
PERCENTILE_DISC(percentile) WITHIN GROUP (ORDER BY sort_item)
percentile::= value between 0 and 1
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

The `ORDER BY` *`sort_item`* must be a numeric value, and only one column/expression is allowed.

MySQL and MariaDB

MySQL does not support the `PERCENTILE_DISC` function in any form. MariaDB supports `PERCENTILE_DISC` as a window function but not as an aggregate function. The syntax is as follows:

```
PERCENTILE_DISC(percentile) WITHIN GROUP
(ORDER BY sort_item) OVER (partitioning)
```

See "SQL Window Functions" on page 625 for a description of partitioning.

Oracle

Oracle supports the SQL standard syntax for the `PERCENTILE_DISC` aggregate function. It also allows use of windowing syntax:

```
PERCENTILE_DISC(percentile) WITHIN GROUP
(ORDER BY sort_list) OVER (partitioning)
```

PostgreSQL

PostgreSQL supports the SQL standard syntax for the `PERCENTILE_DISC` aggregate function. It also supports an `ARRAY` form that allows for specifying multiple *`percentiles`* and returning an array of values:

```
PERCENTILE_DISC(ARRAY[percentiles]) WITHIN GROUP (ORDER BY sort_item)
percentiles ::= percentile[, percentile...]
```

SQL Server

SQL Server only supports PERCENTILE_DISC as a window function, not as an aggregate function. The syntax is as follows:

```
PERCENTILE_DISC(percentile) WITHIN GROUP
(ORDER BY sort_item) OVER (partitioning)
```

Examples

The following example groups the data in *test2* by the column named *x* and invokes PERCENTILE_DISC to return a 50th-percentile value:

```
SELECT Y, X FROM test2;
       Y         X
---------- ----------
         1         3
         2         2
         3         1
         4         4

/** Returns median value (SQL standard, Oracle, and PostgreSQL) **/
SELECT PERCENTILE_DISC(0.50) WITHIN GROUP (ORDER BY X) AS median
FROM test2;
 median
--------------------------------------------
 2

/** Returns median value for window (Oracle, MariaDB, SQL Server) **/
SELECT Y,
   PERCENTILE_DISC(0.50)
   WITHIN GROUP (ORDER BY X) OVER () AS median
FROM test2;
       Y         median
---------- ----------
         1         2
         2         2
         3         2
         4         2

/** PostgreSQL array form **/
SELECT
   PERCENTILE_DISC(ARRAY[0.25, 0.5,1])
   WITHIN GROUP (ORDER BY X) AS median
FROM test2;
 median
--------------------------------------------
 {1,2,4}
```

RANK

The RANK function computes a rank in a group for a hypothetical row that you supply. This is not a dense rank. If the group contains rows that rank identically, it's possible for ranks to be skipped. If you want a dense rank, use the DENSE_RANK function discussed earlier in this section.

SQL standard syntax

```
RANK(value_list) WITHIN GROUP (ORDER BY sort_list)
value_list ::= expression[, expression...]
sort_list ::= sort_item[, sort_item...]
sort_item ::= expression [ASC | DESC] [NULLS FIRST | NULLS LAST]
```

Items in the *value_list* correspond by position to items in the *sort_list*. Therefore, both lists must have the same number of expressions.

MySQL

Does not support the RANK aggregate function.

Oracle

Supports the SQL standard syntax for the RANK aggregate function.

PostgreSQL

Supports the SQL standard syntax for the RANK aggregate function.

SQL Server

Does not support the RANK aggregate function.

Example

The following example determines the rank of the hypothetical new row (*num=4, odd=1*) within each group of rows from *test4*, where groups are distinguished by the values in the *odd* column:

```
/** On Oracle and PostgreSQL **/
SELECT * FROM test4;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
         3          1
         4          0
         5          1
```

```
SELECT odd, RANK(4,1)
   WITHIN GROUP (ORDER BY num, odd)
FROM test4 GROUP BY odd;
       ODD RANK(4,1)WITHINGROUP(ORDERBYNUM,ODD)
---------- -----------------------------------
         0                                   3
         1                                   4
```

In both cases, the rank of the hypothetical new row is 4. In the group *odd=0*, the new row comes after (*0,0*), (*2,0*), and (*4,0*), and thus it is in position 4. In the group *odd=1*, the new row follows (*1,1*), (*3,1*), and a duplicate (*3,1*). In this case, even though two of the rows are duplicates and so have the same rank, the new row is still ranked 4 because it is preceded by three rows. Compare this behavior with that of `DENSE_RANK`.

The REGR Family of Functions

The SQL standard defines a family of functions, having names beginning with `REGR_`, that relate to different aspects of linear regression. The functions work in the context of a least-squares regression line.

SQL standard syntax

Following is the syntax and a brief description of each `REGR_` function:

`REGR_AVGX(`*`dependent, independent`*`)`
: Averages (as in `AVG(`*`x`*`)`) the independent variable values

`REGR_AVGY(`*`dependent, independent`*`)`
: Averages (as in `AVG(`*`y`*`)`) the dependent variable values

`REGR_COUNT(`*`dependent, independent`*`)`
: Counts the number of non-NULL number pairs

`REGR_INTERCEPT(`*`dependent, independent`*`)`
: Computes the y-intercept of the regression line

`REGR_R2(`*`dependent, independent`*`)`
: Computes the coefficient of determination

`REGR_SLOPE(`*`dependent, independent`*`)`
: Computes the slope of the regression line

`REGR_SXX(`*`dependent, independent`*`)`
: Sums the squares of the *independent* variable values

`REGR_SXY(`*`dependent, independent`*`)`
: Sums the products of each pair of values

`REGR_SYY(`*`dependent, independent`*`)`
: Sums the squares of the dependent variable values

The REGR_ functions only work on number pairs containing two non-NULL values. Any number pair with one or more NULL values will be ignored.

MySQL

MySQL does not support the REGR_ family of functions.

Oracle

Oracle supports the SQL standard syntax for all REGR_ functions. It also supports the following analytic syntax:

```
REGR_function(dependent, independent) OVER (window_clause)
```

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

PostgreSQL

PostgreSQL supports the SQL standard syntax for all REGR_ functions.

SQL Server

SQL Server does not support the REGR_ family of functions.

Example

The following REGR_COUNT example demonstrates that any pair with one or more NULL values is ignored. The table *test3* contains three non-NULL number pairs, and three other pairs that have at least one NULL:

```
SELECT * FROM test3;
         Y          X
---------- ----------
         1          3
         2          2
         3          1
         4       NULL
      NULL          4
      NULL       NULL
```

The REGR_COUNT function ignores the pairs containing NULLs, counting only those pairs with two non-NULL values:

```
/** On Oracle and PostgreSQL **/
SELECT REGR_COUNT(y,x) FROM test3;
REGR_COUNT(Y,X)
---------------
              3
```

Likewise, all other REGR_ functions filter out any pairs containing NULL values before performing their respective computations.

STDDEV_POP

Use STDDEV_POP to find the population standard deviation within a group of numeric values. It can also be used as a window aggregate.

SQL standard syntax

```
STDDEV_POP(numeric_expression) [OVER (window_clause)]
```

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

MySQL

Supports the STDDEV_POP function both in aggregate form and window form. It also supports the aliases STD and STDDEV.

Oracle

Supports the STDDEV_POP function both in aggregate form and window form.

PostgreSQL

Supports the STDDEV_POP function both in aggregate form and window form.

SQL Server

Does not support the STDDEV_POP function. Use the STDEVP function instead.

Example

The following example computes the population standard deviation for the values 1, 2, and 3:

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT STDDEV_POP(x) AS sp FROM test;

/** On SQL Server **/
SELECT STDEVP(x) AS sp FROM test;

/** MySQL result **/
sp
```

```
-------------
0.8165

/** Oracle result **/
SP
-------------
  .816496581

/** PostgreSQL result **/
sp
-------------
 0.81649658092772603273

/** SQL Server result **/
sp
-----------------
0.816496580927726
```

STDDEV_SAMP

Use STDDEV_SAMP to find the sample standard deviation within a group of numeric values. It can also be used as a window aggregate.

SQL standard syntax

```
STDDEV_SAMP(numeric_expression) [OVER (window_clause)]
```

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

MySQL

Supports the STDDEV_SAMP function both in aggregate form and window form.

Oracle

Supports the STDDEV_POP function both in aggregate form and window form. It also provides the STDDEV function, which operates similarly to STDDEV_SAMP except that it returns zero (instead of NULL) when there is only one value in the set.

PostgreSQL

Supports the STDDEV_POP function both in aggregate form and window form.

SQL Server

Does not support the STDDEV_SAMP function. Use STDEV (with only one D!) instead.

Example

The following example computes the sample standard deviation for the values 1, 2, and 3:

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT STDDEV_SAMP(x) FROM test;
STDDEV_SAMP(X)
--------------
             1.000..

/** On SQL Server **/
SELECT STDEV(x) FROM test;
STDEV
--------------
             1.000..
```

VAR_POP

Use VAR_POP to compute the population variance of a set of values.

SQL standard syntax

```
VAR_POP(numeric_expression)
```

MySQL

Supports the SQL standard syntax for the VAR_POP aggregate function.

Oracle

Supports the SQL standard aggregate syntax for VAR_POP and also supports it as a window aggregate, with the following syntax:

```
VAR_POP(numeric_expression) [OVER (window_clause)]
```

For an explanation of *window_clause*, see "SQL Window Functions" on page 625.

PostgreSQL

Supports the SQL standard syntax for the VAR_POP aggregate function.

SQL Server

Does not support the VAR_POP function. Use VARP instead.

Example

The following example computes the population variance for the values 1, 2, and 3:

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT VAR_POP(x) FROM test;
VAR_POP(X)
----------
.666666667

/** On SQL Server **/
SELECT VARP(x) FROM test;
VARP(X)
----------
0.666666666666667
```

VAR_SAMP

Use VAR_SAMP to compute the sample variance of a set of values.

SQL standard syntax

```
VAR_SAMP(numeric_expression)
```

MySQL

Supports the SQL standard syntax for the VAR_SAMP aggregate function.

Oracle

Supports the SQL standard syntax for VAR_SAMP and also supports it as a window aggregate, with the following syntax (for an explanation of the *window_clause*, see "SQL Window Functions" on page 625):

```
VAR_SAMP(numeric_expression) [OVER (window_clause)]
```

Oracle also provides a VARIANCE function, which differs from VAR_SAMP by returning zero (instead of NULL) for sets that contain only a single value.

PostgreSQL

Supports the SQL standard syntax for the VAR_SAMP aggregate function.

SQL Server

Does not support the VAR_SAMP function. Use VAR instead.

Example

The following example computes the sample variance for the values 1, 2, and 3:

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT VAR_SAMP(x) AS v FROM test;

/** On SQL Server **/
SELECT VAR(x) AS v FROM test;

/** Result **/
v
-----------
          1
```

Complementary Functions

In this section we'll cover two key features often used in conjunction with aggregate functions: the `GROUPING` function and the `MATCH_RECOGNIZE` clause.

GROUPING

When `GROUPING SETS`, `ROLLUP`, or `CUBE` is used in a `GROUP BY` clause, the `GROUPING` function is allowed in the `SELECT` clause (see "GROUP BY Clause" on page 263 for details on these subclauses). All the platforms support the SQL standard syntax for this function.

SQL standard syntax

```
GROUPING(column_reference)
```

The result of a `GROUPING` call is 1 in the case of a row whose values are the results of aggregation over a *`column_reference`* during the execution of a grouped query containing `CUBE`, `ROLLUP`, or `GROUPING SETS`, and 0 otherwise. The main purpose of `GROUPING` is to distinguish between true NULL values and NULL placeholders resulting from the execution of one of these operations.

Examples

```
/** SQL standard, Oracle, PostgreSQL **/
SELECT royalty, SUM(advance) AS "total advance",
   GROUPING(royalty) AS "grp"
FROM titles
GROUP BY ROLLUP(royalty)
```

```
ORDER BY royalty NULLS FIRST;

/** MySQL, SQL Server (will work on Oracle & PostgreSQL but
    sorting will be different **/
SELECT royalty, SUM(advance) AS "total advance",
   GROUPING(royalty) AS "grp"
FROM titles
GROUP BY ROLLUP(royalty)
ORDER BY royalty;

/** Result **/
 royalty | total advance | grp
---------+---------------+-----
         |               |   0
         |    $95,400.00 |   1
      10 |    $57,000.00 |   0
      12 |     $2,275.00 |   0
      14 |     $4,000.00 |   0
      16 |     $7,000.00 |   0
      24 |    $25,125.00 |   0
```

MATCH_RECOGNIZE

SQL:2016 introduced a row pattern recognition clause that allows for finding patterns between sequentially ordered rows using regular expression syntax. There are two forms of it: one appears in the FROM clause of a SQL statement and utilizes aggregate functions, and the other appears in an OVER WINDOW clause. Oracle is the only one of the platforms we discuss that supports MATCH_RECOGNIZE, but Oracle does not support its use in OVER. Refer to the Modern SQL website for further examples.

SQL standard syntax

```
MATCH_RECOGNIZE(
 [PARTITION BY partition_list]
 [ORDER BY sort_specification]
 [MEASURES pattern_measure_list]
 [ONE ROW PER MATCH | ALL ROWS PER MATCH [row_pattern_empty_matching]]
 [AFTER MATCH SKIP PAST LAST ROW]
 row_pattern_common_syntax )

partition_list ::= column1[, ...]
sort_specification ::= expression1 [ASC | DESC]
   [NULLS FIRST | NULLS LAST][, ...]
pattern_measure_list ::= pattern_measure_definition[, ...]
   pattern_measure_definition ::= pattern_measure_expression
      AS measure_name
   measure_name ::= identifier
row_pattern_empty_matching ::=
   SHOW EMPTY MATCHES | OMIT EMPTY MATCHES | WITH UNMATCHED ROWS
row_pattern_common_syntax ::=
   [AFTER MATCH pattern_skip_to]
   PATTERN (row_recognize_expression)
   DEFINE define_for_expressions_used_in_pattern
   pattern_skip_to ::= SKIP TO NEXT ROW | SKIP PAST LAST ROW |
      SKIP TO FIRST variable_name | SKIP TO LAST variable_name |
      SKIP TO variable_name
   define_for_expressions_used_in_pattern ::=
      <a whole language takes pages>
```

Example

```
SELECT NUM
FROM test4
ORDER BY NUM;
       NUM
----------
         0
         1
         2
         3
         3
         4
         5

/** On Oracle **/
SELECT count(*) AS cnt
FROM test4
MATCH_RECOGNIZE (ORDER BY num
                  PATTERN (new_val)
                  DEFINE new_val AS
                  (num > prev(num))
                 );
CNT
---
4
```

SQL Window Functions

SQL allows for a *window_clause* in aggregate function calls, the addition of which makes those functions into window functions. This section describes how to use the *window_clause* within Oracle and SQL Server.

Oracle tends to refer to window functions as *analytic functions.*

Window (or analytic) functions are similar to standard aggregate functions in that they operate on multiple rows, or groups of rows, within the result set returned from a query. However, the groups of rows that a window function operates on are defined not by a GROUP BY clause, but by partitioning and windowing clauses. Furthermore, the order within these groups is defined by an *ordering* clause, but that order affects only function evaluation and has no effect on the order in which rows are returned by the query.

Window functions are the last items in a query to be evaluated, except for the ORDER BY clause. Because of this late evaluation, window functions *cannot* be used within the WHERE, GROUP BY, or HAVING clauses.

SQL Standard Window Syntax

SQL specifies the following syntax for window functions:

```
FUNCTION_NAME(expr) [filter_clause] OVER window_clause
filter_clause ::= FILTER ( WHERE boolean_expression )
window_clause ::= window_name | (window_specification)
window_specification ::= [partitioning] [ordering] [framing]
partitioning ::= PARTITION BY value[, value...]
   [COLLATE collation_name]
ordering ::= ORDER [SIBLINGS] BY rule[, rule...]
rule ::= {value | position | alias} [ASC | DESC]
   [NULLS {FIRST | LAST}]
framing ::= {ROWS | RANGE | GROUPS} {start | between} [exclusion]
start ::= {UNBOUNDED PRECEDING | unsigned-integer PRECEDING |
   CURRENT ROW}
between ::= BETWEEN bound1 AND bound2
bound1 ::= bound
bound2 ::= bound
bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer FOLLOWING}
exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP | EXCLUDE TIES |
   EXCLUDE NO OTHERS}
```

MySQL Window Syntax

SQL specifies the following syntax for window functions:

```
FUNCTION_NAME(expr) OVER window_clause
window_clause ::= window_name | (window_specification)
window_specification ::= [partitioning] [ordering] [framing]
partitioning ::= PARTITION BY value[, value...]
ordering ::= ORDER BY rule[, rule...]
rule ::= {value | position | alias} [ASC | DESC]
framing ::= {ROWS | RANGE} {start | between} [exclusion]
start ::= {UNBOUNDED PRECEDING | unsigned-integer
   PRECEDING | CURRENT ROW}
between ::= BETWEEN bound1 AND bound2
bound1 ::= bound
bound2 ::= bound
```

```
bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer FOLLOWING}
exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP | EXCLUDE TIES |
   EXCLUDE NO OTHERS}
```

Oracle Window Syntax

Oracle's window function syntax is as follows (the *window_name* clause and the *exclusion* clause are supported only in Oracle 21c, but are included here for completeness):

```
FUNCTION_NAME(expr) OVER {window_clause}
window_clause ::= window_name | (window_specification)
window_specification ::= [partitioning] [ordering] [framing]
partitioning ::= PARTITION BY value[, value...]
   [COLLATE collation_name]
ordering ::= ORDER [SIBLINGS] BY rule[, rule...]
partitioning ::= PARTITION BY value[, value...]
rule ::= {value | position | alias} [ASC | DESC]
   [NULLS {FIRST | LAST}]
framing ::= {ROWS | RANGE | GROUPS}
   {not_range | begin AND end [exclusion]}
not_range ::= {UNBOUNDED PRECEDING | CURRENT ROW | value PRECEDING}
begin ::= {UNBOUNDED PRECEDING | CURRENT ROW |
   value {PRECEDING | FOLLOWING}}
end ::= {UNBOUNDED FOLLOWING | CURRENT ROW |
   value {PRECEDING | FOLLOWING}}
exclusion ::= [ EXCLUDE CURRENT ROW | EXCLUDE GROUPS | EXCLUDE TIES |
   EXCLUDE NO OTHERS ]
```

PostgreSQL Window Syntax

PostgreSQL's window syntax is as follows:

```
FUNCTION_NAME(expr) [filter_clause] OVER window_clause
filter_clause ::= FILTER ( WHERE boolean_expression ) ]
window_clause ::= window_name | (window_specification)
window_specification ::= [partitioning] [ordering] [framing]
partitioning ::= PARTITION BY value[, value...]
ordering ::= ORDER BY rule[, rule...]
rule ::= {value | position | alias} [ASC | DESC]
   [NULLS {FIRST | LAST} | USING operator]
framing ::= {ROWS | RANGE | GROUPS} {start | between} [exclusion]
start ::= {UNBOUNDED PRECEDING | unsigned-integer PRECEDING |
   CURRENT ROW}
between ::= BETWEEN bound1 AND bound2
bound1 ::= bound
bound2 ::= bound
bound ::= {start | UNBOUNDED FOLLOWING | unsigned-integer FOLLOWING}
exclusion ::= {EXCLUDE CURRENT ROW | EXCLUDE GROUP | EXCLUDE TIES |
   EXCLUDE NO OTHERS}
```

SQL Server Window Syntax

SQL Server's window function syntax is as follows. Note that the *window_name* and *framing* clauses, among other things, are not supported:

```
FUNCTION_NAME(expr) OVER ([window_specification])
window_specification ::= [partitioning] [ordering]
partitioning ::= PARTITION BY value[, value...]
ordering ::= ORDER BY rule[, rule...]
rule ::= column [ASC | DESC]
```

Partitioning

Partitioning the rows operated on by the *partitioning* clause is similar to using the GROUP BY expression on a standard SELECT statement. The *partitioning* clause takes a list of expressions that will be used to divide the result set into groups. We'll use the following table as the basis for some examples:

```
SELECT * FROM odd_nums;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
```

The following results illustrate the effects of partitioning by *ODD*. The sum of the even numbers is 2 (0 + 2), and the sum of the odd numbers is 4 (1 + 3). The second column of the result set reports the sum of all values in the partition to which *that row* belongs, yet all the detail rows are returned. The query provides summary results in the context of detail rows:

```
SELECT NUM, SUM(NUM) OVER (PARTITION BY ODD) S FROM ODD_NUMS;
NUM            S
---------      ----------
0              2
2              2
1              4
3              4
```

Not using a *partitioning* clause at all will sum all of the numbers in the *NUM* column for each row returned by the query. In effect, the entire result set is treated as a single large partition:

```
SELECT NUM, SUM(NUM) OVER () S FROM ODD_NUMS;
NUM            S
---------      ----------
0              6
1              6
2              6
3              6
```

Ordering

You specify the order of the rows on which a window function operates using the *ordering* clause. However, this analytic clause does not define the ordering of the result set. To define the overall result set ordering, you must use the query's ORDER BY clause. The following use of Oracle's FIRST_VALUE function illustrates the effects of different orderings of the partitions:

```
SELECT NUM,
 SUM(NUM) OVER (PARTITION BY ODD) S,
 FIRST_VALUE(NUM) OVER (PARTITION BY ODD ORDER BY NUM ASC) first_asc,
 FIRST_VALUE(NUM) OVER (PARTITION BY ODD ORDER BY NUM DESC) first_desc
FROM ODD_NUMS;
       NUM          S  FIRST_ASC FIRST_DESC
---------- ---------- ---------- ----------
         0          2          0          2
         2          2          0          2
         1          4          1          3
         3          4          1          3
```

As you can see, the ORDER BY clauses in the window function invocations affect the ordering of the rows in the respective partitions when those functions are evaluated. ORDER BY NUM ASC orders partitions in ascending order, resulting in 0 for the first value in the even-numbered partitions and 1 for the first value in the odd-numbered partitions, while ORDER BY NUM DESC has the opposite effect.

The preceding query also illustrates an important point: using window functions, you can summarize and order results in many different ways in the same query.

Grouping or Windowing

Many analytic functions also allow you to specify a virtual, moving window surrounding a row within a partition, using the *framing* clause. Such moving windows are useful for calculations such as a running total.

The following Oracle-based example uses the *framing* clause on the analytic variant of SUM to calculate a running sum of the values in the first column. No *partitioning* clause is used, so each invocation of SUM operates over the entire result set. However, the ORDER BY clause sorts the rows for SUM in ascending order of *NUM*'s value, and the BETWEEN clause (which is the windowing clause) causes each invocation of SUM to include values for *NUM* only up through the current row. Each successive invocation of SUM includes yet another value for *NUM*, in order, from the lowest value of *NUM* to the greatest:

```
SELECT NUM, SUM(NUM) OVER (ORDER BY NUM ROWS
 BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW) S FROM ODD_NUMS;
NUM            S
---------      ----------
0              0
1              1
2              3
3              6
```

This example is a bit too easy, as the order of the final result set happens to match the order of the running total. That doesn't need to be the case. The following example generates the same results, but in a different order. You can see that the running total values are appropriate for each value of *NUM*, but the rows are presented in a different order than before. The result set ordering is completely independent of the ordering used for window function calculations:

```
SELECT NUM, SUM(NUM) OVER (ORDER BY NUM ROWS
 BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW) S FROM ODD_NUMS
ORDER BY NUM DESC;
       NUM          S
---------- ----------
         3          6
         2          3
         1          1
         0          0
```

List of Window Functions

SQL specifies that any aggregate function may also be used as a window function. The platforms largely follow the standard in that respect, so you'll find that you can take just about any aggregate function (certainly the standard ones) and apply to it the window function syntax described in the preceding sections. PostgreSQL by default allows any aggregate function, including user-defined aggregates, to be used as a window function unless the aggregate function is specifically marked *read_write* in its final output in its `CREATE AGGREGATE` definition. MySQL (and MariaDB) allow this for the common aggregate functions; see the documentation for a list.

In addition to the aggregate functions, SQL defines the window functions described in the following sections. All examples use the following table and data, which is a variation on the *ODD_NUMS* table used earlier to illustrate the concepts of partitioning, ordering, and grouping:

```
SELECT * FROM test4;
       NUM        ODD
---------- ----------
         0          0
         1          1
         2          0
         3          1
         3          1
         4          0
         5          1
```

or:

```
SELECT * FROM test;
         X
----------
         1
         2
         3
```

Platform-specific window functions are included in the lists in "Platform-Specific Extensions" on page 538.

CUME_DIST

The `CUME_DIST` function calculates the cumulative distribution, or relative rank, of the current row with regard to other rows in the same partition. The calculation for a given row is as follows:

```
number of peer or preceding rows / number of rows in partition
```

Because the result for a given row depends on the number of rows preceding that row in the same partition, it's important to always specify an `ORDER BY` clause when invoking this function.

All the platforms support the SQL standard syntax for the `CUME_DIST` window function.

SQL standard syntax.

```
CUME_DIST() OVER {window_clause}
```

Example. The following example uses `CUME_DIST` to generate a relative rank for each row, ordering by *NUM*, after partitioning the data by *ODD*:

```
SELECT NUM, ODD, CUME_DIST() OVER
 (PARTITION BY ODD ORDER BY NUM) cumedist FROM test4;
       NUM        ODD   CUMEDIST
---------- ---------- ----------
         0          0 .333333333
         2          0 .666666667
         4          0          1
         1          1        .25
         3          1        .75
         3          1        .75
         5          1          1
```

Following is an explanation of the calculation behind the rank for the row in which *NUM* = 0:

1. Because of the `ORDER BY` clause, the rows in the partition are ordered as follows:
   - *NUM* = 0
   - *NUM* = 2
   - *NUM* = 4
2. There are no rows preceding *NUM* = 0.
3. There is one row that is a peer of *NUM* = 0, and that is the *NUM* = 0 row itself. Thus, the divisor is 1.
4. There are three rows in the partition as a whole, making the dividend 3.
5. The result of 1/3 is .33 repeating, as shown in the example output.

DENSE_RANK

The `DENSE_RANK` function assigns a rank to each row in a partition, which should be ordered in some manner. The rank for a given row is computed by counting the number of rows preceding the row in question and then adding 1 to the result. Rows with duplicate `ORDER BY` values will rank the same. Unlike with `RANK`, gaps in rank numbers will not result from two rows sharing the same rank.

SQL standard syntax.

```
DENSE_RANK() OVER {window_clause}
```

MySQL. MySQL supports the SQL standard syntax but does not allow the *`framing`* clause in the *`window_specification`*.

Oracle. Oracle supports the SQL standard syntax but requires the *`ordering`* clause and does not allow the *`framing`* clause in the *`window_specification`*.

PostgreSQL. PostgreSQL supports the SQL standard syntax.

SQL Server. SQL Server requires the *`ordering`* clause in the *`window_specification`*:

```
DENSE_RANK() OVER ([partitioning] ordering)
```

Example. Compare the results from the following Oracle-based example to those shown in the section on the `RANK` function:

```
SELECT NUM, DENSE_RANK() OVER (ORDER BY NUM) rank
FROM test4;
       NUM       RANK
---------- ----------
         0          1
         1          2
         2          3
         3          4
         3          4
         4          5
         5          6
```

The two rows where *NUM* = 3 are both ranked at 3, and the next-higher row is ranked at 4. Rank numbers are not skipped, hence the term "dense."

FIRST_VALUE and LAST_VALUE

`FIRST_VALUE` and `LAST_VALUE` are analytic functions that provide access to more than one row of a table at the same time without a self-join. `FIRST_VALUE` provides the first value in the current partition, and `LAST_VALUE` provides the last value in the set.

SQL standard syntax.

```
FIRST_VALUE(expression) OVER {window_clause} [null_handling]

LAST_VALUE(expression) OVER {window_clause} [null_handling]

null_handling ::= {RESPECT NULLS | IGNORE NULLS}
```

When *`null_handling`* is not specified or supported, the functions behave as if `RESPECT NULLS` were set. `RESPECT NULLS` causes rows that have null values to be considered. `IGNORE NULLS` skips rows that have null values.

MySQL. MySQL supports the SQL standard syntax for these functions, except for the *`null_handling`* option.

Oracle. Oracle supports the SQL standard syntax for these functions. The *`null_handling`* clause can be provided after the `OVER` clause or after the *`expression`*, as follows:

```
FIRST_VALUE(expression [ {RESPECT | IGNORE} NULLS ])
OVER {window_clause}

LAST_VALUE(expression [ {RESPECT | IGNORE} NULLS ])
OVER {window_clause}
```

PostgreSQL. PostgreSQL supports the SQL standard syntax for these functions except for the *`null_handling`* option.

SQL Server. SQL Server does not support the *null_handling* option and requires the *ordering* clause in the *window_specification*.

Example.

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On all platforms **/
SELECT x, FIRST_VALUE(x) OVER (ORDER BY x) AS fv,
LAST_VALUE(x) OVER (ORDER BY x) AS lv
FROM test4;
X        FV       LV
-----------------------
1        1        1
2        1        2
3        1        3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT x, FIRST_VALUE(x) OVER () AS fv,
LAST_VALUE(x) OVER () AS lv
FROM test;
X        FV       LV
-----------------------
1        1        3
2        1        3
3        1        3
```

LAG and LEAD

LAG and LEAD are analytic functions that provide access to more than one row of a table at the same time without a self-join. LAG provides a "lagging" value in the result set that lags *offset* rows behind the current row. LEAD provides a "leading" value in the result set that leads *offset* rows before the current row.

SQL standard syntax.

```
LAG(expression[, offset]) OVER {window_clause} [null_handling]

LEAD(expression[, offset]) OVER {window_clause} [null_handling]

null_handling ::= {RESPECT NULLS | IGNORE NULLS}
```

When *null_handling* is not specified or supported, the functions behave as if RESPECT NULLS were set. RESPECT NULLS causes rows that have null values to be considered. IGNORE NULLS skips rows that have null values.

MySQL. MySQL supports the SQL standard syntax for these functions except for the *null_handling* clause. In addition, it requires the *ordering* clause in the *window_specification*.

Oracle. Oracle supports the SQL standard syntax for the LAG and LEAD functions, but requires the *ordering* clause in the *window_specification*. In addition, it provides an option to specify a *default* value when the result is undefined. The *null_handling* clause can be provided after the OVER clause or after the arguments, as follows:

```
LAG(expression[, offset][, default] [ {RESPECT | IGNORE} NULLS ])
OVER {window_clause}

LEAD(expression[, offset][, default] [ {RESPECT | IGNORE} NULLS ])
OVER {window_clause}
```

PostgreSQL. PostgreSQL supports the SQL standard syntax for these functions except for the *null_handling* clause. In addition, it provides an option to specify a *default* value when there is no preceding row. When no *ordering* clause is present, the sorting order is not guaranteed. The syntax is as follows:

```
LAG(expression[, offset][, default]))
OVER {window_clause}

LEAD(expression[, offset][, default]))
OVER {window_clause}
```

SQL Server. SQL Server does not support the *null_handling* clause and requires an *ordering* clause in the *window_specification*.

Example.

```
SELECT * FROM test;
         X
----------
         1
         2
         3

SELECT x, LAG(x, 1) OVER (ORDER BY x) AS lag,
LEAD(x,1) OVER (ORDER BY x) AS lead
FROM test;
X        LAG        LEAD
-----------------------
1        NULL       2
2        1          3
3        2          NULL
```

NTILE

The NTILE window function divides an ordered dataset into a number of tiles and returns the tile number of the data.

SQL standard syntax.

```
NTILE(number_of_tiles) OVER {window_clause}
```

MySQL. MySQL supports the SQL standard syntax for the NTILE function.

Oracle. Oracle supports the SQL standard syntax for this function, but it requires the *ordering* clause.

PostgreSQL. PostgreSQL supports the SQL standard syntax for the NTILE function.

SQL Server. SQL Server requires an *ordering* clause in the *window_specification*.

Example.

```
SELECT NUM, ODD, NTILE(4) OVER
 (ORDER BY NUM) nt
FROM test4;
       NUM        ODD   nt
---------- ---------- ----------
         1          1          1
         2          0          1
         3          1          2
         3          1          2
         4          0          3
         5          1          4
```

NTH_VALUE

NTH_VALUE is an analytic function that provides access to more than one row of a table at the same time without a self-join; it returns the *n*th value in the current result set.

SQL standard syntax.

```
NTH_VALUE(expression, nth_row) OVER {window_clause}
[null_handling]

nth_row ::= integer or dynamic_expression
dynamic_expession ::= resolves to integer
null_handling ::= {RESPECT NULLS | IGNORE NULLS}
```

When *null_handling* is not specified or supported, the function behaves as if RESPECT NULLS were set. RESPECT NULLS causes rows that have null values to be considered. IGNORE NULLS skips rows that have null values.

MySQL. MySQL supports the SQL standard syntax for the NTH_VALUE function except for the *null_handling* option.

Oracle. Oracle supports the SQL standard syntax for this function except for the *null_handling* option.

PostgreSQL. PostgreSQL supports the SQL standard syntax for the NTH_VALUE function except for the *null_handling* option.

SQL Server. SQL Server does not support the NTH_VALUE window function.

Example.

```
SELECT * FROM test;
         X
----------
         1
         2
         3

/** On MySQL, Oracle, and PostgreSQL **/
SELECT x, NTH_VALUE(x,1) OVER (ORDER BY x) AS nv1,
NTH_VALUE(x,2) OVER (ORDER BY x) AS nv2
FROM test;
X        NV1      NV2
-----------------------
1        1        NULL
2        1        2
3        1        2

/** On MySQL, Oracle, and PostgreSQL **/
SELECT x, NTH_VALUE(x,1) OVER () AS fv,
NTH_VALUE(x,2) OVER () AS lv
FROM test;
X        FV       LV
-----------------------
1        1        2
2        1        2
3        1        2
```

PERCENT_RANK

The PERCENT_RANK function computes the relative rank of a row by dividing that row's rank less 1 by the number of rows in the partition, also less 1:

```
(rank - 1) / (rows - 1)
```

Compare this calculation to that used for CUME_DIST, described earlier in this section.

SQL standard syntax.

```
PERCENT_RANK() OVER {window_clause}
```

MySQL. MySQL supports the SQL standard syntax for the PERCENT_RANK window function, but requires the *ordering* clause and does not allow the *framing* clause.

Oracle. Oracle supports the SQL standard syntax for PERCENT_RANK, but requires the *ordering* clause and does not allow the *framing* clause.

PostgreSQL. PostgreSQL fully supports the SQL standard syntax for PERCENT_RANK.

SQL Server. SQL Server does not support the PERCENT_RANK window function.

Example. The following example assigns relative ranks to the values of *NUM*, partitioning the data on the *ODD* column:

```
/** On MySQL, Oracle, and PostgreSQL **/
SELECT NUM, ODD, PERCENT_RANK() OVER
 (PARTITION BY ODD ORDER BY NUM) pr
FROM test4;
       NUM        ODD    PR
---------- ---------- ----------
         0          0          0
         2          0         .5
         4          0          1
         1          1          0
         3          1 .333333333
         3          1 .333333333
         5          1          1
```

Following is an explanation of the calculation behind the rank for the row in which *NUM* = 2:

1. Row *NUM* = 2 is the second row in its partition; thus, it ranks 2.
2. Subtract 1 from 2 to get a divisor of 1.
3. The dividend is the total number of rows in the partition, or 3.
4. Subtract 1 from 3 to get a dividend of 2.
5. The result of 1/3 is .33 repeating, as shown in the example output.

RANK

The RANK function assigns a rank to each row in a partition, which should be ordered in some manner. The rank for a given row is computed by counting the number of rows preceding the row in question and then adding 1 to the result. Rows with duplicate ORDER BY values will rank the same, leading to gaps in rank numbers.

SQL standard syntax.

```
RANK() OVER {window_name | ([partitioning] [ordering])}
```

MySQL. MySQL supports the SQL standard syntax for the RANK function but requires the *ordering* clause.

Oracle. Oracle supports the SQL standard syntax for `RANK` but requires the *`ordering`* clause.

PostgreSQL. PostgreSQL supports the SQL standard syntax for the `RANK` function. If the *`ordering`* clause is not provided, the ranking is arbitrary.

SQL Server. SQL Server supports the SQL standard syntax for `RANK` but requires the *`ordering`* clause:

```
RANK() OVER ([partitioning] ordering)
```

Example. The following example uses the *NUM* column to rank the rows in the *test4* table:

```
SELECT NUM, RANK() OVER (ORDER BY NUM) rank
FROM test4;
       NUM       RANK
---------- ----------
         0          1
         1          2
         2          3
         3          4
         3          4
         4          6
         5          7
```

Because both rows where *NUM* = 3 rank the same (at 4), the next-higher row will be ranked at 6. The 5 rank is skipped. To avoid this skipping, use `DENSE_RANK` instead (described earlier in this section).

ROW_NUMBER

The `ROW_NUMBER` function assigns a unique number to each row in a partition.

SQL standard syntax.

```
ROW_NUMBER() OVER {window_name | ([partitioning] [ordering])}
```

MySQL. MySQL fully supports the SQL standard syntax for this function. In the absence of an *`ordering`* clause, the `ROW_NUMBER` ordering is random.

Oracle. Oracle supports the SQL standard syntax for the `ROW_NUMBER` function but requires the *`ordering`* clause.

PostgreSQL. PostgreSQL fully supports the SQL standard syntax for this function. In the absence of an *`ordering`* clause, the `ROW_NUMBER` ordering is random.

SQL Server. SQL Server requires an *`ordering`* clause:

```
ROW_NUMBER() OVER ([partitioning] ordering)
```

Example.

