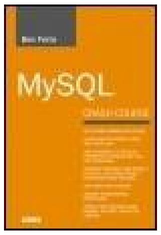

MySQL® Crash Course

By Ben Forta

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Publisher: **Sams**

Pub Date: **December 15, 2005**

ISBN: **0-672-32712-0**

Pages: **336**

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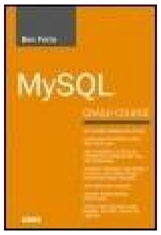
Overview

If you are a MySQL user who wants to find out more about the program, but is not interested in becoming a database administrator just to be able to read books on MySQL, then *MySQL Crash Course* is for you. This tutorial-based book is organized into a series of short, easy-to-follow lessons that take a very hands-on approach to meeting the needs of the average MySQL user. The essentials of MySQL are taught through a series of self-paced lessons in which you will complete exercises that illustrate the most important aspects of MySQL. You will learn how to:

- Use the MySQL toolset.
- Use the aggregate functions to analyze data.
- Perform insert, update and delete operations.
- Combine queries using unions.
- Create and modify tables and access table schemas.
- Manage databases, users and security privileges.

Don't get bogged down in the database theory and relational design of other MySQL books. Let *SQL Crash Course* teach you what you need to know, when you need to know it, so you can quickly get on your way with MySQL.



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Ben Forta is Macromedia's Senior Technical Evangelist, and has almost 20 years of experience in the computer industry in product development, support, training, and product marketing. Ben is the author of the best-selling *Sams Teach Yourself SQL in 10 Minutes* (now in its third edition, and translated into more than a dozen languages), *ColdFusion Web Application Construction Kit* and *Advanced ColdFusion Application Development* (both published by Que), *Sams Teach Yourself Regular Expressions in 10 Minutes*, as well as books on Flash, Java, WAP, Windows 2000, and other subjects. He has extensive experience in database design and development, has implemented databases for several highly successful commercial software programs, and is a frequent lecturer and columnist on Internet and database technologies. Born in London, England, and educated in London, New York, and Los Angeles, Ben now lives in Oak Park, Michigan with his wife Marcy and their seven children. Ben welcomes your email at ben@forta.com, and invites you to visit his website at www.forta.com/.

Acknowledgments

First of all, I'd like to thank the folks at Sams for once again granting me the flexibility and freedom to build this book as I saw fit. Thanks to Mark Renfrow for all of his feedback (on this, and previous, books). Special thanks to Loretta Yates for bravely stepping in midstream to help get the project back on track, and for even greater bravery in signing up for the next two titles in this series.

Thanks to my technical editors, Jochem vanDieten and Timothy Boronczyk, for a superb (and brutally honest) technical review. Oh, and those "mistakes" were all deliberate, just to make sure you were paying attention. ;-)

And finally, this book was written in response to numerous requests from readers of my *Sams Teach Yourself SQL in 10 Minutes*. The feedback and suggestions were invaluable and greatly appreciated, and I hope I have lived up to your expectations.

We Want to Hear from You!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

As an associate publisher for Sams Publishing, I welcome your comments. You can email or write me directly to let me know what you did or didn't like about this bookas well as what we can do to make our books better.

Please note that I cannot help you with technical problems related to the topic of this book. We do have a User Services group, however, where I will forward specific technical questions related to the book.

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Introduction

MySQL has become one of the most popular database management systems in the world. From small development projects to some of the best-known and most prestigious sites on the Web, MySQL has proven itself to be a solid, reliable, fast, and trusted solution to all sorts of data storage needs.

This book is based on my best-selling *Sams Teach Yourself SQL in 10 Minutes*. That book has become one of the most-used SQL tutorials in the world, with an emphasis on teaching what you really need to knowmethodically, systematically, and simply. But as popular and as successful as that book is, it does have some limitations:

- In covering all of the major DBMSs, coverage of DBMS-specific features and functionality had to be kept to a minimum.
- To simplify the SQL taught, the lowest common denominator had to be foundSQL statements that would (as much as possible) work with all major DBMSs. This requirement necessitated that better DBMS-specific solutions not be covered.
- Although basic SQL tends to be rather portable between DBMSs, more advanced SQL most definitely is not. As such, that book could not cover advanced topics, such as triggers, cursors, stored procedures, access control, transactions, and more, in any real detail.

And that is where this book comes in. *MySQL Crash Course* builds on the proven tutorials and structure of *Sams Teach Yourself SQL in 10 Minutes*, without getting bogged down with anything but MySQL. Starting with simple data retrieval and working on to more complex topics, including the use of joins, subqueries, regular expression and full text-based searches, stored procedures, cursors, triggers, table constraints, and much more. You'll learn what you need to know methodically, systematically, and simplyin highly focused chapters designed to make you immediately and effortlessly productive.

So turn to Chapter 1, and get to work. You'll be taking advantage of all MySQL has to offer in no time at all.

Who Is This Book For?

This book is for you if

- You are new to SQL.
- You are just getting started with MySQL and want to hit the ground running.
- You want to quickly learn how to get the most out of MySQL.
- You want to learn how to use MySQL in your own application development.
- You want to be productive quickly and easily using MySQL without having to call someone for help.

Companion Website

This book has a companion website online at http://forta.com/books/0672327120/. Visit the site to access

- Table creation and population scripts used to create the example tables used throughout this book
- Visit the online support forum
- Access online errata (should one be required)
- Find other books that may be of interest to you

Conventions Used in This Book

This book uses different typefaces to differentiate between code and regular English, and also to help you identify important concepts.

Text that you type and text that should appear on your screen is presented in `monospace` type. `It looks like this to mimic the way text looks on your screen`.

Placeholders for variables and expressions appear in *`monospace italic`* font. You should replace the placeholder with the specific value it represents.

This arrow (➥) at the beginning of a line of code means that a single line of code is too long to fit on the printed page. Continue typing all the characters after the ➥ as though they were part of the preceding line.

Note

A Note presents interesting pieces of information related to the surrounding discussion.

Tip

A Tip offers advice or teaches an easier way to do something.

Caution

A Caution advises you about potential problems and helps you steer clear of disaster.

New Term

A New Term box provide clear definitions of new, essential terms.

- **Input**

The Input icon identifies code that you can type in yourself. It usually appears next to a listing.

- **Output**

The Output icon highlights the output produced by running MySQL code. It usually appears after a listing.

- **Analysis**

The Analysis icon alerts you to the author's line-by-line analysis of input or output.

Chapter 1. Understanding SQL

In this chapter, you'll learn about databases and SQL, prerequisites to learning MySQL.

Database Basics

The fact that you are reading this book indicates that you, somehow, need to interact with databases. And so before diving into MySQL and its implementation of the SQL language, it is important that you understand some basic concepts about databases and database technologies.

Whether you are aware of it or not, you use databases all the time. Each time you select a name from your email address book, you are using a database. If you conduct a search on an Internet search site, you are using a database. When you log into your network at work, you are validating your name and password against a database. Even when you use your ATM card at a cash machine, you are using databases for PIN verification and balance checking.

But even though we all use databases all the time, there remains much confusion over what exactly a database is. This is especially true because different people use the same database terms to mean different things. Therefore, a good place to start our study is with a list and explanation of the most important database terms.

Tip

Reviewing Basic Concepts What follows is a very brief overview of some basic database concepts. It is intended to either jolt your memory if you already have some database experience, or to provide you with the absolute basics, if you are new to databases. Understanding databases is an important part of mastering MySQL, and you might want to find a good book on database fundamentals to brush up on the subject if needed.

What Is a Database?

The term *database* is used in many different ways, but for our purposes a database is a collection of data stored in some organized fashion. The simplest way to think of it is to imagine a database as a filing cabinet. The filing cabinet is simply a physical location to store data, regardless of what that data is or how it is organized.

New Term

Database A container (usually a file or set of files) to store organized data.

Caution

Misuse Causes Confusion People often use the term *database* to refer to the database software they are running. This is incorrect, and it is a source of much confusion. Database software is actually called the *Database Management System* (or DBMS). The database is the container created and manipulated via the DBMS. A database might be a file stored on a hard drive, but it might not. And for the most part this is not even significant as you never access a database directly anyway; you always use the DBMS and it accesses the database for you.

Tables

When you store information in your filing cabinet you don't just toss it in a drawer. Rather, you create files within the filing cabinet, and then you file related data in specific files.

In the database world, that file is called a table. A table is a structured file that can store data of a specific type. A table might contain a list of customers, a product catalog, or any other list of information.

New Term

Table A structured list of data of a specific type.

The key here is that the data stored in the table is one type of data or one list. You would never store a list of customers and a list of orders in the same database table. Doing so would make subsequent retrieval and access difficult. Rather, you'd create two tables, one for each list.

Every table in a database has a name that identifies it. That name is always uniquemeaning no other table in that database can have the same name.

Note

Table Names What makes a table name unique is actually a combination of several things, including the database name and table name. This means that while you cannot use the same table name twice in the same database, you definitely can reuse table names in different databases.

Tables have characteristics and properties that define how data is stored in them. These include information about what data may be stored, how it is broken up, how individual pieces of information are named, and much more. This set of information that describes a table is known as a schema, and schema are used to describe specific tables within a database, as well as entire databases (and the relationship between tables in them, if any).

New Term

Schema Information about database and table layout and properties.

Note

Schema or Database? Occasionally schema is used as a synonym for database (and schemata as a synonym for databases). While unfortunate, it is usually clear from the context which meaning of schema is intended. In this book, schema will refer to the definition given here.

Columns and Datatypes

Tables are made up of columns. A column contains a particular piece of information within a table.

New Term

Column A single field in a table. All tables are made up of one or more columns.

The best way to understand this is to envision database tables as grids, somewhat like spreadsheets. Each column in the grid contains a particular piece of information. In a customer table, for example, one column contains the customer number, another contains the customer name, and the address, city, state, and ZIP Code are all stored in their own columns.

Tip

Breaking Up Data It is extremely important to break data into multiple columns correctly. For example, city, state, and ZIP Code should always be separate columns. By breaking these out, it becomes possible to sort or filter data by specific columns (for example, to find all customers in a particular state or in a particular city). If city and state are combined into one column, it would be extremely difficult to sort or filter by state.

Each column in a database has an associated datatype. A datatype defines what type of data the column can contain. For example, if the column is to contain a number (perhaps the number of items in an order), the datatype would be a numeric datatype. If the column were to contain dates, text, notes, currency amounts, and so on, the appropriate datatype would be used to specify this.

New Term

Datatype A type of allowed data. Every table column has an associated datatype that restricts (or allows) specific data in that column.

Datatypes restrict the type of data that can be stored in a column (for example, preventing the entry of alphabetical characters into a numeric field). Datatypes also help sort data correctly, and play an important role in optimizing disk usage. As such, special attention must be given to picking the right datatype when tables are created.

Rows

Data in a table is stored in rows; each record saved is stored in its own row. Again, envisioning a table as a spreadsheet style grid, the vertical columns in the grid are the table columns, and the horizontal rows are the table rows.

For example, a customers table might store one customer per row. The number of rows in the table is the number of records in it.

New Term

Row A record in a table.

Note

Records or Rows? You might hear users refer to database *records* when referring to *rows*. For the most part, the two terms are used interchangeably, but *row* is technically the correct term.

Primary Keys

Every row in a table should have some column (or set of columns) that uniquely identifies it. A table containing customers might use a customer number column for this purpose, whereas a table containing orders might use the order ID. An employee list table might use an employee ID or the employee Social Security number column.

New Term

Primary Key A column (or set of columns) whose values uniquely identify every row in a table.

This column (or set of columns) that uniquely identifies each row in a table is called a primary key. The primary key is used to refer to a specific row. Without a primary key, updating or deleting specific rows in a table becomes extremely difficult because there is no guaranteed safe way to refer to just the rows to be affected.

Tip

Always Define Primary Keys Although primary keys are not actually required, most database designers ensure that every table they create has a primary key so future data manipulation is possible and manageable.

Any column in a table can be established as the primary key, as long as it meets the following conditions:

- No two rows can have the same primary key value.
- Every row must have a primary key value (primary key columns may not allow NULL values).

Note

Primary Key Rules The rules listed here are enforced by MySQL itself.

Primary keys are usually defined on a single column within a table. But this is not required, and multiple columns may be used together as a primary key. When multiple columns are used, the rules previously listed must apply to all columns that make up the primary key, and the values of all columns together must be unique (individual columns need not have unique values).

Tip

Primary Key Best Practices In addition to the rules that MySQL enforces, several universally accepted best practices that should be adhered to are

- Don't update values in primary key columns.
- Don't reuse values in primary key columns.
- Don't use values that might change in primary key columns. (For example, when you use a name as a primary key to identify a supplier, you would have to change the primary key when the supplier merges and changes its name.)

There is another very important type of key called a foreign key, but I'll get to that later on in Chapter 15, "Joining Tables."

What Is SQL?

SQL (pronounced as the letters S-Q-L or as sequel) is an abbreviation for Structured Query Language. SQL is a language designed specifically for communicating with databases.

Unlike other languages (spoken languages such as English, or programming languages such as Java or Visual Basic), SQL is made up of very few words. This is deliberate. SQL is designed to do one thing and do it wellprovide you with a simple and efficient way to read and write data from a database.

What are the advantages of SQL?

- SQL is not a proprietary language used by specific database vendors. Almost every major DBMS supports SQL, so learning this one language enables you to interact with just about every database you'll run into.
- SQL is easy to learn. The statements are all made up of descriptive English words, and there aren't that many of them.
- Despite its apparent simplicity, SQL is actually a very powerful language, and by cleverly using its language elements you can perform very complex and sophisticated database operations.

Note

DBMS-Specific SQL Although SQL is not a proprietary language and there is a standards committee which tries to define SQL syntax that can be used by all DBMSs, the reality is that no two DBMSs implement SQL identically. The SQL taught in this book is specific to MySQL, and while much of the language taught will be usable with other DBMSs, do not assume complete SQL syntax portability.

Try It Yourself

All of the chapters in this book use working examples, showing you the SQL syntax, what it does, and explaining why it does it. I'd strongly suggest that you try each and every example for yourself so as to learn MySQL first hand.

Appendix B, "The Example Tables," describes the example tables used throughout this book, and explains how to obtain and install them. If you have not done so, refer to this appendix before proceeding.

Note

You Need MySQL Obviously, you'll need access to a copy of MySQL to follow along. Appendix A, "Getting Started with MySQL," explains where to get a copy of MySQL and provides some pointers for getting started. If you do not have access to a copy of MySQL, refer to that appendix before proceeding.

Summary

In this first chapter, you learned what SQL is and why it is useful. Because SQL is used to interact with databases, you also reviewed some basic database terminology.

Chapter 2. Introducing MySQL

In this chapter, you'll learn what MySQL is, and the tools you can use when working with it.

What Is MySQL?

In the previous chapter you learned about databases and SQL. As explained, it is the database software (*DBMS* or *Database Management System*) that actually does all the work of storing, retrieving, managing, and manipulating data. MySQL is a DBMS; that is, it is database software.

MySQL has been around for a long time, and is now installed and in use at millions of installations worldwide. Why do so many organizations and developers use MySQL? Here are some of the reasons:

- **Cost** MySQL is open-source, and is usually free to use (and even modify) the software without paying for it.
- **Performance** MySQL is fast (make that very fast).
- **Trusted** MySQL is used by some of the most important and prestigious organizations and sites, all of whom entrust it with their critical data.
- **Simplicity** MySQL is easy to install and get up and running.

In fact, the only real technical criticism of MySQL is that it has not always supported the functionality and features offered by other DBMSs. But as new features are added to each new version, this is changing.

Client-Server Software

DBMSs fall into two categories: shared filebased and client-server. The former (which include products such as Microsoft Access and FileMaker) are designed for desktop use and are generally not intended for use on higher-end or more critical applications.

Databases such as MySQL, Oracle, and Microsoft SQL Server are client-serverbased databases. Client-server applications are split into two distinct parts. The *server* portion is a piece of software that is responsible for all data access and manipulation. This software runs on a computer called the *database server*.

Only the server software interacts with the data files. All requests for data,

data additions and deletions, and data updates are funneled through the server software. These requests or changes come from computers running client software. The *client* is the piece of software with which the user interacts. If you request an alphabetical list of products, for example, the client software submits that request over the network to the server software. The server software processes the request; filters, discards, and sorts data as necessary; and sends the results back to your client software.

Note

How Many Computers? The client and server software may be installed on two computers or on one computer. Regardless, the client software communicates with the server software for all database interaction, be it on the same machine or not.

All this action occurs transparently to you, the user. The fact that data is stored elsewhere or that a database server is even performing all this processing for you is hidden. You never need to access the data files directly. In fact, most networks are set up so that users have no access to the data, or even the drives on which it is stored.

Why is this significant? Because to work with MySQL you'll need access to both a computer running the MySQL server software and client software with which to issue commands to MySQL:

- The server software is the MySQL DBMS. You can be running a locally installed copy, or you can connect to a copy running a remote server to which you have access.
- The client can be MySQL-provided tools, scripting languages (such as Perl), web application development languages (such as ASP, ColdFusion, JSP, and PHP), programming languages (such as C, C++, and Java), and more.

MySQL Versions

Client tools are revisited in a moment. First, a quick word about DBMS versions.

The current version of MySQL is version 5 (although MySQL 3 and 4 are in use in many organizations). Here are the major changes introduced in recent revisions:

- **4** InnoDB engine adding support for transactions and more (Chapter 26, "Managing Transaction Processing"), unions (Chapter 17, "Combining Queries"), improved full text searching (Chapter 18, "Full-Text Searching"), and more.
- **4.1** Significant additions to function libraries, subqueries (Chapter 14, "Working with Subqueries"), integrated help, and more.
- **5** Stored procedures (Chapter 23, "Working with Stored Procedures"), triggers (Chapter 25, "Using Triggers"), cursors (Chapter 24, "Using Cursors"), views (Chapter 22, "Using Views"), and more.

Versions 4.1 and 5 added significant functionality to MySQL, much of which is covered in the later chapters in this book.

Tip

Use 4.1 or Higher MySQL 4.1 introduced significant changes to the MySQL function libraries, and this book was written for use with that version or later. While much of the early content does indeed apply to MySQL 3 and 4, many of the examples will not work with those versions.

Note

Version Requirements Noted Any chapter that requires a specific version of MySQL is clearly noted as such at the start of that chapter.

Caution

Beta Software At the time that this book goes to press, MySQL 5 is still in beta and is not yet final-release software. This does not mean that you cannot use MySQL 5, but it does mean that you should proceed with caution as the software might contain bugs or problems that have yet to be addressed.

MySQL Tools

As just explained, MySQL is a client-server DBMS, and so to use MySQL you'll need a client, an application that you'd use to interact with MySQL (giving it commands to be executed).

There are lots of client application options, but when learning MySQL (and indeed, when writing and testing MySQL scripts) you are best off using a utility designed for just that purpose. And there are three tools in particular that warrant specific mention.

`mysql` Command-Line Utility

Every MySQL installation comes with a simple command-line utility called `mysql`. This utility does not have any drop-down menus, fancy user interfaces, mouse support, or anything like that.

Typing `mysql` at your operating system command prompt brings up a simple prompt that looks like this:

```
Welcome to the MySQL monitor. Commands end with ; or \g.
Your MySQL connection id is 14 to server version: 5.0.4-nt
Type 'help;' or '\h' for help. Type '\c' to clear the buffer.
mysql>
```

Note

MySQL Options and Parameters If you just type `mysql` by itself, you might receive an error message. This will likely be because security credentials are needed or because MySQL is not running locally or on the default port. `mysql` accepts an array of command-line parameters you can (and might need to) use. For example, to specify a user login name of `ben`, you'd use `mysql u ben`. To specify a username, host name, port, and be prompted for a password, you'd use `mysql u ben p h myserver P 9999`.

A complete list of command-line options and parameters can be obtained using `mysql help`.

Of course, your version and connection information might differ, but you'll be able to use this utility regardless. You'll note that

- Commands are typed after the `mysql>` prompt.
- Commands end with `;` or `\g`; in other words, just pressing Enter will not execute the command.
- Type `help` or `\h` to obtain help. You can also provide additional text to obtain help on specific commands (for example, `help select` to obtain help on using the `SELECT` statement).
- Type `quit` or `exit` to quit the command-line utility.

The `mysql` command-line utility is one of the most used and is invaluable for quick testing and executing scripts (such as the sample table creation and population scripts mentioned in the previous chapter and in Appendix B, "The Example Tables"). In fact, all of the output examples used in this book are grabs from the `mysql` command-line output.

Tip

Familiarize Yourself with the `mysql` Command-Line Utility Even if you opt to use one of the graphical tools described next, you should make sure to familiarize yourself with the `mysql` command-line utility, as this is the one client you can safely rely on to always be present (as it is part of the core MySQL installation).

MySQL Administrator

MySQL Administrator is a graphical interactive client designed to simplify the administration of MySQL servers.

Note

Obtaining MySQL Administrator MySQL Administrator is not installed as part of the core MySQL installation. Instead, it must be downloaded from http://dev.mysql.com/downloads/ (versions are available for Linux, Mac OS X, and Windows, and source code is downloadable, too).

MySQL Administrator prompts for server and login information (and allows you to save server definitions for future selection), and then displays icons that allow for the selection of different views. Amongst these are

- **Server Information** displays status and version information about the connected server and client.
- **Service Control** allows you to stop and start MySQL as well as specify server features.
- **User Administration** is used to define MySQL users, logins, and privileges.
- **Catalogs** lists available databases and allows for the creation of databases and tables.

Note

Create a Datasource for This Book You might want to use the `Create New Schema` option to create a datasource for the tables and chapters in this book. The examples use a datasource named `crashcourse`; feel free to use the same name or one of your choice.

Tip

Quick Access to Other Tools The MySQL Administrator Tools menu contains options to launch the `mysql` command-line utility (described previously) and the MySQL Query Browser (described next).

In fact, the MySQL Query Browser also contains menu options to launch the `mysql` command-line utility and the MySQL Administrator.

MySQL Query Browser

MySQL Query Browser is a graphical interactive client used to write and execute MySQL commands.

Note

Obtaining MySQL Query Browser Like MySQL Administrator, MySQL Query Browser is not installed as part of the core MySQL installation. Instead, it too must be downloaded from http://dev.mysql.com/downloads/ (versions are available for Linux, Mac OS X, and Windows, and source code is downloadable, too).

MySQL Query Browser prompts for server and login information (saved definitions are shared between MySQL Query Browser and MySQL Administrator) and then displays the application interface. Note the following:

- MySQL commands are typed into the window at the top of the screen. When the statement has been entered, click the Execute button to submit it to MySQL for processing.
- Results (if there are any) are displayed in a grid in the large area to the left of the screen.
- Multiple statements and results can be rendered in their own tabs to allow for rapid switching between them.
- On the right of the screen is a tab that lists all available datasources (called *schemata* here), expand any datasource to see its tables, and expand any table to see its columns.

- You can also select tables and columns to have MySQL Query Browser write MySQL statements for you.

- To the right of the Schemata tab is a History tab that maintains a history of executed MySQL statements. This is very useful when you need to test different versions of MySQL statements.

- Help on MySQL syntax, functions, and more is available at the bottom right of the screen.

Tip

Execute Saved Scripts You can use MySQL Query Browser to execute saved scriptsthe scripts used to create and populate the tables used in throughout this book, for example. To do this, select File, Open Script, select the script (which will be displayed in a new tab), and click the Execute button.

Summary

In this chapter, you learned what exactly MySQL is. You were also introduced to several client utilities (one included command-line utility and two optional but highly recommended graphical utilities).

Chapter 3. Working with MySQL

In this chapter, you'll learn how to connect and login to MySQL, how to issue MySQL statements, and how to obtain information about databases and tables.

Making the Connection

Now that you have a MySQL DBMS and client software to use with it, it would be worthwhile to briefly discuss connecting to the database.

MySQL, like all client-server DBMSs, requires that you log in to the DBMS before being able to issue commands. Login names might not be the same as your network login name (assuming that you are using a network); MySQL maintains its own list of users internally, and associates rights with each.

When you first installed MySQL, you were probably prompted for an administrative login (often named `root`) and a password. If you are using your own local server and are simply experimenting with MySQL, using this login is fine. In the real world, however, the administrative login is closely protected (as access to it grants full rights to create tables, drop entire databases, change logins and passwords, and more).

Tip

Using MySQL Administrator The MySQL Administrator Users view provides a simple interface that can be used to define new users, including assigning passwords and access rights.

To connect to MySQL you need the following pieces of information:

- The hostname (the name of the computer)this is `localhost` if connecting to a local MySQL server
- The port (if a port other than the default `3306` is used)
- A valid user name
- The user password (if required)

As explained in Chapter 2, "Introducing MySQL," all of this information can be passed to the `mysql` command-line utility, or entered into the server connection screen in MySQL Administrator and MySQL Query Browser.

Note

Using Other Clients If you are using a client other than the ones mentioned here, you still need to provide this information in order to connect to MySQL.

After you are connected, you have access to whatever databases and tables your login name has access to. (Logins, access control, and security are revisited in Chapter 28, "Managing Security").

Selecting a Database

When you first connect to MySQL, you do not have any databases open for use. Before you can perform any database operations, you need to select a database. To do this you use the `USE` keyword.

New Term

Keyword A reserved word that is part of the MySQL language. Never name a table or column using a keyword. Appendix E, "MySQL Reserved Words," lists the MySQL keywords.

For example, to use the `crashcourse` database you would enter the following:

- **Input**

```
USE crashcourse;
```

- **Output**

```
Database changed
```

- **Analysis**

The `USE` statement does not return any results. Depending on the client used, some form of notification might be displayed. For example, the `Database changed` message shown here is displayed by the `mysql` command-line utility upon successful database selection.

Tip

Using MySQL Query Browser In MySQL Query Browser, double-click on any database listed in the Schemata list to use it. You'll not actually see the `USE` command being issued, but you will see the database selected (highlighted in bold) and the application title bar will display the name of the selected database.

Remember, you must always `USE` a database before you can access any data in it.

Learning About Databases and Tables

But what if you don't know the names of the available databases? And for that matter, how are MySQL Administrator and MySQL Query Browser able to display a list of available databases?

Information about databases, tables, columns, users, privileges, and more, are stored within databases and tables themselves (yes, MySQL uses MySQL to store this information). But these internal tables are generally not accessed directly. Instead, the MySQL `SHOW` command is used to display this information (information which MySQL then extracts from those internal tables). Look at the following example:

- **Input**

```
SHOW DATABASES;
```

- **Output**

```
+--------------------+
| Database           |
+--------------------+
| information_schema |
| crashcourse        |
| mysql              |
| forta              |
| coldfusion         |
| flex               |
| test               |
+--------------------+
```

- **Analysis**

`SHOW DATABASES;` returns a list of available databases. Included in this list might be databases used by MySQL internally (such as `mysql` and `information_schema` in this example). Of course, your own list of databases might not look like those shown here.

To obtain a list of tables within a database, use `SHOW TABLES;`, as seen here:

- **Input**

```
SHOW TABLES;
```

- **Output**

```
+-----------------------+
| Tables_in_crashcourse |
+-----------------------+
| customers             |
| orderitems            |
| orders                |
| products              |
| productnotes          |
| vendors               |
+-----------------------+
```

- **Analysis**

`SHOW TABLES;` returns a list of available tables in the currently selected database.

`SHOW` can also be used to display a table's columns:

- **Input**

```
SHOW COLUMNS FROM customers;
```

- **Output**

```
+---------------+-----------+------+-----+---------+----------------
| Field         | Type      | Null | Key | Default | Extra
+---------------+-----------+------+-----+---------+----------------
| cust_id       | int(11)   | NO   | PRI | NULL    | auto_increment
| cust_name     | char(50)  | NO   |     |         |
| cust_address  | char(50)  | YES  |     | NULL    |
| cust_city     | char(50)  | YES  |     | NULL    |
| cust_state    | char(5)   | YES  |     | NULL     |
| cust_zip      | char(10)  | YES  |     | NULL     |
| cust_country  | char(50)  | YES  |     | NULL     |
| cust_contact  | char(50)  | YES  |     | NULL     |
| cust_email    | char(255) | YES  |     | NULL     |
+---------------+-----------+------+-----+----------+--------------
```

• **Analysis**

`SHOW COLUMNS` requires that a table name be specified (`FROM customers` in this example), and returns a row for each field containing the field name, its data type, whether `NULL` is allowed, key information, default value, and extra information (such as `auto_increment` for field `cust_id`).

Note

What Is Auto Increment? Some table columns need unique values. For example, order numbers, employee IDs, or (as in the example just seen) customer IDs. Rather than have to assign unique values manually each time a row is added (and having to keep track of what value was last used), MySQL can automatically assign the next available number for you each time a row is added to a table. This functionality is known as *auto increment*. If it is needed, it must be part of the table definition used when the table is created using the `CREATE` statement. We'll look at `CREATE` in Chapter 21, "Creating and Manipulating Tables."

Tip

The `DESCRIBE` Statement MySQL supports the use of `DESCRIBE` as a shortcut for `SHOW COLUMNS FROM`. In other words, `DESCRIBE customers;` is a shortcut for `SHOW COLUMNS FROM customers;`.

Other `SHOW` statements are supported, too, including

- `SHOW STATUS`, used to display extensive server status information
- `SHOW CREATE DATABASE` and `SHOW CREATE TABLE`, used to display the MySQL statements used to create specified databases or tables respectively
- `SHOW GRANTS`, used to display security rights granted to users (all users or a specific user)
- `SHOW ERRORS` and `SHOW WARNINGS`, used to display server error or warning messages

It is worthwhile to note that client applications use these same MySQL commands as you've seen here. Applications that display interactive lists of databases and tables, that allow for the interactive creation and editing of tables, that facilitate data entry and editing, or that allow for user account and rights management, and more, all accomplish what they do using the same MySQL commands that you can execute directly yourself.

Tip

Learning More About `SHOW` In the `mysql` command-line utility, execute command `HELP SHOW;` to display a list of allowed `SHOW` statements.

Note

New To MySQL 5 MySQL 5 supports a new `INFORMATION_SCHEMA` command that can be used to obtain and filter schema details.

Summary

In this chapter, you learned how to connect and log in to MySQL; how to select databases using `USE`; and how to introspect MySQL databases, tables, and internals using `SHOW`. Armed with this knowledge, you can now dig into the all important `SELECT` statement.

Chapter 4. Retrieving Data

In this chapter, you'll learn how to use the `SELECT` *statement to retrieve one or more columns of data from a table*.

The `SELECT` Statement

As explained in Chapter 1, "Understanding SQL," SQL statements are made up of plain English terms. These terms are called keywords, and every SQL statement is made up of one or more keywords. The SQL statement you'll probably use most frequently is the `SELECT` statement. Its purpose is to retrieve information from one or more tables.

To use `SELECT` to retrieve table data you must, at a minimum, specify two pieces of informationwhat you want to select, and from where you want to select it.

Retrieving Individual Columns

We'll start with a simple SQL `SELECT` statement, as follows:

• **Input**

```
SELECT prod_name
FROM products;
```

• **Analysis**

The previous statement uses the `SELECT` statement to retrieve a single column called `prod_name` from the `products` table. The desired column name is specified right after the `SELECT` keyword, and the `FROM` keyword specifies the name of the table from which to retrieve the data. The output from this statement is shown in the following:

• **Output**

```
+-----------------+
| prod_name       |
+-----------------+
| .5 ton anvil    |
| 1 ton anvil     |
| 2 ton anvil     |
| Oil can         |
| Fuses           |
| Sling           |
| TNT (1 stick)   |
| TNT (5 sticks)  |
| Bird seed       |
| Carrots         |
| Safe            |
| Detonator       |
| JetPack 1000    |
| JetPack 2000    |
+-----------------+
```

Note

Unsorted Data If you tried this query yourself, you might have discovered that the data was displayed in a different order than shown here. If this is the case, don't worryit is working exactly as it is supposed to. If query results are not explicitly sorted (we'll get to that in the next chapter), data will be returned in no order of any significance. It might be the order in which the data was added to the table, but it might not. As long as your query returned the same number of rows, then it is working.

A simple `SELECT` statement like the one just shown returns all the rows in a table. Data is not filtered (so as to retrieve a subset of the results), nor is it sorted. We'll discuss these topics in the next few chapters.

Note

Terminating Statements Multiple SQL statements must be separated by semicolons (the `;` character). MySQL (like most DBMSs) does not require that a semicolon be specified after single statements. Of course, you can always add a semicolon if you wish. It'll do no harm, even if it isn't needed.

If you are using the `mysql` command-line client, the semicolon is always needed (as was explained in Chapter 2, "Introducing MySQL").

Note

SQL Statements and Case It is important to note that SQL statements are not case sensitive, so `SELECT` is the same as `select`, which is the same as `Select`. Many SQL developers find that using uppercase for all SQL keywords and lowercase for column and table names makes code easier to read and debug.

However, be aware that while the SQL language is not case sensitive, identifiers (the names of databases, tables, and columns) might be. In MySQL 4.1 and earlier, identifiers were case sensitive by default, and as of MySQL 4.1.1, identifiers are not case sensitive by default.

As a best practice, pick a case convention, and use it consistently.

Tip

Use of White Space All extra white space within a SQL statement is ignored when that statement is processed. SQL statements can be specified on one long line or broken up over many lines. Most SQL developers find that breaking up statements over multiple lines makes them easier to read and debug.

Retrieving Multiple Columns

To retrieve multiple columns from a table, the same `SELECT` statement is used. The only difference is that multiple column names must be specified after the `SELECT` keyword, and each column must be separated by a comma.

Tip

Take Care with Commas When selecting multiple columns, be sure to specify a comma between each column name, but not after the last column name. Doing so will generate an error.

The following `SELECT` statement retrieves three columns from the `products` table:

- **Input**

```
SELECT prod_id, prod_name, prod_price
FROM products;
```

- **Analysis**

Just as in the prior example, this statement uses the `SELECT` statement to retrieve data from the `products` table. In this example, three column names are specified, each separated by a comma. The output from this statement is as follows:

- **Output**

```
+---------+----------------+------------+
| prod_id | prod_name      | prod_price |
+---------+----------------+------------+
| ANV01   | .5 ton anvil   |       5.99 |
| ANV02   | 1 ton anvil    |       9.99 |
| ANV03   | 2 ton anvil    |      14.99 |
| OL1     | Oil can        |       8.99 |
| FU1     | Fuses          |       3.42 |
| SLING   | Sling            |       4.49 |
| TNT1    | TNT (1 stick)    |       2.50 |
| TNT2    | TNT (5 sticks)   |      10.00 |
| FB      | Bird seed        |      10.00 |
| FC      | Carrots          |       2.50 |
| SAFE    | Safe             |      50.00 |
| DTNTR   | Detonator        |      13.00 |
| JP1000  | JetPack 1000     |      35.00 |
| JP2000  | JetPack 2000     |      55.00 |
+---------+------------------+------------+
```

Note

Presentation of Data SQL statements typically return raw, unformatted data. Data formatting is a presentation issue, not a retrieval issue. Therefore, presentation (for example, alignment and displaying the price values as currency amounts with the currency symbol and commas) is typically specified in the application that displays the data. Actual raw retrieved data (without application-provided formatting) is rarely displayed as is.

Retrieving All Columns

In addition to being able to specify desired columns (one or more, as seen previously), `SELECT` statements can also request all columns without having to list them individually. This is done using the asterisk (`*`) wildcard character in lieu of actual column names, as follows:

- **Input**

```
SELECT *
FROM products;
```

- **Analysis**

When a wildcard (`*`) is specified, all the columns in the table are returned. columns are in the order in which the columns appear in the table definition. However, this cannot be relied on because changes to table schemas (adding and removing columns, for example) could cause ordering changes.

Caution

Using Wildcards As a rule, you are better off not using the `*` wildcard unless you really do need every column in the table. Even though use of wildcards might save you the time and effort needed to list the desired columns explicitly, retrieving unnecessary columns usually slows down the performance of your retrieval and your application.

Tip

Retrieving Unknown Columns There is one big advantage to using wildcards. As you do not explicitly specify column names (because the asterisk retrieves every column), it is possible to retrieve columns whose names are unknown.

Retrieving Distinct Rows

As you have seen, `SELECT` returns all matched rows. But what if you did not want every occurrence of every value? For example, suppose you wanted the vendor ID of all vendors with products in your `products` table:

- **Input**

```
SELECT vend_id
FROM products;
```

- **Output**

```
+---------+
| vend_id |
+---------+
|    1001 |
|    1001 |
|    1001 |
|    1002 |
|    1002 |
|    1003 |
|    1003 |
|    1003 |
|    1003 |
|    1003 |
|    1003 |
|    1003 |
|    1005 |
|    1005 |
+---------+
```

The `SELECT` statement returned 14 rows (even though there are only 4 vendors in that list) because there are 14 products listed in the `products` table. So how could you retrieve a list of distinct values?

The solution is to use the `DISTINCT` keyword which, as its name implies, instructs MySQL to only return distinct values.

- **Input**

```
SELECT DISTINCT vend_id
FROM products;
```

- **Analysis**

`SELECT DISTINCT vend_id` tells MySQL to only return distinct (unique) `vend_id` rows, and so only 4 rows are returned, as seen in the following output. If used, the `DISTINCT` keyword must be placed directly in front of the column names.

- **Output**

```
+---------+
| vend_id |
+---------+
|    1001 |
|    1002 |
|    1003 |
|    1005 |
+---------+
```

Caution

Can't Be Partially `DISTINCT` The `DISTINCT` keyword applies to all columns, not just the one it precedes. If you were to specify `SELECT DISTINCT vend_id, prod_price`, all rows would be retrieved unless *both* of the specified columns were distinct.

Limiting Results

`SELECT` statements return all matched rows, possibly every row in the specified table. To return just the first row or rows, use the `LIMIT` clause. Here is an example:

- **Input**

```
SELECT prod_name
FROM products
LIMIT 5;
```

- **Analysis**

The previous statement uses the `SELECT` statement to retrieve a single column. `LIMIT 5` instj34ructs MySQL to return no more than five rows. The output from this statement is shown in the following:

- **Output**

```
+-----------------+
| prod_name       |
+-----------------+
| .5 ton anvil    |
| 1 ton anvil     |
| 2 ton anvil     |
| Oil can         |
| Fuses           |
+-----------------+
```

To get the next five rows, specify both where to start and the number of rows to retrieve, like this:

- **Input**

```
SELECT prod_name
FROM products
LIMIT 5,5;
```

• **Analysis**

`LIMIT 5,5` instructs MySQL to return five rows starting from row `5`. The first number is where to start, and the second is the number of rows to retrieve. The output from this statement is shown in the following:

• **Output**

```
+-----------------+
| prod_name       |
+-----------------+
| Sling           |
| TNT (1 stick)   |
| TNT (5 sticks)  |
| Bird seed       |
| Carrots         |
+-----------------+
```

So, `LIMIT` with one value specified always starts from the first row, and the specified number is the number of rows to return. `LIMIT` with two values specified can start from wherever that first value tells it to.

Caution

Row `0` The first row retrieved is row `0`, not row `1`. As such, `LIMIT 1,1` will retrieve the second row, not the first one.

Note

When There Aren't Enough Rows The number of rows to retrieve specified in `LIMIT` is the *maximum* number to retrieve. If there aren't enough rows (for example, you specified `LIMIT 10,5`, but there were only 13 rows), MySQL returns as many as it can.

Tip

MySQL 5 `LIMIT` Syntax Does `LIMIT 3,4` mean 3 rows starting from row 4, or 4 rows starting from row 3? As you just learned, it means 4 rows starting from row 3, but it is a bit ambiguous.

For this reason, MySQL 5 supports an alternative syntax for `LIMIT`. `LIMIT 4 OFFSET 3` means to get 4 rows starting from row 3, just like `LIMIT 3,4`.

Using Fully Qualified Table Names

The SQL examples used thus far have referred to columns by just the column names. It is also possible to refer to columns using fully qualified names (using both the table and column names). Look at this example:

- **Input**

```
SELECT products.prod_name
FROM products;
```

This SQL statement is functionally identical to the very first one used in this chapter, but here a fully qualified column name is specified.

Table names, too, may be fully qualified, as seen here:

- **Input**

```
SELECT products.prod_name
FROM crashcourse.products;
```

Once again, this statement is functionally identical to the one just used (assuming, of course, that the `products` table is indeed in the `crashcourse` database).

There are situations where fully qualified names are required, as we will see in later chapters. For now, it is worth noting this syntax so you'll know what it is if you run across it.

Summary

In this chapter, you learned how to use the SQL `SELECT` statement to retrieve a single table column, multiple table columns, and all table columns. Next you'll learn how to sort the retrieved data.

