CHAPTER

34

Java Database Programming

Objectives

- To understand the concepts of databases and database management systems (§34.2).
- To understand the relational data model: relational data structures, constraints, and languages (§34.2).
- To use SQL to create and drop tables and to retrieve and modify data (§34.3).
- To learn how to load a driver, connect to a database, execute statements, and process result sets using JDBC (§34.4).
- To use prepared statements to execute precompiled SQL statements (§34.5).
- To use callable statements to execute stored SQL procedures and functions (§34.6).
- To explore database metadata using the `DatabaseMetaData` and `ResultSetMetaData` interfaces (§34.7).

34.1 Introduction

Key Point

Java provides the API for developing database applications that works with any relational database systems.

You may have heard a lot about database systems. Database systems are everywhere. Your social security information is stored in a database by the government. If you shop online, your purchase information is stored in a database by the company. If you attend a university, your academic information is stored in a database by the university. Database systems not only store data, they also provide means of accessing, updating, manipulating, and analyzing data. Your social security information is updated periodically, and you can register for courses online. Database systems play an important role in society and in commerce.

This chapter introduces database systems, the SQL language, and how database applications can be developed using Java. If you already know SQL, you can skip Sections 34.2 and 34.3.

34.2 Relational Database Systems

Key Point

SQL is the standard database language for defining and accessing databases.

database system

A *database system* consists of a database, the software that stores and manages data in the database, and the application programs that present data and enable the user to interact with the database system, as shown in Figure 34.1.

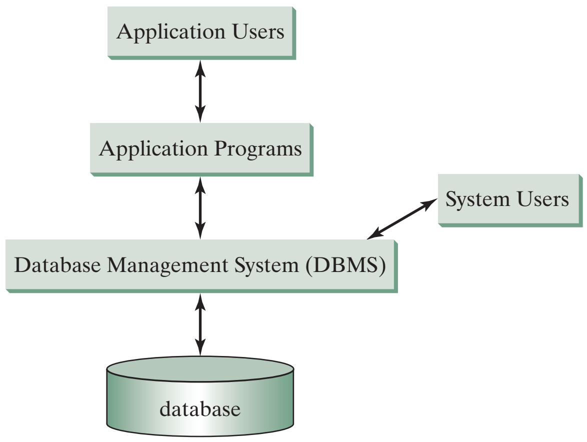


FIGURE 34.1 A database system consists of data, database management software, and application programs.

A *database* is a repository of data that form information. When you purchase a database system—such as MySQL, Oracle, IBM's DB2 and Informix, Microsoft SQL Server, or Sybase—from a software vendor, you actually purchase the software comprising a *database management system* (DBMS). Database management systems are designed for use by professional programmers and are not suitable for ordinary customers. Application programs are built on top of the DBMS for customers to access and update the database. Thus, application programs can be viewed as the *interfaces* between the database system and its users. Application programs may be stand-alone GUI applications or Web applications and may access several different database systems in the network, as shown in Figure 34.2.

DBMS

Most of today's database systems are *relational database systems.* They are based on the relational data model, which has three key components: structure, integrity, and language.

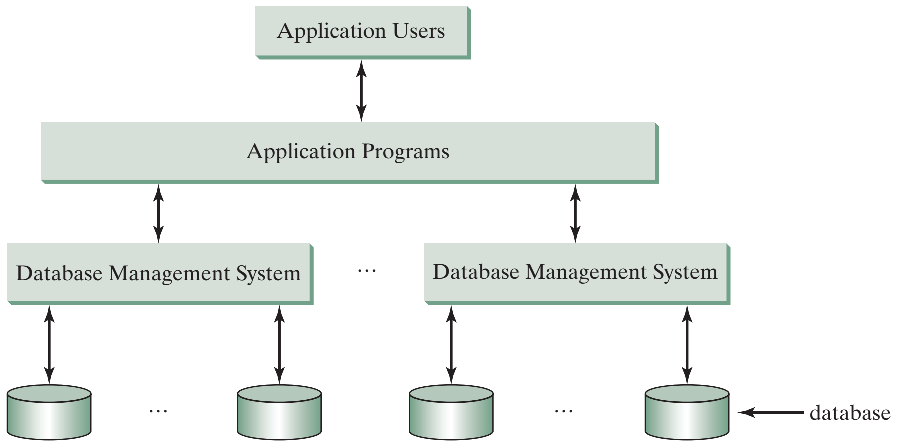


FIGURE 34.2 An application program can access multiple database systems.

Structure defines the representation of the data. *Integrity* imposes constraints on the data. *Language* provides the means for accessing and manipulating data.

34.2.1 Relational Structures

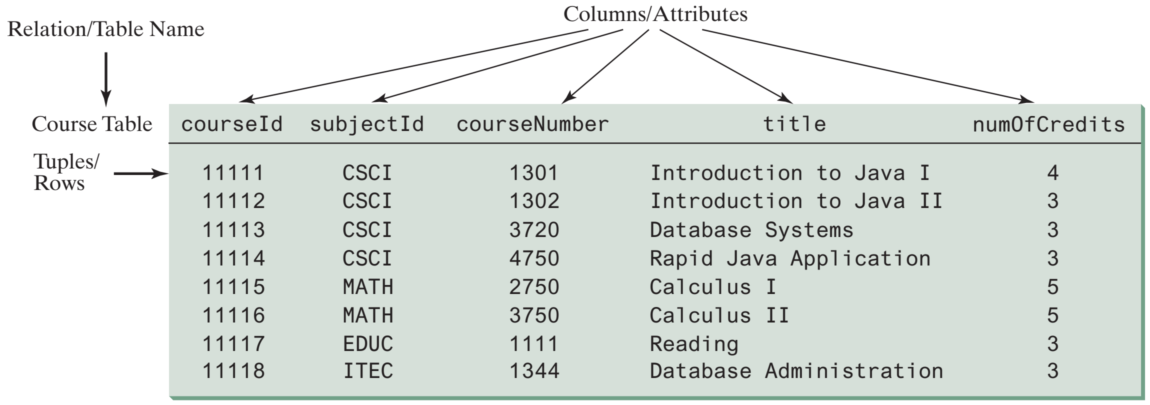
relational model

The relational model is built around a simple and natural structure. A *relation* is actually a table that consists of nonduplicate rows. Tables are easy to understand and use. The relational model provides a simple yet powerful way to represent data.

tuple

attribute

A row of a table represents a *record*, and a column of a table represents the *value of a single attribute* of the record. In relational database theory, a row is called a *tuple*, and a column is called an *attribute*. Figure 34.3 shows a sample table that stores information about the courses offered by a university. The table has eight tuples, and each tuple has five attributes.


Columns/Attributes
Relation/Table Name
Course Table
Tuples/
Rows

courseId	subjectId	courseNumber	title	numOfCredits
11111	CSCI	1301	Introduction to Java I	4
11112	CSCI	1302	Introduction to Java II	3
11113	CSCI	3720	Database Systems	3
11114	CSCI	4750	Rapid Java Application	3
11115	MATH	2750	Calculus I	5
11116	MATH	3750	Calculus II	5
11117	EDUC	1111	Reading	3
11118	ITEC	1344	Database Administration	3

FIGURE 34.3 A table has a table name, column names, and rows.

Tables describe the relationship among data. Each row in a table represents a record of related data. For example, "11111," "CSCI," "1301," "Introduction to Java I," and "4" are related to form a record (the first row in Figure 34.3) in the `Course` table. Just as the data in the same row are related, so too data in different tables may be related through common attributes. Suppose the database has two other tables, `Student` and `Enrollment`, as shown in

Figures 34.4 and 34.5. The **Course** table and the **Enrollment** table are related through their common attribute **courseId**, and the **Enrollment** table and the **Student** table are related through **ssn**.