```
SELECT NUM, ODD, ROW_NUMBER() OVER
 (PARTITION BY ODD ORDER BY NUM) rn
FROM test4;
       NUM        ODD    RN
---------- ---------- ----------
         0          0          1
         2          0          2
         4          0          3
         1          1          1
         3          1          2
         3          1          3
         5          1          4
```

Platform-Specific Extensions

The following sections provide comprehensive listings of key vendor-supported aggregate and window functions that are not defined in the SQL standard. These functions are platform-specific, so a MySQL function, for example, is not guaranteed to be supported by any other vendor. JSON and XML functions are not included here; they will be covered in Chapter 10.

MySQL-Supported Functions

This section provides an alphabetical listing of MySQL-supported aggregate functions that are not part of the SQL standard, with examples and corresponding results.

`BIT_AND(`*`expr`*`)`

Returns the bitwise `AND` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision. The value –1 is returned when no matching rows are found. For example:

```
SELECT BIT_AND(mycolumn) -> 0
```

`BIT_OR(`*`expr`*`)`

Returns the bitwise `OR` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision. The value 0 is returned when no matching rows are found. For example:

```
SELECT BIT_OR(mycolumn) -> 1
```

`BIT_XOR(`*`expr`*`)`

Returns the bitwise `XOR` of all bits in *`expr`*. The calculation is performed with 64-bit (`BIGINT`) precision. The value 0 is returned when no matching rows are found. For example:

```
SELECT BIT_XOR(mycolumn) -> 1
```

`GROUP_CONCAT([DISTINCT]` *`expr`* `[ORDER BY` *`order`* `[ASC | DESC]] [SEPARATOR` *`sep`*`])`

Returns a concatenation of non-NULL values from a grouping where *`expr`* is the expression to use in the concatenation, *`order`* is the expression to use in the ordering, and *`sep`* is the string to insert between concatenated values. For example:

```
SELECT estate, GROUP_CONCAT(tea SEPARATOR ';')
FROM catalog GROUP BY estate;
```

`VARIANCE(`*`expr`*`)`

Synonym for the SQL standard function `VAR_POP`.

Oracle-Supported Functions

This section provides an alphabetical listing of the aggregate functions specific to Oracle, with examples and corresponding results.

`ANY_VALUE(`*`expression`*`)`

Returns any value in a set of values. This function (introduced in Oracle 21c) is useful in an aggregation where you don't care what value you get back and don't want to group by the column. For example:

```
SELECT ANY_VALUE(num) FROM test4 -> 4
```

`APPROX_COUNT(`*`expression`*`)`, `APPROX_COUNT_DISTINCT(`*`expression`*`)`, `APPROX_MAX(`*`expression`*`)`, `APPROX_MEDIAN(`*`expression`*`)`, `APPROX_SUM(`*`expression`*`)`

These are much like the non-`APPROX` variants except they return answers faster and are not exact. There are several more, but these are the most commonly used.

`BIT_AND_AGG(`*`expression`*`)`

Returns the bitwise `AND` of every non-NULL value in *`expression`*. For example:

```
SELECT BIT_AND_AGG( num ) FROM test4 -> 0
```

`BIT_OR_AGG(`*`expression`*`)`

Returns the bitwise `OR` of every non-NULL value in *`expression`*. For example:

```
SELECT BIT_OR_AGG( num ) FROM test4 -> 7
```

`COLLECT(`*`column`*`)`

Creates for each group a nested table consisting of all the values in the *`column`*.

`CORR_K(`*`expr1, expr2`*`[,` *`return_type`*`])`, `CORR_S(`*`expr1, expr2`*`[,` *`return_type`*`])`

`CORR_K` returns Kendall's tau-b correlation coefficient, and `CORR_S` returns Spearman's rho correlation coefficient for a set of numbered pairs (*`expr1`* and *`expr2`*). The *`return_type`* argument, a `VARCHAR2`, can be omitted or can be one of the following values: `'COEFFICIENT'`, `'ONE_SIDED_SIG'`, or

'TWO_SIDED_SIG'. The value 'COEFFICIENT' (the default if this argument is omitted) returns the coefficient of the correlation. The values 'ONE_SIDED_SIG' and 'TWO_SIDED_SIG' return the one- and two-tailed significance of the correlation, respectively.

FIRST
: Returns a specified value from the row that ranks first, given the order specified in the ORDER BY clause. The syntax is:

```
aggregate(aexpr) KEEP (DENSE_RANK FIRST ORDER BY expr[, ... n])
expr ::= [ASC | DESC] [NULLS {FIRST | LAST}]
```

The first ranking row following the order specified by *expr* will be used in the aggregate function *aggregate*. *aexpr* is the expression passed to the aggregate function. For example:

```
SELECT MAX(c1) KEEP (DENSE_RANK FIRST ORDER BY c2)
FROM FIVE_NUMS -> 1
```

GROUP_ID()
: Returns a positive value for each duplicate group returned by a query containing a GROUP BY clause. This function is useful in filtering out duplicate groups created when using CUBE, ROLLUP, or another GROUP BY extension (see "GROUPING" on page 623).

GROUPING_ID(*column_name1*[, *column_name2*, ...])
: Returns the base-10 number that is equal to the binary value constructed by concatenating the GROUPING values on each of the parameters. GROUPING_ID is useful when returning a query containing multiple levels of aggregation created by GROUP BY expressions. Consider using the GROUPING_ID function instead of multiple GROUPING functions within one query. This function is shorthand for:

```
BIN_TO_NUM(GROUPING(column_name1)[, GROUPING(column_name2), ...])
```

KURTOSIS_POP([DISTINCT | ALL | UNIQUE]) [OVER (*partitioning*)]
: Returns the kurtosis population, used to determine outliers. This is new in Oracle 21c.

KURTOSIS_SAMP([DISTINCT | ALL | UNIQUE]) [OVER (*partitioning*)]
: Returns the kurtosis sampling, used to determine outliers. This is new in Oracle 21c.

LAST
: Returns the row that ranks last given the order specified in the ORDER BY clause. The syntax is:

```
aggregate(aexpr) KEEP (DENSE_RANK LAST ORDER BY expr[, ... n])
expr ::= [ASC | DESC] [NULLS {FIRST | LAST}]
```

The last ranking row following the order specified by *expr* will be used in the aggregate function *aggregate*. The *aexpr* is the expression passed to the aggregate function. For example:

```
SELECT MIN(c1) KEEP (DENSE_RANK LAST ORDER BY c1)
FROM FIVE_NUMS -> 5
```

`MEDIAN(`*`expression`*`) [OVER (`*`partitioning`*`)]`

Returns the median value in an ordered set of numeric or datetime values. For example:

```
SELECT MEDIAN(c1) FROM FIVE_NUMS -> 3
```

`POWERMULTISET(`*`nested_table`*`), POWERMULTISET_BY_CARDINALITY (`*`nested_table, cardinality`*`)`

Return a nested table of nested tables of all nonempty subsets of the input nested table in the *`nested_table`* parameter. `POWERMULTISET_BY_CARDINALITY` has an additional parameter that can be used to limit the subsets returned to a specified minimum cardinality. For more information, see the Oracle SQL Reference.

`PREDICTION(), PREDICTION_BOUNDS(), PREDICTION_COST(), PREDICTION_DETAILS(), PREDICTION_PROBABILTY(), PREDICTION_SET()`

Support Oracle's data mining features. See the documentation for the Oracle Data Mining Java API or the `DBMS_DATA_MINING` package for more details on these functions.

`RATIO_TO_REPORT(`*`value_exprs`*`) OVER (`*`partitioning`*`)`

Computes the ratio of a value in *`value_exprs`* to the sum of all *`value_exprs`* with each partition. If *`value_exprs`* is NULL, the ratio-to-report value is also NULL. For example:

```
SELECT c1, RATIO_TO_REPORT(c1) OVER () FROM FIVE_NUMS ->
1              .066666667
2              .133333333
3              .2
4              .266666667
5              .333333333
```

`STATS_BINOMIAL_TEST, STATS_CROSSTAB, STATS_F_TEST, STATS_KS_TEST, STATS_MODE, STATS_MW_TEST, STATS_ONE_WAY_ANOVA, STATS_T_TEST_INDEP, STATS_T_TEST_INDEPU, STATS_T_TEST_ONE, STATS_T_TEST_PAIRED, STATS_WSR_TEST`

Oracle provides many sophisticated statistical functions. For further information on the `STATS_*` functions, see the Oracle SQL Reference.

`VARIANCE([DISTINCT] `*`expression`*`) [OVER (`*`window_clause`*`)]`

Returns the variance of *`expression`*: 0 if the number of rows in *`expression`* = 1, and `VAR_SAMP` if the number of rows in *`expression`* > 1. For example:

```
SELECT VARIANCE(col1) FROM NUMS -> 32.6666667
```

PostgreSQL-Supported Functions

This section lists the aggregate functions specific to PostgreSQL, with examples and corresponding results. Some of the less frequently used functions have been omitted:

`BIT_AND(`*`expression`*`)`
: Returns the bitwise `AND` of every non-NULL value in *`expression`*. For example:

```
SELECT BIT_AND( num ) FROM test4 -> 0
```

`BIT_OR(`*`expression`*`)`
: Returns the bitwise `OR` of every non-NULL value in *`expression`*. For example:

```
SELECT BIT_OR( num ) FROM test4 -> 7
```

`BIT_XOR(`*`expression`*`)`
: Returns the bitwise exclusive `OR` of every non-NULL value in *`expression`*. For example:

```
SELECT BIT_XOR( num ) FROM test4 -> 2
```

`BOOL_AND(`*`expression`*`)`
: Synonym for EVERY(*`expression`*).

`BOOL_OR(`*`expression`*`)`
: Returns the logical `OR` of every non-NULL value in *`expression`*. This is equivalent to the SQL standard `SOME` aggregate function. For example:

```
SELECT BOOL_OR( num = 4 ) FROM test4 -> true
```

`MODE(`*`expression`*`)`
: Computes the *mode*, the most frequent value of the aggregated argument (arbitrarily choosing the first one if there are multiple equally frequent values). The aggregated argument must be of a sortable type. For example:

```
SELECT MODE() WITHIN GROUP (ORDER BY num)
FROM test4 -> 3
```

`RANGE_AGG(`*`any_range`*`)`
: Computes the non-NULL union of a set of ranges and returns a multirange type. For example:

```
SELECT range_agg(d)
FROM (VALUES ( daterange('2021-10-01', '2021-10-30') )
   ,( daterange('2021-09-10', '2021-09-15') )
   , ( daterange('2021-08-15','2021-09-10') )
) AS d(d)
-> {[2021-08-15,2021-09-15),[2021-10-01,2021-10-30)}
```

`RANGE_INTERSECT_AGG(`*`any_range`*`)`
: Computes the non-NULL intersection of a set of ranges and returns a range. It returns empty if not all rows intersect. For example:

```
SELECT range_intersect_agg(d)
FROM (VALUES ( daterange('2021-09-01', '2021-10-30') )
   ,( daterange('2021-09-10', '2021-09-15') )
   , ( daterange('2021-08-15','2021-09-11') )
) AS d(d)-> [2021-09-10,2021-09-11)
```

VARIANCE(*expr*)
: This is a historical alias for the SQL standard VAR_SAMP function.

SQL Server–Supported Functions

This section provides an alphabetical listing of SQL Server–supported aggregate functions, with examples and corresponding results.

APPROX_COUNT_DISTINCT(*expression*)
: Like *COUNT(DISTINCT* *expression*) but returns approximate answers much faster for large tables. For example:

```
SELECT APPROX_COUNT_DISTINCT(title) FROM titles -> 18
```

CHECKSUM_AGG([ALL | DISTINCT] *integer*)
: Returns the checksum value of all values as an integer. For example:

```
SELECT CHECKSUM_AGG(CAST(qty AS integer)) FROM sales -> 111
```

COUNT_BIG([ALL | DISTINCT] *expression)*
: Just like COUNT, except it returns a BIGINT data type instead of an INTEGER data type. For example:

```
SELECT COUNT_BIG(title) FROM titles -> 18
```

GROUPING_ID()
: Returns a positive integer denoting a grouping level in a GROUP BY clause. This function is useful in filtering out duplicate groups created when using CUBE, ROLLUP, or another GROUP BY extension (see "GROUPING" on page 623). For example:

```
SELECT GROUPING_ID(stor_id, ord_date),
 ord_date, stor_id, SUM(qty) AS qty_total
FROM sales
GROUP BY ROLLUP(stor_id, ord_date);
```

STDEV(*expression*)
: Returns the standard deviation of the values in *expression*. For example:

```
SELECT STDEV( qty ) FROM sales -> 16.409201831957116
```

STDEVP(*expression*)
: Returns the standard deviation for the population of values in *expression*. For example:

```
SELECT STDEVP( qty ) FROM sales -> 16.013741264834152
```

VAR(*expression*)

Returns the statistical variance for the values represented by *expression*. This is equivalent to the SQL standard VAR_SAMP function. For example:

```
SELECT VAR(qty) FROM sales -> 269.26190476190476
```

VARP(*expression*)

Returns the statistical variance for the population represented by all values of *expression* in a group. Equivalent to the SQL standard function VAR_POP. For example:

```
SELECT VARP(qty) FROM sales -> 256.43990929705217
```

9 Storing Logic in the Database

Most relational databases allow you to compartmentalize reusable nuggets of logic in what are called *stored procedures* and *user-defined functions* (UDFs). In addition, many relational databases allow you to react to changes in data or even structural changes to the database via the use of *triggers*. The SQL standard defines a syntax for expressing these. In this chapter we'll focus on the SQL standard commands for working with casts, cursors, functions, methods, procedures, triggers, and types and to what extent these commands are supported in the databases covered in this book (including any deviations from or extensions to the standard). One particular feature not covered by the latest SQL standard is syntax for creating aggregate functions. All the databases we cover support this, but they deviate widely in their syntax. In addition, the SQL standard does not cover triggers that take action when objects in a database (such as tables, views, and even functions) are added, altered, or dropped. Again, most of the platforms provide such triggers, but with varying syntax, as you will see.

How to Use This Chapter

When researching a command in this chapter:

1. Read "SQL Platform Support" on page 648.
2. Check Table 9-1.
3. Look up the specific SQL statement, check the syntax, and read the "Keywords," "Rules at a glance," and "Programming tips and gotchas" sections. Do this even if you are looking for a specific platform implementation.
4. Finally, read the platform-specific implementation information.

You will note that the entry for a given platform implementation does *not* duplicate information on any clauses that do not differ from the standard. So, it is possible that you will need to flip between the descriptions for a vendor variation and the SQL standard to cover all possible details of that command.

In our discussions of MySQL, we will also include MariaDB, a fork of MySQL. For the most part, MySQL and MariaDB provide fully code-compatible syntax. In these cases we will refer to them collectively as MySQL. We will explicitly mention MariaDB only in situations where it deviates from MySQL in an important way.

SQL Platform Support

Table 9-1 provides a listing of the SQL statements discussed in this chapter, the platforms that support them, and the degree to which they support them. The following list offers useful tips for reading Table 9-1, as well as an explanation of what each abbreviation stands for:

1. The first column contains the SQL commands, in alphabetical order.
2. The SQL statement class for each command is indicated in the second column.
3. The subsequent columns list the level of support for each vendor:

   Supported (S)
   : The platform supports the SQL standard for the particular command.

   Supported, with variations (SWV)
   : The platform supports the SQL standard for the particular command, using vendor-specific code or syntax.

   Supported, with limitations (SWL)
   : The platform supports some but not all of the functions specified by the SQL standard for the particular command.

   Not supported (NS)
   : The platform does not support the particular command according to the SQL standard.

The sections that follow the table describe the commands in detail. Remember that even if a specific SQL command is listed in the table as "Not supported," the platform usually has alternative coding or syntax to enact the same command or function. Therefore, be sure to read the discussion and examples for each command later in this chapter. Likewise, some of the commands in Table 9-1 are not found in the SQL standard; these are indicated with the term "Non-standard" in the "SQL class" column of the table.

Table 9-1. Alphabetical quick SQL command reference

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
ALTER AGGREGATE	Non-standard	NS	NS	SWV	NS
ALTER FUNCTION	Non-standard	SWV	SWV	SWV	SWV
ALTER METHOD	SQL-schema	NS	NS	NS	NS
ALTER PROCEDURE	SQL-schema	SWV	SWV	SWV	SWV
ALTER TRIGGER	Non-standard	NS	SWV	SWV	SWV
CALL	SQL-schema	[ON ALL SERVER]	SWV	[ON ALL SERVER]	SWL
CLOSE	SQL-data	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]	SWV
CREATE AGGREGATE	Non-standard	SWV	SWV	SWV	SWV
CREATE CAST	SQL-schema	NS	NS	SWV	NS
CREATE FUNCTION	SQL-schema	SWV	SWV	SWV	SWV
CREATE METHOD	SQL-schema	NS	NS	NS	NS
CREATE PROCEDURE	SQL-schema	SWV	SWV	SWV	SWV
CREATE TRIGGER	SQL-schema	SWL	SWV	SWV	SWL
DECLARE CURSOR	SQL-data	SWL	SWL	SWL	SWL
DROP AGGREGATE	Non-standard	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]
DROP CAST	SQL-schema	NS	NS	[ON ALL SERVER]	NS
DROP FUNCTION	SQL-schema	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]
DROP PROCEDURE	SQL-schema	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]
DROP TRIGGER	SQL-schema	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]	[ON ALL SERVER]
FETCH	SQL-data	SWL	SWL	SWV	SWV

SQL command	SQL class	MySQL/ MariaDB	Oracle	PostgreSQL	SQL Server
`OPEN`	SQL-data	`[ON ALL SERVER]`	`SWV`	`[ON ALL SERVER]`	`SWV`
`RETURN`	SQL-schema	`SWL`	`[ON ALL SERVER]`	`SWV`	`SWV`

SQL Command Reference

CALL Statement

The `CALL` statement invokes a stored procedure.

Platform	Command
MySQL	Supported
Oracle	Supported, with variations
PostgreSQL	Supported
SQL Server	Supported, with limitations

SQL syntax

```
CALL procedure_name([parameter[, ...]])
```

Keywords

`procedure_name`
: Specifies the stored procedure that you want to invoke. It must be a previously defined stored procedure that is available in the current user context (instance, database, schema, etc.).

`([`*`parameter`*`[, ... 11)`
: Provides values for each input parameter required by the stored procedure. Each parameter listed is required by the stored procedure in the same ordinal position; thus, the fifth parameter listed will provide the value for the fifth argument required by the stored procedure. The parameters must be enclosed in parentheses and separated by commas. Note that the parentheses are required even if there are no parameter values (i.e., if there are no parameter values, you must still use `CALL()`). Strings should be enclosed in single quotes. If the stored procedure has only `OUT` parameters, place host variables or parameter markers within the parentheses.

Rules at a glance

The CALL statement makes it easy to invoke a stored procedure. Simply provide the name of the stored procedure and include any parameters it uses, enclosing them within parentheses.

This Oracle example creates a simple stored procedure, and then calls it:

```
CREATE PROCEDURE update_employee_salary
   (emp_id NUMBER, updated_salary NUMBER)
IS
BEGIN
   UPDATE employee SET salary = updated_salary
   WHERE employee_id =emp_id;
END;

CALL update_employee_salary(1517, 95000);
```

Programming tips and gotchas

The return status of a called stored procedure can be found, typically, by using GET DIAGNOSTIC. GET DIAGNOSTIC is not widely supported among the various database platforms, so check your platform's documentation for more details.

Many platforms also support an alternative command called EXECUTE to perform the same functionality. In some cases you may prefer EXECUTE to CALL, since the former can be used to execute any kind of prepared SQL, including methods, functions, or batches of SQL code.

MySQL

MySQL supports the SQL standard form of the CALL statement.

Oracle

Oracle allows the CALL statement to invoke standalone stored procedures, functions, and methods, as well as stored procedures and functions contained within a type or package. Following is the Oracle syntax:

```
CALL [schema.][{type_name | package_name}.]procedure_name@dblink
[(parameter[, ...])]
[INTO :variable_name [[INDICATOR] :indicator_name]];
```

where:

`CALL (schema.]({type_name | package_name}.]procedure_name@dblink`
: Calls the named object. You may fully enumerate the object name, including the schema, type, etc., or allow Oracle to assume the current schema and database instance. If the procedure or function resides in another database, simply specify the database via a database link name, shown as *dblink* in the syntax. *dblink* must refer to a previously created database link.

`INTO :`*`variable_name`*
: Specifies the name of a previously declared variable that will store the value returned when you call a function. If you're calling a function, the `INTO` clause is required.

`INDICATOR :`*`indicator_name`*
: Retains the condition of the host variable (for example, whether the return value is NULL) for functions precompiled in a Pro*C/C++ routine.

The parameters used in an Oracle `CALL` statement *may not* include pseudocolumns or the `VALUE` or `REF` functions. You must use a host variable for any parameter that corresponds to an `OUT` or `IN OUT` argument of the called stored procedure.

PostgreSQL

PostgreSQL version 11 and later supports the SQL standard form of the `CALL` statement. Up to version 13, stored procedures cannot return any values; only `IN` parameters are supported. Starting with PostgreSQL 14, stored procedures support `OUT` parameters, allowing the `CALL` statement to return values.

SQL Server

`CALL` is not supported in Transact-SQL code such as stored procedures. Instead, use the nonstandard `EXECUTE` statement. On SQL Server, the `EXECUTE` statement provides a superset of the features of the `CALL` statement. Refer to the vendor documentation for additional information.

The SQL standard syntax for the `CALL` statement is supported via the SQL Server Native Client ODBC driver. This is optimized to use the remote procedure call (RPC) protocol and improves performance by reducing parameter and parsing processing on the server.

See also

- `CREATE/ALTER FUNCTION/PROCEDURE`

CLOSE Statement (Cursors)

The `CLOSE` statement is one of four commands used in cursor processing, along with `DECLARE, FETCH`, and `OPEN`. Cursors allow you to process queries one row at a time, rather than as a complete set. `CLOSE` closes a server-side cursor previously created with a `DECLARE CURSOR` statement and opened with an `OPEN` statement.

Platform	Command
MySQL	Supported
Oracle	Supported
PostgreSQL	Supported
SQL Server	Supported, with variations

SQL syntax

```
CLOSE cursor_name
```

Keywords

`CLOSE` *`cursor_name`*
: Identifies and closes a cursor previously created with the `DECLARE CURSOR` statement.

Rules at a glance

At the highest level, a cursor must be:

1. Created using `DECLARE`
2. Opened using `OPEN`
3. Operated against using `FETCH`
4. Dismissed using `CLOSE`

By following these steps, you create a result set similar to that generated by a `SELECT` statement, except that you can operate against each individual row within the result set.

The `CLOSE` statement closes a cursor and destroys the cursor result set. For example:

```
CLOSE author_names_cursor;
```

All the database platforms release any locks that were held by the cursor, though this is not specified in the SQL standard (locking is a physical feature of each database platform).

For more information on the use of cursors, refer to "DECLARE CURSOR Statement" on page 711 and "FETCH Statement (Cursors)" on page 720.

Programming tips and gotchas

You can also close a cursor implicitly using a `COMMIT` statement or, for cursors defined with `WITH HOLD`, using a `ROLLBACK` statement.

MySQL

MySQL supports the SQL standard form of the `CLOSE` statement.

Oracle

Oracle supports the SQL standard form of the `CLOSE` statement.

PostgreSQL

PostgreSQL supports the SQL standard form of the `CLOSE` statement. It issues an implicit `CLOSE` statement for every open cursor when a transaction is ended with a `COMMIT` or `ROLLBACK` statement.

SQL Server

SQL Server supports the SQL standard syntax for `CLOSE` and an additional `GLOBAL` keyword that identifies the previously defined cursor as a global cursor:

```
CLOSE [GLOBAL] cursor_name
```

Although the locks taken up by the cursor are dropped when it is closed, SQL Server does not automatically reallocate memory structures consumed by a cursor to the memory pool. To accomplish such reallocation, you must issue a `DEALLOCATE` *`cursor_name`* command.

This example from SQL Server opens a cursor and fetches a result set of all employees who have a last name starting with "K," then closes the cursor and deallocates the memory structures:

```
DECLARE employee_cursor CURSOR FOR
   SELECT lname, fname
   FROM pubs.dbo.employee
   WHERE lname LIKE 'K%'
OPEN employee_cursor
FETCH NEXT FROM employee_cursor
WHILE @@FETCH_STATUS = 0
BEGIN
   FETCH NEXT FROM employee_cursor
END
CLOSE employee_cursor
DEALLOCATE employee_cursor
GO
```

See also

- `DECLARE CURSOR`
- `FETCH`
- `OPEN`

CREATE/ALTER AGGREGATE Statement

The `CREATE AGGREGATE` statement creates a special kind of user-defined function called an aggregate, which can be used just like the built-in aggregates discussed in Chapter 8 (`SUM`, `AVG`, `MAX`, `MIN`, etc.). This command is not part of the SQL standard, and there is wide variety in how this feature is supported by the different database platforms and the syntax used. MariaDB, Oracle, and PostgreSQL allow creation of aggregate functions using embedded SQL or PL/SQL-like code, while MySQL and SQL Server require them to be created in external libraries and linked in. Only PostgreSQL supports an `ALTER AGGREGATE` command for changing the definition of an aggregate function.

Platform	Command
MySQL/MariaDB	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

Rules at a glance

The `CREATE AGGREGATE` command creates a new user-defined function in the database that can be used in aggregate queries, such as those with `GROUP BY`. Some databases also allow these to be used as window aggregate functions in conjunction with the `OVER` clause (see Chapter 8 for details).

Programming tips and gotchas

`CREATE AGGREGATE` is an extension of the SQL standard. All the databases covered in this book support it in some shape or form even though it is not explicitly defined in the SQL specifications.

MySQL/MariaDB

In MySQL, the `CREATE AGGREGATE FUNCTION` command essentially binds the name of a function to a shared C++/C library that implements the function. The syntax is as follows:

```
CREATE AGGREGATE FUNCTION function_name
    RETURNS {STRING | INTEGER | REAL | DECIMAL}
    SONAME shared_library_name
```

MariaDB 10.3 and later additionally supports creating aggregates using Oracle-compatible PL/SQL, with the following syntax:

```
CREATE AGGREGATE FUNCTION function_name
   RETURNS return_type
BEGIN
    // All types of declarations
```

```
        DECLARE CONTINUE HANDLER FOR NOT FOUND RETURN return_val;
        LOOP
           FETCH GROUP NEXT ROW; // Fetches next row from table
           // Other instructions
        END LOOP;
    END
```

See the documentation for details.

Oracle

The Oracle syntax for creating an aggregate function is as follows (see the documentation for more information):

```
    CREATE FUNCTION function_name
       RETURN {return_type}
       AGGREGATE USING AggRoutinesType
```

The *AggRoutinesType* takes the following form:

```
    CREATE TYPE AggRoutinesType(
       STATIC FUNCTION ODCIAggregateInitialize(...) ...,
       MEMBER FUNCTION ODCIAggregateIterate(...) ...,
       MEMBER FUNCTION ODCIAggregateMerge(...) ...,
       MEMBER FUNCTION ODCIAggregateTerminate(...)
    );
    CREATE TYPE BODY AggRoutinesType IS
    :
    END;
```

PostgreSQL

PostgreSQL supports creating aggregates in any language installed in the database. This includes the built-in C, SQL, and PL/pgSQL, and numerous others you may have installed, such as PL/V8 (aka JavaScript), PL/R, PL/Perl, and PL/Python. You can even have different bits of an aggregate function programmed in different languages. These aggregates can take more than one argument (multicolumn aggregates), and any aggregate you create in PostgreSQL can be used in a window aggregate of the form `my_agg OVER(PARTITION BY id) AS win_agg`.

The general syntax is as follows (see the documentation for more information):

```
    CREATE [OR REPLACE] AGGREGATE name ( [argmode] [argname]
       arg_data_type[, ...] ) (
        SFUNC = sfunc,
        STYPE = state_data_type
        [, SSPACE = state_data_size]
        [, FINALFUNC = ffunc]
        [, FINALFUNC_EXTRA]
        [, FINALFUNC_MODIFY = { READ_ONLY | SHAREABLE | READ_WRITE }]
        [, COMBINEFUNC = combinefunc]
        [, SERIALFUNC = serialfunc]
        [, DESERIALFUNC = deserialfunc]
        [, INITCOND = initial_condition]
        [, MSFUNC = msfunc]
        [, MINVFUNC = minvfunc]
        [, MSTYPE = mstate_data_type]
        [, MSSPACE = mstate_data_size]
        [, MFINALFUNC = mffunc]
        [, MFINALFUNC_EXTRA]
        [, MFINALFUNC_MODIFY = { READ_ONLY | SHAREABLE | READ_WRITE }]
        [, MINITCOND = minitial_condition]
        [, SORTOP = sort_operator]
        [, PARALLEL = { SAFE | RESTRICTED | UNSAFE }]
    )
```

At a minimum, a PostgreSQL aggregate definition must include the following items:

`name`
: Provides a name for the aggregate.

`sfunc`
: Identifies the state transition function that is called for every row passing through the aggregate. For a single-argument aggregate it generally takes two values, which represent the current state and incoming value, and returns a value of the data type *`state_data_type`*.

`FINALFUNC_MODIFY`
: Indicates whether the final state function modifies its arguments. The default is `READ_ONLY`, which means it doesn't modify the arguments. If `FINALFUNC_MODIFY` is `READ_WRITE`, that bars the function from being used as a window aggregate.

Many of the optional items, such as *combinefunc*, *serialfunc*, and *deserialfunc*, are used to support parallelization of aggregate functions. By default aggregates are marked `PARALLEL UNSAFE`.

PostgreSQL has special data type placeholders called `ANYELEMENT` and `ANYARRAY` that are often used to produce aggregates that can handle many kinds of data types.

By default PostgreSQL aggregates can be used as ordered aggregates, meaning you can add an `ORDER BY` clause in the function call. This makes a lot of sense for aggregates such as `ARRAY_AGG` and `STRING_AGG`, where you need to control the order of the elements in the aggregate. (Conversely, ordering is pretty meaningless for aggregates like `SUM`, where the order of input does not affect the result.)

The following is an example aggregate built with just SQL that returns the first item in a set:

```
-- State function
CREATE FUNCTION first_element_state(param_state anyarray,
   Param_new_element anyelement)
RETURNS anyarray
   LANGUAGE sql
   IMMUTABLE PARALLEL SAFE COST 10
   AS
$sql$
   SELECT
      CASE WHEN array_upper(param_state,1) IS NULL
      THEN array_append(param_state,param_new_element)
      ELSE param_state END;
$sql$;
-- Final function
CREATE FUNCTION first_element(param_state anyarray)
RETURNS anyelement
   LANGUAGE sql
   IMMUTABLE PARALLEL SAFE COST 10
   AS
$sql$
   SELECT param_state[1] ;
$sql$;

CREATE AGGREGATE first(anyelement) (
   SFUNC=first_element_state,
   STYPE=anyarray,
   FINALFUNC=first_element
)
;
```

This aggregate is called `first` and is composed of two functions: `first_element_state`, which manages the state, and `first_element`, which returns the final value.

We can use the function to return the first *title_id* that was published by each publisher and the price of that title alongside the count of titles that the publisher published as follows:

```
SELECT
    pub_id,
    count(*),
    first(title_id ORDER BY pubdate, title_id) AS title_id,
    first(price ORDER BY pubdate, title_id) As price,
    first(pubdate ORDER BY pubdate, title_id) As pubdate,
    min(pubdate) AS min_pubdate
FROM titles
GROUP BY pub_id
ORDER BY pub_id;
```

The output would be:

```
pub_id  | count | title_id | price  |  pubdate   | min_pubdate
--------+-------+----------+--------+------------+------------
 0736   |   5   | PS7777   |  $7.99 | 1991-06-12 | 1991-06-12
 0877   |   7   | MC2222   | $19.99 | 1991-06-09 | 1991-06-09
 1389   |   6   | BU1111   | $11.95 | 1991-06-09 | 1991-06-09
```

In this example the *min_pubdate* and *pubdate* will always be the same since our first sorting is based on *pubdate*.

SQL Server

In SQL Server, you must first build a library in .NET, then load the library into the database using CREATE ASSEMBLY, and then use CREATE AGGREGATE to reference the class within the library. Once completed, your aggregate may only be called if CLR is enabled in your database (CLR execution is disabled by default on SQL Server and is not supported in Azure SQL Database). A full description and explanation of CLR is beyond the scope of this book (see the vendor documentation for further details), but the basic syntax of the CREATE AGGREGATE statement is as follows:

```
CREATE AGGREGATE [schema_name.]aggregate_name
   (@param_name input_sqltype[, ...n])
RETURNS return_sqltype
EXTERNAL NAME assembly_name[.class_name]
input_sqltype ::= system_scalar_type |
   { [udt_schema_name.]udt_type_name }
return_sqltype ::= system_scalar_type |
   { [udt_schema_name.]udt_type_name }
```

See also

- CREATE/ALTER FUNCTION/PROCEDURE
- CREATE/ALTER TYPE in Chapter 3
- GROUP BY in Chapter 4
- OVER in Chapter 4

CREATE CAST Statement

The CREATE CAST statement is used to define custom casting behavior between two data types. Casting is triggered either by calling the CAST function or automatically, for example when inserting a value of one type into a table column of another type.

Platform	Command
MySQL	Not supported
Oracle	Not supported
PostgreSQL	Supported, with variations
SQL Server	Not supported

SQL syntax

```
CREATE CAST (source_type AS target_type)
   WITH FUNCTION function_name [ (argument_type[, ...]) ]
   [ AS ASSIGNMENT ]
```

Keywords

`CREATE CAST (`*`source_type`*` AS `*`target_type`*`)`
: Creates a new cast that converts a *`source_type`* into a *`target_type`*.

`WITH FUNCTION `*`function_name`*
: Specifies an existing function that will be used to do the conversion. The function name can be schema-qualified. If no schema is specified, then the default schema is used to determine which function to use.

`AS ASSIGNMENT`
: Indicates that the cast can be invoked implicitly in assignment contexts. If this is left out, the cast can be invoked implicitly in any context.

Rules at a glance

User-defined casts are a mechanism of coercing data of one type to another type. In DBMSs that support the creation of custom data types, they are invaluable. A basic cast looks like this:

```
CREATE CAST (employee AS person)
    WITH FUNCTION person(employee)
         AS ASSIGNMENT
```

MySQL

MySQL does not support the `CREATE CAST` statement.

Oracle

Oracle does not support the `CREATE CAST` statement.

PostgreSQL

PostgreSQL fully supports the `CREATE CAST` statement and extends it. The syntax to define a new cast takes several forms:

```
CREATE CAST (source_type AS target_type)
    WITH FUNCTION function_name [ (argument_type[, ...]) ]
    [ AS ASSIGNMENT | AS IMPLICIT ]

CREATE CAST (source_type AS target_type)
    WITHOUT FUNCTION
    [ AS ASSIGNMENT | AS IMPLICIT ]

CREATE CAST (source_type AS target_type)
    WITH INOUT
    [ AS ASSIGNMENT | AS IMPLICIT ]
```

where:

`AS IMPLICIT`
: Is equivalent to not specifying an `ASSIGNMENT` clause and is the default behavior.

`WITH INOUT`
: Indicates that the cast is an I/O conversion cast, performed by invoking the output function of the source data type and passing the resulting string to the input function of the target data type.

`WITHOUT FUNCTION`
: Indicates that the source type is binary coercible to the target type.

The following example casts Boolean values to bit 0 for true and 1 for false:

```
-- Define the casting function
CREATE OR REPLACE FUNCTION bool_to_bit(param_val boolean)
RETURNS bit
language sql COST 10 PARALLEL SAFE AS
$$
SELECT CASE param_val WHEN true THEN 1
    WHEN false THEN 0
    ELSE NULL END::bit;
$$;
-- Define the case
CREATE CAST (boolean AS bit)
    WITH FUNCTION bool_to_bit(boolean);
```

To use the cast you can do the following:

```
SELECT CAST(true AS bit);
```

SQL Server

SQL Server does not support the `CREATE CAST` statement.

See also

- `CAST` in Chapter 7
- `CREATE/ALTER FUNCTION/PROCEDURE`
- `CREATE/ALTER TYPE` in Chapter 3

CREATE/ALTER FUNCTION/PROCEDURE Statement

The `CREATE FUNCTION` and `CREATE PROCEDURE` statements (and the respective `ALTER` statements) are very similar in syntax and coding. The `CREATE PROCEDURE` statement creates a *stored procedure*, which takes input arguments and performs conditional processing on various objects in the database. According to the SQL standard, a stored procedure returns no result set (though it may return values in `OUTPUT` parameters). For example, you might use a stored procedure to perform all the processes that close an accounting cycle.

The `CREATE FUNCTION` statement creates a UDF that takes input arguments and returns an output in the same way as a system-supplied function like `CAST` or `UPPER`. In addition to single scalar values, functions can return a set of rows defined using `TABLE (<structure_of_table>)` or a set of values defined as `OUT` or `INOUT` in the argument definition. These functions, once created, can be called in queries and data manipulation operations, such as `INSERT`, `UPDATE`, and the `WHERE` clause of DML statements. Refer to Chapter 7 for descriptions of built-in SQL functions and their individual vendor implementations.

Platform	Command
MySQL/MariaDB	Supported, with variations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL syntax

```
CREATE {PROCEDURE | FUNCTION} object_name
   ( [{[IN | OUT | INOUT] [parameter_name] data_type
   [DEFAULT parameter_default] [AS LOCATOR] [RESULT]}[, ...]] )
[RETURNS data_type [AS LOCATOR] | returns_table_type]
[CAST FROM data_type [AS LOCATOR]]]
[LANGUAGE {ADA | C | COBOL | FORTRAN | M | MUMPS | PASCAL | PLI | SQL}]
[PARAMETER STYLE {SQL | GENERAL}]
[SPECIFIC specific_name]
[DETERMINISTIC | NOT DETERMINISTIC]
[NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA]
[RETURN NULL ON NULL INPUT | CALL ON NULL INPUT]
[DYNAMIC RESULT SETS int]
[STATIC DISPATCH] code_block

returns_table_type ::= TABLE [(column_name1 data_type1,
   column_name2 data_type2[, ...)] | ONLY PASS THROUGH
```

Use the following syntax to alter a preexisting UDF or stored procedure:

```
ALTER {PROCEDURE | FUNCTION} object_name
   [( {parameter_name data_type }[, ...] )]
[NAME new_object_name]
[LANGUAGE {ADA | C | FORTRAN | MUMPS | PASCAL | PLI | SQL}]
[PARAMETER STYLE {SQL | GENERAL}]
[NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA]
[RETURN NULL ON NULL INPUT | CALL ON NULL INPUT]
[DYNAMIC RESULT SETS int]
[CASCADE | RESTRICT]
```

Keywords

`CREATE {PROCEDURE | FUNCTION} object_name`
: Creates a new stored procedure or user-defined function with the name *`object_name`*. A UDF returns a value, whereas a stored procedure (in the SQL standard) does not.

> User-defined functions and stored procedures, when referred to generically, are called *routines*.

`( [{[IN | OUT | INOUT] [parameter_name] data_type [AS LOCATOR] [RESULT]}[, ... ]] )`
: Declares one or more parameters to be passed into a routine in a comma-delimited list enclosed in parentheses. Parameters used may pass a value `IN`, `OUT`, or both in and out via `INOUT`. The default parameter mode is `IN`. In the SQL standard, functions can not specify a parameter mode, so all parameters are `IN`.

The syntax for the parameter declaration is:

```
[{IN | OUT | INOUT}] parameter_name1 data_type,
[{IN | OUT | INOUT}] parameter_name2 data_type,[...]
```

When providing the optional *parameter_name*, make sure the name is unique within the routine. The optional `AS LOCATOR` subclause is used to validate an external routine with a `RETURNS` parameter that is a `BLOB`, `CLOB`, `NCLOB`, `ARRAY`, or user-defined type. If you need to change the data type of a `RETURNS` parameter on the fly, use the `CAST` clause (refer to the section on the function `CAST` in Chapter 4): for example, `RETURNS VARCHAR(12) CAST FROM DATE`. When used with `ALTER`, this clause adds parameters to a preexisting stored procedure. Refer to Chapter 2 for details on data types.

`RETURNS data_type [AS LOCATOR] [CAST FROM data_type [AS LOCATOR]]`
: Declares the data type of the result returned by a function. (This clause is used only in the `CREATE FUNCTION` statement and is not used in stored procedures.)

`RETURNS TABLE (column_name1 data_type1, column_name2 data_type2[, ... ])`
: Returns a set of rows with the defined table structure. SQL:2016 introduced polymorphic table functions, where the table structure is defined at runtime rather than compile time. None of the databases considered here support this syntax, but Oracle 18 and later does support polymorphic table functions with its own proprietary syntax.

`LANGUAGE {ADA | C | FORTRAN | MUMPS | PASCAL | PLI | SQL}`
: Declares the language in which the function is written. Most database platforms do not support all of these languages, and they may support others, such as Java. When omitted, the default is `SQL`. When used with `ALTER`, this clause changes the existing `LANGUAGE` value to the value that you declare.

`PARAMETER STYLE {SQL | GENERAL}`
: Indicates, for external routines only, whether certain implicit and automatic parameters are passed explicitly with the options (`SQL`) or not (`GENERAL`). (The difference between `SQL` style and `GENERAL` style is that `SQL` style automatically passes SQL parameters, such as indicators, while `GENERAL` style does not automatically pass indicators.) The default is `PARAMETER STYLE SQL`. When used with `ALTER`, this clause changes the existing `PARAMETER STYLE` value to the value that you declare.

`SPECIFIC` *`specific_name`*
: Uniquely identifies the function. Generally used with user-defined types.

`DETERMINISTIC | NOT DETERMINISTIC`
: States the nature of values returned by the function. (This clause is used only in `CREATE` and `ALTER FUNCTION` statements.) `DETERMINISTIC` functions always return the same value when given the same parameter values. `NOT DETERMINISTIC` functions may return variable results when given the same parameter values. For example, `CURRENT_TIME` is not deterministic because it returns a constantly advancing value corresponding to the time. The default is `NOT DETERMINISTIC`. Specifying that a function is `DETERMINISTIC` allows the SQL implementation to cache results for a function and just return the cached result rather than executing the function. Use `DETERMINISTIC` with care.

`NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA`
: Specifies, in conjunction with the `LANGUAGE` setting, the type of SQL contained in the user-defined function. When used with `ALTER`, this clause changes the existing `SQL` style value to the value that you declare.

`NO SQL`
: Indicates that no SQL statements of any type are in the function. Used with a non-SQL `LANGUAGE` setting such as `LANGUAGE ADA ... CONTAINS NO SQL`.

`CONTAINS SQL`
: Indicates that SQL statements other than read or modify statements are in the function. This is the default.

`READS SQL DATA`
: Indicates that the function contains `SELECT` or `FETCH` statements.

`MODIFIES SQL DATA`
: Indicates that the function contains `INSERT`, `UPDATE`, or `DELETE` statements.

`RETURN NULL ON NULL INPUT | CALL ON NULL INPUT`
: These options are for use with a host `LANGUAGE` that cannot support NULLs. The `RETURNS NULL ON NULL INPUT` setting causes the function to immediately return a NULL value if it is passed a NULL value. The `CALL ON NULL INPUT` setting causes the function to handle NULLs according to standard rules: for example, returning `UNKNOWN` when a comparison of two NULL values occurs. (This clause is used in the `CREATE` and `ALTER PROCEDURE` and `FUNCTION` statements.) When used with `ALTER`, this clause changes the existing NULL-style value to the value that you declare.

`DYNAMIC RESULT SETS` *`int`*
: Declares that a certain number of cursors (*int*) can be opened by the stored procedure and that those cursors are visible after returning from the procedure. When omitted, the default is `DYNAMIC RESULT SETS 0`. (This clause is not used in `CREATE FUNCTION` statements.) When used with `ALTER`, this clause changes the existing `DYNAMIC RESULT SETS` value to the value that you declare.

`STATIC DISPATCH`
: Returns the static values of a user-defined type or `ARRAY` data type. Required for non-SQL functions that contain parameters that use user-defined types or `ARRAY`s. (This clause is not used in `CREATE PROCEDURE` statements.) This clause must be the last clause in the function or procedure declaration before the *`code_block`*.

`code_block`
: Declares the procedural statements that handle all processing within the user-defined function or stored procedure. This is the most important, and usually largest, part of a function or procedure.

  While we assume that you're interested in SQL-based UDFs and stored procedures (this is a SQL book, after all), you can declare that the code block is derived externally. The syntax for external *`code_block`*s is:

```
EXTERNAL [NAME external_routine_name] [PARAMETER STYLE
   {SQL | GENERAL}] [TRANSFORM GROUP group_name]
```

  where:

  `EXTERNAL [NAME` *`external_routine_name`*`]`
  : Defines an external routine and assigns a name to it. When omitted, the unqualified routine name is used.

  `PARAMETER STYLE {SQL | GENERAL}`
  : Same as for `CREATE PROCEDURE`.

  `TRANSFORM GROUP` *`group_name`*
  : Transforms values between user-defined types and host variables in a user-defined function or a stored procedure. When omitted, the default is `TRANSFORM GROUP DEFAULT`.

`NAME` *`new_object_name`*

Declares the new name to use for a previously defined UDF or stored procedure. This clause is used only with `ALTER FUNCTION` and `ALTER PROCEDURE` statements.

`CASCADE | RESTRICT`

Allows you to cause changes to `CASCADE` down to all dependent UDFs or stored procedures, or to `RESTRICT` a change from happening if there are dependent objects. We strongly recommend that you *do not* issue an `ALTER` statement against UDFs or stored procedures that have dependent objects. This clause is used only with `ALTER FUNCTION` and `ALTER PROCEDURE` statements.

Rules at a glance

With a user-defined function, you declare the input arguments and the return argument that the function passes back out. You can then call the UDF just as you would any other function: for example, in `SELECT` statements, `INSERT` statements, or `WHERE` clauses.

Similarly, with a user-defined procedure, you declare the input arguments that go into the procedure and the output arguments that come out from it. You invoke a stored procedure using the `CALL` statement. The content of the procedure's *code_block* must conform to the rules of whatever procedural language the database platform supports. Stored procedures cannot be used in `SELECT` statements, `INSERT` statements, or `WHERE` clauses. Some vendors do not have their own internal procedural languages, requiring you to use `EXTERNAL` *`code_block`* constructs.

The SQL Server stored procedure in the following example generates a unique 22-digit value (based on elements of the system date and time) and returns it to the calling process:

```
-- A SQL Server stored procedure
CREATE PROCEDURE get_next_nbr
   @next_nbr CHAR(22) OUTPUT
AS
BEGIN
  DECLARE @random_nbr INT
  SELECT @random_nbr = RAND() * 1000000
SELECT @next_nbr =
  RIGHT('000000' + CAST(ROUND(RAND(@random_nbr)*1000000,0))AS
    CHAR(6), 6) +
  RIGHT('0000' + CAST(DATEPART (yy, GETDATE() ) AS CHAR(4)), 2) +
  RIGHT('000'  + CAST(DATEPART (dy, GETDATE() ) AS CHAR(3)), 3) +
  RIGHT('00'   + CAST(DATEPART (hh, GETDATE() ) AS CHAR(2)), 2) +
  RIGHT('00'   + CAST(DATEPART (mi, GETDATE() ) AS CHAR(2)), 2) +
  RIGHT('00'   + CAST(DATEPART (ss, GETDATE() ) AS CHAR(2)), 2) +
  RIGHT('000'  + CAST(DATEPART (ms, GETDATE() ) AS CHAR(3)), 3)
END
GO
Here, we change the name of an existing stored procedure:
```

```
ALTER PROCEDURE get_next_nbr
NAME "get_next_ID"
RESTRICT;
```

Programming tips and gotchas

A stored procedure or function has several advantages over plain SQL. One advantage is the fact that in many databases it is *precompiled*, meaning that once it's been created, its query plans are already stored in the database. Precompiled routines can often (though not always) be cached in database memory to provide an additional boost in performance by allowing future runs of the same routine to skip the compile phase. Another advantage is that a stored procedure or user-defined function can perform many statements with a single communication to the server, thus reducing network traffic. A third is that it compartmentalizes often complex logic and allows it to be used across many queries or applications without having to repeat that logic.

Implementations of user-defined functions and stored procedures vary widely by platform. Some database platforms do not support internal *`code_block`* content. On these platforms, you can only write an external *`code_block`*. The following sections outline the variations and the capabilities of each platform.

If you execute an `ALTER PROCEDURE/FUNCTION` statement, dependent objects may become invalid after a change to an object on which they depend. This may require an explicit revalidation step. Be careful to check all dependencies when altering UDFs or stored procedures on which other UDFs or stored procedures may depend.

MySQL and MariaDB

MySQL and MariaDB support the `CREATE/ALTER FUNCTION` and `CREATE/ALTER PROCEDURE` statements. In addition, MariaDB supports the `CREATE [OR REPLACE]` syntax for both.

The syntax for functions and procedures follows:

```
CREATE
[DEFINER = {user | CURRENT_USER}]
{ FUNCTION | PROCEDURE }  [database_name.]routine_name
   ( [{IN | OUT | INOUT}] [parameter[, ...] )
[RETURNS type]
LANGUAGE SQL
 | [NOT] DETERMINISTIC
 | [NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA]
 | [COMMENT 'string'] routine_body;
```

And here is the MariaDB `CREATE` syntax for functions and procedures:

```
CREATE [OR REPLACE]
[DEFINER = {user | CURRENT_USER}]
```

```
{ FUNCTION | PROCEDURE }  [database_name.]routine_name
   ( [{IN | OUT | INOUT}] [parameter[, ...] )
[RETURNS type]
LANGUAGE SQL
 | [NOT] DETERMINISTIC
 | [NO SQL | CONTAINS SQL | READS SQL DATA | MODIFIES SQL DATA]
 | [COMMENT 'string'] routine_body;
```

where:

`CREATE { FUNCTION | PROCEDURE } [`*`database_name`*`.]`*`routine_name`*
: Creates a function or procedure with a *`routine_name`* of not more than 64 characters. The module is stored in the *proctable* in the MySQL database.

`DEFINER`
: Assigns a *`user`*, in the format *`user_name@host_name`*, as the owner of the routine. When omitted, the `CURRENT_USER` is the default.

`([{IN | OUT | INOUT}]` *`parameter`*`[, ... ] )`
: Defines one or more parameters for the routine. All function parameters must be `IN` parameters, but procedure parameters may be any of the three types. When this clause is omitted on a procedure, parameters are `IN` by default.

`RETURNS` *`type`*
: Returns a value of type *`type`*, which can be any valid MySQL data type. Only for use with `CREATE` or `ALTER FUNCTION`, where it is mandatory.

`COMMENT '`*`string`*`'`
: Adds a comment to the routine. The comment(s) may be displayed using the `SHOW CREATE PROCEDURE` and `SHOW CREATE FUNCTION` statements.

`routine_body`
: Contains one or more valid SQL statements. Multiple SQL statements should be nested within `BEGIN` and `END`. The *`routine_body`* can also contain procedural language such as declarations, loops, and other control structures.

Procedures and functions may contain Data Definition Language (DDL) statements such as `CREATE`, `ALTER`, or `DROP`. Procedures, but not functions, may contain transaction control statements such as `COMMIT` and `ROLLBACK`. Functions may not use statements that perform explicit or implicit rollbacks or commits, nor may functions contain statements that return uncontrolled result sets, such as a `SELECT` statement without the `INTO` clause. Neither procedures nor functions may contain the command `LOAD DATA INFILE`.

Once implemented, a MySQL function may be called just like any built-in function, such as `ABS` or `SOUNDEX`. Procedures, on the other hand, are invoked using the `CALL` statement.

The implementation of `CREATE FUNCTION` in MySQL and MariaDB supports both user-defined functions through an implementation that depends on external procedural code in C/C++ under an operating system that supports dynamic loading and SQL language functions where the code body is part of the function.

In the case of C/C++, a program is named in the *shared_program_library_name* option. The function may be compiled either directly into the MySQL server, making it permanently available, or as a dynamically callable program. For example, the code behind the UDF created in the following statement might be found on a Unix server:

```
CREATE FUNCTION find_radius RETURNS INT SONAME "radius.so";
```

MySQL and MariaDB also support SQL functions. Here is an example:

```
CREATE FUNCTION formatted_name (fname VARCHAR(30), lname VARCHAR(30))
 RETURNS VARCHAR(60) DETERMINISTIC
    RETURN CONCAT(fname,' ',lname);
```

You could then use this user-defined function just as you would any other function:

```
SELECT formatted_name(au_fname, au_lname) AS name, au_id AS id
FROM authors;
```

Oracle

Oracle supports ALTER and CREATE for both the FUNCTION and PROCEDURE object types.

Oracle packages can also be used to create UDFs and stored procedures; for more information see the vendor documentation on the CREATE PACKAGE statement and the discussion of packages in the Oracle section in "Platform-Specific Extensions" on page 734.

Oracle's CREATE FUNCTION/PROCEDURE syntax is as follows:

```
CREATE [OR REPLACE] {FUNCTION | PROCEDURE} [schema.]object_name
[(parameter1 [IN | OUT | IN OUT] [NOCOPY] data_type[, ...])]
RETURN data_type
[DETERMINISTIC | SQL_MACRO(SCALAR | TABLE)]
[AUTHID {CURRENT_USER | DEFINER}]
[PARALLEL_ENABLE [(PARTITION prtn_name BY {ANY | {HASH | RANGE}
   (column[, ...])}) [{ORDER | CLUSTER} BY (column[, ...])]]]
{{PIPELINED | AGGREGATE} [USING [schema.]implementation_type] |
   [PIPELINED] {IS | AS}}
{code_block | LANGUAGE {JAVA NAME external_program_name |
   C [NAME external_program_name]}
   LIBRARY lib_name [AGENT IN (argument[, ...])] [WITH CONTEXT]
   [PARAMETERS (params[, ...])]}
```

The ALTER FUNCTION/PROCEDURE statement, whose syntax is shown next, is used to recompile invalid UDFs or stored procedures:

```
ALTER {FUNCTION | PROCEDURE) [schema.]object_name COMPILE [DEBUG]
 [compiler_param = value [...]] [REUSE SETTINGS]
```

Following are the parameter descriptions. Certain clauses are only used with user-defined functions, including the `RETURN` clause, the `DETERMINISTIC` clause, `SQL_MACRO`, and the entirety of the `USING` clause:

`CREATE [OR REPLACE] {FUNCTION | PROCEDURE} [`*`schema`*`.]`*`object_name`*
: Creates a new UDF or stored procedure. Use `CREATE OR REPLACE` to replace an existing procedure or UDF without first dropping it and then having to reassign all permissions to it.

`IN | OUT | IN OUT`
: Specifies whether a parameter is an input to the function, an output from the function, or both.

`NOCOPY`
: Speeds up performance when an `OUT` or `IN OUT` argument is very large, as with a `VARRAY` or `RECORD` data type.

`AUTHID {CURRENT_USER | DEFINER}`
: Forces the routine to run in the permission context of either the current user or the person who owns the function, using `AUTHID CURRENT_USER` or `AUTHID DEFINER`, respectively.

`PARALLEL_ENABLE`
: Enables the routine to be executed by a parallel query operation on a symmetric multiprocessor (SMP) or parallel-processor server. This clause is used only for UDFs. (*Do not* use session state or package variables, because they can't be expected to be shared among parallel-execution servers.) Define the behavior of the `PARALLEL_ENABLE` query operation using these subclauses:

  `PARTITION `*`prtn_name`*` BY {ANY | {HASH | RANGE} (column[, ... ])}`
  : Defines partitioning of inputs on functions with `REF CURSOR` arguments. This may benefit table functions. `ANY` allows random partitioning. You can restrict partitioning to a specific `RANGE` or `HASH` partition on a comma-delimited *`column`* list.

  `{ORDER | CLUSTER} BY (`*`column`*`[, ... ])`
  : Orders or clusters parallel processing based on a comma-delimited *`column`* list. `ORDER BY` causes the rows to be locally ordered on the parallel-execution server according to the *`column`* list. `CLUSTER BY` restricts the rows on the parallel-execution server to the key values identified in the *`column`* list.

`{PIPELINED | AGGREGATE} [USING [`*`schema`*`.]`*`implementation_type`*`]`
: `PIPELINED` iteratively returns the results of a table function, instead of the normal serial return of the `VARRAY` or nested table result set. This clause is used only for UDFs. The clause `PIPELINED USING `*`implementation_type`* is for

an external UDF that uses a language such as C++ or Java. The `AGGREGATE USING` *`implementation_type`* clause defines a UDF as an aggregate function (a function that evaluates many rows but returns a single value).

`IS | AS`
: Oracle treats `IS` and `AS` equally. Use either one to introduce the *`code_block`*.

`code_block`
: Oracle allows a PL/SQL code block for user-defined functions and stored procedures. Alternatively, you may use the `LANGUAGE` clause for stored procedures written in Java or C.

`LANGUAGE {JAVA NAME` *`external_program_name`* `| C [NAME` *`external_program_name`*`] LIBRARY` *`lib_name`* `[AGENT IN (`*`argument`*`[, ... ])] [WITH CONTEXT] [PARAMETERS (`*`params`*`[, ... ])] }`
: Defines the Java or C implementation of the external program. The parameters and semantics of each declaration are specific to Java and C, not SQL.

`ALTER {FUNCTION | PROCEDURE} [`*`schema.`*`]` *`object_name`*
: Recompiles an invalid standalone stored routine. Use *CREATE ... OR REPLACE* to change the arguments, declarations, or definition of an existing routine.

`COMPILE [DEBUG] [REUSE SETTINGS]`
: Recompiles the routine. Note that `COMPILE` is required. (You can see compile errors with the SQL*Plus command `SHOW ERRORS`.) The routine is marked valid if no compiler errors are encountered. The following optional subclauses may also be included with the `COMPILE` clause:

  `DEBUG`
  : Generates and stores code used by the PL/SQL debugger.

  `compiler_param` `=` *`value`* `[ ... ]`
  : Specifies a PL/SQL compiler parameter. Allowable parameters include `PLSQL_OPTIMIZE_LEVEL`, `PLSQL_CODE_TYPE`, `PLSQL_DEBUG`, `PLSQL_WARNINGS`, and `NLS_LENGTH_SEMANTICS`. Refer to Oracle's documentation on the PL/SQL compiler for more details.

  `REUSE SETTINGS`
  : Maintains the existing compiler switch settings and reuses them for recompilation. Normally, Oracle drops and reacquires compiler switch settings.

In Oracle, UDFs and stored procedures are very similar in composition and structure. The primary difference is that a stored procedure cannot return a value to the invoking process, while a function may return a single value to the invoking process.

For example, you can pass in the name of a construction project to the following function to obtain the project's profit:

```
CREATE OR REPLACE FUNCTION project_revenue (project IN varchar2)
RETURN NUMBER
AS
   proj_rev NUMBER(10,2);
BEGIN
   SELECT SUM(DECODE(action,'COMPLETED',amount,0)) -
          SUM(DECODE(action,'STARTED',amount,0))   +
          SUM(DECODE(action,'PAYMENT',amount,0))
   INTO proj_rev
   FROM construction_actions
   WHERE project_name = project;
   RETURN (proj_rev);
END;
/
```

In this example, the UDF accepts the project name as an argument. Then it processes the project revenue, behind the scenes, by subtracting the starting costs from the completion payment and adding any other payments into the amount. The `RETURN (`*`proj_rev`*`);` line returns the amount to the invoking process.

Here is the same UDF we created earlier for MySQL/MariaDB implemented as an Oracle function:

```
CREATE OR REPLACE FUNCTION formatted_name (fname varchar2,
   lname varchar2)
RETURN varchar2 DETERMINISTIC IS

BEGIN
    RETURN fname || ' ' || lname;
END;
/
```

SQL macros are a new kind of function introduced in Oracle 21c and backported to Oracle 19c in the 19.6 release. They're inlined in a SQL query, and unlike regular functions must be very simple (see "Platform-Specific Extensions" on page 538 for more on SQL macros and inline functions). In general they have better performance than regular functions because they are not called per row of data. Here is the preceding function written as a SQL macro:

```
CREATE OR REPLACE FUNCTION formatted_name (fname VARCHAR2,
   lname VARCHAR2)
RETURN VARCHAR2 SQL_MACRO(SCALAR)

BEGIN
    RETURN q'{ fname || ' ' || lname  }';
END;
/
```

You could then use this user-defined function just as you would any other function:

```
SELECT formatted_name(au_fname, au_lname) AS name, au_id AS id
FROM authors;
```

In Oracle, UDFs can be bound to external libraries written in C and Java. Here is an example of a UDF defined in a C library:

```
CREATE PROCEDURE find_root
( x IN REAL )
IS LANGUAGE C
NAME c_find_root
LIBRARY c_utils
PARAMETERS ( x BY REFERENCE );
/
```

In Oracle:

- UDFs cannot be used in a `CHECK` constraint or `DEFAULT` constraint of a `CREATE TABLE` or `ALTER TABLE` statement.
- In a `SELECT`, `INSERT`, `UPDATE`, or `DELETE`, the UDF cannot, either directly or indirectly (if invoked by another routine):
  - — Have an `OUT` or `IN OUT` parameter. (Indirect calls may take `OUT` and `IN OUT` parameters.)
  - — Terminate the transaction with `COMMIT`, `ROLLBACK`, `SAVEPOINT`, or a `CREATE`, `ALTER`, or `DROP` statement that implicitly issues a `COMMIT` or `ROLLBACK`.
  - — Use session control (`SET ROLE`) or system control (the Oracle-specific `ALTER SYSTEM`) statements.
  - — Write to a database (when a component of a `SELECT` statement or a parallelized `INSERT`, `UPDATE`, or `DELETE` statement).
  - — Write to the same table that is modified by the statement that calls the UDF.

When you recompile a routine with the `ALTER` statement, it is marked valid if no compiler errors are encountered. If any errors are encountered, it is marked invalid. However, perhaps more importantly, any objects that depend upon the recompiled routine are marked invalid regardless of whether or not an error occurs. You can either recompile those dependent objects yourself, or allow Oracle to take some additional time to recompile them at runtime.

By way of example, the following statement recompiles the *project_revenue* function and maintains any compiler information for the PL/SQL debugger:

```
ALTER FUNCTION project_revenue COMPILE DEBUG;
```

Oracle also supports set-returning (`TABLE`) functions. These can be regular PL/SQL, C, or SQL macros.

Here is a SQL macro `TABLE` function:

```
CREATE OR REPLACE FUNCTION stores_titles_sales(param_stor_id VARCHAR2,
    param_date_since date DEFAULT NULL)
```

```
  RETURN VARCHAR2 SQL_MACRO(TABLE)
IS
BEGIN
  RETURN q'{
SELECT t.title, SUM(s.qty) AS qty
  FROM sales AS s
  JOIN titles AS t ON t.title_id = s.title_id
  WHERE s.stor_id = param_stor_id
    AND (param_date_since IS NULL OR s.ord_date >= param_date_since)
  GROUP BY t.title
  }';
END;
/
```

You can use the `stores_titles_sales` function in any SQL statement as follows:

```
SELECT *
FROM stores_titles_sales('7066' , '10-JAN-2022' );
```

You can also combine it with a `LATERAL` clause to return sales for each store as follows:

```
SELECT s.stor_name, sts.title, sts.qty
FROM stores AS s
  LEFT JOIN LATERAL
  stores_titles_sales(s.stor_id) AS sts ON 1=1;
```

PostgreSQL

PostgreSQL supports the `CREATE [OR REPLACE] FUNCTION/PROCEDURE` and `ALTER FUNCTION/PROCEDURE` statements. For versions of PostgreSQL prior to v11, PostgreSQL functions can be used to simulate the processing performed by a procedure.

Functions can update data at the same time as returning a value, whereas PostgreSQL procedures cannot return values. The main benefit of using a procedure in PostgreSQL over using a function is that you can have `COMMIT` statements in a stored procedure. In contrast, a function runs in a single transaction and either fails or succeeds. PostgreSQL allows `OUT` parameters for functions, and starting with v14 stored procedures can have `OUT` parameters too. `OUT` parameters in functions are an alternative way for expressing `RETURNS TABLE`.

The syntax to use to create a function or procedure in PostgreSQL is:

```
CREATE [OR REPLACE] {FUNCTION | PROCEDURE} routine_name
   ( [ parameter[, ...] ] )
[RETURNS data_type / TABLE (colname coltype[, ...]) | SETOF data_type]
{ LANGUAGE {c | sql | internal | plpgsql | other_lang} |
   TRANSFORM {FOR TYPE type_name}[, ... ] |
   WINDOW |
   {IMMUTABLE | STABLE | VOLATILE} |
   [NOT] LEAKPROOF |
   {CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT} |
   [EXTERNAL] SECURITY INVOKER | [EXTERNAL] SECURITY DEFINER ] |
   PARALLEL {UNSAFE | RESTRICTED | SAFE} |
   COST execution_cost |
   ROWS result_rows |
   SUPPORT support_function |
   SET configuration_parameter { TO value | = value | FROM CURRENT } |
   AS {code_block | object_file, link_symbol} }
parameter ::= [IN | OUT | INOUT | VARIADIC]
   [argname] argtype [{DEFAULT | =} value]
```

The PostgreSQL syntax for ALTER FUNCTION and ALTER PROCEDURE follows:

```
ALTER {FUNCTION | PROCEDURE} routine_name
   ( [ parameter[, ...] ] ) action
{ [RESTRICT] |
   RENAME TO new_routine_name |
   OWNER TO new_owner_name |
   SET SCHEMA new_schema_name |
   [NO] DEPENDS ON EXTENSION extension_name }
```

The supported clauses are:

`CREATE [OR REPLACE] {FUNCTION | PROCEDURE}` *`routine_name`*
: Creates a new function or procedure of the name you provide, or replaces an existing function or procedure. `OR REPLACE` does not enable you to change the name, input parameters, input parameter names, or output results of an existing routine; you must drop and re-create a routine to change any of those settings. You also cannot convert a procedure to a function or function to procedure using `REPLACE`.

`parameter`
: A function takes as input zero or more parameters. A parameter declaration consists of a type and an optional mode qualifier, argument name, and default value. The available mode qualifiers are `IN`, `OUT`, `INOUT`, and `VARIADIC`. `IN` parameters can only be input to the function, and `OUT` parameters can only be output by the function. `INOUT` parameters are both input and output. `VARIADIC` allows for an arbitrary number of parameters for input that are all of the same type. The *argname* can be used to explicitly set input values when calling the function and can also be used to reference the argument within the body of a function in many languages. When no *`argname`* is provided, parameters can only be referenced by their ordinal position within the body of the function. If you specify a `DEFAULT` value, this value is used when no input is provided for the parameter. Parameters that have defaults and are at the end of the parameter list can be skipped. Default arguments can also be skipped when using call by parameter name syntax.

`RETURNS {`*`data_type`*` | TABLE(`*`colname coltype`*`[, ... ])}`
: Specifies the type of data required by the function or the table structure of the returned output for set-returning functions. Not used with a procedure.

`LANGUAGE {c | sql | internal | plpgsql | other_lang}`

Defines a call to an external program or an internal SQL routine. The languages SQL and C are always installed in each database. PL/pgSQL is by default installed in PostgreSQL databases, but can be removed with:

```
DROP EXTENSION plpgsql;
```

There are many other languages you can install, and since languages are installed per database, you can have different languages installed in each one. The language SQL is not really a procedural language as it lacks control loops and flow. SQL functions are the simplest to write and tend to perform better than those written in other languages. They're often inlined by the query planner, which means they are not treated as black boxes and can take advantage of things such as indexes on a table. SQL functions are very similar to Oracle SQL macros, described in the previous subsection, but unlike those they can be used within other functions and procedures like any other function.

PL/pgSQL provides SQL and procedural support, so is most similar to Oracle and MariaDB's PL/SQL.

> You can add a new language not installed by default in PostgreSQL by using the `CREATE EXTENSION <language_name>` statement, but this requires additional libraries to be installed on the system. Common extensions people use are *plperl*, *plpythonu*, *plpython*, *plperlu*, *plr*, and *plv8* (for JavaScript). *plrust*, *plsh*, and *pljava* are also available. Before using any of these, make sure they are supported in your version of PostgreSQL.

`TRANSFORM {FOR TYPE type_name}[, ... ]`

Lists the transforms a call to the function should apply to convert between SQL types and language-specific types.

`WINDOW`

Denotes that this function is a window function for use in `WINDOW` SQL clauses. Not all languages support writing window functions. Window functions are often written in C, PLV8, or PLR but cannot be written in SQL or PL/pgSQL.

`IMMUTABLE | STABLE | VOLATILE`

Describes the behavior of a function. `IMMUTABLE` describes a deterministic function that does not modify data and returns the same value for the same inputs. `STABLE` describes a deterministic function that may modify or access data stored within the database, but whose outputs will be the same within the same query given the same inputs. When no value is specified PostgreSQL assumes `VOLATILE`, which indicates that the function is not deterministic (i.e., may give different results even when the inputs are the same).

`[NOT] LEAKPROOF`
: Indicates whether a function has side effects that could expose internal values, such as updating data or throwing errors. The default if not specified is `NOT LEAKPROOF`. `LEAKPROOF` is used to denote that a function is safe to be called before any security policies are applied.

`CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT`
: `STRICT` is a synonym for `RETURNS NULL ON NULL INPUT`. Both `RETURNS NULL ON NULL INPUT` and `CALLED ON NULL INPUT` are part of the SQL standard and were described earlier. When omit ted, the default behavior is similar to `CALLED ON NULL INPUT`.

`[EXTERNAL] SECURITY {INVOKER | DEFINER}`
: Tells PostgreSQL to execute using the privileges of the user that called the routine (`INVOKER`) or the privileges of the user that created the routine (`DEFINER`). `EXTERNAL` is a noise word and is included only for SQL standard compliance.

`PARALLEL {UNSAFE | RESTRICTED | SAFE}`
: Denotes whether a function is safe to be run by parallel workers. When omitted, the function is assumed to be unsafe. If a function used in a query is marked as `PARALLEL UNSAFE`, then the query itself cannot be broken apart and run by parallel worker nodes (i.e., it prevents parallelization of the query it is used in). If a function is marked as `RESTRICTED`, then any query that function is used in can only be run on the leader node. `SAFE` means the function can be run in any node, including the parallel worker nodes. Procedures are never `PARALLEL SAFE` so do not have this attribute.

`COST` *`execution_cost`*
: Provides an indication of how costly a function is relative to other operations. When not specified, it defaults to 100 for SQL functions and 1 for C functions. This information is used by the query planner for deciding the order of functions and short-circuiting with `AND` clauses, as well as for other uses like determining `JOIN` order. For example, if you had two functions of varying cost and you issued a query such as the following:

```
SELECT * FROM some_table WHERE very_costly(a) AND not_costly(b);
```

the planner would execute the `not_costly(b)` call before the `very_costly(a)` call because it knows it can skip the `very_costly` if `not_costly` is false.

`ROWS` *`result_rows`*
: Indicates the estimated number of rows returned by the function in an average run, for functions that return a set of records. This information is used by the query planner for optimization.

`SUPPORT` *`support_function`*
: Provides the name of a planner support function to be used with this function. This allows a function to utilize an index where it otherwise wouldn't be able to.

`SET` *`configuration_parameter`*

Allows setting of various server states that apply only for the life of the function call (e.g., `SET search_path`). Most configuration parameters are allowed, but setting these can impact performance within an overall query, so this should be done with caution. For example, setting the `search_path` often disables use of an index in a query.

`code_block` `|` *`object_file, link_symbol`*

Defines the composition of the user-defined function. The `code_block` can be a string defining the function (dependent on the `LANGUAGE` setting), such as an internal function name, the path and name of an object file, a SQL query, or the text of a procedural language. Alternatively, for a C-language function, the definition can be an object file and link symbol. If the *`code_block`* is specified using single quotes, then quotes need to be escaped. However, PostgreSQL offers a feature called dollar quoting to ease writing of *`code_block`*s, which looks like this:

```
$some_block$ <body goes here> $some_block$
```

where *`some_block`* is a made-up term of your own choosing that is not used within the body of the routine. The body of the routine can also use dollar quoting to express string variables that may contain quotes. For more information on this feature, see the PostgreSQL section in "Platform-Specific Extensions" on page 734.

`[RESTRICT] | RENAME TO` *`new_routine_name`* `| OWNER TO` *`new_owner_name`* `|`
`SET SCHEMA` *`new_schema_name`*

Assigns a new name, owner, or schema to the routine. The `RESTRICT` keyword is noise.

`[NO] DEPENDS ON EXTENSION` *`extension_name`*

Marks the routine as dependent on or (with `NO`) as no longer dependent on an extension. A routine that's dependent on an extension is automatically dropped when that extension is dropped.

> An existing function cannot be dropped without dropping dependent objects first.

For example, you might want to build a user-defined function in PostgreSQL that returns the first and last name of a person as a single string:

```
CREATE FUNCTION formatted_name (fname text, lname text)
RETURNS text
  IMMUTABLE COST 1 LANGUAGE SQL
AS
$body$
```

```
    SELECT fname || ' ' ||  lname;
  $body$;
```

You could then use this UDF just as you would any other function:

```
SELECT formatted_name(au_fname, au_lname) AS name, au_id AS id
FROM authors;
```

Here's an example of a simple SQL function in PostgreSQL that accepts a `stor_id` and an optional date:

```
CREATE OR REPLACE FUNCTION stores_titles_sales(param_stor_id
    VARCHAR(4), param_date_since date DEFAULT NULL)
RETURNS TABLE(title varchar(80), qty bigint)
  LANGUAGE sql STABLE
AS
$body$
SELECT t.title, SUM(s.qty) AS qty
  FROM sales AS s
  JOIN titles AS t ON t.title_id = s.title_id
  WHERE s.stor_id = param_stor_id
    AND (param_date_since IS NULL OR s.ord_date >= param_date_since)
  GROUP BY t.title;
$body$;
```

In this example, we created a UDF that returns the quantity of sales for each title for a specific store. We can then use this function to return sales for each title for all time:

```
SELECT *
FROM stores_titles_sales('7066');
```

Or from a particular point in time as follows:

```
SELECT *
FROM stores_titles_sales('7066' , '2022-01-10' );
```

You can also use table functions with the `LATERAL` clause to return values based on earlier tables. This next example returns all stores and corresponding sales for each store:

```
SELECT s.stor_name, sts.title, sts.qty
FROM stores AS s
  LEFT JOIN LATERAL stores_titles_sales(s.stor_id) AS sts
    ON true;
```

PostgreSQL supports custom data types and table types as inputs to and outputs from functions too, as the following example demonstrates:

```
CREATE OR REPLACE FUNCTION authors_titles(param_author authors)
RETURNS SETOF titles
  LANGUAGE sql STABLE
AS
$body$
SELECT t
```

```
  FROM titles AS t
    INNER JOIN titleauthor AS ta
      ON t.title_id = ta.title_id
  WHERE ta.au_id = param_author.au_id;
$body$;
```

You can call this function as follows:

```
SELECT t.title_id, t.title, t.pubdate
FROM authors AS a, authors_titles(a) AS t
WHERE a.au_id = '409-56-7008';
```

You can also call the function using named argument syntax. This is useful if you have several arguments and some are defaults, or just for clarity. Here is the previous example using named argument call syntax:

```
SELECT t.title_id, t.title, t.pubdate
FROM authors AS a, authors_titles(param_author => a) AS t
WHERE a.au_id = '409-56-7008';
```

Note that in PostgreSQL, you use procedures and functions a little differently. Functions can be called from any SQL statement. Procedures cannot be used in SQL statements. Instead, they use the `CALL` syntax, as follows:

```
CALL update_titles();
```

PostgreSQL functions and procedures use the same namespace. As such, you cannot define both a procedure and a function with the same name that take the same input arguments. PostgreSQL does support function overloading, which means you can define a function with the same name as another one that takes a different data type or set of arguments for input and can also return a different output type.

As mentioned previously, PostgreSQL also supports default arguments, which allows you to skip an argument and have some default value be used instead. Here is a revised version of the `authors_titles` function, to demonstrate overloading and default arguments:

```
CREATE OR REPLACE FUNCTION authors_titles(text param_au_id
    DEFAULT NULL)
RETURNS SETOF titles
  LANGUAGE sql STABLE
AS
$body$
SELECT t
  FROM  titles AS t
    INNER JOIN titleauthor AS ta
      ON t.title_id = ta.title_id
  WHERE (ta.au_id = param_au_id) OR (param_au_id IS NULL);
$body$;
```

We can call this function as follows:

```
SELECT t.title_id, t.title, t.pubdate
FROM authors AS a, authors_titles(a.au_id ) AS t
WHERE a.au_id = '409-56-7008';
```

Or return all titles as follows:

```
SELECT t.title_id, t.title, t.pubdate
FROM authors_titles() AS t;
```

PostgreSQL C and SQL language handlers are supported out of the box in all versions. A C or C++ stored function would be bound to a function in a C/C++ library that is specially designed to be loaded by the PostgreSQL service process. See the documentation for details on creating these libraries.

Once you've created the library, you can reference functions in it using the library name (minus the file extension) and the name of the function within the library. The following example defines a window function. SQL, PL/pgSQL, and most scripted languages (with the notable exceptions of PL/R and PL/V8) do not support the creation of window functions, so C and C++ are popular options for creating such functions:

```
CREATE OR REPLACE FUNCTION run_begin(
  arg anyelement,
  ofs integer)
  RETURNS boolean
  LANGUAGE c
  COST 50
  WINDOW PARALLEL SAFE
AS '$libdir/my_functions', 'window_run_begin';
```

The *$libdir* is resolved by the PostgreSQL process to the PostgreSQL library path, where all extended libraries are installed.

One drawback of building compiled libraries is that a library is always tied to a particular PostgreSQL major version. So, for example, your *my_functions* library would need to be recompiled if you upgraded from PostgreSQL 14 to PostgreSQL 15 even if the code in the function didn't change.

PostgreSQL supports creating functions in many languages. The *plpgsql* language handler is installed by default. To install other languages, you install the library and environment for that language on your OS and then enable it in your database with `CREATE EXTENSION`.

To install Perl untrusted, Perl trusted, and Python untrusted languages in a database, you would do the following.

```
CREATE EXTENSION IF NOT EXISTS plperlu;
CREATE EXTENSION IF NOT EXISTS plperl;
CREATE EXTENSION IF NOT EXISTS plpython3u;
CREATE EXTENSION IF NOT EXISTS plv8;
CREATE EXTENSION IF NOT EXISTS plr;
```

Untrusted languages are not guarded from interacting with the operating system, whereas trusted languages (generally those without a *u*) are prevented from escaping the database or calling external libraries. Python and Perl are scripted languages. As with most scripted languages, the code for the function is embedded in the function definition.

PostgreSQL functions are used to define actions for `CREATE TRIGGER`. When PostgreSQL functions are used to define trigger actions, they return a special return type called a trigger. We'll cover triggers later in this chapter.

SQL Server

SQL Server supports `CREATE` and `ALTER` for both procedures and functions. In addition, it supports the syntax `CREATE OR ALTER`, which checks for an existing routine with the specified name and updates its code if there are changes, or creates the function or procedure if it does not already exist in the database.

By default, stored procedures in SQL Server can return result sets, unlike in the SQL standard. This makes SQL Server procedures more flexible and powerful. SQL Server user-defined functions may return single or multi-row result sets using the `TABLE` data type or a table-valued function on `RETURNS` arguments. SQL Server functions cannot directly update data in the database. This means you can't have logic in a SQL Server function that, for example, updates or inserts data into a table.

Use the following syntax to create a user-defined function or stored procedure in SQL Server:

```
CREATE [OR ALTER] {FUNCTION | PROCEDURE}
   [schema_name.]object_name[;int]
([{@parameter data_type [VARYING] [=default] [OUTPUT]}
   [READONLY][, ...]])
[RETURNS {data_type | TABLE [(table_definition)]]]
[WITH {ENCRYPTION | SCHEMABINDING | RECOMPILE |
   RECOMPILE, ENCRYPTION |
   [RETURNS NULL ON NULL INPUT | CALLED ON NULL INPUT] |
   EXEC[UTE] AS {CALLER | SELF | OWNER | 'user_name'}} |
   [INLINE = {ON | OFF}]]
[FOR REPLICATION]
[AS]
   code_block
```

Use the following syntax to alter an existing user-defined function or stored procedure:

```
ALTER {FUNCTION | PROCEDURE) [schema_name.]object_name[;int]
([{@parameter data_type [VARYING] [=default] [OUTPUT]}[, ...]])
[RETURNS {data_type | TABLE}]
[WITH {ENCRYPTION | SCHEMABINDING | RECOMPILE |
   RECOMPILE, ENCRYPTION |
   RETURNS NULL ON NULL INPUT | CALLED ON NULL INPUT |
   EXEC[UTE] AS {CALLER | SELF | OWNER | 'user_name'}}]
```

```
    [FOR REPLICATION]
    [AS]
       code_block
```

Following are the parameter descriptions:

`CREATE [OR ALTER] {FUNCTION | PROCEDURE}`
`[`*`schema_name`*`.]`*`object_name`*`[;`*`int`*`]`
: Creates a new UDF or stored procedure in the current database. For SQL Server stored procedures, you may optionally specify a version number in the format *`procedure_name;n`*, where *`n`* is an integer indicating the version number. This facility allows you to have multiple versions of a single stored procedure.

`{@`*`parameter data_type`*` [VARYING] [=`*`default`*`] [OUTPUT]} [READONLY]`
`[, ... ]`
: Defines one or more input arguments for a UDF or stored procedure. SQL Server parameters are always declared with an at sign (`@`) as the first character.

`VARYING`
: Used in stored procedures with a `CURSOR` data type parameter. Indicates that the procedure constructs the result set dynamically.

`=`*`default`*
: Assigns a default value to the parameter. The default value is used whenever the stored procedure or UDF is invoked without a value being supplied for the parameter.

`OUTPUT`
: Used for stored procedures, `OUTPUT` is functionally equivalent to the standard `OUT` clause in the `CREATE FUNCTION` statement. The value stored in the return parameter is passed back to the calling procedure through the return variables of the SQL Server `EXEC[UTE]` command. Output parameters can be any data type except the deprecated `TEXT` and `IMAGE`.

`READONLY`
: Used in functions to indicate that the parameter cannot be updated or modified within the routine code body. This is especially useful for user-defined table-valued parameters (TVPs).

`RETURNS {`*`data_type`*` | TABLE [ (`*`table_definition`*`) ]}`
: Allows SQL Server UDFs to return a single *`data_type`* value or to return multiple values via the `TABLE` data type. The `TABLE` data type is considered *inline* if it has no accompanying column list and is defined with a single `SELECT` statement. If the `RETURNS` clause returns multiple values via the `TABLE` data type, and if the `TABLE` has defined columns and data types, the function is considered a *multi-statement table-valued* function (TVF).

  When creating a TVP, the *`table_definition`* (which must be in parentheses) follows the standard conventions for creating a regular database table, including one or more named columns with a declared data type, constraints such as NULL or NOT NULL, keys, defaults, check constraints, and the like.

When creating a routine for SQL Server In-Memory OLTP, the syntax for the *code_block* and the function's WITH options are somewhat changed. First, the *code_block* should follow the form BEGIN ATOMIC WITH (*set_option*[*, ...n*]) *code_block* RETURN *scalar_expression* END. An in-memory routine allows the WITH options of a regular routine except ENCRYPTION and INLINE subclauses, but adds another option, NATIVE_COMPILATION. This in-memory-only option, when specified, tells SQL Server whether the UDF is natively compiled and is required for natively compiled, scalar in-memory UDFs.

WITH
: Allows the assignment of additional characteristics to a SQL Server UDF or stored procedure.

ENCRYPTION
: Tells SQL Server to encrypt the text of the function or stored procedure, thus preventing unwarranted review of the internal code. Usable by both UDFs and stored procedures.

SCHEMABINDING
: Specifies that the function is bound to a specific database object, such as a table or view. That database object cannot be altered or dropped as long as the function exists (or maintains the SCHEMABINDING option). Usable only by UDFs.

RECOMPILE
: Tells SQL Server not to store a cache plan for the stored procedure, but instead to recompile the execution plan each time the stored procedure is executed. This is useful when using atypical or temporary values in the procedure which might create a suboptimal execution plan, but it can cause degradation in performance. Usable only by stored procedures. Note that RECOMPILE and ENCRYPTION can be invoked together.

RETURNS NULL ON NULL INPUT | CALLED ON NULL INPUT
: When used in a scalar function, tells SQL Server to enable or disable the OnNULLCall attribute, respectively. The default, CALLED ON NULL INPUT, means that the routine executes even when passed NULL as an argument. On the other hand, specifying RETURNS NULL ON NULL INPUT means that the routine will not execute and returns NULL as the output.

EXEC[UTE] AS {CALLER | SELF | OWNER | '*user_name*'}
: Specifies the privileges under which the routine will execute. This is an optional clause for both procedures and functions. CALLER (the default value when this clause is omitted) indicates the routine will run with the privileges of the user invoking it. SELF indicates that the routine will run with the privileges

of the creator of the routine, `OWNER` indicates the routine will run with the privileges of the current owner of the routine, and *`'user_name'`* indicates the routine will run with the privileges of the named preexisting user.

`INLINE = { ON | OFF }`
: Tells SQL Server whether the scalar function is inlined or not. (This option only applies to scalar user-defined functions.) When omitted, the default is automatically set to `ON` or `OFF` depending on whether the UDF syntax is inlinable. If this is set to `ON` for a UDF that is not inlinable, SQL Server will throw an error. Inline functions generally perform faster than non-inlined ones because the code is folded into the definition of the query and thus does not need to make a function call for each row; for more on this feature see "Platform-Specific Extensions" on page 538.

`FOR REPLICATION`
: Disables execution of the stored procedure on a subscribing server. This clause is used primarily to create a filtering stored procedure that is executed only by SQL Server's built-in replication engine. It is incompatible with `WITH RECOMPILE`.

Like tables (see "CREATE/ALTER TABLE Statement" on page 140), local and global temporary stored procedures may be declared by prefixing a pound sign (#) or double pound sign (##) to the name of the procedure, respectively. Temporary procedures exist only for the duration of the user or process session that created them. When that session ends, the temporary procedures automatically delete themselves.

The `ALTER FUNCTION` and `ALTER PROCEDURE` statements in SQL Server support the full syntax provided by the corresponding `CREATE` statements. You can use the `ALTER` statements to change any of the attributes of an existing routine without changing permissions or affecting any dependent objects. Conversely, when a routine is created with `SCHEMABINDING`, that routine is bound to any database objects it references. Those referenced base objects cannot be modified in a way that would impact the routine definition without first modifying or dropping the function or procedure to remove the dependencies.

A SQL Server stored procedure or UDF may have as many as 2,100 input parameters, specified by the at sign (`@`). Parameters are defined using SQL Server data types. (Parameters of the `CURSOR` data type must be defined with both `VARYING` and `OUTPUT`.) The user or calling process must supply values for any input parameters. However, a default value can be supplied for any input parameter to allow the procedure to execute without a user- or process-supplied value. The default must be a constant or NULL, but it may contain wildcard characters.

SQL Server requires that one or more user-supplied parameters be declared for a given user-defined function. All SQL Server data types are supported as parameters, except TIMESTAMP. Values returned by the function can be any data type except TIMESTAMP, TEXT, NTEXT, or IMAGE. If an inline table value is required, the TABLE option without an accompanying column list may be used.

For UDFs, the *code_block* is either a single SELECT statement for an inline function, in the format RETURN (SELECT ...), or a series of Transact-SQL statements following the AS clause for a multi-statement operation. When using RETURN (SELECT), the AS clause is optional. Here are some other rules for SQL Server UDFs:

- When using the AS clause, the *code_body* should be enclosed in BEGIN ... END delimiters.
- UDFs cannot make any permanent changes to data or cause other lasting side effects. A number of other restrictions exist as a result. For example, INSERT, UPDATE, and DELETE statements may modify only TABLE variables local to the function or stored procedure.
- When returning a scalar value, a SQL Server UDF must contain the clause RETURN *data_type*, where *data_type* is the same as that identified in the RETURNS clause.
- The last statement of the *code_block* must be an unconditional RETURN that returns a single *data_type* value or TABLE value.
- The *code_block* may not contain any global variables that return a perpetually changing value, such as @@CONNECTIONS or GETDATE. However, it may contain variables that return a single, unchanging value, such as @@SERVERNAME.

For example, you might want to build a user-defined function in SQL Server that returns the first and last name of a person as a single string:

```
CREATE FUNCTION formatted_name (@fname VARCHAR(30),
    @lname VARCHAR(30))
RETURNS VARCHAR(60)
AS
BEGIN
  RETURN @fname + ' ' + @lname
END;
```

You could then use this UDF just as you would any other function:

```
SELECT dbo.formatted_name(au_fname, au_lname)
AS name, au_id AS id
FROM authors;
```

An inline table-valued UDF supplies values via a single SELECT statement using an AS RETURN clause. For example, we can supply a store ID and find all of that store's *titles*:

```
CREATE FUNCTION stores_titles_sales(@stor_id varchar(30))
RETURNS TABLE
AS
```

```
    RETURN (SELECT title, qty
      FROM sales AS s
      JOIN titles AS t ON t.title_id = s.title_id
      WHERE s.stor_id = @stor_id)
```

User-defined functions that return TABLE values are often selected as result set values or used in the FROM clause of a SELECT statement, just like regular tables are used. In addition, inputs from earlier tables can be used using the CROSS APPLY/ OUTER APPLY constructs. These multi-statement TVFs can have very elaborate code bodies since the *code_block* is composed of many Transact-SQL statements that populate a TABLE return variable.

Here is an example invoking a multi-statement TVF in a FROM clause. Notice that a table alias is assigned, just as for a regular table, and an OUTER APPLY is used to return sales from each store. The OUTER APPLY will cause a store's data to be returned regardless of whether it has any sales:

```
    SELECT s.stor_name, sts.title, sts.qty
    FROM stores AS s OUTER APPLY
      stores_titles_sales(s.stor_id) AS sts;
```

For stored procedures, the *code_block* clause contains one or more Transact-SQL commands, up to a maximum size of 128 MB, delimited by BEGIN and END clauses. Some rules about SQL Server stored procedures include:

- The *code_block* allows most valid Transact-SQL statements, but SET SHOW PLAN_TEXT and SET SHOWPLAN_ALL are prohibited.
- Some other commands have usage restrictions within stored procedures, including ALTER TABLE, CREATE INDEX, CREATE TABLE, all DBCC statements, DROP TABLE, DROP INDEX, TRUNCATE TABLE, and UPDATE STATISTICS.
- SQL Server allows deferred name resolution, meaning that a stored procedure compiles without an error even though it references an object that has not yet been created. SQL Server creates the execution plan and fails only when the object is actually invoked (for instance, in a stored procedure), if the object still doesn't exist.
- Stored procedures can be nested easily in SQL Server. Whenever a stored procedure invokes another stored procedure, the system variable @@NESTLEVEL is incremented by 1. It is decremented by 1 when the called procedure completes. Use SELECT @@NESTLEVEL inside a procedure or from an ad hoc query session to find the current nesting depth.

In the following example, a SQL Server stored procedure generates a unique 22-digit value (based on elements of the system date and time) and returns it to the calling process:

```
    -- A SQL Server stored procedure
    CREATE PROCEDURE get_next_nbr
      @next_nbr CHAR(22) OUTPUT
```

```
AS
BEGIN
  DECLARE @random_nbr INT
  SELECT @random_nbr = RAND() * 1000000
SELECT @next_nbr =
  RIGHT('000000' + CAST(ROUND(RAND(@random_nbr)*1000000,0))
     AS CHAR(6), 6) +
  RIGHT('0000' + CAST(DATEPART (yy, GETDATE())
     AS CHAR(4)), 2) +
  RIGHT('000'  + CAST(DATEPART (dy, GETDATE())
     AS CHAR(3)), 3) +
  RIGHT('00'   + CAST(DATEPART (hh, GETDATE())
     AS CHAR(2)), 2) +
  RIGHT('00'   + CAST(DATEPART (mi, GETDATE())
     AS CHAR(2)), 2) +
  RIGHT('00'   + CAST(DATEPART (ss, GETDATE())
     AS CHAR(2)), 2) +
  RIGHT('000'  + CAST(DATEPART (ms, GETDATE())
     AS CHAR(3)), 3)
END
GO
```

SQL Server supports functions and procedures written in Microsoft .NET Framework CLR methods that can take and return user-supplied parameters. These routines have similar `CREATE` and `ALTER` declarations to regular SQL routines and functions; however, the code bodies are external assemblies. Refer to the SQL Server documentation if you want to learn more about programming routines using the CLR.

See also

- `CALL`
- `LATERAL` (under `JOIN`) in Chapter 4
- `OVER` in Chapter 4
- `RETURN`
- `SELECT` in Chapter 4
- "Platform-Specific Extensions" on page 734

CREATE/ALTER METHOD Statement

The `CREATE` and `ALTER METHOD` statements allow the creation of a new database method or the alteration of an existing database method, respectively. An easy (but loose) way to think of a method is that it is a user-defined function associated with a user-defined type. For example, a method called *Office*, of type *Address*, can accept a `VARCHAR` input parameter and return a result *Address*. None of the major database platforms support these statements since the `CREATE/ALTER FUNCTION/PROCEDURE` statements can provide the same functionality.

An implicitly defined method is created every time a structured type is created. Using a combination of the `CREATE TYPE` statement and the `CREATE METHOD` statement creates user-defined methods.

SQL syntax

```
{CREATE | ALTER} [INSTANCE | STATIC | CONSTRUCTOR]
 METHOD method_name
   ( [{IN | OUT | INOUT}] param data_type [AS LOCATOR]
     [RESULT][, ...] )
RETURNS data_type
FOR udt_name
[SPECIFIC specific_name] code_body
```

Keywords

`{CREATE | ALTER} [INSTANCE | STATIC | CONSTRUCTOR] METHOD` *`method_name`*
: Creates a new method or alters an existing method, and optionally specifies it as an `INSTANCE`, `STATIC`, or `CONSTRUCTOR` method. An `INSTANCE` method is one called on an instance of an object that is of type *`udt_name`*. A `STATIC` method can be called directly against the *`udt_name`* type. A `CONSTRUCTOR` method is a method used to create an instance of type *`udt_name`*.

`([{IN | OUT | INOUT}]` *`param data_type`* `[AS LOCATOR] [RESULT][, ... ])`
: Declares one or more parameters to be passed into the method in a comma-delimited list enclosed in parentheses. Parameters used with a method may pass a value `IN`, `OUT`, or both in and out via `INOUT`. Make sure the name is unique within the method. When used with `ALTER`, this clause adds parameters to a preexisting method. Refer to Chapter 2 for details on data types.

`AS LOCATOR`
: Validates an external routine with a `RETURNS` parameter that is a `BLOB`, `CLOB`, `NCLOB`, `ARRAY`, or user-defined type. The locator (i.e., a pointer) for the `LOB` is returned, but not the entire value of the `LOB`.

`RESULT`
: Designates a user-defined type. Not needed for standard data types.

`RETURNS` *`data_type`*
: Declares the data type of the results returned by the method. The key purpose of a user-defined method is to return a value.

`FOR` *`udt_name`*
: Associates the method with a specific preexisting user-defined type, created using `CREATE TYPE`.

`SPECIFIC` *`specific_name`*
: Uniquely identifies the function; generally used with user-defined types.

The SQL standard CREATE METHOD statement is supported only by IBM's UDB DB2 platform at this time, not by any of the database platforms covered in this book. A *method* is essentially a special-purpose user-defined function and follows the same syntax as that outlined here. You can approximate the functionality of a method using a stored procedure or function, depending upon the vendor implementation.

See also

- CREATE/ALTER FUNCTION/PROCEDURE
- CREATE/ALTER METHOD
- CREATE/ALTER TYPE in Chapter 3

CREATE/ALTER/DROP TRIGGER Statement

A *trigger* is a special kind of stored procedure that fires automatically (hence the name) when a specific data modification statement is executed against a table. The trigger is directly associated with the table and is considered a dependent object. For example, you might want an audit timestamp to be updated on a record whenever the record is updated. You can accomplish this with a trigger.

ALTER TRIGGER is not a SQL standard–supported statement. All the platforms support the SQL standard syntax for DROP TRIGGER.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with variations
PostgreSQL	Supported, with variations
SQL Server	Supported, with limitations

SQL syntax

```
CREATE TRIGGER trigger_name
{BEFORE | AFTER | INSTEAD OF} {DELETE | INSERT |
   UPDATE [OF column[, ...]]}
ON table_name
[REFERENCING {OLD {[ROW] | TABLE} [AS] old_name |
   NEW {ROW | TABLE} [AS] new_name}]
[FOR EACH {ROW | STATEMENT}]
[WHEN (conditions)]
```

```
    [BEGIN ATOMIC]code_block
    [END]
```

The syntax for `DROP TRIGGER` is as follows:

```
    DROP TRIGGER trigger_name ON table_name
```

Keywords

`CREATE TRIGGER` *`trigger_name`*
: Creates a trigger named *`trigger_name`* and associates it with a specific table.

`BEFORE | AFTER`
: Declares that the trigger logic is fired either `BEFORE` or `AFTER` the data manipulation operation that invoked the trigger. `BEFORE` triggers perform their operations before the `INSERT`, `UPDATE`, or `DELETE` operation occurs, allowing you to do dramatic things like circumvent the data manipulation operation altogether. `AFTER` triggers fire after the operation has completed and are useful for after-the-fact operations like recalculating running totals.

`DELETE | INSERT | UPDATE [OF` *`column`*`[, ... ]]`
: Defines the data manipulation operation that causes the trigger to fire: `DELETE` statements, `INSERT` statements, or `UPDATE` statements. You may optionally choose which columns will trigger an `UPDATE` trigger using `UPDATE OF` *`column`*`[, ... ]`. If an update occurs on any columns not in the column list, the trigger will not fire.

`ON` *`table_name`*
: Declares the preexisting table on which the trigger is dependent.

`REFERENCING {OLD {[ROW] | TABLE} [AS]` *`old_name`* `| NEW {ROW | TABLE} [AS]` *`new_name`*`}`
: Enables aliasing for the old or new `ROW` or `TABLE` acted upon by the trigger. Although the syntax shows the options as exclusive, you may have up to four aliasing references: one for the old row, one for the old table, one for the new row, and one for the new table. The alias `OLD` refers to the data contained in the table or row before the data manipulation operation that fired the trigger, while the alias `NEW` refers to the data that will be contained in the table or row after the data manipulation operation that fired the trigger. Note that the syntax indicates that `ROW` is optional, but `TABLE` is not. (That is, `OLD ROW AS` is the same as `OLD AS`, but for `TABLE`, the only valid option is `OLD TABLE AS`.) `INSERT` triggers do not have an `OLD` context, while `DELETE` triggers do not have a `NEW` context. The keyword `AS` is noise and may be omitted. If the `REFERENCING` clause specifies either `OLD ROW` or `NEW ROW`, the `FOR EACH ROW` clause is required.

`FOR EACH { ROW | STATEMENT }`
: Tells the database to apply the trigger for each row in the table that has changed (`ROW`) or for each SQL statement issued against the table (`STATEMENT`). Consider

a single `UPDATE` statement that updates the salaries of 100 employees. If you specify `FOR EACH ROW`, the trigger will execute 100 times. If you specify `FOR EACH STATEMENT`, the trigger will execute only once.

`WHEN (`*`conditions`*`)`
: Allows you to define additional criteria for a trigger. For example, you might have a trigger called `DELETE` *`employee`* that will fire whenever an employee is deleted. When a trigger fires, if the search conditions contained in the `WHEN` clause evaluate to `TRUE`, the trigger action will fire. Otherwise, it will not fire.

`[BEGIN ATOMIC] |` *`code_block`* `| [END]`
: The SQL standard requires that the *`code_block`* contain only one SQL statement or, if it contains multiple SQL statements, that they be enclosed in a `BEGIN` and `END` block.

Rules at a glance

The SQL standard only defines triggers on DML events (such as `INSERT/UPDATE/DELETE`) on a table. Most of the databases we cover also support triggers on DDL events such as `CREATE`, `ALTER`, and `DROP`. We will cover both kinds of triggers in this section.

DML triggers, by default, fire once at the *statement level*. That is, a single `INSERT` statement might insert 500 rows into a table, but an `INSERT` trigger on that table will fire only one time. However, some vendors have a `FOR EACH ROW` clause that causes the trigger to fire for each row of the data modification operation. A statement that inserts 500 rows into a table that has a row-level `FOR EACH ROW` insert trigger will cause that trigger to fire 500 times, once for each inserted row.

In addition to being associated with a specific data modification statement (`INSERT`, `UPDATE`, or `DELETE`) on a given table, triggers are associated with a specific *time* of firing. In general, triggers can fire `BEFORE` the data modification statement is processed, `AFTER` it is processed, or (when supported by the vendor) `INSTEAD OF` the statement being processed. Triggers that fire before or instead of the data modification statement can change the update that a statement makes, while those that fire afterward can see the final changes and act upon the final changes rendered. `AFTER` statements cannot change the original update.

Triggers make use of two *pseudotables*. (They are pseudotables in the sense that they are not declared with a `CREATE TABLE` statement, but they exist logically within the trigger.) The pseudotables have different names on the different platforms, but we'll call them *before* and *after* here. They are structured exactly the same as the table a trigger is associated with, but they contain snapshots of the table's data: the *before* table contains a snapshot of all the records in the table before the trigger fired, while the *after* table contains a snapshot of how all the records in the table will look after the event that fires the trigger has occurred. You can then use comparison operations to compare the data in the table before and after the event to determine exactly what you want to happen.

Adding triggers to a table that already has data in it does not cause the triggers to fire. A trigger will fire only for data modification statements declared in the trigger definition that occur after the trigger is created.

Once in place, a trigger generally ignores structural changes to tables, such as an added column or an altered data type on an existing column, unless the modification directly interferes with the operation of the trigger. For example, if you add a new column to a table, existing triggers will ignore the new column (with the exception of `UPDATE` triggers). On the other hand, removing from a table a column that is used by a trigger will cause that trigger to fail every time it executes.

Programming tips and gotchas

One of the key programming issues associated with triggers is the inappropriate and uncontrolled use of nested and recursive triggers. A *nested trigger* is a trigger that invokes a data manipulation operation that causes other triggers to fire. For example, assume we have three tables, *T1*, *T2*, and *T3*. Table *T1* has a `BEFORE INSERT` trigger that inserts a record into table *T2*. Table *T2* also has a `BEFORE INSERT` trigger that inserts a record into table *T3*. Although this is not necessarily a bad thing if your logic is well considered and fully thought out, it does introduce two problems. First, an `INSERT` into table *T1* now requires many more I/O operations and transactions than a simple `INSERT` statement typically does. Second, you can get yourself into hot water if table *T3* performs an `INSERT` operation against table *T1*. In a case like that, you may have a looping trigger process that can consume all the available disk space and even shut down the server.

Recursive triggers are triggers that can fire themselves; for example, an `INSERT` trigger that performs an `INSERT` against its own base table. If the procedural logic within the `code_body` is not properly constructed, adding a recursive trigger can cause a looping trigger error. In recognition of this danger, using recursive triggers often requires setting a special configuration flag on the various database platforms.

MySQL

The MySQL implementation of the `CREATE TRIGGER` statement follows:

```
trigger_order: { FOLLOWS | PRECEDES } other_trigger_name
CREATE [DEFINER = {user_name | CURRENT_USER}]
   TRIGGER trigger_name {BEFORE | AFTER} {INSERT | UPDATE |
      DELETE}
   ON table_name
   FOR EACH ROW
    [trigger_order]
    code_body
```

where:

`DEFINER = {`*`user_name`*` | CURRENT_USER}`
: Specifies the user account to use when checking privileges. You may specify either a preexisting user or the user who issued the `CREATE TRIGGER` statement

(i.e., the CURRENT_USER). CURRENT_USER is the default when this clause is omitted.

MySQL does not allow triggers on temporary tables. INSERT triggers will fire any time data is inserted into a table, not just on INSERT statements; that is, they will also fire when LOAD DATA and REPLACE statements are executed. Similarly, a DELETE trigger will also fire on a REPLACE statement. Triggers are not, however, activated by cascading foreign key actions or TRUNCATE TABLE.

You cannot have two triggers with the same name in the same schema, because triggers are stored in schemas.

MySQL supports multiple triggers per table, even for the same action. By default, MySQL triggers on a table fire in the order they were defined unless qualified with a *trigger_order* clause.

MySQL does not yet support the ALTER TRIGGER statement.

DML triggers. Here is an example trigger that stamps records in the *sales* table as updated:

```
delimiter //
CREATE TRIGGER trig_01_stamp_updated BEFORE UPDATE ON sales
  FOR EACH ROW
BEGIN
  SET new.date_update = CURRENT_TIMESTAMP;
END;//
delimiter ;
```

DDL triggers. MySQL does not support DDL triggers.

Oracle

Oracle supports the SQL standard for CREATE TRIGGER, with several additions and variations:

```
CREATE [OR REPLACE] TRIGGER trigger_name
{BEFORE | AFTER | INSTEAD OF}
{ {[object_event] [database_event] [...] ON
   {DATABASE | schema.SCHEMA}} |
   {[DELETE] [OR] [INSERT] [OR] [UPDATE [OF column[, ...]]] [...]}
      ON {table_name | [NESTED TABLE column_name OF] view_name}
   [REFERENCING {[OLD [AS] old_name] [NEW [AS] new_name]
      [PARENT [AS] parent_name]}]
   [FOR EACH ROW] }
[FOLLOWS trigger_name]
[{ENABLE | DISABLE}]
[WHEN (conditions)] code_block
```

Here is the syntax for ALTER TRIGGER, which allows you to rename, enable, or disable a trigger without dropping and re-creating it:

```
ALTER TRIGGER trigger_name
{ {ENABLE | DISABLE} | RENAME TO new_name |
   COMPILE [compiler_directives] [DEBUG] [REUSE SETTINGS] }
```

The parameters are:

`OR REPLACE`
: Re-creates an existing trigger named *`trigger_name`* by assigning it a new definition.

`object_event`
: In addition to the standard data modification events, Oracle allows triggers to fire based on object events. `object_event` operations may be paired with `BEFORE` and `AFTER` keywords. An `object_event` fires the trigger whenever such an event occurs, according to the following keywords:

`ALTER`
: Fires whenever an `ALTER` statement (except `ALTER DATABASE`) is issued.

`ANALYZE`
: Fires whenever Oracle validates the structure of a database object, or collects or deletes statistics on an index.

`ASSOCIATE STATISTICS`
: Fires whenever Oracle associates a statistics type with a database object.

`AUDIT`
: Fires whenever Oracle tracks a SQL statement or operation against a schema object.

`COMMENT`
: Fires whenever an Oracle comment is added in the data dictionary to a database object.

`DDL`
: Fires whenever Oracle encounters any `object_event` in this list.

`DISASSOCIATE STATISTICS`
: Fires whenever Oracle disassociates a statistics type from a database object.

`DROP`
: Fires whenever a `DROP` statement erases a database object from the data dictionary.

`GRANT`
: Fires whenever a user grants privileges or roles to another user or role.

`NOAUDIT`
: Fires whenever the `NOAUDIT` statement causes Oracle to stop tracking SQL statements or operations against schema objects.

`RENAME`
: Fires whenever the `RENAME` statement changes the name of a database object.

`REVOKE`
: Fires whenever a user revokes privileges or roles from another user or role.

`TRUNCATE`
: Fires whenever a `TRUNCATE` statement is issued against a table or cluster.

`database_event`
: In addition to the standard data modification events, Oracle allows triggers to fire based on database events. *`database_event`* operations may be paired with `BEFORE` and `AFTER` keywords. The list of allowable *`database_event`* keywords is as follows:

  `LOGOFF`
  : Fires whenever a client application logs off of the database. Valid for `BEFORE` triggers only.

  `LOGON`
  : Fires whenever a client application logs on to the database. Valid for `AFTER` triggers only.

  `SERVERERROR`
  : Fires whenever a server error message is logged. Valid for `AFTER` triggers only.

  `SHUTDOWN`
  : Fires whenever an instance of the database is shut down. Valid only for `BEFORE` triggers with the `ON DATABASE` clause.

  `STARTUP`
  : Fires whenever an instance of the database is opened. Valid only for `AFTER` triggers with the `ON DATABASE` clause.

  `SUSPEND`
  : Fires whenever a server error causes a transaction to suspend. Valid for `AFTER` triggers only.

`ON {DATABASE |` *`schema`*`.SCHEMA}`
: Declares that the trigger fires whenever any database user invokes a triggering event with `ON DATABASE`. The trigger then fires for events occurring anywhere in the entire database. Otherwise, `ON` *`schema`*`.SCHEMA` declares that the trigger fires whenever a user connected as *schema* invokes a triggering event. The trigger then fires for events occurring anywhere in the current schema.

ON [NESTED TABLE *column_name* OF] *view_name*
: Declares that the trigger fires only if the data manipulation operation applies to the column(s) of the view called *view_name*. The ON NESTED TABLE clause is compatible only with INSTEAD OF triggers.

REFERENCING PARENT [AS] *parent_name*
: Defines the alias for the current row of the parent table (i.e., supertable). Otherwise, identical to the SQL standard.

FOLLOWS *trigger_name*
: Specifies that the new trigger is of the same type as another trigger and that it should fire only after the other trigger has fired. The *trigger_name* must already exist. Rather than creating a series of triggers that must fire in a specific order, it is recommended that you instead create a single trigger with logic to handle all of the situations that the multiple triggers would have handled.

ENABLE
: Enables a deactivated trigger when used with ALTER TRIGGER, or creates a new trigger in enabled mode (the default). You may alternatively use the statement ALTER TABLE *table_name* ENABLE ALL TRIGGERS.

DISABLE
: Disables an activated trigger when used with ALTER TRIGGER, or creates a new trigger in disabled mode. You may alternatively use the statement ALTER TABLE *table_name* DISABLE ALL TRIGGERS.

RENAME TO *new_name*
: Renames the trigger to *new_name*, though the state of the trigger remains unchanged when used with ALTER TRIGGER.

COMPILE [DEBUG] [REUSE SETTINGS]
: Compiles a trigger, whether valid or invalid, and all the objects on which the trigger depends. If any of the objects are invalid, the trigger is invalid. If all of the objects are valid, including the code_body of the trigger, the trigger is valid.

DEBUG
: Tells the PL/SQL compiler to generate and store extra information for use by the PL/SQL debugger.

REUSE SETTINGS
: Tells Oracle to retain all compiler switch settings, which can save significant time during the compile process.

compiler_directives
: Defines one or more special values for the PL/SQL compiler in the format *directive* = '*value*'. The available directives are: PLSQL_OPTIMIZE_LEVEL, PLSQL_CODE_TYPE, PLSQL_DEBUG, PLSQL_WARNINGS, and NLS_LENGTH_SEMANTICS. They may each specify a value once in the statement. The directive is valid only for the unit being compiled.

DML triggers. When referencing values in the *old* and *new* pseudotables, the values must be prefaced with a colon (`:`), except in the trigger's `WHEN` clause, where no colons are used. In this example, we'll call a procedure in the *`code_body`* and use both *`:old`* and *`:new`* values as arguments:

```
CREATE TRIGGER scott.sales_check
BEFORE INSERT OR UPDATE OF ord_id, qty ON scott.sales
  FOR EACH ROW
  WHEN (new.qty > 10)
  CALL check_inventory(:new.ord_id, :new.qty, :old.qty);
```

Here is an Oracle `BEFORE` trigger that uses the *old* and *new* pseudotables to compare values. By way of comparison, SQL Server uses the *deleted* and *inserted* pseudotables in the same way, while PostgreSQL, like Oracle, uses the pseudotables *old* and *new*. This trigger creates an audit record before changing an employee's pay record:

```
CREATE TRIGGER if_emp_changes
BEFORE DELETE OR UPDATE ON employee
FOR EACH ROW
WHEN (new.emp_salary <> old.emp_salary)
BEGIN
  INSERT INTO employee_audit
  VALUES ('old', :old.emp_id, :old.emp_salary, :old.emp_ssn);
END;
```

Multiple trigger types may be combined into a single trigger command *if* they are of the same level (row or statement) and they are on the same table. When triggers are combined in a single statement, the clauses `IF INSERTING THEN`, `IF UPDATING THEN`, and `IF DELETING THEN` may be used in the PL/SQL block to break the code logic into distinct segments. An `ELSE` clause can be used in this structure too.

You can also take advantage of capabilities within each database platform to make your triggers more powerful and easier to program. For example, Oracle has a special `IF ... THEN` clause for use just in triggers. This `IF ... THEN` clause takes the form `IF {DELETING | INSERTING | UPDATING} THEN`. The following example builds an Oracle `DELETE` and `UPDATE` trigger that uses the `IF DELETING THEN` clause:

```
CREATE TRIGGER if_emp_changes
BEFORE DELETE OR UPDATE ON employee
FOR EACH ROW
BEGIN
  IF DELETING THEN
    INSERT INTO employee_audit
    VALUES ('DELETED', :old.emp_id, :old.emp_salary,
      :old.emp_ssn);
  ELSE
    INSERT INTO employee_audit
    VALUES ('UPDATED', :old.emp_id, :new.emp_salary,
      :old.emp_ssn);
  END IF;
END;
```

DDL triggers. Oracle has support for DDL triggers, meaning that you can have a trigger fire, for example, when a new table is created or when a view is dropped. The DDL trigger syntax is:

```
CREATE [ OR REPLACE ] TRIGGER [schema.]trigger
   { BEFORE | AFTER | INSTEAD OF }
   { dml_event_clause | { ddl_event [ OR ddl_event ]... |
     database_event [ OR database_event ]... }
     ON { [schema.]SCHEMA | DATABASE }
   }
   [ WHEN (condition) ]
   { pl/sql_block | call_procedure_statement }
```

DDL triggers may be created on either a DATABASE or a SCHEMA for events like CREATE, ALTER, or DROP. For example:

```
CREATE TRIGGER audit_object_changes AFTER CREATE ON SCHEMA
  code_body;
```

The full list of DDL trigger events includes the firing of any of these statements: ALTER, ANALYZE, ASSOCIATE STATISTICS, AUDIT, COMMENT, CREATE, DISASSOCIATE STATISTICS, DROP, GRANT, NOAUDIT, RENAME, REVOKE, TRUNCATE, and DDL (which will fire the trigger when any of the preceding DDL statements are issued). You may also create a DDL trigger that fires on a specific database state, rather than on a DDL statement. The database states you may use include AFTER STARTUP, BEFORE SHUTDOWN, AFTER DB_ROLE_CHANGE, AFTER LOGON, BEFORE LOGOFF, AFTER SERVERERROR, and AFTER SUSPEND.

Following is an example of a *database_event*-style trigger that fires on any kind of server error:

```
CREATE TRIGGER track_errors
AFTER SERVERERROR ON DATABASE
BEGIN
  IF (IS_SERVERERROR (04030))
    THEN INSERT INTO errors ('Memory error');
  ELSE (IS_SERVERERROR (01403))
    THEN INSERT INTO errors ('Data not found');
  END IF;
END;
```

This example creates a DDL trigger that is SCHEMA-wide in scope and prevents creation of any object in the schema *scott*:

```
CREATE OR REPLACE TRIGGER create_trigger
AFTER CREATE ON scott.SCHEMA
BEGIN
  RAISE_APPLICATION_ERROR (num => -20000, msg =>
  'Scott created an object');
END;
```

PostgreSQL

PostgreSQL's implementation of CREATE TRIGGER offers most of the features found in the SQL standard. In PostgreSQL, a trigger may fire BEFORE a data modification operation is attempted on a record and before any constraints are fired, or it may fire AFTER a data manipulation operation completes (and after constraints have been checked), making all operations involved in the transaction visible to the trigger. Finally, the trigger may fire INSTEAD OF the data modification operation and completely replace the INSERT, UPDATE, or DELETE statement with some other behavior. INSTEAD OF triggers are only supported on views and views do not support BEFORE/AFTER triggers, as those would be triggered upon insertions to the underlying tables.

The PostgreSQL CREATE TRIGGER syntax is:

```
CREATE [OR REPLACE] [CONSTRAINT] TRIGGER trigger_name
{BEFORE | AFTER | INSTEAD OF}
{ [DELETE] [OR | ,] [INSERT] [OR | ,] [UPDATE] [OF column[, ...]]
   [OR | ,] [TRUNCATE] [OR | ,] }
   ON table_name [FROM referenced_table_name]
   [ NOT DEFERRABLE | [DEFERRABLE] [INITIALLY IMMEDIATE |
      INITIALLY DEFERRED] ]
   [REFERENCING { {OLD | NEW} TABLE [AS] transition_relation_name }]
   FOR [EACH] {ROW | STATEMENT}
   [WHEN (conditions)]
   EXECUTE {FUNCTION | PROCEDURE} function_name (parameters)
```

PostgreSQL's implementation of ALTER TRIGGER merely allows you to rename an existing trigger:

```
ALTER TRIGGER trigger_name ON table_name RENAME TO new_trigger_name
```

The parameters are:

OR REPLACE
: Re-creates an existing trigger named *trigger_name* by assigning it a new definition.

CONSTRAINT
: Creates a constraint trigger, where the timing of the trigger firing can be adjusted using SET CONSTRAINTS.

OR
: Declares an additional trigger action. The OR keyword is a synonym for the comma delimiter.

REFERENCING { {OLD | NEW} TABLE [AS] *transition_relation_name* }
: Enables collection of *transition relations*, which are row sets comprised of all the rows inserted, deleted, or modified by the current SQL statement. This allows the trigger to see a global view of what the statement did. Allowed only for an AFTER trigger that is not a constraint trigger, and when used with an UPDATE trigger it must not specify a *column_name* list. OLD TABLE can only be

used with `UPDATE` or `DELETE` triggers; it creates a transition relation containing the "before" images of all rows affected by the statement. `NEW TABLE` can only be used with `UPDATE` or `INSERT` triggers and creates a transition relation containing the "after" images of all rows affected by the statement.

`FOR EACH {ROW | STATEMENT}`
: Tells the database to apply the trigger for each row in the table that has changed (`ROW`) or for each SQL statement issued against the table (`STATEMENT`). A ROW trigger only has access to the `NEW` and/or `OLD` rows. A `STATEMENT` trigger has access to what is known as a transition table.

`EXECUTE PROCEDURE` *`function_name`* `(`*`parameters`*`)`
: Executes a previously defined function (created using `CREATE FUNCTION`) rather than a block of procedural code. The function executed must be defined to return a `TRIGGER` and can be used by more than one trigger. The function cannot be written in SQL but can be written in almost any other language, with the most common being PL/pgSQL.

Trigger functions have access to several special variables; see the documentation for details.

DML triggers. Unlike in most other databases, in PostgreSQL triggers do not have bodies. They instead reference a special type of function that returns a trigger. One major benefit of this approach is that you can bind the same trigger function to multiple tables. The following is an example of a PostgreSQL trigger that time-stamps data when it is inserted or updated. The *`new`* variable is a variable available to all functions used in row-level triggers when they are called during an `INSERT OR UPDATE` event. *`new`* is a reference to the newly created row and can be altered during `BEFORE` events. Similarly, *`old`* is a variable available to all trigger functions used in `ROW`-level triggers when called from an `UPDATE` or `DELETE` event. You can bind this trigger function to any table that has a column called *date_update*:

```
-- Trigger function
CREATE FUNCTION trig_date_update()
  RETURNS trigger
  LANGUAGE plpgsql
AS $body$
BEGIN
  new.date_update = CURRENT_TIMESTAMP;
RETURN new;
END; $body$;
-- Use of function in trigger
-- Add column if it doesn't exist already
ALTER TABLE sales ADD COLUMN IF NOT EXISTS date_update timestamptz;

-- Bind trigger function to trigger
CREATE TRIGGER trig_01_stamp_updated
BEFORE INSERT OR UPDATE ON sales
```

```
FOR EACH ROW
EXECUTE PROCEDURE trig_date_update();
```

The *new* and *old* variables contain at most one row that has the same structure as the triggered table. Each trigger function gets called for each row that is updated.

An AFTER trigger can't change data, but these are often used for auditing. The following is an example trigger that logs a change into a logging table and stores the old and new records as JSON, but only if data in the *date_update* column has changed. Since any row can be converted to JSON in PostgreSQL, this trigger can be applied to any table in the database:

```
-- Trigger function
CREATE OR REPLACE FUNCTION trig_log_data_changes()
  RETURNS trigger
  LANGUAGE plpgsql
  COST 100
AS $body$
DECLARE var_old jsonb; var_new jsonb;
BEGIN
var_new = null;
var_old = null;
IF TG_OP IN('DELETE', 'INSERT') OR
  (old.date_update <> new.date_update ) THEN
  IF TG_OP IN('INSERT', 'UPDATE') THEN
    var_new = to_jsonb(new);
  END IF;
  IF TG_OP IN( 'DELETE', 'UPDATE') THEN
    var_old = to_jsonb(old);
  END IF;

  INSERT INTO log_data_changes(
    table_name, action,
    old_row, new_row, date_audit)
  VALUES (tg_relname::varchar, TG_OP, var_old, var_new,
    CURRENT_TIMESTAMP );
END IF;
RETURN new;
END;
$body$;

-- Use of function in trigger
CREATE TRIGGER trig_01_stamp_updated
BEFORE INSERT OR UPDATE ON sales
FOR EACH ROW
EXECUTE PROCEDURE trig_date_update();
```

PostgreSQL supports adding multiple triggers to a table. The ordering of the triggers is first based on the events, with BEFORE triggers firing first; then, within each event type triggers are fired alphabetically. A common convention to follow is to prefix trigger name with labels such as *trig_01* to control the order of firing.

If you update, delete, and insert many records in a single statement, it is more efficient to use a statement-level trigger than a row-level trigger. Statement-level triggers provide their functions with transition tables (*old_table*, *new_table*) instead of the row-level variables *old* and *new*.

INSTEAD OF triggers in PostgreSQL completely skip the data modification operation that triggered them in favor of code that you substitute for that operation. These triggers are commonly used on views to redirect updates to the underlying tables.

Here's an example of an INSTEAD OF trigger:

```
-- Trigger function
CREATE FUNCTION insert_california_authors()
RETURNS trigger
  $body$
BEGIN
  INSERT INTO authors(au_lname, au_fname, au_id,
    au_full_name, au_state)
  VALUES (NEW.au_lname, NEW.au_fname, NEW.au_id,
    NEW.au_full_name, 'CA');
RETURN new;
END; $body$;
-- Use of function in trigger on a view
CREATE TRIGGER california_author_insert
  INSTEAD OF INSERT ON california_authors
  FOR EACH ROW
  EXECUTE FUNCTION insert_california_author();
```

DDL triggers. PostgreSQL also has support for DDL triggers, which allows you to specify what to do whenever a database object is created, altered, or dropped. DDL triggers return a type called an event_trigger. They are defined at the DATABASE level and can be created for most relational database objects, including tables, views, schemas, function, procedures, types, and casts. They cannot be used for system shared objects such as roles, databases, and tablespaces. See the documentation for a full list of supported objects.

You use the CREATE EVENT TRIGGER command to create DDL triggers, and you must be a superuser to do so. The CREATE EVENT TRIGGER command is not defined in the SQL standard. Its syntax is:

```
CREATE EVENT TRIGGER trigger_name
ON event
[WHEN filter_variable IN (filter_value[, ... ]) [ AND ... ]]
EXECUTE {FUNCTION | PROCEDURE} function_name (parameters)
```

where:

ON *event*
: Identifies the event that triggers a call to the given function. See the vendor documentation for more information on events.

`WHEN`

Defines conditions that must be true for the event trigger to be fired. *`filter_variable`* is the name of the variable used to filter. Currently only TAG is supported. The `(`*`filter_value`*`[, ... ])` clause defines a set of values that are allowed. These must be in the set of command tags as noted in the vendor documentation.

`EXECUTE {FUNCTION | PROCEDURE}` *`function_name`* `(`*`parameters`*`)`

Executes a previously defined function (created using `CREATE FUNCTION`) rather than a block of procedural code. The function executed must be defined to return an `EVENT TRIGGER` and can be used by more than one `EVENT TRIGGER`. The function cannot be written in SQL but can be written in almost any other language, with the most common being PL/pgSQL. The `PROCEDURE` keyword is allowed for backward compatibility, but the *`function_name`* has to be the name of a function and not a procedure in either case.

The following is an example trigger that logs whenever a table is created, dropped, or altered:

```
-- Create the trigger function
CREATE OR REPLACE FUNCTION trig_log_ddl()
RETURNS event_trigger AS $$
BEGIN
  IF tg_tag IN('CREATE TABLE', 'CREATE TABLE AS',
      'CREATE FOREIGN TABLE',
      'DROP FOREIGN TABLE', 'DROP TABLE',
      'ALTER TABLE'
    ) THEN
      INSERT INTO event_logging(event, tag)
      VALUES (tg_event, tg_tag);
  END IF;
END;
$$ LANGUAGE plpgsql;

-- Create the trigger
CREATE EVENT TRIGGER trig_log_ddl_table
  ON ddl_command_end
  WHEN TAG IN IN('CREATE TABLE','CREATE TABLE AS',
    'DROP TABLE', 'ALTER TABLE')
  EXECUTE FUNCTION trig_log_ddl;
```

SQL Server

SQL Server supports the basics of the SQL standard with a few variations and additions. It supports the optional `[OR ALTER]` syntax but does not support the `REFERENCING` or `WHEN` clauses of the standard. In all supported versions of SQL Server you may create triggers on tables. SQL Server 2014 and later allow you to create triggers on views and memory-optimized tables. SQL Server implicitly fires in the `FOR EACH STATEMENT` style of the SQL standard.

SQL Server has different syntax for defining DML and DDL triggers. The syntax for DML triggers is:

```
CREATE [OR ALTER] TRIGGER trigger_name ON table_name
[WITH {[SCHEMABINDING] | [NATIVE_COMPILATION] | [ENCRYPTION] |
   [EXEC[UTE] AS {CALLER | SELF | OWNER | 'user_name'}]}[,...]]
{FOR | AFTER | INSTEAD OF}
{dml_events}
[WITH APPEND]
[NOT FOR REPLICATION]
AS {code_block | EXTERNAL NAME method_specifier [;]}
```

where:

`CREATE [OR ALTER] TRIGGER` *`trigger_name`*
: Creates a new trigger named *`trigger_name`* or (with `OR ALTER`) alters an existing trigger of that name by adding or changing trigger properties or the trigger *`code_block`*. When altering an existing trigger, the permissions and dependencies of the existing trigger are maintained.

`ON` *`table_name`*
: Declares the table or view on which the trigger is dependent. You may optionally specify the schema name. Views may have `INSTEAD OF` triggers defined on them, as long as they are updatable and do not have the `WITH CHECK` clause on them.

`WITH {SCHEMABINDING | NATIVE_COMPILATION | ENCRYPTION | EXEC[UTE] AS {CALLER | SELF | OWNER | '`*`user_name`*`'}}`
: `SCHEMABINDING` ensures that the table(s) referenced by a trigger cannot be dropped or altered without first dropping dependent objects. This clause is required for triggers on memory-optimized tables, but not allowed on traditional tables.

  `NATIVE_COMPILATION` specifies that the trigger is natively compiled; this is used only on memory-optimized tables.

  `ENCRYPTION` encrypts the text of the `CREATE TRIGGER` statement in system metadata, and prevents the trigger from being used in a SQL Server replication scheme. This option is useful to protect important intellectual property. Azure SQL Database does not support this clause at present.

  The `EXECUTE AS` clause specifies the privileges under which the trigger will execute. `CALLER` (the default when this clause is omitted) indicates the routine will run with the privileges of the user invoking the routine. `SELF` indicates the routine will run with the privileges of the creator of the routine, `OWNER` indicates the routine will run with the privileges of its current owner, and '*user_name*' indicates the routine will run with the privileges of the named preexisting user.

`FOR | AFTER | INSTEAD OF`
: Tells SQL Server when the trigger should fire. `FOR` and `AFTER` are synonyms and specify that the trigger should fire only after the triggering data modification statement (and any cascading actions and constraint checks) have completed successfully. `INSTEAD OF` is similar to the SQL standard `BEFORE` in that the code of the trigger may completely replace the data modification operation. It specifies that the trigger be executed instead of the modification statement that fired the trigger. Also note that `INSTEAD OF` triggers are not currently supported on memory-optimized tables. `INSTEAD OF DELETE` triggers cannot be used when there is a cascading action on the delete. Only `INSTEAD OF` triggers can access `TEXT`, `NTEXT`, or `IMAGE` columns.

`dml_events`
: Specifies that the trigger fires for standard DML statements like `DELETE`, `INSERT`, and/or `UPDATE`. You may specify one or more DML events in a `CREATE TRIGGER` statement.

`WITH APPEND`
: Adds an additional trigger of an existing type to a table or view. This clause is supported for backward compatibility with earlier versions of SQL Server and can be used only with `FOR` triggers. It cannot be used with `INSTEAD OF` triggers or if `AFTER` is explicitly stated during creation, nor can it be used with CLR triggers.

`NOT FOR REPLICATION`
: Prevents data manipulation operations invoked through SQL Server's built-in replication engine from firing the trigger.

`AS EXTERNAL NAME` *`method_specifier`*
: Used with a CLR trigger to specify the method of an assembly to bind with the trigger. It takes no arguments and returns void. CLR coding is beyond the scope of this book; refer to the SQL Server documentation if you want to learn more about programming routines using the CLR.

DML triggers. In SQL Server, any combination of triggers is possible in a single trigger definition statement; simply separate each option with a comma. (When you do so, the same code fires for each statement in the combination definition.)

SQL Server also allows multiple triggers for a given data manipulation operation on a table or view. Thus, three `UPDATE` triggers are possible on a single table, and multiple `AFTER` triggers are possible on a given table. Their specific order is undefined, though the first and last triggers can be explicitly declared using the *`sp_settrigger-order`* system stored procedure. Only one `INSTEAD OF` trigger is possible per `INSERT`, `UPDATE`, or `DELETE` statement on a given table.

This SQL Server example stamps an updated date on a specific table:

```
-- Add a date_update column if not present
ALTER TABLE sales ADD date_update datetime2;
CREATE TRIGGER trig_01_stamp_updated
  ON  sales
  AFTER INSERT, UPDATE
AS
BEGIN
  UPDATE sales SET date_update = CURRENT_TIMESTAMP
  FROM inserted
  WHERE sales.stor_id = inserted.stor_id
    AND  sales.ord_num = inserted.ord_num
    AND sales.title_id = inserted.title_id;
END
GO
```

In the following example we specify that all new contractor employees inserted into the *employee* table will instead be inserted into the *contractor* table, using an `INSTEAD OF INSERT` trigger:

```
CREATE TRIGGER if_emp_is_contractor
INSTEAD OF INSERT ON employee
BEGIN
  INSERT INTO contractor
  SELECT * FROM inserted WHERE status = 'CON'
  INSERT INTO employee
  SELECT * FROM inserted WHERE status = 'FTE'
END
GO
```

SQL Server instantiates two important pseudotables when a trigger is fired: *deleted* and *inserted*. They are equivalent, respectively, to the *before* and *after* pseudotables described in "Rules at a glance" on page 692. These tables are identical in structure to the table on which the triggers are defined, except that they contain the old data before the data modification statement fired (*deleted*) and the new values of the table after the data modification statement has fired (*inserted*).

The `IF UPDATE(`*`column`*`)` clause tests specifically for `INSERT` or `UPDATE` actions on a given column or columns, in the way the SQL standard statement uses the `UPDATE(`*`column`*`)` syntax. Specify multiple columns by adding separate `UPDATE(`*`column`*`)` clauses after the first. Follow the `AS IF UPDATE(`*`column`*`)` clause with a Transact-SQL `BEGIN ... END` block to allow the trigger to fire multiple Transact-SQL operations. This clause is functionally equivalent to the `IF ... THEN ... ELSE` operation.

In addition to intercepting data modification statements as shown in the SQL standard example, SQL Server allows you to perform other sorts of actions when a data modification operation occurs. In the following example, we've decided that the table *sales_archive_2002* is off-limits and that anyone who attempts to alter data in this table is to be notified of that restriction:

```
CREATE TRIGGER archive_trigger
ON sales_archive_2002
FOR INSERT, UPDATE
AS RAISERROR (50009, 16, 10, 'No changes allowed to this table')
GO
```

SQL Server *does not* allow the following statements within the Transact-SQL *`code_block`* of a DML trigger: `ALTER`, `CREATE`, `DROP`, `DENY`, `GRANT`, `REVOKE`, `LOAD`, `RESTORE`, `RECONFIGURE`, or `TRUNCATE`. In addition, it does not allow any `DISK` statements or the `UPDATE STATISTICS` command.

You can cause triggers to fire recursively using the *recursive triggers* setting of the *sp_dboption* system stored procedure. Recursive triggers, by their own action, cause themselves to fire again. For example, if an `INSERT` trigger on table *T1* performs an `INSERT` operation on table *T1*, it might perform a recursive operation. Since recursive triggers can be dangerous, this functionality is disabled by default.

Similarly, SQL Server allows *nested triggers* up to 32 levels deep. If any one of the nested triggers performs a `ROLLBACK` operation, no further triggers execute. An example of nested triggers is a trigger on table *T1* firing an operation against table *T2*, which also has a trigger that fires an operation against table *T3*. The triggers cancel if an infinite loop is encountered. Nested triggers are enabled with the nested triggers setting of the system stored procedure *sp_configure*. If nested triggers are disabled, recursive triggers are disabled as well, regardless of what the recursive triggers setting is in *sp_dboption*.

In the following example, we want to reroute the user activity that occurs on the *people* table—especially `UPDATE` transactions—so that changes to records in the *people* table are instead written to the *people_reroute* table. Our `UPDATE` trigger will record any changes to columns 2, 3, or 4 of the *people* table and write them to the *people_reroute* table. The trigger will also record which user issued the `UPDATE` statement and the time of the transaction:

```
CREATE TABLE people
  (people_id     CHAR(4),
   people_name   VARCHAR(40),
   people_addr   VARCHAR(40),
   city          VARCHAR(20),
   state         CHAR(2),
   zip           CHAR(5),
   phone         CHAR(12),
   sales_rep     empid NOT NULL)
GO
CREATE TABLE people_reroute
  (reroute_log_id        UNIQUEIDENTIFIER DEFAULT NEWID(),
   reroute_log_type      CHAR (3) NOT NULL,
   reroute_people_id     CHAR(4),
   reroute_people_name   VARCHAR(40),
   reroute_people_addr   VARCHAR(40),
   reroute_city          VARCHAR(20),
   reroute_state         CHAR(2),
   reroute_zip          CHAR(5),
   reroute_phone        CHAR(12),
   reroute_sales_rep    empidNOT NULL,
   reroute_user sysname  DEFAULT SUSER_SNAME(),
   reroute_changed datetime DEFAULT GETDATE())
GO
CREATE TRIGGER update_person_data
ON people
FOR UPDATE AS
IF (UPDATE(people_name)
  OR UPDATE(people_addr)
  OR UPDATE(city))
BEGIN
-- Audit OLD record
  INSERT INTO people_reroute (reroute_log_type, reroute_people_id,
    reroute_people_name, reroute_people_addr, reroute_city)
  SELECT 'old', d.people_id, d.people_name, d.people_addr, d.city
  FROM deleted AS d
-- Audit NEW record
  INSERT INTO people_reroute (reroute_log_type, reroute_people_id,
    reroute_people_name, reroute_people_addr, reroute_city)
  SELECT 'new', n.people_id, n.people_name, n.people_addr, n.city
  FROM inserted AS n
END
GO
```

Note that SQL Server `CREATE` statements allow *deferred name resolution*, meaning that commands will be processed even if they refer to a database object that does not yet exist in the database.

DDL triggers. SQL Server also supports triggers for DDL events such as creating, altering, or dropping objects in a database, which are commonly used in change-tracking use cases. Additionally, triggers are allowed on `LOGO[ON ALL SERVER]` events, such as when a particular user logs in (again, these are typically used in auditing and change-tracking scenarios).

The SQL Server syntax for creating a DDL trigger is as follows:

```
CREATE [OR ALTER] TRIGGER trigger_name
ON {ALL SERVER | DATABASE}
[WITH {[ENCRYPTION] | [EXEC[UTE] AS {CALLER | SELF | 'user_name'}]}
   [,...]]
{FOR | AFTER}
{{ddl_events} | LOGON}
AS {code_block | EXTERNAL NAME method_specifier [;]}
```

where the parameters that differ from the DML syntax are:

`ON {ALL SERVER | DATABASE}`
: Specifies whether the defined trigger applies to all DDL or `LOGON` actions for the entire instance of SQL Server (`ALL SERVER`, not allowed on Azure SQL Database) or for the currently scoped database (`DATABASE`).

`ddl_events`
: Specifies the DDL event or events that cause the trigger to fire (`CREATE`, `ALTER`, `DROP`, `GRANT`, `DENY`, `REVOKE`, `BIND`, `UNBIND`, `RENAME`, or `UPDATE STATISTICS`). DDL events may fire `FOR` or `AFTER` the event. SQL Server also provides a number of shortcuts called "DDL event groups" that include many DDL events under a single term; for example, `DDL_TABLE_EVENTS` includes the `CREATE`, `ALTER`, and `DROP TABLE` event types. Refer to the SQL Server documentation for a full listing.

`LOGON`
: Specifies a trigger that fires `FOR` or `AFTER LOGON`. Typically used to add an entry to an audit table whenever users access an instance or database of SQL Server.

Here is an example that logs table `CREATES`, `DELETES`, and `ALTERS`:

```
-- Table to hold audit information
CREATE TABLE log_table_ddl(action_statement nvarchar(1000),
  date_done datetime DEFAULT CURRENT_TIMESTAMP));

CREATE TRIGGER log_create_drop_alter_tables
ON DATABASE
FOR DROP_TABLE, ALTER_TABLE, CREATE_TABLE
AS
  INSERT INTO log_table_ddl(action_statement)
SELECT EVENTDATA().value(
  '(/EVENT_INSTANCE/TSQLCommand/CommandText)[1]', 'nvarchar(max)'
);
GO
```

Now whenever you create, drop, or alter a table, you'll see the DDL for the action in the *log_table_ddl* table.

See also

- `CALL`
- `CREATE/ALTER FUNCTION/PROCEDURE`
- `DELETE` in Chapter 5
- `DROP` in Chapter 3
- `INSERT` in Chapter 5
- `UPDATE` in Chapter 5

DECLARE CURSOR Statement

The `DECLARE CURSOR` statement is one of four commands used in cursor processing, along with `FETCH`, `OPEN`, and `CLOSE`. Cursors allow you to process queries one row at a time, rather than in a complete set. The `DECLARE CURSOR` command specifies the exact records to be retrieved and manipulated (one row at a time) from a specific table or view.

Cursors are especially important for relational databases because databases are set-based, while most client-centric programming languages are row-based. Cursors allow programmers to program using methodologies supported by their favorite row-based programming languages. However, cursors run counter to the default behavior of some relational database platforms, which operate on sets of records, and on those specific platforms cursor operations may be noticeably slower than standard set-based operations.

Platform	Command
MySQL/MariaDB	Supported, with limitations
Oracle	Supported, with limitations
PostgreSQL	Supported, with limitations
SQL Server	Supported, with limitations

SQL syntax

```
DECLARE cursor_name [{SENSITIVE | INSENSITIVE | ASENSITIVE}]
[[NO] SCROLL] CURSOR [{WITH | WITHOUT} HOLD]
   [{WITH | WITHOUT} RETURN]
FOR select_statement
[FOR {READ ONLY | UPDATE [OF column[, ...]]}]
```

Keywords

`DECLARE` *`cursor_name`*
: Gives the cursor a unique name in the context in which it is defined (for example, in the database or schema where it is created). No other cursors may share the same name.

`SENSITIVE | INSENSITIVE | ASENSITIVE`
: Defines the manner in which the cursor interacts with the source table and the result set retrieved by the cursor query, where:

  `SENSITIVE`
  : Tells the database to operate directly against the result set, so that the cursor will see changes to its result set as it moves through the records.

`INSENSITIVE`
: Tells the database to create a temporary but separate copy of the result set, so that all changes made against the result set by other operations are invisible to the cursor during the cursor operation.

`ASENSITIVE`
: Allows the database implementation to determine whether to make a copy of the result set. `ASENSITIVE` is the SQL standard default.

`[NO] SCROLL`
: Tells the database whether to enforce processing one row at a time (`NO SCROLL`) or not (`SCROLL`). With `SCROLL` rows are processed using `FETCH NEXT`, but all forms of the `FETCH` clause are allowed against the result set.

`{WITH | WITHOUT} HOLD`
: Tells the cursor to remain open when a transaction encounters the `COMMIT` statement (`WITH HOLD`), or to close when the transaction encounters a `COMMIT` statement (`WITHOUT HOLD`). A cursor that uses `WITH HOLD` can only be and is always closed with a `ROLLBACK` statement or a `CLOSE CURSOR` statement.

`{WITH | WITHOUT} RETURN`
: Used only in stored procedures. The `WITH RETURN` clause tells the database to return the result set, if it is still open, when the procedure terminates. With the `WITHOUT RETURN` clause, which is the default, all open cursors are implicitly closed when the procedure terminates.

`FOR` *`select_statement`*
: Defines the underlying `SELECT` statement that determines the rows in the result set of the cursor. As with a regular `SELECT` statement, the results of the query may be sorted according to an `ORDER BY` clause.

`FOR {READ ONLY | UPDATE [OF` *`column`*`[, ... ]]}`
: Specifies that the cursor is not updatable in any way, using `FOR READ ONLY`. This is the default when the cursor is defined with the `SCROLL` or `INSENSITIVE` properties, and when the query contains an `ORDER BY` clause or is against a non-updatable table. Alternatively, you can specify `FOR UPDATE OF` *`column1`*`[,` *`column2`*`, ... ]`, defining the column(s) where you want to execute `UPDATE` statements, or omit the column list to include all columns in the cursor.

Rules at a glance

Cursors enable the retrieval and manipulation of records from a table one row at a time. That is, they allow row-by-row processing, rather than the traditional set processing offered by SQL.

At a high level, these are the steps you follow when working with a cursor:

1. Create the cursor using `DECLARE`.

2. Open the cursor using `OPEN`.
3. Operate against the cursor using `FETCH`.
4. Dismiss the cursor using `CLOSE`.

The `DECLARE CURSOR` command works by specifying a `SELECT` statement. Each row returned by the `SELECT` statement may be individually retrieved and manipulated. In this Oracle example, the cursor is declared in the declaration block, along with some other variables. The cursor is then opened, fetched against, and closed in the `BEGIN ... END` block that follows:

```
DECLARE CURSOR title_price_cursor FOR
SELECT title, price
FROM titles
WHERE price IS NOT NULL;
   title_price_val title_price_cursor%ROWTYPE;
   new_price NUMBER(10,2);
BEGIN
   OPEN title_price_cursor;
   FETCH title_price_cursor INTO title_price_val;
   new_price := "title_price_val.price" * 1.25
   INSERT INTO new_title_price
   VALUES (title_price_val.title, new_price)
   CLOSE title_price_cursor;
END;
```

Because this example uses PL/SQL, much of the code is beyond the scope of this book. However, the `DECLARE` block clearly shows that the cursor is declared. In the PL/SQL execution block, the cursor is initialized with the `OPEN` command, values are retrieved with the `FETCH` command, and the cursor finally is terminated with the `CLOSE` command.

The `SELECT` statement is the heart of your cursor, so it is a good idea to test it thoroughly before embedding it in the `DECLARE CURSOR` statement. The `SELECT` statement may operate against a base table or a view. For that matter, read-only cursors may operate against non-updatable views. The `SELECT` statement can have subclauses such as `ORDER BY`, `GROUP BY`, and `HAVING` if it is not updating the base table. If the cursor is `FOR UPDATE`, however, it is a good idea to exclude these clauses from the `SELECT` statement.

In this next example from SQL Server, a cursor from the *publishers* table is declared and opened. The cursor takes the first record from *publishers* that matches the `SELECT` statement and inserts it into another table; it then moves to the next record and then the next, until all records are processed. Finally, the cursor is closed and deallocated (`DEALLOCATE` is used only with SQL Server):

```
DECLARE @publisher_name VARCHAR(20)
DECLARE pub_cursor CURSOR
FOR SELECT pub_name FROM publishers
   WHERE country <> 'USA'
```

```
OPEN pub_cursor
FETCH NEXT FROM pub_cursor INTO @publisher_name
WHILE @@FETCH_STATUS = 0
BEGIN
   INSERT INTO foreign_publishers VALUES(@publisher_name)
END
CLOSE pub_cursor
DEALLOCATE pub_cursor
```

In this example, you see how the cursor moves through a set of records. (The example was intended only to demonstrate this concept, since there is actually a better way to accomplish the same task; namely, an `INSERT ... SELECT` statement.)

Programming tips and gotchas

Most platforms do not support dynamically executed cursors. Rather, cursors are embedded within an application program, stored procedure, user-defined function, etc. In other words, the various statements for creating and using a cursor are usually used only in the context of a stored procedure or other database-programming object, not in a straight SQL script.

For ease of programming and migration, don't use the `SCROLL` clause or the various sensitivity keywords. Some platforms support only forward-scrolling cursors, so you can avoid headaches later by just sticking to the simplest form of cursor.

Cursors behave differently on the various database platforms when crossing a transaction boundary—for example, when a set of transactions is rolled back in the midst of a cursor operation. Be sure to familiarize yourself with exactly how each database platform behaves in these circumstances.

MySQL does not support server-side cursors in the SQL standard style, but it does support extensive C programming extensions that provide the same functionality.

MySQL and MariaDB

MySQL supports a subset of the SQL standard syntax:

```
DECLARE cursor_name
FOR select_statement
```

It only allows cursors within stored procedures, functions, and triggers. MySQL cursors are always read-only, non-updatable, non-scrollable (the cursor only moves in one direction and cannot skip rows), and asensitive (meaning that the server will choose whether to make a copy of the result table according to what is most expedient). MySQL will not allow you to create more than one cursor in a block with the same name. Cursors must be declared after variables and conditions, but before handlers.

MariaDB 10.3 and later support an Oracle mode (`SET SQL_MODE='ORACLE'`); in that mode MariaDB supports a subset of the Oracle `CURSOR` syntax, such as parameters for cursors.

Oracle

Oracle has a rather interesting implementation of cursors. In reality, all Oracle data modification statements (`INSERT`, `UPDATE`, `DELETE`, and `SELECT`) implicitly open a cursor. For example, a C program accessing Oracle would not need to issue a `DECLARE CURSOR` statement to retrieve data on a record-by-record basis, because that is the implicit behavior of Oracle. Because of this behavior, you'll only use `DECLARE CURSOR` in PL/SQL constructs such as stored procedures, not in a script that is purely SQL.

> Since cursors can only be used in stored procedures and user-defined functions in Oracle, they are documented in the Oracle PL/SQL reference material, not in the SQL reference material.

Oracle utilizes a variation of the `DECLARE CURSOR` statement that supports parameterized inputs, as the following syntax demonstrates:

```
DECLARE CURSOR cursor_name [ (parameter data_type[, ...]) ]
IS select_statement
[FOR UPDATE [OF column_name[, ...]]]
```

where:

`[ (parameter data_type[, ... ]) ] IS select_statement`
: Defines the parameter name and data type of each input parameter as well as the *`select_statement`* used to retrieve the cursor result set. Serves the same purpose as the SQL standard `FOR` *`select_statement`* clause.

`FOR UPDATE [OF column_name]`
: Defines the cursor or specific columns of the cursor as updatable. Otherwise, the cursor is assumed to be read-only.

In Oracle, variables are not allowed in the `WHERE` clause of the `SELECT` statement unless they are first declared as variables. The parameters are not assigned in the `DECLARE` statement; instead, they are assigned values in the `OPEN` command. This is important since any system function will return an identical value for all rows in the cursor result set.

PostgreSQL

PostgreSQL only supports read-only cursors, so it does not support the `FOR {READ ONLY | UPDATE}` clause. It also does not support the `{WITH | WITHOUT} RETURN` clause, but it does allow you to return result sets in binary rather than text format (and the compiler will not cause errors with many of the SQL standard keywords).

PostgreSQL has different rules for declaring cursors at the SQL level versus at the procedural level. The SQL-level definition looks as follows:

```
DECLARE cursor_name [BINARY] [ASENSITIVE | INSENSITIVE]
   [[NO] SCROLL] CURSOR
[{WITH | WITHOUT} HOLD]
[FOR select_statement]
```

PostgreSQL's implementation for using cursors in procedural languages such as PL/pgSQL looks as follows:

```
DECLARE cursor_name [[NO] SCROLL]
   CURSOR[(variable_name data_type[, ...])]
[FOR select_statement]
```

where:

`BINARY`
: Forces the cursor to retrieve binary-formatted data rather than text-formatted data.

`INSENSITIVE`
: Indicates that data retrieved by the cursor is unaffected by updates from other processes or cursors. This is PostgreSQL's default behavior, so omitting this keyword has no effect.

`[NO] SCROLL`
: Allows multiple rows to be retrieved by a single `FETCH` operation in either a forward or backward direction. Be aware that `SCROLL` can slow down processing. `NO SCROLL` specifies that the cursor reads only in a forward direction and that it does not skip any records.

`{WITH | WITHOUT} HOLD`
: Specifies that the cursor can continue to be used after the transaction that created it successfully commits (`WITH HOLD`), or that the cursor cannot be used outside of the transaction that created it (`WITHOUT HOLD`). If neither `WITHOUT HOLD` nor `WITH HOLD` is specified, `WITHOUT HOLD` is the default.

PostgreSQL allows cursors only within a transaction. You should enclose a cursor within a `BEGIN` and `COMMIT` or `ROLLBACK` transaction block.

`BINARY` cursors tend to be faster, because PostgreSQL stores data as binary on the backend. However, user applications are only text-aware, so you'll have to build in binary handling for any `BINARY` cursors.

Here's an example cursor declaration:

```
DECLARE pub_cursor CURSOR
FOR SELECT pub_name FROM publishers
    WHERE country <> 'USA';
```

PostgreSQL does not support an explicit `OPEN` command for SQL cursors because `DECLARE` automatically opens the cursor. For cursors used in PL/pgSQL and some other languages, `OPEN` is supported and used to open an unbounded cursor. You can also return cursors as the output of PL/pgSQL functions; the type returned is *refcursor*.

PostgreSQL cursors support the SQL standard `CLOSE` command as well as an extension, `CLOSE ALL`, that closes all open cursors in a session. PostgreSQL closes any existing cursor when a newly declared cursor is created with the same name.

SQL Server

SQL Server supports the SQL standard syntax for declaring a cursor, as well as a second form with several Transact-SQL extensions that provide flexibility in how a cursor scrolls through a result set and manipulates data, as shown here:

```
-- SQL standard syntax
DECLARE cursor_name [ INSENSITIVE ] [ SCROLL ] CURSOR
FOR select_statement
[ FOR { READ ONLY | UPDATE [ OF column_name[, ...] ] } ]

-- Transact-SQL extended syntax
DECLARE cursor_name CURSOR
[ LOCAL | GLOBAL ] [ SCROLL | FORWARD_ONLY ]
[ STATIC | KEYSET | DYNAMIC | FAST_FORWARD ]
[ READ_ONLY | SCROLL_LOCKS | OPTIMISTIC ]
[ TYPE_WARNING ]
FOR select_statement
[ FOR UPDATE [ OF column_name[, ...] ] ]
```

These syntax forms are not compatible. You cannot mix together keywords of the two forms.

The parameters are as follows:

`INSENSITIVE | SCROLL | FORWARD_ONLY`
: Determines how the cursor will move through the result set, with three options:

  `INSENSITIVE`
  : Creates the result set as a table in *tempdb*. Changes to the base table are not reflected in the cursor result set. Not compatible with SQL Server extensions to the `DECLARE CURSOR` command such as `LOCAL`, `GLOBAL`, `STATIC`, `KEYSET`, `DYNAMIC`, `FAST_FORWARD`, etc., and can only be used in a SQL standard–style `DECLARE CURSOR` statement, such as `DECLARE` *`sample`* `CURSOR INSENSITIVE FOR` *`select_statement`* `FOR UPDATE`.

  `SCROLL`
  : Enables all `FETCH` options (`ABSOLUTE`, `FIRST`, `LAST`, `NEXT`, `PRIOR`, and `RELATIVE`). Otherwise, only `FETCH NEXT` is available. With the extended

syntax, if `DYNAMIC`, `STATIC`, or `KEYSET` is used, the cursor defaults to `SCROLL` behavior. `FAST_FORWARD` is mutually exclusive of `SCROLL`.

`FORWARD_ONLY`
: Indicates that the cursor must scroll from the first to the last record in the result set and that `FETCH NEXT` is the only supported form of the `FETCH` statement. The cursor is assumed to be `DYNAMIC` unless `STATIC` or `KEYSET` is used. `FAST_FORWARD` is mutually exclusive of `FORWARD_ONLY` and only available with the extended syntax.

`LOCAL | GLOBAL`
: Scopes the cursor for the local Transact-SQL batch or makes the cursor available to all Transact-SQL batches issued by the current session via `OPEN` and `FETCH` statements, respectively. A global cursor name can be referenced by any stored procedure, function, or Transact-SQL batch executed in the current session. A global cursor is implicitly deallocated at disconnect, but a local cursor must be manually deallocated. The `LOCAL` and `GLOBAL` keywords are optional. The default behavior, if neither is specified, is defined by the *default to local* database property.

`STATIC | KEYSET | DYNAMIC | FAST_FORWARD`
: Determines how records are manipulated in the result set. These settings are incompatible with the `FOR UPDATE` clause. There are four options:

`STATIC`
: Makes a temporary copy of the result set data and stores it in *tempdb*. Modifications made to the source table or view do not show up when processing the cursor. `STATIC` cursors cannot modify data in the source table or view.

`KEYSET`
: Makes a temporary copy of the result set with membership and fixed row order (also known as a keyset) in *tempdb*. The keyset correlates the data in the cursor result set to the base table or view, so that the cursor can see changes made to the underlying data. Rows that have been deleted or updated show an `@@FETCH_STATUS` of `–2` (unless the update was done using `UPDATE ... WHERE CURRENT OF`, in which case they are fully visible), while rows inserted by other users are not visible at all.

`DYNAMIC`
: Determines the records in the cursor result set as each `FETCH` operation is executed. Thus, `DYNAMIC` cursors see all changes made to the base table or view, even those by other users. Because the result set may be in constant flux, `DYNAMIC` cursors do not support `FETCH ABSOLUTE`.

`FAST_FORWARD`
: Creates a `FORWARD_ONLY`, `READ_ONLY` cursor that quickly reads through the entire cursor result set at one time.

`READ_ONLY | SCROLL_LOCKS | OPTIMISTIC`
: Determines concurrency and positional update behavior for the cursor. These settings are incompatible with `FOR UPDATE`. The allowable parameters are:

    `READ_ONLY`
    : Prevents updates to the cursor and disallows the cursor from being referenced in `UPDATE` or `DELETE` statements that contain `WHERE CURRENT OF`.

    `SCROLL_LOCKS`
    : Ensures that positional updates and deletes succeed by locking the cursor result set rows as they are read into the cursor. The locks are held until the cursor is closed and deallocated. `SCROLL_LOCKS` is mutually exclusive of `FAST_FORWARD`.

    `OPTIMISTIC`
    : Ensures that positional updates and deletes succeed unless the row being updated or deleted in the cursor result set has changed since it was read into the cursor. SQL Server accomplishes this by comparing a timestamp, or a checksum value when no timestamp exists, on the columns. It does not lock the rows in the cursor result set. `OPTIMISTIC` is mutually exclusive of `FAST_FORWARD`.

`TYPE_WARNING`
: Warns the user when the cursor is implicitly converted from one type to another (for example, from `SCROLL` to `FORWARD_ONLY`).

`FOR {READ ONLY | UPDATE [OF` *`column_name`*`[, ... ]]}`
: `FOR READ ONLY` identifies the cursor as read-only, using the SQL standard syntax. This clause is not available in the extended syntax; use `READ_ONLY` instead. `FOR UPDATE` allows updates to columns in the cursor using `UPDATE` and `DELETE` statements with the `WHERE CURRENT OF` clause. If `FOR UPDATE` is used without a column list, all columns in the cursor are updatable. Otherwise, only those columns listed are updatable.

The SQL standard syntax is supported to enable your code to be more transportable. The Transact-SQL extended syntax enables you to define cursors using the same cursor types that are available in popular database APIs such as ODBC, OLEDB, and ADO, but it may only be used in SQL Server stored procedures, user-defined functions, triggers, and ad hoc queries.

If you define a Transact-SQL extension cursor but do not define concurrency behavior using the `OPTIMISTIC`, `READ_ONLY`, or `SCROLL_LOCKS` keywords, then:

- The cursor defaults to `READ_ONLY` if it was defined as `FAST_FORWARD` or `STATIC`, or the user has insufficient privileges to update the base table or view.
- The cursor defaults to `OPTIMISTIC` if the cursor was defined as `DYNAMIC` or `KEYSET`.

Note that variables may be used in the *select_statement* of a SQL Server cursor, but the variables are evaluated when the cursor is declared. Thus, a cursor containing a column based on the system function GETDATE() will have the same date and time for every record in the cursor result set.

In the following SQL Server example, we use a KEYSET cursor to change blank spaces to dashes in the *phone* column of the *authors* table:

```
SET NOCOUNT ON
DECLARE author_name_cursor CURSOR LOCAL KEYSET TYPE_WARNING
   FOR SELECT au_fname FROM pubs.dbo.authors
DECLARE @name varchar(40)
OPEN author_name_cursor
FETCH NEXT FROM author_name_cursor INTO @name
WHILE (@@fetch_status <> -1)
BEGIN
-- @@fetch_status checks for 'record not found' conditions and errors
   IF (@@fetch_status <> -2)
   BEGIN
      PRINT 'updating record for ' + @name
      UPDATE pubs.dbo.authors
      SET phone = replace(phone, ' ', '-')
      WHERE CURRENT OF author_name_cursor
   END
   FETCH NEXT FROM author_name_cursor INTO @name
END
CLOSE author_name_cursor
DEALLOCATE author_name_cursor
GO
```

See also

- CLOSE
- FETCH
- OPEN

FETCH Statement (Cursors)

The FETCH statement is one of four commands used in cursor processing, along with DECLARE, OPEN, and CLOSE. Cursors allow you to process queries one row at a time, rather than as a complete set. FETCH positions a cursor on a specific row and retrieves that row from the result set.

There is another FETCH clause, which can be used directly in SQL statements. Refer to "ORDER BY Clause" on page 294 for details on the OFFSET ... FETCH clause.

Cursors are important in relational databases because relational databases are set-based, while most client-centric programming languages are row-based. Cursors allow you to perform operations on a single row at a time, to better fit what a client program can do, rather than operating on a whole set of records at once. You will find the use of cursors mostly in SQL procedures and functions.

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported, with limitations
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL standard syntax

```
FETCH [ { NEXT | PRIOR | FIRST | LAST |
   { ABSOLUTE int | RELATIVE int } } FROM ] cursor_name
[INTO variable1[, ...]]
```

Keywords

`NEXT`
: Tells the cursor to return the record immediately following the current row, and increments the current row to the row returned. `FETCH NEXT` is the default behavior for `FETCH`. It retrieves the first record if `FETCH` is performed as the first fetch against a cursor.

`PRIOR`
: Tells the cursor to return the record immediately preceding the current row and decrements the current row to the row returned. `FETCH PRIOR` does not retrieve a record if it is performed as the first fetch against the cursor.

`FIRST`
: Tells the cursor to return the first record in the cursor result set, making it the current row.

`LAST`
: Tells the cursor to return the last record in the cursor result set, making it the current row.

`ABSOLUTE` *`int`*
: Tells the cursor to return the *`int`* record from the cursor record set counting from the top if *`int`* is a positive integer or the *`int`* record counting from the bottom if *int* is a negative integer, making the returned record the new current record of the cursor. If *`int`* is 0, no rows are returned. If the value of *`int`* moves the cursor past the end of the cursor result set, the cursor is positioned after the last row (for a positive *`int`*) or before the first row (for a negative *int*).

`RELATIVE int`
: Tells the cursor to return the record `int` rows after the current record if `int` is positive or `int` rows before the current record if `int` is negative, making the returned record the new current row of the cursor. If `int` is 0, the current row is returned. If the value of `int` moves the cursor past the end of the cursor result set, the cursor is positioned after the last row (for a positive `int`) or before the first row (for a negative *int*).

`[FROM] cursor_name`
: Gives the name of the (open) cursor from which you want to retrieve rows. The cursor must have been previously created and instantiated using the `DECLARE` and `OPEN` statements. `FROM` is optional, but encouraged.

`INTO variable1[, ... ]`
: Stores data from each column in the open cursor into a local variable. Each column in the cursor must have a corresponding variable of a matching data type in the `INTO` clause. Each column value is directly related to the variables in ordinal positions.

Rules at a glance

At the highest level, a cursor must be:

1. Created using `DECLARE`
2. Opened using `OPEN`
3. Operated against using `FETCH`
4. Dismissed using `CLOSE`

By following these steps, you create a result set similar to that of a `SELECT` statement, except that you can operate against each individual row within the result set separately.

Each database platform has its own rules about how variables are used. For example, SQL Server requires an at sign (`@`) as a prefix, PostgreSQL and Oracle have no prefix, and so forth. The SQL standard says that a colon (:) prefix is necessary for languages that are embedded, like C or COBOL, but no prefix is needed for procedural SQL.

A cursor rests either directly on a row, before the first row, or after the last row. When a cursor is resting directly on a row, that row is known as the *current row*. You can use cursors to position an `UPDATE` or `DELETE` statement in the current row using the `WHERE CURRENT OF` clause.

It is important to remember that a cursor result set does not wrap around. Thus, if you have a result set containing 10 records and you tell the cursor to move forward

12 records, it will not wrap back around to the beginning and continue its count from there. Instead, the default cursor behavior is to stop after the last record in the result set when scrolling forward, and to stop before the first record when scrolling back. For example, on SQL Server:

```
FETCH RELATIVE 12 FROM employee_cursor
INTO @emp_last_name, @emp_first_name, @emp_id
```

When fetching values from the database into variables, make sure that the data types and numbers of columns and variables match. Otherwise, you'll get an error. For example, this will fail since the *employee_cursor* contains three columns while the fetch operation has only two variables:

```
FETCH PRIOR FROM employee_cursor
INTO @emp_last_name, @emp_id
```

Programming tips and gotchas

The most common errors encountered with the FETCH statement are mismatches between the number, order, or data types of the variables and the values in the cursor. So, before you write your FETCH statements, make sure you know exactly what values are in the cursor and what their data types are.

Typically, the database will lock at least the current row and possibly all rows held by the cursor. According to the SQL standard, cursor locks are not held through ROLLBACK or COMMIT operations, although this behavior varies from platform to platform.

Although the FETCH statement is detailed in isolation here, it should always be managed as a group with the DECLARE, OPEN, and CLOSE statements. For example, every time you open a cursor, the server consumes memory. If you forget to close your cursors, you could create memory-management problems. So, you need to make sure that every declared and opened cursor is eventually closed.

Cursors are also often used in stored procedures or batches of procedural code. The reason for this is because sometimes you need to perform actions on individual rows rather than on entire sets of data at a time. But because cursors operate on individual rows and not sets of data, they are often much slower than other means of accessing your data. It's important to analyze your approach. Many challenges, such as a convoluted DELETE operation or a very complex UPDATE, can be solved by using clever WHERE and JOIN clauses instead of cursors.

MySQL

MySQL supports the basics of the SQL standard FETCH statement:

```
FETCH cursor_name INTO variable_name1[, ...]
```

It will fetch the next row (if one exists) using the specified open cursor and advance the cursor pointer one increment. When no more rows are available, MySQL returns a SQLSTATE value of '02000' and a NO DATA condition event. You can detect and treat this occurrence using a handler for the SQLSTATE value or for a NOT FOUND condition.

Oracle

Oracle cursors are implicitly forward-only cursors that always scroll forward one record at a time. An Oracle cursor, when compared to the SQL standard, is essentially a FETCH NEXT 1 cursor. Oracle cursors must either insert the retrieved values into matching variables or use the BULK COLLECT clause to insert all of the records of the result set into an array. Oracle does not support keywords like PRIOR, ABSOLUTE, and RELATIVE. However, it does support both forward-only and scrollable cursors in the database via the Oracle Call Interface (OCI). The OCI also supports features like PRIOR, ABSOLUTE, and RELATIVE for read-only cursors whose result sets are based on read-consistent snapshots.

Oracle's FETCH syntax is:

```
FETCH cursor_name
{ INTO variable_name1[, ...] | BULK COLLECT INTO
    collection_name[, ...] [LIMIT int] }
```

where:

BULK COLLECT INTO *collection_name*
: Retrieves the entire rowset, or a specified number of rows (see LIMIT), into a client-side array or collection variable named *collection_name*.

LIMIT *int*
: Limits the number of records fetched from the database when using the BULK statement. The *int* value is a nonzero integer (or a variable representing an integer value).

Oracle supports dynamic SQL-based cursors whose text can be built at runtime. It also supports *cursor_name*s that may be any allowable variable, parameter, or host-array type. In fact, you may also use user-defined or %ROWTYPE record variables for the INTO clause. This allows you to construct flexible, dynamic cursors in a template-like structure.

For example:

```
DECLARE
   TYPE namelist IS TABLE OF employee.lname%TYPE;
   names namelist;
   CURSOR employee_cursor IS SELECT lname FROM employee;
BEGIN
   OPEN employee_cursor;
   FETCH employee_cursor BULK COLLECT INTO names;
   ...
   CLOSE employee_cursor;
END;
```

Oracle's FETCH is often paired with a PL/SQL FOR loop (or other kind of loop) to cycle through all the rows in the cursor. You should use the cursor attributes %FOUND or %NOTFOUND to detect the end of the rowset. For example:

```
DECLARE
   TYPE employee_cursor IS REF CURSOR RETURN employee%ROWTYPE;
   employee_cursor  EmpCurTyp;
   employee_rec     employee%ROWTYPE;
BEGIN
   LOOP
      FETCH employee_cursor INTO employee_rec;
      EXIT WHEN employee_cursor%NOTFOUND;
      ...
   END LOOP;
CLOSE employee_cursor;
END;
```

This example uses a standard PL/SQL loop with an EXIT clause to end the loop when there are no more rows in the cursor to process.

PostgreSQL

PostgreSQL supports both forward- and backward-scrolling cursors with a superset of modes compared to the SQL standard. The syntax for FETCH in PostgreSQL is:

```
FETCH { FORWARD [ {ALL | int} ] | BACKWARD [ {ALL | int} ] |
   ABSOLUTE int | RELATIVE int | int | ALL | NEXT | PRIOR |
   FIRST | LAST }
{ IN | FROM } cursor_name
[ INTO :variable1[, ...] ]
```

where:

FORWARD [{ALL | *int*}]
: Fetches the next row (same as NEXT), if there are no other keywords specified. This is the default if no other mode is defined. FORWARD ALL fetches all remaining rows in the cursor and positions the cursor after the last remaining row, while FORWARD *int* returns all rows up to *int* rows forward (or the current row if *int* is 0) and places the cursor after the last row fetched.

BACKWARD [{ALL | *int}]*
: Fetches the prior row, if no other keywords are specified. BACKWARD ALL fetches all prior rows in the cursor and positions the cursor before the first row, while BACKWARD *int* returns all rows up to *int* rows back (or the current row if *int* is 0) and places the cursor before the last row fetched.

ABSOLUTE *int*
: Fetches the row occurring at position *int*.

RELATIVE *int*
: Fetches the *int* next rows (if positive) or *int* prior rows (if negative).

`int`
: Indicates how many records to scroll forward (if positive) or backward (if negative). `int` is a signed integer.

`ALL`
: Retrieves all records remaining in the cursor.

`NEXT`
: Retrieves the next single record.

`PRIOR`
: Retrieves the previous single record.

`IN | FROM cursor_name`
: Specifies the previously declared and opened cursor from which data will be retrieved.

`INTO variable`
: Assigns a cursor value to a specific variable. As with SQL standard cursors, the values retrieved by the cursor and the variables must match in number, data type, and order.

PostgreSQL cursors must be used with transactions explicitly declared using `BEGIN` and must be closed with `COMMIT` or `ROLLBACK`.

The following PostgreSQL statement retrieves five records from the *employee* table and displays them:

```
FETCH FORWARD 5 IN employee_cursor;
```

PostgreSQL also supports a separate command, `MOVE`, to move to a specific cursor position. It differs from `FETCH` only by not returning values into variables:

```
MOVE { [FORWARD | BACKWARD | ABSOLUTE | RELATIVE] }
     { [int | ALL | NEXT | PRIOR] }
{ IN | FROM } cursor_name
```

For example, the following code declares a cursor, skips forward five records, and then returns the values in the sixth record:

```
BEGIN WORK;
   DECLARE employee_cursor CURSOR FOR SELECT * FROM employee;
   MOVE FORWARD 5 IN employee_cursor;
   FETCH 1 IN employee_cursor;
   CLOSE employee_cursor;
COMMIT WORK;
```

The preceding code will return a single row from the *employee_cursor* result set.

SQL Server

SQL Server supports a variation of `FETCH` that is very close to the SQL standard:

```
FETCH [ { NEXT | PRIOR | FIRST | LAST |
        { ABSOLUTE int | RELATIVE int } } ]
[FROM] [GLOBAL] cursor_name
[INTO @variable1[, ...]]
```

The differences between SQL Server's implementation and the SQL standard are very small. First, SQL Server allows you to use variables in place of the *`int`* and *`cursor_name`* values. Second, SQL Server allows the declaration and use of `GLOBAL` cursors that can be accessed by any user or session, not just the ones that created them.

There are some rules that apply to how you use the `FETCH` command based upon how you issued the `DECLARE CURSOR` command:

- When you declare a `SCROLL` SQL standard cursor, all `FETCH` options are supported. In all other SQL standard cursors, `NEXT` is the only option supported. (There is also an alternative Transact-SQL-style `DECLARE CURSOR` statement.)
- `DYNAMIC SCROLL` cursors support all `FETCH` options except `ABSOLUTE`.
- `FORWARD_ONLY` and `FAST_FORWARD` cursors support only `FETCH NEXT`.
- `KEYSET` and `STATIC` cursors support all `FETCH` options.

SQL Server also requires a `DEALLOCATE` statement, in addition to `CLOSE`, to release memory consumed by a cursor.

Here's a full example that declares and opens a cursor, initiates several fetches, and then finally closes and deallocates the cursor:

```
DECLARE @vc_lname VARCHAR(30), @vc_fname VARCHAR(30), @i_emp_id CHAR(5)
DECLARE employee_cursor SCROLL CURSOR FOR
   SELECT lname, fname, emp_id
   FROM employee
   WHERE hire_date <= 'FEB-14-2004'
OPEN employee_cursor
-- Fetch the last row in the cursor.
FETCH LAST FROM employee_cursor
-- Fetch the row immediately prior to the current row in the cursor.
FETCH PRIOR FROM employee_cursor
-- Fetch the fifth row in the cursor.
FETCH ABSOLUTE 5 FROM employee_cursor
-- Fetch the row that is two rows after the current row.
FETCH RELATIVE 2 FROM employee_cursor
-- Fetch values eight rows prior to the current row into variables.
FETCH RELATIVE -8 FROM employee_cursor
INTO @vc_lname, @vc_fname, @i_emp_id
```

```
    CLOSE employee_cursor
    DEALLOCATE employee_cursor
    GO
```

Remember that in SQL Server you must not only `CLOSE` the cursor, but also `DEALLOCATE` it. In some rare cases, you might wish to reopen a closed cursor. You can reuse any cursor that you have closed but not deallocated. The cursor is permanently destroyed only when it is deallocated.

See also

- `CLOSE`
- `DECLARE CURSOR`
- `OPEN`
- `ORDER BY` in Chapter 4

OPEN Statement (Cursors)

The `OPEN` statement is one of four commands used in cursor processing, along with `DECLARE`, `FETCH`, and `CLOSE`. Cursors allow you to process queries one row at a time, rather than as a complete set. The `OPEN` statement opens a preexisting cursor created with the `DECLARE CURSOR` statement.

Cursors are especially important in relational databases because databases are set-based, while most client-centric programming languages are row-based. Cursors allow programmers and databases to perform operations a single row at a time, while the default behavior of a relational database is to operate on a whole set of records.

Platform	Command
MySQL	Supported
Oracle	Supported, with variations
PostgreSQL	Supported
SQL Server	Supported, with variations

SQL standard syntax

```
    OPEN cursor_name
```

Keywords

`OPEN` *`cursor_name`*
: Identifies and opens a previously defined cursor created with the `DECLARE CURSOR` command.

Rules at a glance

At the highest level, a cursor must be:

1. Created using DECLARE
2. Opened using OPEN
3. Operated against using FETCH
4. Dismissed using CLOSE

By following these steps, you create a result set similar to that generated by a SELECT statement, except that you can operate against each individual row within the result set.

The following generic SQL example opens a cursor and fetches the first and last names of all of the authors from the *authors* table:

```
DECLARE employee_cursor CURSOR FOR
   SELECT au_lname, au_fname
   FROM pubs.dbo.authors
   WHERE lname LIKE 'K%'
OPEN employee_cursor
FETCH NEXT FROM employee_cursor
BEGIN
  FETCH NEXT FROM employee_cursor
END
CLOSE employee_cursor
```

Programming tips and gotchas

The most common error encountered with the OPEN statement is failing to close the cursor properly. Although the OPEN statement is detailed in isolation here, it should always be managed as a group with the DECLARE, FETCH, and CLOSE statements. You won't get an error message if you fail to close a cursor, but the cursor may continue to hold locks and consume memory and other resources on the server as long as it is open. If you forget to close your cursors, you could end up creating a problem similar to a memory leak. Each cursor consumes memory until it is closed, so even if you're no longer using the cursors, they're still taking up memory that the database server might otherwise be using elsewhere. It's worth taking a little extra time to make sure that every declared and opened cursor is eventually closed.

Cursors are often used in stored procedures and in batches of procedural code. They are useful when you need to perform actions on individual rows rather than on entire sets of data at a time. But because cursors operate on individual rows and not on sets of data, they are often much slower than other means of accessing data. Make sure that you analyze your approach carefully. Many challenges, such as a convoluted DELETE operation or a very complex UPDATE, can be solved by using clever WHERE and JOIN clauses instead of cursors.

MySQL

MySQL supports the SQL standard.

Oracle

Oracle fully supports the SQL standard, and it allows parameters to be passed directly in to the cursor when it is opened. Do this using the following format:

```
OPEN cursor_name [parameter1[, ...]]
```

PostgreSQL

PostgreSQL supports the SQL standard. Additionally, it implicitly opens a cursor when it is created using the `DECLARE` statement.

SQL Server

In addition to the standard `OPEN` statement, SQL Server allows "global" cursors using the following syntax:

```
OPEN [GLOBAL] cursor_name
```

`GLOBAL` cursors can be referenced by multiple users, even if they have not explicitly been assigned permissions to the cursor. If this keyword is omitted, a local cursor is assumed.

SQL Server allows you to declare several different kinds of cursors. If a cursor is `INSENSITIVE` or `STATIC`, the `OPEN` statement creates a temporary table to hold the cursor result set. Similarly, if the cursor is declared with the `KEYSET` option, a temporary table is automatically created to hold the keyset.

See also

- `CLOSE`
- `DECLARE CURSOR`
- `FETCH`
- `SELECT` in Chapter 4

RETURN Statement

The `RETURN` statement terminates processing within a SQL-invoked function (as opposed to a host-invoked function) or stored procedure and returns the routine's result value.

Some vendors use `RETURNS` instead of `RETURN` (the SQL standard).

Platform	Command
MySQL	Supported, with limitations
Oracle	Supported

Platform	Command
PostgreSQL	Supported, with variations
SQL Server	Supported, with variations

SQL syntax

```
RETURN return_parameter_value | NULL
```

Keywords

return_parameter_value
: Represents a value returned by the routine code. A wide variety of value types are possible.

NULL
: Terminates the function without returning an actual value.

Rules at a glance

Use the RETURN statement within procedural code to terminate processing. For example, you might create a user-defined function that takes a complex and often-used CASE expression and, when passed a parameter, returns a single, easy-to-understand expression value.

Programming tips and gotchas

Although the RETURN statement is categorized as a separate command within SQL, it is deeply intertwined with the CREATE FUNCTION and CREATE PROCEDURE statements. Consequently, the RETURN statement is almost always found embedded in one of these other commands. Check "CREATE/ALTER FUNCTION/PROCEDURE Statement" on page 661 or your vendor documentation to get a more complete understanding of each platform's implementation of RETURN within the context of these statements.

MySQL

MySQL supports the SQL standard syntax for RETURN, excluding the NULL keyword:

```
RETURN return_parameter_value
```

For example:

```
DELIMITER $$
CREATE FUNCTION metric_volume(length decimal(4,1),
   width decimal(4,1),
   height decimal(4,1)
) RETURNS DECIMAL
BEGIN
   RETURN length * width * height;
END;
```

```
$$
DELIMITER ;
```

Oracle

Oracle supports the SQL standard syntax for RETURN, excluding the NULL keyword. (Oracle does support the return of a NULL value, just not using the SQL standard syntax.) Oracle allows the RETURN clause only in user-defined functions and user-defined operators. The returned value cannot be a LONG, LONG RAW, or REF data type in the CREATE OPERATOR statement. PL/SQL user-defined functions fully support Boolean data types internally, but you cannot invoke a Boolean UDF from a SQL statement. To hold Boolean values, use INT (0 or 1) or VARCHAR2 ('TRUE' or 'FALSE').

The following example creates a function that returns the value stored in the proj_rev variable to the calling session:

```
CREATE FUNCTION project_revenue (project IN varchar2)
RETURN NUMBER
AS
   proj_rev NUMBER(10,2);
BEGIN
   SELECT SUM(DECODE(action,'COMPLETED',amount,0) -
          SUM(DECODE(action,'STARTED',amount,0)   +
          SUM(DECODE(action,'PAYMENT',amount,0)
   INTO proj_rev
   FROM construction_actions
   WHERE project_name = project;
   RETURN (proj_rev);
END;
```

PostgreSQL

PostgreSQL supports the SQL standard syntax for RETURN and several variations of it:

```
RETURN
RETURN return_parameter_value
RETURN QUERY (sql_statement)
RETURN QUERY EXECUTE command-sql-string [ USING expression[, ... ] ]
RETURN NEXT
```

PostgreSQL allows you to define user-defined functions in various languages (see the PostgreSQL section in "CREATE/ALTER FUNCTION/PROCEDURE Statement" on page 661 for details. The common nonprocedural SQL function type does not have a RETURN clause within its body, so we will limit our discussion to the use of RETURN in PL/pgSQL functions. (Stored procedures do not support RETURN of a value, but you can use RETURN without any value to exit the stored procedure. Any variables that need to be output by a stored procedure must be done using OUT parameters.) The basic form looks as follows:

```
CREATE FUNCTION metric_volume -- Input dimensions in centimeters
   (length decimal(4,1),
    width decimal(4,1),
    height decimal(4,1) )
RETURNS decimal -- Cubic centimeters
AS
$$
BEGIN
   RETURN ( length * width * height );
END;
$$ LANGUAGE plpgsql;
```

For set-returning functions, you may use RETURN QUERY, RETURN QUERY EXECUTE, or RETURN NEXT.

RETURN NEXT is used if you need to do additional processing to each row or need to skip a row before returning the answer. It returns each row. RETURN QUERY, on the other hand, returns the results of a query. RETURN QUERY EXECUTE is similar but takes a quoted query instead of an unquoted query. It is often used if you are building the query condition based on other inputs.

Here is an example that uses RETURN QUERY:

```
CREATE FUNCTION pets
   (num_pets integer )
RETURNS SETOF text
AS
$$
BEGIN
   RETURN QUERY
   (SELECT name::text
      FROM unnest(ARRAY['cat','dog', 'fish', 'raccoon', 'ferret'])
   AS f(name) LIMIT num_pets);
END;
$$ LANGUAGE plpgsql;
```

SQL Server

SQL Server supports the RETURN statement with this syntax:

```
RETURN [return_integer_value]
```

The RETURN command is typically used in stored procedures or user-defined functions. It causes an immediate and complete exit from the program and, optionally, returns an integer value upon exit. SQL Server procedures implicitly return a zero value if no RETURN clause is supplied in the procedure definition. Any commands that follow the RETURN statement are ignored.

The RETURN statement in the following function returns an integer representing the calculated value:

```
CREATE FUNCTION metric_volume -- Input dimensions in centimeters
   (@length decimal(4,1),
    @width decimal(4,1),
    @height decimal(4,1) )
RETURNS decimal(12,3) -- Cubic centimeters
AS
BEGIN
   RETURN ( @length * @width * @height )
END
GO
```

This example creates a function that returns a calculated value—the metric volume of a space—to the calling session.

See also

- `CREATE/ALTER FUNCTION/PROCEDURE`
- `CREATE/ALTER/DROP TRIGGER`

Platform-Specific Extensions

This section covers programming features specific to each database platform that are not covered by the SQL standard. This is not an exhaustive list of features, but ones we think you might find useful on a day-to-day basis.

MySQL and MariaDB

MySQL and MariaDB provide a few useful extensions to the SQL standard. SQL modes are a unique feature that affect the SQL syntax the server supports and the data validation checks it performs. MariaDB also supports Oracle-style packages, which group together related functions and database objects.

SQL_MODE. Both MySQL and MariaDB have a setting called `SQL_MODE` that can be set at the session level or globally, using the *sql-mode* option or *sql_mode* system variable. This setting controls how the databases process SQL.

You can check the current session-level and global settings using the following code:

```
SELECT @@SQL_MODE, @@GLOBAL.SQL_MODE;
```

MySQL's `SQL_MODE` options are a subset of what MariaDB offers. Both have the following notable offerings:

`ANSI_QUOTES`
: Causes " to be treated as an identifier quote character, like `, not as a string quote character.

`ANSI`
: Causes syntax and behavior to be more in line with the SQL standard. This is shorthand for the following comma-separated list of modes: `REAL_AS_FLOAT`, `PIPES_AS_CONCAT`, `ANSI_QUOTES`, `IGNORE_SPACE`.

TRADITIONAL
: Causes the database to give an error instead of a warning (more traditional database behavior) when invalid data is inserted into a column, such as a date like '0000-00-00' or text that is too long for a field. This is shorthand for specifying STRICT_TRANS_TABLES, STRICT_ALL_TABLES, NO_ZERO_IN_DATE, NO_ZERO_DATE, ERROR_FOR_DIVISION_BY_ZERO, NO_ENGINE_SUBSTITUTION.

The most notable mode options MariaDB offers that MySQL doesn't are for impersonating other databases (including their stored routines behavior):

ORACLE
: Allows the server to understand a subset of Oracle's PL/SQL language and supports Oracle's "packages" feature..

MSSQL
: Supports SQL Server's idiosyncratic use of [] as well as the SQL standard "" and `` for quoting identifiers. In version 10.4.5 and later, it also supports a limited subset of SQL Server's Transact-SQL language.

MariaDB packages. As mentioned in the previous section, MariaDB supports Oracle-style stored packages and a subset of the PL/SQL dialect when SQL_MODE=ORACLE is enabled. (This mode is not available in MySQL).

MariaDB packages can be used to manage related functions and objects as a single unit. A package is defined with two statements: CREATE PACKAGE creates the specification for the package and declares the public routines, and CREATE PACKAGE BODY creates the body for a previously specified stored package, including public and private routines, private variables, and initialization code. The syntax of the CREATE PACKAGE command is as follows:

```
CREATE [OR REPLACE]
   [DEFINER = { user | CURRENT_USER | role | CURRENT_ROLE }]
   PACKAGE [ IF NOT EXISTS ]
   [db_name.]package_name
   [ package_characteristic ... ]
{ AS | IS }
   [ package_specification_element ... ]
END [ package_name ]

package_characteristic:
   COMMENT 'string' | SQL SECURITY { DEFINER | INVOKER }
package_specification_element:
   FUNCTION_SYM package_specification_function ; |
   PROCEDURE_SYM package_specification_procedure ;
package_specification_function:
   func_name [ ( func_param[, func_param]... ) ]
   RETURNS func_return_type
   [ package_routine_characteristic... ]
package_specification_procedure:
   proc_name [ ( proc_param [, proc_param]... ) ]
```

```
      [ package_routine_characteristic... ]
   func_return_type:
      type
   func_param:
      param_name [ IN | OUT | INOUT | IN OUT ] type
   proc_param:
      param_name [ IN | OUT | INOUT | IN OUT ] type
   type:
      Any valid MariaDB explicit or anchored data type
   package_routine_characteristic:
      COMMENT 'string' | LANGUAGE SQL |
      { CONTAINS SQL | NO SQL | READS SQL DATA | MODIFIES SQL DATA } |
      SQL SECURITY { DEFINER | INVOKER }
```

The syntax of the `CREATE PACKAGE BODY` command is identical, except that you specify `PACKAGE BODY` instead of just `PACKAGE`. The abridged version is:

```
CREATE PACKAGE BODY package_name AS
[BEGIN
 ⋮
END [name];
```

Here is an example of a MariaDB package definition:

```
SET sql_mode=ORACLE;
DELIMITER $$
CREATE PACKAGE nutshell AS
FUNCTION metric_volume(length NUMBER,
   width NUMBER,
   height NUMBER)
RETURN NUMBER;
END nutshell;
$$

CREATE PACKAGE BODY nutshell AS
FUNCTION metric_volume
   (length NUMBER,
    width NUMBER,
    height NUMBER)
RETURN NUMBER IS
BEGIN
   RETURN (length * width * height);
END metric_volume;
END nutshell;
$$
DELIMITER ;
```

Oracle

Oracle supports numerous programming constructs not defined in the SQL standard. In this section we'll cover some of Oracle's unique features.

SQL macros. SQL macros, added in Oracle 19c (version 19.6), are a new structure similar in concept to what PostgreSQL and SQL Server refer to as *inline functions*. You can define SCALAR macros and TABLE macros, and use them within SQL statements. The main disadvantage with SQL macros is that they can't be used in regular stored procedures and functions, like PostgreSQL and SQL Server inline functions can; however, their performance is much better than that of regular PL/SQL functions because the function definition is folded into the query definition and thus does not need to be called per row. SQL macros can be called within other SQL macros. You saw examples of their use in "CREATE/ALTER FUNCTION/PROCEDURE Statement" on page 661. One additional benefit of TABLE SQL macros is that, unlike other table functions, you do not need to predefine the structure of each row, so there's no need to define a companion table type.

Packages. A *package* in Oracle is a collection of related program objects stored together in the database. Packages can include procedures, functions, variables, constants, cursors, and exceptions. Oracle also allows for including external C and Java libraries in packages.

A package is defined with two statements. CREATE PACKAGE declares the publicly exposed types, items, variables, and subprograms:

```
CREATE [OR REPLACE] [{EDITIONABLE | NONEDITIONABLE}]
PACKAGE name [...] {IS | AS}
<package_item_list>
END [name];
```

CREATE PACKAGE BODY defines these objects along with any private program objects and provides any required initialization code:

```
CREATE [OR REPLACE] [{EDITIONABLE | NONEDITIONABLE}]
PACKAGE BODY name {IS | AS}
<declare_section>
[ <initialize_section> ]
END [name];
```

In addition to providing the ability to create packages, Oracle ships with quite a few packages; for example, the Spatial Data Objects packages (which have names prefixed with SDO_) include numerous functions and definitions of types for doing geospatial work.

Here is an example of a package definition:

```
CREATE PACKAGE nutshell AS
FUNCTION metric_volume(length NUMBER,
   width NUMBER,
   height NUMBER )
RETURN NUMBER;
END nutshell;
/
```

```
CREATE PACKAGE BODY nutshell AS
FUNCTION metric_volume
   (length NUMBER,
    width NUMBER,
    height NUMBER)
RETURN NUMBER IS
BEGIN
   RETURN (length * width * height);
END metric_volume;
END nutshell;
/
```

You can reference package functions and other content by prefixing them with the package name. For example to call the `metric_volume` function inside the package we just defined, you would do:

```
SELECT nutshell.metric_volume(10.2,5,4) FROM dual;
```

Pipelined table functions. Pipelined table functions are set-returning functions that allow for termination and partial return before the whole set of data is returned. The main benefits of a pipeline function over a non-pipelined function are:

- Memory does not need to be allocated to hold the full dataset before sending it.
- The output of the function can be used immediately, before piping of all the records is complete.
- The function is parallelizable.

These features generally result in reduced memory consumption and faster performance.

> There are a number of restrictions on how you can use pipelined table functions, detailed in the documentation.

A pipeline function, unlike other set-returning functions, outputs data using the `PIPE` statement. Here is an example of a pipelined function that returns a table of sequential integers based on the start and end range you provide. All pipelined functions return a collection type. You should define the collection type before defining the function:

```
CREATE TYPE iset_t IS TABLE OF INTEGER;
/
CREATE FUNCTION number_range(i_start INTEGER,
  i_end INTEGER) RETURN iset_t PIPELINED IS
  BEGIN
    FOR i IN i_start..i_end LOOP
      PIPE ROW(i);
    END LOOP;
    RETURN;
  END number_range;
/
```

In versions of Oracle prior to 18c, you needed to wrap the function in a `TABLE` function call, as follows:

```
SELECT * FROM TABLE( number_range(1,100) );
```

In versions of Oracle from 18c on you can skip the `TABLE` call:

```
SELECT * FROM number_range(1,100);
```

To really experience the benefit of a pipelined function you need to run a query that will force termination early, such as the following one. Note that our range is huge, but the pipelined function will terminate once it has output the first 10 rows and does not need to allocate memory for 100,000,000 entries:

```
SELECT *
FROM number_range(1,100000000)
FETCH FIRST 10 ROWS ONLY;
```

PostgreSQL

PostgreSQL has several features for managing logic beyond the SQL standard–defined stored procedures, functions, and triggers. We'll cover the key ones here.

Dollar quoting. PostgreSQL has a feature for escaping strings called *dollar quoting*. A dollar-quoted string follows this convention:

```
$something$
body
$something$
```

where the quoting begins with some set of characters enclosed in *$$* and ends with the same set of characters in *$$*. You'll find many functions written in dollar quotes.

Dollar-quoted strings can encase other dollar-quoted strings. The following is an example of a function that uses dollar quotes to define a function body and then to specify the output. Note that you should not use the same variable string for both the inner and outer names. First, here's what it looks like without dollar quoting:

```
CREATE OR REPLACE FUNCTION hello_dollars()
RETURNS text AS
'SELECT ''Charlie''''s dog stays at John''''s house'';'
language sql;
```

And here's the same example with dollar quoting:

```
CREATE OR REPLACE FUNCTION hello_dollars()
RETURNS text AS
$body$
```

```
    SELECT $inner$Charlie's dog stays at John's house$inner$;
    $body$ language sql;
```

In both cases, the result is:

```
    Charlie's dog stays at John's house
```

Inline functions. An inline function is one whose definition is completely folded into the overall query definition. A function cannot be inlined if any of these conditions are true:

- The function is not written in SQL.
- The function is marked as `SECURITY DEFINER`.
- The function is marked as `STRICT` (`STRICT` functions are generally not inlinable except under very special circumstances beyond the scope of this book).

Inline functions have a number of benefits over non-inlined ones. Since the query planner makes no distinction between an inline SQL function and the rest of a SQL query, it can see if the function is using tables already in the query, and it can utilize indexes. In addition, these functions are not called per row since their definition is collapsed into the query definition. This makes them generally faster. The *`formatted_name`* and *`stores_titles_sales`* functions in "CREATE/ALTER FUNCTION/PROCEDURE Statement" on page 661 are examples of inlined functions.

PostgreSQL has no specific keyword to designate a function as inline.

Extensions. Much of the extensibility of PostgreSQL is thanks to the feature called *extensions*. Extensions are a mechanism of packaging a bundle of related objects so they can be easily installed or dropped in a single step. Extensions can contain more than just functions and procedures; they can contain aggregates, tables, types, views, domains, language handlers, foreign data wrappers, full-text search dictionaries, and pretty much any other type of object that PostgreSQL supports. Extensions include a number of files: usually a single binary library, one or more SQL scripts that contain logic to install the objects or upgrade existing objects in the extension, and a control file ending with file extension *.control*. The control file denotes the name of the extension and the module library (if any), and the version of the extension. (An extension need not have a library and can consist of just SQL and PL/pgSQL or other language functions and statements.) These files are then deployed into the PostgreSQL install share/extension folder.

If you want to create your own extensions, refer to the documentation for details.

Many popular extensions are shipped separately from PostgreSQL. For example, one of the most popular and biggest extensions is the PostGIS geospatial extension, which has over 800 functions; it introduces new types for geospatial work and follows the SQL/MM Part 3 standard. PostGIS is packaged separately from PostgreSQL but generally available via any PostgreSQL Database as a Service (DBaaS) and from most repositories that include PostgreSQL as an offering.

There are also many small extensions that are included in the PostgreSQL source code, with binaries and extension files preinstalled. Most of these are not enabled by default, with the exception of the *plpgsql* extension. You can find help for using these included extensions in Appendix F of the vendor documentation.

To use an extension, you need to install whatever OS dependencies it relies on. Each extension then needs to be enabled in each database you use it in. It's standard practice to install extensions in specific dedicated schemas. For example, you can create a schema called *contrib* and install the extensions in that schema; this is a common choice for the name because PostgreSQL's packaged extensions are located in the *contrib* folder of the PostgreSQL source tarball.

In addition, you may want to make it so that users do not have to prefix the functions with the schema name when using them. You can allow this by revising the database `search_path` to include the schemas the extensions are installed in.

The following code installs two popular included extensions for text pattern matching, *fuzzystrmatch* and *pg_trgm*:

```
CREATE SCHEMA contrib;
CREATE EXTENSION IF NOT EXISTS fuzzystrmatch SCHEMA contrib;
CREATE EXTENSION IF NOT EXISTS pg_trgm SCHEMA contrib;
ALTER DATABASE nutshell SET search_path=public,contrib;
```

The *fuzzystrmatch* extension includes the `soundex` function, which is often preinstalled in other vendor databases, as well as the `levenstein` and `dmetaphone` functions.

The *pg_trgm* extension contains additional functions for text pattern matching and new index classes. It is often used to make it possible for case-insensitive searches like `first_name ILIKE '%John%'` and for regular expressions to take advantage of indexes.

You use extension functions just as you would any other functions you create. The following example uses the `soundex` function that is part of the *fuzzystrmatch* extension:

```
SELECT contrib.soundex('Hello There') As soundex,
  contrib.dmetaphone('Hello There') AS dmetaphone
```

Extensions can be upgraded using:

```
ALTER EXTENSION name_of_extension UPDATE;
```

To upgrade an extension to a specific version, use the following command:

```
ALTER EXTENSION name_of_extension UPDATE TO "version_num";
```

DO. PostgreSQL supports a SQL command called `DO` that allows running code in any scripted language that is installed in the database (`DO` is not supported for the SQL language because any code written is naturally assumed to be SQL unless otherwise stated). A `DO` command cannot return a value, so it's usually reserved for echoing information or doing DML work. Think of `DO` as an anonymous stored procedure that disappears after it has finished its work. Here is an example of running PL/pgSQL code in a `DO` block:

```
DO $$
BEGIN
RAISE NOTICE 'Hello, it is: %s', clock_timestamp();
END
$$ LANGUAGE plpgsql;
```

SQL Server

SQL Server extensions to the SQL standard include support for performance-optimized inline functions and CLR functions.

Inline functions. An inline function is one in which the definition of the function is completely folded into the overall query definition. SQL Server does not require you mark a scalar function as `INLINE = ON` to make it inlinable; however, if you do, it will throw an error if the scalar function is not inlinable. The requirements for inlining are as follows:

- The function must be a Transact-SQL function.
- The function must not contain any procedural logic, such as looping of variables.

Set-returning functions can also be inlined, as long as they are defined with a single `SELECT` statement. Because their definition is collapsed into the query definition, inline functions are not called per row. This makes them generally faster.

Assemblies. Aside from Transact-SQL stored procedures and functions, SQL Server allows for including more complex logic by utilizing external .NET libraries. These libraries in turn often reference other .NET libraries. For these to work, the supported .NET Framework and whatever extra libraries referenced need to be installed on the server.

Assemblies are .NET libraries that are registered for use in SQL Server using the vendor-specific CREATE ASSEMBLY DDL command. Once an assembly is registered, it can be bound to a stored procedure, stored function, or aggregate function. Such functions are often referred to as common language runtime (CLR) functions; refer to the documentation for more information.

By default, CLR support is not enabled; you can enable it as needed by setting the *clr enabled* configuration option to *1*. You can also set the *clr strict security* configuration option, which controls whether unsigned assemblies can be registered or not. Here is an example that registers a library and binds it:

```
EXEC sp_configure 'show advanced options',1;
GO
EXEC sp_configure 'clr enabled',1;
GO
sp_configure 'clr strict security',0
RECONFIGURE;
GO
CREATE ASSEMBLY CLRRegex from 'C:\Regexp\CLRRegex.dll'
WITH PERMISSION_SET = SAFE
GO

EXEC sp_configure 'clr strict security',1;

RECONFIGURE;
GO
```

Once you have an assembly registered, you can link to functions in it using the following syntax:

```
CREATE FUNCTION
CLRRegexReplace(@pattern NVARCHAR(MAX),
   @replaceString NVARCHAR(MAX),
   @subjectString NVARCHAR(MAX),
   @isIgnoreCase bit, @isMultiline bit)
RETURNS NVARCHAR(MAX)
AS EXTERNAL NAME CLRRegex.CLRRegex.RegexReplace;
GO
```

Note that CLR support is never available in SQL Server Azure.

See also

- CREATE/ALTER FUNCTION/PROCEDURE

10 Flexible and Schemaless

One of the strengths of relational databases is their ability to enforce data structures. You constrain data in a relational database by defining tables and defining columns within those tables that enforce basic data types like strings, dates, and numbers, and then define relationships between tables. SQL, as the lingua franca of relational databases, is by extension a tool for transforming this well-structured relatable data into a format digestible by applications. In the early days of relational databases, data types were simple and people looked to relational databases for structure. This started to change with the advent of SQL:1999. The big leap in SQL:1999 was that types need not be just primitives, but could also be composites of primitives. This allowed table columns to store arrays, nested tables, and even user-defined types. Specialized data types sprung up to support networks, encryption, full text search, geospatial applications, and much more.

A relational database is not the only way to organize data, however. Here are some alternatives to the relational model, often referred to as *NoSQL* or *not-only-SQL* databases:

Key/value stores
: Data is stored as a set of key/value pairs, where the key acts as a unique identifier. Support is often limited to retrieval, insertion, modification, and deletion.

Document stores
: This is similar to a filesystem. Each document (record) is a complex object in its own right. The storage format is often proprietary, and there are few or no relationships between documents.

Graph databases
: This is a straightforward method for organizing and storing hierarchical data or network data—think binary trees, schematics, and street maps. Data lives in nodes; edges connect (relate) nodes.

Wide-column stores
: Data is stored in columns and rows, but columns and names of columns can vary across rows.

What most NoSQL databases have in common is a lack of support for the standard beyond SQL:1992. They also sacrifice data consistency and data integrity in exchange for speedier operations and scalability. Conversely, to address some of the shortcomings pointed out by the NoSQL movement, the SQL standard has gradually added support for non-relational data types such as XML/XPath, JSON Path, and JSON.

Graph Databases

The main benefit of graph databases is the ability to query highly related data without the need of many joins. The database language standards committees are working on two graph language specifications, which share a common pattern matching language for queries:

- SQL Property Graph Queries (SQL/PGQ) allows you to create property graph views on top of existing SQL tables and query those property graph views in a SQL `FROM` clause
- The Graph Query Language (GQL) is a full database language to create graphs and insert, update, delete, and query graph data.

The details of GQL, SQL/PGQ, and graph databases are beyond the scope of this book.

To learn more about the graph pattern matching language, take a look at the paper "Graph Pattern Matching in GQL and SQL/PGQ" by Alin Deutsch et al. (at the time of writing, this is a not-yet-reviewed version of a paper submitted to a SIGMOD conference).

In this chapter we'll cover the JSON and XML support found in MySQL, MariaDB, Oracle, PostgreSQL, and SQL Server. XML has been overtaken by JSON in recent years, but it is still widely used, and it allows for stricter definition and rules than JSON.

Much of the popularity of JSON is driven by the ubiquity of JavaScript as the language of the web. Application developers (and pretty much anyone supervising developers) want fast turnaround and rapid prototyping. This often means storing the data exactly as the application produces it, without establishing a well-thought-out relational structure in advance.

Why JSON?

When JSON first arrived on the scene in the early 2000s, many database practitioners wondered if relational databases should accommodate what is clearly a non-relational data structure. The purists, wanting to preserve the sanctity of relations, opined that JSON could be relegated to NoSQL databases. The more moderate faction held that there were flaws with this approach. A majority of the NoSQL offerings sacrificed database essentials such as transactions, consistency, and integrity. What's more, they did not share common protocols; rather than being united in their rebellion against the totalitarianism of SQL, they had splintered. NoSQL had no standards, and there was no common language that could be used across all NoSQL databases. Thus, letting NoSQL handle JSON begged the question of which NoSQL, which soon led to the existential question of "What is NoSQL?"

Soon, the SQL community embraced the idea that perhaps the rules could be bent to accommodate non-relational data types. XML had crept into the SQL standard, and while storing JSON in a relational database might feel icky, leaving it to the Wild West of NoSQL was certainly worse. So, somewhat reluctantly, SQL welcomed JSON into the fold.

As time went on, relational databases started getting really good at storing JSON, encouraging the SQL standard to evolve to work with it. In their most recent versions, all the platforms discussed in this book have functions for querying JSON data. You now have the many benefits of a relational system coupled with the flexibility of a non-relational subsystem.

So what role can JSON play as a data type in SQL? Under what circumstances might its flexible structure be helpful in an otherwise rows-and-columns architecture? All the reasons for adopting JSON revolved around the ability to store heterogeneous data. Tables in a relational database demand homogeneity. All data entering the table must have a predetermined number of attributes, manifested as columns; no deviation allowed. While this rigidity results in impeccable organization of the data, it means tables are incapable of handling data with variable attributes.

Here's a crude example: let's say you're designing a database to store survey data. Each department in the organization wishes to pose its own set of survey questions to the customers. Some departments have more questions than others, and they want to be able to adjust those questions (removing some and adding others) over time. An elementary survey table would demand that each question occupy a single column. If each department developed its own set of questions, the survey table could easily mushroom into hundreds of columns. And every time any department wanted to add a new question or drop a question, the structure of the table would have to undergo modification.

Further, let's say that each department has its own customer base; customers are rarely served by more than one department. The organization could have a fine arts department and a heavy machinery department, and a reasonable prediction would be that customers who buy art supplies are not the same as customers who buy tunnel borers. A monolithic survey table design would mean that NULL values would have to be stored for a huge number of questions for all customers. And finally, if we assume that departments are encouraged to create their survey questions without worrying about whether the answers will be used later, it follows that many of the questions and answers may not end up ever being considered. Under these fluid circumstances, maintaining a rigorous rows-and-columns structure feels wasteful, not to mention the insanity of constantly altering the columns. The downside of the one-answer-per-row relational model is that it adds complexity to the programming required to query and edit a single user survey. If you instead stored the questions and answers for each survey as columns and rows in related tables, you could allow for growth and avoid including unneeded columns in one monolithic table.

Here's where JSON steps in. Instead of hundreds of columns devoted to all the possible questions that have ever been asked in the survey, a JSON column only needs to store the questions posed to a given customer (and store only responses with answers). The JSON column does not require a predetermined schema that each row must abide by. A survey filled out 10 years ago by an artist could be completely different from a survey filled out yesterday by a civil engineer.

So how do we introduce a JSON column, and what support functions are available to manage the JSON data?

Exporting Relational Data as JSON

Even if you are a strong opponent of storing JSON in a relational database, you might still find utility in exporting relational data in JSON format. By doing this, you are using JSON as an interchange format to interact with other systems. The JSON functions introduced in SQL:2016 help you deal with this use case. Similarly there are functions that will take a JSON document as input and expand it into a fully structured flat table.

For the examples in this chapter for demonstrating exporting relational data into JSON and XML format, we will be using this example table (as usual, in the case of MariaDB and MySQL, we will refer only to MySQL except in cases where MariaDB deviates from MySQL behavior):

```
/** Oracle might require setting of the date format **/
ALTER SESSION SET NLS_DATE_FORMAT = 'YYYY-MM-DD';

/** On all platforms **/
CREATE TABLE friends(id integer, name_first varchar(50),
   name_last varchar(50), date_birth date);

INSERT INTO friends(id, name_first, name_last, date_birth)
VALUES (1, 'John', 'Smith', '1935-01-01');

INSERT INTO friends(id, name_first, name_last, date_birth)
VALUES (2, 'Jane', 'Doe', '1937-01-01');
```

JSON Support

JSON support was added to Part 2, SQL/Foundation, in the SQL:2016 standard, but several databases had already implemented their own support by then. You will find equivalent ways of querying JSON data, but under different names, in these databases. We'll try to highlight these differences in our discussion of the SQL standard JSON functions, and show how the various platforms deviate from or go beyond the standard.

JSON Data Types

The SQL:2016 spec did not define a data type specifically for JSON data. JSON is assumed to use the existing `BLOB` and string data types. Some databases have decided to implement a JSON-specific data type to make clear that the column is storing JSON data, check that it is valid JSON, and improve performance. The JSON-specific data types are covered in this section.

MySQL

MySQL supports a `JSON` type.

Oracle

In Oracle 19c and earlier, JSON is stored as `VARCHAR2`. Oracle 21c introduced a `JSON` type.

PostgreSQL

PostgreSQL supports two data types for JSON. `JSON` is a plain-text data type that validates that the JSON is well formed and preserves the original format of the data, including extra spaces, the order of the JSON keys, and any duplicate keys. When selecting the whole `JSON` type object, the system will return exactly what you inserted/updated.

The newer `JSONB` is a binary storage format that reorders the data for efficiency, dedupes duplicate keys (taking the last entry), and strips out spaces between elements. It has much richer index, operator, and function support than the `JSON` type. `JSONB` supports indexing of the whole `JSONB` object and also supports full-text search, whereas the `JSON` data type does not. You can cast `JSON` to `JSONB` to take advantage of some of the features `JSONB` has that `JSON` lacks, but if you cast back you will not have the same `JSON` you started with (when `JSONB` is output the keys of the elements in the object are reordered and whitespace between keys is removed). `JSONB` is designed for efficiency of both storage and operations. You'll find that most operations on JSON documents are significantly faster with `JSONB` than when using the `JSON` type. How much faster depends on the level of nesting and size of the document.

PostgreSQL also includes another type, called JSONPATH, which should be formatted as a SQL/JSON path expression. Although this type is not normally used as a column data type, it can be used if you want to store JSON path queries. It is also useful for validating that a string expression is a valid SQL/JSON path expression that PostgreSQL supports.

PostgreSQL 14 introduced support for subscripting, a feature that has existed for arrays for some time and now is allowed for other data types. JSONB is one of the first types to take advantage of this feature. The main benefit of subscripting is that it allows a cleaner way to edit data (see the documentation for details). An example of subscripting follows:

```
CREATE TABLE products(id integer primary key, data jsonb);
INSERT INTO products(id, data) VALUES (1,
 '{"name":"Refrigerator","type":"Kitchen Appliance",
   "dimensions":{"width": 20, "height": 100 } }');

UPDATE products SET data['dimensions']['width'] = to_jsonb(25)
 WHERE id= 1;
```

SQL Server

SQL Server does not have a dedicated JSON type. For storing JSON, NVARCHAR(*max*) is generally used. If JSON will not grow beyond a certain size, you can gain some efficiency by specifying the maximum length; e.g., NVARCHAR(3000).

Examples

This example demonstrates how to create a table with a column that holds JSON in the various databases and then add some data to it:

```
/** MySQL, Oracle 21c+, PostgreSQL **/
CREATE TABLE bag_o_json(id integer primary key, data json);

/** Oracle < 21c **/
CREATE TABLE bag_o_json(id integer primary key, data varchar2(3800));

/** SQL Server **/
CREATE TABLE bag_o_json(id integer primary key, data nvarchar(3800));

/** PostgreSQL binary JSON **/
CREATE TABLE bag_o_json(id integer primary key, data jsonb);

/** All platforms (add data) **/
INSERT INTO bag_o_json(id, data)
VALUES (1, '{"lname":"Doe","fname":"Jane","alive":true, "age": 20}');

INSERT INTO bag_o_json(id, data)
VALUES (2, '{
  "contact": {
     "first_name": "John",
      "last_name": "Doe",
      "address": {
         "city": "Boston",
         "state": "MA",
         "country": "United States"
              }
    },
      "tags": ["Missing", "Presumed Dead"]
}');
```

SQL/JSON Path

SQL/JSON Path is the query language you use to navigate JSON documents in SQL. Many of the JSON functions you will use will take as input a JSON Path query. The most common of these are `JSON_VALUE` and `JSON_QUERY`. JSON Path is syntactically similar to the JSONPath language used in JavaScript; both JSON Path and JSONPath borrow from XPath, which is used to navigate XML documents. The support for SQL/JSON Path varies wildly across the relational databases discussed in this book.

SQL/JSON Path key elements

The key elements supported in SQL/JSON Path are shown in Table 10-1.

Table 10-1. SQL/JSON Path key elements

Element	Description
`$`	Root object/element.
`@`	Current object/element.
`.` or `[]`	Child operator.
`..`	Recursive descent. JSON Path borrows this syntax from E4X.
`*`	Wildcard. All objects/elements regardless of names.
`[]`	Subscript operator. XPath uses this to iterate over element collections and for predicates. In JavaScript and JSON it is the native array operator.
`[,]`	Union operator. In XPath, this results in a combination of node sets. JSON Path allows alternative names or array indices as a set.
`[start:end:step]`	Array slice operator. Borrowed from ES4.
`?()`	Applies a filter (script) expression.
`()`	Script expression, using the underlying script engine.
`&&, ||, !`	Used in filter expressions to denote AND, OR, and NOT.

SQL/JSON Path literals

SQL/JSON Path also supports certain literals:

boolean
: Takes on a value of *true* or *false*. It should not be quoted.

null
: Equivalent to NULL. It should not be quoted.

numerics
: Used to express any number; e.g., an integer like 11, a fraction like 11.3, or scientific notation like 11.3e0. These should not be quoted.

strings
: Used to express string literals; e.g., *"This is a dog"*. These should be quoted. If the text has double quotes within it, they should be escaped with JavaScript escaping: e.g., *"Say \"hello\" to my dog"*.

SQL/JSON Path functions

SQL/JSON Path includes the following functions that can be applied to an item:

`$.type()`
: Returns the data type of an element

`$.size()`
: Returns the size of an element

`$.double()`
: Converts an element to double precision

`$.ceiling()`
: For numbers, returns the ceiling as an integer

`$.floor()`
: For numerics, returns the floor as an integer

`$.abs()`
: For numerics, returns the absolute value

`$.datetime()`
: Converts an element to a datetime value

`$.keyvalue()`
: Converts a JSON object into a set of key/value pairs

SQL/JSON Path modes

SQL/JSON Path has two modes, *lax* and *strict*. Most databases do not support the keywords for these distinctions and default to lax mode. For databases that do support it in their functions, lax mode is assumed if there is no explicit request for strict mode. Keep in mind that modes are not supported in all databases and even when supported may not be supported by all functions that take a JSON path expression. Lax mode specifies that if a value fitting the JSON path expression is not found, a NULL value should be returned. In strict mode, if no value is found based on the JSON path expression an error is raised. The mode specifier is included before the path. For instance, this example from SQL Server will trigger an error and cancel the query if the requested element is not found in at least one row:

```
SELECT id, JSON_VALUE(data, 'strict $.contact.address.state') As jobj
FROM bag_o_json;
```

In SQL standard specs lax and strict modes also dictate whether or not keys are quoted and if literals can be quoted.

See also

- `JSON_QUERY`
- `JSON_VALUE`

SQL Standard JSON Functions

This section lists all the JSON functions defined in the standard and provides details on their implementations in the various relational databases, including alternative syntax or alternative functions where relevant (for information on vendor-provided functions, see "JSON Platform-Specific Extensions" on page 767).

JSON_ARRAY

The `JSON_ARRAY` function accepts as input one or more value expressions and returns a JSON array.

SQL standard syntax.