Chapter 5. Sorting Retrieved Data

In this chapter, you will learn how to use the `SELECT` *statement's* `ORDER BY` *clause to sort retrieved data as needed*.

Sorting Data

As you learned in the previous chapter, the following SQL statement returns a single column from a database table. But look at the output. The data appears to be displayed in no particular order at all.

- **Input**

```
SELECT prod_name
FROM products;
```

- **Output**

```
+----------------+
| prod_name      |
+----------------+
| .5 ton anvil   |
| 1 ton anvil    |
| 2 ton anvil    |
| Oil can        |
| Fuses          |
| Sling          |
| TNT (1 stick)  |
| TNT (5 sticks) |
| Bird seed      |
| Carrots        |
| Safe           |
| Detonator      |
| JetPack 1000   |
| JetPack 2000   |
+----------------+
```

Actually, the retrieved data is not displayed in a mere random order. If unsorted, data is typically displayed in the order in which it appears in the underlying tables. This could be the order in which the data was added to the tables initially. However, if data was subsequently updated or deleted, the order is affected by how MySQL reuses reclaimed storage space. The end result is that you cannot (and should not) rely on the sort order if you do not explicitly control it. Relational database design theory states that the sequence of retrieved data cannot be assumed to have significance if ordering was not explicitly specified.

New Term

Clause SQL statements are made up of clauses, some required and some optional. A clause usually consists of a keyword and supplied data. An example of this is the `SELECT` statement's `FROM` clause, which you saw in the previous chapter.

To explicitly sort data retrieved using a `SELECT` statement, the `ORDER BY` clause is used. `ORDER BY` takes the name of one or more columns by which to sort the output. Look at the following example:

- **Input**

```
SELECT prod_name
FROM products
ORDER BY prod_name;
```

- **Analysis**

This statement is identical to the earlier statement, except it also specifies an `ORDER BY` clause instructing MySQL to sort the data alphabetically by the `prod_name` column. The results are as follows:

- **Output**

```
+-----------------+
| prod_name       |
+-----------------+
| .5 ton anvil    |
| 1 ton anvil     |
| 2 ton anvil     |
| Bird seed       |
| Carrots         |
| Detonator       |
| Fuses          |
| JetPack 1000   |
| JetPack 2000   |
| Oil can        |
| Safe           |
| Sling          |
| TNT (1 stick)  |
| TNT (5 sticks) |
+----------------+
```

Tip

Sorting by Nonselected Columns More often than not, the columns used in an `ORDER BY` clause are ones that were selected for display. However, this is actually not required, and it is perfectly legal to sort data by a column that is not retrieved.

Sorting by Multiple Columns

It is often necessary to sort data by more than one column. For example, if you are displaying an employee list, you might want to display it sorted by last name and first name (first sort by last name, and then within each last name sort by first name). This would be useful if there are multiple employees with the same last name.

To sort by multiple columns, simply specify the column names separated by commas (just as you do when you are selecting multiple columns).

The following code retrieves three columns and sorts the results by two of themfirst by price and then by name.

- **Input**

```
SELECT prod_id, prod_price, prod_name
FROM products
ORDER BY prod_price, prod_name;
```

- **Output**

```
+---------+------------+----------------+
| prod_id | prod_price | prod_name      |
+---------+------------+----------------+
| FC      |       2.50 | Carrots        |
| TNT1    |       2.50 | TNT (1 stick)  |
| FU1     |       3.42 | Fuses          |
| SLING   |       4.49 | Sling          |
| ANV01   |       5.99 | .5 ton anvil   |
| OL1     |       8.99 | Oil can        |
| ANV02   |       9.99 | 1 ton anvil    |
| FB      |      10.00 | Bird seed      |
| TNT2    |      10.00 | TNT (5 sticks) |
| DTNTR   |      13.00 | Detonator      |
| ANV03   |      14.99 | 2 ton anvil    |
| JP1000  |      35.00 | JetPack 1000   |
| SAFE    |      50.00 | Safe           |
| JP2000  |      55.00 | JetPack 2000   |
+---------+------------+----------------+
```

It is important to understand that when you are sorting by multiple columns, the sort sequence is exactly as specified. In other words, using the output in the previous example, the products are sorted by the `prod_name` column only when multiple rows have the same `prod_price` value. If all the values in the `prod_price` column had been unique, no data would have been sorted by `prod_name`.

Specifying Sort Direction

Data sorting is not limited to ascending sort orders (from `A` to `Z`). Although this is the default sort order, the `ORDER BY` clause can also be used to sort in descending order (from `Z` to `A`). To sort by descending order, the keyword `DESC` must be specified.

The following example sorts the products by price in descending order (most expensive first):

- **Input**

```
SELECT prod_id, prod_price, prod_name
FROM products
ORDER BY prod_price DESC;
```

- **Output**

```
+---------+------------+-----------------+
| prod_id | prod_price | prod_name       |
+---------+------------+-----------------+
| JP2000  |      55.00 | JetPack 2000    |
| SAFE    |      50.00 | Safe            |
| JP1000  |      35.00 | JetPack 1000    |
| ANV03   |      14.99 | 2 ton anvil     |
| DTNTR   |      13.00 | Detonator       |
| TNT2    |      10.00 | TNT (5 sticks)  |
| FB      |      10.00 | Bird seed       |
| ANV02   |       9.99 | 1 ton anvil     |
| OL1     |       8.99 | Oil can         |
| ANV01   |       5.99 | .5 ton anvil    |
| SLING   |       4.49 | Sling           |
| FU1     |       3.42 | Fuses           |
| FC      |       2.50 | Carrots         |
| TNT1    |       2.50 | TNT (1 stick)   |
+---------+------------+-----------------+
```

But what if you were to sort by multiple columns? The following example sorts the products in descending order (most expensive first), plus product name:

• **Input**

```
SELECT prod_id, prod_price, prod_name
FROM products
ORDER BY prod_price DESC, prod_name;
```

• **Output**

```
+---------+------------+----------------+
| prod_id | prod_price | prod_name      |
+---------+------------+----------------+
| JP2000  |      55.00 | JetPack 2000   |
| SAFE    |      50.00 | Safe           |
| JP1000  |      35.00 | JetPack 1000   |
| ANV03   |      14.99 | 2 ton anvil    |
| DTNTR   |      13.00 | Detonator      |
| FB      |      10.00 | Bird seed      |
| TNT2    |      10.00 | TNT (5 sticks) |
| ANV02   |       9.99 | 1 ton anvil    |
| OL1     |       8.99 | Oil can        |
| ANV01   |       5.99 | .5 ton anvil   |
| SLING   |       4.49 | Sling          |
| FU1     |       3.42 | Fuses          |
| FC      |       2.50 | Carrots        |
| TNT1    |       2.50 | TNT (1 stick)  |
+---------+------------+----------------+
```

• **Analysis**

The `DESC` keyword only applies to the column name that directly precedes it. In the previous example, `DESC` was specified for the `prod_price` column, but not for the `prod_name` column. Therefore, the `prod_price` column is sorted in descending order, but the `prod_name` column (within each price) is still sorted in standard ascending order.

Tip

Sorting Descending on Multiple Columns If you want to sort descending on multiple columns, be sure each column has its own `DESC` keyword.

The opposite of `DESC` is `ASC` (for *ascending*), which may be specified to sort in ascending order. In practice, however, `ASC` is not usually used because ascending order is the default sequence (and is assumed if neither `ASC` nor `DESC` are specified).

Tip

Case Sensitivity and Sort Orders When you are sorting textual data, is `A` the same as `a`? And does `a` come before `B` or after `Z`? These are not theoretical questions, and the answers depend on how the database is set up.

In *dictionary* sort order, `A` is treated the same as `a`, and that is the default behavior in MySQL (and indeed most DBMSs). However, administrators can change this behavior if needed. (If your database contains lots of foreign language characters, this might become necessary.)

The key here is that, if you do need an alternate sort order, you cannot accomplish it with a simple `ORDER BY` clause. You must contact your database administrator.

Using a combination of `ORDER BY` and `LIMIT`, it is possible to find the highest or lowest value in a column. The following example demonstrates how to find the value of the most expensive item:

- **Input**

```
SELECT prod_price
FROM products
ORDER BY prod_price DESC
LIMIT 1;
```

- **Output**

```
+-------------+
| prod_price |
+-------------+
|      55.00 |
+-------------+
```

- **Analysis**

`prod_price DESC` ensures that rows are retrieved from most to least expensive, and `LIMIT 1` tells MySQL to just return one row.

Caution

Position of `ORDER BY` Clause When specifying an `ORDER BY` clause, be sure that it is after the `FROM` clause. If `LIMIT` is used, it must come *after* `ORDER BY`. Using clauses out of order will generate an error message.

Summary

In this chapter, you learned how to sort retrieved data using the `SELECT` statement's `ORDER BY` clause. This clause, which must be the last in the `SELECT` statement, can be used to sort data on one or more columns as needed.

Chapter 6. Filtering Data

In this chapter, you will learn how to use the `SELECT` *statement's* `WHERE` *clause to specify search conditions*.

Using the `WHERE` Clause

Database tables usually contain large amounts of data, and you seldom need to retrieve all the rows in a table. More often than not, you'll want to extract a subset of the t able's data as needed for specific operations or reports. Retrieving just the data you want involves specifying *search criteria*, also known as a *filter condition*.

Within a `SELECT` statement, data is filtered by specifying search criteria in the `WHERE` clause. The `WHERE` clause is specified right after the table name (the `FROM` clause) as follows:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE prod_price = 2.50;
```

- **Analysis**

This statement retrieves two columns from the `products` table, but instead of returning all rows, only rows with a `prod_price` value of `2.50` are returned, as follows:

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| Carrots        |       2.50 |
| TNT (1 stick)  |       2.50 |
+----------------+------------+
```

This example uses a simple equality test: It checks to see if a column has a specified value, and it filters the data accordingly. But SQL enables you to do more than just test for equality.

Tip

SQL Versus Application Filtering Data can also be filtered at the application level. To do this, the SQL `SELECT` statement retrieves more data than is actually required for the client application, and the client code loops through the returned data to extract just the needed rows.

As a rule, this practice is strongly discouraged. Databases are optimized to perform filtering quickly and efficiently. Making the client application (or development language) do the database's job dramatically impacts application performance and creates applications that cannot scale properly. In addition, if data is filtered at the client, the server has to send unneeded data across the network connections, resulting in a waste of network bandwidth resources.

Caution

`WHERE` Clause Position When using both `ORDER BY` and `WHERE` clauses, make sure `ORDER BY` comes after the `WHERE`; otherwise an error will be generated. (See Chapter 5, "Sorting Retrieved Data," for more information on using `ORDER BY`.)

The WHERE Clause Operators

The first WHERE clause we looked at tests for equalitydetermining if a column contains a specific value. MySQL supports a whole range of conditional operators, some of which are listed in Table 6.1.

Table 6.1. WHERE Clause Operators

Operator	Description
=	Equality
<>	Nonequality
!=	Nonequality
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to
BETWEEN	Between two specified values

Checking Against a Single Value

We have already seen an example of testing for equality. Here's one more:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE prod_name = 'fuses';
```

• **Output**

```
+-----------+------------+
| prod_name | prod_price |
+-----------+------------+
| Fuses     |       3.42 |
+-----------+------------+
```

• **Analysis**

Checking for `WHERE prod_name = 'fuses'` returned a single row with a value of `Fuses`. By default, MySQL is not case sensitive when performing matches, and so `fuses` and `Fuses` matched.

Now look at a few examples to demonstrate the use of other operators.

This first example lists all products that cost less than `10`:

• **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE prod_price < 10;
```

• **Output**

```
+---------------+------------+
| prod_name     | prod_price |
+---------------+------------+
| .5 ton anvil  |       5.99 |
| 1 ton anvil   |       9.99 |
| Carrots       |       2.50 |
| Fuses         |       3.42 |
| Oil can       |       8.99 |
| Sling         |       4.49 |
| TNT (1 stick) |       2.50 |
+---------------+------------+
```

This next statement retrieves all products costing 10 or less (resulting in two additional matches):

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE prod_price <= 10;
```

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| .5 ton anvil   |       5.99 |
| 1 ton anvil    |       9.99 |
| Bird seed      |      10.00 |
| Carrots        |       2.50 |
| Fuses          |       3.42 |
| Oil can        |       8.99 |
| Sling          |       4.49 |
| TNT (1 stick)  |       2.50 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

Checking for Nonmatches

This next example lists all products not made by vendor 1003:

- **Input**

```
SELECT vend_id, prod_name
FROM products
WHERE vend_id <> 1003;
```

- **Output**

```
+---------+--------------+
| vend_id | prod_name    |
+---------+--------------+
|    1001 | .5 ton anvil |
|    1001 | 1 ton anvil  |
|    1001 | 2 ton anvil  |
|    1002 | Fuses        |
|    1005 | JetPack 1000 |
|    1005 | JetPack 2000 |
|    1002 | Oil can      |
+---------+--------------+
```

Tip

When to Use Quotes If you look closely at the conditions used in the examples' `WHERE` clauses, you will notice that some values are enclosed within single quotes (such as `'fuses'` used previously), and others are not. The single quotes are used to delimit strings. If you are comparing a value against a column that is a string *datatype*, the delimiting quotes are required. Quotes are not used to delimit values used with numeric columns.

The following is the same example, except this one uses the `!=` operator instead of `<>`:

- **Input**

```
SELECT vend_id, prod_name
FROM products
WHERE vend_id != 1003;
```

Checking for a Range of Values

To check for a range of values, you can use the `BETWEEN` operator. Its syntax is a little different from other `WHERE` clause operators because it requires two values:

the beginning and end of the range. The BETWEEN operator can be used, for example, to check for all products that cost between 5 and 10 or for all dates that fall between specified start and end dates.

The following example demonstrates the use of the BETWEEN operator by retrieving all products with a price between 5 and 10:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE prod_price BETWEEN 5 AND 10;
```

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| .5 ton anvil   |       5.99 |
| 1 ton anvil    |       9.99 |
| Bird seed      |      10.00 |
| Oil can        |       8.99 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

- **Analysis**

As seen in this example, when BETWEEN is used, two values must be specifiedthe low end and high end of the desired range. The two values must also be separated by the AND keyword. BETWEEN matches all the values in the range, including the specified range start and end values.

Checking for No Value

When a table is created, the table designer can specify whether individual columns can contain no value. When a column contains no value, it is said to contain a NULL value.

New Term

NULL No value, as opposed to a field containing 0, or an empty string, or just spaces.

The `SELECT` statement has a special `WHERE` clause that can be used to check for columns with `NULL` valuesthe `IS NULL` clause. The syntax looks like this:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_price IS NULL;
```

This statement returns a list of all products that have no price (an empty `prod_price` field, not a price of `0`), and because there are none, no data is returned. The `customers` table, however, does contain columns with `NULL` valuesthe `cust_email` column contains `NULL` if a customer has no email address on file:

- **Input**

```
SELECT cust_id
FROM customers
WHERE cust_email IS NULL;
```

- **Output**

```
+---------+
| cust_id |
+---------+
|   10002 |
|   10005 |
+---------+
```

Caution

`NULL` and Nonmatches You might expect that when you filter to select all rows that do not have a particular value, rows with a `NULL` will be returned. But they will not. Because of the special meaning of unknown, the database does not know whether they match, and so they are not returned when filtering for matches or when filtering for nonmatches.

When filtering data, make sure to verify that the rows with a `NULL` in the filtered column are really present in the returned data.

Summary

In this chapter, you learned how to filter returned data using the `SELECT` statement's `WHERE` clause. You learned how to test for equality, nonequality, greater than and less than, value ranges, and `NULL` values.

Chapter 7. Advanced Data Filtering

In this chapter, you'll learn how to combine `WHERE` *clauses to create powerful and sophisticated search conditions. You'll also learn how to use the* `NOT` *and* `IN` *operators*.

Combining `WHERE` Clauses

All the `WHERE` clauses introduced in Chapter 6, "Filtering Data," filter data using a single criteria. For a greater degree of filter control, MySQL allows you to specify multiple `WHERE` clauses. These clauses may be used in two ways: as `AND` clauses or as `OR` clauses.

New Term

Operator A special keyword used to join or change clauses within a `WHERE` clause. Also known as *logical operators*.

Using the `AND` Operator

To filter by more than one column, you use the `AND` operator to append conditions to your `WHERE` clause. The following code demonstrates this:

- **Input**

```
SELECT prod_id, prod_price, prod_name
FROM products
WHERE vend_id = 1003 AND prod_price <= 10;
```

- **Analysis**

The preceding SQL statement retrieves the product name and price for all products made by vendor `1003` as long as the price is `10` or less. The `WHERE` clause in this `SELECT` statement is made up of two conditions, and the keyword `AND` is used to join them. `AND` instructs the DBMS to return only rows that meet all the conditions specified. If a product is made by vendor `1003` but it costs more than `10`, it is not retrieved. Similarly, products that cost less than `10` that are made by a vendor other than the one specified are not retrieved. The output generated by this SQL statement is as follows:

• **Output**

```
+---------+------------+----------------+
| prod_id | prod_price | prod_name      |
+---------+------------+----------------+
| FB      |      10.00 | Bird seed      |
| FC      |       2.50 | Carrots        |
| SLING   |       4.49 | Sling          |
| TNT1    |       2.50 | TNT (1 stick)  |
| TNT2    |      10.00 | TNT (5 sticks) |
+---------+------------+----------------+
```

New Term

AND A keyword used in a WHERE clause to specify that only rows matching all the specified conditions should be retrieved.

The example just used contained a single AND clause and was thus made up of two filter conditions. Additional filter conditions could be used as well, each seperated by an AND keyword.

Using the OR Operator

The OR operator is exactly the opposite of AND. The OR operator instructs MySQL to retrieve rows that match either condition.

Look at the following SELECT statement:

• **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE vend_id = 1002 OR vend_id = 1003;
```

• **Analysis**

The preceding SQL statement retrieves the product name and price for any products made by either of the two specified vendors. The OR operator tells the DBMS to match either condition, not both. If an AND operator would have been used here, no data would be returned (it would have created a WHERE clause that could never be matched). The output generated by this SQL statement is as follows:

• **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| Detonator      |      13.00 |
| Bird seed      |      10.00 |
| Carrots        |       2.50 |
| Fuses          |       3.42 |
| Oil can        |       8.99 |
| Safe           |      50.00 |
| Sling          |       4.49 |
| TNT (1 stick)  |       2.50 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

New Term

OR A keyword used in a WHERE clause to specify that any rows matching either of the specified conditions should be retrieved.

Understanding Order of Evaluation

WHERE clauses can contain any number of AND and OR operators. Combining the two enables you to perform sophisticated and complex filtering.

But combining AND and OR operators presents an interesting problem. To demonstrate this, look at an example. You need a list of all products costing `10` or more made by vendors `1002` and `1003`. The following `SELECT` statement uses a combination of `AND` and `OR` operators to build a `WHERE` clause:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE vend_id = 1002 OR vend_id = 1003 AND prod_price >= 10;
```

- **Output**

```
+-----------------+------------+
| prod_name       | prod_price |
+-----------------+------------+
| Detonator       |      13.00 |
| Bird seed       |      10.00 |
| Fuses           |       3.42 |
| Oil can         |       8.99 |
| Safe            |      50.00 |
| TNT (5 sticks)  |      10.00 |
+-----------------+------------+
```

- **Analysis**

Look at the previously listed results. Two of the rows returned have prices less than `10`so, obviously, the rows were not filtered as intended. Why did this happen? The answer is the order of evaluation. SQL (like most languages) processes `AND` operators before `OR` operators. When SQL sees the preceding `WHERE` clause, it reads *products made by vendor* `1002` *regardless of price, and any products costing* `10` *or more made by vendor* `1003`. In other words, because `AND` ranks higher in the order of evaluation, the wrong operators were joined together.

The solution to this problem is to use parentheses to explicitly group related operators. Take a look at the following `SELECT` statement and output:

- **Input**

```
SELECT prod_name, prod_price
```

```
FROM products
WHERE (vend_id = 1002 OR vend_id = 1003) AND prod_price >= 10;
```

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| Detonator      |      13.00 |
| Bird seed      |      10.00 |
| Safe           |      50.00 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

- **Analysis**

The only difference between this `SELECT` statement and the earlier one is that, in this statement, the first two `WHERE` clause conditions are enclosed within parentheses. As parentheses have a higher order of evaluation than either `AND` or `OR` operators, the DBMS first filters the `OR` condition within those parentheses. The SQL statement then becomes *any products made by either vendor* `1002` *or vendor* `1003` *costing* `10` *or greater*, which is exactly what you want.

Tip

Using Parentheses in `WHERE` Clauses Whenever you write `WHERE` clauses that use both `AND` and `OR` operators, use parentheses to explicitly group operators. Don't ever rely on the default evaluation order, even if it is exactly what you want. There is no downside to using parentheses, and you are always better off eliminating any ambiguity.

Using the IN Operator

Parentheses have another very different use in WHERE clauses. The IN operator is used to specify a range of conditions, any of which can be matched. IN takes a comma-delimited list of valid values, all enclosed within parentheses. The following example demonstrates this:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE vend_id IN (1002,1003)
ORDER BY prod_name;
```

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| Bird seed      |      10.00 |
| Carrots        |       2.50 |
| Detonator      |      13.00 |
| Fuses          |       3.42 |
| Oil can        |       8.99 |
| Safe           |      50.00 |
| Sling          |       4.49 |
| TNT (1 stick)  |       2.50 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

- **Analysis**

The SELECT statement retrieves all products made by vendor 1002 and vendor 1003. The IN operator is followed by a comma-delimited list of valid values, and the entire list must be enclosed within parentheses.

If you are thinking that the IN operator accomplishes the same goal as OR, you are right. The following SQL statement accomplishes the exact same thing as the previous example:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE vend_id  = 1002 OR vend_id = 1003
ORDER BY prod_name;
```

- **Output**

```
+----------------+------------+
| prod_name      | prod_price |
+----------------+------------+
| Bird seed      |      10.00 |
| Carrots        |       2.50 |
| Detonator      |      13.00 |
| Fuses          |       3.42 |
| Oil can        |       8.99 |
| Safe           |      50.00 |
| Sling          |       4.49 |
| TNT (1 stick)  |       2.50 |
| TNT (5 sticks) |      10.00 |
+----------------+------------+
```

Why use the `IN` operator? The advantages are

- When you are working with long lists of valid options, the `IN` operator syntax is far cleaner and easier to read.
- The order of evaluation is easier to manage when `IN` is used (as there are fewer operators used).
- `IN` operators almost always execute more quickly than lists of `OR` operators.
- The biggest advantage of `IN` is that the `IN` operator can contain another `SELECT` statement, enabling you to build highly dynamic `WHERE` clauses. You'll look at this in detail in Chapter 14, "Working with Subqueries."

New Term

`IN` A keyword used in a `WHERE` clause to specify a list of values to be matched using an `OR` comparison.

Using the NOT Operator

The WHERE clause's NOT operator has one function and one function onlyNOT negates whatever condition comes next.

NOT A keyword used in a WHERE clause to negate a condition.

The following example demonstrates the use of NOT. To list the products made by all vendors except vendors 1002 and 1003, you can use the following:

- **Input**

```
SELECT prod_name, prod_price
FROM products
WHERE vend_id NOT IN (1002,1003)
ORDER BY prod_name;
```

- **Output**

```
+--------------+------------+
| prod_name    | prod_price |
+--------------+------------+
| .5 ton anvil |       5.99 |
| 1 ton anvil  |       9.99 |
| 2 ton anvil  |      14.99 |
| JetPack 1000 |      35.00 |
| JetPack 2000 |      55.00 |
+--------------+------------+
```

- **Analysis**

The NOT here negates the condition that follows it; so instead of matching vend_id to 1002 or 1003, MySQL matches vend_id to anything that is not 1002 or 1003.

So why use NOT? Well, for simple WHERE clauses, there really is no advantage to using NOT. NOT is useful in more complex clauses. For example, using NOT in conjunction with an IN operator makes it simple to find all rows that do not match a list of criteria.

Note

NOT in MySQL MySQL supports the use of NOT to negate IN, BETWEEN, and EXISTS clauses. This is quite different from most other DBMSs that allow NOT to be used to negate any conditions.

Summary

This chapter picked up where the previous chapter left off and taught you how to combine `WHERE` clauses with the `AND` and `OR` operators. You also learned how to explicitly manage the order of evaluation, and how to use the `IN` and `NOT` operators.

Chapter 8. Using Wildcard Filtering

In this chapter, you'll learn what wildcards are, how they are used, and how to perform wildcard searches using the `LIKE` *operator for sophisticated filtering of retrieved data*.

Using the `LIKE` Operator

All the previous operators we studied filter against known values. Be it matching one or more values, testing for greater-than or less-than known values, or checking a range of values, the common denominator is that the values used in the filtering are known. But filtering data that way does not always work. For example, how could you search for all products that contained the text *anvil* within the product name? That cannot be done with simple comparison operators; that's a job for wildcard searching. Using wildcards, you can create search patterns that can be compared against your data. In this example, if you want to find all products that contain the words *anvil*, you could construct a wildcard search pattern enabling you to find that *anvil* text anywhere within a product name.

New Term

Wildcards Special characters used to match parts of a value.

New Term

Search pattern A search condition made up of literal text, wildcard characters, or any combination of the two.

The wildcards themselves are actually characters that have special meanings within SQL `WHERE` clauses, and SQL supports several wildcard types.

To use wildcards in search clauses, the `LIKE` operator must be used. `LIKE` instructs MySQL that the following search pattern is to be compared using a wildcard match rather than a straight equality match.

Note

Predicates When is an operator not an operator? When it is a *predicate*. Technically, `LIKE` is a predicate, not an operator. The end result is the same;

just be aware of this term in case you run across it in the MySQL documentation.

The Percent Sign (`%`) Wildcard

The most frequently used wildcard is the percent sign (`%`). Within a search string, `%` means *match any number of occurrences of any character*. For example, to find all products that start with the word `jet`, you can issue the following `SELECT` statement:

- **Input**

```
SELECT prod_id, prod_name
FROM products
WHERE prod_name LIKE 'jet%';
```

- **Output**

```
+---------+--------------+
| prod_id | prod_name    |
+---------+--------------+
| JP1000  | JetPack 1000 |
| JP2000  | JetPack 2000 |
+---------+--------------+
```

- **Analysis**

This example uses a search pattern of `'jet%'`. When this clause is evaluated, any value that starts with `jet` is retrieved. The `%` tells MySQL to accept any characters after the word `jet`, regardless of how many characters there are.

Note

Case-Sensitivity Depending on how MySQL is configured, searches might be case-sensitive, in which case `'jet%'` would not match `JetPack 1000`.

Wildcards can be used anywhere within the search pattern, and multiple wildcards can be used as well. The following example uses two wildcards, one at either end of the pattern:

- **Input**

```
SELECT prod_id, prod_name
FROM products
WHERE prod_name LIKE '%anvil%';
```

- **Output**

```
+---------+--------------+
| prod_id | prod_name    |
+---------+--------------+
| ANV01   | .5 ton anvil |
| ANV02   | 1 ton anvil  |
| ANV03   | 2 ton anvil  |
+---------+--------------+
```

- **Analysis**

The search pattern `'%anvil%'` means *match any value that contains the text anvil anywhere within it, regardless of any characters before or after that text*.

Wildcards can also be used in the middle of a search pattern, although that is rarely useful. The following example finds all products that begin with an `s` and end with an `e`:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name LIKE 's%e';
```

It is important to note that, in addition to matching one or more characters, `%` also matches zero characters. `%` represents zero, one, or more characters at the specified location in the search pattern.

Note

Watch for Trailing Spaces Trailing spaces can interfere with wildcard matching. For example, if any of the anvils had been saved with one or more spaces after the word *anvil*, the clause `WHERE prod_name LIKE '%anvil'` would not have matched them as there would have been additional characters after the final `l`. One simple solution to this problem is to always append a final `%` to the search pattern. A better solution is to trim the spaces using functions, as is discussed in Chapter 11, "Using Data Manipulation Functions."

Caution

Watch for `NULL` Although it might seem that the `%` wildcard matches anything, there is one exception`NULL`. Not even the clause `WHERE prod_name LIKE '%'` will match a row with the value `NULL` as the product name.

The Underscore (`_`) Wildcard

Another useful wildcard is the underscore (`_`). The underscore is used just like `%`, but instead of matching multiple characters, the underscore matches just a single character.

Take a look at this example:

- **Input**

```
SELECT prod_id, prod_name
FROM products
```

```
WHERE prod_name LIKE '_ ton anvil';
```

- **Output**

```
+---------+-------------+
| prod_id | prod_name   |
+---------+-------------+
| ANV02   | 1 ton anvil |
| ANV03   | 2 ton anvil |
+---------+-------------+
```

- **Analysis**

The search pattern used in this `WHERE` clause specifies a wildcard followed by literal text. The results shown are the only rows that match the search pattern: The underscore matches `1` in the first row and `2` in the second row. The `.5 ton anvil` product did not match because the search pattern matched a single character, not two. By contrast, the following `SELECT` statement uses the `%` wildcard and returns three matching products:

- **Input**

```
SELECT prod_id, prod_name
FROM products
WHERE prod_name LIKE '% ton anvil';
```

- **Output**

```
+---------+--------------+
| prod_id | prod_name    |
+---------+--------------+
| ANV01   | .5 ton anvil |
| ANV02   | 1 ton anvil  |
| ANV03   | 2 ton anvil  |
+---------+--------------+
```

Unlike `%`, which can match zero characters, `_` always matches one characterno more and no less.

Tips for Using Wildcards

As you can see, MySQL's wildcards are extremely powerful. But that power comes with a price: Wildcard searches typically take far longer to process than any other search types discussed previously. Here are some tips to keep in mind when using wildcards:

- Don't overuse wildcards. If another search operator will do, use it instead.
- When you do use wildcards, try to not use them at the beginning of the search pattern unless absolutely necessary. Search patterns that begin with wildcards are the slowest to process.
- Pay careful attention to the placement of the wildcard symbols. If they are misplaced, you might not return the data you intended.

Having said that, wildcards are an important and useful search tool, and one that you will use frequently.

Summary

In this chapter, you learned what wildcards are and how to use SQL wildcards within your `WHERE` clauses. You also learned that wildcards should be used carefully and never overused.

Chapter 9. Searching Using Regular Expressions

In this chapter, you'll learn how to use regular expressions within MySQL `WHERE` *clauses for greater control over data filtering*.

Understanding Regular Expressions

The filtering examples in the previous two chapters enabled you to locate data using matches, comparisons, and wildcard operators. For basic filtering (and even some not-so-basic filtering) this might be enough. But as the complexity of filtering conditions grows, so does the complexity of the `WHERE` clauses themselves.

And this is where regular expressions become useful. Regular expressions are special strings (sets of characters) that are used to match text. If you needed to extract phone numbers from a text file, you might use a regular expression. If you needed to locate all files with digits in the middle of their names, you might use a regular expression. If you wanted to find all repeated words in a block of text, you might use a regular expression. And if you wanted to replace all URLs in a page with actual HTML links to those same URLs, yes, you might use a regular expression (or two, for this last example).

Regular expressions are supported in all sorts of programming languages, text editors, operating systems, and more. And savvy programmers and network managers have long regarded regular expressions as a vital component of their technical toolboxes.

Regular expressions are created using the regular expression language, a specialized language designed to do everything that was just discussed and much more. Like any language, regular expressions have a special syntax and instructions that you must learn.

Note

To Learn More Full coverage of regular expressions is beyond the scope of this chapter. While the basics are covered here, for a more thorough introduction to regular expressions you might want to obtain a copy of my *Sams Teach Yourself Regular Expressions in 10 Minutes* (ISBN 0672325667).

Using MySQL Regular Expressions

So what does this have to do with MySQL? As already explained, all regular expressions do is match text, comparing a pattern (the regular expression) with a string of text. MySQL provides rudimentary support for regular expressions with `WHERE` clauses, allowing you to specify regular expressions that are used to filter data retrieved using `SELECT`.

Note

Just a Subset of the Regular Expression Language If you are already familiar with regular expressions, take note. MySQL only supports a small subset of what is supported in most regular expression implementations, and this chapter covers most of what is supported.

This will all become much clearer with some examples.

Basic Character Matching

We'll start with a very simple example. The following statement retrieves all rows where column `prod_name` contains the text `1000`:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '1000'
ORDER BY prod_name;
```

- **Output**

```
+--------------+
| prod_name    |
+--------------+
| JetPack 1000 |
+--------------+
```

* **Analysis**

This statement looks much like the ones that used `LIKE` (in Chapter 8, "Using Wildcard Filtering"), except that the keyword `LIKE` has been replaced with `REGEXP`. This tells MySQL that what follows is to be treated as a regular expression (one that just matches the literal text `1000`).

So, why bother using a regular expression? Well, in the example just used, regular expressions really add no value (and probably hurt performance), but consider this next example:

* **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '.000'
ORDER BY prod_name;
```

* **Output**

```
+--------------+
| prod_name    |
+--------------+
| JetPack 1000 |
| JetPack 2000 |
+--------------+
```

* **Analysis**

Here the regular expression `.000` was used. `.` is a special character in the regular expression language. It means *match any single character*, and so both `1000` and `2000` matched and were returned.

Of course, this particular example could also have been accomplished using `LIKE` and wildcards (as seen in Chapter 8).

Note

`LIKE` Versus `REGEXP` There is one very important difference between `LIKE` and `REGEXP`. Look at these two statements:

```
SELECT prod_name
FROM products
WHERE prod_name LIKE '1000'
ORDER BY prod_name;
```

and

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '1000'
ORDER BY prod_name;
```

If you were to try them both you'd discover that the first returns no data and the second returns one row. Why is this?

As seen in Chapter 8, `LIKE` matches an entire column. If the text to be matched existed in the middle of a column value, `LIKE` would not find it and the row would not be returned (unless wildcard characters were used). `REGEXP`, on the other hand, looks for matches within column values, and so if the text to be matched existed in the middle of a column value, `REGEXP` would find it and the row would be returned. This is a very important distinction.

So can `REGEXP` be used to match entire column values (so that it functions like `LIKE`)? Actually, yes, using the `^` and `$` anchors, as will be explained later in this chapter.

Tip

Matches Are Not Case-Sensitive Regular expression matching in MySQL (as of version 3.23.4) are not case-sensitive (either case will be matched). To force case-sensitivity, you can use the BINARY keyword, as in

```
WHERE prod_name REGEXP BINARY 'JetPack .000'
```

Performing OR Matches

To search for one of two strings (either one or the other), use | as seen here:

• **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '1000|2000'
ORDER BY prod_name;
```

• **Output**

```
+--------------+
| prod_name    |
+--------------+
| JetPack 1000 |
| JetPack 2000 |
+--------------+
```

• **Analysis**

Here the regular expression 1000|2000 was used. | is the regular expression OR operator. It means *match one or the other*, and so both 1000 and 2000 matched and were returned.

Using | is functionally similar to using OR statements in SELECT statements, with multiple OR conditions being consolidated into a single regular expression.

Tip

More Than Two OR Conditions More than two `OR` conditions may be specified. For example, `'1000|2000|3000'` would match `1000` or `2000` or `3000`.

Matching One of Several Characters

`.` matches any single character. But what if you wanted to match only specific characters? You can do this by specifying a set of characters enclosed within `[` and `]`, as seen here:

• **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '[123] Ton'
ORDER BY prod_name;
```

• **Output**

```
+-------------+
| prod_name   |
+-------------+
| 1 ton anvil |
| 2 ton anvil |
+-------------+
```

• **Analysis**

Here the regular expression `[123] Ton` was used. `[123]` defines a set of characters, and here it means *match* `1` *or* `2` *or* `3`, so both `1 ton` and `2 ton` matched and were returned (there was no `3 ton`).

As you have just seen, `[]` is another form of `OR` statement. In fact, the regular expression `[123] Ton` is shorthand for `[1|2|3] Ton`, which also would have worked. But the `[]` characters are needed to define what the `OR` statement is looking for. To better understand this, look at the next example:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '1|2|3 Ton'
ORDER BY prod_name;
```

- **Output**

```
+----------------+
| prod_name      |
+----------------+
| 1 ton anvil    |
| 2 ton anvil    |
| JetPack 1000   |
| JetPack 2000   |
| TNT (1 stick)  |
+----------------+
```

- **Analysis**

Well, that did not work. The two required rows were retrieved, but so were three others. This happened because MySQL assumed that you meant *'1' or '2' or '3 ton'*. The `|` character applies to the entire string unless it is enclosed with a set.

Sets of characters can also be negated. That is, they'll match anything *but* the specified characters. To negate a character set, place a `^` at the start of the set. So, whereas `[123]` matches characters `1`, `2`, or `3`, `[^123]` matches anything but those characters.

Matching Ranges

Sets can be used to define one or more characters to be matched. For example, the following will match digits `0` tHRough `9`:

```
[0123456789]
```

To simplify this type of set, `-` can be used to define a range. The following is functionally identical to the list of digits just seen:

```
[0-9]
```

Ranges are not limited to complete sets`[1-3]` and `[6-9]` are valid ranges, too. In addition, ranges need not be numeric, and so `[a-z]` will match any alphabetical character.

Here is an example:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '[1-5] Ton'
ORDER BY prod_name;
```

- **Output**

```
+--------------+
| prod_name    |
+--------------+
| .5 ton anvil |
| 1 ton anvil  |
| 2 ton anvil  |
+--------------+
```

- **Analysis**

Here the regular expression `[1-5] Ton` was used. `[1-5]` defines a range, and so this expression means *match* `1` *through* `5`, and so three matches were returned.

`.5 ton` was returned because `5 ton` matched (without the `.` character).

Matching Special Characters

The regular expression language is made up of special characters that have specific meanings. You've already seen `.`, `[]`, `|`, and `-`, and there are others, too. Which begs the question, if you needed to match those characters, how would you do so? For example, if you wanted to find values that contain the `.` character, how would you search for it? Look at this example:

- **Input**

```
SELECT vend_name
FROM vendors
WHERE vend_name REGEXP '.'
ORDER BY vend_name;
```

- **Output**

```
+----------------+
| vend_name      |
+----------------+
| ACME           |
| Anvils R Us    |
| Furball Inc.   |
| Jet Set        |
| Jouets Et Ours |
| LT Supplies    |
+----------------+
```

- **Analysis**

That did not work. `.` matches any character, and so every row was retrieved.

To match special characters they must be preceded by `\\`. So, `\\-` means find and `\\.` means find `.`:

- **Input**

```
SELECT vend_name
FROM vendors
WHERE vend_name REGEXP '\\.'
ORDER BY vend_name;
```

- **Output**

```
+--------------+
| vend_name    |
+--------------+
| Furball Inc. |
+--------------+
```

- **Analysis**

That worked. `\\.` matches `.`, and so only a single row was retrieved. This process is known as *escaping*, and all characters that have special significance within regular expressions must be escaped this way. This includes `.`, `|`, `[]`, and all of the other special characters used thus far.

`\\` is also used to refer to metacharacters (characters that have specific meanings), as listed in Table 9.1.

Table 9.1. Whitespace Metacharacters

Metacharacter	Description
`\\f`	Form feed
`\\n`	Line feed
`\\r`	Carriage return
`\\t`	Tab
`\\v`	Vertical tab

Tip

To Match `\` To match the backslash character itself (`\`), you would need to use `\\\`.

Note

`\` or `\\`? Most regular expression implementation use a single backslash to escape special characters to be able to use them as literals. MySQL, however, requires two backslashes (MySQL itself interprets one and the regular expression library interprets the other).

Matching Character Classes

There are matches that you'll find yourself using frequently, digits, or all alphabetical characters, or all alphanumerical characters, and so on. To make working with these easier, you may use predefined character sets known as *character classes*. Table 9.2 lists the character classes and what they mean.

Table 9.2. Character Classes

Class	Description
`[:alnum:]`	Any letter or digit, (same as `[a-zA-Z0-9]`)
`[:alpha:]`	Any letter (same as `[a-zA-Z]`)
`[:blank:]`	Space or tab (same as `[\\t ]`)
`[:cntrl:]`	ASCII control characters (ASCII `0` tHRough `31` and `127`)
`[:digit:]`	Any digit (same as `[0-9]`)
`[:graph:]`	Same as `[:print:]` but excludes space

`[:lower:]`	Any lowercase letter (same as `[a-z]`)
`[:print:]`	Any printable character
`[:punct:]`	Any character that is neither in `[:alnum:]` nor `[:cntrl:]`
`[:space:]`	Any whitespace character including the space (same as `[\\f\\n\\r\\t\\v ]`)
`[:upper:]`	Any uppercase letter (same as `[A-Z]`)
`[:xdigit:]`	Any hexadecimal digit (same as `[a-fA-F0-9]`)

Matching Multiple Instances

All of the regular expressions used thus far attempt to match a single occurrence. If there is a match, the row is retrieved and if not, nothing is retrieved. But sometimes you'll require greater control over the number of matches. For example, you might want to locate all numbers regardless of how many digits the number contains, or you might want to locate a word but also be able to accommodate a trailing `s` if one exists, and so on.

This can be accomplished using the regular expressions repetition metacharacters, listed in Table 9.3.

Table 9.3. Repetition Metacharacters

Metacharacter	Description
`*`	0 or more matches
`+`	1 or more matches (equivalent to `{1,}`)
`?`	0 or 1 match (equivalent to `{0,1}`)
`{n}`	Specific number of matches
`{n,}`	No less than a specified number of matches

`{n,m}`	Range of matches (`m` not to exceed 255)

Following are some examples.

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '\\([0-9] sticks?\\)'
ORDER BY prod_name;
```

- **Output**

```
+----------------+
| prod_name      |
+----------------+
| TNT (1 stick)  |
| TNT (5 sticks) |
+----------------+
```

- **Analysis**

Regular expression `\\([0-9] sticks?\\)` requires some explanation. `\\(` matches `(`, `[0-9]` matches any digit (`1` and `5` in this example), `sticks?` matches `stick` and `sticks` (the `?` after the `s` makes that `s` optional because `?` matches 0 or 1 occurrence of whatever it follows), and `\\)` matches the closing `)`. Without `?` it would have been very difficult to match both `stick` and `sticks`.