Student Table

ssn	firstName	mi	lastName	phone	birthDate	street	zipCode	deptID
444111110	Jacob	R	Smith	9129219434	1985-04-09	99 Kingston Street	31435	BIOL
444111111	John	K	Stevenson	9129219434	null	100 Main Street	31411	BIOL
444111112	George	K	Smith	9129213454	1974-10-10	1200 Abercorn St.	31419	CS
444111113	Frank	E	Jones	9125919434	1970-09-09	100 Main Street	31411	BIOL
444111114	Jean	K	Smith	9129219434	1970-02-09	100 Main Street	31411	CHEM
444111115	Josh	R	Woo	7075989434	1970-02-09	555 Franklin St.	31411	CHEM
444111116	Josh	R	Smith	9129219434	1973-02-09	100 Main Street	31411	BIOL
444111117	Joy	P	Kennedy	9129229434	1974-03-19	103 Bay Street	31412	CS
444111118	Toni	R	Peterson	9129229434	1964-04-29	103 Bay Street	31412	MATH
444111119	Patrick	R	Stoneman	9129229434	1969-04-29	101 Washington St.	31435	MATH
444111120	Rick	R	Carter	9125919434	1986-04-09	19 West Ford St.	31411	BIOL

Figure 34.4 A **Student** table stores student information.

Enrollment Table

ssn	courseId	dateRegistered	grade
444111110	11111	2004-03-19	A
444111110	11112	2004-03-19	B
444111110	11113	2004-03-19	C
444111111	11111	2004-03-19	D
444111111	11112	2004-03-19	F
444111111	11113	2004-03-19	A
444111112	11114	2004-03-19	B
444111112	11115	2004-03-19	C
444111112	11116	2004-03-19	D
444111113	11111	2004-03-19	A
444111113	11113	2004-03-19	A
444111114	11115	2004-03-19	B
444111115	11115	2004-03-19	F
444111115	11116	2004-03-19	F
444111116	11111	2004-03-19	D
444111117	11111	2004-03-19	D
444111118	11111	2004-03-19	A
444111118	11112	2004-03-19	D
444111118	11113	2004-03-19	B

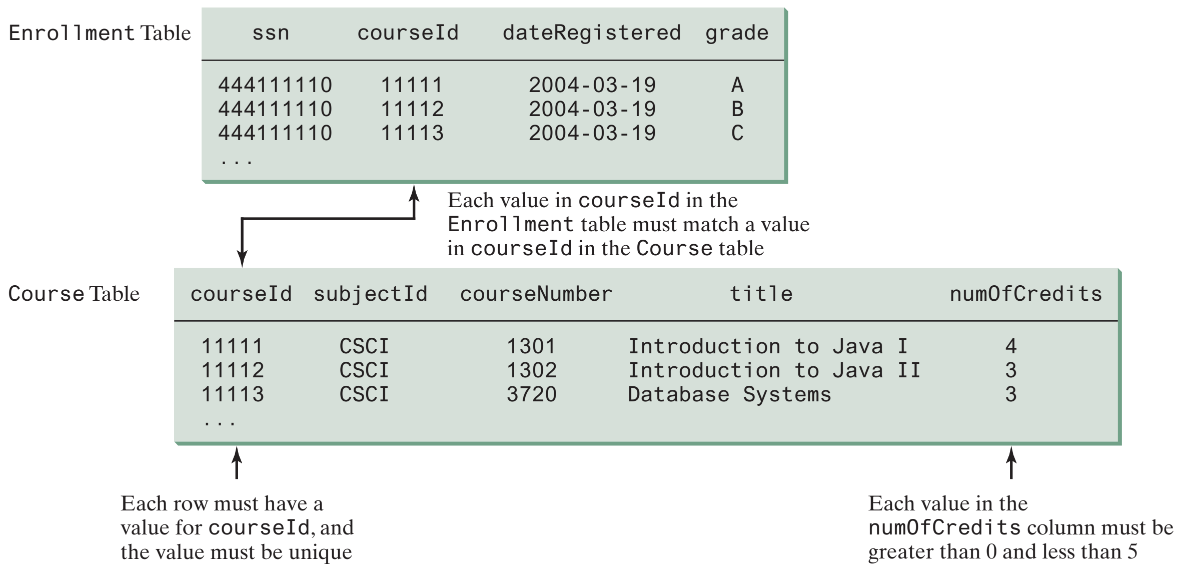
Figure 34.5 An **Enrollment** table stores student enrollment information.

34.2.2 Integrity Constraints

integrity constraint

An *integrity constraint* imposes a condition that all the legal values in a table must satisfy. Figure 34.6 shows an example of some integrity constraints in the **Subject** and **Course** tables.

In general, there are three types of constraints: domain constraints, primary key constraints, and foreign key constraints. *Domain constraints* and *primary key constraints* are known as *intrarelational constraints*, meaning that a constraint involves only one relation. The *foreign key constraint* is *interrelational*, meaning that a constraint involves more than one relation.


Enrollment Table
Course Table
Each value in courseId in the Enrollment table must match a value in courseId in the Course table
Each row must have a value for courseId, and the value must be unique
Each value in the numOfCredits column must be greater than 0 and less than 5

Enrollment Table

ssn	courseId	dateRegistered	grade
444111110	11111	2004-03-19	A
444111110	11112	2004-03-19	B
444111110	11113	2004-03-19	C
...			

Course Table

courseId	subjectId	courseNumber	title	numOfCredits
11111	CSCI	1301	Introduction to Java I	4
11112	CSCI	1302	Introduction to Java II	3
11113	CSCI	3720	Database Systems	3
...				

FIGURE 34.6 The `Enrollment` table and the `Course` table have integrity constraints.

Domain Constraints

Domain constraints specify the permissible values for an attribute. Domains can be specified using standard data types, such as integers, floating-point numbers, fixed-length strings, and variant-length strings. The standard data type specifies a broad range of values. Additional constraints can be specified to narrow the ranges. For example, you can specify that the `numOfCredits` attribute (in the `Course` table) must be greater than 0 and less than 5. If an attribute has different values for each tuple in a relation, you can specify the attribute to be unique. You can also specify whether an attribute can be `null`, which is a special value in a database meaning unknown or not applicable. As shown in the `Student` table, `birthDate` may be `null`.

domain constraint

Primary Key Constraints

A primary key is a set of attributes that uniquely identifyies the tuples in a relations. Why is it called a primary key, rather than simply key? To understand this, it is helpful to know superkeys, keys, and candidate keys. A *superkey* is an attribute or a set of attributes that uniquely identifies the relation. That is, no two tuples have the same values on a superkey. By definition, a relation consists of a set of distinct tuples. The set of all attributes in the relation forms a superkey.

superkey

A *key* `K` is a minimal superkey, meaning that any proper subset of `K` is not a superkey. A relation can have several keys. In this case, each of the keys is called a *candidate key*. The *primary key* is one of the candidate keys designated by the database designer. The primary key is often used to identify tuples in a relation. As shown in Figure 34.6, `courseId` is the primary key in the `Course` table, and `ssn` and `courseId` form a primary key in the `Enrollment` table.

candidate key

primary key

Foreign Key Constraints

In a *relational database*, data are related. Tuples in a relation are related, and tuples in different relations are related through their common attributes. Informally speaking, the common attributes are foreign keys. The *foreign key constraints* define the relationships among relations.

relational database

foreign key constraint

Formally, a set of attributes *FK* is a *foreign key* in a relation *R* that references relation *T* if it satisfies the following two rules:

foreign key

- The attributes in *FK* have the same domain as the primary key in *T*.
- A nonnull value on *FK* in *R* must match a primary key value in *T*.

As shown in Figure 34.6, `courseId` is the foreign key in `Enrollment` that references the primary key `courseId` in `Course`. Every `courseId` value must match a `courseId` value in `Course`.

Enforcing Integrity Constraints

auto enforcement

The database management system enforces integrity constraints and rejects operations that would violate them. For example, if you attempt to insert the new record ("11115," "CSCI," "2490," "C++ Programming," "0") into the `Course` table, it would fail because the credit hours must be greater than `0`; if you attempted to insert a record with the same primary key as an existing record in the table, the DBMS would report an error and reject the operation; if you attempted to delete a record from the `Course` table whose primary key value is referenced by the records in the `Enrollment` table, the DBMS would reject this operation.

Note

All relational database systems support primary key constraints and foreign key constraints, but not all database systems support domain constraints. In the Microsoft Access database, for example, you cannot specify the constraint that `numOfCredits` is greater than `0` and less than `5`.