```
JSON_ARRAY(expression1[, expression2[, ...])
```

MySQL. MySQL supports the `JSON_ARRAY` function.

Oracle. Oracle supports the `JSON_ARRAY` function.

PostgreSQL. PostgreSQL does not support the `JSON_ARRAY` function. Use the equivalent `JSON_BUILD_ARRAY` or `JSONB_BUILD_ARRAY` instead.

SQL Server. SQL Server does not support the `JSON_ARRAY` function. Use concatenation functions and operators instead.

Examples.

```
/** SQL standard, MySQL **/
SELECT JSON_ARRAY('abc', 'def') AS ja;

/** Oracle **/
SELECT JSON_ARRAY('abc', 'def') AS ja FROM dual;

/** PostgreSQL **/
SELECT JSON_BUILD_ARRAY('abc', 'def')  AS ja;
```

```
/** SQL  Server **/
SELECT '[' +
   CONCAT_WS(',', QUOTENAME(STRING_ESCAPE('abc', 'json'), '"'),
      QUOTENAME('def', '"'))
   + ']'  AS ja;

 ja
----------
 ["abc", "def"]
```

JSON_ARRAYAGG

JSON_ARRAYAGG is an aggregate function that takes a set of values and converts them to a JSON array. Refer to Chapter 8 for details on working with aggregate functions.

SQL standard syntax.

```
JSON_ARRAYAGG( [ALL | DISTINCT] expression
    [ORDER BY sort_specification] )

sort_specification ::= expression1 [ASC | DESC]
    [NULLS FIRST | NULLS LAST][, ...]
```

MySQL. MySQL supports the JSON_ARRAYAGG aggregate function, with the exception of the NULLS FIRST and NULLS LAST clauses.

Oracle. Oracle fully supports the JSON_ARRAYAGG aggregate function.

PostgreSQL. PostgreSQL does not support the JSON_ARRAYAGG function. Use the equivalent JSON_AGG or JSONB_AGG instead; both functions support any type, including table types, and support ORDER BY with NULLS FIRST or NULLS LAST and DISTINCT clauses. For table types, the result of each array element will be a JSON object. The syntax of these functions is as follows:

```
JSON_AGG( [ALL | DISTINCT] anyelement
   [ORDER BY sort_specification] ) [filter_clause]
   [OVER window_name | window_specification]

JSONB_AGG( [ALL | DISTINCT] expression
   [ORDER BY sort_specification] ) [filter_clause]
   [OVER window_name | window_specification]

sort_specification ::= expression1 [ASC | DESC]
   [NULLS FIRST | NULLS LAST][, ...]
```

SQL Server. SQL Server does not support the JSON_ARRAYAGG function. Use something like STRING_AGG for simple JSON arrays, and for full JSON documents use the JSON PATH construct.

Examples.

```
/** SQL standard, MySQL, Oracle **/
SELECT odd, JSON_ARRAYAGG(num ORDER BY num) AS nums
FROM test4
GROUP BY odd;

/** PostgreSQL **/
SELECT odd, JSON_AGG(num ORDER BY num) AS nums
FROM test4
GROUP BY odd;

/** SQL Server **/
SELECT odd,
   '[' + STRING_AGG(num, ',') WITHIN GROUP(ORDER BY num) + ']' as nums
FROM test4
GROUP BY odd;

 odd |  nums
-----+-------------
   0 | [2, 4]
   1 | [1, 3, 3, 5]
```

JSON_EXISTS

The JSON_EXISTS function takes a JSON expression and returns TRUE or FALSE depending on whether it exists in a JSON object.

SQL standard syntax.

```
JSON_EXISTS(json_object, json_path
   [json_exists_error_behavior ON ERROR])

json_path ::= refer to the "SQL/JSON Path" section for details
json_object ::= any valid JSON object or array
json_exists_error_behavior ::= TRUE | FALSE | UNKNOWN | ERROR
```

MySQL and MariaDB. MySQL does not support the JSON_EXISTS function; its JSON_CONTAINS function offers similar functionality.

MariaDB supports JSON_EXISTS but returns 1 for TRUE and 0 for FALSE. If any of the inputs are NULL, MariaDB returns NULL instead of UNKNOWN or ERROR.

Oracle. Oracle supports the JSON_EXISTS function, but not in the SELECT clause. It can only be used in the WHERE clause.

PostgreSQL. PostgreSQL does not support the JSON_EXISTS function. The *?* and *@?* operators offer similar functionality and can be used anywhere in an SQL statement. They return Boolean true/false values; the syntax is as follows:

```
jsonb_object @? json_path
jsonb_object ? object_name
json_object ? object_name
```

SQL Server. SQL Server does not support the `JSON_EXISTS` function. The closest proxy is to use `JSON_VALUE`.

Examples.

```
/** MariaDB (doesn't seem to work for complex JSON path queries) **/
SELECT id
FROM bag_o_json
WHERE JSON_EXISTS(data, "$.fname") ;

/** Oracle **/
-- check if attribute exists
SELECT id
FROM bag_o_json
WHERE JSON_EXISTS(data, '$.fname');

-- check if attribute equals some value
SELECT id
FROM bag_o_json
WHERE JSON_EXISTS(data, '$?(@.fname == "Jane")');

/** PostgreSQL **/
-- check if attribute exists on upper level
SELECT id
FROM bag_o_json
WHERE data::jsonb ? 'fname';

-- check if attribute equals some value
SELECT id
FROM bag_o_json
WHERE data::jsonb @? '$?(@.fname == "Jane")';

/** SQL  Server **/
-- check if attribute exists on upper level
SELECT id
WHERE JSON_VALUE(data, '$.fname') IS NOT NULL;

SELECT id
WHERE JSON_VALUE(data, '$.fname') = 'Jane';

id
-----
1
```

JSON_OBJECT

The JSON_OBJECT function takes a sequence of name/value pairs and builds a single JSON object from these.

SQL standard syntax.

```
JSON_OBJECT( json_name_value[{, json_name_value}]
   [json_constructor_null_clause]
   [json_key_uniqueness_constraint]
   [json_output_clause]
)

json_name_value ::= [KEY] json_name VALUE json_value |
   json_name : json_value
json_constructor_null_clause ::= NULL ON NULL | ABSENT ON NULL
json_key_uniqueness_constraint ::= WITH UNIQUE [KEYS] |
   WITHOUT UNIQUE [KEYS]
json_representation ::= JSON [ENCODING {UTF8 | UTF16 | UTF32}]
json_output_clause ::= RETURNING data_type [FORMAT json_representation]
```

MySQL. MySQL supports JSON_OBJECT with just the key/value input, as follows:

```
JSON_OBJECT(json_name_value[{, json_name_value}])
json_name_value ::= json_name, json_value
```

Oracle. Oracle fully supports the JSON_OBJECT function, with some enhancements:

```
JSON_OBJECT( json_name_value[{, json_name_value}]
   [json_constructor_null_clause]
   [json_key_uniqueness_constraint]
   [json_output_clause]
)

json_name_value ::= [KEY] json_name VALUE json_value |
   json_name : json_value | * | table_name.*
json_output_clause ::= RETURNING { VARCHAR2 [(size [BYTE | CHAR])] |
   CLOB | BLOB | JSON }
```

Oracle supports a wildcard option for *json_name_value* that adds all columns in a query or all columns in a table to the object as key/value JSON pairs. The JSON format option in the *json_output_clause* was introduced in Oracle 21c.

PostgreSQL. PostgreSQL has JSON_OBJECT, JSONB_OBJECT, JSON_BUILD_OBJECT, and JSONB_BUILD_OBJECT functions that serve the same purpose as the JSON_OBJECT function, but with slightly different syntax. The JSONB variants return a binary JSON object and the JSON variants return plain-text JSON. The syntax for these functions is as follows:

```
JSON_BUILD_OBJECT(json_name_values)
JSONB_BUILD_OBJECT(json_name_values)
JSON_OBJECT(text_array | keys, values)
```

```
JSONB_OBJECT(text_array | keys, values)

json_name_value ::= json_name, json_value
json_name_values ::= json_name_value[{, json_name_value}]
keys ::= text_array
values ::= text_array
```

To mimic the wildcard format offered by Oracle, you can use the `TO_JSON(`*`table_name_or_alias`*`)` and `TO_JSONB(`*`table_name_or_alias`*`)` functions.

SQL Server. SQL Server does not support the `JSON_OBJECT` function; use the `FOR JSON AUTO, WITHOUT_ARRAY_WRAPPER` clause instead. Without the `WITHOUT_ARRAY_WRAPPER`, SQL Server will return a query as a single JSON object with an array wrapped around the whole set. If the `WITHOUT_ARRAY_WRAPPER` clause exists, then each row is returned as separate JSON documents.

```
select_statement
FOR JSON { {AUTO | PATH} [ [, ROOT [('RootName')]]
    [, INCLUDE_NULL_VALUES]
    [, WITHOUT_ARRAY_WRAPPER] ] }
```

Examples. For these examples, we'll use the following table:

```
CREATE TABLE friends(id integer, name_first varchar(50),
   name_last varchar(50), date_birth date);
INSERT INTO friends(id, name_first, name_last, date_birth)
VALUES (1, 'John', 'Smith', '1935-01-01');
INSERT INTO friends(id, name_first, name_last, date_birth)
VALUES (2, 'Jane', 'Doe', '1937-01-01');
```

This example selects columns from the **friends** table and outputs them as a JSON object with different property names from the original names:

```
-- SQL standard, Oracle
SELECT id, json_object('last': name_last,
   'first': name_first,
   'birth_age': date_birth) AS jobj
FROM friends;

-- MySQL
SELECT id, json_object('last', name_last,
   'first', name_first,
   'birth_age', date_birth) AS jobj
FROM friends;

-- PostgreSQL
SELECT id, json_build_object('last', name_last,
   'first', name_first,
   'birth_age', date_birth) AS jobj
FROM friends;
```

```
-- SQL Server
SELECT id, (SELECT f.name_last AS last,
   f.name_first AS first,
   f.date_birth AS birth_date
   FROM friends AS f
   WHERE f.id = friends.id
   FOR JSON PATH, WITHOUT_ARRAY_WRAPPER) AS jobj
FROM friends;

id |                              jobj
----+-----------------------------------------------------------------
  1 | {"last" : "Smith", "first" : "John", "birth_age" : "1935-01-01"}
  2 | {"last" : "Doe", "first" : "Jane", "birth_age" : "1937-01-01"}
(2 rows)
```

To maintain the names of table columns and output all columns, you could do the following:

```
-- Oracle
SELECT id, json_object(*) AS jobj
FROM friends;

-- PostgreSQL
SELECT id, to_json(friends) AS jobj
FROM friends;

-- SQL Server
SELECT id, (SELECT f.*
 FROM friends AS f
 WHERE f.id = friends.id
 FOR JSON PATH, WITHOUT_ARRAY_WRAPPER) AS jobj
FROM friends;
```

JSON_OBJECTAGG

`JSON_OBJECTAGG` is an aggregate function that takes one name/value pair for each row and then aggregates all the rows into a single JSON object.

SQL standard syntax.

```
JSON_OBJECTAGG( json_name_value [json_constructor_null_clause]
   [json_key_uniqueness_constraint] [json_output_clause] )

json_name_value ::= [KEY] json_key VALUE json_value |
   json_key : json_value
json_constructor_null_clause ::= NULL ON NULL | ABSENT ON NULL
json_key_uniqueness_constraint ::= WITH UNIQUE [KEYS] |
   WITHOUT UNIQUE [KEYS]
json_representation ::= JSON [ENCODING {UTF8 | UTF16 | UTF32}]
json_output_clause ::= RETURNING data_type [FORMAT json_representation]
```

MySQL. MySQL supports a basic form of the `JSON_OBJECTAGG` function with just key/value input, as follows:

```
JSON_OBJECTAGG(json_key, json_value)
```

Oracle. Oracle supports the `JSON_OBJECTAGG` function, with some enhancements:

```
JSON_OBJECTAGG( json_name_value [json_constructor_null_clause]
   [json_key_uniqueness_constraint]
   [json_output_clause]
)

json_output_clause ::= RETURNING
   { VARCHAR2 [(size [BYTE | CHAR])] | CLOB | BLOB | JSON }
json_name_value ::= [KEY] json_key VALUE json_value
```

`json_key` has to be a string. Oracle supports a wildcard option for this that adds all columns in a query or all columns in a table to the object as key/value JSON pairs. The JSON format option in the *`json_output_clause`* was introduced in Oracle 21c.

PostgreSQL. PostgreSQL does not support the `JSON_OBJECTAGG` function; use `JSON_OBJECT_AGG` or `JSONB_OBJECT_AGG` instead. The syntax of these functions is as follows:

```
JSON_OBJECT_AGG(json_key, json_value)
JSONB_OBJECT_AGG(json_key, json_value)
```

SQL Server. SQL Server does not support the `JSON_OBJECTAGG` function.

Examples. For these examples we'll use the **friends** table we created in the previous section:

```
-- SQL standard, Oracle
SELECT json_objectagg(
 KEY CAST(id AS varchar(20)) VALUE name_first) AS jobj
FROM friends;

-- MySQL (only supports one key, value pair)
SELECT json_objectagg(id, name_first) AS jobj
FROM friends;

-- PostgreSQL
SELECT json_object_agg(id, name_first) AS jobj
FROM friends;

SELECT jsonb_object_agg(id, name_first) AS jobj
FROM friends;
{"1": "John", "2": "Jane"}
```

JSON_QUERY

The `JSON_QUERY` function extracts JSON text from a document using SQL/JSON path query syntax.

SQL standard syntax.

```
JSON_QUERY( json_api_common_syntax [json_output_clause]
   [json_query_wrapper_behavior WRAPPER]
   [json_query_quotes_behavior QUOTES [ON SCALAR STRING]]
   [json_query_empty_behavior ON EMPTY]
   [json_query_error_behavior ON ERROR]
)

json_api_common_syntax ::= item json_path_specification
   [AS json_table_path_name]
   [PASSING value AS identifier[, value AS identifier, ...]]
json_constructor_null_clause ::= NULL ON NULL | ABSENT ON NULL
json_key_uniqueness_constraint ::= WITH UNIQUE [KEYS] |
   WITHOUT UNIQUE [KEYS]
json_representation ::= JSON [ENCODING {UTF8 | UTF16 | UTF32}]
json_output_clause ::= RETURNING data_type [FORMAT json_representation]
```

MySQL and MariaDB. MySQL does not support the `JSON_QUERY` function, but `JSON_EXTRACT` is equivalent in purpose:

```
JSON_EXTRACT(json_doc, json_path_expression)
```

MariaDB supports a basic form of the `JSON_QUERY` function that accepts as input a *`json_doc`* containing JSON-formatted data and a *`json_path_expression`*, which is a query expression described using SQL/JSON Path syntax. The MariaDB syntax for this function is:

```
JSON_QUERY(json_doc, json_path_expression)
```

Oracle. Oracle has a `JSON_QUERY` function that follows the standard and provides some improvements. Its syntax is as follows:

```
JSON_QUERY( expr [FORMAT JSON], json_path_expression
   [json_query_returning_clause] [json_query_wrapper_clause]
   [json_query_empty_error ON ERROR]
   [json_query_empty_error ON EMPTY]
)

json_query_returning_clause ::=
   [ RETURNING {VARCHAR2 [(size [BYTE | CHAR] [TRUNCATE])]} |
     {CLOB | BLOB} ] [PRETTY] [ASCII]
json_query_wrapper_clause ::= WITHOUT [ARRAY] WRAPPER |
   WITH [UNCONDITIONAL | CONDITIONAL] [ARRAY] WRAPPER
json_query_empty_error ::= { ERROR | NULL | EMPTY |
   EMPTY ARRAY | EMPTY OBJECT }
```

PostgreSQL. PostgreSQL does not support the JSON_QUERY function; use JSONB_PATH_QUERY or JSONB_PATH_QUERY_FIRST instead. The syntax is as follows:

```
JSONB_PATH_QUERY(jsonb_document, json_path_expression)
JSONB_PATH_QUERY_FIRST(jsonb_document, json_path_expression)
```

jsonb_document is an expression or column of type JSONB. To use these functions with the JSON type, cast JSON to JSONB. Note that unlike the SQL standard function, which by default returns NULL for no matches and only one JSON object, JSONB_PATH_QUERY is a set-returning function that returns one or more values per expression and returns no records if there is no match. The JSONB_PATH_QUERY_FIRST function returns the first JSONB object in the document that matches the query and returns NULL if there is no match.

SQL Server. SQL Server supports the JSON_QUERY function in the most basic form. The syntax is as follows:

```
JSON_QUERY(json_doc, json_path_expression)
```

Examples. For these examples we'll use the *bag_o_json* table we created in "JSON Data Types" on page 749:

```
-- SQL standard, MariaDB, Oracle, SQL Server
SELECT id, json_query(data, '$.contact.address') As jobj
FROM bag_o_json;

-- PostgreSQL
SELECT id, jsonb_path_query_first(j.data::jsonb, '$.contact.address')
   AS jobj
FROM bag_o_json AS j ;
```

The output in all cases is (plus or minus whitespace):

```
1    NULL
2    { "city": "Boston", "state": "MA", "country": "United States" }
```

Here's the equivalent query on PostgreSQL using the JSONB_PATH_QUERY function:

```
-- PostgreSQL
SELECT id, jobj
FROM bag_o_json AS j
   CROSS JOIN jsonb_path_query(j.data::jsonb, '$.contact.address')
    AS jobj;

2    { "city": "Boston", "state": "MA", "country": "United States" }
```

JSON_TABLE

JSON_TABLE is a set-returning function that maps a subset of a JSON object's data to table columns and returns a row for each match.

SQL standard syntax.

```
JSON_TABLE( json_doc, json_path json_table_columns_clause
   [ json_table_plan_clause ]
   [ {ERROR | EMPTY} ON ERROR ]
)

json_path ::= valid json_path reference to a data element
json_empty_error ::= ERROR | NULL | EMPTY ARRAY | EMPTY OBJECT
json_table_column_definition ::= column_name FOR ORDINALITY |
   column_name data_type [PATH json_path_column_expression]
   [json_empty_error ON EMPTY] [json_empty_error ON ERROR] |
   column_name data_type FORMAT json_expression
   [PATH json_path_column_expression]
   [json_empty_error ON EMPTY] [json_empty_error ON ERROR]
json_table_columns_clause ::= COLUMNS(json_table_column_definition
   [{, json_table_column_definition}...])
json_returning_clause ::= RETURNING data_type
   [FORMAT json_representation]
```

The `JSON_TABLE` function takes at minimum a JSON document (which can be a JSON column in a table or inlined JSON), the *json_path* (which is the beginning element in the document from which the columns will be derived), and a column clause (which defines what elements within the *json_path* should be mapped). If only column names and data types are specified for each column, the column name is assumed to be a key within the *json_path* expression.

MySQL. MySQL supports the `JSON_TABLE` function with a subset of the SQL standard syntax options. The MySQL syntax is as follows:

```
JSON_TABLE(json_doc, json_path json_table_columns_clause
   [json_table_plan_clause] [{ERROR | EMPTY} ON ERROR])

json_table_column_definition ::= column_name FOR ORDINALITY |
   column_name data_type PATH json_path_column_expression
   [json_empty_error ON EMPTY] [json_empty_error ON ERROR] |
   column_name data_type EXISTS PATH json_path_column_expression |
   NESTED [PATH] path COLUMNS (column_list)
column_list ::= column[, column][, ...]
json_empty_error ::= {NULL | DEFAULT json_string | ERROR}
```

Oracle. Oracle fully supports the SQL standard syntax for the `JSON_TABLE` function.

PostgreSQL. PostgreSQL does not support the `JSON_TABLE` function until PostgreSQL. There are many JSON functions and operators you can use to achieve the same result, depending on what you want to do and how deeply nested your JSON is.

SQL Server. SQL Server does not support the `JSON_TABLE` function. Use `OPENJSON` instead:

```
OPENJSON(json_doc)
[WITH (column_definition[, column_definition, ...])]

column_definition ::= column_name data_type json_path_column_expression
```

The OPENJSON function returns a table. If no WITH column definition set is provided, then OPENJSON extracts each key/value pair within the document as a column with data type nvarchar(max).

Examples. For these examples we'll use the *bag_o_json* table we created in "JSON Data Types" on page 749. Here, we expand a JSON array into separate rows. Note that only rows from *bag_o_json* that have tags will be included:

```
-- SQL standard, MySQL, Oracle
SELECT bag_o_json.id, jt.*
FROM bag_o_json,
   JSON_TABLE(data, '$.tags[*]'
      COLUMNS (tag VARCHAR(50) PATH '$')
   ) AS jt;

-- PostgreSQL
SELECT bag_o_json.id, jt.*
FROM bag_o_json,
   JSON_ARRAY_ELEMENTS_TEXT(data->'tags') AS jt(tag);

-- SQL Server
SELECT id,
   jt.*
FROM bag_o_json AS j
CROSS APPLY OPENJSON(j.data, '$.tags')
   WITH (tag varchar(50) '$') AS jt;
```

The output is as follows (note that Oracle returns the column names in uppercase):

```
        ID  TAG
---------- -------------------
         2  Missing
         2  Presumed Dead
```

This example expands a nested property in a table:

```
-- SQL standard, MySQL, Oracle
SELECT bag_o_json.id, jt.*
FROM  bag_o_json,
   JSON_TABLE(bag_o_json.data, '$.contact.address'
      COLUMNS (city VARCHAR(50) PATH '$.city'  NULL ON EMPTY,
         state varchar(2) PATH '$.state',
         country VARCHAR(50) PATH '$.country'
      )
   ) AS jt;

-- PostgreSQL
SELECT id,
   jt.*
FROM bag_o_json AS j,
   json_to_record(j.data->'contact'->'address')
   AS jt(city varchar(50),
      state varchar(2),
      country varchar(50))
WHERE jt.city is not null;

-- SQL Server
SELECT id,
   jt.*
FROM bag_o_json AS j
CROSS APPLY OPENJSON(j.data, '$.contact.address')
   WITH (city varchar(50) '$.city',
      state varchar(2) '$.state',
      country varchar(50) '$.country') AS jt;
```

The output in all cases is (plus or minus whitespace):

```
 id | city   | state | country
----+--------+-------+--------------
  2 | Boston | MA.   | United States
```

JSON_VALUE

The JSON_VALUE function extracts a SQL value from a JSON document based on a JSON path expression. This allows elements nested in a JSON document to be retrieved.

SQL standard syntax.

```
JSON_VALUE(json_api_common_syntax [json_returning_clause]
   [json_empty_error ON EMPTY]
   [json_empty_error ON ERROR]
)

json_api_common_syntax ::= json_doc, json_path_specification
   [AS json_table_path_name]
   [PASSING value AS identifier[, value AS identifier, ...]]
json_returning_clause ::= RETURNING data_type
   [FORMAT json_representation]
json_empty_error ::= ERROR | NULL | DEFAULT value
```

MySQL. MySQL supports a basic form of the JSON_VALUE function with the following syntax:

```
JSON_VALUE(json_doc, json_path_expression)
```

Oracle. Oracle supports the JSON_VALUE function with the following syntax:

```
JSON_VALUE(json_doc [FORMAT JSON], json_path_expression
   [json_returning_clause]
   [json_empty_error ON EMPTY]
```

```
      [json_empty_error ON ERROR]
      [json_value_on_mismatch_clause]
   )

   json_value_return_object_instance ::= object_type_name
      [USING CASE-SENSITIVE MAPPING]
   return_type ::= { VARCHAR2 [(size [BYTE | CHAR] [TRUNCATE])] |
      NUMBER [(precision[, scale])] | DATE | TIMESTAMP [WITH TIME ZONE] |
      CLOB | SDO_GEOMETRY | json_value_return_object_instance }
   json_returning_clause ::= RETURNING return_type
      [FORMAT json_representation]
   json_empty_error ::= ERROR | NULL | DEFAULT value
   json_value_on_mismatch ::= ((IGNORE | ERROR | NULL) ON MISMATCH
      [((MISSING DATA) | (EXTRA DATA) | (TYPE ERROR))]) ...
```

PostgreSQL. PostgreSQL does not provide the `JSON_VALUE` function; use the `JSON` -> or ->> or `JSONB` -#> or -#>> operators instead. More details are provided in the following section covering platform-specific extensions, but the basic syntax is as follows:

```
jsonb_document -> {text | integer}
json_document -> {text | integer}
json_document ->> {text | integer}
jsonb_document ->> {text | integer}
json_document #> text_array
jsonb_document #> text_array
json_document #>> text_array
jsonb_document #>> text_array
```

-> returns a `JSON` or `JSONB` object (based on the type of the original document) that matches the key represented by *`text`* | *`integer`*. The *`integer`* option is for the *n*th element in a JSON array. ->> returns the result as text instead of as a JSON document. #> and #>> take as input a text array representing the nesting of a value with a document. It is common practice to chain -> to navigate a nested JSON document and then end with a ->> call.

SQL Server. SQL Server supports a basic form of the `JSON_VALUE` function with the following syntax:

```
JSON_VALUE(json_doc, json_path_expression)
```

Examples. For these examples we'll use the *bag_o_json* table we created in "JSON Data Types" on page 749. Here, we select a nested value in a JSON column:

```
-- SQL standard, MySQL, Oracle, SQL Server
SELECT id, JSON_VALUE(data, '$.contact.address.state') As jobj
FROM bag_o_json;

-- PostgreSQL
SELECT id, j.data #>> '{contact,address,state}' AS jobj
FROM bag_o_json AS j ;
```

The output in all cases is (plus or minus whitespace):

```
Id   jobj
---  -----
1    NULL
2    MA
```

JSON Platform-Specific Extensions

This section provides an alphabetical listing of vendor-supported JSON functions not covered in the previous section.

MySQL JSON functions

`JSON_ARRAY_APPEND(`*`json_doc`*`, `*`path`*`, `*`value`*`[, `*`path`*`, `*`value`*`] ... )`

Appends a value at the end of a JSON array in the specified *path* location. For example:

```
SELECT JSON_ARRAY_APPEND(b.data, '$.tags', 'Alive Maybe')
FROM bag_o_json AS b
WHERE id = 2;

{"contact": {"first_name": "John", "last_name": "Doe",
 "address": {"city": "Boston", "state": "MA",
  "country": "United States"}},
 "tags": ["Missing", "Presumed Dead", "Alive Maybe"]}
```

Oracle JSON functions

`JSON_DATAGUIDE( `*`expr`*` [, `*`format`*`[, `*`flag`*`]] )`

Takes JSON data in a column and returns a `CLOB` with guide information. This is an aggregate function. For example:

```
SELECT JSON_DATAGUIDE(data, dbms_json.format_flat,
    DBMS_JSON.PRETTY) AS guide
FROM bag_o_json;

GUIDE
--------------------------------------------------------------------
[
  {
    "o:path" : "$.age",
    "type" : "number",
    "o:length" : 2
  },
  {
    "o:path" : "$.tags",
    "type" : "array",
    "o:length" : 32
  },
:
:
```

For further details, see the documentation.

`JSON_MERGEPATCH(` *`target_json_doc`*`,` *`merge_patch_doc`* `[`*`returning_type`*`] [PRETTY] [ASCII] [TRUNCATE] [`*`on_error_clause`*`] )`

Modifies a target JSON document using a merge document patch. A merge document patch can include new additions, updates, and deletions. Deletions are noted with a *null*. For example:

```
SELECT JSON_MERGEPATCH(data,
   '{"lname" : "Does", "age" : null, "eye_color" : "violet"}')
   AS new_data
FROM bag_o_json
WHERE id = 1;

NEW_DATA
---------------------------------------------------------------------
{"lname":"Does","fname":"Jane","alive":true,"eye_color":"violet"}
```

Refer to the documentation for details.

`JSON_SERIALIZE(` *`json_doc`* `[PRETTY] [ASCII] [TRUNCATE] [{NULL | ERROR | EMPTY { ARRAY | OBJECT} )`

Returns a textual representation of JSON data. For example:

```
SELECT JSON_SERIALIZE(data PRETTY) AS pretty
FROM bag_o_json WHERE id = 1;

PRETTY
---------------------------------------------------------------------
{
  "lname" : "Doe",
  "fname" : "Jane",
  "alive" : true,
  "age" : 20
}
```

Refer to the documentation for details.

`JSON_TRANSFORM(` *`input_expr`*`, (`*`operation`*`) ... ) [RETURNING` *`data_type`*`] [`*`json_passing_clause`*`]`

Used to modify JSON data using operations (`APPEND`, `INSERT`, `KEEP`, `REMOVE`, `RENAME`, `SET`) or commands. Refer to the documentation for details and examples.

PostgreSQL JSON functions and operators

PostgreSQL has various functions and operators that work with the `JSON` type, and many more that work with `JSONB` type. One benefit of using operators over functions is that they are named the same across all data types that support them. Using operators is also a much more concise way of querying JSON data than using functions, and many functions can be represented as operators. We'll cover both modes in the following subsections.

PostgreSQL has more JSON-specific functions than any other database discussed in this book. We will not itemize all of them here. For a full list, refer to the vendor documentation.

Operators. For the examples in this section we are using a `SELECT` to show the output, but you can use the output just as easily in an `UPDATE` statement to save the changes to the database:

`json_doc :: type`
: The `::` operator is shorthand for the `CAST` function. This example converts the column data from `JSON` to `JSONB`:

```
SELECT data AS before, data::jsonb AS after
FROM bag_o_json
WHERE id=1;

-[ RECORD 1 ]-----------------------------------------------------
before | {"fname":"Jane","lname":"Doe","alive":true, "age": 20}
after  | {"age": 20, "alive": true, "fname": "Jane", "lname": "Doe"}
```

Casting from `JSON` to `JSONB` is useful to access the additional functions provided for `JSONB` that are not available for `JSON`. Note, however, that casting to `JSONB` changes the order of keys, so don't use this for updating data unless you don't care about the order of the keys.

`*jsonb* - {*text* | *text*[] | *integer*}`
: The - operator subtracts an element from a document where *`text`* or *`text`*`[]` are keys in the document or *`integer`* is an array index of an upper-level key. For array indexes, numbering follows the JavaScript convention of starting at 0 instead of the PostgreSQL convention of starting at 1. The `JSON` type does not support this operator. Here are some examples:

```
SELECT data::jsonb - 'fname'
FROM bag_o_json
WHERE id = 1;

{"age": 20, "alive": true, "lname": "Doe"}

SELECT data::jsonb - '{fname,lname}'::text[]
FROM bag_o_json
WHERE id = 1;

{"age": 20, "alive": true}

SELECT data::jsonb->'tags' AS before,
    (data::jsonb->'tags') - 0  AS after
FROM bag_o_json
WHERE id = 2;

             before             |        after
------------------------------+-------------------
```

```
 ["Missing", "Presumed Dead"] | ["Presumed Dead"]
```

jsonb #- *text*[]

The #- operator subtracts an element from a document, where *text*[] denotes the path of the key. The JSON type does not support this operator. This example removes the address from the contact:

```
SELECT data::jsonb #- '{contact, address}'::text[]
FROM bag_o_json
WHERE id = 2;

{"tags": ["Missing", "Presumed Dead"],
 "contact": {"last_name": "Doe", "first_name": "John"}}
```

jsonb || *jsonb*

The || operator is the conventional concatenation operator in PostgreSQL and is supported by the JSONB but not the JSON type to concatenate documents. Since JSONB can't have duplicate keys, it is often used to update data. It can also be used to append new information. In this example, we update the age from 20 to 30 and add a *date_missing* value:

```
SELECT data::jsonb || '{"age":30, "date_missing": "2021-10-12"}'::jsonb
FROM bag_o_json
WHERE id = 1;

{"age": 30, "alive": true, "fname": "Jane",
 "lname": "Doe", "date_missing": "2021-10-12"}
```

The value used is the value associated with the last instance of a key, so the order is important. This next example would add a *date_missing* value but not update the age:

```
SELECT '{"age":30, "date_missing": "2021-10-12"}'::jsonb || data::jsonb
FROM bag_o_json
WHERE id = 1;

{"age": 20, "alive": true, "fname": "Jane",
 "lname": "Doe", "date_missing": "2021-10-12"}
```

input_doc -> {*key_text* | *index_integer*}

The -> operator returns a subelement of a JSONB or JSON document as the same data type as the *input_doc*. It treats the *key_text* as a key. *index_integer* is used to pull out elements of an array. The returned value is JSON in case of a JSON-type *input_doc* and JSONB in case of a JSONB *input_doc*. This operator can be chained. For example:

```
SELECT data->'fname' AS fname,
   data->'tags'->1 AS tag_1
FROM bag_o_json;

 fname   |      tag_1
---------+-----------------
 "Jane"  |
         | "Presumed Dead"
```

input_doc ->> {*key_text* | *index_integer*}

The ->> operator returns a subelement of a JSONB or JSON document as text. If *key_text* is passed, it treats the *key_text* as a key. *index_integer* is used to pull out elements of an array. For example:

```
SELECT data->>'fname' AS fname,
   data->'tags'->>1 AS tag_1
FROM bag_o_json;

 fname |     tag_1
-------+---------------
 Jane  |
       | Presumed Dead
```

This operator cannot be chained since the TEXT type does not have a ->> operator.

input_doc #> {*key_text_array*}

The #> operator returns a subelement of a JSONB or JSON document as the same data type as the *input_doc*. It treats the *key_text_array* as a nested key. The returned value is JSON in case of a JSON-type *input_doc* and JSONB in case of a JSONB *input_doc*. This operator can be chained. For example:

```
SELECT data#>'{contact,address,city}' AS city,
   data#>'{tags,1}' AS tag_1
FROM bag_o_json
WHERE id = 2;

   city   |      tag_1
----------+-----------------
 "Boston" | "Presumed Dead"
```

input_doc #>> {*key_text_array*}

The #>> operator returns a subelement of a JSONB or JSON document as text. It treats the *key_text_array* as a nested key. The operator cannot be chained. For example;

```
SELECT data#>>'{contact,address,city}' AS city,
   data#>>'{tags,1}' AS tag_1
FROM bag_o_json
WHERE id = 2;

  city  |     tag_1
--------+---------------
 Boston | Presumed Dead
```

jsonb @> *jsonb*

The @> operator returns a Boolean denoting whether the first *jsonb* contains the second *jsonb* (not supported for the JSON type). For example:

```
SELECT id,
   data::jsonb @> '{"fname":"Jane"}'::jsonb AS contains_1,
   '{"fname":"Jane"}'::jsonb @> data::jsonb AS contains_2
```

```
FROM bag_o_json;

 id | contains_1 | contains_2
----+------------+------------
  1 | t          | f
  2 | f          | f
```

jsonb <@ jsonb

The <@ operator returns a Boolean denoting whether the first *jsonb* is contained by the second *jsonb* (not supported for the JSON type). This gives the same result as using @> and switching the order of the arguments. For example:

```
SELECT id,
   data::jsonb <@ '{"fname":"Jane"}'::jsonb AS contained_by_1,
   '{"fname":"Jane"}'::jsonb <@ data::jsonb AS contained_by_2
FROM bag_o_json;

 id | contained_by_1 | contained_by_2
----+----------------+----------------
  1 | f              | t
  2 | f              | f
```

jsonb ? *text*

The *?* operator returns a Boolean denoting whether the *jsonb* contains the *text* as a top-level key (not supported for the JSON type). For example:

```
SELECT id,
   data::jsonb ? 'fname' AS contains_key
FROM bag_o_json;

 id | contains_key
----+-------------
  1 | true
  2 | false
```

jsonb ?| *text*[]

The *?* operator returns a Boolean denoting whether the *jsonb* contains the key path defined by the *text*[] array (not supported for the JSON type). For example:

```
SELECT id,
   data::jsonb ?| ARRAY['contact','first_name'] AS contains_key
FROM bag_o_json;

 id | contains_key
----+-------------
  1 | false
  2 | true
```

jsonb @@ *jsonpath*

The @@ operator returns a Boolean denoting whether the *jsonb* satisfies the *jsonpath* expression (not supported for the JSON type). For example:

```
SELECT id,
   data::jsonb @@ '($.age > 15)'::jsonpath AS older_than_15
FROM bag_o_json;

 id | older_than_15
----+---------------
  1 | true
  2 | false
```

Functions.

`JSON_AGG(`*`row_or_value`*`), JSONB_AGG(`*`row_or_value`*`)`
: Builds a `JSON/JSONB` array from any type of data, including rows. This is an aggregate function. Here we create a `JSON/JSONB` dataset for each state:

```
-- Row aggregate
SELECT s.state, json_agg(s ORDER BY s.stor_name) AS data_json
FROM (SELECT stor_name, city, state
      FROM stores) AS s
GROUP BY s.state;

state    |   data_json
—----------------------
CA       [{"stor_name":"Barnum's","city":"Tustin","state":"CA"},
  ,:
 {"stor_name":"News & Brews","city":"Los Gatos","state":"CA"}]
WA         [{"stor_name":"Doc-U-Mat: ... "state":"WA"}]

-- Column aggregate
SELECT s.state,
   json_agg(s.city ORDER BY s.city) AS data_json
FROM stores AS s
GROUP BY s.state;
 state |             data_json
-------+-----------------------------------
 CA    | ["Fremont", "Los Gatos", "Tustin"]
 :
 WA    | ["Remulade", "Seattle"]
```

`JSON_BUILD_ARRAY(`*`VARIADIC "any"`*`), JSONB_BUILD_ARRAY(`*`VARIADIC "any"`*`)`
: Builds a `JSON` or `JSONB` array from a heterogeneous list of items. The canonical representation of both types of array will be the same. For example:

```
SELECT JSON_BUILD_ARRAY(1,2, 'Jack', 'Jill');
SELECT JSONB_BUILD_ARRAY(1,2, 'Jack', 'Jill');

[1, 2, "Jack", "Jill"]
```

`JSON_BUILD_OBJECT(`*`VARIADIC "any"`*`), JSONB_BUILD_OBJECT(`*`VARIADIC "any"`*`)`
: Builds a `JSON` or `JSONB` object from alternating key/value pairs. The `JSON` object will preserve the order of input but the `JSONB` object will not. For example:

```
SELECT JSON_BUILD_OBJECT('name', 'John Smith', 'age', 25);
```

```
{"name" : "John Smith", "age" : 25}

SELECT JSONB_BUILD_OBJECT('name', 'John Smith', 'age', 25);

{"age": 25, "name": "John Smith"}
```

`JSON_EACH(`*`json`*`), JSONB_EACH(`*`jsonb`*`)`
: Returns a key/value pair for each upper-level element of a document. This is a set-returning function. The key is `TEXT` and the value is `JSON` or `JSONB` depending on the function used. For example:

```
SELECT kv.*
FROM bag_o_json, JSON_EACH(data) AS kv
WHERE id = 1;

  key  | value
-------+--------
 fname | "Jane"
 lname | "Doe"
 alive | true
 age   | 20
```

`JSON_EACH_TEXT(`*`json`*`), JSONB_EACH_TEXT(`*`jsonb`*`)`
: Like `JSON_EACH`/`JSONB_EACH`, but returns `TEXT` for the value instead of `JSON`/`JSONB`. For example:

```
SELECT kv.*
FROM bag_o_json, JSON_EACH_TEXT(data) AS kv
WHERE id = 1;

  key  | value
-------+--------
 fname | Jane
 lname | Doe
 alive | true
 age   | 20
```

`TO_JSON(`*`any_element`*`), TO_JSONB(`*`any_element`*`)`
: Equivalent to the `:: jsonb` and `:: json` operations, except when dealing with tuples (rows). All elements can be input into these functions, including row types. `TO_JSON` preserves the column ordering of the table when casting a row object whereas `TO_JSONB` reorders for optimal performance. For example:

```
SELECT id, TO_JSON(f) AS row_json
FROM friends AS f;

id  |                                  row_json
----+-----------------------------------------------
--------------------------
  1 | {"id":1,"name_first":"John","name_last":"Smith",
"date_birth":"1935-01-01"}
  2 | {"id":2,"name_first":"Jane","name_last":"Doe",
"date_birth":"1937-01-01"}
```

```
SELECT id, TO_JSONB(f) AS row_json
FROM friends AS f;

 id |                                    row_json
----+-----------------------------------------------------------------
---------------------
  1 | {"id": 1, "name_last": "Smith", "date_birth": "1935-01-01",
"name_first": "John"}
  2 | {"id": 2, "name_last": "Doe", "date_birth": "1937-01-01",
"name_first": "Jane"}
```

SQL Server JSON functions and keywords

In addition to some functions to support JSON, SQL Server defines several new SQL keywords that are used to return query results in JSON format. The following subsections present those keywords and functions.

Keywords.

`*sql_query* FOR JSON {AUTO | PATH}`
: Produces JSON-formatted text from a SQL query. Refer to the documentation for details.

`AUTO`
: Follows `FOR JSON` and makes an array where each row is a separate object and the column names and values are the key/value pairs in each object. For example:

```
SELECT name_first AS name
FROM friends
FOR JSON AUTO;

[{"name":"John"},{"name":"Jane"}]
```

`PATH`
: Follows `FOR JSON` and makes an array where each row is a separate element and the column names define the path in the document. Especially useful if you have data from various tables and you want to format accordingly. For example:

```
SELECT name_first AS 'name.first', name_last AS 'name.last'
FROM friends
FOR JSON PATH;

[{"name":{"first":"John","last":"Smith"}},
 {"name":{"first":"Jane","last":"Doe"}}]
```

`INCLUDE_NULL_VALUES`
: Follows `FOR JSON [AUTO | PATH]` and denotes whether NULLs should be output. Without this clause, any elements that are NULL are left out of the output. For example:

```
SELECT name_last,
   CASE WHEN name_last = 'Smith' THEN 20 END AS age
FROM friends
FOR JSON AUTO, INCLUDE_NULL_VALUES;

[{"name_last":"Smith","age":20},
 {"name_last":"Doe","age":null}]

SELECT name_last,
   CASE WHEN name_last = 'Smith' THEN 20 END AS age
FROM friends
FOR JSON AUTO;

[{"name_last":"Smith","age":20},{"name_last":"Doe"}]
```

`WITHOUT_ARRAY_WRAPPER`
: Follows `FOR JSON [AUTO | PATH]` and denotes whether there should be an array wrapper. For example:

```
SELECT name_last
FROM friends
FOR JSON AUTO, WITHOUT_ARRAY_WRAPPER;

{"name_last":"Smith"},{"name_last":"Doe"}
```

Functions.

`ISJSON(`*`text`*`)`
: Returns 0 if text in the column is not valid JSON text and 1 if the text is valid JSON text. For example:

```
SELECT ISJSON(data)
FROM bag_o_json
WHERE id = 2;

1
```

`JSON_MODIFY(`*`json_doc_text, path, new_value`*`)`
: Returns a modified *`json_doc_text`* at the location specified by *`path`* with the value *`new_value`*. For example:

```
SELECT JSON_MODIFY(data,'$.contact.address.state', 'CA')
FROM bag_o_json
WHERE id = 2;

{
   "contact": {
      "first_name": "John",
      "last_name": "Doe",
      "address": {
         "city": "Boston",
         "state": "CA",
         "country": "United States"
              }
    },
      "tags": ["Missing", "Presumed Dead"]
}
```

OPENJSON(*json_doc_text*[, *path*]) [*with_clause*]

Returns a set of rows from a *json_doc_text*. If no *with_clause* (of the format WITH ({*colName type* [*column_path*] [AS JSON]}[, ...n]))) is specified for the mapping, returns a set of key/value pairs. This is a table-valued function. For example:

```
SELECT jd.*
FROM bag_o_json
   CROSS APPLY OPENJSON(data, '$.contact.address') AS jd
WHERE id = 2;

key      value    type
—--------------------------
city     Boston          1
state    MA              1
country  United States   1
```

Why XML?

All the platforms discussed in this book provide support for XML, though its use as a data storage format is dwindling today. It is still popular as a file format, however, and is often a better option than JSON if you have many business rules about what items can be stored in a document, what data types can be used, and what elements can have other elements as children. Such documents often have a header, which is a URL link to a document type descriptor (DTD) document or an XML schema document (XSD) that specifies the required structure and rules of the document. Storing the data relationally is also a good option if you have many such rules: you can store different parts of the document in separate relational tables and then aggregate them together for output as XML if such output is needed.

You use the XPath standard, defined by the W3C standards-making group, to query within an XML document. All the databases discussed here use XPath syntax for extracting elements of XML documents.

XML Data Types

The SQL:2003 spec defined a data type specifically for XML data, and many databases have implemented an XML-specific type to validate that the data is valid XML, implement better storage, and allow access methods. The XML-specific data types are covered in this section.

MySQL and MariaDB

MySQL and MariaDB do not support an XML data type; to store XML in these databases, use a TEXT column. However, MariaDB does support XML tables, using the CONNECTION storage engine to link to an XML file.

Oracle

Oracle has an XMLTYPE data type for storing XML data. XMLTYPE is a system-defined opaque type with predefined member functions to extract XML nodes and fragments.

PostgreSQL

PostgreSQL has an XML data type. Only valid XML can be inserted into an XML data type. If the data is not valid, the XML parser will throw an error detailing the issue with the XML document.

SQL Server

SQL Server has an XML data type. Only valid XML can be inserted into an XML data type. If the data is not valid, the XML parser will throw an error detailing the issue with the XML document. In addition, SQL Server has implemented object methods on the XML type and uses those instead of functions for many operations.

Examples

This example demonstrates how to create a table with a column that holds XML in the various databases and then add some data to it:

```
/** PostgreSQL, SQL Server **/
CREATE TABLE bag_o_xml(id integer primary key, data xml);

/** Oracle **/
CREATE TABLE bag_o_xml(id integer primary key, data XMLTYPE );

/** All platforms (add data) **/
INSERT INTO bag_o_xml(id, data)
VALUES (1, '<person age="20" alive="true">
  <lname>Doe</lname><fname>Jane</fname>
  </person>');

INSERT INTO bag_o_xml(id, data)
VALUES (2, '<entity>
  <contact>
    <first_name>John</first_name>
    <last_name>Doe</last_name>
    <address city="Boston" state="MA" country="United States" />
  </contact>
  <tags><tag>Missing</tag><tag>Presumed Dead</tag></tags>
  </entity>');
```

XPath

XPath is the query language used to navigate XML documents. The query syntax for querying XML documents in the database is the same as the standard XPath you use for querying XML anywhere. You will find XPath commonly used as input to the SQL standard XMLEXISTS function, MySQL/MariaDB/Oracle's EXTRACTVALUE functions, Oracle's EXTRACT function, PostgreSQL's XPATH function, and SQL Server's *exist*, *nodes*, and *query* XML methods.

The key elements supported in XPath are shown in Table 10-2.

Table 10-2. XPath supported elements

Path	Description
`nodename`	Selects all nodes named `nodename`.
`/`	Selects from the root node of the document.
`//`	Selects nodes from the current node regardless of how deeply nested they are in the document.
`.`	Selects the current contents of the document.
`..`	Selects the parent of the current node.
`@`	Selects an attribute.
[*expression*]	A predicate expression used to filter for a subset of nodes in a collection. The expression may contain an integer to denote an index position in a collection, functions like `LAST` or `POSITION`, or Boolean expressions like *age>20*.

SQL XML Functions

The following are XML functions defined in the standard that are widely supported by the database platforms covered in this book. Alternatives are listed where appropriate (see "XML Platform-Specific Extensions" on page 783 for details) but minor syntax differences are not discussed.

XMLAGG

XMLAGG is an aggregate function that concatenates a set of XML row values into a single XML document.

SQL standard syntax.