Here's another example. This time we'll try to match four consecutive digits:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '[[:digit:]]{4}'77
ORDER BY prod_name;
```

• **Output**

```
+---------------+
| prod_name     |
+---------------+
| JetPack 1000 |
| JetPack 2000 |
+---------------+
```

• **Analysis**

As explained previously, `[:digit:]` matches any digit, and so `[[:digit:]]` is a set of digits. `{4}` requires exactly four occurrences of whatever it follows (any digit), and so `[[:digit:]]{4}` matches any four consecutive digits.

It is worth noting that when using regular expressions there is almost always more than one way to write a specific expression. The previous example could have also been written as follows:

• **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '[0-9][0-9][0-9][0-9]'
ORDER BY prod_name;
```

Anchors

All of the examples thus far have matched text anywhere within a string. To match text at specific locations, you need to use anchors as listed in Table 9.4.

Table 9.4. Anchor Metacharacters

Metacharacter	Description
`^`	Start of text

`$`	End of text
`[[:<:]]`	Start of word
`[[:>:]]`	End of word

For example, what if you wanted to find all products that started with a number (including numbers starting with a decimal point)? A simple search for `[0-9\\.]` (or `[[:digit:]\\.]`) would not work because it would find matches anywhere within the text. The solution is to use the `^` anchor, as seen here:

- **Input**

```
SELECT prod_name
FROM products
WHERE prod_name REGEXP '^[0-9\\.]'
ORDER BY prod_name;
```

- **Output**

```
+--------------+
| prod_name    |
+--------------+
| .5 ton anvil |
| 1 ton anvil  |
| 2 ton anvil  |
+--------------+
```

- **Analysis**

`^` matches the start of a string. As such, `^[0-9\\.]` matches `.` or any digit only if they are the first characters within a string. Without the `^`, four other rows would have been retrieved, too (those that have digits in the middle).

Note

The Dual Purpose `^` `^` has two uses. Within a set (defined using `[` and `]`) it is used to negate that set. Otherwise it is used to refer to the start of a string.

Note

Making `REGEXP` Behave Like `LIKE` Earlier in this chapter I mentioned that `LIKE` and `REGEXP` behaved differently in that `LIKE` matched an entire string and `REGEXP` matched substrings, too. Using anchors, `REGEXP` can be made to behave just like `LIKE` by simply starting each expression with `^` and ending it with `$`.

Tip

Simple Regular Expression Testing You can use `SELECT` to test regular expressions without using database tables. `REGEXP` checks always return `0` (not a match) or `1` (match). You can use `REGEXP` with literal strings to test expressions and to experiment with them. The syntax would look like this:

```
SELECT 'hello' REGEXP '[0-9]';
```

This example would obviously return `0` (as there are no digits in the text `hello`).

Summary

In this chapter, you learned the basics of regular expressions, and how to use them in MySQL `SELECT` statements via the `REGEXP` keyword.

Chapter 10. Creating Calculated Fields

In this chapter, you will learn what calculated fields are, how to create them, and how to use aliases to refer to them from within your application.

Understanding Calculated Fields

Data stored within a database's tables is often not available in the exact format needed by your applications. Here are some examples:

- You need to display a field containing the name of a company along with the company's location, but that information is stored in separated table columns.
- City, state, and ZIP Code are stored in separate columns (as they should be), but your mailing label printing program needs them retrieved as one correctly formatted field.
- Column data is in mixed upper- and lowercase, and your report needs all data presented in uppercase.
- An order items table stores item price and quantity but not the expanded price (price multiplied by quantity) of each item. To print invoices, you need that expanded price.
- You need total, averages, or other calculations based on table data.

In each of these examples, the data stored in the table is not exactly what your application needs. Rather than retrieve the data as it is and then reformat it within your client application or report, what you really want is to retrieve converted, calculated, or reformatted data directly from the database.

This is where calculated fields come in. Unlike all the columns we retrieved in the chapters thus far, calculated fields don't actually exist in database tables. Rather, a calculated field is created on-the-fly within a SQL `SELECT` statement.

New Term

Field Essentially means the same thing as *column* and often is used interchangeably, although database *columns* are typically called columns and the term *fields* is normally used in conjunction with calculated fields.

It is important to note that only the database knows which columns in a `SELECT` statement are actual table columns and which are calculated fields. From the perspective of a client (for example, your application), a calculated field's data is returned in the same way as data from any other column.

Tip

Client Versus Server Formatting Many of the conversions and reformatting that can be performed within SQL statements can also be performed directly in your client application. However, as a rule, it is far quicker to perform these operations on the database server than it is to perform them within the client because Database Management Systems (DBMS) are built to perform this type of processing quickly and efficiently.

Concatenating Fields

To demonstrate working with calculated fields, let's start with a simple examplecreating a title made up of two columns.

The `vendors` table contains vendor name and address information. Imagine you are generating a vendor report and need to list the vendor location as part of the vendor name in the format `name (location)`.

The report wants a single value, and the data in the table is stored in two columns: `vend_name` and `vend_country`. In addition, you need to surround `vend_country` with parenthesis, and those are definitely not stored in the database table. The `SELECT` statement that returns the vendor names and locations is simple enough, but how would you create this combined value?

New Term

Concatenate Joining values together (by appending them to each other) to form a single long value.

The solution is to concatenate the two columns. In MySQL `SELECT` statements, you can concatenate columns using the `Concat()` function.

Tip

MySQL Is Different Most DBMSs use operators `+` or `||` for concatenation; MySQL uses the `Concat()` function. Keep this in mind when converting SQL statements to MySQL.

- **Input**

```
SELECT Concat(vend_name, ' (', vend_country, ')')
FROM vendors
ORDER BY vend_name;
```

• **Output**

```
+-----------------------------------------------+
| Concat(vend_name, ' (', vend_country, ')') |
+-----------------------------------------------+
| ACME (USA)                                    |
| Anvils R Us (USA)                             |
| Furball Inc. (USA)                            |
| Jet Set (England)                             |
| Jouets Et Ours (France)                       |
| LT Supplies (USA)                             |
+-----------------------------------------------+
```

• **Analysis**

`Concat()` concatenates strings, appending them to each other to create one bigger string. `Concat()` requires one or more values to be specified, each separated by commas. The previous `SELECT` statements concatenate four elements:

- The name stored in the `vend_name` column
- A string containing a space and an open parenthesis
- The state stored in the `vend_country` column
- A string containing the close parenthesis

As you can see in the output shown previously, the `SELECT` statement returns a single column (a calculated field) containing all four of these elements as one unit.

Back in Chapter 8, "Using Wildcard Filtering," I mentioned the need to trim data so as to remove any trailing spaces. This can be done using the MySQL `RTrim()` function, as follows:

• **Input**

```
SELECT Concat(RTrim(vend_name), ' (', RTrim(vend_country), ')')
FROM vendors
ORDER BY vend_name;
```

• **Analysis**

The `RTrim()` function trims all spaces from the right of a value. By using `RTrim()`, the individual columns are all trimmed properly.

Note

The `trim()` Functions In addition to `RTrim()` (which, as just seen, trims the right side of a string), MySQL supports the use of `LTrim()` (which trims the left side of a string), and `trim()` (which trims both the right and left).

Using Aliases

The `SELECT` statement used to concatenate the address field works well, as seen in the previous output. But what is the name of this new calculated column? Well, the truth is, it has no name; it is simply a value. Although this can be fine if you are just looking at the results in a SQL query tool, an unnamed column cannot be used within a client application because the client has no way to refer to that column.

To solve this problem, SQL supports column aliases. An *alias* is just that, an alternative name for a field or value. Aliases are assigned with the `AS` keyword. Take a look at the following `SELECT` statement:

• **Input**

```
SELECT Concat(RTrim(vend_name), ' (', RTrim(vend_country), ')') AS
vend_title
FROM vendors
ORDER BY vend_name;
```

• **Output**

```
+--------------------------+
| vend_title               |
+--------------------------+
| ACME (USA)               |
| Anvils R Us (USA)        |
| Furball Inc. (USA)       |
| Jet Set (England)        |
| Jouets Et Ours (France)  |
| LT Supplies (USA)        |
+--------------------------+
```

• **Analysis**

The `SELECT` statement itself is the same as the one used in the previous code snippet, except that here the calculated field is followed by the text `AS vend_title`. This instructs SQL to create a calculated field named `vend_title` containing the results of the specified calculation. As you can see in the output, the results are the same as before, but the column is now named `vend_title` and any client application can refer to this column by name, just as it would to any actual table column.

Tip

Other Uses for Aliases Aliases have other uses, too. Some common uses include renaming a column if the real table column name contains illegal characters (for example, spaces) and expanding column names if the original names are either ambiguous or easily misread.

Note

Derived Columns Aliases are also sometimes referred to as *derived columns*, so regardless of the term you run across, they mean the same thing.

Performing Mathematical Calculations

Another frequent use for calculated fields is performing mathematical calculations on retrieved data. Let's take a look at an example. The `orders` table contains all orders received, and the `orderitems` table contains the individual items within each order. The following SQL statement retrieves all the items in order number `20005`:

- **Input**

```
SELECT prod_id, quantity, item_price
FROM orderitems
WHERE order_num = 20005;
```

- **Output**

```
+---------+----------+------------+
| prod_id | quantity | item_price |
+---------+----------+------------+
| ANV01   |       10 |       5.99 |
| ANV02   |        3 |       9.99 |
| TNT2    |        5 |      10.00 |
| FB      |        1 |      10.00 |
+---------+----------+------------+
```

The `item_price` column contains the per unit price for each item in an order. To expand the item price (item price multiplied by quantity ordered), you simply do the following:

- **Input**

```
SELECT prod_id,
       quantity,
       item_price,
       quantity*item_price AS expanded_price
FROM orderitems
WHERE order_num = 20005;
```

• Output

```
+---------+----------+------------+----------------+
| prod_id | quantity | item_price | expanded_price |
+---------+----------+------------+----------------+
| ANV01   |       10 |       5.99 |          59.90 |
| ANV02   |        3 |       9.99 |          29.97 |
| TNT2    |        5 |      10.00 |          50.00 |
| FB      |        1 |      10.00 |          10.00 |
+---------+----------+------------+----------------+
```

• Analysis

The `expanded_price` column shown in the previous output is a calculated field; the calculation is simply `quantity*item_price`. The client application can now use this new calculated column just as it would any other column.

MySQL supports the basic mathematical operators listed in Table 10.1. In addition, parentheses can be used to establish order of precedence. Refer to Chapter 7, "Advanced Data Filtering," for an explanation of precedence.

Table 10.1. MySQL Mathematical Operators

Operator	Description
`+`	Addition
`-`	Subtraction
`*`	Multiplication
`/`	Division

Tip

How to Test Calculations `SELECT` provides a great way to test and experiment with functions and calculations. Although `SELECT` is usually used to retrieve data from a table, the `FROM` clause may be omitted to simply access and work with expressions. For example, `SELECT 3 * 2`; would return `6`, `SELECT Trim(' abc ');` would return `abc`, and `SELECT Now()` uses the `Now()` function to return the current date and time. You get the ideause `SELECT` to experiment as needed.

Summary

In this chapter, you learned what calculated fields are and how to create them. We used examples demonstrating the use of calculated fields for both string concatenation and mathematical operations. In addition, you learned how to create and use aliases so your application can refer to calculated fields.

Chapter 11. Using Data Manipulation Functions

In this chapter, you'll learn what functions are, what types of functions MySQL supports, and how to use these functions.

Understanding Functions

Like almost any other computer language, SQL supports the use of functions to manipulate data. Functions are operations that are usually performed on data, usually to facilitate conversion and manipulation.

An example of a function is the `RTrim()` that we used in the last chapter to trim any spaces from the end of a string.

Note

Functions Are Less Portable Than SQL Code that runs on multiple systems is said to be *portable*. Most SQL statements are relatively portable, and when differences between SQL implementations do occur they are usually not that difficult to deal with. Functions, on the other hand, tend to be far less portable. Just about every major Database Management System (DBMS) supports functions that others don't, and sometimes the differences are significant.

With code portability in mind, many SQL programmers opt not to use any implementation-specific features. Although this is a somewhat noble and idealistic view, it is not always in the best interests of application performance. If you opt not to use these functions, you make your application code work harder. It must use other methods to do what the DBMS could have done more efficiently.

If you do decide to use functions, make sure you comment your code well, so that at a later date you (or another developer) will know exactly to which SQL implementation you were writing.

Using Functions

Most SQL implementations support the following types of functions:

- Text functions are used to manipulate strings of text (for example, trimming or padding values and converting values to upper- and lowercase).
- Numeric functions are used to perform mathematical operations on numeric data (for example, returning absolute numbers and performing algebraic calculations).
- Date and time functions are used to manipulate date and time values and to extract specific components from these values (for example, returning differences between dates and checking date validity).
- System functions return information specific to the DBMS being used (for example, returning user login information or checking version specifics).

Text Manipulation Functions

You've already seen an example of text-manipulation functions in the last chapterthe `RTrim()` function was used to trim white space from the end of a column value. Here is another example, this time using the `Upper()` function:

• **Input**

```
SELECT vend_name, UPPER(vend_name) AS vend_name_upcase
FROM vendors
ORDER BY vend_name;
```

• **Output**

```
+-----------------+-------------------+
| vend_name       | vend_name_upcase  |
+-----------------+-------------------+
| ACME            | ACME              |
| Anvils R Us     | ANVILS R US       |
| Furball Inc.    | FURBALL INC.      |
| Jet Set         | JET SET           |
| Jouets Et Ours  | JOUETS ET OURS    |
| LT Supplies     | LT SUPPLIES       |
+-----------------+-------------------+
```

• **Analysis**

As you can see, `Upper()` converts text to uppercase and so in this example each vendor is listed twice, first exactly as stored in the `vendors` table, and then converted to uppercase as column `vend_name_upcase`.

Table 11.1 lists some commonly used text-manipulation functions.

Table 11.1. Commonly Used Text-Manipulation Functions

Function	Description
`Left()`	Returns characters from left of string
`Length()`	Returns the length of a string
`Locate()`	Finds a substring within a string
`Lower()`	Converts string to lowercase
`LTrim()`	Trims white space from left of string
`Right()`	Returns characters from right of string
`RTrim()`	Trims white space from right of string
`Soundex()`	Returns a string's SOUNDEX value
`SubString()`	Returns characters from within a string
`Upper()`	Converts string to uppercase

One item in Table 11.1 requires further explanation. SOUNDEX is an algorithm that converts any string of text into an alphanumeric pattern describing the phonetic representation of that text. SOUNDEX takes into account similar sounding characters and syllables, enabling strings to be compared by how they sound rather than how they have been typed. Although SOUNDEX is not a SQL concept, MySQL (like many other DBMSs) offers SOUNDEX support.

Here's an example using the `Soundex()` function. Customer `Coyote Inc.` is in the `customers` table and has a contact named `Y. Lee`. But what if that were a typo, and the contact actually was supposed to have been `Y. Lie`? Obviously, searching by the correct contact name would return no data, as shown here:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers
WHERE cust_contact = 'Y. Lie';
```

- **Output**

```
+-------------+--------------+
| cust_name   | cust_contact |
+-------------+--------------+
```

Now try the same search using the `Soundex()` function to match all contact names that sound similar to `Y. Lie`:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers
WHERE Soundex(cust_contact) = Soundex('Y Lie');
```

- **Output**

```
+-------------+--------------+
| cust_name   | cust_contact |
+-------------+--------------+
| Coyote Inc. | Y Lee        |
+------------+-------------+
```

- **Analysis**

In this example, the `WHERE` clause uses the `Soundex()` function to convert both the `cust_contact` column value and the search string to their SOUNDEX values. Because `Y. Lee` and `Y. Lie` sound alike, their SOUNDEX values match, and so the `WHERE` clause correctly filtered the desired data.

Date and Time Manipulation Functions

Date and times are stored in tables using special datatypes using special internal formats so they may be sorted or filtered quickly and efficiently, as well as to save physical storage space.

The format used to store dates and times is usually of no use to your applications, and so date and time functions are almost always used to read, expand, and manipulate these values. Because of this, date and time manipulation functions are some of the most important functions in the MySQL language.

Table 11.2 lists some commonly used date and time manipulation functions.

Table 11.2. Commonly Used Date and Time Manipulation Functions

Function	Description
`AddDate()`	Add to a date (days, weeks, and so on)
`AddTime()`	Add to a time (hours, minutes, and so on)
`CurDate()`	Returns the current date
`CurTime()`	Returns the current time
`Date()`	Returns the date portion of a date time
`DateDiff()`	Calculates the difference between two dates
`Date_Add()`	Highly flexible date arithmetic function

`Date_Format()`	Returns a formatted date or time string
`Day()`	Returns the day portion of a date
`DayOfWeek()`	Returns the day of week for a date
`Hour()`	Returns the hour portion of a time
`Minute()`	Returns the minute portion of a time
`Month()`	Returns the month portion of a date
`Now()`	Returns the current date and time
`Second()`	Returns the second portion of a time
`Time()`	Returns the time portion of a date time
`Year()`	Returns the year portion of a date

This would be a good time to revisit data filtering using `WHERE`. Thus far we have filtered data using `WHERE` clauses that compared numbers and text, but frequently data needs to be filtered by date. Filtering by date requires some extra care, and the use of special MySQL functions.

The first thing to keep in mind is the date format used by MySQL. Whenever you specify a date, be it inserting or updating table values, or filtering using `WHERE` clauses, the date must be in the format `yyyy-mm-dd`. So, for September 1st, 2005 specify `2005-09-01`. Although other date formats might be recognized, this is the preferred date format because it eliminates ambiguity (after all, is 04/05/06 May 4th 2006, or April 5th 2006, or May 6th 2004, or... you get the idea).

Tip

Always Use Four-Digit Years Two-digit years are supported, and MySQL treats years `00`-`69` as `2000`-`2069` and `70`-`99` as `1970`-`1999`. While these might in fact be the intended years, it is far safer to always use a full four-digit year so MySQL does not have to make any assumptions for you.

As such, a basic date comparison should be simple enough:

- **Input**

```
SELECT cust_id, order_num
FROM orders
WHERE order_date = '2005-09-01';
```

- **Output**

```
+---------+-----------+
| cust_id | order_num |
+---------+-----------+
|   10001 |     20005 |
+---------+-----------+
```

- **Analysis**

That `SELECT` statement worked; it retrieved a single order record, one with an `order_date` of `2005-09-01`.

But is using `WHERE order_date = '2005-09-01'` safe? `order_date` has a datatype of *datetime*. This type stores dates along with time values. The values in our example tables all have times of `00:00:00`, but that might not always be the case. What if order dates were stored using the current date and time (so you'd not only know the order date but also the time of day that the order was placed)? Then `WHERE order_date = '2005-09-01'` fails if, for example, the stored `order_date` value is `2005-09-01 11:30:05`. Even though a row with that date is present, it is not retrieved because the `WHERE` match failed.

The solution is to instruct MySQL to only compare the specified date to the date portion of the column instead of using the entire column value. To do this you must use the `Date()` function. `Date(order_date)` instructs MySQL to extract just the date part of the column, and so a safer `SELECT` statement is

- **Input**

```
SELECT cust_id, order_num
```

```
FROM orders
WHERE Date(order_date) = '2005-09-01';
```

Tip

If You Mean Date Use `Date()` It's a good practice to use `Date()` if what you want is just the date, even if you know that the column only contains dates. This way, if somehow a date time value ends up in the table in the future, your SQL won't break. Oh, and yes, there is a `Time()` function, too, and it should be used when you want the time.

Both `Date()` and `Time()` were first introduced in MySQL 4.1.1.

Now that you know how to use dates to test for equality, using all of the other operators (introduced in Chapter 6, "Filtering Data") should be self-explanatory.

But one other type of date comparison warrants explanation. What if you wanted to retrieve all orders placed in September 2005? A simple equality test does not work as it matches the day of month, too. There are several solutions, one of which follows:

- **Input**

```
SELECT cust_id, order_num
FROM orders
WHERE Date(order_date) BETWEEN '2005-09-01' AND '2005-09-30';
```

- **Output**

```
+---------+-----------+
| cust_id | order_num |
+---------+-----------+
|   10001 |     20005 |
|   10003 |     20006 |
|   10004 |     20007 |
+---------+-----------+
```

- **Analysis**

Here a `BETWEEN` operator is used to define `2005-09-01` and `2005-09-30` as the range of dates to match.

Here's another solution (one that won't require you to remember how many days are in each month, or worry about Feburary in leap years):

- **Input**

```
SELECT cust_id, order_num
FROM orders
WHERE Year(order_date) = 2005 AND Month(order_date) = 9;
```

- **Analysis**

`Year()` is a function that returns the year from a date (or a date time). Similarly, `Month()` returns the month from a date. `WHERE Year(order_date) = 2005 AND Month(order_date) = 9` thus retrieves all rows that have an `order_date` in year `2005` and in month `9`.

Note

MySQL Version Differences Many of the MySQL date and time functions were added in MySQL 4.1.1. If you are using an earlier version of MySQL, be sure to consult your documentation to determine exactly which of these functions is available to you.

Numeric Manipulation Functions

Numeric manipulation functions do just thatmanipulate numeric data. These functions tend to be used primarily for algebraic, trigonometric, or geometric calculations and, therefore, are not as frequently used as string or date and time manipulation functions.

The ironic thing is that of all the functions found in the major DBMSs, the numeric functions are the ones that are most uniform and consistent. Table 11.3 lists some of the more commonly used numeric manipulation functions.

Table 11.3. Commonly Used Numeric Manipulation Functions

Function	Description
`Abs()`	Returns a number's absolute value
`Cos()`	Returns the trigonometric cosine of a specified angle
`Exp()`	Returns the exponential value of a specific number
`Mod()`	Returns the remainder of a division operation
`Pi()`	Returns the value of pi
`Rand()`	Returns a random number
`Sin()`	Returns the trigonometric sine of a specified angle
`Sqrt()`	Returns the square root of a specified number
`Tan()`	Returns the trigonometric tangent of a specified angle

Summary

In this chapter, you learned how to use SQL's data manipulation functions, and paid special attention to working with dates.

Chapter 12. Summarizing Data

In this chapter, you will learn what the SQL aggregate functions are and how to use them to summarize table data.

Using Aggregate Functions

It is often necessary to summarize data without actually retrieving it all, and MySQL provides special functions for this purpose. Using these functions, MySQL queries are often used to retrieve data for analysis and reporting purposes. Examples of this type of retrieval are

- Determining the number of rows in a table (or the number of rows that meet some condition or contain a specific value)
- Obtaining the sum of a group of rows in a table
- Finding the highest, lowest, and average values in a table column (either for all rows or for specific rows)

In each of these examples, you want a summary of the data in a table, not the actual data itself. Therefore, returning the actual table data would be a waste of time and processing resources (not to mention bandwidth). To repeat, all you really want is the summary information.

To facilitate this type of retrieval, MySQL features a set of aggregate functions, some of which are listed in Table 12.1. These functions enable you to perform all the types of retrieval just enumerated.

Table 12.1. SQL Aggregate Functions

Function	Description
`AVG()`	Returns a column's average value
`COUNT()`	Returns the number of rows in a column
`MAX()`	Returns a column's highest value
`MIN()`	Returns a column's lowest value
`SUM()`	Returns the sum of a column's values

New Term

Aggregate Functions Functions that operate on a set of rows to calculate and return a single value.

The use of each of these functions is explained in the following sections.

Note

Standard Deviation A series of standard deviation aggregate functions are also supported by MySQL, but they are not covered in this book.

The `AVG()` Function

`AVG()` is used to return the average value of a specific column by counting both the number of rows in the table and the sum of their values. `AVG()` can be used to return the average value of all columns or of specific columns or rows.

This first example uses `AVG()` to return the average price of all the products in the `products` table:

- **Input**

```
SELECT AVG(prod_price) AS avg_price
FROM products;
```

- **Output**

```
+-----------+
| avg_price |
+-----------+
| 16.133571 |
+-----------+
```

- **Analysis**

The previous `SELECT` statement returns a single value, `avg_price`, that contains the average price of all products in the `products` table. `avg_price` is an alias as explained in Chapter 10, "Creating Calculated Fields."

`AVG()` can also be used to determine the average value of specific columns or rows. The following example returns the average price of products offered by a specific vendor:

- **Input**

```
SELECT AVG(prod_price) AS avg_price
FROM products
WHERE vend_id = 1003;
```

- **Output**

```
+-----------+
| avg_price |
+-----------+
| 13.212857 |
+-----------+
```

- **Analysis**

This `SELECT` statement differs from the previous one only in that this one contains a `WHERE` clause. The `WHERE` clause filters only products with a `vend_id` of `1003`, and, therefore, the value returned in `avg_price` is the average of just that vendor's products.

Caution

Individual Columns Only `AVG()` may only be used to determine the average of a specific numeric column, and that column name must be specified as the function parameter. To obtain the average value of multiple columns, multiple

AVG() functions must be used.

Note

NULL Values Column rows containing NULL values are ignored by the AVG() function.

The COUNT() Function

COUNT() does just that: It counts. Using COUNT(), you can determine the number of rows in a table or the number of rows that match a specific criterion.

COUNT() can be used two ways:

- Use COUNT(*) to count the number of rows in a table, whether columns contain values or NULL values.
- Use COUNT(column) to count the number of rows that have values in a specific column, ignoring NULL values.

This first example returns the total number of customers in the customers table:

- **Input**

```
SELECT COUNT(*) AS num_cust
FROM customers;
```

- **Output**

```
+----------+
| num_cust |
+-----------+
|         5 |
+-----------+
```

- **Analysis**

In this example, `COUNT(*)` is used to count all rows, regardless of values. The count is returned in `num_cust`.

The following example counts just the customers with an email address:

- **Input**

```
SELECT COUNT(cust_email) AS num_cust
FROM customers;
```

- **Output**

```
+-----------+
| num_cust  |
+-----------+
|         3 |
+-----------+
```

- **Analysis**

This `SELECT` statement uses `COUNT(cust_email)` to count only rows with a value in the `cust_email` column. In this example, `cust_email` is `3` (meaning that only three of the five customers have email addresses).

Note

`NULL` Values Column rows with `NULL` values in them are ignored by the `COUNT()` function if a column name is specified, but not if the asterisk (`*`) is used.

The `MAX()` Function

`MAX()` returns the highest value in a specified column. `MAX()` requires that the column name be specified, as seen here:

- **Input**

```
SELECT MAX(prod_price) AS max_price
FROM products;
```

- **Output**

```
+-----------+
| max_price |
+-----------+
|     55.00 |
+-----------+
```

- **Analysis**

Here `MAX()` returns the price of the most expensive item in `products` table.

Tip

Using `MAX()` with Non-Numeric Data Although `MAX()` is usually used to find the highest numeric or date values, MySQL allows it to be used to return the highest value in any column including textual columns. When used with textual data, `MAX()` returns the row that would be the last if the data were sorted by that column.

Note

`NULL` Values Column rows with `NULL` values in them are ignored by the `MAX()` function.

The `MIN()` Function

`MIN()` does the exact opposite of `MAX()`; it returns the lowest value in a specified column. Like `MAX()`, `MIN()` requires that the column name be specified, as seen here:

- **Input**

```
SELECT MIN(prod_price) AS min_price
FROM products;
```

- **Output**

```
+-----------+
| min_price |
+-----------+
| 2.50      |
+-----------+
```

- **Analysis**

Here `MIN()` returns the price of the least expensive item in `products` table.

Tip

Using `MIN()` with Non-Numeric Data As with the `MAX()` function, MySQL allows `MIN()` to be used to return the lowest value in any columns including textual columns. When used with textual data, `MIN()` returns the row that would be first if the data were sorted by that column.

Note

NULL Values Column rows with NULL values in them are ignored by the MIN() function.

The SUM() Function

SUM() is used to return the sum (total) of the values in a specific column.

Here is an example to demonstrate this. The orderitems table contains the actual items in an order, and each item has an associated quantity. The total number of items ordered (the sum of all the quantity values) can be retrieved as follows:

- **Input**

```
SELECT SUM(quantity) AS items_ordered
FROM orderitems
WHERE order_num = 20005;
```

- **Output**

```
+----------------+
| items_ordered |
+----------------+
| 19             |
+----------------+
```

- **Analysis**

The function SUM(quantity) returns the sum of all the item quantities in an order, and the WHERE clause ensures that just the right order items are included.

SUM() can also be used to total calculated values. In this next example the total order amount is retrieved by totaling item_price*quantity for each item:

- **Input**

```
SELECT SUM(item_price*quantity) AS total_price
FROM orderitems
WHERE order_num = 20005;
```

- **Output**

```
+-------------+
| total_price |
+-------------+
|      149.87 |
+-------------+
```

- **Analysis**

The function `SUM(item_price*quantity)` returns the sum of all the expanded prices in an order, and again the `WHERE` clause ensures that just the correct order items are included.

Tip

Performing Calculations on Multiple Columns All the aggregate functions can be used to perform calculations on multiple columns using the standard mathematical operators, as shown in the example.

Note

`NULL` Values Column rows with `NULL` values in them are ignored by the `SUM()` function.

Aggregates on Distinct Values

Note

MySQL 5 or Later The use of `DISTINCT` in aggregate functions, as about to be described, was added in MySQL 5.0.3. The following does not work in MySQL 4.x.

The five aggregate functions can all be used in two ways:

- To perform calculations on all rows, specify the `ALL` argument, or specify no argument at all (because `ALL` is the default behavior).
- To only include unique values, specify the `DISTINCT` argument.

Tip

`ALL` Is Default The `ALL` argument need not be specified because it is the default behavior. If `DISTINCT` is not specified, `ALL` is assumed.

The following example uses the `AVG()` function to return the average product price offered by a specific vendor. It is the same `SELECT` statement used in the previous example, but here the `DISTINCT` argument is used so the average only takes into account unique prices:

- **Input**

```
SELECT AVG(DISTINCT prod_price) AS avg_price
FROM products
WHERE vend_id = 1003;
```

• **Output**

```
+-----------+
| avg_price |
+-----------+
| 15.998000 |
+-----------+
```

• **Analysis**

As you can see, in this example `avg_price` is higher when `DISTINCT` is used because there are multiple items with the same lower price. Excluding them raises the average price.

Caution

Caution `DISTINCT` may only be used with `COUNT()` if a column name is specified. `DISTINCT` may not be used with `COUNT(*)`, and so `COUNT(DISTINCT *)` is not allowed and generates an error. Similarly, `DISTINCT` must be used with a column name and not with a calculation or expression.

Tip

Using `DISTINCT` with `MIN()` and `MAX()` Although `DISTINCT` can technically be used with `MIN()` and `MAX()`, there is actually no value in doing so. The minimum and maximum values in a column are the same whether or not only distinct values are included.

Combining Aggregate Functions

All the examples of aggregate functions used thus far have involved a single function. But actually, `SELECT` statements may contain as few or as many aggregate functions as needed. Look at this example:

- **Input**

```
SELECT COUNT(*) AS num_items,
       MIN(prod_price) AS price_min,
       MAX(prod_price) AS price_max,
       AVG(prod_price) AS price_avg
FROM products;
```

- **Output**

```
+-----------+-----------+-----------+-----------+
| num_items | price_min | price_max | price_avg |
+-----------+-----------+-----------+-----------+
|        14 |      2.50 |     55.00 | 16.133571 |
+-----------+-----------+-----------+-----------+
```

- **Analysis**

Here a single `SELECT` statement performs four aggregate calculations in one step and returns four values (the number of items in the `products` table; and the highest, lowest, and average product prices).

Tip

Naming Aliases When specifying alias names to contain the results of an aggregate function, try to not use the name of an actual column in the table. Although there is nothing actually illegal about doing so, using unique names makes your SQL easier to understand and work with (and troubleshoot in the future).

Summary

Aggregate functions are used to summarize data. MySQL supports a range of aggregate functions, all of which can be used in multiple ways to return just the results you need. These functions are designed to be highly efficient, and they usually return results far more quickly than you could calculate them yourself within your own client application.

Chapter 13. Grouping Data

In this chapter, you'll learn how to group data so you can summarize subsets of table contents. This involves two new `SELECT` *statement clauses: the* `GROUP BY` *clause and the* `HAVING` *clause*.

Understanding Data Grouping

In the previous chapter, you learned that the SQL aggregate functions can be used to summarize data. This enables you to count rows, calculate sums and averages, and obtain high and low values without having to retrieve all the data.

All the calculations thus far were performed on all the data in a table or on data that matched a specific `WHERE` clause. As a reminder, the following example returns the number of products offered by vendor `1003`:

- **Input**

```
SELECT COUNT(*) AS num_prods
FROM products
WHERE vend_id = 1003;
```

- **Output**

```
+-----------+
| num_prods |
+-----------+
|         7 |
+-----------+
```

But what if you want to return the number of products offered by each vendor? Or products offered by vendors who offer a single product, or only those who offer more than 10 products?

This is where groups come into play. Grouping enables you to divide data into logical sets so you can perform aggregate calculations on each group.

Creating Groups

Groups are created using the `GROUP BY` clause in your `SELECT` statement. The best way to understand this is to look at an example:

- **Input**

```
SELECT vend_id, COUNT(*) AS num_prods
FROM products
GROUP BY vend_id;
```

- **Output**

```
+---------+-----------+
| vend_id | num_prods |
+---------+-----------+
|    1001 |         3 |
|    1002 |         2 |
|    1003 |         7 |
|    1005 |         2 |
+---------+-----------+
```

- **Analysis**

The above `SELECT` statement specifies two columns, `vend_id`, which contains the ID of a product's vendor, and `num_prods`, which is a calculated field (created using the `COUNT(*)` function). The `GROUP BY` clause instructs MySQL to sort the data and group it by `vend_id`. This causes `num_prods` to be calculated once per `vend_id` rather than once for the entire table. As you can see in the output, vendor `1001` has `3` products listed, vendor `1002` has `2` products listed, vendor `1003` has `7` products listed, and vendor `1005` has `2` products listed.

Because you used `GROUP BY`, you did not have to specify each group to be evaluated and calculated. That was done automatically. The `GROUP BY` clause instructs MySQL to group the data and then perform the aggregate on each group rather than on the entire result set.

Before you use `GROUP BY`, here are some important rules about its use that you need to know:

- GROUP BY clauses can contain as many columns as you want. This enables you to nest groups, providing you with more granular control over how data is grouped.
- If you have nested groups in your GROUP BY clause, data is summarized at the last specified group. In other words, all the columns specified are evaluated together when grouping is established (so you won't get data back for each individual column level).
- Every column listed in GROUP BY must be a retrieved column or a valid expression (but not an aggregate function). If an expression is used in the SELECT, that same expression must be specified in GROUP BY. Aliases cannot be used.
- Aside from the aggregate calculations statements, every column in your SELECT statement should be present in the GROUP BY clause.
- If the grouping column contains a row with a NULL value, NULL will be returned as a group. If there are multiple rows with NULL values, they'll all be grouped together.
- The GROUP BY clause must come after any WHERE clause and before any ORDER BY clause.

Tip

Using ROLLUP To obtain values at each group and at a summary level (for each group), use the WITH ROLLUP keyword, as seen here:

```
SELECT vend_id, COUNT(*) AS num_prods
FROM products
GROUP BY vend_id WITH ROLLUP;
```

Filtering Groups

In addition to being able to group data using `GROUP BY`, MySQL also allows you to filter which groups to include and which to exclude. For example, you might want a list of all customers who have made at least two orders. To obtain this data you must filter based on the complete group, not on individual rows.

You've already seen the `WHERE` clause in action (introduced in Chapter 6, "Filtering Data"). But `WHERE` does not work here because `WHERE` filters specific rows, not groups. As a matter of fact, `WHERE` has no idea what a group is.

So what do you use instead of `WHERE`? MySQL provides yet another clause for this purpose: the `HAVING` clause. `HAVING` is very similar to `WHERE`. In fact, all types of `WHERE` clauses you learned about thus far can also be used with `HAVING`. The only difference is that `WHERE` filters rows and `HAVING` filters groups.

Tip

`HAVING` Supports All of `WHERE`'s Operators In Chapter 6 and Chapter 7, "Advanced Data Filtering," you learned about `WHERE` clause conditions (including wildcard conditions and clauses with multiple operators). All the techniques and options you learned about `WHERE` can be applied to `HAVING`. The syntax is identical; just the keyword is different.

So how do you filter rows? Look at the following example:

- **Input**

```
SELECT cust_id, COUNT(*) AS orders
FROM orders
GROUP BY cust_id
HAVING COUNT(*) >= 2;
```

- **Output**

```
j115+---------+--------+
| cust_id | orders |
+---------+--------+
|   10001 |      2 |
+---------+--------+
```

• **Analysis**

The first three lines of this `SELECT` statement are similar to the statements seen previously. The final line adds a `HAVING` clause that filters on those groups with a `COUNT(*) >= 2`two or more orders.

As you can see, a `WHERE` clause does not work here because the filtering is based on the group aggregate value, not on the values of specific rows.

Note

The Difference Between `HAVING` and `WHERE` Here's another way to look at it: `WHERE` filters before data is grouped, and `HAVING` filters after data is grouped. This is an important distinction; rows that are eliminated by a `WHERE` clause are not included in the group. This could change the calculated values, which in turn could affect which groups are filtered based on the use of those values in the `HAVING` clause.

So is there ever a need to use both `WHERE` and `HAVING` clauses in one statement? Actually, yes, there is. Suppose you want to further filter the previous statement so it returns any customers who placed two or more orders in the past 12 months. To do that, you can add a `WHERE` clause that filters out just the orders placed in the past 12 months. You then add a `HAVING` clause to filter just the groups with two or more rows in them.

To better demonstrate this, look at the following example that lists all vendors who have `2` or more products priced at `10` or more:

• **Input**

```
SELECT vend_id, COUNT(*) AS num_prods
FROM products
WHERE prod_price >= 10
```

```
GROUP BY vend_id
HAVING COUNT(*) >= 2;
```

• **Output**

```
+---------+-----------+
| vend_id | num_prods |
+---------+-----------+
|    1003 |         4 |
|    1005 |         2 |
+---------+-----------+
```

• **Analysis**

This statement warrants an explanation. The first line is a basic `SELECT` using an aggregate functionmuch like the examples thus far. The `WHERE` clause filters all rows with a `prod_price` of at least `10`. Data is then grouped by `vend_id`, and then a `HAVING` clause filters just those groups with a count of `2` or more. Without the `WHERE` clause two extra rows would have been retrieved (vendor `1002` who only sells products all priced under `10`, and vendor `1001` who sells three products but only one of them is priced greater or equal to `10`) as seen here:

• **Input**

```
SELECT vend_id, COUNT(*) AS num_prods
FROM products
GROUP BY vend_id
HAVING COUNT(*) >= 2;
```

• **Output**

```
+---------+-----------+
| vend_id | num_prods |
+---------+-----------+
|    1001 |         3 |
|    1002 |         2 |
|    1003 |         7 |
|     1005 |           2 |
+----------+-------------+
```

Grouping and Sorting

It is important to understand that `GROUP BY` and `ORDER BY` are very different, even though they often accomplish the same thing. Table 13.1 summarizes the differences between them.