Check Point

34.2.1 What are superkeys, candidate keys, and primary keys?
34.2.2 What is a foreign key?
34.2.3 Can a relation have more than one primary key or foreign key?
34.2.4 Does a foreign key need to be a primary key in the same relation?
34.2.5 Does a foreign key need to have the same name as its referenced primary key?
34.2.6 Can a foreign key value be null?

34.3 SQL

Key Point

Structured Query Language (SQL) is the language for defining tables and integrity constraints, and for accessing and manipulating data.

SQL

database language

SQL (pronounced "S-Q-L" or "sequel") is the universal language for accessing relational database systems. Application programs may allow users to access a database without directly using SQL, but these applications themselves must use SQL to access the database. This section introduces some basic SQL commands.

Note

standard SQL

There are many relational database management systems. They share the common SQL language but do not all support every feature of SQL. Some systems have their own extensions to SQL. This section introduces standard SQL supported by all systems.

SQL can be used on MySQL, Oracle, Sybase, IBM DB2, IBM Informix, MS Access, Apache Derby, or any other relational database system. Apache Derby is an open source relational database management system developed using Java. Oracle distributes Apache Derby as Java DB and bundled with Java so you can use it in any Java application without installing a database. Java DB is ideal for supporting a small database in a Java application. This chapter uses MySQL to demonstrate SQL and Java database programming.

The Companion Website contains the following supplements on how to install and use three popular databases: MySQL, Oracle, and Java DB:

MySQL Tutorial
- Supplement IV.B: Tutorial for MySQL

Oracle Tutorial
- Supplement IV.C: Tutorial for Oracle

Java DB Tutorial
- Supplement IV.D: Tutorial for Java DB

34.3.1 Creating a User Account on MySQL

Assume you have installed MySQL 5 with the default configuration. To match all the examples in this book, you should create a user named *scott* with the password *tiger*. You can perform the administrative tasks using the MySQL Workbench or using the command line. MySQL Workbench is a GUI tool for managing MySQL databases. Here are the steps to create a user from the command line:

1. From the DOS command prompt, type

   ```
   mysql –uroot -p
   ```

   You will be prompted to enter the root password, as shown in Figure 34.7.

2. At the mysql prompt, enter

   ```
   use mysql;
   ```

3. To create user **scott** with password **tiger**, enter

   ```
   create user 'scott'@'localhost' identified by 'tiger';
   ```

4. To grant privileges to **scott**, enter

   ```
   grant select, insert, update, delete, create, create view, drop,
      execute, references on *.* to 'scott'@'localhost';
   ```

   - If you want to enable remote access of the account from any IP address, enter

     ```
     grant all privileges on *.* to 'scott'@'%'
       identified by 'tiger';
     ```

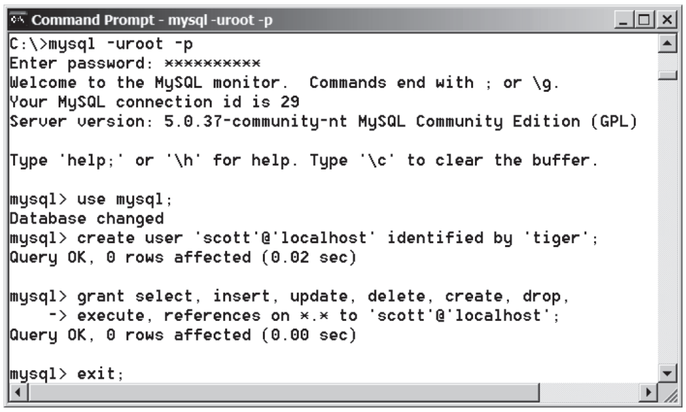
   - If you want to restrict the account's remote access to just one particular IP address, enter

     ```
     grant all privileges on *.* to 'scott'@'ipAddress'
       identified by 'tiger';
     ```

5. Enter

   ```
   exit;
   ```

   to exit the MySQL console.



```
C:\>mysql -uroot -p
Enter password: **********
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 29
Server version: 5.0.37-community-nt MySQL Community Edition (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> use mysql;
Database changed
mysql> create user 'scott'@'localhost' identified by 'tiger';
Query OK, 0 rows affected (0.02 sec)

mysql> grant select, insert, update, delete, create, drop,
    -> execute, references on *.* to 'scott'@'localhost';
Query OK, 0 rows affected (0.00 sec)

mysql> exit;
```

FIGURE 34.7 You can access a MySQL database server from the command window.

Note

`stop mysql`
`start mysql`

On Windows, your MySQL database server starts every time your computer starts. You can stop it by typing the command `net stop mysql` and restart it by typing the command `net start mysql`.

By default, the server contains two databases named **mysql** and **test**. The **mysql** database contains the tables that store information about the server and its users. This database is intended for the server administrator to use. For example, the administrator can use it to create users and grant or revoke user privileges. Since you are the owner of the server installed on your system, you have full access to the **mysql** database. However, you should not create user tables in the mysql database. You can use the **test** database to store data or create new databases. You can also create a new database using the command `create database` ***`databasename`*** or delete an existing database using the command `drop database` ***`databasename`***.

34.3.2 Creating a Database

To match the examples in this book, you should create a database named **javabook**. Here are the steps to create it:

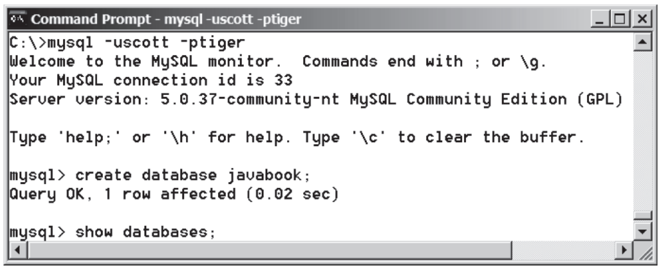
1. From the DOS command prompt, type

   ```
   mysql –uscott -ptiger
   ```

   to login to mysql, as shown in Figure 34.8.

2. At the mysql prompt, enter

   ```
   create database javabook;
   ```


Command Prompt - mysql -uscott -ptiger

```
C:\>mysql -uscott -ptiger
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 33
Server version: 5.0.37-community-nt MySQL Community Edition (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> create database javabook;
Query OK, 1 row affected (0.02 sec)

mysql> show databases;
```

FIGURE 34.8 You can create databases in MySQL.

For your convenience, the SQL statements for creating and initializing tables used in this book are provided in Supplement IV.A. You can download the script for MySQL and save it to **script.sql**. To execute the script, first switch to the **javabook** database using the following command:

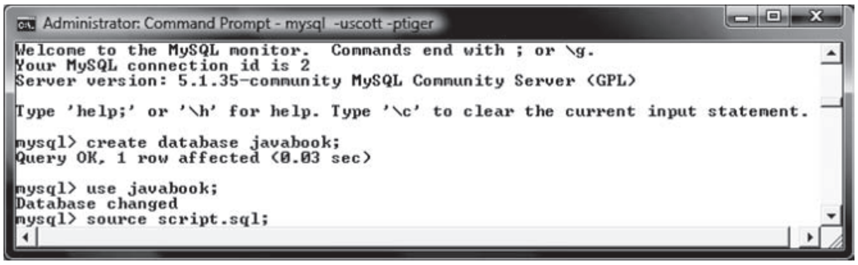
```
use javabook;
```

then type

run script file

```
source script.sql;
```

as shown in Figure 34.9.



```
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 2
Server version: 5.1.35-community MySQL Community Server (GPL)

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

mysql> create database javabook;
Query OK, 1 row affected (0.03 sec)

mysql> use javabook;
Database changed
mysql> source script.sql;
```

Figure 34.9 You can run SQL commands in a script file.