```
XMLAGG(xml [ORDER BY column[, column...]) [OVER (...)]
```

MySQL. MySQL does not support the XMLAGG function.

Oracle. Oracle supports the XMLAGG function.

PostgreSQL. PostgreSQL supports the XMLAGG function.

SQL Server. SQL Server does not support the XMLAGG function.

Example. This example converts elements of a relational table row into XML fragments:

```
-- SQL Standard, Oracle, PostgreSQL
SELECT XMLAGG(data)
FROM bag_o_xml;
```

XMLEXISTS

`XMLEXISTS` is a function that returns true or false depending on whether an XML document satisfies the path expression.

SQL standard syntax.

```
XMLEXISTS(text PASSING [BY {REF|VALUE}] xml [BY {REF|VALUE}])
```

MySQL. MySQL does not support the `XMLEXISTS` function. Use `EXTRACTVALUE` instead.

Oracle. Oracle supports the `XMLEXISTS` function, but only allows its use in the `WHERE` clause.

PostgreSQL. PostgreSQL supports the `XMLEXISTS` function and allows its use in both `WHERE` and `SELECT` clauses.

SQL Server. SQL Server does not support the `XMLEXIST` function. Use the *XML.exist*(`text`) method instead.

Examples. This example checks to see if an XML fragment exists in the XML column data:

```
-- SQL standard, Oracle, PostgreSQL
SELECT id
FROM bag_o_xml
WHERE XMLEXISTS('//lname[text() = ''Doe'']'
   PASSING BY VALUE bag_o_xml.data);

-- SQL Server
SELECT id
WHERE data.exist('//lname[text() = ''Doe'']') = 1
FROM bag_o_xml;

 id
----+
  1
```

XMLFOREST

`XMLFOREST` is a function that takes one or more values and attributes alias pairs to form an XML fragment.

SQL standard syntax.

```
XMLFOREST(value AS alias[, ...])
```

MySQL. MySQL does not support the `XMLFOREST` function.

Oracle. Oracle supports the `XMLFOREST` function.

PostgreSQL. PostgreSQL supports the `XMLFOREST` function.

SQL Server. SQL Server does not support the `XMLFOREST` function. Use the `FOR XML PATH` construct instead.

Example. This example converts elements of a relational table row into XML fragments:

```
-- SQL standard, Oracle, PostgreSQL
SELECT XMLFOREST(id AS id,
   name_last AS last_name,
   name_first AS first_name)
FROM friends;

-- SQL Server
SELECT
   REPLACE(
      REPLACE(r.row, '<row>',''),
      '</row>','') AS fragment
FROM friends CROSS APPLY (SELECT id AS id,
   name_last AS last_name,
   name_first AS first_name
   FOR XML PATH('row') ) AS r(row);

<id>1</id><last_name>Smith</last_name><first_name>John</first_name>
<id>2</id><last_name>Doe</last_name><first_name>Jane</first_name>
```

XMLTABLE

`XMLTABLE` is a set-returning function that maps a subset of an XML object's data to table columns and returns a row for each match.

SQL standard syntax.

```
XMLTABLE( [XMLNAMESPACES(namespace uri AS namespace name[, ...])]
   row_expression PASSING [BY REF] xml_document_expression [BY REF]
   COLUMNS name { type [PATH xpath_column_expression]
      [DEFAULT default_expression] [NOT NULL | NULL] | FOR ORDINALITY }
[, ...] )
```

The `XMLTABLE` function takes at minimum the *`row_expression`*, which is an XPath statement that filters for each row of data, and *`xml_document_expression`*, which is the XML data.

MySQL. MySQL does not support the XMLTABLE function. You can use the EXTRACTVALUE function to achieve the same or similar results.

Oracle. Oracle supports the XMLTABLE function.

PostgreSQL. PostgreSQL supports the XMLTABLE function.

SQL Server. SQL Server does not support the XMLTABLE function. Use the XML methods of the XML data type instead; see "SQL Server XML keywords, functions, procedures, and methods" on page 787 for details.

Examples. For these examples we'll use the *bag_o_xml* table we created in "XML Data Types" on page 777. Here, we expand the XML tags into separate rows. Note that only rows from *bag_o_xml* that have tags will be included:

```
-- SQL standard, Oracle, PostgreSQL
SELECT bag_o_xml.id, jt.*
FROM bag_o_xml, XMLTABLE('//tags/tag' PASSING bag_o_xml.data
      COLUMNS tag VARCHAR(50) PATH '.')
       AS jt;

-- SQL Server
SELECT id,
   jt.n.value('.', 'varchar(50)') AS tag
FROM bag_o_xml AS j
CROSS APPLY j.data.nodes('//tags/tag') AS jt(n);
```

The output is as follows (note that Oracle returns the results in uppercase):

```
       id       tag
---------- -------------------
         2 Missing
         2 Presumed Dead
```

In MySQL there's no easy way to get this set of values because EXTRACTVALUE is a scalar rather than a set-returning function. Calling EXTRACTVALUE is equivalent to calling *xpath_expression* with the */text()* function at the end:

```
--  MySQL
SELECT bag_o_xml.id, EXTRACTVALUE(bag_o_xml.data, '//tags/tag')
FROM bag_o_xml
WHERE CAST(EXTRACTVALUE(bag_o_xml.data, 'count(//tags/tag)')
   AS integer) > 0;

       id       tag
---------- -------------------
         2 Missing Presumed Dead
```

This example expands a nested property to a table:

```
-- SQL standard, Oracle, PostgreSQL
SELECT bag_o_xml.id, jt.*
FROM  bag_o_xml,
    XMLTABLE( '//contact/address' PASSING bag_o_xml.data
      COLUMNS city VARCHAR(50) PATH '@city',
      state varchar(2) PATH '@state',
      country VARCHAR(50) PATH '@country'
      ) AS jt;

-- SQL Server
SELECT id,
   jt.n.value('@city', 'varchar(50)') AS city,
   jt.n.value('@state', 'varchar(2)') AS state,
   jt.n.value('@country', 'varchar(50)') AS country
FROM bag_o_xml AS j
CROSS APPLY j.data.nodes('//contact/address') AS jt(n);
```

The output in all cases is (plus or minus whitespace):

```
 id |  city  | state |    country
----+--------+-------+---------------
  2 | Boston | MA    | United States
```

XML Platform-Specific Extensions

This section provides an alphabetical listing of vendor-supported XML functions not covered in the preceding section.

MySQL XML functions

MySQL provides two functions for working with XML data:

`EXTRACTVALUE(`*`xml_fragment, xpath`*`)`

Extracts a value from an *`xml_fragment`* that matches the XPath expression *`xpath`* and returns the result. For example:

```
SELECT EXTRACTVALUE(data, '//first_name/text() | //fname/text()')
FROM bag_o_xml;

Jane
John
```

`UPDATEXML(`*`xmldoc, xpath, replacementxml`*`)`

Returns a new XML document based on replacing the data in *`xmldoc`* at the location defined by *`xpath`* with the specified *`replacementxml`*. If the path does not exist, no change is made. For example:

```
SELECT UPDATEXML(data, '/person/lname', '<lname>Does</lname>')
FROM bag_o_xml;
<person age="20" alive="true">
<lname>Does</lname><fname>Jane</fname>
</person>
```

Oracle XML functions

Oracle has a lot of functions for XML; we will only highlight a few here. Refer to the documentation for a full list, and for more information on the functions included here.

For more information on XML queries, refer to the Oracle SQL Reference.

`DELETEXML(`*`xml_fragment`*`, `*`xpath`*`[, `*`namespace`*`])`
: Deletes nodes within *`xml_fragment`* that match the XPath expression *`xpath`* and returns the result. The optional *`namespace`* parameter specifies the namespace for the XPath expression. For example:

```
SELECT DELETEXML('<a><b>Sifl</b><c>Olly</c></a>', '/a/c') FROM DUAL;
'<a><b>Sifl</b></a>'
```

`DEPTH(`*`number`*`)`
: Returns the depth of the path specified by the `UNDER_PATH` condition in an XML query.

`EXTRACT(`*`instance`*`, `*`xpath`*`[, `*`namespace`*`])`
: Returns the XML nodes from *`instance`* returned by running the XPath query contained in the *`xpath`* parameter. The optional *`namespace`* parameter specifies the XML namespace in the query. (Oracle also supports an `EXTRACT` function for date values, which was covered in Chapter 7.) For example:

```
SELECT EXTRACT(data, '//first_name/ | //fname') AS first_name_node
FROM bag_o_xml;

FIRST_NAME
--------------------
Jane
John
```

`EXTRACTVALUE(`*`instance`*`, `*`xpath`*`[, `*`namespace`*`])`
: Returns the value from an XML node returned by running the XPath query contained in the *`xpath`* parameter. The optional *`namespace`* parameter specifies the XML namespace in the query. For example:

```
SELECT EXTRACTVALUE(XMLTYPE('<foo><bar>Hello, World!</bar></foo>'),
   '/foo/bar')
FROM DUAL;
Hello, World!
```

`INSERTCHILDXML(`*`xml_fragment, xpath, child_expr, value_expr`*`[, `*`name space`*`])`

Injects the nodes in *`value_expr`* specified by *`child_expr`* into *`xml_fragment`* at the location given by the XPath query *`xpath`*, and returns the result. The optional *`namespace`* argument provides the namespace for the XPath query. For example:

```
SELECT INSERTCHILDXML('<a></a>', '/a', 'b', '<b>B1</b><b>B2</b>')
FROM DUAL;
'<a><b>B1</b><b>B2</b></a>'
```

`INSERTXMLBEFORE(`*`xml_fragment, xpath, value_expr`*`[, `*`namespace`*`])`

Injects *`value_expr`* into *`xml_fragment`* at the location given by the XPath query *`xpath`* and returns the result. The optional *`namespace`* argument provides the namespace for the XPath query. For example:

```
SELECT INSERTXMLBEFORE('<a><b>B2</b></a>', '/a/b', '<b>B1</b>')
FROM DUAL;
'<a><b>B1</b><b>B2</b></a>'
```

`SYS_XMLAGG(`*`expr`*`[, `*`format`*`])`

Returns a single XML document created by aggregating the XML documents or fragments in *`expr`*. The optional *`format`* parameter can be used to format the XML document.

`SYS_XMLGEN(`*`expr`*`[, `*`format`*`])`

Returns a single XML document created from *`expr`*. The optional *`format`* parameter can be used to format the XML document.

`XMLCAST(`*`value`*` AS `*`data_type`*`)`

Casts *`value`* to the type *`data_type`* and returns the result.

`XMLCDATA(`*`value`*`)`

Returns *`value`* as an XML CDATA section.

`XMLCOLATTVAL(`*`expr`*` [AS `*`alias`*`][, ... ])`

Returns an XML fragment from the *`expr`* arguments. The optional `AS` clause can be used to change the value of the *name* attribute.

`XMLCONCAT(`*`instance`*`[, ... ])`

Returns an XML instance that is the union of all XML *`instance`* parameters.

`XMLDIFF(`*`xml1, xml2`*`[, `*`hashlevel, flags`*`])`

Returns an Xdiff schema that's the result of diffing *`xml1`* and *`xml2`*.

`XMLELEMENT([NAME] `*`name`*`[, XMLATTRIBUTES(`*`expr`*` [AS `*`alias`*`][, ... ])][, `*`value`*`[, ... ]])`

Returns an `XMLELEMENT` with the name specified in the *`name`* parameter and the attributes specified in the optional `XMLATTRIBUTES` clause. The *`value`* parameters provide the values of the `XMLELEMENT` result.

`XMLEXISTS(`*`xquery`*`[, `*`passing_clause`*`])`
: Returns `TRUE` if the XQuery specified in *`xquery`* returns a nonempty XQuery result, and `FALSE` otherwise.

`XMLPARSE([DOCUMENT | CONTENT] `*`value`*` [WELLFORMED])`
: Returns an XML instance constructed as a result of parsing the XML document in *`value`*.

`XMLPATCH(`*`xml, xdiff`*`)`
: Returns an XML instance as a result of patching the XML document in *`xml`* with the Xdiff found in *`xdiff`*.

`XMLQUERY(`*`query`*`)`
: Returns the results of executing the XMLQuery found in *`query`*.

`XMLROOT(`*`value`*`, VERSION [`*`version`*` | NO VALUE][, STANDALONE {YES | NO | NO VALUE}])`
: Returns a new XML document using *`value`* as the body and the version information for the XML document prolog.

`XMLSEQUENCE(`*`instance`*`)`
: Returns an array of XML fragments constructed from the top-level nodes in the XML instance provided by the *`instance`* parameter.

`XMLSERIALIZE( ... )`
: Returns an XML expression serialized to a string.

`XMLTRANSFORM(`*`instance, stylesheet`*`)`
: Returns the result of applying the XSL stylesheet in the *`stylesheet`* parameter to the XML document contained in *`instance`*.

PostgreSQL XML functions

PostgreSQL has many functions for XML. We highlight a few here; refer to the documentation for a full list.

`XMLCOMMENT(`*`text`*`)`
: Formats a piece of text as an XML comment. For example:

```
SELECT XMLCOMMENT('My document');
<!--My document-->
```

`XMLCONCAT(`*`xml`*`, [, ... ])`
: Concatenates an arbitrary number of XML documents into one. For example:

```
SELECT XMLCONCAT('<?xml version="1.1"?><cat>Jerry</cat>',
   '<?xml version="1.1"?><dog>Snoopy</dog>');

<?xml version="1.1"?>
<cat>Jerry</cat>
<dog>Snoopy</dog>
```

XMLELEMENT(NAME *name*[, XMLATTRIBUTES (*attvalue* [AS *attname*] [, ...])] [, *content* [, ...]])

Produces an XML element with the given name, attributes, and content. For example:

```
SELECT XMLELEMENT(NAME person, XMLATTRIBUTES('Joe' AS name));

<person name="Joe"/>
```

XPATH(*path_expression*, *xml*[, *nsarray_text*[]])

Returns an array of XML values from the input XML that satisfy the XPath 1.0 *path_expression*. For example:

You will often see this function paired with array subscription to pick out an element from the array or the UNNEST function to expand the array. This value is often then cast to text to make it usable. For example:

```
SELECT id, dm[1]::text AS first_name, dm AS raw_array
FROM bag_o_xml,
   XPATH('//first_name/text() | //fname/text()', data) AS dm;

 id | first_name | raw_array
----+------------+----------
  1 | Jane       | {Jane}
  2 | John       | {John}
```

XMLPI(NAME *name* [, *content*])

Produces an XML processing instruction, commonly used to provide application instructions associated with all or part of an XML document. For example:

```
SELECT XMLPI(NAME javascript, 'function hello() {
   alert("hello world");
}' );

 <?javascript function hello() {
     alert("hello world");
 }?>
```

SQL Server XML keywords, functions, procedures, and methods

XML is a data type in SQL Server. Like most other data types, it can be used as both a column data type and a variable data type. As a complex data type, it has methods attached to it. In addition, SQL Server defines new SQL keywords specifically for XML that are used to return a query in XML format. The following subsections describe those key elements.

Keywords.

sql_query FOR XML {RAW | AUTO | EXPLICIT | PATH}

Produces an XML document from a SQL query. Refer to the documentation for details.

`AUTO`
: Follows `FOR XML` and makes table names the object and column names or aliases as attributes. The `SELECT` statement must have a `FROM` clause. For example:

```
SELECT name_first AS name
FROM friends
FOR XML AUTO;

<friends name="John" />
<friends name="Jane" />
```

`EXPLICIT`
: Follows `FOR XML` and requires that the columns define explicitly what parts go into which part of the XML document (refer to the `EXPLICIT` mode documentation for details). For example:

```
SELECT 1  AS Tag,
       NULL AS Parent,
       f.name_first AS "friend!1!first",
       f.name_last AS  "friend!1!last"
FROM friends AS f
FOR XML EXPLICIT;

<friend first="John" last="Smith" />
<friend first="Jane" last="Doe" />
```

`PATH [(`*`path_name`*`)] [, ROOT (`*`root_name`*`)]`
: Follows `FOR XML` and allows for a query to return both elements and attributes. Refer to the PATH mode documentation for details. Precede the alias name with an `@` to make a column an attribute. If there is no `@` in the alias, then the column is converted to a tag. For example:

```
SELECT
   f.name_first AS "@first",
   f.name_last AS  "@last"
FROM friends AS f
FOR XML PATH ('friend'), ROOT ('friends');

<friends>
  <friend first="John" last="Smith" />
  <friend first="Jane" last="Doe" />
</friends>

SELECT
   f.name_first AS "first",
   f.name_last AS  "last"
FROM friends AS f
FOR XML PATH ('friend'), ROOT ('friends');

<friends>
  <friend>
    <first>John</first>
    <last>Smith</last>
  </friend>
  <friend>
    <first>Jane</first>
    <last>Doe</last>
  </friend>
</friends>
```

`RAW`

Follows `FOR XML` and returns an XML where there is no root tag and all rows are returned in <row> tags. Refer to the RAW mode documentation for details. For example:

```
SELECT
       f.name_first AS "first",
       f.name_last AS  "last"
FROM friends AS f
FOR XML RAW;

<row first="John" last="Smith" />
<row first="Jane" last="Doe" />
```

Functions and procedures.

`OPENXML(`*`@docHandle`*`) [WITH` *`existing_table_or_in_line_column_def`*`]`

A function that can be used in `FROM`. It takes as input a document handle returned by `SP_XML_PREPAREDOCUMENT`. This example follows the `SP_XML_PREPAREDOCUMENT` example to create a table from the prepared document. The optional `WITH` clause defines the structure of the data. For example:

```
EXEC sp_xml_preparedocument @docHandle OUTPUT, @xmlDocument;

SELECT *
INTO friends2
FROM OPENXML(@docHandle, N'/friends/friend')
    WITH (name_first nvarchar(50) '@first',
            name_last nvarchar(50) '@last'
    );
```

`SP_XML_PREPAREDOCUMENT` *`@docHandle`* `OUTPUT,` *`@xmlDocument`*

A stored procedure that returns a document pointer to XML data for later use in `OPENXML`. Mostly useful for large XML documents; for smaller documents, you can use `CAST(`*`string`* `AS` *`xml`*`)`. For example:

```
DECLARE @docHandle int;
DECLARE @xmlDocument nvarchar(max); -- Or XML type
SET @xmlDocument = N'<friends>
   <friend first="John" last="Smith" />
   <friend first="Jane" last="Doe" />
   </friends>';
EXEC sp_xml_preparedocument @docHandle OUTPUT, @XMLDocument;
```

XML methods. XML methods are called with object-oriented dot notation on the data. Refer to the documentation for further details and examples.

`exist``(`*`xpath`*`)`
: Returns 1 if the *`xpath`* exists in the document or 0 if it doesn't. See "XMLEXISTS" on page 780 for an example.

`modify``(XML_DML)`
: Updates data using the provided XML Data Modification Language command (`XML_DML`). Can only be used in `UPDATE` statements, not `SELECT` statements. For example:

```
UPDATE bag_o_xml
   SET  data.modify('replace value of (/person/fname/text())[1]
     with "Janet"')
WHERE id = 1;
```

`nodes``(`*`xpath`*`)`
: Returns a set of XML nodes that match the XPath expression. For example:

```
SELECT id, jt.n.value('.', 'varchar(50)') AS tag
FROM bag_o_xml AS j
CROSS APPLY j.data.nodes('//tags/tag') AS jt(n);
```

`query``(`*`xpath`*`)`
: Returns XML data satisfying the query condition. For example:

```
SELECT
   data.query('//address') AS address
FROM bag_o_xml
WHERE id = 2;

<address city="Boston" state="MA" country="United States" />
```

`value``(`*`xpath`*`, `*`data_type`*`)`
: Returns the scalar value at a given path. Doesn't support XPath union operations (the | operator). For example:

```
SELECT id,
   data.value('(//address/@city)[1]', 'varchar(50)') AS value
FROM bag_o_xml;

id        value
--        -----
1         NULL
2         Boston
```

APPENDIX

Shared and Platform-Specific Keywords

This appendix is intended to serve as a quick reference for words that you should not use as object or variable names in your databases. Strictly speaking, a *keyword* is a word with special meaning within a specific computer programming context, while a *reserved word* is a word that cannot be used as an identifier for objects like tables, views, and procedures, because the word is reserved for use by the computer language itself. These terms are often used interchangeably, although they are not truly synonyms. In our case, we use the term "keywords" colloquially defined as "words you should not use in an identifier, whether strictly prohibited or not."

Of course, the names of all SQL statements and built-in functions are keywords, as are the names of other language elements (clauses, predicates, expressions, etc.). We have attempted to identify and list them all here, but because they are so numerous, and because the language and the various database platforms are constantly evolving, it is possible that we have missed some. Consequently, you should treat the following lists as guidelines, but not as definitively complete. (And if you identify any gaps, please submit them to the errata.)

The following sections contain two expansive lists of keywords, ordered alphabetically from A to Z. First, we provide a list of keywords identified in the SQL:2019 standard. Second, we present a list of shared keywords that are not part of the standard but are used by at least two of the four database platforms we cover in this book. Since those shared keywords are widespread in the industry, we recommend that you avoid using them as identifiers even though they may be allowed on some database platforms. Refer to each vendor's documentation for the full list of keywords that are unique to that platform.

SQL Standard Keywords

A

A
ABS
ABSOLUTE
ACOS
ACTION
ADA
ADD
ADMIN
AFTER
ALL
ALLOCATE
ALTER
ALWAYS
AND
ANY
ARE
ARRAY
ARRAY_AGG
ARRAY_MAX_CARDINALITY
AS
ASC
ASENSITIVE
ASIN
ASSERTION
ASSIGNMENT
ASYMMETRIC
AT
ATAN
ATOMIC
ATTRIBUTE
ATTRIBUTES
AUTHORIZATION
AVG

B

BEFORE
BEGIN
BEGIN_FRAME
BEGIN_PARTITION
BERNOULLI
BETWEEN
BIGINT
BINARY
BLOB
BOOLEAN
BOTH
BREADTH
BY

C

C
CALL
CALLED
CARDINALITY
CASCADE
CASCADED
CASE
CAST
CATALOG
CATALOG_NAME
CEIL
CEILING
CHAIN
CHAINING
CHAR
CHAR_LENGTH
CHARACTER
CHARACTER_LENGTH
CHARACTER_SET_CATALOG
CHARACTER_SET_NAME
CHARACTER_SET_SCHEMA
CHARACTERISTICS
CHARACTERS
CHECK
CLASS_ORIGIN
CLASSIFIER
CLOB
CLOSE
COALESCE
COBOL
COLLATE
COLLATION
COLLATION_CATALOG
COLLATION_NAME
COLLATION_SCHEMA
COLLECT
COLUMN
COLUMN_NAME
COLUMNS
COMMAND_FUNCTION
COMMAND_FUNCTION_CODE
COMMIT
COMMITTED
CONDITION
CONDITION_NUMBER
CONDITIONAL
CONNECT
CONNECTION
CONNECTION_NAME
CONSTRAINT

CONSTRAINT_CATALOG
CONSTRAINT_NAME
CONSTRAINT_SCHEMA
CONSTRAINTS
CONSTRUCTOR
CONTAINS
CONTINUE
CONVERT
COPY
CORR
CORRESPONDING
COS
COSH
COUNT
COVAR_POP
COVAR_SAMP
CREATE
CROSS
CUBE
CUME_DIST
CURRENT
CURRENT_CATALOG
CURRENT_DATE
CURRENT_DEFAULT_TRANSFORM_GROUP
CURRENT_PATH
CURRENT_ROLE
CURRENT_ROW
CURRENT_SCHEMA
CURRENT_TIME
CURRENT_TIMESTAMP
CURRENT_TRANSFORM_GROUP_FOR_TYPE
CURRENT_USER
CURSOR
CURSOR_NAME
CYCLE

D

DATA
DATE
DATETIME_INTERVAL_CODE
DATETIME_INTERVAL_PRECISION
DAY
DEALLOCATE
DEC
DECIMAL
DECFLOAT
DECLARE
DEFAULT
DEFAULTS
DEFERRABLE
DEFERRED
DEFINE
DEFINED
DEFINER
DEGREE
DELETE
DENSE_RANK
DEPTH
DEREF
DERIVED
DESC
DESCRIBE
DESCRIBE_CATALOG
DESCRIBE_NAME
DESCRIBE_PROCEDURE_SPECIFIC_CATALOG
DESCRIBE_PROCEDURE_SPECIFIC_NAME
DESCRIBE_PROCEDURE_SPECIFIC_SCHEMA
DESCRIBE_SCHEMA
DESCRIPTOR
DETERMINISTIC
DIAGNOSTICS
DISCONNECT
DISPATCH
DISTINCT
DOMAIN
DOUBLE
DYNAMIC_FUNCTION
DYNAMIC_FUNCTION_CODE

E

EACH
ELEMENT
ELSE
EMPTY
ENCODING
END
END_FRAME
END_PARTITION
ENFORCED
EQUALS
ERROR
ESCAPE
EVERY
EXCEPT
EXCLUDE
EXCLUDING
EXEC
EXECUTE
EXISTS
EXP
EXPRESSION
EXTERNAL
EXTRACT

F

FALSE
FETCH
FILTER
FINAL
FINISH
FINISH_CATALOG
FINISH_NAME
FINISH_PROCEDURE_SPECIFIC_CATALOG
FINISH_PROCEDURE_SPECIFIC_NAME
FINISH_PROCEDURE_SPECIFIC_SCHEMA
FINISH_SCHEMA
FIRST
FIRST_VALUE
FLAG
FLOAT
FLOOR
FOLLOWING
FOR
FOREIGN
FORMAT
FORTRAN
FOUND
FRAME_ROW
FREE
FROM
FULFILL
FULFILL_CATALOG
FULFILL_NAME
FULFILL_PROCEDURE_SPECIFIC_CATALOG
FULFILL_PROCEDURE_SPECIFIC_NAME
FULFILL_PROCEDURE_SPECIFIC_SCHEMA
FULFILL_SCHEMA
FULL
FUNCTION
FUSION

G–H

G
GENERAL
GENERATED
GET
GLOBAL
GO
GOTO
GRANT
GRANTED
GROUP
GROUPING
GROUPS
HAS_PASS_THROUGH_COLUMNS
HAS_PASS_THRU_COLS
HAVING
HIERARCHY
HOLD
HOUR

I

IDENTITY
IGNORE
IMMEDIATE
IMMEDIATELY
IMPLEMENTATION
IN
INCLUDING
INCREMENT
INDICATOR
INITIAL
INITIALLY
INNER
INOUT
INPUT
INSENSITIVE
INSERT
INSTANCE
INSTANTIABLE
INSTEAD
INT
INTEGER
INTERSECT
INTERSECTION
INTERVAL
INTO
INVOKER
IS
IS_PRUNABLE
ISOLATION

J

JOIN
JSON
JSON_ARRAY
JSON_ARRAYAGG
JSON_EXISTS
JSON_OBJECT
JSON_OBJECTAGG
JSON_QUERY
JSON_TABLE
JSON_TABLE_PRIMITIVE
JSON_VALUE

K–L

K	LANGUAGE	LEFT	LOCAL
KEEP	LARGE	LENGTH	LOCALTIME
KEY	LAST	LEVEL	LOCALTIMESTAMP
KEY_MEMBER	LAST_VALUE	LIKE	LOCATOR
KEY_TYPE	LATERAL	LIKE_REGEX	LOG
KEYS	LEAD	LISTAGG	LOG10
LAG	LEADING	LN	LOWER

M

M	MEMBER	MOD
MAP	MERGE	MODIFIES
MATCH	MESSAGE_LENGTH	MODULE
MATCH_NUMBER	MESSAGE_OCTET_LENGTH	MONTH
MATCH_RECOGNIZE	MESSAGE_TEXT	MORE
MATCHED	METHOD	MULTISET
MATCHES	MIN	MUMPS
MAX	MINUTE	
MAXVALUE	MINVALUE	

N

NAME	NESTING	NO	NULL
NAMES	NEW	NONE	NULLABLE
NATIONAL	NEXT	NORMALIZE	NULLIF
NATURAL	NFC	NORMALIZED	NULLS
NCHAR	NFD	NOT	NUMBER
NCLOB	NFKC	NTH_VALUE	NUMERIC
NESTED	NFKD	NTILE	

O

OBJECT	OMIT	OR	OUTPUT
OCCURRENCES_REGEX	ON	ORDER	OVER
OCTET_LENGTH	ONE	ORDERING	OVERFLOW
OCTETS	ONLY	ORDINALITY	OVERLAPS
OF	OPEN	OTHERS	OVERLAY
OFFSET	OPTION	OUT	OVERRIDING
OLD	OPTIONS	OUTER	

P–Q

P	PARAMETER_SPECIFIC_SCHEMA	PATTERN
PAD	PARTIAL	PER
PARAMETER	PARTITION	PERCENT
PARAMETER_MODE	PASCAL	PERCENT_RANK
PARAMETER_NAME	PASS	PERCENTILE_CONT
PARAMETER_ORDINAL_POSITION	PASSING	PERCENTILE_DISC
PARAMETER_SPECIFIC_CATALOG	PAST	PERIOD
PARAMETER_SPECIFIC_NAME	PATH	PLACING

PLAN	PRECISION	PRIVILEGES
PLI	PREPARE	PROCEDURE
PORTION	PRESERVE	PRUNE
POSITION	PRIMARY	PTF
POSITION_REGEX	PRIOR	PUBLIC
POWER	PRIVATE	QUOTES
PRECEDES	PRIVATE_PARAMETERS	
PRECEDING	PRIVATE_PARAMS_S	

R

RANGE	REGR_SXY	RETURNS
RANK	REGR_SYY	RETURNS_ONLY_PASS_THROUGH
READ	RELATIVE	REVOKE
READS	RELEASE	RIGHT
REAL	REPEATABLE	ROLE
RECURSIVE	RESPECT	ROLLBACK
REF	RESTART	ROLLUP
REFERENCES	RESTRICT	ROUTINE
REFERENCING	RESULT	ROUTINE_CATALOG
REGR_AVGX	RET_ONLY_PASS_THRU	ROUTINE_NAME
REGR_AVGY	RETURN	ROUTINE_SCHEMA
REGR_COUNT	RETURNED_CARDINALITY	ROW
REGR_INTERCEPT	RETURNED_LENGTH	ROW_COUNT
REGR_R2	RETURNED_OCTET_LENGTH	ROW_NUMBER
REGR_SLOPE	RETURNED_SQLSTATE	ROWS
REGR_SXX	RETURNING	RUNNING

S

SAVEPOINT	SET
SCALAR	SETS
SCALE	SHOW
SCHEMA	SIBLINGS
SCHEMA_NAME	SIMILAR
SCOPE	SIMPLE
SCOPE_CATALOG	SIN
SCOPE_NAME	SINH
SCOPE_SCHEMA	SIZE
SCROLL	SKIP
SEARCH	SMALLINT
SECOND	SOME
SECTION	SOURCE
SECURITY	SPACE
SEEK	SPECIFIC
SELECT	SPECIFIC_NAME
SELF	SPECIFICTYPE
SENSITIVE	SQL
SEQUENCE	SQLEXCEPTION
SERIALIZABLE	SQLSTATE
SERVER_NAME	SQLWARNING
SESSION	SQRT
SESSION_USER	START

START_CATALOG
START_NAME
START_PROCEDURE_SPECIFIC_CATALOG
START_PROCEDURE_SPECIFIC_NAME
START_PROCEDURE_SPECIFIC_SCHEMA
START_SCHEMA
STATE
STATEMENT
STATIC
STDDEV_POP
STDDEV_SAMP
STRING
STRUCTURE
STYLE
SUBCLASS_ORIGIN
SUBMULTISET
SUBSET
SUBSTRING
SUBSTRING_REGEX
SUCCEEDS
SUM
SYMMETRIC
SYSTEM
SYSTEM_TIME
SYSTEM_USER

T

T
TABLE
TABLE_NAME
TABLE_SEMANTICS
TABLESAMPLE
TAN
TANH
TEMP| TEMPORARY
THEN
THROUGH
TIES
TIME
TIMESTAMP
TIMEZONE_HOUR
TIMEZONE_MINUTE
TO
TOP_LEVEL_COUNT
TRAILING
TRAN
TRANSACTION
TRANSACTION_ACTIVE
TRANSACTIONS_COMMITTED
TRANSACTIONS_ROLLED_BACK
TRANSFORM
TRANSFORMS
TRANSLATE
TRANSLATE_REGEX
TRANSLATION
TREAT
TRIGGER
TRIGGER_CATALOG
TRIGGER_NAME
TRIGGER_SCHEMA
TRIM
TRIM_ARRAY
TRUE
TRUNCATE
TYPE

U

UESCAPE
UNBOUNDED
UNCOMMITTED
UNCONDITIONAL
UNDER
UNION
UNIQUE
UNKNOWN
UNNAMED
UNNEST
UPDATE
UPPER
USAGE
USER
USER_DEFINED_TYPE_CATALOG
USER_DEFINED_TYPE_CODE
USER_DEFINED_TYPE_NAME
USER_DEFINED_TYPE_SCHEMA
USING
UTF8
UTF16
UTF32

V–Z

VALUE
VALUE_OF
VALUES
VAR_POP
VAR_SAMP
VARBINARY
VARCHAR
VARYING
VERSIONING
VIEW
WHEN
WHENEVER
WHERE
WIDTH_BUCKET
WINDOW
WITH
WITHIN
WITHOUT
WORK
WRAPPER
WRITE
XML
YEAR
ZONE

Keywords Shared Across Multiple Platforms

ACCESS
ANALYZE
ATAN2
BACKUP
CACHE
CHECKPOINT
CLUSTER
COMMENT
COT
DATABASE
DEGREES
DISABLE
DISCARD
DISK
ENABLE
ENUM
EVENT
EXCLUSIVE
EXPLAIN
FETCH
FILE
FILTER
FIRST_VALUE
FOLLOWING
FORCE
FOUND
IDENTIFIED
IMPORT
INDEX
INDEXES
INOUT
KILL
LOAD
LOCK
LOCKED
MODE
NAME
NOWAIT
OWNER
PARSER
PARTITION
PASSWORD
RADIANS
REGEXP_INSTR
RENAME
REPLACE
REPLICA
REPLICATION
RESET
RESOURCE
RESTORE
RULE
SERVER
SHARE
SHUTDOWN
SNAPSHOT
STATISTICS
STORAGE
TABLES
TABLESPACE
TEXT
TYPES
XML

Index

About the Authors

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Colophon

The animal on the cover of *SQL in a Nutshell* is a veiled chameleon (*Chamaeleo calyptratus*). Also known as cone-headed chameleons, veiled chameleons are named after the "pointy knob" on their heads (more formally known as a casque). The casque helps to direct drips or trickles of water to the mouth.

Veiled chameleons thrive in semi-arid and tropical climates, making their homes in trees or large plants. Their diet generally consists of insects, although occasionally they will eat larger prey or plants. They are native to the southwestern Arabian peninsula but are also found in Hawaii (where they were introduced) and Florida (where a wild population has developed through pet escapes). They can be kept as pets but being held or handled frequently increases their stress levels.

Females can lay up to 85 eggs in a clutch and typically mate several times a year. At birth, veiled chameleons are light green; as they grow older, they develop their stripes and brighter colors. They typically live between five and eight years, with males living longer than females.

As with other chameleons, changes in their color result from a variety of factors, from stress and conflict to reproductive status and temperature. When contemplating battle, males intensify their stripe colors. The more intense the stripe brightening (and the longer it lasts), the stronger the bite. This strength signaling allows the chameleons to determine whether a fight is reasonable between two combatants before they actually enter a conflict.

The veiled chameleon's conservation status is Least Concern. Many of the animals on O'Reilly covers are endangered; all of them are important to the world.

The cover illustration is by Karen Montgomery, based on an antique line engraving from *Dover's Animals*. The cover fonts are Gilroy Semibold and Guardian Sans. The text font is Adobe Minion Pro; the heading font is Adobe Myriad Condensed; and the code font is Dalton Maag's Ubuntu Mono.