Table 13.1. `ORDER BY` Versus `GROUP BY`

`ORDER BY`	`GROUP BY`
Sorts generated output.	Groups rows. The output might not be in group order, however.
Any columns (even columns not selected) may be used.	Only selected columns or expressions columns may be used, and every selected column expression must be used.
Never required.	Required if using columns (or expressions) with aggregate functions.

The first difference listed in Table 13.1 is extremely important. More often than not, you will find that data grouped using `GROUP BY` will indeed be output in group order. But that is not always the case, and it is not actually required by the SQL specifications. Furthermore, you might actually want it sorted differently than it is grouped. Just because you group data one way (to obtain group-specific aggregate values) does not mean that you want the output sorted that same way. You should always provide an explicit `ORDER BY` clause as well, even if it is identical to the `GROUP BY` clause.

Tip

Don't Forget `ORDER BY` As a rule, anytime you use a `GROUP BY` clause, you should also specify an `ORDER BY` clause. That is the only way to ensure that data is sorted properly. Never rely on `GROUP BY` to sort your data.

To demonstrate the use of both `GROUP BY` and `ORDER BY`, let's look at an example.

The following SELECT statement is similar to the ones seen previously. It retrieves the order number and total order price of all orders with a total price of 50 or more:

- **Input**

```
SELECT order_num, SUM(quantity*item_price) AS ordertotal
FROM orderitems
GROUP BY order_num
HAVING SUM(quantity*item_price) >= 50;
```

- **Output**

```
+-----------+------------+
| order_num | ordertotal |
+-----------+------------+
|     20005 | 149.87     |
|     20006 | 55.00      |
|     20007 | 1000.00    |
|     20008 | 125.00     |
+-----------+------------+
```

To sort the output by order total, all you need to do is add an ORDER BY clause, as follows:

- **Input**

```
SELECT order_num, SUM(quantity*item_price) AS ordertotal
FROM orderitems
GROUP BY order_num
HAVING SUM(quantity*item_price) >= 50
ORDER BY ordertotal;
```

- **Output**

```
+-----------+------------+
| order_num | ordertotal |
+-----------+------------+
|      20006 | 55.00        |
|      20008 | 125.00       |
|      20005 | 149.87       |
|      20007 | 1000.00      |
+-----------+------------+
```

• Analysis

In this example, the `GROUP BY` clause is used to group the data by order number (the `order_num` column) so that the `SUM(*)` function can return the total order price. The `HAVING` clause filters the data so that only orders with a total price of `50` or more are returned. Finally, the output is sorted using the `ORDER BY` clause.

SELECT Clause Ordering

This is probably a good time to review the order in which `SELECT` statement clauses are to be specified. Table 13.2 lists all the clauses you have learned thus far, in the order they must be used.

Table 13.2. `SELECT` Clauses and Their Sequence

Clause	Description	Required
`SELECT`	Columns or expressions to be returned	Yes
`FROM`	Table to retrieve data from	Only if selecting data from a table
`WHERE`	Row-level filtering	No
`GROUP BY`	Group specification	Only if calculating aggregates by group
`HAVING`	Group-level filtering	No
`ORDER BY`	Output sort order	No
`LIMIT`	Number of rows to retrieve	No

Summary

In Chapter 12, "Summarizing Data," you learned how to use the SQL aggregate functions to perform summary calculations on your data. In this chapter, you learned how to use the `GROUP BY` clause to perform these calculations on groups of data, returning results for each group. You saw how to use the `HAVING` clause to filter specific groups. You also learned the difference between `ORDER BY` and `GROUP BY` and between `WHERE` and `HAVING`.

Chapter 14. Working with Subqueries

In this chapter, you'll learn what subqueries are and how to use them.

Understanding Subqueries

Note

Version Requirements Support for subqueries was introduced in MySQL 4.1. To use the SQL described in this chapter, you must be running MySQL 4.1 or later.

`SELECT` statements are SQL queries. All the `SELECT` statements you have seen thus far are simple queries: single statements retrieving data from individual database tables.

New Term

Query Any SQL statement. However, the term is usually used to refer to `SELECT` statements.

SQL also enables you to create *subqueries*: queries that are embedded into other queries. Why would you want to do this? The best way to understand this concept is to look at a couple of examples.

Filtering by Subquery

The database tables used in all the chapters in this book are relational tables. (See Appendix B, "The Example Tables," for a description of each of the tables and their relationships.) Order data is stored in two tables. The `orders` table stores a single row for each order containing order number, customer ID, and order date. The individual order items are stored in the related `orderitems` table. The `orders` table does not store customer information. It only stores a customer ID. The actual customer information is stored in the `customers` table.

Now suppose you wanted a list of all the customers who ordered item `TNT2`. What would you have to do to retrieve this information? Here are the steps:

1. Retrieve the order numbers of all orders containing item `TNT2`.
2. Retrieve the customer ID of all the customers who have orders listed in the order numbers returned in the previous step.
3. Retrieve the customer information for all the customer IDs returned in the previous step.

Each of these steps can be executed as a separate query. By doing so, you use the results returned by one `SELECT` statement to populate the `WHERE` clause of the next `SELECT` statement.

You can also use subqueries to combine all three queries into one single statement.

The first `SELECT` statement should be self-explanatory by now. It retrieves the `order_num` column for all order items with a `prod_id` of `TNT2`. The output lists the two orders containing this item:

- **Input**

```
SELECT order_num
FROM orderitems
WHERE prod_id = 'TNT2';
```

- **Output**

```
+-----------+
| order_num |
+-----------+
|     20005 |
|     20007 |
+-----------+
```

The next step is to retrieve the customer IDs associated with orders `20005` and `20007`. Using the `IN` clause described in Chapter 7, "Advanced Data Filtering," you can create a `SELECT` statement as follows:

- **Input**

```
SELECT cust_id
FROM orders
WHERE order_num IN (20005,20007);
```

- **Output**

```
+---------+
| cust_id |
+---------+
|   10001 |
|   10004 |
+---------+
```

Now, combine the two queries by turning the first (the one that returned the order numbers) into a subquery. Look at the following `SELECT` statement:

- **Input**

```
SELECT cust_id
FROM orders
WHERE order_num IN (SELECT order_num
                    FROM orderitems
                    WHERE prod_id = 'TNT2');
```

• **Output**

```
+---------+
| cust_id |
+---------+
|   10001 |
|   10004 |
+---------+
```

• **Analysis**

Subqueries are always processed starting with the innermost `SELECT` statement and working outward. When the preceding `SELECT` statement is processed, MySQL actually performs two operations.

First it runs the subquery

```
SELECT order_num FROM orderitems WHERE prod_id='TNT2'
```

That query returns the two order numbers `20005` and `20007`. Those two values are then passed to the `WHERE` clause of the outer query in the comma-delimited format required by the `IN` operator. The outer query now becomes

```
SELECT cust_id FROM orders WHERE order_num IN (20005,20007)
```

As you can see, the output is correct and exactly the same as the output returned by the previous hard-coded `WHERE` clause.

Tip

Formatting Your SQL `SELECT` statements containing subqueries can be difficult to read and debug, especially as they grow in complexity. Breaking up the queries over multiple lines and indenting the lines appropriately as shown here can greatly simplify working with subqueries.

You now have the IDs of all the customers who ordered item `TNT2`. The next step is to retrieve the customer information for each of those customer IDs. The SQL statement to retrieve the two columns is

• **Input**

```
SELECT cust_name, cust_contact
FROM customers
WHERE cust_id IN (10001,10004);
```

Instead of hard-coding those customer IDs, you can turn this `WHERE` clause into yet another subquery:

• **Input**

```
SELECT cust_name, cust_contact
FROM customers
WHERE cust_id IN (SELECT cust_id
                  FROM orders
                  WHERE order_num IN (SELECT order_num
                                      FROM orderitems
                                      WHERE prod_id = 'TNT2'));
```

• **Output**

```
+----------------+--------------+
| cust_name      | cust_contact |
+----------------+--------------+
| Coyote Inc.    | Y Lee        |
| Yosemite Place | Y Sam        |
+----------------+--------------+
```

• **Analysis**

To execute this `SELECT` statement, MySQL had to actually perform three `SELECT` statements. The innermost subquery returned a list of order numbers that were then used as the `WHERE` clause for the subquery above it. That subquery returned a list of customer IDs that were used as the `WHERE` clause for the top-level query. The top-level query actually returned the desired data.

As you can see, using subqueries in a `WHERE` clause enables you to write extremely powerful and flexible SQL statements. There is no limit imposed on the number of subqueries that can be nested, although in practice you will find that performance tells you when you are nesting too deeply.

Caution

Columns Must Match When using a subquery in a `WHERE` clause (as seen here), make sure that the `SELECT` statements have the same number of columns as in the `WHERE` clause. Usually, a single column will be returned by the subquery and matched against a single column, but multiple columns may be used if needed.

Although usually used in conjunction with the `IN` operator, subqueries can also be used to test for equality (using `=`), non-equality (using `<>`), and so on.

Caution

Subqueries and Performance The code shown here works, and it achieves the desired result. However, using subqueries is not always the most efficient way to perform this type of data retrieval, although it might be. More on this is in Chapter 15, "Joining Tables," where you will revisit this same example.

Using Subqueries As Calculated Fields

Another way to use subqueries is in creating calculated fields. Suppose you want to display the total number of orders placed by every customer in your `customers` table. Orders are stored in the `orders` table along with the appropriate customer ID.

To perform this operation, follow these steps:

1. Retrieve the list of customers from the `customers` table.
2. For each customer retrieved, count the number of associated orders in the `orders` table.

As you learned in the previous two chapters, you can use `SELECT COUNT(*)` to count rows in a table, and by providing a `WHERE` clause to filter a specific customer ID, you can count just that customer's orders. For example, the following code counts the number of orders placed by customer `10001`:

- **Input**

```
SELECT COUNT(*) AS orders
FROM orders
WHERE cust_id = 10001;
```

To perform that `COUNT(*)` calculation for each customer, use `COUNT*` as a subquery. Look at the following code:

- **Input**

```
SELECT cust_name,
       cust_state,
       (SELECT COUNT(*)
        FROM orders
        WHERE orders.cust_id = customers.cust_id) AS orders
FROM customers
ORDER BY cust_name;
```

- **Output**

```
+-----------------+------------+--------+
| cust_name       | cust_state | orders |
+-----------------+------------+--------+
| Coyote Inc.     | MI         |      2 |
| E Fudd          | IL         |      1 |
| Mouse House     | OH         |      0 |
| Wascals         | IN         |      1 |
| Yosemite Place  | AZ         |      1 |
+-----------------+------------+--------+
```

- **Analysis**

This SELECT statement returns three columns for every customer in the customers table: cust_name, cust_state, and orders. orders is a calculated field that is set by a subquery provided in parentheses. That subquery is executed once for every customer retrieved. In this example, the subquery is executed five times because five customers were retrieved.

The WHERE clause in the subquery is a little different from the WHERE clauses used previously because it uses fully qualified column names (first mentioned in Chapter 4, "Retrieving Data"). The following clause tells SQL to compare the cust_id in the orders table to the one currently being retrieved from the customers table:

```
WHERE orders.cust_id = customers.cust_id
```

New Term

Correlated Subquery A subquery that refers to the outer query.

The type of subquery is called a *correlated subquery*. This syntaxthe table name and the column name separated by a periodmust be used whenever there is possible ambiguity about column names. Why? Well, let's look at what happens if fully qualified column names are not used:

- **Input**

```
SELECT cust_name,
       cust_state,
       (SELECT COUNT(*)
        FROM orders
        WHERE cust_id = cust_id) AS orders
FROM customers
ORDER BY cust_name;
```

- **Output**

```
+----------------+------------+--------+
| cust_name      | cust_state | orders |
+----------------+------------+--------+
| Coyote Inc.    | MI         |      5 |
| E Fudd         | IL         |      5 |
| Mouse House    | OH         |      5 |
| Wascals        | IN         |      5 |
| Yosemite Place | AZ         |      5 |
+----------------+------------+--------+
```

- **Analysis**

Obviously the returned results are incorrect (compare them to the previous results), but why did this happen? There are two `cust_id` columns, one in `customers` and one in `orders`, and those two columns need to be compared to correctly match orders with their appropriate customers. Without fully qualifying the column names, MySQL assumes you are comparing the `cust_id` in the `orders` table to itself. And

```
SELECT COUNT(*) FROM orders WHERE cust_id = cust_id;
```

always returns the total number of orders in the `orders` table (because MySQL checks to see that every order's `cust_id` matches itself, which it always does, of course).

Although subqueries are extremely useful in constructing this type of `SELECT` statement, care must be taken to properly qualify ambiguous column names.

Note

Always More Than One Solution As explained earlier in this chapter, although the sample code shown here works, it is often not the most efficient way to perform this type of data retrieval. You will revisit this example in a later chapter.

Tip

Build Queries with Subqueries Incrementally Testing and debugging queries with subqueries can be tricky, particularly as these statements grow in complexity. The safest way to build (and test) queries with subqueries is to do so incrementally, in much the same way as MySQL processes them. Build and test the innermost query first. Then build and test the outer query with hard-coded data, and only after you have verified that it is working embed the subquery. Then test it again. And keep repeating these steps as for each additional query. This will take just a little longer to construct your queries, but doing so saves you lots of time later (when you try to figure out why queries are not working) and significantly increases the likelihood of them working the first time.

Summary

In this chapter, you learned what subqueries are and how to use them. The most common uses for subqueries are in `WHERE` clauses, in `IN` operators, and for populating calculated columns. You saw examples of both of these types of operations.

Chapter 15. Joining Tables

In this chapter, you'll learn what joins are, why they are used, and how to create `SELECT` *statements using them*.

Understanding Joins

One of SQL's most powerful features is the capability to join tables on-the-fly within data retrieval queries. Joins are one of the most important operations you can perform using SQL `SELECT`, and a good understanding of joins and join syntax is an extremely important part of learning SQL.

Before you can effectively use joins, you must understand relational tables and the basics of relational database design. What follows is by no means a complete coverage of the subject, but it should be enough to get you up and running.

Understanding Relational Tables

The best way to understand relational tables is to look at a realworld example.

Suppose you had a database table containing a product catalog, with each catalog item in its own row. The kind of information you would store with each item would include a product description and price, along with vendor information about the company that creates the product.

Now suppose you had multiple catalog items created by the same vendor. Where would you store the vendor information (things such as vendor name, address, and contact information)? You wouldn't want to store that data along with the products for several reasons:

- Because the vendor information is the same for each product that vendor produces, repeating the information for each product is a waste of time and storage space.

- If vendor information changes (for example, if the vendor moves or his area code changes), you would need to update every occurrence of the vendor information.

- When data is repeated (that is, the vendor information is used with each product), there is a high likelihood that the data will not be entered exactly the same way each time. Inconsistent data is extremely difficult to use in reporting.

The key here is that having multiple occurrences of the same data is never a good thing, and that principle is the basis for relational database design. Relational tables are designed so information is split into multiple tables, one for each data type. The tables are related to each other through common values (and thus the *relational* in relational design).

In our example, you can create two tables, one for vendor information and one for product information. The `vendors` table contains all the vendor information, one table row per vendor, along with a unique identifier for each vendor. This value, called a *primary key*, can be a vendor ID, or any other unique value. (Primary keys were first mentioned in Chapter 1, "Understanding SQL").

The `products` table stores only product information, and no vendor specific information other than the vendor ID (the `vendors` table's primary key). This key, called a *foreign key*, relates the `vendors` table to the `products` table, and using this vendor ID enables you to use the `vendors` table to find the details about the appropriate vendor.

New Term

Foreign Key A column in one table that contains the primary key values from another table, thus defining the relationships between tables.

What does this do for you? Well, consider the following:

- Vendor information is never repeated, and so time and space are not wasted.
- If vendor information changes, you can update a single record in the `vendors` table. Data in related tables does not change.
- As no data is repeated, the data used is obviously consistent, making data reporting and manipulation much simpler.

The bottom line is that relational data can be stored efficiently and manipulated easily. Because of this, relational databases scale far better than non-relational databases.

New Term

Scale Able to handle an increasing load without failing. A well-designed database or application is said to *scale well*.

Why Use Joins?

As just explained, breaking data into multiple tables enables more efficient storage, easier manipulation, and greater scalability. But these benefits come with a price.

If data is stored in multiple tables, how can you retrieve that data with a single `SELECT` statement?

The answer is to use a join. Simply put, a join is a mechanism used to associate tables within a `SELECT` statement (and thus the name join). Using a special syntax, multiple tables can be joined so a single set of output is returned, and the join associates the correct rows in each table on-the-fly.

Note

Maintaining Referential Integrity It is important to understand that a join is not a physical entityin other words, it does not exist in the actual database tables. A join is created by MySQL as needed, and it persists for the duration of the query execution.

When using relational tables, it is important that only valid data is inserted into relational columns. Going back to the example, if products were stored in the `products` table with an invalid vendor ID (one not present in the `vendors` table), those products would be inaccessible because they would not be related to any vendor.

To prevent this from occurring, MySQL can be instructed to only allow valid values (ones present in the `vendors` table) in the vendor ID column in the `products` table. This is known as maintaining *referential integrity*, and is achieved by specifying the primary and foreign keys as part of the table definitions (as will be explained in Chapter 21, "Creating and Manipulating Tables").

Creating a Join

Creating a join is very simple. You must specify all the tables to be included and how they are related to each other. Look at the following example:

- **Input**

```
SELECT vend_name, prod_name, prod_price
FROM vendors, products
WHERE vendors.vend_id = products.vend_id
ORDER BY vend_name, prod_name;
```

- **Output**

```
+-------------+----------------+------------+
| vend_name   | prod_name      | prod_price |
+-------------+----------------+------------+
| ACME        | Bird seed      | 10.00      |
| ACME        | Carrots        | 2.50       |
| ACME        | Detonator      | 13.00      |
| ACME        | Safe           | 50.00      |
| ACME        | Sling          | 4.49       |
| ACME        | TNT (1 stick)  | 2.50       |
| ACME        | TNT (5 sticks) | 10.00      |
| Anvils R Us | .5 ton anvil   | 5.99       |
| Anvils R Us | 1 ton anvil    | 9.99       |
| Anvils R Us | 2 ton anvil    | 14.99      |
| Jet Set     | JetPack 1000   | 35.00      |
| Jet Set     | JetPack 2000   | 55.00      |
| LT Supplies | Fuses          | 3.42       |
| LT Supplies | Oil can        | 8.99       |
+-------------+----------------+------------+
```

- **Analysis**

Take a look at the preceding code. The `SELECT` statement starts in the same way as all the statements you've looked at thus far, by specifying the columns to be retrieved. The big difference here is that two of the specified columns (`prod_name` and `prod_price`) are in one table, whereas the other (`vend_name`) is in another table.

Now look at the `FROM` clause. Unlike all the prior `SELECT` statements, this one has two tables listed in the `FROM` clause, `vendors` and `products`. These are the names of the two tables that are being joined in this `SELECT` statement. The tables are correctly joined with a `WHERE` clause that instructs MySQL to match `vend_id` in the `vendors` table with `vend_id` in the `products` table.

You'll notice that the columns are specified as `vendors.vend_id` and `products.vend_id`. This fully qualified column name is required here because if you just specified `vend_id`, MySQL cannot tell which `vend_id` columns you are referring to (as there are two of them, one in each table).

Caution

Fully Qualifying Column Names You must use the fully qualified column name (table and column separated by a period) whenever there is a possible ambiguity about to which column you are referring. MySQL returns an error message if you refer to an ambiguous column name without fully qualifying it with a table name.

The Importance of the `WHERE` Clause

It might seem strange to use a `WHERE` clause to set the join relationship, but actually, there is a very good reason for this. Remember, when tables are joined in a `SELECT` statement, that relationship is constructed on-the-fly. Nothing in the database table definitions can instruct MySQL how to join the tables. You have to do that yourself. When you join two tables, what you are actually doing is pairing every row in the first table with every row in the second table. The `WHERE` clause acts as a filter to only include rows that match the specified filter conditionthe join condition, in this case. Without the `WHERE` clause, every row in the first table is paired with every row in the second table, regardless of if they logically go together or not.

New Term

Cartesian Product The results returned by a table relationship without a join condition. The number of rows retrieved is the number of rows in the first table multiplied by the number of rows in the second table.

To understand this, look at the following `SELECT` statement and output:

- **Input**

```
SELECT vend_name, prod_name, prod_price
FROM vendors, products
ORDER BY vend_name, prod_name;
```

- **Output**

```
+-----------------+-----------------+------------+
| vend_name       | prod_name       | prod_price |
+-----------------+-----------------+------------+
| ACME            | .5 ton anvil    | 5.99       |
| ACME            | 1 ton anvil     | 9.99       |
| ACME            | 2 ton anvil     | 14.99      |
| ACME            | Bird seed       | 10.00      |
| ACME            | Carrots         | 2.50       |
| ACME            | Detonator       | 13.00      |
| ACME            | Fuses           | 3.42       |
| ACME            | JetPack 1000    | 35.00      |
| ACME            | JetPack 2000    | 55.00      |
| ACME            | Oil can         | 8.99       |
| ACME            | Safe            | 50.00      |
| ACME            | Sling           | 4.49       |
| ACME            | TNT (1 stick)   | 2.50       |
| ACME            | TNT (5 sticks)  | 10.00      |
| Anvils R Us     | .5 ton anvil    | 5.99       |
| Anvils R Us     | 1 ton anvil     | 9.99       |
| Anvils R Us     | 2 ton anvil     | 14.99      |
| Anvils R Us     | Bird seed       | 10.00      |
| Anvils R Us     | Carrots         | 2.50       |
| Anvils R Us     | Detonator       | 13.00      |
| Anvils R Us     | Fuses           | 3.42       |
| Anvils R Us     | JetPack 1000   | 35.00         |
| Anvils R Us     | JetPack 2000   | 55.00         |
| Anvils R Us     | Oil can        | 8.99          |
| Anvils R Us     | Safe           | 50.00         |
| Anvils R Us     | Sling          | 4.49          |
| Anvils R Us     | TNT (1 stick)  | 2.50          |
| Anvils R Us     | TNT (5 sticks) | 10.00         |
| Furball Inc.    | .5 ton anvil   | 5.99          |
| Furball Inc.    | 1 ton anvil    | 9.99          |
| Furball Inc.    | 2 ton anvil    | 14.99         |
| Furball Inc.    | Bird seed      | 10.00         |
| Furball Inc.    | Carrots        | 2.50          |
| Furball Inc.    | Detonator      | 13.00         |
| Furball Inc.    | Fuses          | 3.42          |
| Furball Inc.    | JetPack 1000   | 35.00         |
| Furball Inc.    | JetPack 2000   | 55.00         |
| Furball Inc.    | Oil can        | 8.99          |
| Furball Inc.    | Safe           | 50.00         |
| Furball Inc.    | Sling          | 4.49          |
| Furball Inc.    | TNT (1 stick)  | 2.50          |
| Furball Inc.    | TNT (5 sticks) | 10.00         |
| Jet Set         | .5 ton anvil   | 5.99          |
| Jet Set         | 1 ton anvil    | 9.99          |
| Jet Set         | 2 ton anvil    | 14.99         |
| Jet Set         | Bird seed      | 10.00         |
| Jet Set         | Carrots        | 2.50          |
| Jet Set         | Detonator      | 13.00         |
| Jet Set         | Fuses          | 3.42          |
| Jet Set         | JetPack 1000   | 35.00         |
| Jet Set         | JetPack 2000   | 55.00         |
| Jet Set         | Oil can        | 8.99          |
| Jet Set         | Safe           | 50.00         |
| Jet Set         | Sling          | 4.49          |
| Jet Set         | TNT (1 stick)  | 2.50          |
| Jet Set         | TNT (5 sticks) | 10.00         |
| Jouets Et Ours  | .5 ton anvil   | 5.99          |
| Jouets Et Ours  | 1 ton anvil    | 9.99          |
| Jouets Et Ours  | 2 ton anvil    | 14.99         |
| Jouets Et Ours  | Bird seed      | 10.00         |
| Jouets Et Ours  | Carrots        | 2.50          |
| Jouets Et Ours  | Detonator      | 13.00         |
| Jouets Et Ours  | Fuses          | 3.42          |
| Jouets Et Ours  | JetPack 1000   | 35.00         |
| Jouets Et Ours | JetPack 2000    | 55.00      |
| Jouets Et Ours | Oil can         | 8.99       |
| Jouets Et Ours | Safe            | 50.00      |
| Jouets Et Ours | Sling           | 4.49       |
| Jouets Et Ours | TNT (1 stick)   | 2.50       |
| Jouets Et Ours | TNT (5 sticks)  | 10.00      |
| LT Supplies    | .5 ton anvil    | 5.99       |
| LT Supplies    | 1 ton anvil     | 9.99       |
| LT Supplies    | 2 ton anvil     | 14.99      |
| LT Supplies    | Bird seed       | 10.00      |
| LT Supplies    | Carrots         | 2.50       |
| LT Supplies    | Detonator       | 13.00      |
| LT Supplies    | Fuses           | 3.42       |
| LT Supplies    | JetPack 1000    | 35.00      |
| LT Supplies    | JetPack 2000    | 55.00      |
| LT Supplies    | Oil can         | 8.99       |
| LT Supplies    | Safe            | 50.00      |
| LT Supplies    | Sling           | 4.49       |
| LT Supplies    | TNT (1 stick)   | 2.50       |
| LT Supplies    | TNT (5 sticks)  | 10.00      |
+----------------+-----------------+------------+
```

• **Analysis**

As you can see in the preceding output, the Cartesian product is seldom what you want. The data returned here has matched every product with every vendor, including products with the incorrect vendor (and even vendors with no products at all).

Caution

Don't Forget the `WHERE` Clause Make sure all your joins have `WHERE` clauses, or MySQL returns far more data than you want. Similarly, make sure your `WHERE` clauses are correct. An incorrect filter condition causes MySQL to return incorrect data.

Tip

Cross Joins Sometimes you'll hear the type of join that returns a Cartesian Product referred to as a *cross join*.

Inner Joins

The join you have been using so far is called an *equijoin*a join based on the testing of equality between two tables. This kind of join is also called an *inner join*. In fact, you may use a slightly different syntax for these joins, specifying the type of join explicitly. The following `SELECT` statement returns the exact same data as the preceding example:

- **Input**

```
SELECT vend_name, prod_name, prod_price
FROM vendors INNER JOIN products
 ON vendors.vend_id = products.vend_id;
```

- **Analysis**

The `SELECT` in the statement is the same as the preceding `SELECT` statement, but the `FROM` clause is different. Here the relationship between the two tables is part of the `FROM` clause specified as `INNER JOIN`. When using this syntax the join condition is specified using the special `ON` clause instead of a `WHERE` clause. The actual condition passed to `ON` is the same as would be passed to `WHERE`.

Note

Which Syntax to Use? Per the ANSI SQL specification, use of the `INNER JOIN` syntax is preferable. Furthermore, although using the `WHERE` clause to define joins is indeed simpler, using explicit join syntax ensures that you will never forget the join condition, and it can affect performance, too (in some cases).

Joining Multiple Tables

SQL imposes no limit to the number of tables that may be joined in a `SELECT` statement. The basic rules for creating the join remain the same. First list all the tables, and then define the relationship between each. Here is an example:

- **Input**

```
SELECT prod_name, vend_name, prod_price, quantity
FROM orderitems, products, vendors
WHERE products.vend_id = vendors.vend_id
  AND orderitems.prod_id = products.prod_id
  AND order_num = 20005;
```

- **Output**

```
+-----------------+-------------+------------+----------+
| prod_name       | vend_name   | prod_price | quantity |
+-----------------+-------------+------------+----------+
| .5 ton anvil    | Anvils R Us |       5.99 |       10 |
| 1 ton anvil     | Anvils R Us |       9.99 |        3 |
| TNT (5 sticks)  | ACME        |      10.00 |        5 |
| Bird seed       | ACME        |      10.00 |        1 |
+-----------------+-------------+------------+----------+
```

- **Analysis**

This example displays the items in order number `20005`. Order items are stored in the `orderitems` table. Each product is stored by its product ID, which refers to a product in the `products` table. The products are linked to the appropriate vendor in the `vendors` table by the vendor ID, which is stored with each product record. The `FROM` clause here lists the three tables, and the `WHERE` clause defines both of those join conditions. An additional `WHERE` condition is then used to filter just the items for order `20005`.

Caution

Performance Considerations MySQL processes joins at run-time, relating each table as specified. This process can become very resource intensive, so be careful not to join tables unnecessarily. The more tables you join, the more performance degrades.

Now would be a good time to revisit the following example from Chapter 14, "Working with Subqueries." As you will recall, this `SELECT` statement returns a list of customers who ordered product `TNT2`:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers
WHERE cust_id IN (SELECT cust_id
                  FROM orders
                  WHERE order_num IN (SELECT order_num
                                      FROM orderitems
                                      WHERE prod_id = 'TNT2'));
```

As mentioned in Chapter 14, subqueries might not always the most efficient way to perform complex `SELECT` operations, and so as promised, here is the same query using joins:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers, orders, orderitems
WHERE customers.cust_id = orders.cust_id
  AND orderitems.order_num = orders.order_num
  AND prod_id = 'TNT2';
```

- **Output**

```
+----------------+--------------+
| cust_name      | cust_contact |
+----------------+--------------+
| Coyote Inc.    | Y Lee        |
| Yosemite Place | Y Sam        |
+----------------+--------------+
```

- **Analysis**

As explained in Chapter 14, returning the data needed in this query requires the use of three tables. But instead of using them within nested subqueries, here two joins are used to connect the tables. There are three `WHERE` clause conditions here. The first two connect the tables in the join, and the last one filters the data for product `TNT2`.

Tip

It Pays to Experiment As you can see, there is often more than one way to perform any given SQL operation. And there is rarely a definitive right or wrong way. Performance can be affected by the type of operation, the amount of data in the tables, whether indexes and keys are present, and a whole slew of other criteria. Therefore, it is often worth experimenting with different selection mechanisms to find the one that works best for you.

Summary

Joins are one of the most important and powerful features in SQL, and using them effectively requires a basic understanding of relational database design. In this chapter, you learned some of the basics of relational database design as an introduction to learning about joins. You also learned how to create an equijoin (also known as an inner join), which is the most commonly used form of join. In the next chapter you'll learn how to create other types of joins.

Chapter 16. Creating Advanced Joins

In this chapter, you'll learn all about additional join typeswhat they are and how to use them. You'll also learn how to use table aliases and how to use aggregate functions with joined tables.

Using Table Aliases

In Chapter 10, "Creating Calculated Fields," you learned how to use aliases to refer to retrieved table columns. The syntax to alias a column looks like this:

- **Input**

```
SELECT Concat(RTrim(vend_name), ' (', RTrim(vend_country), ')') AS
vend_title
FROM vendors
ORDER BY vend_name;
```

In addition to using aliases for column names and calculated fields, SQL also enables you to alias table names. There are two primary reasons to do this:

- To shorten the SQL syntax
- To enable multiple uses of the same table within a single `SELECT` statement

Take a look at the following `SELECT` statement. It is basically the same statement as an example used in the previous chapter, but it has been modified to use aliases:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers AS c, orders AS o, orderitems AS oi
WHERE c.cust_id = o.cust_id
  AND oi.order_num = o.order_num
  AND prod_id = 'TNT2';
```

- **Analysis**

You'll notice that the three tables in the `FROM` clauses all have aliases. `customers AS c` establishes `c` as an alias for `customers`, and so on. This enables you to use the abbreviated `c` instead of the full text `customers`. In this example, the table aliases were used only in the `WHERE` clause, but aliases are not limited to just

`WHERE`. You can use aliases in the `SELECT` list, the `ORDER BY` clause, and in any other part of the statement as well.

It is also worth noting that table aliases are only used during query execution. Unlike column aliases, table aliases are never returned to the client.

Using Different Join Types

So far, you have used only simple joins known as inner joins or *equijoins*. You'll now take a look at three additional join types: the self join, the natural join, and the outer join.

Self Joins

As mentioned earlier, one of the primary reasons to use table aliases is to be able to refer to the same table more than once in a single `SELECT` statement. An example will demonstrate this.

Suppose that a problem was found with a product (item id `DTNTR`), and you therefore wanted to know all of the products made by the same vendor so as to determine if the problem applied to them, too. This query requires that you first find out which vendor creates item `DTNTR`, and next find which other products are made by the same vendor. The following is one way to approach this problem:

- **Input**

```
SELECT prod_id, prod_name
FROM products
WHERE vend_id = (SELECT vend_id
                 FROM products
                 WHERE prod_id = 'DTNTR');
```

- **Output**

```
+---------+----------------+
| prod_id | prod_name      |
+---------+----------------+
| DTNTR   | Detonator      |
| FB      | Bird seed      |
| FC      | Carrots        |
| SAFE    | Safe           |
| SLING   | Sling          |
| TNT1    | TNT (1 stick)  |
| TNT2     | TNT (5 sticks) |
+----------+----------------+
```

• **Analysis**

This first solution uses subqueries. The inner `SELECT` statement does a simple retrieval to return the `vend_id` of the vendor that makes item `DTNTR`. That ID is the one used in the `WHERE` clause of the outer query so all items produced by that vendor are retrieved. (You learned all about subqueries in Chapter 14, "Working with Subqueries." Refer to that chapter for more information.)

Now look at the same query using a join:

• **Input**

```
SELECT p1.prod_id, p1.prod_name
FROM products AS p1, products AS p2
WHERE p1.vend_id = p2.vend_id
  AND p2.prod_id = 'DTNTR';
```

• **Output**

```
+----------+----------------+
| prod_id  | prod_name      |
+----------+----------------+
| DTNTR    | Detonator      |
| FB       | Bird seed      |
| FC       | Carrots        |
| SAFE     | Safe           |
| SLING    | Sling          |
| TNT1     | TNT (1 stick)  |
| TNT2     | TNT (5 sticks) |
+----------+----------------+
```

• **Analysis**

The two tables needed in this query are actually the same table, and so the `products` table appears in the `FROM` clause twice. Although this is perfectly legal, any references to table `products` would be ambiguous because MySQL could not know to which instance of the `products` table you are referring.

To resolve this problem, table aliases are used. The first occurrence of `products` has an alias of `p1`, and the second has an alias of `p2`. Now those aliases can be used as table names. The `SELECT` statement, for example, uses the `p1` prefix to explicitly state the full name of the desired columns. If it did not, MySQL would return an error because there are two columns named `prod_id` and `prod_name`. It cannot know which one you want (even though, in truth, they are one and the same). The `WHERE` clause first joins the tables (by matching `vend_id` in `p1` to `vend_id` in `p2`), and then it filters the data by `prod_id` in the second table to return only the desired data.

Tip

Self Joins Instead of Subqueries Self joins are often used to replace statements using subqueries that retrieve data from the same table as the outer statement. Although the end result is the same, sometimes these joins execute far more quickly than they do subqueries. It is usually worth experimenting with both to determine which performs better.

Natural Joins

Whenever tables are joined, at least one column appears in more than one table (the columns being joined). Standard joins (the inner joins you learned about in the previous chapter) return all data, even multiple occurrences of the same column. A *natural join* simply eliminates those multiple occurrences so only one of each column is returned.

How does it do this? The answer is it doesn'tyou do it. A natural join is a join in which you select only columns that are unique. This is typically done using a wildcard (`SELECT *`) for one table and explicit subsets of the columns for all other tables. The following is an example:

- **Input**

```
SELECT c.*, o.order_num, o.order_date,
       oi.prod_id, oi.quantity, OI.item_price
```

```
FROM customers AS c, orders AS o, orderitems AS oi
WHERE c.cust_id = o.cust_id
  AND oi.order_num = o.order_num
  AND prod_id = 'FB';
```

- **Analysis**

In this example, a wildcard is used for the first table only. All other columns are explicitly listed so no duplicate columns are retrieved.

The truth is, every inner join you have created thus far is actually a natural join, and you will probably never even need an inner join that is not a natural join.

Outer Joins

Most joins relate rows in one table with rows in another. But occasionally, you want to include rows that have no related rows. For example, you might use joins to accomplish the following tasks:

- Count how many orders each customer placed, including customers who have yet to place an order
- List all products with order quantities, including products not ordered by anyone
- Calculate average sale sizes, taking into account customers who have not yet placed an order

In each of these examples, the join includes table rows that have no associated rows in the related table. This type of join is called an *outer join*.

The following `SELECT` statement is a simple inner join. It retrieves a list of all customers and their orders:

- **Input**

```
SELECT customers.cust_id, orders.order_num
FROM customers INNER JOIN orders
```

```
 ON customers.cust_id = orders.cust_id;
```

Outer join syntax is similar. To retrieve a list of all customers, including those who have placed no orders, you can do the following:

• **Input**

```
SELECT customers.cust_id, orders.order_num
FROM customers LEFT OUTER JOIN orders
 ON customers.cust_id = orders.cust_id;
```

• **Output**

```
+---------+-----------+
| cust_id | order_num |
+---------+-----------+
|   10001 |     20005 |
|   10001 |     20009 |
|   10002 |      NULL |
|   10003 |     20006 |
|   10004 |     20007 |
|   10005 |     20008 |
+---------+-----------+
```

• **Analysis**

Like the inner join seen in the previous chapter, this SELECT statement uses the keywords OUTER JOIN to specify the join type (instead of specifying it in the WHERE clause). But unlike inner joins, which relate rows in both tables, outer joins also include rows with no related rows. When using OUTER JOIN syntax you must use the RIGHT or LEFT keywords to specify the table from which to include all rows (RIGHT for the one on the right of OUTER JOIN, and LEFT for the one on the left). The previous example uses LEFT OUTER JOIN to select all the rows from the table on the left in the FROM clause (the customers table). To select all the rows from the table on the right, you use a RIGHT OUTER JOIN as seen in this example:

• **Input**

```
SELECT customers.cust_id, orders.order_num
FROM customers RIGHT OUTER JOIN orders
 ON orders.cust_id = customers.cust_id;
```

Note

No `*=` MySQL does not support the use of the simplified `*=` and `=*` syntax popularized by other DBMSs.

Tip

Outer Join Types There are two basic forms of outer joinsthe left outer join and the right outer join. The only difference between them is the order of the tables they are relating. In other words, a left outer join can be turned into a right outer join simply by reversing the order of the tables in the `FROM` or `WHERE` clause. As such, the two types of outer join can be used interchangeably, and the decision about which one is used is based purely on convenience.

Using Joins with Aggregate Functions

As you learned in Chapter 12, "Summarizing Data," aggregate functions are used to summarize data. Although all the examples of aggregate functions thus far only summarized data from a single table, these functions can also be used with joins.

To demonstrate this, let's look at an example. You want to retrieve a list of all customers and the number of orders that each has placed. The following code uses the `COUNT()` function to achieve this:

- **Input**

```
SELECT customers.cust_name,
       customers.cust_id,
       COUNT(orders.order_num) AS num_ord
FROM customers INNER JOIN orders
 ON customers.cust_id = orders.cust_id
GROUP BY customers.cust_id;
```

- **Output**

```
+----------------+---------+---------+
| cust_name      | cust_id | num_ord |
+----------------+---------+---------+
| Coyote Inc.    |   10001 |       2 |
| Wascals        |   10003 |       1 |
| Yosemite Place |   10004 |       1 |
| E Fudd         |   10005 |       1 |
+----------------+---------+---------+
```

- **Analysis**

This `SELECT` statement uses `INNER JOIN` to relate the `customers` and `orders` tables to each other. The `GROUP BY` clause groups the data by customer, and so the function call `COUNT(orders.order_num)` counts the number of orders for each customer and returns it as `num_ord`.

Aggregate functions can be used just as easily with other join types. See the following example:

- **Input**

```
SELECT customers.cust_name,
       customers.cust_id,
       COUNT(orders.order_num) AS num_ord
FROM customers LEFT OUTER JOIN orders
 ON customers.cust_id = orders.cust_id
GROUP BY customers.cust_id;
```

- **Output**

```
+----------------+---------+---------+
| cust_name      | cust_id | num_ord |
+----------------+---------+---------+
| Coyote Inc.    |   10001 |       2 |
| Mouse House    |   10002 |       0 |
| Wascals        |   10003 |       1 |
| Yosemite Place |   10004 |       1 |
| E Fudd         |   10005 |       1 |
+----------------+---------+---------+
```

- **Analysis**

This example uses a left outer join to include all customers, even those who have not placed any orders. The results show that customer `Mouse House` (with `0` orders) is also included this time.

Using Joins and Join Conditions

Before wrapping up this two-chapter discussion on joins, it is worthwhile to summarize some key points regarding joins and their use:

- Pay careful attention to the type of join being used. More often than not, you'll want an inner join, but there are often valid uses for outer joins, too.
- Make sure you use the correct join condition, or you'll return incorrect data.
- Make sure you always provide a join condition, or you'll end up with the Cartesian product.
- You may include multiple tables in a join and even have different join types for each. Although this is legal and often useful, make sure you test each join separately before testing them together. This makes troubleshooting far simpler.

Summary

This chapter was a continuation of the previous chapter on joins. This chapter started by teaching you how and why to use aliases, and then continued with a discussion on different join types and various forms of syntax used with each. You also learned how to use aggregate functions with joins, and some important do's and don'ts to keep in mind when working with joins.

Chapter 17. Combining Queries

In this chapter you'll learn how to use the `UNION` *operator to combine multiple* `SELECT` *statements into one result set*.

Understanding Combined Queries

Most SQL queries contain a single `SELECT` statement that returns data from one or more tables. MySQL also enables you to perform multiple queries (multiple `SELECT` statements) and return the results as a single query result set. These combined queries are usually known as *unions* or *compound queries*.

There are basically two scenarios in which you'd use combined queries:

- To return similarly structured data from different tables in a single query
- To perform multiple queries against a single table returning the data as one query

Tip

Combining Queries and Multiple `WHERE` Conditions For the most part, combining two queries to the same table accomplishes the same thing as a single query with multiple `WHERE` clause conditions. In other words, any `SELECT` statement with multiple `WHERE` clauses can also be specified as a combined query, as you'll see in the section that follows. The performance of each of the two techniques, however, can vary based on the queries used. As such, it is always good to experiment to determine which is preferable for specific queries.

Creating Combined Queries

SQL queries are combined using the `UNION` operator. Using `UNION`, multiple `SELECT` statements can be specified, and their results can be combined into a single result set.

Using `UNION`

Using `UNION` is simple enough. All you do is specify each `SELECT` statement and place the keyword `UNION` between each.

Let's look at an example. You need a list of all products costing `5` or less. You also want to include all products made by vendors `1001` and `1002`, regardless of price. Of course, you can create a `WHERE` clause that will do this, but this time you'll use a `UNION` instead.

As just explained, creating a `UNION` involves writing multiple `SELECT` statements. First look at the individual statements:

- **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE prod_price <= 5;
```

- **Output**

```
+---------+---------+------------+
| vend_id | prod_id | prod_price |
+---------+---------+------------+
|    1003 | FC      |       2.50 |
|    1002 | FU1     |       3.42 |
|    1003 | SLING   |       4.49 |
|    1003 | TNT1    |       2.50 |
+---------+---------+------------+
```

• **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE vend_id IN (1001,1002);
```

• **Output**

```
+---------+---------+------------+
| vend_id | prod_id | prod_price |
+---------+---------+------------+
|    1001 | ANV01   |       5.99 |
|    1001 | ANV02   |       9.99 |
|    1001 | ANV03   |      14.99 |
|    1002 | FU1     |       3.42 |
|    1002 | OL1     |       8.99 |
+---------+---------+------------+
```

• **Analysis**

The first `SELECT` retrieves all products with a price of no more than `5`. The second `SELECT` uses `IN` to find all products made by vendors `1001` and `1002`.

To combine these two statements, do the following:

• **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE prod_price <= 5
UNION
SELECT vend_id, prod_id, prod_price
FROM products
WHERE vend_id IN (1001,1002);
```

• **Output**

```
+---------+---------+------------+
| vend_id | prod_id | prod_price |
+---------+---------+------------+
|    1003 | FC      | 2.50       |
|    1002 | FU1     | 3.42       |
|    1003 | SLING   | 4.49       |
|    1003 | TNT1    | 2.50       |
|    1001 | ANV01   | 5.99       |
|    1001 | ANV02   | 9.99       |
|    1001 | ANV03   | 14.99      |
|    1002 | OL1     | 8.99       |
+---------+---------+------------+
```

• **Analysis**

The preceding statements are made up of both of the previous `SELECT` statements separated by the `UNION` keyword. `UNION` instructs MySQL to execute both `SELECT` statements and combine the output into a single query result set.