Note
You can populate the **javabook** database using the script from Supplement IV.A.

populating database

34.3.3 Creating and Dropping Tables

create table

Tables are the essential objects in a database. To create a table, use the `create table` statement to specify a table name, attributes, and types, as in the following example:

```
create table Course (
  courseId char(5),
  subjectId char(4) not null,
  courseNumber integer,
  title varchar(50) not null,
  numOfCredits integer,
  primary key (courseId)
);
```

This statement creates the `Course` table with attributes `courseId`, `subjectId`, `courseNumber`, `title`, and `numOfCredits`. Each attribute has a data type that specifies the type of data stored in the attribute. `char(5)` specifies that `courseId` consists of five characters. `varchar(50)` specifies that `title` is a variant-length string with a maximum of 50 characters. `integer` specifies that `courseNumber` is an integer. The primary key is `courseId`.

The tables `Student` and `Enrollment` can be created as follows:

```
create table Student (
  ssn char(9),
  firstName varchar(25),
  mi char(1),
  lastName varchar(25),
  birthDate date,
  street varchar(25),
  phone char(11),
  zipCode char(5),
  deptId char(4),
  primary key (ssn)
);
```

```
create table Enrollment (
  ssn char(9),
  courseId char(5),
  dateRegistered date,
  grade char(1),
  primary key (ssn, courseId),
  foreign key (ssn) references
    Student(ssn),
  foreign key (courseId) references
    Course(courseId)
);
```

Note
SQL keywords are not case sensitive. This book adopts the following naming conventions: tables are named in the same way as Java classes, and attributes are named in the same way as Java variables. SQL keywords are named in the same way as Java keywords.

naming convention

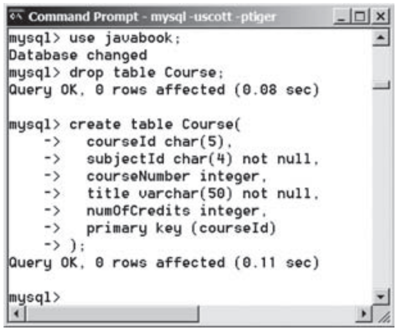
drop table

If a table is no longer needed, it can be dropped permanently using the `drop table` command. For example, the following statement drops the `Course` table:

```
drop table Course;
```

If a table to be dropped is referenced by other tables, you have to drop the other tables first. For example, if you have created the tables `Course`, `Student`, and `Enrollment` and want to drop `Course`, you have to first drop `Enrollment`, because `Course` is referenced by `Enrollment`.

Figure 34.10 shows how to enter the `create table` statement from the MySQL console.

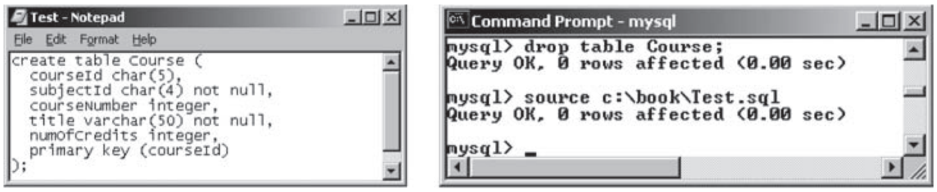


Command Prompt - mysql -uscott -ptiger

```
mysql> use javabook;
Database changed
mysql> drop table Course;
Query OK, 0 rows affected (0.08 sec)

mysql> create table Course(
    ->   courseId char(5),
    ->   subjectId char(4) not null,
    ->   courseNumber integer,
    ->   title varchar(50) not null,
    ->   numOfCredits integer,
    ->   primary key (courseId)
    -> );
Query OK, 0 rows affected (0.11 sec)

mysql>
```

FIGURE 34.10 A table is created using the `create table` statement.

If you make typing errors, you have to retype the whole command. To avoid retyping, you can save the command in a file, then run the command from the file. To do so, create a text file to contain commands, named, for example, **test.sql**. You can create the text file using any text editor, such as Notepad, as shown in Figure 34.11a. To comment a line, precede it with two dashes. You can now run the script file by typing `source test.sql` from the SQL command prompt, as shown in Figure 34.11b.



Test - Notepad

```
create table Course (
  courseId char(5),
  subjectId char(4) not null,
  courseNumber integer,
  title varchar(50) not null,
  numOfCredits integer,
  primary key (courseId)
);
```

Command Prompt - mysql

```
mysql> drop table Course;
Query OK, 0 rows affected (0.00 sec)

mysql> source c:\book\Test.sql
Query OK, 0 rows affected (0.00 sec)

mysql> _
```

(a) (b)

FIGURE 34.11 (a) You can use Notepad to create a text file for SQL commands. (b) You can run the SQL commands in a script file from MySQL.

34.3.4 Simple Insert, Update, and Delete

Once a table is created, you can insert data into it. You can also update and delete records. This section introduces simple insert, update, and delete statements.

The syntax to insert a record into a table is:

```
insert into tableName [(column1, column2, ..., column)]
values (value1, value2, ..., valuen);
```

For example, the following statement inserts a record into the Course table. The new record has the courseId '11113', subjectId 'CSCI', courseNumber '3720', title 'Database Systems', and creditHours 3.

```
insert into Course (courseId, subjectId, courseNumber, title, numOfCredits)
values ('11113', 'CSCI', '3720', 'Database Systems', 3);
```

The column names are optional. If they are omitted, all the column values for the record must be entered, even though the columns have default values. String values are case sensitive and enclosed inside single quotation marks in SQL.

The syntax to update a table is:

```
update tableName
set column1 = newValue1 [, column2 = newValue2, ...]
[where condition];
```

For example, the following statement changes the numOfCredits for the course whose title is Database Systems to 4.

```
update Course
set numOfCredits = 4
where title = 'Database Systems';
```

The syntax to delete records from a table is:

```
delete from tableName
[where condition];
```

For example, the following statement deletes the Database Systems course from the Course table:

```
delete from Course
where title = 'Database Systems';
```

The following statement deletes all the records from the Course table:

```
delete from Course;
```

34.3.5 Simple Queries

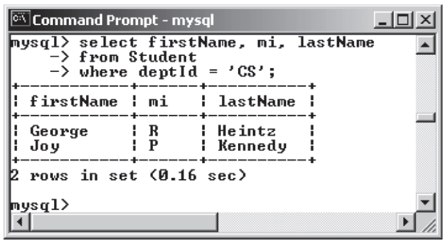
To retrieve information from tables, use a select statement with the following syntax:

```
select column-list
from table-list
[where condition];
```

The select clause lists the columns to be selected. The from clause refers to the tables involved in the query. The optional where clause specifies the conditions for the selected rows.

Query 1: Select all the students in the CS department, as shown in Figure 34.12.

```
select firstName, mi, lastName
from Student
where deptId = 'CS';
```



```
mysql> select firstName, mi, lastName
    -> from Student
    -> where deptId = 'CS';
+-----------+------+----------+
| firstName | mi   | lastName |
+-----------+------+----------+
| George    | R    | Heintz   |
| Joy       | P    | Kennedy  |
+-----------+------+----------+
2 rows in set (0.16 sec)

mysql>
```

FIGURE 34.12 The result of the select statement is displayed in the MySQL console.

34.3.6 Comparison and Boolean Operators

SQL has six comparison operators, as shown in Table 34.1, and three Boolean operators, as shown in Table 34.2.

TABLE 34.1 Comparison Operators

Operator	*Description*
=	Equal to
<> or !=	Not equal to
<	Less than
<=	Less than or equal to
>	Greater than
>=	Greater than or equal to

TABLE 34.2 Boolean Operators

Operator	*Description*
not	Logical negation
and	Logical conjunction
or	Logical disjunction

Note

The comparison and Boolean operators in SQL have the same meanings as in Java. In SQL the equal to operator is =, but in Java it is ==. In SQL the not equal to operator is <> or !=, but in Java it is !=. The not, and, and or operators are !, && (&), and || (|) in Java.

Query 2: Get the names of the students who are in the CS dept and live in the ZIP code 31411.

```
select firstName, mi, lastName
from Student
where deptId = 'CS' and zipCode = '31411';
```

Note

To select all the attributes from a table, you don't have to list all the attribute names in the select clause. Instead, you can just use an *asterisk* (*), which stands for all the attributes. For example, the following query displays all the attributes of the students who are in the CS dept and live in ZIP code 31411.

```
select *
from Student
where deptId = 'CS' and zipCode = '31411';
```

34.3.7 The `like`, `between-and`, and `is null` Operators

SQL has a `like` operator that can be used for pattern matching. The syntax to check whether a string `s` has a pattern `p` is

`s like p` or `s not like p`

You can use the wildcard characters `%` (percent symbol) and _ (underline symbol) in the pattern `p`. `%` matches zero or more characters, and _ matches any single character in `s`. For example, `lastName like '_mi%'` matches any string whose second and third letters are `m` and `i`. `lastName not like '_mi%'` excludes any string whose second and third letters are `m` and `i`.

Note
In earlier versions of MS Access, the wildcard character is `*`, and the character `?` matches any single character.

The `between-and` operator checks whether a value `v` is between two other values, `v1` and `v2`, using the following syntax:

`v between v1 and v2` or `v not between v1 and v2`

`v between v1 and v2` is equivalent to `v >= v1 and v <= v2`, and `v not between v1 and v2` is equivalent to `v < v1 or v > v2`.

The `is null` operator checks whether a value `v` is `null` using the following syntax:

`v is null` or `v is not null`

Query 3: Get the Social Security numbers of the students whose grades are between 'C' and 'A'.

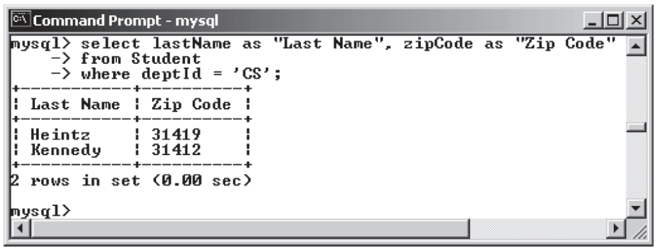
```
select ssn
from Enrollment
where grade between 'C' and 'A';
```

34.3.8 Column Alias

When a query result is displayed, SQL uses the column names as column headings. Usually the user gives abbreviated names for the columns, and the columns cannot have spaces when the table is created. Sometimes it is desirable to give more descriptive names in the result heading. You can use the column aliases with the following syntax:

```
select columnName [as] alias
```

Query 4: Get the last name and ZIP code of the students in the CS department. Display the column headings as "Last Name" for lastName and "Zip Code" for zipCode. The query result is shown in Figure 34.13.



```
mysql> select lastName as "Last Name", zipCode as "Zip Code"
    -> from Student
    -> where deptId = 'CS';
+-----------+----------+
| Last Name | Zip Code |
+-----------+----------+
| Heintz    | 31419    |
| Kennedy   | 31412    |
+-----------+----------+
2 rows in set (0.00 sec)

mysql>
```

FIGURE 34.13 You can use a column alias in the display.

```
select lastName as "Last Name", zipCode as "Zip Code"
from Student
where deptId = 'CS';
```

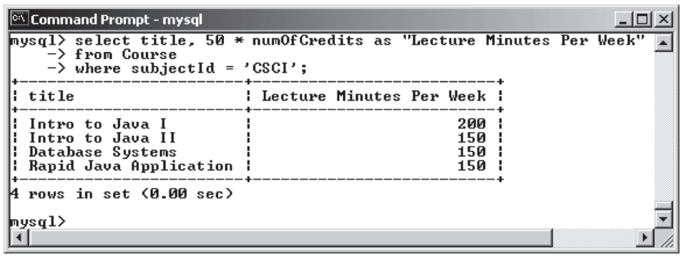
Note
The `as` keyword is optional in MySQL and Oracle, but it is required in MS Access.

34.3.9 The Arithmetic Operators

You can use the arithmetic operators `*` (multiplication), `/` (division), `+` (addition), and `-` (subtraction) in SQL.

Query 5: Assume a credit hour is 50 minutes of lectures and get the total minutes for each course with the subject CSCI. The query result is shown in Figure 34.14.

```
select title, 50 * numOfCredits as "Lecture Minutes Per Week"
from Course
where subjectId = 'CSCI';
```



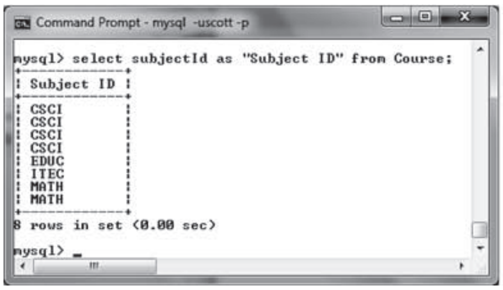
```
mysql> select title, 50 * numOfCredits as "Lecture Minutes Per Week"
    -> from Course
    -> where subjectId = 'CSCI';
+-------------------------+--------------------------+
| title                   | Lecture Minutes Per Week |
+-------------------------+--------------------------+
| Intro to Java I         |                      200 |
| Intro to Java II        |                      150 |
| Database Systems        |                      150 |
| Rapid Java Application  |                      150 |
+-------------------------+--------------------------+
4 rows in set (0.00 sec)

mysql>
```

FIGURE 34.14 You can use arithmetic operators in SQL.

34.3.10 Displaying Distinct Tuples

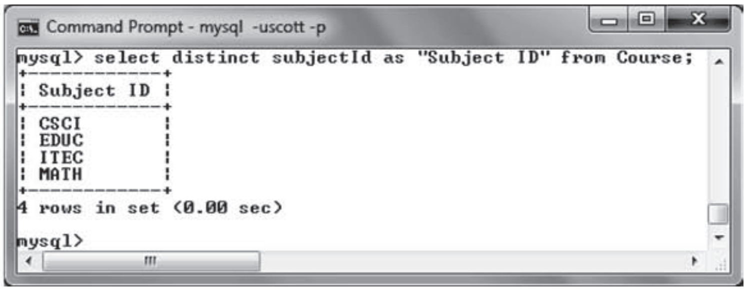
SQL provides the `distinct` keyword, which can be used to eliminate duplicate tuples in the result. Figure 34.15a displays all the subject IDs used by the courses, and Figure 34.15b displays all the distinct subject IDs used by the courses using the following statement:

```
select distinct subjectId as "Subject ID"
from Course;
```



```
mysql> select subjectId as "Subject ID" from Course;
+------------+
| Subject ID |
+------------+
| CSCI       |
| CSCI       |
| CSCI       |
| CSCI       |
| EDUC       |
| ITEC       |
| MATH       |
| MATH       |
+------------+
8 rows in set (0.00 sec)

mysql> _
```

(a)



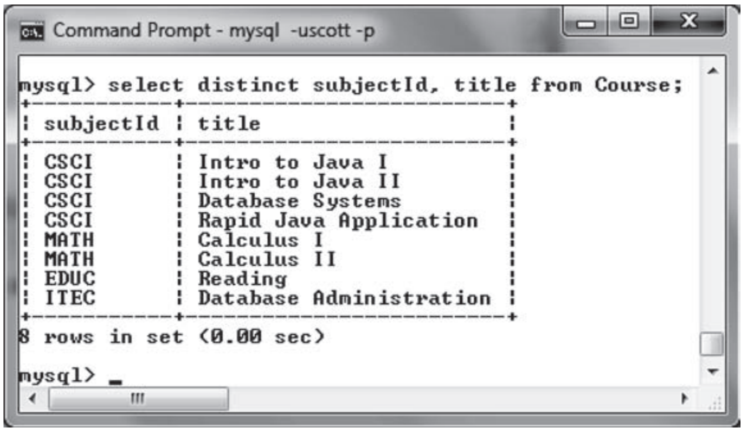
```
mysql> select distinct subjectId as "Subject ID" from Course;
+------------+
| Subject ID |
+------------+
| CSCI       |
| EDUC       |
| ITEC       |
| MATH       |
+------------+
4 rows in set (0.00 sec)

mysql>
```

(b)

FIGURE 34.15 (a) The duplicate tuples are displayed. (b) The distinct tuples are displayed.