As a point of reference, here is the same query using multiple `WHERE` clauses instead of a `UNION`:

• **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE prod_price <= 5
  OR vend_id IN (1001,1002);
```

In this simple example, the `UNION` might actually be more complicated than using a `WHERE` clause. But with more complex filtering conditions, or if the data is being retrieved from multiple tables (and not just a single table), the `UNION` could have made the process much simpler.

`UNION` Rules

As you can see, unions are very easy to use. But a few rules govern exactly which can be combined:

- A UNION must be comprised of two or more SELECT statements, each separated by the keyword UNION (so, if combining four SELECT statements, three UNION keywords would be used).

- Each query in a UNION must contain the same columns, expressions, or aggregate functions (although columns need not be listed in the same order).

- Column datatypes must be compatible: They need not be the exact same type, but they must be of a type that MySQL can implicitly convert (for example, different numeric types or different date types).

Aside from these basic rules and restrictions, unions can be used for any data retrieval tasks.

Including or Eliminating Duplicate Rows

Go back to the preceding section titled "Using UNION" and look at the sample SELECT statements used. You'll notice that when executed individually, the first SELECT statement returns four rows, and the second SELECT statement returns five rows. However, when the two SELECT statements are combined with a UNION, only eight rows are returned, not nine.

The UNION automatically removes any duplicate rows from the query result set (in other words, it behaves just as multiple WHERE clause conditions in a single SELECT would). Because vendor 1002 creates a product that costs less than 5, that row was returned by both SELECT statements. When the UNION was used, the duplicate row was eliminated.

This is the default behavior of UNION, but you can change this if you so desire. If you do, in fact, want all occurrences of all matches returned, you can use UNION ALL instead of UNION.

Look at the following example:

- **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE prod_price <= 5
UNION ALL
```

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE vend_id IN (1001,1002);
```

• **Output**

```
+---------+---------+------------+
| vend_id | prod_id | prod_price |
+---------+---------+------------+
|    1003 | FC      |       2.50 |
|    1002 | FU1     |       3.42 |
|    1003 | SLING   |       4.49 |
|    1003 | TNT1    |       2.50 |
|    1001 | ANV01   |       5.99 |
|    1001 | ANV02   |       9.99 |
|    1001 | ANV03   |      14.99 |
|    1002 | FU1     |       3.42 |
|    1002 | OL1     |       8.99 |
+---------+---------+------------+
```

• **Analysis**

Using `UNION ALL`, MySQL does not eliminate duplicates. Therefore, the preceding example returns nine rows, one of them occurring twice.

Tip

`UNION` versus `WHERE` The beginning of this chapter said that `UNION` almost always accomplishes the same thing as multiple `WHERE` conditions. `UNION ALL` is the form of `UNION` that accomplishes what cannot be done with `WHERE` clauses. If you do, in fact, want all occurrences of matches for every condition (including duplicates), you must use `UNION ALL` and not `WHERE`.

Sorting Combined Query Results

SELECT statement output is sorted using the ORDER BY clause. When combining queries with a UNION, only one ORDER BY clause may be used, and it must occur after the final SELECT statement. There is very little point in sorting part of a result set one way and part another way, and so multiple ORDER BY clauses are not allowed.

The following example sorts the results returned by the previously used UNION:

- **Input**

```
SELECT vend_id, prod_id, prod_price
FROM products
WHERE prod_price <= 5
UNION
SELECT vend_id, prod_id, prod_price
FROM products
WHERE vend_id IN (1001,1002)
ORDER BY vend_id, prod_price;
```

- **Output**

```
+---------+---------+------------+
| vend_id | prod_id | prod_price |
+---------+---------+------------+
|    1001 | ANV01   |       5.99 |
|    1001 | ANV02   |       9.99 |
|    1001 | ANV03   |      14.99 |
|    1002 | FU1     |       3.42 |
|    1002 | OL1     |       8.99 |
|    1003 | TNT1    |       2.50 |
|    1003 | FC      |       2.50 |
|    1003 | SLING   |       4.49 |
+---------+---------+------------+
```

- **Analysis**

This UNION takes a single ORDER BY clause after the final SELECT statement. Even though the ORDER BY appears to only be a part of that last SELECT statement, MySQL will in fact use it to sort all the results returned by all the SELECT statements.

Note

Combining Different Tables For the sake of simplicity, all of the examples in this chapter combined queries using the same table. However, everything you learned here also applies to using `UNION` to combine queries of different tables.

Summary

In this chapter, you learned how to combine `SELECT` statements with the `UNION` operator. Using `UNION`, you can return the results of multiple queries as one combined query, either including or excluding duplicates. The use of `UNION` can greatly simplify complex `WHERE` clauses and retrieving data from multiple tables.

Chapter 18. Full-Text Searching

In this chapter, you'll learn how to use MySQL's full-text searching capabilities to perform sophisticated data querying and selection.

Understanding Full-Text Searching

Note

Not All Engines Support Full-Text Searching As will be explained in Chapter 21, "Creating and Manipulating Tables," MySQL supports the use of several underlying database engines. Not all engines support full-text searching as is described in this chapter. The two most commonly used engines are `MyISAM` and `InnoDB`; the former supports full-text searching and the latter does not. This is why, although most of the sample tables used in this book were created to use `InnoDB`, one (the `productnotes` table) was created to use `MyISAM`. If you need full-text searching functionality in your applications, keep this in mind.

In Chapter 8, "Using Wildcard Filtering," you were introduced to the `LIKE` keyword that is used to match text (and partial text) using wildcard operators. Using `LIKE` it is possible to locate rows that contain specific values or parts of values, regardless of the location of those values within row columns.

In Chapter 9, "Searching Using Regular Expressions," text-based searching was taken one step further with the introduction to using regular expressions to match column values. Using regular expressions, it is possible to write very sophisticated matching patterns to locate the desired rows.

But as useful as these search mechanisms are, they have several very important limitations:

- **Performance** Wildcard and regular expression matching usually requires that MySQL try and match each and every row in a table (and table indexes are rarely of use in these searches). As such, these searches can be very time-consuming as the number of rows to be searched grows.
- **Explicit control** Using wildcard and regular expression matching, it is very difficult (and not always possible) to explicitly control what is and what is not matched. An example of this is a search specifying a word that must be matched, a word that must not be matched, and a word that may or may not be matched but only if the first word is indeed matched.

- **Intelligent results** Although wildcard- and regular expressionbased searching provide for very flexible searching, neither provide an intelligent way to select results. For example, searching for a specific word would return all rows that contained that word, and not distinguish between rows that contain a single match and those that contained multiple matches (ranking them as potentially better matches). Similarly, searches for a specific word would not find rows that did not contain that word but did contain other related words.

All of these limitations and more are addressed by full-text searching. When full-text searching is used, MySQL does not need to look at each row individually, analyzing and processing each word individually. Rather, an index of the words (in specified columns) is created by MySQL, and searches can be made against those words. MySQL can thus quickly and efficiently determine which words match (which rows contain them), which don't, how often they match, and so on.

Using Full-Text Searching

In order to perform full-text searches, the columns to be searched must be indexed and constantly re-indexed as data changes. MySQL handles all indexing and re-indexing automatically after table columns have been appropriately designated.

After indexing, `SELECT` can be used with `Match()` and `Against()` to actually perform the searches.

Enabling Full-Text Searching Support

Generally, full-text searching is enabled when a table is created. The `CREATE TABLE` statement (which will be introduced in Chapter 21) accepts a `FULLTEXT` clause, which is a comma-delimited list of the columns to be indexed.

The following `CREATE` statement demonstrates the use of the `FULLTEXT` clause:

- **Input**

```
CREATE TABLE productnotes
(
  note_id    int           NOT NULL AUTO_INCREMENT,
  prod_id    char(10)      NOT NULL,
  note_date datetime       NOT NULL,
  note_text  text          NULL ,
  PRIMARY KEY(note_id),
  FULLTEXT(note_text)
) ENGINE=MyISAM;
```

- **Analysis**

We'll look at the `CREATE TABLE` statement in detail in Chapter 21. For now, just note that this `CREATE TABLE` statement defines table `productnotes` and lists the columns that it is to contain. One of those columns is named `note_text`, and it is indexed by MySQL for full-text searching as instructed by the clause `FULLTEXT(note_text)`. Here `FULLTEXT` indexes a single column, but multiple columns may be specified if needed.

Once defined, MySQL automatically maintains the index. When rows are added, updated, or deleted, the index is automatically updated accordingly.

`FULLTEXT` may be specified at table creation time, or later on (in which case all existing data would have to be immediately indexed).

Tip

Don't Use `FULLTEXT` When Importing Data Updating indexes takes timenot a lot of time, but time nonetheless. If you are importing data into a new table, you should not enable `FULLTEXT` indexing at that time. Rather, first import all of the data, and then modify the table to define `FULLTEXT`. This makes for a much faster data import (and the total time needed to index all data will be less than the sum of the time needed to index each row individually).

Performing Full-Text Searches

After indexing, full-text searches are performed using two functions: `Match()` to specify the columns to be searched and `Against()` to specify the search expression to be used.

Here is a basic example:

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('rabbit');
```

- **Output**

```
+-------------------------------------------------------------------
| note_text
+-------------------------------------------------------------------
| Customer complaint: rabbit has been able to detect trap, food
| apparently less effective now.
| Quantity varies, sold by the sack load. All guaranteed to be
| bright and orange, and suitable for use as rabbit bait.
+-------------------------------------------------------------------
```

• **Analysis**

The `SELECT` statement retrieves a single row, `note_text`. For the `WHERE` clause, a full-text search is performed. `Match(note_text)` instructs MySQL to perform the search against that named column, and `Against('rabbit')` specifies the word `rabbit` as the search text. As two rows contained the word `rabbit`, those two rows were returned.

Note

Use `Full Match()` Specification The value passed to `Match()` must be the same as the one used in the `FULLTEXT()` definition. If multiple columns are specified, all of them must be listed (and in the correct order).

Note

Searches Are Not Case Sensitive Full-text searches are not case sensitive, unless `BINARY` mode (not covered in this chapter) is used.

The truth is that the search just performed could just as easily have used a `LIKE` clause, as seen here:

• **Input**

```
SELECT note_text
FROM productnotes
WHERE note_text LIKE '%rabbit%';
```

• **Output**

```
+-------------------------------------------------------------------
| note_text
+-------------------------------------------------------------------
| Quantity varies, sold by the sack load. All guaranteed to be
| bright and orange, and suitable for use as rabbit bait.
| Customer complaint: rabbit has been able to detect trap, food
| apparently less effective now.
+-------------------------------------------------------------------
```

• **Analysis**

This SELECT retrieves the same two rows, but the order is different (although that may not always be the case).

Neither of the two SELECT statements contained an ORDER BY clause. The latter (using LIKE) returns data in no particularly useful order. But the former (using full-text searching) returns data ordered by how well the text matched. Both rows contained the word rabbit, but the row that contained the word rabbit as the third word ranked higher than the row that contained it as the twentieth word. This is important. An important part of full-text searching is the ranking of results. Rows with a higher rank are returned first (as there is a higher degree of likelihood that those are the ones you really wanted).

To demonstrate how ranking works, look at this example:

• **Input**

```
SELECT note_text,
       Match(note_text) Against('rabbit') AS rank
FROM productnotes;
```

• **Output**

```
+-------------------------------------------------+-----------------
| note_text                                       | rank
+-------------------------------------------------+-----------------
| Customer complaint: Sticks not individually     |                0
| wrapped, too easy to mistakenly detonate all    |
| at once. Recommend individual wrapping.             |
| Can shipped full, refills not available. Need       |                0
| to order new can if refill needed.                  |
| Safe is combination locked, combination not         |                0
| provided with safe. This is rarely a problem        |
| as safes are typically blown up or dropped by       |
| customers.                                          |
| Quantity varies, sold by the sack load. All         | 1.5905543170914
| guaranteed to be bright and orange, and             |
| suitable for as rabbit bait.                        |
| Included fuses are short and have been known to |                0
| detonate too quickly for some customers. Longer |
| fuses are available (item FU1) and should be        |
| recommended.                                        |
| Matches not included, recommend purchase of         |                0
| matches or detonator (item DTNTR).                  |
| Please note that no returns will be accepted if |                0
| safe opened using explosives.                       |
| Multiple customer returns, anvils failing to        |                0
| drop fast enough or falling backwards on            |
| purchaser. Recommend that customer considers        |
| using heavier anvils.                               |
| Item is extremely heavy. Designed for dropping, |                0
| not recommended for use with slings, ropes,         |
| pulleys, or tightropes.                             |
| Customer complaint: rabbit has been able to         | 1.6408053837485
| detect trap, food apparently less effective         |
| now.                                                |
| Shipped unassembled, requires common tools          |                0
| (including oversized hammer).                       |
| Customer complaint: Circular hole in safe floor |                0
| can apparently be easily cut with handsaw.          |
| Customer complaint: Not heavy enough to             |                0
| generate flying stars around head of victim.        |
| If being purchased for dropping, recommend          |
| ANV02 or ANV03 instead.                             |
| Call from individual trapped in safe plummeting |                0
| to the ground, suggests an escape hatch be          |
| added. Comment forwarded to vendor.                 |
+-----------------------------------------------------+-----------------
```

• **Analysis**

Here `Match()` and `Against()` are used in the `SELECT` instead of the `WHERE` clause. This causes all rows to be returned (as there is no `WHERE` clause). `Match()` and `Against()` are used to create a calculated column (with the alias `rank`) which contains the ranking value calculated by the full-text search. The ranking is calculated by MySQL based on the number of words in the row, the number of unique words, the total number of words in the entire index, and the number of rows that contain the word. As you can see, the rows that do not contain the word `rabbit` have a rank of `0` (and were therefore not selected by the `WHERE` clause in the previous example). The two rows that do contain the word `rabbit` each have a rank value, and the one with the word earlier in the text has a higher rank value than the one in which the word appeared later.

This helps demonstrate how full-text searching eliminates rows (those with a rank of `0`), and how it sorts results (by rank in descending order).

Note

Ranking Multiple Search Terms If multiple search terms are specified, those that contain the most matching words will be ranked higher than those with less (or just a single match).

As you can see, full-text searching offers functionality not available with simple `LIKE` searches. And as data is indexed, full-text searches are considerably faster, too.

Using Query Expansion

Query expansion is used to try to widen the range of returned full-text search results. Consider the following scenario. You want to find all notes with references to `anvils` in them. Only one note contains the word `anvils`, but you also want any other rows that may be related to your search, even if the specific word `anvils` is not contained within them.

This is a job for query expansion. When query expansion is used, MySQL makes two passes through the data and indexes to perform your search:

- First, a basic full-text search is performed to find all rows that match the search criteria.
- Next, MySQL examines those matched rows and selects all useful words (we'll explain how MySQL figures out what is useful and what is not shortly).
- Then, MySQL performs the full-text search again, this time using not just the original criteria, but also all of the useful words.

Using query expansion you can therefore find results that might be relevant, even if they don't contain the exact words for which you were looking.

Note

MySQL Version 4.1.1 or Later Only Query expansion functionality was introduced in MySQL 4.1.1, and can therefore not be used in prior versions.

Here is an example. First, a simple full-text search, without query expansion:

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('anvils');
```

- **Output**

```
+-------------------------------------------------------------------
| note_text
+-------------------------------------------------------------------
| Multiple customer returns, anvils failing to drop fast enough or
| falling backwards on purchaser. Recommend that customer considers
| using heavier anvils.
+-------------------------------------------------------------------
```

• **Analysis**

Only one row contains the word `anvils`, so only one row is returned.

Here is the same search, this time using query expansion:

• **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('anvils' WITH QUERY EXPANSION);
```

• **Output**

```
+--------------------------------------------------------------------
| note_text
+--------------------------------------------------------------------
| Multiple customer returns, anvils failing to drop fast enough or
| falling backwards on purchaser. Recommend that customer considers
| using heavier anvils.
| Customer complaint: Sticks not individually wrapped, too easy to
| mistakenly detonate all at once. Recommend individual wrapping.
| Customer complaint: Not heavy enough to generate flying stars
| around head of victim. If being purchased for dropping, recommend
| ANV02 or ANV03 instead.
| Please note that no returns will be accepted if safe opened using
| explosives.
| Customer complaint: rabbit has been able to detect trap, food
| apparently less effective now.
| Customer complaint: Circular hole in safe floor can apparently be
| easily cut with handsaw.
| Matches not included, recommend purchase of matches or detonator
| (item DTNTR).
+--------------------------------------------------------------------
```

• **Analysis**

This time seven rows were returned. The first contains the word `anvils` and is thus ranked highest. The second row has nothing to do with `anvils`, but as it contains two words that are also in the first row (`customer` and `recommend`) it was retrieved, too. The third row also contains those same two words, but they are further into the text and further apart, and so it was included, but ranked third. And this third row does indeed refer to anvils (by their product name).

As you can see, query expansion greatly increases the number of rows returned, but in doing so also increases the number of returns that you might not actually want.

Tip

The More Rows the Better The more rows in your table (and the more text within those rows), the better the results returned when using query expansion.

Boolean Text Searches

MySQL supports an additional form of full-text searching called *boolean mode*. In Boolean mode you may provide specifics as to

- Words to be matched
- Words to be excluded (if a row contained this word it would not be returned, even though other specified words were matched)
- Ranking hints (specifying which words are more important than others so they can be ranked higher)
- Expression grouping
- And more

Tip

Useable Even Without a `FULLTEXT` Index Boolean mode differs from the full-text search syntax used thus far in that it may be used even if no `FULLTEXT` index is defined. However, this would be a very slow operation (and the performance would degrade further as data volume increased).

To demonstrate what `IN BOOLEAN MODE` does, here is a simple example:

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('heavy' IN BOOLEAN MODE);
```

- **Output**

```
+-------------------------------------------------------------------
| note_text
+-------------------------------------------------------------------
| Item is extremely heavy. Designed for dropping, not recommended
| for use with slings, ropes, pulleys, or tightropes.
| Customer complaint: Not heavy enough to generate flying stars
| around head of victim. If being purchased for dropping, recommend
| ANV02 or ANV03 instead.
+-------------------------------------------------------------------
```

- **Analysis**

This full-text search retrieves all rows containing the word `heavy` (there are two of them). The keywords `IN BOOLEAN MODE` are specified, but no boolean operators are actually specified and so the results are just as if boolean mode had not been specified.

Note

`IN BOOLEAN MODE` Behaves Differently Although the results in this example are the same as they would be without `IN BOOLEAN MODE`, there is an important difference in behavior (even if it did not manifest itself in this particular example). I'll point these out in the use notes later in this chapter.

To match the rows that contain `heavy` but not any word beginning with `rope`, the following can be used:

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('heavy rope*' IN BOOLEAN MODE);
```

- **Output**

```
+---------------------------------------------------------------------
| note_text
+---------------------------------------------------------------------
| Customer complaint: Not heavy enough to generate flying stars
| around head of victim. If being purchased for dropping, recommend
| ANV02 or ANV03 instead.
+---------------------------------------------------------------------
```

- **Analysis**

This time only one row is returned. Again, the word `heavy` is matched, but this time `rope*` instructs MySQL to explicitly exclude any row that contains `rope*` (any word beginning with `rope`, including `ropes`, which is why one of the rows was excluded).

Note

Code Change Needed in MySQL 4.x If you are using MySQL 4.x, the previous example might not have returned any rows at all. This is the result of a bug in the processing of the `*` operator. To use this example in MySQL 4.x, use `-ropes` instead of `-rope*` (exclude `ropes` instead of any word beginning with `rope`).

You have now seen two full-text search boolean operators: `-` excludes a word and `*` is the truncation operator (think of it as a wildcard used at the end of a word). Table 18.1 lists all of the supported boolean operators.

Table 18.1. Full-Text Boolean Operators

Privilege	Description
`+`	Include, word must be present.
`-`	Exclude, word must not be present.
`>`	Include, and increase ranking value.
`<`	Include, and decrease ranking value.
`()`	Group words into subexpressions (allowing them to be included, excluded, ranked, and so forth as a group).
`~`	Negate a word's ranking value.
`*`	Wildcard at end of word.
`""`	Defines a phrase (as opposed to a list of individual words, the entire phrase is matched for inclusion or exclusion).

Here are some more examples to demonstrate the use of some of these operators:

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('+rabbit +bait"' IN BOOLEAN MODE);
```

- **Analysis**

This search matches rows that contain both the words `rabbit` and `bait`.

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('rabbit bait' IN BOOLEAN MODE);
```

- **Analysis**

Without operators specified, this search matches rows that contain at least one of `rabbit` or `bait`.

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('"rabbit bait"' IN BOOLEAN MODE);
```

- **Analysis**

This search matches the phrase `rabbit bait` instead of the two words `rabbit` and `bait`.

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('>rabbit <carrot' IN BOOLEAN MODE);
```

- **Analysis**

Match both `rabbit` and `carrot`, increasing the rank of the former and decreasing the rank of the latter.

- **Input**

```
SELECT note_text
FROM productnotes
WHERE Match(note_text) Against('+safe +(<combination)' IN BOOLEAN
MODE);
```

• **Analysis**

This search matches the words `safe` and `combination`, lowering the ranking of the latter.

Note

Ranked, but Not Sorted In boolean mode, rows will not be returned sorted descending by ranking score.

Full-Text Search Usage Notes

Before finishing this chapter, here are some important notes pertaining to the use of full-text searching:

- When indexing full-text data, short words are ignored and are excluded from the index. Short words are defined as those having three or fewer characters (this number can be changed if needed).
- MySQL comes with a built-in list of *stopwords*, words that are always ignored when indexing full-text data. This list can be overridden if needed. (Refer to the MySQL documentation to learn how to accomplish this.)
- Many words appear so frequently that searching on them would be useless (too many results would be returned). As such, MySQL honors a 50% ruleif a word appears in 50% or more rows, it is treated as a stopword and is effectively ignored. (The 50% rule is not used for `IN BOOLEAN MODE`).
- Full-text searching never returns any results if there are fewer than three rows in a table (because every word is always in at least 50% of the rows).
- Single quote characters in words are ignored. For example, `don't` is indexed

as `dont`.

- Languages that don't have word delimiters (including Japanese and Chinese) will not return full-text results properly.

- As already noted, full-text searching is only supported in the MyISAM database engine.

Note

No Proximity Operators One feature supported by many full-text search engines is proximity searching, the ability to search for words that are near each other (in the same sentence, in the same paragraph, or no more than a specific number of words apart, and so on). Proximity operators are not yet supported by MySQL full-text searching, although this is planned for a future release.

Summary

In this chapter, you learned why full-text searching is used, and how to use the MySQL `Match()` and `Against()` functions to perform these searches. You also learned about query expansion as a way to increase the chances of finding related matches, and how to use boolean mode for more granular lookup control.

Chapter 19. Inserting Data

In this chapter, you will learn how to insert data into tables using the SQL `INSERT` *statement*.

Understanding Data Insertion

`SELECT` is undoubtedly the most frequently used SQL statement (which is why the past 17 chapters were dedicated to it). But there are three other frequently used SQL statements that you should learn. The first one is `INSERT`. (You'll get to the other two in the next chapter.)

As its name suggests, `INSERT` is used to insert (add) rows to a database table. `INSERT` can be used in several ways:

- To insert a single complete row
- To insert a single partial row
- To insert multiple rows
- To insert the results of a query

You'll now look at each of these.

Tip

`INSERT` and System Security Use of the `INSERT` statement can be disabled per table or per user using MySQL security, as will be explained in Chapter 28, "Managing Security."

Inserting Complete Rows

The simplest way to insert data into a table is to use the basic `INSERT` syntax, which requires that you specify the table name and the values to be inserted into the new row. Here is an example of this:

- **Input**

```
INSERT INTO Customers
VALUES(NULL,
   'Pep E. LaPew',
   '100 Main Street',
   'Los Angeles',
   'CA',
   '90046',
   'USA',
   NULL,
   NULL);
```

Note

No Output `INSERT` statements usually generate no output.

- **Analysis**

The preceding example inserts a new customer into the `customers` table. The data to be stored in each table column is specified in the `VALUES` clause, and a value must be provided for every column. If a column has no value (for example, the `cust_contact` and `cust_email` columns), the `NULL` value should be used (assuming the table allows no value to be specified for that column). The columns must be populated in the order in which they appear in the table definition. The first column, `cust_id`, is also `NULL`. This is because that column is automatically incremented by MySQL each time a row is inserted. You'd not want to specify a value (that is MySQL's job), and nor could you omit the column (as already stated, every column must be listed), and so a `NULL` value is specified (it is ignored by MySQL, which inserts the next available `cust_id` value in its place).

Although this syntax is indeed simple, it is not at all safe and should generally be avoided at all costs. The previous SQL statement is highly dependent on the order in which the columns are defined in the table. It also depends on information about that order being readily available. Even if it is available, there is no guarantee that the columns will be in the exact same order the next time the table is reconstructed. Therefore, writing SQL statements that depend on specific column ordering is very unsafe. If you do so, something will inevitably break at some point.

The safer (and unfortunately more cumbersome) way to write the `INSERT` statement is as follows:

- **Input**

```
INSERT INTO customers(cust_name,
   cust_address,
   cust_city,
   cust_state,
   cust_zip,
   cust_country,
   cust_contact,
   cust_email)
VALUES('Pep E. LaPew',
   '100 Main Street',
   'Los Angeles',
   'CA',
   '90046',
   'USA',
   NULL,
   NULL);
```

- **Analysis**

This example does the exact same thing as the previous `INSERT` statement, but this time the column names are explicitly stated in parentheses after the table name. When the row is inserted MySQL will match each item in the columns list with the appropriate value in the `VALUES` list. The first entry in `VALUES` corresponds to the first specified column name. The second value corresponds to the second column name, and so on.

Because column names are provided, the VALUES must match the specified column names in the order in which they are specified, and not necessarily in the order that the columns appear in the actual table. The advantage of this is that, even if the table layout changes, the INSERT statement will still work correctly. You'll also notice that the NULL for cust_id was not needed, the cust_id column was not listed in the column list and so no value was needed.

The following INSERT statement populates all the row columns (just as before), but it does so in a different order. Because the column names are specified, the insertion will work correctly:

- **Input**

```
INSERT INTO customers(cust_name,
   cust_contact,
   cust_email,
   cust_address,
   cust_city,
   cust_state,
   cust_zip,
   cust_country)
VALUES('Pep E. LaPew',
   NULL,
   NULL,
   '100 Main Street',
   'Los Angeles',
   'CA',
   '90046',
   'USA');
```

Tip

Always Use a Columns List As a rule, never use INSERT without explicitly specifying the column list. This will greatly increase the probability that your SQL will continue to function in the event that table changes occur.

Caution

Use `VALUES` Carefully Regardless of the `INSERT` syntax being used, the correct number of `VALUES` must be specified. If no column names are provided, a value must be present for every table column. If columns names are provided, a value must be present for each listed column. If none is present, an error message will be generated, and the row will not be inserted.

Using this syntax, you can also omit columns. This means you only provide values for some columns, but not for others. (You've actually already seen an example of this; `cust_id` was omitted when column names were explicitly listed).

Caution

Omitting Columns You may omit columns from an `INSERT` operation if the table definition so allows. One of the following conditions must exist:

- The column is defined as allowing `NULL` values (no value at all).
- A default value is specified in the table definition. This means the default value will be used if no value is specified.

If you omit a value from a table that does not allow `NULL` values and does not have a default, MySQL generates an error message, and the row is not inserted.

Tip

Improving Overall Performance Databases are frequently accessed by multiple clients, and it is MySQL's job to manage which requests are processed and in which order. `INSERT` operations can be time consuming (especially if there are many indexes to be updated), and this can hurt the performance of `SELECT` statements that are waiting to be processed.

If data retrieval is of utmost importance (as is usually is), you can instruct MySQL to lower the priority of your `INSERT` statement by adding the keyword

`LOW_PRIORITY` in between `INSERT` and `INTO`, like this:

```
INSERT LOW_PRIORITY INTO
```

Incidentally, this also applies to the `UPDATE` and `DELETE` statements that you'll learn about in the next chapter.

Inserting Multiple Rows

`INSERT` inserts a single row into a table. But what if you needed to insert multiple rows? You could simply use multiple `INSERT` statements, and could even submit them all at once, each terminated by a semicolon, like this:

- **Input**

```
INSERT INTO customers(cust_name,
   cust_address,
   cust_city,
   cust_state,
   cust_zip,
   cust_country)
VALUES('Pep E. LaPew',
   '100 Main Street',
   'Los Angeles',
   'CA',
   '90046',
   'USA');
INSERT INTO customers(cust_name,
   cust_address,
   cust_city,
   cust_state,
   cust_zip,
   cust_country)
VALUES('M. Martian',
   '42 Galaxy Way',
   'New York',
   'NY',
   '11213',
   'USA');
```

Or, as long as the column names (and order) are identical in each `INSERT`, you could combine the statements as follows:

- **Input**

```
INSERT INTO customers(cust_name,
   cust_address,
   cust_city,
   cust_state,
   cust_zip,
   cust_country)
VALUES(
        'Pep E. LaPew',
        '100 Main Street',
        'Los Angeles',
        'CA',
        '90046',
        'USA'
     ),
      (
        'M. Martian',
        '42 Galaxy Way',
        'New York',
        'NY',
        '11213',
        'USA'
   );
```

- **Analysis**

Here a single INSERT statement has multiple sets of values, each enclosed within parentheses, and separated by commas.

Tip

Improving INSERT Performance This technique can improve the performance of your database possessing, as MySQL will process multiple insertions in a single INSERT faster than it will multiple INSERT statements.

Inserting Retrieved Data

`INSERT` is usually used to add a row to a table using specified values. There is another form of `INSERT` that can be used to insert the result of a `SELECT` statement into a table. This is known as `INSERT SELECT`, and, as its name suggests, it is made up of an `INSERT` statement and a `SELECT` statement.

Suppose you want to merge a list of customers from another table into your `customers` table. Instead of reading one row at a time and inserting it with `INSERT`, you can do the following:

Note

Instructions Needed for the Next Example The following example imports data from a table named `custnew` into the `customers` table. To try this example, create and populate the `custnew` table first. The format of the `custnew` table should be the same as the `customers` table described in Appendix B, "The Example Tables." When populating `custnew`, be sure not to use `cust_id` values that were already used in `customers` (the subsequent `INSERT` operation will fail if primary key values are duplicated), or just omit that column and have MySQL generate new values during the import process.

- **Input**

```
INSERT INTO customers(cust_id,
    cust_contact,
    cust_email,
    cust_name,
    cust_address,
    cust_city,
    cust_state,
    cust_zip,
    cust_country)
SELECT cust_id,
    cust_contact,
    cust_email,
    cust_name,
    cust_address,
    cust_city,
    cust_state,
    cust_zip,
    cust_country
FROM custnew;
```

• **Analysis**

This example uses `INSERT SELECT` to import all the data from `custnew` into `customers`. Instead of listing the `VALUES` to be inserted, the `SELECT` statement retrieves them from `custnew`. Each column in the `SELECT` corresponds to a column in the specified columns list. How many rows will this statement insert? That depends on how many rows are in the `custnew` table. If the table is empty, no rows will be inserted (and no error will be generated because the operation is still valid). If the table does, in fact, contain data, all that data is inserted into `customers`.

This example imports `cust_id` (and assumes that you have ensured that `cust_id` values are not duplicated). You could also simply omit that column (from both the `INSERT` and the `SELECT`) so MySQL would generate new values.

Tip

Column Names in `INSERT SELECT` This example uses the same column names in both the `INSERT` and `SELECT` statements for simplicity's sake. But there is no requirement that the column names match. In fact, MySQL does not even pay attention to the column names returned by the `SELECT`. Rather, the column position is used, so the first column in the `SELECT` (regardless of its name) will be used to populate the first specified table column, and so on. This is very useful when importing data from tables that use different column names.

The `SELECT` statement used in an `INSERT SELECT` can include a `WHERE` clause to filter the data to be inserted.

Note

More Examples Looking for more examples of `INSERT` use? See the example table population scripts (described in Appendix B) used to create the example tables used in this book.

Summary

In this chapter, you learned how to use `INSERT` to insert rows into a database table. You learned several other ways to use `INSERT`, and why explicit column specification is preferred. You also learned how to use `INSERT SELECT` to import rows from another table. In the next chapter, you'll learn how to use `UPDATE` and `DELETE` to further manipulate table data.

Chapter 20. Updating and Deleting Data

In this chapter, you will learn how to use the `UPDATE` *and* `DELETE` *statements to enable you to further manipulate your table data*.

Updating Data

To update (modify) data in a table the `UPDATE` statement is used. `UPDATE` can be used in two ways:

- To update specific rows in a table
- To update all rows in a table

Let's take a look at each of these uses.

Caution

Don't Omit the `WHERE` Clause Special care must be exercised when using `UPDATE` because it is all too easy to mistakenly update every row in your table. Please read this entire section on `UPDATE` before using this statement.

Tip

`UPDATE` and Security Use of the `UPDATE` statement can be restricted and controlled. More on this in Chapter 28, "Managing Security."

The `UPDATE` statement is very easy to usesome would say too easy. The basic format of an `UPDATE` statement is made up of three parts:

- The table to be updated
- The column names and their new values
- The filter condition that determines which rows should be updated

Let's take a look at a simple example. Customer `10005` now has an email address, and so his record needs updating. The following statement performs this update:

- **Input**

```
UPDATE customers
SET cust_email = 'elmer@fudd.com'
WHERE cust_id = 10005;
```

The `UPDATE` statement always begins with the name of the table being updated. In this example, it is the `customers` table. The `SET` command is then used to assign the new value to a column. As used here, the `SET` clause sets the `cust_email` column to the specified value:

```
SET cust_email = 'elmer@fudd.com'
```

The `UPDATE` statement finishes with a `WHERE` clause that tells MySQL which row to update. Without a `WHERE` clause, MySQL would update all the rows in the `customers` table with this new email addressdefinitely not the desired effect.

Updating multiple columns requires a slightly different syntax:

- **Input**

```
UPDATE customers
SET cust_name = 'The Fudds',
    cust_email = 'elmer@fudd.com'
WHERE cust_id = 10005;
```

When updating multiple columns, only a single `SET` command is used, and each `column = value` pair is separated by a comma. (No comma is specified after the last column.) In this example, columns `cust_name` and `cust_email` will both be updated for customer `10005`.

Tip

Using Subqueries in an `UPDATE` Statement Subqueries may be used in `UPDATE` statements, enabling you to update columns with data retrieved with a `SELECT` statement. Refer to Chapter 14, "Working with Subqueries," for more information on subqueries and their uses.

Tip

The `IGNORE` Keyword If your `UPDATE` statement updates multiple rows and an error occurs while updating one or more of those rows, the entire `UPDATE` operation is cancelled (and any rows updated before the error occurred are restored to their original values). To continue processing updates, even if an error occurs, use the `IGNORE` keyword, like this:

```
UPDATE IGNORE customers ...
```

To delete a column's value, you can set it to `NULL` (assuming the table is defined to allow `NULL` values). You can do this as follows:

- **Input**

```
UPDATE customers
SET cust_email = NULL
WHERE cust_id = 10005;
```

Here the `NULL` keyword is used to save no value to the `cust_email` column.

Deleting Data

To delete (remove) data from a table, the `DELETE` statement is used. `DELETE` can be used in two ways:

- To delete specific rows from a table
- To delete all rows from a table

You'll now take a look at each of these.

Caution

Don't Omit the `WHERE` Clause Special care must be exercised when using `DELETE` because it is all too easy to mistakenly delete every row from your table. Please read this entire section on `DELETE` before using this statement.

Tip

`UPDATE` and Security Use of the `UPDATE` statement can be restricted and controlled. More on this in Chapter 28.

I already stated that `UPDATE` is very easy to use. The good (and bad) news is that `DELETE` is even easier to use.

The following statement deletes a single row from the `customers` table:

- **Input**

```
DELETE FROM customers
WHERE cust_id = 10006;
```

This statement should be self-explanatory. `DELETE FROM` requires that you specify the name of the table from which the data is to be deleted. The `WHERE` clause filters which rows are to be deleted. In this example, only customer `10006` will be deleted. If the `WHERE` clause were omitted, this statement would have deleted every customer in the table.

`DELETE` takes no column names or wildcard characters. `DELETE` deletes entire rows, not columns. To delete specific columns use an `UPDATE` statement (as seen earlier in this chapter).

Note

Table Contents, Not Tables The `DELETE` statement deletes rows from tables, even all rows from tables. But `DELETE` never deletes the table itself.

Tip

Faster Deletes If you really do want to delete all rows from a table, don't use `DELETE`. Instead, use the `trUNCATE TABLE` statement that accomplished the same thing but does it much quicker (`trUNCATE` actually drops and recreates the table, instead of deleting each row individually).

Guidelines for Updating and Deleting Data

The `UPDATE` and `DELETE` statements used in the previous sections all have `WHERE` clauses, and there is a very good reason for this. If you omit the `WHERE` clause, the `UPDATE` or `DELETE` is applied to every row in the table. In other words, if you execute an `UPDATE` without a `WHERE` clause, every row in the table is updated with the new values. Similarly if you execute `DELETE` without a `WHERE` clause, all the contents of the table are deleted.

Here are some best practices that many SQL programmers follow:

- Never execute an `UPDATE` or a `DELETE` without a `WHERE` clause unless you really do intend to update and delete every row.
- Make sure every table has a primary key (refer to Chapter 15, "Joining Tables," if you have forgotten what this is), and use it as the `WHERE` clause whenever possible. (You may specify individual primary keys, multiple values, or value ranges.)
- Before you use a `WHERE` clause with an `UPDATE` or a `DELETE`, first test it with a `SELECT` to make sure it is filtering the right recordsit is far too easy to write incorrect `WHERE` clauses.
- Use database enforced referential integrity (refer to Chapter 15 for this one, too) so MySQL will not allow the deletion of rows that have data in other tables related to them.

Caution

Use with Caution The bottom line is that MySQL has no Undo button. Be very careful using `UPDATE` and `DELETE`, or you'll find yourself updating and deleting the wrong data.

Summary

In this chapter, you learned how to use the `UPDATE` and `DELETE` statements to manipulate the data in your tables. You learned the syntax for each of these statements, as well as the inherent dangers they expose. You also learned why `WHERE` clauses are so important in `UPDATE` and `DELETE` statements, and you were given guidelines that should be followed to help ensure that data does not get damaged inadvertently.

Chapter 21. Creating and Manipulating Tables

In this chapter you'll learn the basics of table creation, alteration, and deletion.

Creating Tables

MySQL statements are not used just for table data manipulation. Indeed, MySQL can be used to perform all database and table operations, including the creation and manipulation of tables themselves.

There are generally two ways to create database tables:

- Using an administration tool (like the ones discussed in Chapter 2, "Introducing MySQL") that can be used to create and manage database tables interactively.

- Tables may also be manipulated directly with MySQL statements.

To create tables programmatically, the `CREATE TABLE` SQL statement is used. It is worth noting that when you use interactive tools, you are actually using MySQL statements. Instead of your writing these statements, however, the interface generates and executes the MySQL seamlessly for you (the same is true for changes to existing tables).

Note

Additional Examples For additional examples of table creation scripts, see the code used to create the sample tables used in this book.

Basic Table Creation

To create a table using `CREATE TABLE`, you must specify the following information:

- The name of the new table specified after the keywords `CREATE TABLE`.

- The name and definition of the table columns separated by commas.

The `CREATE TABLE` statement can also include other keywords and options, but at a minimum you need the table name and column details. The following MySQL statement creates the `customers` table used throughout this book:

• **Input**

```
CREATE TABLE customers
(
  cust_id      int        NOT NULL AUTO_INCREMENT,
  cust_name    char(50)   NOT NULL ,
  cust_address char(50)   NULL ,
  cust_city    char(50)   NULL ,
  cust_state   char(5)    NULL ,
  cust_zip     char(10)   NULL ,
  cust_country char(50)   NULL ,
  cust_contact char(50)   NULL ,
  cust_email   char(255)  NULL ,
  PRIMARY KEY (cust_id)
) ENGINE=InnoDB;
```

• **Analysis**

As you can see in the preceding statement, the table name is specified immediately following the `CREATE TABLE` keywords. The actual table definition (all the columns) is enclosed within parentheses. The columns themselves are separated by commas. This particular table is made up of nine columns. Each column definition starts with the column name (which must be unique within the table), followed by the column's datatype. (Refer to Chapter 1, "Understanding SQL," for an explanation of datatypes. In addition, Appendix D, "MySQL Datatypes," lists the datatypes supported by MySQL.) The table's primary key may be specified at table creation time using the `PRIMARY KEY` keywords; here, column `cust_id` is specified as the primary key column. The entire statement is terminated with a semicolon after the closing parenthesis. (Ignore the `ENGINE=InnoDB` and `AUTO_INCREMENT` statements for now; we'll come back to that later).

Tip

Statement Formatting As you will recall, whitespace is ignored in MySQL statements. Statements can be typed on one long line or broken up over many lines. It makes no difference at all. This enables you to format your SQL as best suits you. The preceding `CREATE TABLE` statement is a good example of

MySQL statement formattingthe code is specified over multiple lines, with the column definitions indented for easier reading and editing. Formatting your MySQL in this way is entirely optional, but highly recommended.

Tip

Handling Existing Tables When you create a new table, the table name specified must not exist or you'll generate an error. To prevent accidental overwriting, SQL requires that you first manually remove a table (see later sections for details) and then re-create it, rather than just overwriting it.

If you want to create a table only if it does not already exist, specify `IF NOT EXISTS` after the table name. This does not check to see that the schema of the existing table matches the one you are about to create. It simply checks to see if the table name exists, and only proceeds with table creation if it does not.

Working with `NULL` Values

Back in Chapter 6, "Filtering Data," you learned that `NULL` values are no values or the lack of a value. A column that allows `NULL` values also allows rows to be inserted with no value at all in that column. A column that does not allow `NULL` values does not accept rows with no valuein other words, that column will always be required when rows are inserted or updated.

Every table column is either a `NULL` column or a `NOT NULL` column, and that state is specified in the table definition at creation time. Take a look at the following example:

- **Input**

```
CREATE TABLE orders
(
  order_num  int      NOT NULL AUTO_INCREMENT,
  order_date datetime NOT NULL ,
  cust_id    int       NOT NULL ,
  PRIMARY KEY (order_num)
) ENGINE=InnoDB;
```

- **Analysis**

This statement creates the `orders` table used throughout this book. `orders` contains three columns: order number, order date, and the customer ID. All three columns are required, and so each contains the keyword `NOT NULL`. This will prevent the insertion of columns with no value. If someone tries to insert no value, an error will be returned, and the insertion will fail.

This next example creates a table with a mixture of `NULL` and `NOT NULL` columns:

- **Input**

```
CREATE TABLE vendors
(
  vend_id      int      NOT NULL AUTO_INCREMENT,
  vend_name    char(50) NOT NULL ,
  vend_address char(50) NULL ,
  vend_city    char(50) NULL ,
  vend_state   char(5)  NULL ,
  vend_zip     char(10) NULL ,
  vend_country char(50) NULL ,
  PRIMARY KEY (vend_id)
) ENGINE=InnoDB;
```

- **Analysis**

This statement creates the `vendors` table used throughout this book. The vendor ID and vendor name columns are both required, and are, therefore, specified as `NOT NULL`. The five remaining columns all allow `NULL` values, and so `NOT NULL` is not specified. `NULL` is the default setting, so if `NOT NULL` is not specified, `NULL` is assumed.

Caution

Understanding `NULL` Don't confuse `NULL` values with empty strings. A `NULL` value is the lack of a value; it is not an empty string. If you were to specify `''` (two single quotes with nothing in between them), that would be allowed in a `NOT NULL` column. An empty string is a valid value; it is not no value. `NULL` values are specified with the keyword `NULL`, not with an empty string.

Primary Keys Revisited

As already explained, primary key values must be unique. That is, every row in a table must have a unique primary key value. If a single column is used for the primary key, it must be unique; if multiple columns are used, the combination of them must be unique.

The `CREATE TABLE` examples seen thus far use a single column as the primary key. The primary key is thus defined using a statement such as

```
PRIMARY KEY (vend_id)
```

To create a primary key made up of multiple columns, simply specify the column names as a comma delimited list, as seen in this example:

```
CREATE TABLE orderitems
(
  order_num  int          NOT NULL ,
  order_item int          NOT NULL ,
  prod_id    char(10)     NOT NULL ,
  quantity   int          NOT NULL ,
  item_price decimal(8,2) NOT NULL ,
  PRIMARY KEY (order_num, order_item)
) ENGINE=InnoDB;
```

The `orderitems` table contains the order specifics for each order in the `orders` table. There may be multiple items per order, but each order will only ever have one first item, one second item, and so on. As such, the combination of order number (column `order_num`) and order item (column `order_item`) are unique, and thus suitable to be the primary key which is defined as

```
PRIMARY KEY (order_num, order_item)
```

Primary keys may be defined at table creation time (as seen here) or after table creation (as will be discussed later in this chapter).

Tip

Primary Keys and `NULL` Values Back in Chapter 1, you learned that primary keys are columns whose values uniquely identify every row in a table. Only columns that do not allow `NULL` values can be used in primary keys. Columns that allow no value at all cannot be used as unique identifiers.

Using `AUTO_INCREMENT`

Let's take a look at the `customers` and `orders` tables again. Customers in the `customers` table are uniquely identified by column `cust_id`, a unique number for each and every customer. Similarly, orders in the `orders` table each have a unique order number which is stored in column `order_num`.

These numbers have no special significance, other than the fact that they are unique. When a new customer or order is added, a new customer ID or order number is needed. The numbers can be anything, so long as they are unique.

Obviously, the simplest number to use would be whatever comes next, whatever is one higher than the current highest number. For example, if the highest `cust_id` is `10005`, the next customer inserted into the table could have a `cust_id` of `10006`.

Simple, right? Well, not really. How would you determine the next number to be used? You could, of course, use a `SELECT` statement to get the highest number (using the `Max()` function introduced in Chapter 12, "Summarizing Data") and then add 1 to it. But that would not be safe (you'd need to find a way to ensure that no one else inserted a row in between the time that you performed the `SELECT` and the `INSERT`, a legitimate possibility in multi-user applications). Nor would it be efficient (performing additional MySQL operations is never ideal).

And that's where `AUTO_INCREMENT` comes in. Look at the following line (part of the `CREATE TABLE` statement used to create the `customers` table)

```
cust_id      int      NOT NULL AUTO_INCREMENT,
```

`AUTO_INCREMENT` tells MySQL that this column is to be automatically incremented each time a row is added. Each time an `INSERT` operation is performed MySQL automatically increments (and thus `AUTO_INCREMENT`) the column, assigning it the next available value. This way each row is assigned a unique `cust_id` which is then used as the primary key value.

Only one `AUTO_INCREMENT` column is allowed per table, and it must be indexed (for example, by making it a primary key).

Note

Overriding `AUTO_INCREMENT` Need to use a specific value if a column designated as `AUTO_INCREMENT`? You cansimply specify a value in the `INSERT` statement and as long as it is unique (has not been used yet), that value will be used instead of an automatically generated one. Subsequent incrementing will start using the value manually inserted. (See the table population scripts used in this book for examples of this.)

Tip

Determining the `AUTO_INCREMENT` Value One downside of having MySQL generate (via auto increment) primary keys for you is that you don't know what those values are.

Consider this scenario: You are adding a new order. This requires creating a single row in the `orders` table and then a row for each item ordered in the `orderitems` table. The `order_num` is stored along with the order details in `orderitems`. This is how the `orders` and `orderitems` table are related to each other. And that obviously requires that you know the generated `order_num` after the `orders` row was inserted and before the `orderitems` rows are inserted.

So how could you obtain this value when an `AUTO_INCREMENT` column is used? By using the `last_insert_id()` function, like this:

```
SELECT last_insert_id();
```

This returns the last `AUTO_INCREMENT` value, which you can then use in subsequent MySQL statements.

Specifying Default Values

MySQL enables you to specify default values to be used if no value is specified when a row is inserted. Default values are specified using the `DEFAULT` keyword in the column definitions in the `CREATE TABLE` statement.

Look at the following example:

- **Input**

```
CREATE TABLE orderitems
(
  order_num  int          NOT NULL ,
  order_item int          NOT NULL ,
  prod_id    char(10)     NOT NULL ,
  quantity   int          NOT NULL  DEFAULT 1,
  item_price decimal(8,2) NOT NULL ,
  PRIMARY KEY (order_num, order_item)
) ENGINE=InnoDB;
```

- **Analysis**

This statement creates the `orderitems` table that contains the individual items that make up an order. (The order itself is stored in the `orders` table.) The `quantity` column contains the quantity for each item in an order. In this example, adding the text `DEFAULT 1` to the column description instructs MySQL to use a quantity of `1` if no quantity is specified.

Caution

Functions Are Not Allowed Unlike most DBMSs, MySQL does not allow the use of functions as `DEFAULT` values; only constants are supported.

Tip

Using `DEFAULT` Instead of `NULL` Values Many database developers use `DEFAULT` values instead of `NULL` columns, especially in columns that will be used in calculations or data groupings.

Engine Types

You might have noticed that the `CREATE TABLE` statements used thus far all ended with an `ENGINE=InnoDB` statement.

Like every other DBMS, MySQL has an internal engine that actually manages and manipulates data. When you use the `CREATE TABLE` statement, that engine is used to actually create the tables, and when you use the `SELECT` statement or perform any other database processing, the engine is used internally to process your request. For the most part, the engine is buried within the DBMS and you need not pay much attention to it.

But unlike every other DBMS, MySQL does not come with a single engine. Rather, it ships with several engines, all buried within the MySQL server, and all capable of executing commands such as `CREATE TABLE` and `SELECT`.

So why bother shipping multiple engines? Because they each have different capabilities and features, and being able to pick the right engine for the job gives you unprecedented power and flexibility.

Of course, you are free to totally ignore database engines. If you omit the `ENGINE=` statement, the default engine is used (most likely `MyISAM`), and most of your SQL statements will work as is. But not all of them will, and that is why this is important (and why two engines are used in the same tables used in this book).

Here are several engines of which to be aware:

- `InnoDB` is a transaction-safe engine (see Chapter 26, "Managing Transaction Processing"). It does not support full-text searching.
- `MEMORY` is functionally equivalent to `MyISAM`, but as data is stored in memory (instead of on disk) it is extremely fast (and ideally suited for temporary tables).
- `MyISAM` is a very high-performance engine. It supports full-text searching (see Chapter 18, "Full-Text Searching"), but does not support transactional processing.

Note

To Learn More For a complete list of supported engines (and the differences between them), see http://dev.mysql.com/doc/refman/5.0/en/storage-engines.html.

Engine types may be mixed. The example tables used throughout this book all use `InnoDB` with the exception of the `productnotes` table, which uses `MyISAM`. The reason for this is that I wanted support for transactional processing (and thus used `InnoDB`) but also needed full-text searching support in `productnotes` (and thus `MyISAM` for that table).

Caution

Foreign Keys Can't Span Engines There is one big downside to mixing engine types. Foreign keys (used to enforce referential integrity, as explained in Chapter 1, "Understanding SQL") cannot span engines. That is, a table using one engine cannot have a foreign key referring to a table that uses another engine.

So, which should you use? Well, that will depend on what features you need. `MyISAM` tends to be the most popular engine because of its performance and features. But if you do need transaction-safe processing, you will need to use another engine.

Updating Tables

To update table definitions, the `ALTER TABLE` statement is used. But, ideally, tables should never be altered after they contain data. You should spend sufficient time anticipating future needs during the table design process so extensive changes are not required later on.

To change a table using `ALTER TABLE`, you must specify the following information:

- The name of the table to be altered after the keywords `ALTER TABLE`. (The table must exist or an error will be generated.)
- The list of changes to be made.

The following example adds a column to a table:

• **Input**

```
ALTER TABLE vendors
ADD vend_phone CHAR(20);
```

• **Analysis**

This statement adds a column named `vend_phone` to the `vendors` table. The datatype must be specified.

To remove this newly added column, you can do the following:

• **Input**

```
ALTER TABLE Vendors
DROP COLUMN vend_phone;
```

One common use for `ALTER TABLE` is to define foreign keys. The following is the code used to define the foreign keys used by the tables in this book:

```
ALTER TABLE orderitems
```

```
ADD CONSTRAINT fk_orderitems_orders
FOREIGN KEY (order_num) REFERENCES orders (order_num);
ALTER TABLE orderitems
ADD CONSTRAINT fk_orderitems_products FOREIGN KEY (prod_id)
REFERENCES products (prod_id);

ALTER TABLE orders
ADD CONSTRAINT fk_orders_customers FOREIGN KEY (cust_id)
REFERENCES customers (cust_id);

ALTER TABLE products
ADD CONSTRAINT fk_products_vendors
FOREIGN KEY (vend_id) REFERENCES vendors (vend_id);
```

Here four `ALTER TABLE` statements are used, as four different tables are being altered. To make multiple alterations to a single table, a single `ALTER TABLE` statement could be used with each of the alterations specified comma delimited.

Complex table structure changes usually require a manual move process involving these steps:

- Create a new table with the new column layout.
- Use the `INSERT SELECT` statement (see Chapter 19, "Inserting Data," for details of this statement) to copy the data from the old table to the new table. Use conversion functions and calculated fields, if needed.
- Verify that the new table contains the desired data.
- Rename the old table (or delete it, if you are really brave).
- Rename the new table with the name previously used by the old table.
- Re-create any triggers, stored procedures, indexes, and foreign keys as needed.

Caution

Use `ALTER TABLE` Carefully Use `ALTER TABLE` with extreme caution, and be sure you have a complete set of backups (both schema and data) before proceeding. Database table changes cannot be undoneand if you add columns you don't need, you might not be able to remove them. Similarly, if you drop a column that you do need, you might lose all the data in that column.

Deleting Tables

Deleting tables (actually removing the entire table, not just the contents) is very easyarguably too easy. Tables are deleted using the `DROP TABLE` statement:

- **Input**

```
DROP TABLE customers2;
```

- **Analysis**

This statement deletes the `customers2` table (assuming it exists). There is no confirmation, nor is there an undoexecuting the statement will permanently remove the table.

Renaming Tables

To rename a table, use the `RENAME TABLE` statement as follows:

- **Input**

```
RENAME TABLE customers2 TO customers;
```

- **Analysis**

`RENAME TABLE` does just that, it renames a table. Multiple tables may be renamed in one operation using the syntax:

```
RENAME TABLE backup_customers TO customers,
             backup_vendors TO vendors,
             backup_products TO products;
```

Summary

In this chapter, you learned several new SQL statements. `CREATE TABLE` is used to create new tables, `ALTER TABLE` is used to change table columns (or other objects like constraints or indexes), and `DROP TABLE` is used to completely delete a table. These statements should be used with extreme caution, and only after backups have been made. You also learned about database engines, defining primary and foreign keys, and other important table and column options.

Chapter 22. Using Views

In this chapter you'll learn exactly what views are, how they work, and when they should be used. You'll also see how views can be used to simplify some of the SQL operations performed in earlier chapters.

Understanding Views

Note

Requires MySQL 5 Support for views was added to MySQL 5. As such, this chapter is applicable to MySQL 5 or later only.

Views are virtual tables. Unlike tables that contain data, views simply contain queries that dynamically retrieve data when used.

The best way to understand views is to look at an example. Back in Chapter 15, "Joining Tables," you used the following `SELECT` statement to retrieve data from three tables:

- **Input**

```
SELECT cust_name, cust_contact
FROM customers, orders, orderitems
WHERE customers.cust_id = orders.cust_id
  AND orderitems.order_num = orders.order_num
  AND prod_id = 'TNT2';
```

That query was used to retrieve the customers who had ordered a specific product. Anyone needing this data would have to understand the table structure, as well as how to create the query and join the tables. To retrieve the same data for another product (or for multiple products), the last `WHERE` clause would have to be modified.

Now imagine that you could wrap that entire query in a virtual table called `productcustomers`. You could then simply do the following to retrieve the same data:

- **Input**

```
SELECT cust_name, cust_contact
FROM productcustomers
```

```
WHERE prod_id = 'TNT2';
```

This is where views come into play. `productcustomers` is a view, and as a view, it does not contain any actual columns or data as a table would. Instead, it contains a SQL querythe same query used previously to join the tables properly.

Why Use Views

You've already seen one use for views. Here are some other common uses:

- To reuse SQL statements.
- To simplify complex SQL operations. After the query is written, it can be reused easily, without having to know the details of the underlying query itself.
- To expose parts of a table instead of complete tables.
- To secure data. Users can be given access to specific subsets of tables instead of to entire tables.
- To change data formatting and representation. Views can return data formatted and presented differently from their underlying tables.

For the most part, after views are created, they can be used in the same way as tables. You can perform `SELECT` operations, filter and sort data, join views to other views or tables, and possibly even add and update data. (There are some restrictions on this last item. More on that in a moment.)

The important thing to remember is views are just that, views into data stored elsewhere. Views contain no data themselves, so the data they return is retrieved from other tables. When data is added or changed in those tables, the views will return that changed data.

Caution

Performance Issues Because views contain no data, any retrieval needed to execute a query must be processed every time the view is used. If you create complex views with multiple joins and filters, or if you nest views, you may find that performance is dramatically degraded. Be sure you test execution before deploying applications that use views extensively.

View Rules and Restrictions

Here are some of the most common rules and restrictions governing view creation and usage:

- Like tables, views must be uniquely named. (They cannot be named with the name of any other table or view).
- There is no limit to the number of views that can be created.
- To create views, you must have security access. This is usually granted by the database administrator.
- Views can be nested; that is, a view may be built using a query that retrieves data from another view.
- `ORDER BY` may be used in a view, but it will be overridden if `ORDER BY` is also used in the `SELECT` that retrieves data from the view.
- Views cannot be indexed, nor can they have triggers or default values associated with them.
- Views can be used in conjunction with tables, for example, to create a `SELECT` statement which joins a table and a view.

Using Views

So now that you know what views are (and the rules and restrictions that govern them), let's look at view creation:

- Views are created using the `CREATE VIEW` statement.
- To view the statement used to create a view, use `SHOW CREATE VIEW` *`viewname;`*.
- To remove a view, the `DROP` statement is used. The syntax is simply `DROP VIEW` *`viewname;`*.
- To update a view you may use the `DROP` statement and then the `CREATE` statement again, or just use `CREATE OR REPLACE VIEW`, which will create it if it does not exist and replace it if it does.

Using Views to Simplify Complex Joins

One of the most common uses of views is to hide complex SQL, and this often involves joins. Look at the following statement:

- **Input**

```
CREATE VIEW productcustomers AS
SELECT cust_name, cust_contact, prod_id
FROM customers, orders, orderitems
WHERE customers.cust_id = orders.cust_id
  AND orderitems.order_num = orders.order_num;
```

- **Analysis**

This statement creates a view named `productcustomers`, which joins three tables to return a list of all customers who have ordered any product. If you were to `SELECT * FROM productcustomers`, you'd list every customer who ordered anything.

To retrieve a list of customers who ordered product `TNT2`, you can do the following:

• **Input**

```
SELECT cust_name, cust_contact
FROM productcustomers
WHERE prod_id = 'TNT2';
```

• **Output**

```
+----------------+--------------+
| cust_name      | cust_contact |
+----------------+--------------+
| Coyote Inc.    | Y Lee        |
| Yosemite Place | Y Sam        |
+----------------+--------------+
```

• **Analysis**

This statement retrieves specific data from the view by issuing a `WHERE` clause. When MySQL processes the request, it adds the specified `WHERE` clause to any existing `WHERE` clauses in the view query so the data is filtered correctly.

As you can see, views can greatly simplify the use of complex SQL statements. Using views, you can write the underlying SQL once and then reuse it as needed.

Tip

Creating Reusable Views It is a good idea to create views that are not tied to specific data. For example, the view created in this example returns customers for all products, not just product `TNT2` (for which the view was first created). Expanding the scope of the view enables it to be reused, making it even more useful. It also eliminates the need for you to create and maintain multiple similar views.

Using Views to Reformat Retrieved Data

As mentioned previously, another common use of views is for reformatting retrieved data. The following SELECT statement (from Chapter 10, "Creating Calculated Fields") returns vendor name and location in a single combined calculated column:

- **Input**

```
SELECT Concat(RTrim(vend_name), ' (', RTrim(vend_country), ')')
       AS vend_title
FROM vendors
ORDER BY vend_name;
```

- **Output**

```
+--------------------------+
| vend_title               |
+--------------------------+
| ACME (USA)               |
| Anvils R Us (USA)        |
| Furball Inc. (USA)       |
| Jet Set (England)        |
| Jouets Et Ours (France)  |
| LT Supplies (USA)        |
+--------------------------+
```

Now suppose that you regularly needed results in this format. Rather than perform the concatenation each time it was needed, you could create a view and use that instead. To turn this statement into a view, you can do the following:

- **Input**

```
CREATE VIEW vendorlocations AS
SELECT Concat(RTrim(vend_name), ' (', RTrim(vend_country), ')')
       AS vend_title
FROM vendors
ORDER BY vend_name;
```

• **Analysis**

This statement creates a view using the exact same query as the previous `SELECT` statement. To retrieve the data to create all mailing labels, simply do the following:

• **Input**

```
SELECT *
FROM vendorlocations;
```

• **Output**

```
+---------------------------+
| vend_title                |
+---------------------------+
| ACME (USA)                |
| Anvils R Us (USA)         |
| Furball Inc. (USA)        |
| Jet Set (England)         |
| Jouets Et Ours (France)   |
| LT Supplies (USA)         |
+---------------------------+
```

Using Views to Filter Unwanted Data

Views are also useful for applying common `WHERE` clauses. For example, you might want to define a `customeremaillist` view so it filters out customers without email addresses. To do this, you can use the following statement:

• **Input**

```
CREATE VIEW customeremaillist AS
SELECT cust_id, cust_name, cust_email
FROM customers
WHERE cust_email IS NOT NULL;
```

- **Analysis**

Obviously, when sending email to a mailing list you'd want to ignore users who have no email address. The `WHERE` clause here filters out those rows that have `NULL` values in the `cust_email` columns so they'll not be retrieved.

View `customeremaillist` can now be used for data retrieval just like any table.

- **Input**

```
SELECT *
FROM customeremaillist;
```

- **Output**

```
+---------+----------------+---------------------+
| cust_id | cust_name      | cust_email          |
+---------+----------------+---------------------+
|   10001 | Coyote Inc.    | ylee@coyote.com     |
|   10003 | Wascals        | rabbit@wascally.com |
|   10004 | Yosemite Place | sam@yosemite.com    |
+---------+----------------+---------------------+
```

Note

`WHERE` Clauses and `WHERE` Clauses If a `WHERE` clause is used when retrieving data from the view, the two sets of clauses (the one in the view and the one passed to it) will be combined automatically.

Using Views with Calculated Fields

Views are exceptionally useful for simplifying the use of calculated fields. The following is a `SELECT` statement introduced in Chapter 10. It retrieves the order items for a specific order, calculating the expanded price for each item:

• **Input**

```
SELECT prod_id,
       quantity,
       item_price,
       quantity*item_price AS expanded_price
FROM orderitems
WHERE order_num = 20005;
```

• **Output**

```
+---------+----------+------------+----------------+
| prod_id | quantity | item_price | expanded_price |
+---------+----------+------------+----------------+
| ANV01   |       10 | 5.99       | 59.90          |
| ANV02   |        3 | 9.99       | 29.97          |
| TNT2    |        5 | 10.00      | 50.00          |
| FB      |        1 | 10.00      | 10.00          |
+---------+----------+------------+----------------+
```

To turn this into a view, do the following:

• **Input**

```
CREATE VIEW orderitemsexpanded AS
SELECT order_num,
       prod_id,
       quantity,
       item_price,
       quantity*item_price AS expanded_price
FROM orderitems;
```

To retrieve the details for order `20005` (the previous output), do the following:

• **Input**

```
SELECT *
FROM orderitemsexpanded
```

```
WHERE order_num = 20005;
```

• **Output**

```
+---------+----------+------------+----------------+
| prod_id | quantity | item_price | expanded_price |
+---------+----------+------------+----------------+
| ANV01   |       10 | 5.99       | 59.90          |
| ANV02   |        3 | 9.99       | 29.97          |
| TNT2    |        5 | 10.00      | 50.00          |
| FB      |        1 | 10.00      | 10.00          |
+---------+----------+------------+----------------+
```

As you can see, views are easy to create and even easier to use. Used correctly, views can greatly simplify complex data manipulation.

Updating Views

All of the views thus far have been used with `SELECT` statements. But can view data be updated? The answer is that it depends.

As a rule, yes, views are updateable (that is, you can use `INSERT`, `UPDATE`, and `DELETE` on them). Updating a view updates the underlying table (the view, you will recall, has no data of its own); if you add or remove rows from a view you are actually removing them from the underlying table.

But not all views are updateable. Basically, if MySQL is unable to correctly ascertain the underlying data to be updated, updates (this includes inserts and deletes) are not allowed. In practice, this means that if any of the following are used you'll not be able to update the view:

- Grouping (using `GROUP BY` and `HAVING`)
- Joins
- Subqueries

- Unions
- Aggregate functions (`Min()`, `Count()`, `Sum()`, and so forth)
- `DISTINCT`
- Derived (calculated) columns

In other words, many of the examples used in this chapter would not be updateable. This might sound like a serious restriction, but in reality it isn't because views are primarily used for data retrieval anyway.

Note

Subject to Change The previous list was accurate as of MySQL 5. Future MySQL updates will likely remove some of these restrictions.

Tip

Use Views for Retrieval As a rule, use views for data retrieval (`SELECT` statements) and not for updates (`INSERT`, `UPDATE`, and `DELETE`).

Summary

Views are virtual tables. They do not contain data, but they contain queries that retrieve data as needed, instead. Views provide a level of encapsulation around MySQL `SELECT` statements and can be used to simplify data manipulation, as well as to reformat or secure underlying data.

Chapter 23. Working with Stored Procedures

In this chapter, you'll learn what stored procedures are, why they are used, and how they are used. You'll also look at the basic syntax for creating and using them.

Understanding Stored Procedures

Note

Requires MySQL 5 Support for stored procedures was added to MySQL 5. As such, this chapter is applicable to MySQL 5 or later only.

Most of the SQL statements that we've used thus far are simple in that they use a single statement against one or more tables. Not all operations are that simpleoften, multiple statements will be needed to perform a complete operation. For example, consider the following scenario:

- To process an order, checks must be made to ensure that items are in stock.
- If items are in stock, they need to be reserved so they are not sold to anyone else, and the available quantity must be reduced to reflect the correct amount in stock.
- Any items not in stock need to be ordered; this requires some interaction with the vendor.
- The customer needs to be notified as to which items are in stock (and can be shipped immediately) and which are back ordered.

This is obviously not a complete example, and it is even beyond the scope of the example tables that we have been using in this book, but it will suffice to help make a point. Performing this process requires many MySQL statements against many tables. In addition, the exact statements that need to be performed and their order are not fixed; they can (and will) vary according to which items are in stock and which are not.

How would you write this code? You could write each of the statements individually and execute other statements conditionally, based on the result. You'd have to do this every time this processing was needed (and in every application that needed it).

Or you could create a stored procedure. Stored procedures are simply collections of one or more MySQL statements saved for future use. You can think of them as batch files, although in truth they are more than that.

Why Use Stored Procedures

Now that you know what stored procedures are, why use them? There are many reasons, but here are the primary ones:

- To simplify complex operations (as seen in the previous example) by encapsulating processes into a single easy-to-use unit.
- To ensure data integrity by not requiring that a series of steps be created over and over. If all developers and applications use the same (tried and tested) stored procedure, the same code will be used by all.

  An extension of this is to prevent errors. The more steps that need to be performed, the more likely it is that errors will be introduced. Preventing errors ensures data consistency.
- To simplify change management. If tables, column names, or business logic (or just about anything) changes, only the stored procedure code needs to be updated, and no one else will need even to be aware that changes were made.

  An extension of this is security. Restricting access to underlying data via stored procedures reduces the chance of data corruption (unintentional or otherwise).
- To improve performance, as stored procedures typically execute quicker than do individual SQL statements.
- There are MySQL language elements and features that are available only within single requests. Stored procedures can use these to write code that is more powerful and flexible. (We'll see an example of this in the next chapter).

In other words, there are three primary benefitssimplicity, security, and performance. Obviously all are extremely important. Before you run off to turn all your SQL code into stored procedures, here's the downside:

- Stored procedures tend to be more complex to write than basic SQL statements, and writing them requires a greater degree of skill and experience.

- You might not have the security access needed to create stored procedures. Many database administrators restrict stored procedure creation rights, allowing users to execute them but not necessarily create them.

Nonetheless, stored procedures are very useful and should be used whenever possible.

Note

Can't Write Them? You Can Still Use Them MySQL distinguishes the security and access needed to write stored procedures from the security and access needed to execute them. This is a good thing; even if you can't (or don't want to) write your own stored procedures, you can still execute them when appropriate.

Using Stored Procedures

Using stored procedures requires knowing how to execute (run) them. Stored procedures are executed far more often than they are written, so we'll start there. And then we'll look at creating and working with stored procedures.

Executing Stored Procedures

MySQL refers to stored procedure execution as *calling*, and so the MySQL statement to execute a stored procedure is simply `CALL`. `CALL` takes the name of the stored procedure and any parameters that need to be passed to it. Take a look at this example:

- **Input**

```
CALL productpricing(@pricelow,
                    @pricehigh,
                    @priceaverage);
```

- **Analysis**

Here a stored procedure named `productpricing` is executed; it calculates and returns the lowest, highest, and average product prices.

Stored procedures might or might not display results, as you will see shortly.

Creating Stored Procedures

As already explained, writing a stored procedure is not trivial. To give you a taste for what is involved, let's look at a simple examplea stored procedure that returns the average product price. Here is the code:

- **Input**

```
CREATE PROCEDURE productpricing()
BEGIN
   SELECT Avg(prod_price) AS priceaverage
   FROM products;
END;
```

• **Analysis**

Ignore the first and last lines for a moment; we'll come back to them shortly. The stored procedure is named `productpricing` and is thus defined with the statement `CREATE PROCEDURE productpricing()`. Had the stored procedure accepted parameters, these would have been enumerated between the `(` and `)`. This stored procedure has no parameters, but the trailing `()` is still required. `BEGIN` and `END` statements are used to delimit the stored procedure body, and the body itself is just a simple `SELECT` statement (using the `Avg()` function learned in Chapter 12, "Summarizing Data").

When MySQL processes this code it creates a new stored procedure named `productpricing`. No data is returned because the code does not call the stored procedure, it simply creates it for future use.

Note

mysql Command-line Client Delimiters If you are using the mysql command-line utility, pay careful attention to this note.

The default MySQL statement delimiter is `;` (as you have seen in all of the MySQL statement used thus far). However, the mysql command-line utility also uses `;` as a delimiter. If the command-line utility were to interpret the `;` characters inside of the stored procedure itself, those would not end up becoming part of the stored procedure, and that would make the SQL in the stored procedure syntactically invalid.

The solution is to temporarily change the command-line utility delimiter, as seen here:

```
DELIMITER //

CREATE PROCEDURE productpricing()
BEGIN
   SELECT Avg(prod_price) AS priceaverage
   FROM products;
END //
```

```
DELIMITER ;
```

Here, `DELIMITER //` tells the command-line utility to use `//` as the new end of statement delimiter, and you will notice that the `END` that closes the stored procedure is defined as `END //` instead of the expected `END;`. This way the `;` within the stored procedure body remains intact and is correctly passed to the database engine. And then, to restore things back to how they were initially, the statement closes with a `DELIMITER ;`.

Any character may be used as the delimiter except for `\`.

If you are using the mysql command-line utility, keep this in mind as you work through this chapter.

So how would you use this stored procedure? Like this:

- **Input**

```
CALL productpricing();
```

- **Output**

```
+--------------+
| priceaverage |
+--------------+
|    16.133571 |
+--------------+
```

- **Analysis**

`CALL productpricing();` executes the just-created stored procedure and displays the returned result. As a stored procedure is actually a type of function, `()` characters are required after the stored procedure name (even when no parameters are being passed).

Dropping Stored Procedures

After they are created, stored procedures remain on the server, ready for use, until dropped. The drop command (similar to the statement seen Chapter 21, "Creating and Manipulating Tables") removes the stored procedure from the server.

To remove the stored procedure we just created, use the following statement:

- **Input**

```
DROP PROCEDURE productpricing;
```

- **Analysis**

This removes the just-created stored procedure. Notice that the trailing `()` is not used; here just the stored procedure name is specified.

Tip

Drop Only If It Exists `DROP PROCEDURE` will throw an error if the named procedure does not actually exist. To delete a procedure if it exists (and not throw an error if it does not), use `DROP PROCEDURE IF EXISTS`.

Working with Parameters

`productpricing` is a really simple stored procedureit simply displays the results of a `SELECT` statement. Typically stored procedures do not display results; rather, they return them into variables that you specify.

New Term

Variable A named location in memory, used for temporary storage of data.

Here is an updated version of `productpricing` (you'll not be able to create the stored procedure again if you did not previously drop it):

• **Input**

```
CREATE PROCEDURE productpricing(
   OUT pl DECIMAL(8,2),
   OUT ph DECIMAL(8,2),
   OUT pa DECIMAL(8,2)
)
BEGIN
   SELECT Min(prod_price)
   INTO pl
   FROM products;
   SELECT Max(prod_price)
   INTO ph
   FROM products;
   SELECT Avg(prod_price)
   INTO pa
   FROM products;
END;
```

• **Analysis**

This stored procedure accepts three parameters: `pl` to store the lowest product price, `ph` to store the highest product price, and `pa` to store the average product price (and thus the variable names). Each parameter must have its type specified; here a decimal value is used. The keyword `OUT` is used to specify that this parameter is used to send a value out of the stored procedure (back to the caller). MySQL supports parameters of types `IN` (those passed to stored procedures), `OUT` (those passed from stored procedures, as we've used here), and `INOUT` (those used to pass parameters to and from stored procedures). The stored procedure code itself is enclosed within `BEGIN` and `END` statements as seen before, and a series of `SELECT` statements are performed to retrieve the values that are then saved into the appropriate variables (by specifying the `INTO` keyword).

Note

Parameter Datatypes The datatypes allowed in stored procedure parameters are the same as those used in tables. Appendix D, "MySQL Datatypes," lists these types.

Note that a recordset is not an allowed type, and so multiple rows and columns could not be returned via a parameter. This is why three parameters (and three `SELECT` statements) are used in the previous example.

To call this updated stored procedure, three variable names must be specified, as seen here:

- **Input**

```
CALL productpricing(@pricelow,
                    @pricehigh,
                    @priceaverage);
```

- **Analysis**

As the stored procedure expects three parameters, exactly three parameters must be passed, no more and no less. Therefore, three parameters are passed to this `CALL` statement. These are the names of the three variables that the stored procedure will store the results in.

Note

Variable Names All MySQL variable names must begin with `@`.

When called, this statement does not actually display any data. Rather, it returns variables that can then be displayed (or used in other processing).

To display the retrieved average product price you could do the following:

- **Input**

```
SELECT @priceaverage;
```

- **Output**

```
+----------------+
| @priceaverage |
+----------------+
| 16.133571428  |
+----------------+
```

To obtain all three values, you can use the following:

- **Input**

```
SELECT @pricehigh, @pricelow, @priceaverage;
```

- **Output**

```
+------------+-----------+----------------+
| @pricehigh | @pricelow | @priceaverage |
+------------+-----------+----------------+
| 55.00      | 2.50      | 16.133571428  |
+------------+-----------+----------------+
```

Here is another example, this time using both `IN` and `OUT` parameters. `ordertotal` accepts an order number and returns the total for that order:

- **Input**

```
CREATE PROCEDURE ordertotal(
   IN onumber INT,
   OUT ototal DECIMAL(8,2)
)
BEGIN
   SELECT Sum(item_price*quantity)
   FROM orderitems
   WHERE order_num = onumber
   INTO ototal;
END;
```

- **Analysis**

`onumber` is defined as `IN` because the order number is passed in to the stored procedure. `ototal` is defined as `OUT` because the total is to be returned from the stored procedure. The `SELECT` statement used both of these parameters, the `WHERE` clause uses `onumber` to select the right rows, and `INTO` uses `ototal` to store the calculated total.

To invoke this new stored procedure you can use the following:

- **Input**

```
CALL ordertotal(20005, @total);
```

- **Analysis**

Two parameters must be passed to `ordertotal`; the first is the order number and the second is the name of the variable that will contain the calculated total.

To display the total you can then do the following:

- **Input**

```
SELECT @total;
```

- **Output**

```
+---------+
| @total  |
+---------+
| 149.87  |
+---------+
```

• **Analysis**

`@total` has already been populated by the `CALL` statement to `ordertotal`, and `SELECT` displays the value it contains.

To obtain a display for the total of another order, you would need to call the stored procedure again, and then redisplay the variable:

• **Input**

```
CALL ordertotal(20009, @total);
SELECT @total;
```

Building Intelligent Stored Procedures

All of the stored procedures used thus far have basically encapsulated simple MySQL `SELECT` statements. And while they are all valid examples of stored procedures, they really don't do anything more than what you could do with those statements directly (if anything, they just make things a little more complex). The real power of stored procedures is realized when business rules and intelligent processing are included within them.