When there is more than one column in the select clause, the distinct keyword applies to the whole tuple in the result. For example, the following statement displays all tuples with distinct subjectId and title, as shown in Figure 34.16. Note some tuples may have the same subjectId but different title. These tuples are distinct.

```
select distinct subjectId, title
from Course;
```



```
mysql> select distinct subjectId, title from Course;
+-----------+----------------------------+
| subjectId | title                      |
+-----------+----------------------------+
| CSCI      | Intro to Java I            |
| CSCI      | Intro to Java II           |
| CSCI      | Database Systems           |
| CSCI      | Rapid Java Application     |
| MATH      | Calculus I                 |
| MATH      | Calculus II                |
| EDUC      | Reading                    |
| ITEC      | Database Administration    |
+-----------+----------------------------+
8 rows in set (0.00 sec)

mysql> _
```

FIGURE 34.16 The keyword distinct applies to the entire tuple.

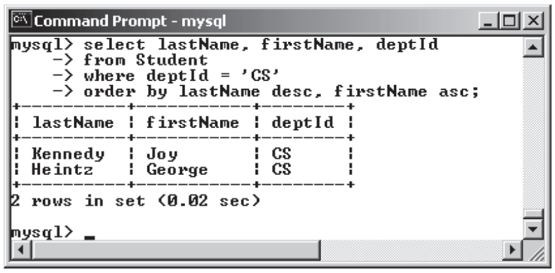
34.3.11 Displaying Sorted Tuples

SQL provides the order by clause to sort the output using the following syntax:

```
select column-list
from table-list
[where condition]
[order by columns-to-be-sorted];
```

In the syntax, columns-to-be-sorted specifies a column or a list of columns to be sorted. By default, the order is ascending. To sort in a descending order, append the desc keyword. You could also append the asc keyword after columns-to-be-sorted, but it is not necessary. When multiple columns are specified, the rows are sorted based on the first column, then the rows with the same values on the first column are sorted based on the second column, and so on.

Query 6: List the full names of the students in the CS department, ordered primarily on their last names in descending order and secondarily on their first names in ascending order. The query result is shown in Figure 34.17.



```
mysql> select lastName, firstName, deptId
    -> from Student
    -> where deptId = 'CS'
    -> order by lastName desc, firstName asc;
+----------+-----------+--------+
| lastName | firstName | deptId |
+----------+-----------+--------+
| Kennedy  | Joy       | CS     |
| Heintz   | George    | CS     |
+----------+-----------+--------+
2 rows in set (0.02 sec)

mysql> _
```

FIGURE 34.17 You can sort results using the order by clause.

```
select lastName, firstName, deptId
from Student
where deptId = 'CS'
order by lastName desc, firstName asc;
```

34.3.12 Joining Tables

Often you need to get information from multiple tables, as demonstrated in the next query.

Query 7: List the courses taken by the student Jacob Smith. To solve this query, you need to join tables `Student` and `Enrollment`, as shown in Figure 34.18.

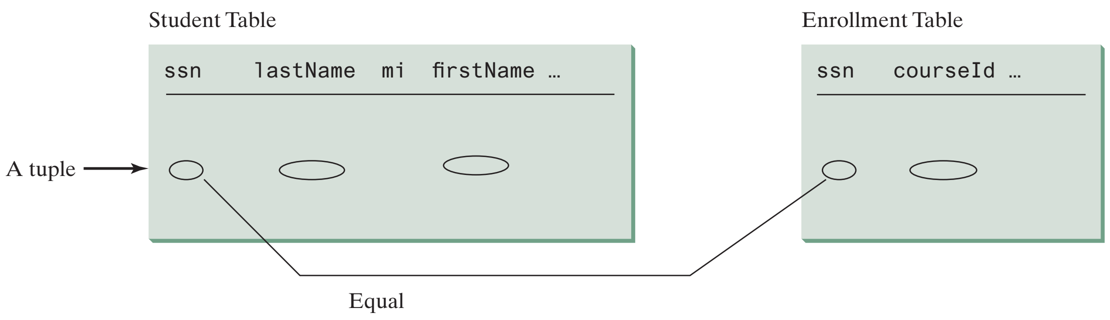
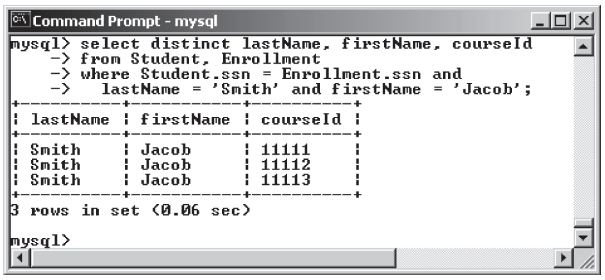


FIGURE 34.18 `Student` and `Enrollment` are joined on `ssn`.

You can write the query in SQL as follows:

```
select distinct lastName, firstName, courseId
from Student, Enrollment
where Student.ssn = Enrollment.ssn and
  lastName = 'Smith' and firstName = 'Jacob';
```

The tables `Student` and `Enrollment` are listed in the `from` clause. The query examines every pair of rows, each made of one item from `Student` and another from `Enrollment` and selects the pairs that satisfy the condition in the `where` clause. The rows in `Student` have the last name, Smith, and the first name, Jacob, and both rows from `Student` and `Enrollment` have the same `ssn` values. For each pair selected, `lastName` and `firstName` from `Student` and `courseId` from `Enrollment` are used to produce the result, as shown in Figure 34.19. `Student` and `Enrollment` have the same attribute `ssn`. To distinguish them in a query, use `Student.ssn` and `Enrollment.ssn`.



```
mysql> select distinct lastName, firstName, courseId
    -> from Student, Enrollment
    -> where Student.ssn = Enrollment.ssn and
    ->   lastName = 'Smith' and firstName = 'Jacob';
+----------+-----------+----------+
| lastName | firstName | courseId |
+----------+-----------+----------+
| Smith    | Jacob     | 11111    |
| Smith    | Jacob     | 11112    |
| Smith    | Jacob     | 11113    |
+----------+-----------+----------+
3 rows in set (0.06 sec)

mysql>
```

FIGURE 34.19 Query 7 demonstrates queries involving multiple tables.

For more features of SQL, see Supplements IV.H and IV.I.

Check Point

34.3.1 Create the tables `Course`, `Student`, and `Enrollment` using the `create table` statements in Section 34.3.3, Creating and Dropping Tables. Insert rows into the `Course`, `Student`, and `Enrollment` tables using the data in Figures 34.3–34.5.

34.3.2 List all CSCI courses with at least four credit hours.

34.3.3 List all students whose last names contain the letter *e* two times.

34.3.4 List all students whose birthdays are null.

34.3.5 List all students who take Math courses.

34.3.6 List the number of courses in each subject.

34.3.7 Assume each credit hour is 50 minutes of lectures. Get the total minutes for the courses that each student takes.

34.4 JDBC

Key Point

JDBC is the Java API for accessing relational database.

The Java API for developing Java database applications is called *JDBC*. JDBC is the trademarked name of a Java API that supports Java programs that access relational databases. JDBC is not an acronym, but it is often thought to stand for Java Database Connectivity.

JDBC provides Java programmers with a uniform interface for accessing and manipulating relational databases. Using the JDBC API, applications written in the Java programming language can execute SQL statements, retrieve results, present data in a user-friendly interface, and propagate changes back to the database. The JDBC API can also be used to interact with multiple data sources in a distributed, heterogeneous environment.

The relationships among Java programs, JDBC API, JDBC drivers, and relational databases are shown in Figure 34.20. The JDBC API is a set of Java interfaces and classes used to write Java programs for accessing and manipulating relational databases. Since a JDBC driver serves as the interface to facilitate communications between JDBC and a proprietary database, JDBC drivers are database specific and are normally provided by the database vendors. You need

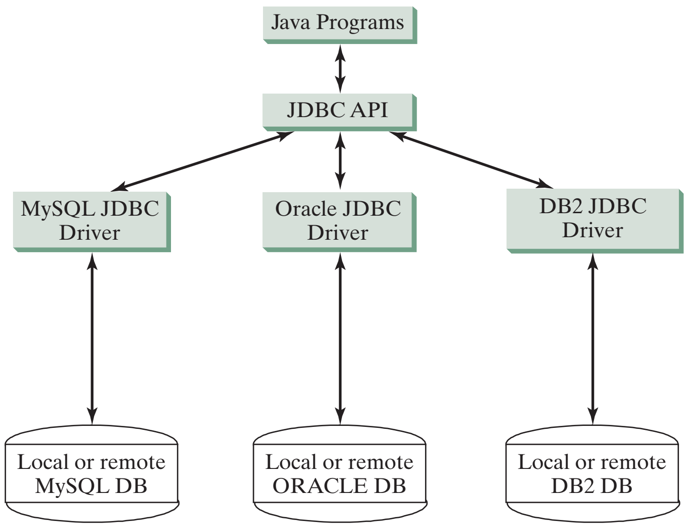


FIGURE 34.20 Java programs access and manipulate databases through JDBC drivers.