Consider this scenario. You need to obtain order totals as before, but also need to add sales tax to the total, but only for some customers (perhaps the ones in your own state). Now you need to do several things:

- Obtain the total (as before).
- Conditionally add tax to the total.
- Return the total (with or without tax).

That's a perfect job for a stored procedure:

• **Input**

```
-- Name: ordertotal
-- Parameters: onumber = order number
--             taxable = 0 if not taxable, 1 if taxable
--              ototal = order total variable

CREATE PROCEDURE ordertotal(
   IN onumber INT,
   IN taxable BOOLEAN,
   OUT ototal DECIMAL(8,2)
) COMMENT 'Obtain order total, optionally adding tax'
BEGIN

   -- Declare variable for total
   DECLARE total DECIMAL(8,2);
   -- Declare tax percentage
   DECLARE taxrate INT DEFAULT 6;

   -- Get the order total
   SELECT Sum(item_price*quantity)
   FROM orderitems
   WHERE order_num = onumber
   INTO total;

   -- Is this taxable?
   IF taxable THEN
      -- Yes, so add taxrate to the total
      SELECT total+(total/100*taxrate) INTO total;
   END IF;

   -- And finally, save to out variable
   SELECT total INTO ototal;

END;
```

• **Analysis**

The stored procedure has changed dramatically. First of all, comments have been added throughout (preceded by `--`). This is extremely important as stored procedures increase in complexity. An additional parameter has been added`taxable` is a `BOOLEAN` (specify true if taxable, false if not). Within the stored procedure body, two local variables are defined using `DECLARE` statements.

`DECLARE` requires that a variable name and datatype be specified, and also supports optional default values (`taxrate` in this example is set to 6%). The

SELECT has changed so the result is stored in total (the local variable) instead of ototal. Then an IF statement checks to see if taxable is true, and if it is, another SELECT statement is used to add the tax to local variable total. And finally, total (which might or might not have had tax added) is saved to ototal using another SELECT statement.

Tip

The COMMENT Keyword The stored procedure for this example included a COMMENT value in the CREATE PROCEDURE statement. This is not required, but if specified, is displayed in SHOW PROCEDURE STATUS results.

This is obviously a more sophisticated and powerful stored procedure. To try it out, use the following two statements:

- **Input**

```
CALL ordertotal(20005, 0, @total);
SELECT @total;
```

- **Output**

```
+---------+
| @total  |
+---------+
| 149.87  |
+---------+
```

- **Input**

```
CALL ordertotal(20005, 1, @total);
SELECT @total;
```

- **Output**

```
+----------------+
| @total         |
+----------------+
| 158.862200000 |
+----------------+
```

• **Analysis**

`BOOLEAN` values may be specified as `1` for true and `0` for false (actually, any non-zero value is considered true and only `0` is considered false). By specifying `0` or `1` in the middle parameter you can conditionally add tax to the order total.

Note

The `IF` Statement This example showed the basic use of the MySQL `IF` statement. `IF` also supports `ELSEIF` and `ELSE` clauses (the former also uses a `THEN` clause, the latter does not). We'll be seeing additional uses of `IF` (as well as other flow control statements) in future chapters.

Inspecting Stored Procedures

To display the `CREATE` statement used to create a stored procedure, use the `SHOW CREATE PROCEDURE` statement:

• **Input**

```
SHOW CREATE PROCEDURE ordertotal;
```

To obtain a list of stored procedures including details on when and who created them, use `SHOW PROCEDURE STATUS`.

Note

Limiting Procedure Status Results `SHOW PROCEDURE STATUS` lists all stored procedures. To restrict the output you can use `LIKE` to specify a filter pattern, for example:

```
SHOW PROCEDURE STATUS LIKE 'ordertotal';
```

Summary

In this chapter, you learned what stored procedures are and why they are used. You also learned the basics of stored procedure execution and creation syntax, and you saw some of the ways these can be used. We'll continue this subject in the next chapter.

Chapter 24. Using Cursors

In this chapter, you'll learn what cursors are and how to use them.

Understanding Cursors

Note

Requires MySQL 5 Support for cursors was added to MySQL 5. As such, this chapter is applicable to MySQL 5 or later only.

As you have seen in previous chapters, MySQL retrieval operations work with sets of rows known as result sets. The rows returned are all the rows that match a SQL statementzero or more of them. Using simple `SELECT` statements, there is no way to get the first row, the next row, or the previous 10 rows, for example. Nor is there an easy way to process all rows, one at a time (as opposed to all of them in a batch).

Sometimes there is a need to step through rows forward or backward and one or more at a time. This is what cursors are used for. A cursor is a database query stored on the MySQL servernot a `SELECT` statement, but the result set retrieved by that statement. Once the cursor is stored, applications can scroll or browse up and down through the data as needed.

Cursors are used primarily by interactive applications in which users need to scroll up and down through screens of data, browsing or making changes.

Note

Only in Stored Procedures Unlike most DBMSs, MySQL cursors may only be used within stored procedures (and functions).

Working with Cursors

Using cursors involves several distinct steps:

1. Before a cursor can be used it must be declared (defined). This process does not actually retrieve any data; it merely defines the `SELECT` statement to be used.

2. After it is declared, the cursor must be opened for use. This process actually retrieves the data using the previously defined `SELECT` statement.

3. With the cursor populated with data, individual rows can be fetched (retrieved) as needed.

4. When it is done, the cursor must be closed.

After a cursor is declared, it may be opened and closed as often as needed. After it is open, fetch operations can be performed as often as needed.

Creating Cursors

Cursors are created using the `DECLARE` statement (seen in Chapter 23, "Working with Stored Procedures"). `DECLARE` names the cursor and takes a `SELECT` statement, complete with `WHERE` and other clauses if needed. For example, this statement defines a cursor named `ordernumbers` using a `SELECT` statement that retrieves all orders:

- **Input**

```
CREATE PROCEDURE processorders()
BEGIN
   DECLARE ordernumbers CURSOR
   FOR
   SELECT ordernum FROM orders;
END;
```

• **Analysis**

This stored procedure does not do a whole lot. A `DECLARE` statement is used to define and name the cursorin this case `ordernumbers`. Nothing is done with the cursor, and as soon as the stored procedure finishes processing it will cease to exist (as it is local to the stored procedure itself).

Now that the cursor is defined, it is ready to be opened.

Opening and Closing Cursors

Cursors are opened using the `OPEN CURSOR` statement, like this:

• **Input**

```
OPEN ordernumbers;
```

• **Analysis**

When the `OPEN` statement is processed, the query is executed, and the retrieved data is stored for subsequent browsing and scrolling.

After cursor processing is complete, the cursor should be closed using the `CLOSE` statement, as follows:

• **Input**

```
CLOSE ordernumbers;
```

• **Analysis**

`CLOSE` frees up any internal memory and resources used by the cursor, and so every cursor should be closed when it is no longer needed.

After a cursor is closed, it cannot be reused without being opened again. However, a cursor does not need to be declared again to be used; an `OPEN` statement is sufficient.

Note

Implicit Closing If you do not explicitly close a cursor, MySQL will close it automatically when the `END` statement is reached.

Here is an updated version of the previous example:

- **Input**

```
CREATE PROCEDURE processorders()
BEGIN
   -- Declare the cursor
   DECLARE ordernumbers CURSOR
   FOR
   SELECT order_num FROM orders;

   -- Open the cursor
   OPEN ordernumbers;

   -- Close the cursor
   CLOSE ordernumbers;

END;
```

- **Analysis**

This stored procedure declares, opens, and closes a cursor. However, nothing is done with the retrieved data.

Using Cursor Data

After a cursor is opened, each row can be accessed individually using a `FETCH` statement. `FETCH` specifies what is to be retrieved (the desired columns) and where retrieved data should be stored. It also advances the internal row pointer within the cursor so the next `FETCH` statement will retrieve the next row (and not the same one over and over).

The first example retrieves a single row from the cursor (the first row):

- **Input**

```
CREATE PROCEDURE processorders()
BEGIN

   -- Declare local variables
   DECLARE o INT;

   -- Declare the cursor
   DECLARE ordernumbers CURSOR
   FOR
   SELECT order_num FROM orders;

   -- Open the cursor
   OPEN ordernumbers;

   -- Get order number
   FETCH ordernumbers INTO o;

   -- Close the cursor
   CLOSE ordernumbers;

END;
```

- **Analysis**

Here `FETCH` is used to retrieve the `order_num` column of the current row (it'll start at the first row automatically) into a local declared variable named `o`. Nothing is done with the retrieved data.

In the next example, the retrieved data is looped through from the first row to the last:

- **Input**

```
CREATE PROCEDURE processorders()
BEGIN

   -- Declare local variables
   DECLARE done BOOLEAN DEFAULT 0;
   DECLARE o INT;
   -- Declare the cursor
   DECLARE ordernumbers CURSOR
   FOR
   SELECT order_num FROM orders;

   -- Declare continue handler
   DECLARE CONTINUE HANDLER FOR SQLSTATE '02000' SET done=1;

   -- Open the cursor
   OPEN ordernumbers;

   -- Loop through all rows
   REPEAT

      -- Get order number
      FETCH ordernumbers INTO o;

   -- End of loop
   UNTIL done END REPEAT;

   -- Close the cursor
   CLOSE ordernumbers;

END;
```

- **Analysis**

Like the previous example, this example uses `FETCH` to retrieve the current `order_num` into a declared variable named `o`. Unlike the previous example, the `FETCH` here is within a `REPEAT` so it is repeated over and over until `done` is true (as specified by `UNTIL done END REPEAT;`). To make this work, variable `done` is defined with a `DEFAULT 0` (false, not done). So how does `done` get set to true when done? The answer is this statement:

```
DECLARE CONTINUE HANDLER FOR SQLSTATE '02000' SET done=1;
```

This statement defines a `CONTINUE HANDLER`, code that will be executed when a condition occurs. Here it specifies that when `SQLSTATE '02000'` occurs, then `SET done=1`. And `SQLSTATE '02000'` is a *not found* condition and so it occurs when `REPEAT` cannot continue because there are no more rows to loop through.

Note

`MySQL Error Codes` For a complete list of MySQL error codes used by MySQL 5, see http://dev.mysql.com/doc/mysql/en/error-handling.html.

Caution

`DECLARE` Statement Sequence There is specific order in which `DECLARE` statements, if used, must be issued. Local variables defined with `DECLARE` must be defined before any cursors or handlers are defined, and handlers must be defined after any cursors. Failure to follow this sequencing will generate an error message.

If you were to call this stored procedure it would define variables and a `CONTINUE HANDLER`, define and open a cursor, repeat through all rows, and then close the cursor.

With this functionality in place you can now place any needed processing inside the loop (after the `FETCH` statement and before the end of the loop).

Note

`REPEAT` or `LOOP`? In addition to the `REPEAT` statement used here, MySQL also supports a `LOOP` statement that can be used to repeat code until the `LOOP` is manually exited using a `LEAVE` statement. In general, the syntax of the `REPEAT` statement makes it better suited for looping through cursors.

To put this all together, here is one further revision of our example stored procedure with cursor, this time with some actual processing of fetched data:

• **Input**

```
CREATE PROCEDURE processorders()
BEGIN

   -- Declare local variables
   DECLARE done BOOLEAN DEFAULT 0;
   DECLARE o INT;
   DECLARE t DECIMAL(8,2);

   -- Declare the cursor
   DECLARE ordernumbers CURSOR
   FOR
   SELECT order_num FROM orders;
   -- Declare continue handler
   DECLARE CONTINUE HANDLER FOR SQLSTATE '02000' SET done=1;

   -- Create a table to store the results
   CREATE TABLE IF NOT EXISTS ordertotals
      (order_num INT, total DECIMAL(8,2));

   -- Open the cursor
   OPEN ordernumbers;

   -- Loop through all rows
   REPEAT

      -- Get order number
      FETCH ordernumbers INTO o;

      -- Get the total for this order
      CALL ordertotal(o, 1, t);

      -- Insert order and total into ordertotals
      INSERT INTO ordertotals(order_num, total)
      VALUES(o, t);

   -- End of loop
   UNTIL done END REPEAT;

   -- Close the cursor
   CLOSE ordernumbers;
```

```
END;
```

- **Analysis**

In this example, we've added another variable named `t` (this will store the total for each order). The stored procedure also creates a new table on the fly (if it does not exist) named `ordertotals`. This table will store the results generated by the stored procedure. `FETCH` fetches each `order_num` as it did before, and then used `CALL` to execute another stored procedure (the one we created in the previous chapter) to calculate the total with tax for each order (the result of which is stored in `t`). And then finally, `INSERT` is used to save the order number and total for each order.

This stored procedure returns no data, but it does create and populate another table that can then be viewed using a simple `SELECT` statement:

- **Input**

```
SELECT *
FROM ordertotals;
```

- **Output**

```
+-----------+---------+
| order_num | total   |
+-----------+---------+
|     20005 |  158.86 |
|     20006 |   58.30 |
|     20007 | 1060.00 |
|     20008 |  132.50 |
|     20009 |   40.78 |
+-----------+---------+
```

And then you have it, a complete working example of stored procedures, cursors, row-by-row processing, and even stored procedures calling other stored procedures.

Summary

In this chapter, you learned what cursors are and why they are used. You also saw examples demonstrating basic cursor use, as well as techniques for looping through cursor results and for row-by-row processing.

Chapter 25. Using Triggers

In this chapter, you'll learn what triggers are, why they are used, and how. You'll also look at the syntax for creating and using them.

Understanding Triggers

Note

Requires MySQL 5 Support for triggers was added to MySQL 5. As such, this chapter is applicable to MySQL 5 or later only.

MySQL statements are executed when needed, as are stored procedures. But what if you wanted a statement (or statements) to be executed automatically when events occur? For example:

- Every time a customer is added to a database table, check that the phone number is formatted correctly and that the state abbreviation is in uppercase.
- Every time a product is ordered, subtract the ordered quantity from the number in stock.
- Whenever a row is deleted, save a copy in an archive table.

What all these examples have in common is that they need to be processed automatically whenever a table change occurs. And that is exactly what triggers are. A *trigger* is a MySQL statement (or a group of statements enclosed within `BEGIN` and `END` statements) that are automatically executed by MySQL in response to any of these statements:

- `DELETE`
- `INSERT`
- `UPDATE`

No other MySQL statements support triggers.

Creating Triggers

When creating a trigger you need to specify four pieces of information:

- The unique trigger name
- The table to which the trigger is to be associated
- The action that the trigger should respond to (`DELETE`, `INSERT`, or `UPDATE`)
- When the trigger should be executed (before or after processing)

Tip

Keep Trigger Names Unique per Database In MySQL 5 trigger names must be unique per table, but not per database. This means that two tables in the same database can have triggers of the same name. This is not allowed in other DBMSs where trigger names must be unique per database, and it is very likely that MySQL will make the naming rules stricter in a future release. As such, it is a good idea to use database-wide unique trigger names now.

Triggers are created using the `CREATE TRIGGER` statement. Here is a really simple example:

- **Input**

```
CREATE TRIGGER newproduct AFTER INSERT ON products
FOR EACH ROW SELECT 'Product added';
```

- **Analysis**

`CREATE TRIGGER` is used to create the new trigger named `newproduct`. triggers can be executed before or after an operation occurs, and here `AFTER INSERT` is specified so the trigger will execute after a successful `INSERT` statement has been executed. The trigger then specifies `FOR EACH ROW` and the code to be executed for each inserted row. In this example, the text `Product added` will be displayed once for each row inserted.

To test this trigger, use the `INSERT` statement to add one or more rows to `products`; you'll see the `Product added` message displayed for each succesful insertion.

Note

Only Tables Triggers are only supported on tables, not on views (and not on temporary tables).

Triggers are defined per time per event per table, and only one trigger per time per event per table is allowed. As such, up to six triggers are supported per table (before and after each of `INSERT`, `UPDATE`, and `DELETE`). A single trigger cannot be associated with multiple events or multiple tables, so if you need a trigger to be executed for both `INSERT` and `UPDATE` operations, you'll need to define two triggers.

Note

When Triggers Fail If a `BEFORE` TRigger fails, MySQL will not perform the requested operation. In addition, if either a `BEFORE` trigger or the statement itself fails, MySQL will not exdcute an `AFTER` trigger (if one exists).

Dropping Triggers

By now the syntax for dropping a trigger should be apparent. To drop a trigger, use the `DROP TRIGGER` statement, as seen here:

- **Input**

```
DROP TRIGGER newproduct;
```

- **Analysis**

Triggers cannot be updated or overwritten. To modify a trigger, it must be dropped and re-created.

Using Triggers

With the basics covered, we will now look at each of the supported trigger types, and the differences between them.

`INSERT` TRiggers

`INSERT` triggers are executed before or after an `INSERT` statement is executed. Be aware of the following:

- Within `INSERT` TRigger code, you can refer to a virtual table named `NEW` to access the rows being inserted.
- In a `BEFORE INSERT` trigger, the values in `NEW` may also be updated (allowing you to change values about to be inserted).
- For `AUTO_INCREMENT` columns, `NEW` will contain `0` before and the new automatically generated value after.

Here's an example (a really useful one, actually). `AUTO_INCREMENT` columns have values that are automatically assigned by MySQL. Chapter 21, "Creating and Manipulating Tables," suggested several ways to determine the newly generated value, but here is an even better solution:

- **Input**

```
CREATE TRIGGER neworder AFTER INSERT ON orders
FOR EACH ROW SELECT NEW.order_num;
```

- **Analysis**

The code creates a trigger named `neworder` that is executed by `AFTER INSERT ON orders`. When a new order is saved in `orders`, MySQL generates a new order number and saves it in `order_num`.

This trigger simply obtains this value from `NEW.order_num` and returns it. This trigger must be executed by `AFTER INSERT` because before the `BEFORE INSERT` statement is executed, the new `order_num` has not been generated yet. Using this trigger for every insertion into `orders` will always return the new order number.

To test this trigger, try inserting a new order, like this:

- **Input**

```
INSERT INTO orders(order_date, cust_id)
VALUES(Now(), 10001);
```

- **Output**

```
+-----------+
| order_num |
+-----------+
|     20010 |
+-----------+
```

- **Analysis**

`orders` contains three columns. `order_date` and `cust_id` must be specified, `order_num` is automatically generated by MySQL, and `order_num` is also now returned automatically.

Tip

`BEFORE` or `AFTER`? As a rule, use `BEFORE` for any data validation and cleanup (you'd want to make sure that the data inserted into the table was exactly as needed). This applies to `UPDATE` triggers, too.

`DELETE` triggers

`DELETE` triggers are executed before or after a `DELETE` statement is executed. Be aware of the following:

- Within DELETE trigger code, you can refer to a virtual table named OLD to access the rows being deleted.

- The values in OLD are all read-only and cannot be updated.

The following example demonstrates the use of OLD to save rows about to be deleted into an archive table:

- **Input**

```
CREATE TRIGGER deleteorder BEFORE DELETE ON orders
FOR EACH ROW
BEGIN
   INSERT INTO archive_orders(order_num, order_date, cust_id)
   VALUES(OLD.order_num, OLD.order_date, OLD.cust_id);
END;
```

- **Analysis**

Before any order is deleted this trigger will be executed. It used an INSERT statement to save the values in OLD (the order about to be deleted) into an archive table named archive_orders. (To actually use this example you'll need to create a table named archive_orders with the same columns as orders).

The advantage of using a BEFORE DELETE TRigger (as opposed to an AFTER DELETE TRigger) is that if, for some reason, the order could not be archived, the DELETE itself will be aborted.

Note

Multi-Statement Triggers You'll notice that trigger deleteorder uses BEGIN and END statements to mark the trigger body. This is actually not necessary in this example, although it does no harm being there. The advantage of using a BEGIN END block is that the trigger would then be able to accommodate multiple SQL statements (one after the other within the BEGIN END block).

`UPDATE` triggers

`UPDATE` triggers are executed before or after an `UPDATE` statement is executed. Be aware of the following:

- Within `UPDATE` trigger code, you can refer to a virtual table named `OLD` to access the previous (pre-`UPDATE` statement) values and `NEW` to access the new updated values.
- In a `BEFORE UPDATE` trigger, the values in `NEW` may also be updated (allowing you to change values about to be used in the `UPDATE` statement).
- The values in `OLD` are all read-only and cannot be updated.

The following example ensures that state abbreviations are always in uppercase (regardless of how they were actually specified in the `UPDATE` statement):

• **Input**

```
CREATE TRIGGER updatevendor BEFORE UPDATE ON vendors
FOR EACH ROW SET NEW.vend_state = Upper(NEW.vend_state);
```

• **Analysis**

Obviously, any data cleanup needs to occur in the `BEFORE UPDATE` statement as it does in this example. Each time a row is updated, the value in `NEW.vend_state` (the value that will be used to update table rows) is replaced with `Upper(NEW.vend_state)`.

More on Triggers

Before wrapping this chapter, here are some important points to keep in mind when using triggers:

- Trigger support in MySQL 5 is rather rudimentary at best when compared to other DBMSs. There are plans to improve and enhance trigger support in future versions of MySQL.

- Creating triggers might require special security access. However, trigger execution is automatic. If an `INSERT`, `UPDATE`, or `DELETE` statement may be executed, any associated triggers will be executed, too.

- Triggers should be used to ensure data consistency (case, formatting, and so on). The advantage of performing this type of processing in a trigger is that it always happens, and happens transparently, regardless of client application.

- One very interesting use for triggers is in creating an audit trail. Using triggers it would be very easy to log changes (even before and after states if needed) to another table.

- Unfortunately the `CALL` statement is not supported in MySQL triggers. This means that stored procedures cannot be invoked from within triggers. Any needed stored procedure code would need to be replicated within the trigger itself.

Summary

In this chapter, you learned what triggers are and why they are used. You learned the trigger types and the times that they can be executed. You also saw examples of triggers used for `INSERT`, `DELETE`, and `UPDATE` operations.

Chapter 26. Managing Transaction Processing

In this chapter you'll learn what transactions are and how to use `COMMIT` *and* `ROLLBACK` *statements to manage transaction processing*.

Understanding Transaction Processing

Note

Not All Engines Support Transactions As explained in Chapter 21, "Creating and Manipulating Tables," MySQL supports the use of several underlying database engines. Not all engines support explicit management of transaction processing, as will be explained in this chapter. The two most commonly used engines are `MyISAM` and `InnoDB`. The former does not support explicit transaction management and the latter does. This is why the sample tables used in this book were created to use `InnoDB` instead of the more commonly used `MyISAM`. If you need transaction processing functionality in your applications, be sure to use the correct engine type.

Transaction processing is used to maintain database integrity by ensuring that batches of MySQL operations execute completely or not at all.

As explained back in Chapter 15, "Joining Tables," relational databases are designed so data is stored in multiple tables to facilitate easier data manipulation, management, and reuse. Without going in to the hows and whys of relational database design, take it as a given that well-designed database schemas are relational to some degree.

The orders tables you've been using in prior chapters are a good example of this. Orders are stored in two tables: `orders` stores actual orders, and `orderitems` stores the individual items ordered. These two tables are related to each other using unique IDs called primary keys (as discussed in Chapter 1, "Understanding SQL"). These tables, in turn, are related to other tables containing customer and product information.

The process of adding an order to the system is as follows:

1. Check if the customer is already in the database (present in the `customers` table). If not, add him or her.
2. Retrieve the customer's ID.

3. Add a row to the `orders` table associating it with the customer ID.

4. Retrieve the new order ID assigned in the `orders` table.

5. Add one row to the `orderitems` table for each item ordered, associating it with the `orders` table by the retrieved ID (and with the `products` table by product ID).

Now imagine that some database failure (for example, out of disk space, security restrictions, table locks) prevents this entire sequence from completing. What would happen to your data?

Well, if the failure occurred after the customer was added and before the `orders` table was added, there is no real problem. It is perfectly valid to have customers without orders. When you run the sequence again, the inserted customer record will be retrieved and used. You can effectively pick up where you left off.

But what if the failure occurred after the `orders` row was added, but before the `orderitems` rows were added? Now you'd have an empty order sitting in your database.

Worse, what if the system failed during adding the `orderitems` rows? Now you'd end up with a partial order in your database, but you wouldn't know it.

How do you solve this problem? That's where *transaction processing* comes in. Transaction processing is a mechanism used to manage sets of MySQL operations that must be executed in batches to ensure that databases never contain the results of partial operations. With transaction processing, you can ensure that sets of operations are not aborted mid-processingthey either execute in their entirety or not at all (unless explicitly instructed otherwise). If no error occurs, the entire set of statements is committed (written) to the database tables. If an error does occur, a rollback (undo) can occur to restore the database to a known and safe state.

So, looking at the same example, this is how the process would work:

1. Check if the customer is already in the database; if not, add him or her.

2. Commit the customer information.

Retrieve the customer's ID.

3.

4. Add a row to the `orders` table.

5. If a failure occurs while adding the row to `orders`, roll back.

6. Retrieve the new order ID assigned in the `orders` table.

7. Add one row to the `orderitems` table for each item ordered.

8. If a failure occurs while adding rows to `orderitems`, roll back all the `orderitems` rows added and the `orders` row.

9. Commit the order information.

When working with transactions and transaction processing, there are a few keywords that'll keep reappearing. Here are the terms you need to know:

- **Transaction** A block of SQL statements
- **Rollback** The process of undoing specified SQL statements
- **Commit** Writing unsaved SQL statements to the database tables
- **Savepoint** A temporary placeholder in a transaction set to which you can issue a rollback (as opposed to rolling back an entire transaction)

Controlling Transactions

Now that you know what transaction processing is, let's look at what is involved in managing transactions.

The key to managing transactions involves breaking your SQL statements into logical chunks and explicitly stating when data should be rolled back and when it should not.

The MySQL statement used to mark the start of a transaction is

• **Input**

```
START TRANSACTION
```

Using `ROLLBACK`

The MySQL `ROLLBACK` command is used to roll back (undo) MySQL statements, as seen in this next statement:

• **Input**

```
SELECT * FROM ordertotals;
START TRANSACTION;
DELETE FROM ordertotals;
SELECT * FROM ordertotals;
ROLLBACK;
SELECT * FROM ordertotals;
```

• **Analysis**

This example starts by displaying the contents of the `ordertotals` table (this table was populated in Chapter 24, "Using Cursors"). First a `SELECT` is performed to show that the table is not empty. Then a transaction is started, and all of the rows in `ordertables` are deleted with a `DELETE` statement. Another `SELECT` verifies that, indeed, `ordertotals` is empty. Then a `ROLLBACK` statement is used to roll back all statements until the `START TRANSACTION`, and the final `SELECT` shows that the table is no longer empty.

Obviously, `ROLLBACK` can only be used within a transaction (after a `START TRANSACTION` command has been issued).

Tip

Which Statements Can You Roll Back? Transaction processing is used to manage `INSERT`, `UPDATE`, and `DELETE` statements. You cannot roll back `SELECT` statements. (There would not be much point in doing so anyway.) You cannot roll back `CREATE` or `DROP` operations. These statements may be used in a transaction block, but if you perform a rollback they will not be undone.

Using `COMMIT`

MySQL statements are usually executed and written directly to the database tables. This is known as an *implicit commit*the commit (write or save) operation happens automatically.

Within a transaction block, however, commits do not occur implicitly. To force an explicit commit, the `COMMIT` statement is used, as seen here:

- **Input**

```
START TRANSACTION;
DELETE FROM orderitems WHERE order_num = 20010;
DELETE FROM orders WHERE order_num = 20010;
COMMIT;
```

- **Analysis**

In this example, order number `20010` is deleted entirely from the system. Because this involves updating two database tables, `orders` and `orderitems`, a transaction block is used to ensure that the order is not partially deleted. The final `COMMIT` statement writes the change only if no error occurred. If the first

`DELETE` worked, but the second failed, the `DELETE` would not be committed (it would effectively be automatically undone).

Note

Implicit Transaction Closes After a `COMMIT` or `ROLLBACK` statement has been executed, the transaction is automatically closed (and future changes will implicitly commit).

Using Savepoints

Simple `ROLLBACK` and `COMMIT` statements enable you to write or undo an entire transaction. Although this works for simple transactions, more complex transactions might require partial commits or rollbacks.

For example, the process of adding an order described previously is a single transaction. If an error occurs, you only want to roll back to the point before the `orders` row was added. You do not want to roll back the addition to the `customers` table (if there was one).

To support the rollback of partial transactions, you must be able to put placeholders at strategic locations in the transaction block. Then, if a rollback is required, you can roll back to one of the placeholders.

These placeholders are called savepoints, and to create one use the `SAVEPOINT` statement, as follows:

- **Input**

```
SAVEPOINT delete1;
```

Each savepoint takes a unique name that identifies it so that, when you roll back, MySQL knows where you are rolling back to. To roll back to this savepoint, do the following:

- **Input**

```
ROLLBACK TO delete1;
```

Tip

The More Savepoints the Better You can have as many savepoints as you'd like within your MySQL code, and the more the better. Why? Because the more savepoints you have the more flexibility you have in managing rollbacks exactly as you need them.

Note

Releasing Savepoints Savepoints are automatically released after a transaction completes (a `ROLLBACK` or `COMMIT` is issued). As of MySQL 5, savepoints can also be explicitly released using `RELEASE SAVEPOINT`.

Changing the Default Commit Behavior

As already explained, the default MySQL behavior is to automatically commit any and all changes. In other words, any time you execute a MySQL statement, that statement is actually being performed against the tables, and the changes made occur immediately. To instruct MySQL to not automatically commit changes, you need to use the following statement:

- **Input**

```
SET autocommit=0;
```

- **Analysis**

The `autocommit` flag determines whether changes are committed automatically without requiring a manual `COMMIT` statement. Setting `autocommit` to `0` (false) instructs MySQL to not automatically commit changes (until the flag is set back to true).

Note

Flag Is Connection Specific The `autocommit` flag is per connection, not server-wide.

Summary

In this chapter, you learned that transactions are blocks of SQL statements that must be executed as a batch. You learned how to use the `COMMIT` and `ROLLBACK` statements to explicitly manage when data is written and when it is undone. You also learned how to use savepoints to provide a greater level of control over rollback operations.

Chapter 27. Globalization and Localization

In this chapter, you'll learn the basics of how MySQL handles different character sets and languages.

Understanding Character Sets and Collation Sequences

Database tables are used to store and retrieve data. Different languages and character sets need to be stored and retrieved differently. As such, MySQL needs to accommodate different character sets (different alphabets and characters) as well as different ways to sort and retrieve data.

When discussing multiple languages and characters sets, you will run into the following important terms:

- **Character sets** are collections of letters and symbols.
- **Encodings** are the internal representations of the members of a character set.
- **Collations** are the instructions that dictate how characters are to be compared.

Note

Why Collations Are Important Sorting text in English is easy, right? Well, maybe not. Consider the words APE, apex, and Apple. Are they in the correct sorted order? That would depend on whether you wanted a case-sensitive or a not case-sensitive sorting. The words would be sorted one way using a case-sensitive collation, and another way using a not case-sensitive collation. And this affects more than just sorting (as in data sorted using `ORDER BY`); it also affects searches (whether or not a `WHERE` clause looking for apple finds APPLE, for example). The situation gets even more complex when characters such as the French à or German ö are used, and even more complex when non-Latin-based character sets are used (Japanese, Hebrew, Russian, and so on).

In MySQL there is not much to worry about during regular database activity (`SELECT`, `INSERT`, and so forth). Rather, the decision as to which character set and collation to use occurs at the server, database, and table level.

Working with Character Set and Collation Sequences

MySQL supports a vast number of character sets. To see the complete list of supported character sets, use this statement:

- **Input**

```
SHOW CHARACTER SET;
```

- **Analysis**

This statement displays all available character sets, along with the description and default collation for each.

To see the complete list of supported collations, use this statement:

- **Input**

```
SHOW COLLATION;
```

- **Analysis**

This statement displays all available collations, along with the character sets to which they apply. You will notice that several character sets have more than one collation. `latin1`, for example, has several for different European languages, and many appear twice, once case sensitive (designated by `_cs`) and once not case sensitive (designated by `_ci`).

A default character set and collation are defined (usually by the system administration at installation time). In addition, when databases are created, default character sets and collations may be specified, too. To determine the character sets and collations in use, use these statements:

- **Input**

```
SHOW VARIABLES LIKE 'character%';
SHOW VARIABLES LIKE 'collation%';
```

In practice, character sets can seldom be server-wide (or even database-wide) settings. Different tables, and even different columns, may require different character sets, and so both may be specified when a table is created.

To specify a character set and collation for a table, `CREATE TABLE` (seen in Chapter 21, "Creating and Manipulating Tables") is used with additional clauses:

• Input

```
CREATE TABLE mytable
(
   columnn1   INT,
   columnn2   VARCHAR(10)
) DEFAULT CHARACTER SET hebrew
  COLLATE hebrew_general_ci;
```

• Analysis

This statement creates a two column table, and specifies both a character set and a collate sequence.

In this example both `CHARACTER SET` and `COLLATE` were specified, but if only one (or neither) is specified, this is how MySQL determines what to use:

- If both `CHARACTER SET` and `COLLATE` are specified, those values are used.
- If only `CHARACTER SET` is specified, it is used along with the default collation for that character set (as specified in the `SHOW CHARACTER SET` results).
- If neither `CHARACTER SET` nor `COLLATE` are specified, the database default is used.

In addition to being able to specify character set and collation table wide, MySQL also allows these to be set per column, as seen here:

• Input

```
CREATE TABLE mytable
(
   columnn1   INT,
   columnn2   VARCHAR(10),
   column3    VARCHAR(10) CHARACTER SET latin1 COLLATE latin1_gener
) DEFAULT CHARACTER SET hebrew
  COLLATE hebrew_general_ci;
```

• **Analysis**

Here CHARACTER SET and COLLATE are specified for the entire table as well as for a specific column.

As mentioned previously, the collation plays a key role in sorting data that is retrieved with an ORDER BY clause. If you need to sort specific SELECT statements using a collation sequence other than the one used at table creation time, you may do so in the SELECT statement itself:

• **Input**

```
SELECT * FROM customers
ORDER BY lastname, firstname COLLATE latin1_general_cs;
```

• **Analysis**

This SELECT uses COLLATE to specify an alternate collation sequence (in this example, a case-sensitive one). This will obviously affect the order in which results are sorted.

Tip

Occasional Case Sensitivity The SELECT statement just seen demonstrates a useful technique for performing case-sensitive searches on a table that is usually not case sensitive. And of course, the reverse works just as well.

Note

Other SELECT COLLATE Clauses In addition to being used in ORDER BY clauses, as seen here, COLLATE can be used with GROUP BY, HAVING, aggregate functions, aliases, and more.

One final point worth noting is that strings may be converted between character sets if absolutely needed. To do this, use the `Cast()` or `Convert()` functions.

Summary

In this chapter, you learned the basics of character sets and collations. You also learned how to define the character sets and collations for specific tables and columns, and how to use alternate collations when needed.

Chapter 28. Managing Security

Database servers usually contain critical data, and ensuring the safety and integrity of that data requires that access control be used. In this chapter you'll learn about MySQL access control and user management.

Understanding Access Control

The basis of security for your MySQL server is this: *Users should have appropriate access to the data they need, no more and no less*. In other words, users should not have too much access to too much data.

Consider the following:

- Most users need to read and write data from tables, but few users will ever need to be able to create and drop tables.
- Some users might need to read tables but might not need to update them.
- You might want to allow users to add data, but not delete data.
- Some users (managers or administrators) might need rights to manipulate user accounts, but most should not.
- You might want users to access data via stored procedures, but never directly.
- You might want to restrict access to some functionality based on from where the user is logging in.

These are just examples, but they help demonstrate an important point. You need to provide users with the access they need and just the access they need. This is known as *access control*, and managing access control requires creating and managing user accounts.

Tip

Use MySQL Administrator The MySQL Administrator (described in Chapter 2, "Introducing MySQL") provides a graphical user interface that can be used to manage users and account rights. Internally, MySQL Administrator uses the statements described in this chapter, enabling you to manage access control interactively and simply.

Back in Chapter 3, "Working with MySQL," you learned that you need to log in to MySQL in order to perform any operations. When first installed, MySQL creates a user account named `root` which has complete and total control over the entire MySQL server. You might have been using the `root` login throughout the chapters in this book, and that is fine when experimenting with MySQL on non-live servers. But in the real world you'd never use `root` on a day-to-day basis. Instead, you'd create a series of accounts, some for administration, some for users, some for developers, and so on.

Note

Preventing Innocent Mistakes It is important to note that access control is not just intended to keep out users with malicious intent. More often than not, data nightmares are the result of an inadvertent mistake, a mistyped MySQL statement, being in the wrong database, or some other user error. Access control helps avoid these situations by ensuring that users are unable to execute statements they should not be executing.

Caution

Don't Use `root` The `root` login should be considered sacred. Use it only when absolutely needed (perhaps if you cannot get in to other administrative accounts). `root` should never be used in day-to-day MySQL operations.

Managing Users

MySQL user accounts and information are stored in a MySQL database named `mysql`. You usually do not need to access the `mysql` database and tables directly (as you will soon see), but sometimes you might. One of those times is when you want to obtain a list of all user accounts. To do that, use the following code:

- **Input**

```
USE mysql;
SELECT user FROM user;
```

- **Output**

```
+-------+
| user |
+-------+
| root |
+-------+
```

- **Analysis**

The `mysql` database contains a table named `user` which contains all user accounts. `user` contains a column named `user` that contains the user login name. A newly installed server might have a single user listed (as seen here); established servers will likely have far more.

Tip

Test Using Multiple Clients The easiest way to test changes made to user accounts and rights is to open multiple database clients (multiple copies of the mysql command-line utility, for example), one logged in with the administrative login and the others logged in as the users being tested.

Creating User Accounts

To create a new user account, use the `CREATE USER` statement, as seen here:

- **Input**

```
CREATE USER ben IDENTIFIED BY 'p@$$w0rd';
```

- **Analysis**

`CREATE USER` creates a new user account. A password need not be specified at user account creation time, but this example does specify a password using `IDENTIFIED BY 'p@$$w0rd'`.

If you were to list the user accounts again, you'd see the new account listed in the output.

Tip

Specifying a Hashed Password The password specified by `IDENTIFIED BY` is plain text that MySQL will encrypt before saving it in the `user` table. To specify the password as a hashed value, use `IDENTIFIED BY PASSWORD` instead.

Note

Using `GRANT` or `INSERT` The `GRANT` statement (which we will get to shortly) can also create user accounts, but generally `CREATE USER` is the cleanest and simplest syntax. In addition, it is possible to add users by inserting rows into `user` directly, but to be safe this is generally not recommended. The tables used by MySQL to store user account information (as well as table schemas and more) are extremely important, and any damage to them could seriously harm the MySQL server. As such, it is always better to use tags and functions to manipulate these tables as opposed to manipulating them directly.

To rename a user account, use the `RENAME USER` statement like this:

- **Input**

```
RENAME USER ben TO bforta;
```

Note

Pre MySQL 5 `RENAME USER` is only supported in MySQL 5 or later. To rename a user in earlier versions of MySQL, use `UPDATE` to update the `user` table directly.

Deleting User Accounts

To delete a user account (along with any associated rights and privileges), use the `DROP USER` statement as seen here:

- **Input**

```
DROP USER bforta;
```

Note

Pre MySQL 5 As of MySQL 5, `DROP USER` deletes user accounts and all associated account rights and privileges. Prior to MySQL 5 `DROP USER` could only be used to drop user accounts with no associated account rights and privileges. As such, if you are using an older version of MySQL you will need to first remove associated account rights and privileges using `REVOKE`, and then use `DROP USER` to delete the actual account.

Setting Access Rights

With user accounts created, you must next assign access rights and privileges. Newly created user accounts have no access at all. They can log into MySQL but will see no data and will be unable to perform any database operations.

To see the rights granted to a user account, use `SHOW GRANTS FOR` as seen in this example:

- **Input**

```
SHOW GRANTS FOR bforta;
```

- **Output**

```
+---------------------------------------------+
| Grants for bforta@%                         |
+---------------------------------------------+
| GRANT USAGE ON *.* TO 'bforta'@'%'          |
+---------------------------------------------+
```

- **Analysis**

The output shows that user `bforta` has a single right granted, `USAGE ON *.*`. `USAGE` means *no rights at all* (not overly intuitive, I know), so the results mean *no rights to anything on any database and any table*.

Note

Users Are Defined As *`user@host`* MySQL privileges are defined using a combination of user name and hostname. If no host name is specified, a default hostname of % is used (effectively granting access to the user regardless of the hostname).