MySQL JDBC drivers to access the MySQL database, Oracle JDBC drivers to access the Oracle database, and DB2 JDBC driver to access the DB2 database.

34.4.1 Developing Database Applications Using JDBC

The JDBC API is a Java application program interface to generic SQL databases that enables Java developers to develop DBMS-independent Java applications using a uniform interface.

The JDBC API consists of classes and interfaces for establishing connections with databases, sending SQL statements to databases, processing the results of SQL statements, and obtaining database metadata. Four key interfaces are needed to develop any database application using Java: `Driver`, `Connection`, `Statement`, and `ResultSet`. These interfaces define a framework for generic SQL database access. The JDBC API defines these interfaces, and the JDBC driver vendors provide the implementation for the interfaces. Programmers use these interfaces.

The relationship of these interfaces is shown in Figure 34.21. A JDBC application loads an appropriate driver using the `Driver` interface, connects to the database using the `Connection` interface, creates and executes SQL statements using the `Statement` interface, and processes the result using the `ResultSet` interface if the statements return results. Note some statements, such as SQL data definition statements and SQL data modification statements, do not return results.

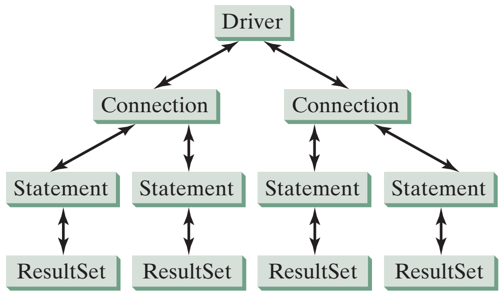


FIGURE 34.21 JDBC classes enable Java programs to connect to the database, send SQL statements, and process results.

The JDBC interfaces and classes are the building blocks in the development of Java database programs. A typical Java program takes the following steps to access a database.

1. Loading drivers.

An appropriate driver must be loaded using the statement shown below before connecting to a database.

```
Class.forName("JDBCDriverClass");
```

A driver is a concrete class that implements the `java.sql.Driver` interface. The drivers for MySQL, Oracle, and Java DB are listed in Table 34.3. If your program accesses several different databases, all their respective drivers must be loaded.

mysql-connector-java-5.1.26.jar
ojdbc6.jar

The most recent platform independent version of MySQL JDBC driver is **mysql-connector-java-5.1.26.jar.** This file is contained in a ZIP file downloadable from dev.mysql.com/downloads/connector/j/. The most recent version of Oracle JDBC driver is **ojdbc6.jar** (downloadable from www.oracle.com/technetwork/database/enterprise-edition/jdbc-112010-090769.html).

Table 34.3 JDBC Drivers

Database	*Driver Class*	*Source*
MySQL	`com.mysql.jdbc.Driver`	**mysql-connector-java-5.1.26.jar**
Oracle	`oracle.jdbc.driver.OracleDriver`	**ojdbc6.jar**
Java DB (embedded)	`org.apache.derby.jdbc.EmbeddedDriver`	**derby.jar**
Java DB (network)	`org.apache.derby.jdbc.ClientDriver`	**derbynet.jar**

Java DB has two versions: embedded and networked. Embedded version is used when you access Java DB locally, while the network version enables you to access Java DB on the network. To use these drivers, you have to add their jar files in the classpath using the following DOS command on Windows:

```
set classpath=%classpath%;c:\book\lib\mysql-connector-java-5.1.26.
jar;c:\book\lib\ojdbc6.jar;c:\program files\jdk1.8.0\db\lib\derby.
jar
```

If you use an IDE such as Eclipse or NetBeans, you need to add these jar files into the library in the IDE.

Note

`com.mysql.jdbc.Driver` is a class in `mysql-connector-java-5.1.26.jar`, and `oracle.jdbc.driver.OracleDriver` is a class in `ojdbc6.jar`. `mysql-connector-java-5.1.26.jar`, `ojdbc6.jar`, and `derby.jar` contains many classes to support the driver. These classes are used by JDBC but not directly by JDBC programmers. When you use a class explicitly in the program, it is automatically loaded by the JVM. The driver classes, however, are not used explicitly in the program, so you have to write the code to tell the JVM to load them.

why load a driver?

Note

Java supports automatic driver discovery, so you don't have to load the driver explicitly. At the time of this writing, however, this feature is not supported for all database drivers. To be safe, load the driver explicitly.

automatic driver discovery

2. Establishing connections.

To connect to a database, use the static method `getConnection(databaseURL)` in the `DriverManager` class, as follows:

```
Connection connection = DriverManager.getConnection(databaseURL);
```

where `databaseURL` is the unique identifier of the database on the Internet. Table 34.4 lists the URL patterns for the MySQL, Oracle, and Java DB.

Table 34.4 JDBC URLs

Database	*URL Pattern*
MySQL	`jdbc:mysql://hostname/dbname`
Oracle	`jdbc:oracle:thin:@hostname:port#:oracleDBSID`
Java DB (embedded)	`jdbc:derby:dbname`
Java DB (network)	`jdbc:derby://hostname/dbname`

The databaseURL for a MySQL database specifies the host name and database name to locate a database. For example, the following statement creates a Connection object for the local MySQL database javabook with username *scott* and password *tiger*:

connect MySQL DB

```
Connection connection = DriverManager.getConnection
  ("jdbc:mysql://localhost/javabook", "scott", "tiger");
```

Recall that by default, MySQL contains two databases named *mysql* and *test*. Section 34.3.2, Creating a Database, created a custom database named javabook. We will use javabook in the examples.

The databaseURL for an Oracle database specifies the *hostname*, the *port#* where the database listens for incoming connection requests, and the *oracleDBSID* database name to locate a database. For example, the following statement creates a Connection object for the Oracle database on liang.armstrong.edu with the username *scott* and password *tiger*:

connect Oracle DB

```
Connection connection = DriverManager.getConnection
  ("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl",
   "scott", "tiger");
```

3. Creating statements.

If a Connection object can be envisioned as a cable linking your program to a database, an object of Statement can be viewed as a cart that delivers SQL statements for execution by the database and brings the result back to the program. Once a Connection object is created, you can create statements for executing SQL statements as follows:

```
Statement statement = connection.createStatement();
```

4. Executing statements.

SQL data definition language (DDL) and update statements can be executed using executeUpdate(String sql), and an SQL query statement can be executed using executeQuery(String sql). The result of the query is returned in ResultSet. For example, the following code executes the SQL statement create table Temp (col1 char(5), col2 char(5)):

```
statement.executeUpdate
  ("create table Temp (col1 char(5), col2 char(5))");
```

This next code executes the SQL query select firstName, mi, lastName from Student where lastName = 'Smith':

```
// Select the columns from the Student table
ResultSet resultSet = statement.executeQuery
  ("select firstName, mi, lastName from Student where lastName "
    + " = 'Smith'");
```

5. Processing ResultSet.

The ResultSet maintains a table whose current row can be retrieved. The initial row position is null. You can use the next method to move to the next row and the various getter methods to retrieve values from a current row. For example, the following code displays all the results from the preceding SQL query:

```
// Iterate through the result and print the student names
while (resultSet.next())
  System.out.println(resultSet.getString(1) + " " +
    resultSet.getString(2) + " " + resultSet.getString(3));
```

The getString(1), getString(2), and getString(3) methods retrieve the column values for firstName, mi, and lastName, respectively. Alternatively, you can use getString("firstName"), getString("mi"), and getString("lastName") to retrieve the same three column values. The first execution of the next() method sets the current row to the first row in the result set, and subsequent invocations of the next() method set the current row to the second row, third row, and so on, to the last row.