To set rights the `GRANT` statement is used. At a minimum, `GRANT` requires that you specify

- The privilege being granted
- The database or table being granted access to
- The user name

The following example demonstrates the use of `GRANT`:

- **Input**

```
GRANT SELECT ON crashcourse.* TO beforta;
```

- **Analysis**

This `GRANT` allows the use of `SELECT` on `crashcourse.*` (`crashcourse` database, all tables). By granting `SELECT` access only, user `bforta` has read-only access to all data in the `crashcourse` database.

`SHOW GRANTS` reflects this change:

- **Input**

```
SHOW GRANTS FOR bforta;
```

- **Output**

```
+---------------------------------------------------+
| Grants for bforta@%                               |
+---------------------------------------------------+
| GRANT USAGE ON *.* TO 'bforta'@'%'                |
| GRANT SELECT ON 'crashcourse'.* TO 'bforta'@'%' |
+---------------------------------------------------+
```

- **Analysis**

Each GRANT adds (or updates) a permission statement for the user. MySQL reads all of the grants and determines the rights and permissions based on them.

The opposite of GRANT is REVOKE, which is used to revoke specific rights and permissions. Here is an example:

- **Input**

```
REVOKE SELECT ON crashcourse.* FROM beforta;
```

- **Analysis**

This REVOKE statement takes away the SELECT access just granted to user bforta. The access being revoked must exist or an error will be thrown.

GRANT and REVOKE can be used to control access at several levels:

- Entire server, using GRANT ALL and REVOKE ALL
- Entire database, using ON database.*
- Specific tables, using ON database.table
- Specific columns
- Specific stored procedures

Table 28.1 lists each of the rights and privileges that may be granted or revoked.

Table 28.1. Rights and Privileges

Privilege	Description
ALL	All privileges except GRANT OPTION
ALTER	Use of ALTER TABLE
ALTER ROUTINE	Use of ALTER PROCEDURE and DROP PROCEDURE
CREATE	Use of CREATE TABLE

`CREATE ROUTINE`	Use of `CREATE PROCEDURE`
`CREATE TEMPORARY TABLES`	Use of `CREATE TEMPORARY TABLE`
`CREATE USER`	Use of `CREATE USER`, `DROP USER`, `RENAME USER`, and `REVOKE ALL PRIVILEGES`
`CREATE VIEW`	Use of `CREATE VIEW`
`DELETE`	Use of `DELETE`
`DROP`	Use of `DROP TABLE`
`EXECUTE`	Use of `CALL` and stored procedures
`FILE`	Use of `SELECT INTO OUTFILE` and `LOAD DATA INFILE`
`GRANT OPTION`	Use of `GRANT` and `REVOKE`
`INDEX`	Use of `CREATE INDEX` and `DROP INDEX`
`INSERT`	Use of `INSERT`
`LOCK TABLES`	Use of `LOCK TABLES`
`PROCESS`	Use of `SHOW FULL PROCESSLIST`
`RELOAD`	Use of `FLUSH`
`REPLICATION CLIENT`	Access to location of servers
`REPLICATION SLAVE`	Used by replication slaves
`SELECT`	Use of `SELECT`
`SHOW DATABASES`	Use of `SHOW DATABASES`
`SHOW VIEW`	Use of `SHOW CREATE VIEW`
`SHUTDOWN`	Use of `mysqladmin shutdown` (used to shut down MySQL)
`SUPER`	Use of `CHANGE MASTER`, `KILL`, `LOGS`, `PURGE MASTER`, and `SET GLOBAL`. Also allows `mysqladmin debug` login.

`UPDATE`	Use of `UPDATE`
`USAGE`	No access

Using `GRANT` and `REVOKE` in conjunction with the privileges listed in Table 28.1, you have complete control over what users can and cannot do with your precious data.

Note

Granting for the Future When using `GRANT` and `REVOKE`, the user account must exist, but the objects being referred to need not. This allows administrators to design and implement security before databases and tables are even created.

A side effect of this is that if a database or table is removed (with a `DROP` statement) any associated access rights will still exist. And if the database or table is re-created in the future, those rights will apply to them.

Tip

Simplifying Multiple Grants Multiple `GRANT` statements may be strung together by listing the privileges and comma delimiting them, as seen in this example:

```
GRANT SELECT, INSERT ON crashcourse.* TO beforta;
```

Changing Passwords

To change user passwords use the `SET PASSWORD` statement. New passwords must be encrypted as seen here:

• **Input**

```
SET PASSWORD FOR bforta = Password('n3w p@$$w0rd');
```

• **Analysis**

`SET PASSWORD` updates a user password. The new password must be encrypted by being passed to the `Password()` function.

`SET PASSWORD` can also be used to set your own password:

• **Input**

```
SET PASSWORD = Password('n3w p@$$w0rd');
```

• **Analysis**

When no user name is specified, `SET PASSWORD` updates the password for the currently logged in user.

Summary

In this chapter, you learned about access control and how to secure your MySQL server by assigning specific rights to users.

Chapter 29. Database Maintenance

In this chapter, you'll learn how to perform common database maintenance tasks.

Backing Up Data

Like all data, MySQL data must be backed up regularly. As MySQL databases are disk-based files, normal backup systems and routines can back up MySQL data. However, as those files are always open and in use, normal file copy backup may not always work.

Here are possible solutions to this problem:

- Use the command line `mysqldump` utility to dump all database contents to an external file. This utility should ideally be run before regular backups occur so the dumped file will be backed up properly.
- The command line `mysqlhotcopy` utility can be used to copy all data from a database (this one is not supported by all database engines).
- You can also use MySQL to dump all data to an external file using `BACKUP TABLE` or `SELECT INTO OUTFILE`. Both statements take the name of a system file to be created, and that file must not already exist or an error will be generated. Data can be restored using `RESTORE TABLE`.

Tip

Flush Unwritten Data First To ensure that all data is written to disk (including any index data) you might need to use a `FLUSH TABLES` statement before performing your backup.

Performing Database Maintenance

MySQL features a series of statements that can (and should) be used to ensure that databases are correct and functioning properly.

Here are some statements you should be aware of:

- `ANALYZE TABLE` is used to check that table keys are correct. `ANALYZE TABLE` returns status information, as seen here:

- **Input**

```
ANALYZE TABLE orders;
```

- **Output**

```
+--------------------+---------+----------+----------+
| Table              | Op      | Msg_type | Msg_text |
+--------------------+---------+----------+----------+
| crashcourse.orders | analyze | status   | OK       |
+--------------------+---------+----------+----------+
```

- `CHECK TABLE` is used to check tables for a variety of problems. Indexes are also checked on a `MyISAM` table. `CHECK TABLE` supports a series of modes for use with `MyISAM` tables. `CHANGED` checks tables that have changed since the last check, `EXTENDED` performs the most thorough check, `FAST` only checks tables that were not closed properly, `MEDIUM` checks all deleted links and performs key verification, and `QUICK` performs a quick scan only. As seen here, `CHECK TABLE` found and repaired a problem:

- **Input**

```
CHECK TABLE orders, orderitems;
```

- **Output**

```
+-------------------------+-------+----------+----------------------
| Table                   | Op    | Msg_type | Msg_text
+-------------------------+-------+----------+----------------------
| crashcourse.orders      | check | status   | OK
| crashcourse.orderitems  | check | warning  | Table is marked as
|                         |       |          | crashed
| crashcourse.orderitems  | check | status   | OK
+-------------------------+-------+----------+----------------------
```

- If `MyISAM` table access produces incorrect and inconsistent results, you might need to repair the table using `REPAIR TABLE`. This statement should not be used frequently, and if regular use is required, there is likely a far bigger problem that needs addressing.

- If you delete large amounts of data from a table, `OPTIMIZE TABLE` should be used to reclaim previously used space, thus optimizing the performance of the table.

Diagnosing Startup Problems

Server startup problems usually occur when a change has been made to MySQL configuration or the server itself. MySQL reports errors when this occurs, but because most MySQL servers are started automatically as system processes or services, these messages might not be seen.

When troubleshooting system startup problems, try to manually start the server first. The MySQL server itself is started by executing `mysqld` on the command line. Here are several important command `mysqld` line options:

- `--help` displays help, a list of options.
- `--safe-mode` loads the server minus some optimizations.
- `--verbose` displays full text messages (use in conjunction with `--help` for more detailed help messages).
- `--version` displays version information and then quits.

Several additional command-line options (pertaining to the use of log files) are listed in the next section.

Review Log Files

MySQL maintains a series of log files that administrators rely on extensively. The primary log files are

- The error log contains details about startup and shutdown problems and any critical errors. The log is usually named `hostname.err` in the `data` directory. This name can be changed using the `--log-error` command-line option.
- The query log logs all MySQL activity and can be very useful in diagnosing problems. This log file can get very large very quickly, so it should not be used for extended periods of time. The log is usually named `hostname.log` in the `data` directory. This name can be changed using the `--log` command-line option.
- The binary log logs all statements that updated (or could have updated) data. The log is usually named `hostname-bin` in the `data` directory. This name can be changed using the `--log-bin` command-line option. Note that this log file was added in MySQL 5; the update log is used in earlier versions of MySQL.
- As its name suggests, the slow query log logs any queries that execute slowly. This log can be useful in determining where database optimizations are needed. The log is usually named `hostname-slow.log` in the `data` directory. This name can be changed using the `--log-slow-queries` command-line option.

When logging is being used, the `FLUSH LOGS` statement can be used to flush and restart all log files.

Summary

In this chapter, you learned some basic MySQL database maintenance tools and techniques.

Chapter 30. Improving Performance

In this chapter, you'll review some important points pertaining to the performance of MySQL.

Improving Performance

Database administrators spend a significant portion of their lives tweaking and experimenting to improve DBMS performance. Poorly performing databases (and database queries, for that matter) tend to be the most frequent culprits when diagnosing application sluggishness and performance problems.

What follows is not, by any stretch of the imagination, the last word on MySQL performance. This is intended to review key points made in the previous 29 chapters, as well as to provide a springboard from which to launch performance optimization discussion and analysis.

So, here goes:

- First and foremost, MySQL (like all DBMSs) has specific hardware recommendations. Using any old computer as a database server is fine when learning and playing with MySQL. But production servers should adhere to all recommendations.

- As a rule, critical production DBMSs should run on their own dedicated servers.

- MySQL is preconfigured with a series of default settings that are usually a good place to start. But after a while you might need to tweak memory allocation, buffer sizes, and more. (To see the current settings use `SHOW VARIABLES;` and `SHOW STATUS;`.)

- MySQL is a multi-user multi-threaded DBMS; in other words, it often performs multiple tasks at the same time. And if one of those tasks is executing slowly, all requests will suffer. If you are experiencing unusually poor performance, use `SHOW PROCESSLIST` to display all active processes (along with their thread IDs and execution time). You can also use the `KILL` command to terminate a specific process (you'll need to be logged in as an administrator to use that one).

- There is almost always more than one way to write a `SELECT` statement. Experiment with joins, unions, subqueries, and more to find what is optimum for you and your data.

- Use the `EXPLAIN` statement to have MySQL explain how it will execute a

`SELECT` statement.

- As a general rule, stored procedures execute quicker than individual MySQL statements.

- Use the right data types, always.

- Never retrieve more data than you need. In other words, no `SELECT *` (unless you truly do need each and every column).

- Some operations (including `INSERT`) support an optional `DELAYED` keyword that, if used, returns control to the calling application immediately and actually performs the operation as soon as possible.

- When importing data, turn off autocommit. You may also want to drop indexes (including `FULLTEXT` indexes) and then re-create them after the import has completed.

- Database tables must be indexed to improve the performance of data retrieval. Determining what to index is not a trivial task, and involves analyzing used `SELECT` statements to find recurring `WHERE` and `ORDER BY` clauses. If a simple `WHERE` clause is taking too long to return results, you can bet that the column (or columns) being used is a good candidate for indexing.

- Have a series of complex `OR` conditions in your `SELECT` statement? You might see a significant performance improvement by using multiple `SELECT` statements and `UNION` statements to connect them.

- Indexes improve the performance of data retrieval, but hurt the performance of data insertion, deletion, and updating. If you have tables that collect data and are not often searched, don't index them until needed. (Indexes can be added and dropped as needed).

- `LIKE` is slow. As a general rule, you are better off using `FULLTEXT` rather than `LIKE`.

- Databases are living entities. A well-optimized set of tables might not be so after a while. As table usage and contents change, so might the ideal optimization and configuration.

- And the most important rule is simply thisevery rule is meant to be broken at some point.

Tip

Browse the Docs The MySQL documentation at http://dev.mysql.com/doc/ is full of useful tips and tricks (and even user-provided comments and feedback). Be sure to check out this invaluable resource.

Summary

In this chapter, you reviewed some important tips and notes pertaining to MySQL performance. Of course, this is just the tip of the iceberg, but now that you have completed the *MySQL Crash Course* you are free to experiment and learn as you best see fit.

Appendix A. Getting Started with MySQL

If you are new to MySQL, here is what you need to know to get started.

What You'll Need

To start using MySQL and to follow along with the chapters in this book, you will need access to a MySQL server and copies of client applications (software used to access the server).

You do not need your own installed copy of MySQL, but you do need access to a server. You basically have two options:

- Access to an existing MySQL server, perhaps one by your hosting company or place of business or school. To use this server you will be granted a server account (a login name and password).
- You may download and install a free copy of the MySQL server for installation on your own computer (MySQL runs on all major platforms including Windows, Linux, Solaris, Mac OSX, and more).

Tip

If You Can, Install a Local Server For complete control, including access to commands and features that you will probably not be granted is using someone else's MySQL server, install your own local server. Even if you don't end up using your local server as your final production DBMS, you'll still benefit from having complete and unfettered access to all the server has to offer.

Regardless of whether you use a local server, you need client software (the program you use to actually run MySQL commands). The most readily available is the mysql command-line utility (which is included with every MySQL installation). Other important utilities are the MySQL Administrator and the MySQL Query Browser.

Obtaining the Software

To learn more about MySQL, go to www.mysql.com/.

To download a copy of the server, go to www.dev.mysql.com/downloads/. To follow along with this book it is recommended that you download and install MySQL 5 (or later). The exact download varies by platform, but it clearly explained.

MySQL Administrator and MySQL Query Browser are not installed as part of the core MySQL installation. Instead, it must be downloaded from http://dev.mysql.com/downloads/.

Installing the Software

If you are installing a local MySQL server, do so before installing the optional MySQL utilities. The installation procedure varies from platform to platform, but all installations prompt you for needed information, including

- Installation location (the default is usually fine).
- Password for `root` user.
- Ports, service or process names, and more. As a rule, use default values if you are unsure of what to specify.

Tip

Multiple MySQL Server Multiple copies of MySQL server may be installed on a single machine, as long as each uses a different port.

Preparing for Your Chapters

After you have installed MySQL, Chapter 3, "Working with MySQL," will show you how to login and logout of the server, and how to execute commands.

The chapters in this book all use real MySQL statements and real data. Appendix B, "The Example Tables," describes the example tables used in this book, and explains how to obtain and use the table creation and population scripts.

Appendix B. The Example Tables

This appendix outlines the tables in this book and their use.

Writing SQL statements requires a good understanding of the underlying database design. Without knowing what information is stored in what table, how tables are related to each other, and the actual breakup of data within a row, it is impossible to write effective SQL.

You are strongly advised to actually try every example in every chapter in this book. All the chapters use a common set of data files. To assist you in better understanding the examples and to enable you to follow along with the chapters, this appendix describes the tables used, their relationships, and how to obtain them.

Understanding the Sample Tables

The tables used throughout this book are part of an order entry system used by an imaginary distributor of paraphernalia that might be needed by your favorite cartoon characters (yes, cartoon characters; no one said that learning MySQL needed to be boring). The tables are used to perform several tasks:

- Manage vendors
- Manage product catalogs
- Manage customer lists
- Enter customer orders

Making this all work requires six tables that are closely interconnected as part of a relational database design. A description of each of the tables appears in the following sections.

Note

Simplified Examples The tables used here are by no means complete. A real-world order entry system would have to keep track of lots of other data that has not been included here (for example, payment and accounting information, shipment tracking, and more). However, these tables do demonstrate the kinds of data organization and relationships you will encounter in most real installations. You can apply these techniques and technologies to your own databases.

Table Descriptions

What follows is a description of each of the six tables, along with the name of the columns within each table and their descriptions.

Note

Why Out of Order? If you are wondering why the six tables are listed in the order they are, it is due to their dependencies. As the `products` tables is dependent on the `vendors` table, `vendors` is listed first, and so on.

The `vendors` Table

The `vendors` table stores the vendors whose products are sold. Every vendor has a record in this table, and that vendor ID (the `vend_id`) column is used to match products with vendors.

Table B.1. `vendors` Table Columns

Column	Description
`vend_id`	Unique numeric vendor ID
`vend_name`	Vendor name
`vend_address`	Vendor address
`vend_city`	Vendor city
`vend_state`	Vendor state
`vend_zip`	Vendor ZIP Code
`vend_country`	Vendor country

- All tables should have primary keys defined. This table should use `vend_id` as its primary key. `vend_id` is an auto increment field.

The `products` Table

The `products` table contains the product catalog, one product per row. Each product has a unique ID (the `prod_id` column) and is related to its vendor by `vend_id` (the vendor's unique ID).

Table B.2. `products` Table Columns

Column	Description
`prod_id`	Unique product ID
`vend_id`	Product vendor ID (relates to `vend_id` in `vendors` table)
`prod_name`	Product name
`prod_price`	Product price
`prod_desc`	Product description

- All tables should have primary keys defined. This table should use `prod_id` as its primary key.
- To enforce referential integrity, a foreign key should be defined on `vend_id`, relating it to `vend_id` in `vendors`.

The `customers` Table

The `customers` table stores all customer information. Each customer has a unique ID (the `cust_id` column).

Table B.3. `customers` Table Columns

Column	Description
`cust_id`	Unique numeric customer ID
`cust_name`	Customer name
`cust_address`	Customer address

`cust_city`	Customer city
`cust_state`	Customer state
`cust_zip`	Customer ZIP Code
`cust_country`	Customer country
`cust_contact`	Customer contact name
`cust_email`	Customer contact email address

- All tables should have primary keys defined. This table should use `cust_id` as its primary key. `cust_id` is an auto increment field.

The `orders` Table

The `orders` table stores customer orders (but not order details). Each order is uniquely numbered (the `order_num` column). Orders are associated with the appropriate customers by the `cust_id` column (which relates to the customer's unique ID in the `customers` table).

Table B.4. `orders` Table Columns

Column	Description
`order_num`	Unique order number
`order_date`	Order date
`cust_id`	Order customer ID (relates to `cust_id` in `customers` table)

- All tables should have primary keys defined. This table should use `order_num` as its primary key. order_num is an auto increment field.

- To enforce referential integrity, a foreign key should be defined on cust_id, relating it to cust_id in customers.

The orderitems Table

The orderitems table stores the actual items in each order, one row per item per order. For every row in orders there are one or more rows in orderitems. Each order item is uniquely identified by the order number plus the order item (first item in order, second item in order, and so on). Order items are associated with their appropriate order by the order_num column (which relates to the order's unique ID in orders). In addition, each order item contains the product ID of the item orders (which relates the item back to the products table).

Table B.5. orderitems Table Columns

Column	Description
order_num	Order number (relates to order_num in orders table)
order_item	Order item number (sequential within an order)
prod_id	Product ID (relates to prod_id in products table)
quantity	Item quantity
item_price	Item price

- All tables should have primary keys defined. This table should use order_num and order_item as its primary keys.

- To enforce referential integrity, foreign keys should be defined on order_num, relating it to order_num in orders, and prod_id, relating it to prod_id in products.

The productnotes Table

The `productnotes` table stores notes associated with specific products. Not all products may have associated notes, and some products might have many associated notes.

Table B.6. `productnotes` Table Columns

Column	Description
`note_id`	Unique `note id`
`prod_id`	Product ID (corresponds to `prod_id` in `products` table)
`note_date`	Date note added
`note_text`	Note text

- All tables should have primary keys defined. This table should use `note_id` as its primary key.
- Column `note_text` must be indexed for `FULLTEXT` search use.
- As this table uses full-text searching, `ENGINE=MyISAM` must be specified.

Creating the Sample Tables

In order to follow along with the examples, you need a set of populated tables. Everything you need to get up and running can be found on this book's web page at http://www.forta.com/books/0672327120/.

The web page contains two SQL script files that you may download:

- `create.sql` contains the MySQL statements to create the six database tables (including defining all primary keys and foreign key constraints).
- `populate.sql` contains the SQL `INSERT` statements used to populate these tables.

Note

For MySQL Only The SQL statements in the downloadable `.sql` files are very DBMS specific, and are designed to be used only with MySQL.

The scripts have been tested extensively with MySQL 4.1 and MySQL 5 and have not been tested with earlier versions of MySQL.

After you have downloaded the scripts, you can use them to create and populate the tables needed to follow along with the chapters in this book. Here are the steps to follow:

1. Create a new datasource (do not use any existing datasource, just to be on the safe side). The simplest way to do this is using the MySQL Administrator (described in Chapter 2, "Introducing MySQL").
2. Make sure the new datasource is selected (use the `USE` command if using the `mysql` command-line utility, or select the datasource if using the MySQL Query Browser).
3. Execute the `create.sql` script. If using the `mysql` command lint utility, you can specify `source create.sql`; (specifying the full path to the `create.sql` file). If

3. you are using the MySQL Query Browser, select File, Open Script, create.sql, and click the Execute button.
4. Repeat the previous step using the `populate.sql` file to populate the new tables.

And with that you should be good to go!

Note

Create, Then Populate You must run the table creation scripts *before* the table population scripts. Be sure to check for any error messages returned by these scripts. If the creation scripts fail, you will need to remedy whatever problem might exist before continuing with table population.

Appendix C. MySQL Statement Syntax

To help you find the syntax you need when you need it, this appendix lists the syntax for the most frequently used MySQL operations. Each statement starts with a brief description and then displays the appropriate syntax. For added convenience, you'll also find cross-references to the chapters where specific statements are taught.

When reading statement syntax, remember the following:

- The `|` symbol is used to indicate one of several options, so `NULL|NOT NULL` means specify either `NULL` or `NOT NULL`.
- Keywords or clauses contained within square parentheses `[like this]` are optional.
- Not all MySQL statements are listed, nor is every clause and option listed.

ALTER TABLE

`ALTER TABLE` is used to update the schema of an existing table. To create a new table, use `CREATE TABLE`. See Chapter 21, "Creating and Manipulating Tables," for more information.

- **Input**

```
ALTER TABLE tablename
(
    ADD     column          datatype  [NULL|NOT NULL]  [CONSTRAINTS
    CHANGE  column columns  datatype  [NULL|NOT NULL]  [CONSTRAINTS
    DROP    column,
    ...
);
```

COMMIT

`COMMIT` is used to write a transaction to the database. See Chapter 26, "Managing Transaction Processing," for more information.

- **Input**

```
COMMIT;
```

CREATE INDEX

`CREATE INDEX` is used to create an index on one or more columns. See Chapter 21 for more information.

- **Input**

```
CREATE INDEX indexname
ON tablename (column [ASC|DESC], ...);
```

`CREATE PROCEDURE`

`CREATE PROCEDURE` is used to create a stored procedure. See Chapter 23, "Working with Stored Procedures," for more information.

- **Input**

```
CREATE PROCEDURE procedurename( [parameters] )
BEGIN
...
END;
```

CREATE TABLE

CREATE TABLE is used to create new database tables. To update the schema of an existing table, use ALTER TABLE. See Chapter 21 for more information.

- **Input**

```
CREATE TABLE tablename
(
       column    datatype    [NULL|NOT NULL]    [CONSTRAINTS],
       column    datatype    [NULL|NOT NULL]    [CONSTRAINTS],
       ...
);
```

CREATE USER

`CREATE USER` is used to add a new user account to the system. See Chapter 28, "Managing Security," for more information.

- **Input**

```
CREATE USER username[@hostname]
[IDENTIFIED BY [PASSWORD] 'password'];
```

CREATE VIEW

`CREATE VIEW` is used to create a new view of one or more tables. See Chapter 22, "Using Views," for more information.

- **Input**

```
CREATE [OR REPLACE] VIEW viewname
AS
SELECT ...;
```

DELETE

`DELETE` deletes one or more rows from a table. See Chapter 20, "Updating and Deleting Data," for more information.

- **Input**

```
DELETE FROM tablename
[WHERE ...];
```

DROP

`DROP` permanently removes database objects (tables, views, indexes, and so forth). See Chapters 21; 22; 23; 24, "Using Cursors"; 26; and 28 for more information.

- **Input**

```
DROP DATABASE|INDEX|PROCEDURE|TABLE|TRIGGER|USER|VIEW
    itemname;
```

INSERT

`INSERT` adds a single row to a table. See Chapter 19, "Inserting Data," for more information.

- **Input**

```
INSERT INTO tablename [(columns, ...)]
VALUES(values, ...);
```

INSERT SELECT

INSERT SELECT inserts the results of a SELECT into a table. See Chapter 19 for more information.

- **Input**

```
INSERT INTO tablename [(columns, ...)]
SELECT columns, ... FROM tablename, ...
[WHERE ...];
```

ROLLBACK

`ROLLBACK` is used to undo a transaction block. See Chapter 26 for more information.

- **Input**

```
ROLLBACK [ TO savepointname];
```

SAVEPOINT

`SAVEPOINT` defines a savepoint for use with a `ROLLBACK` statement. See Chapter 26 for more information.

- **Input**

```
SAVEPOINT sp1;
```

SELECT

`SELECT` is used to retrieve data from one or more tables (or views). See Chapter 4, "Retrieving Data"; Chapter 5, "Sorting Retrieved Data"; and Chapter 6, "Filtering Data," for more basic information. (Chapters 417 all cover aspects of `SELECT`.)

- **Input**

```
SELECT columnname, ...
FROM tablename, ...
[WHERE ...]
[UNION ...]
[GROUP BY ...]
[HAVING ...]
[ORDER BY ...];
```

START TRANSACTION

`START TRANSACTION` is used to start a new transaction block. See Chapter 26 for more information.

- **Input**

```
START TRANSACTION;
```

UPDATE

`UPDATE` updates one or more rows in a table. See Chapter 20 for more information.

- **Input**

```
UPDATE tablename
SET columnname = value, ...
[WHERE ...];
```

Appendix D. MySQL Datatypes

This appendix explains the different datatypes used in MySQL.

As explained in Chapter 1, "Understanding SQL," datatypes are basically rules that define what data may be stored in a column and how that data is actually stored.

Datatypes are used for several reasons:

- Datatypes enable you to restrict the type of data that can be stored in a column. For example, a numeric datatype column only accepts numeric values.

- Datatypes allow for more efficient storage, internally. Numbers and date time values can be stored in a more condensed format than text strings.

- Datatypes allow for alternate sorting orders. If everything is treated as strings, `1` comes before `10`, which comes before `2`. (Strings are sorted in dictionary sequence, one character at a time starting from the left.) As numeric datatypes, the numbers would be sorted correctly.

When designing tables, pay careful attention to the datatypes being used. Using the wrong datatype can seriously impact your application. Changing the datatypes of existing populated columns is not a trivial task. (In addition, doing so can result in data loss.)

Although this appendix is by no means a complete tutorial on datatypes and how they are to be used, it explains the major MySQL datatype types, and what they are used for.

String Datatypes

The most commonly used datatypes are string datatypes. These store strings: for example, names, addresses, phone numbers, and ZIP Codes. As listed in Table D.1, there are basically two types of string datatype that you can usefixed-length strings and variable-length strings.

Table D.1. String Datatypes

Datatype	Description
`CHAR`	Fixed-length string from 1 to 255 chars long. Its size must be specified at create time, or MySQL assumes `CHAR(1)`.
`ENUM`	Accepts one of a predefined set of up to 64K strings.
`LONGTEXT`	Same as `TEXT`, but with a maximum size of 4GB.
`MEDIUMTEXT`	Same as `TEXT`, but with a maximum size of 16K.
`SET`	Accepts zero or more of a predefined set of up to 64 strings.
`TEXT`	Variable-length text with a maximum size of 64K.
`TINYTEXT`	Same as `TEXT`, but with a maximum size of 255 bytes.
`VARCHAR`	Same as `CHAR`, but stores just the text. The size is a maximum, not a minimum.

Fixed-length strings are datatypes that are defined to accept a fixed number of characters, and that number is specified when the table is created. For example, you might allow 30 characters in a firstname column or 11 characters in a social-security-number column (the exact number needed allowing for the two dashes). Fixed-length columns do not allow more than the specified number of characters. They also allocate storage space for as many characters as specified. So, if the string `Ben` is stored in a 30-character firstname field, a full 30 bytes are stored. `CHAR` is an example of a fixed-length string type.

Variable-length strings store text of variable length. Some variable-length datatypes have a defined maximum size. Others are entirely variable. Either way, only the data specified is saved (and no extra data is stored). `TEXT` is an example of a variable-length string type.

If variable-length datatypes are so flexible, why would you ever want to use fixed-length datatypes? The answer is performance. MySQL can sort and manipulate fixed-length columns far more quickly than it can sort variable-length columns. In addition, MySQL does not allow you to index variable-length columns (or the variable portion of a column). This also dramatically affects performance.

Tip

Using Quotes Regardless of the form of string datatype being used, string values must always be surrounded by quotes (single quotes are often preferred).

Caution

When Numeric Values Are Not Numeric Values You might think that phone numbers and ZIP Codes should be stored in numeric fields (after all, they only store numeric data), but doing so would not be advisable. If you store the ZIP Code 01234 in a numeric field, the number 1234 would be saved. You'd actually lose a digit.

The basic rule to follow is this: If the number is a number used in calculations (sums, averages, and so on), it belongs in a numeric datatype column. If it is used as a literal string (that happens to contain only digits), it belongs in a string datatype column.

Numeric Datatypes

Numeric datatypes store numbers. MySQL supports several numeric datatypes, each with a different range of numbers that can be stored in it. Obviously, the larger the supported range, the more storage space needed. In addition, some numeric datatypes support the use of decimal points (and fractional numbers) whereas others support only whole numbers. Table D.2 lists the frequently used MySQL numeric datatypes.

Table D.2. Numeric Datatypes

Datatype	Description
`BIT`	A bit-field, from `1` to `64` bits wide. (Prior to MySQL 5 `BIT` was functionally equivalent to `TINYINT`.)
`BIGINT`	Integer value, supports numbers from `-9223372036854775808` to `9223372036854775807` (or `0` to `18446744073709551615` if `UNSIGNED`).
`BOOLEAN (or BOOL`)	Boolean flag, either `0` or `1`, used primarily for on/off flags.
`DECIMAL (or DEC`)	Floating point values with varying levels of precision.
`DOUBLE`	Double-precision floating point values.
`FLOAT`	Single-precision floating point values.
`INT (or INTEGER`)	Integer value, supports numbers from `-2147483648` to `2147483647` (or `0` to `4294967295` if `UNSIGNED`).
`MEDIUMINT`	Integer value, supports numbers from `-8388608` to `8388607` (or `0` to `16777215` if `UNSIGNED`).
REAL	4-byte floating point values.
`SMALLINT`	Integer value, supports numbers from `-32768` to `32767` (or `0` to `65535` if `UNSIGNED`)
`TINYINT`	Integer value, supports numbers from `-128` to `127` (or `0` to `255` if `UNSIGNED`).

Note

Signed Or `UNSIGNED`? All numeric datatypes (with the exception of `BIT` and `BOOLEAN`) can be signed or unsigned. Signed numeric columns can store both positive and negative numbers, unsigned numeric columns store only positive numbers. Signed is the default, but if you know that you'll not need to store negative values you can use the `UNSIGNED` keyword, doing so will allow you to store values twice as large.

Tip

Not Using Quotes Unlike strings, numeric values should never be enclosed within quotes.

Tip

Storing Currency There is no special MySQL datatype for currency values, use `DECIMAL(8,2)` instead.

Date and Time Datatypes

MySQL uses special datatypes for the storage of date and time values as listed in Table D.3.

Table D.3. Date and Time Datatypes

Datatype	Description
`DATE`	Date from `1000-01-01` to `9999-12-31` in the format `YYYY-MM-DD`.
`DATETIME`	A combination of `DATE` and `TIME`.
`TIMESTAMP`	Functionally equivalent to `DATETIME` (but with a smaller range).
`TIME`	Time in the format `HH:MM:SS`.
`YEAR`	A 2 or 4 digit year, 2 digit years support a range of `70` (1970) to `69` (2069), 4 digit years support a range of `1901` to `2155`.

Binary Datatypes

Binary datatypes are used to store all sorts of data (even binary information), such as graphic images, multimedia, and word processor documents (see Table D.4).

Table D.4. Binary Datatypes

Datatype	Description
`BLOB`	Blob with a maximum length of 64K.
`MEDIUMBLOB`	Blob with a maximum length of 16MB.
`LONGBLOB`	Blob with a maximum length of 4GB.
`TINYBLOB`	Blob with a maximum length of 255 bytes.

Note

Datatypes in Use If you would like to see a real-world example of how different databases are used, see the sample table creation scripts (described in Appendix B, "The Example Tables").

Appendix E. MySQL Reserved Words

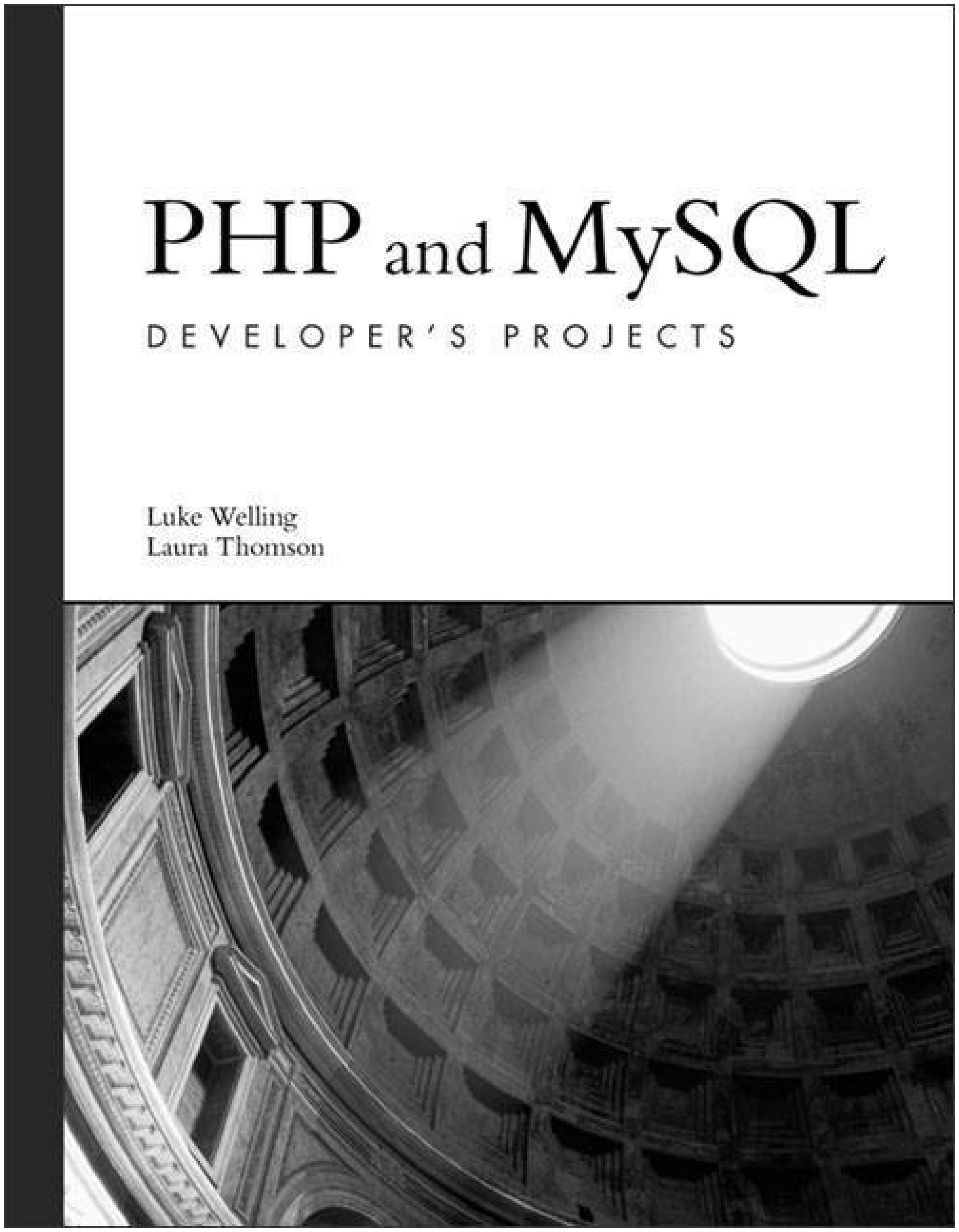
MySQL is made up of keywordsspecial words used in performing SQL operations. Do not use these keywords when naming databases, tables, columns, and any other database objects. These keywords are considered reserved. This appendix lists all of the MySQL reserved words (as of MySQL 5).

ACTION	CASE	DATABASE
ADD	CHANGE	DATABASES
ALL	CHAR	DATE
ALTER	CHARACTER	DAY_HOUR
ANALYZE	CHECK	DAY_MICROSECOND
AND	COLLATE	DAY_MINUTE
AS	COLUMN	DAY_SECOND
ASC	CONDITION	DEC
ASENSITIVE	CONNECTION	DECIMAL
BEFORE	CONSTRAINT	DECLARE
BETWEEN	CONTINUE	DEFAULT
BIGINT	CONVERT	DELAYED
BINARY	CREATE	DELETE
BIT	CROSS	DESC
BLOB	CURRENT_DATE	DESCRIBE
BOTH	CURRENT_TIME	DETERMINISTIC
BY	CURRENT_TIMESTAMP	DISTINCT
CALL	CURRENT_USER	DISTINCTROW
CASCADE	CURSOR	DIV

DOUBLE	HOUR_MINUTE	LINES
DROP	HOUR_SECOND	LOAD
DUAL	IF	LOCALTIME
EACH	IGNORE	LOCALTIMESTAMP
ELSE	IN	LOCK
ELSEIF	INDEX	LONG
ENCLOSED	INFILE	LONGBLOB
ENUM	INNER	LONGTEXT
ESCAPED	INOUT	LOOP
EXISTS	INSENSITIVE	LOW_PRIORITY
EXIT	INSERT	MATCH
EXPLAIN	INT	MEDIUMBLOB
FALSE	INTEGER	MEDIUMINT
FETCH	INTERVAL	MEDIUMTEXT
FLOAT	INTO	MIDDLEINT
FOR	IS	MINUTE_MICROSECOND
FORCE	ITERATE	MINUTE_SECOND
FOREIGN	JOIN	MOD
FROM	KEY	MODIFIES
FULLTEXT	KEYS	NATURAL
GOTO	KILL	NO
GRANT	LEADING	NO_WRITE_TO_BINLOG
GROUP	LEAVE	NOT

HAVING	LEFT	NULL
HIGH_PRIORITY	LIKE	NUMERIC
HOUR_MICROSECOND	LIMIT	ON
OPTIMIZE	RLIKE	THEN
OPTION	SCHEMA	TIME
OPTIONALLY	SCHEMAS	TIMESTAMP
OR	SECOND_MICROSECOND	TINYBLOB
ORDER	SELECT	TINYINT
OUT	SENSITIVE	TINYTEXT
OUTER	SEPARATOR	TO
OUTFILE	SET	TRAILING
PRECISION	SHOW	trIGGER
PRIMARY	SMALLINT	TRUE
PROCEDURE	SONAME	UNDO
PURGE	SPATIAL	UNION
READ	SPECIFIC	UNIQUE
READS	SQL	UNLOCK
REAL	SQL_BIG_RESULT	UNSIGNED
REFERENCES	SQL_CALC_FOUND_ROWS	UPDATE
REGEXP	SQL_SMALL_RESULT	USAGE
RELEASE	SQLEXCEPTION	USE
RENAME	SQLSTATE	USING
REPEAT	SQLWARNING	UTC_DATE

REPLACE	SSL	UTC_TIME
REQUIRE	STARTING	UTC_TIMESTAMP
RESTRICT	STRAIGHT_JOIN	VALUES
RETURN	TABLE	VARBINARY
REVOKE	TERMINATED	VARCHAR
RIGHT	TEXT	VARCHARACTER
VARYING		
WHEN		
WHERE		
WHILE		
WITH		
WRITE		
XOR		
YEAR_MONTH		
ZEROFILL		



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