Listing 34.1 is a complete example that demonstrates connecting to a database, executing a simple query, and processing the query result with JDBC. The program connects to a local MySQL database and displays the students whose last name is Smith.

Listing 34.1 SimpleJdbc.java

```java
 1  import java.sql.*;
 2
 3  public class SimpleJdbc {
 4    public static void main(String[] args)
 5        throws SQLException, ClassNotFoundException {
 6      // Load the JDBC driver
 7      Class.forName("com.mysql.jdbc.Driver");
 8      System.out.println("Driver loaded");
 9
10      // Connect to a database
11      Connection connection = DriverManager.getConnection
12        ("jdbc:mysql://localhost/javabook", "scott", "tiger");
13      System.out.println("Database connected");
14
15      // Create a statement
16      Statement statement = connection.createStatement();
17
18      // Execute a statement
19      ResultSet resultSet = statement.executeQuery
20        ("select firstName, mi, lastName from Student where lastName "
21        + " = 'Smith'");
22
23      // Iterate through the result and print the student names
24      while (resultSet.next())
25        System.out.println(resultSet.getString(1) + "\t" +
26          resultSet.getString(2) + "\t" + resultSet.getString(3));
27
28      // Close the connection
29      connection.close();
30    }
31  }
```

load driver

connect database

create statement

execute statement

get result

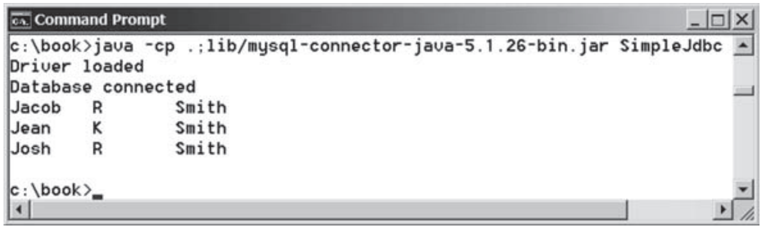
close connection

The statement in line 7 loads a JDBC driver for MySQL, and the statement in lines 11–13 connects to a local MySQL database. You can change them to connect to an Oracle or other databases. The program creates a Statement object (line 16), executes an SQL statement and returns a ResultSet object (lines 19–21), and retrieves the query result from the ResultSet object (lines 24–26). The last statement (line 29) closes the connection and releases resources related to the connection. You can rewrite this program using the try-with-resources syntax. See www.cs.armstrong.edu/liang/intro11e/html/SimpleJdbcWithAutoClose.html.

Note

If you run this program from the DOS prompt, specify the appropriate driver in the classpath, as shown in Figure 34.22.

run from DOS prompt



```
c:\book>java -cp .;lib/mysql-connector-java-5.1.26-bin.jar SimpleJdbc
Driver loaded
Database connected
Jacob   R       Smith
Jean    K       Smith
Josh    R       Smith

c:\book>
```

FIGURE 34.22 You must include the driver file to run Java database programs.

The classpath directory and jar files are separated by commas. The period (`.`) represents the current directory. For convenience, the driver files are placed under the **lib** directory.

the semicolon issue

Caution

Do not use a semicolon (`;`) to end the Oracle SQL command in a Java program. The semicolon may not work with the Oracle JDBC drivers. It does work, however, with the other drivers used in this book.

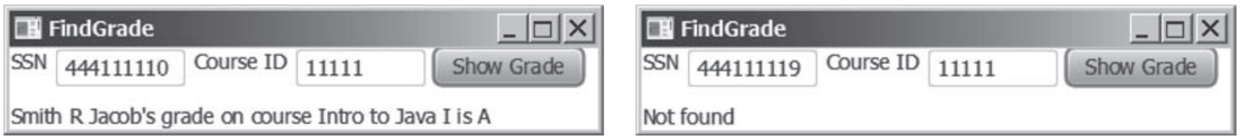
autocommit

Note

The `Connection` interface handles transactions and specifies how they are processed. By default, a new connection is in autocommit mode, and all its SQL statements are executed and committed as individual transactions. The commit occurs when the statement completes or the next execute occurs, whichever comes first. In the case of statements returning a result set, the statement completes when the last row of the result set has been retrieved or the result set has been closed. If a single statement returns multiple results, the commit occurs when all the results have been retrieved. You can use the `setAutoCommit(false)` method to disable autocommit, so all SQL statements are grouped into one transaction that is terminated by a call to either the `commit()` or the `rollback()` method. The `rollback()` method undoes all the changes made by the transaction.

34.4.2 Accessing a Database from JavaFX

This section gives an example that demonstrates connecting to a database from a JavaFX program. The program lets the user enter the SSN and the course ID to find a student's grade, as shown in Figure 34.23. The code in Listing 34.2 uses the MySQL database on the localhost.



Smith R Jacob's grade on course Intro to Java I is A

Not found

FIGURE 34.23 A JavaFX client can access the database on the server.

LISTING 34.2 FindGrade.java

```java
import javafx.application.Application;
import javafx.scene.Scene;
import javafx.scene.control.Button;
import javafx.scene.control.Label;
import javafx.scene.control.TextField;
import javafx.scene.layout.HBox;
import javafx.scene.layout.VBox;
import javafx.stage.Stage;
import java.sql.*;
```

```

public class FindGrade extends Application {
  // Statement for executing queries
  private Statement stmt;
  private TextField tfSSN = new TextField();
  private TextField tfCourseId = new TextField();
  private Label lblStatus = new Label();

  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Initialize database connection and create a Statement object
    initializeDB();

    Button btShowGrade = new Button("Show Grade");
    HBox hBox = new HBox(5);
    hBox.getChildren().addAll(new Label("SSN"), tfSSN,
      new Label("Course ID"), tfCourseId, (btShowGrade));

    VBox vBox = new VBox(10);
    vBox.getChildren().addAll(hBox, lblStatus);

    tfSSN.setPrefColumnCount(6);
    tfCourseId.setPrefColumnCount(6);
    btShowGrade.setOnAction(e -> showGrade());                  button listener

    // Create a scene and place it in the stage
    Scene scene = new Scene(vBox, 420, 80);
    primaryStage.setTitle("FindGrade"); // Set the stage title
    primaryStage.setScene(scene); // Place the scene in the stage
    primaryStage.show(); // Display the stage
  }

  private void initializeDB() {
    try {
      // Load the JDBC driver
      Class.forName("com.mysql.jdbc.Driver");                   load driver
//      Class.forName("oracle.jdbc.driver.OracleDriver");       Oracle driver commented
      System.out.println("Driver loaded");

      // Establish a connection
      Connection connection = DriverManager.getConnection       connect to MySQL database
        ("jdbc:mysql://localhost/javabook", "scott", "tiger");
//    ("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl",       connect to Oracle commented
//     "scott", "tiger");
      System.out.println("Database connected");

      // Create a statement
      stmt = connection.createStatement();                      execute statement
    }
    catch (Exception ex) {
      ex.printStackTrace();
    }
  }

  private void showGrade() {                                    show result
    String ssn = tfSSN.getText();
    String courseId = tfCourseId.getText();
    try {
      String queryString = "select firstName, mi, " +
        "lastName, title, grade from Student, Enrollment, Course " +   create statement
70            "where Student.ssn = '" + ssn + "' and Enrollment.courseId "
71            + "= '" + courseId +
72            "' and Enrollment.courseId = Course.courseId " +
73            " and Enrollment.ssn = Student.ssn";
74 
75          ResultSet rset = stmt.executeQuery(queryString);
76 
77          if (rset.next()) {
78            String lastName = rset.getString(1);
79            String mi = rset.getString(2);
80            String firstName = rset.getString(3);
81            String title = rset.getString(4);
82            String grade = rset.getString(5);
83 
84            // Display result in a label
85            lblStatus.setText(firstName + " " + mi +
86              " " + lastName + "'s grade on course " + title + " is " +
87              grade);
88          } else {
89            lblStatus.setText("Not found");
90          }
91        }
92        catch (SQLException ex) {
93          ex.printStackTrace();
94        }
95      }
96    }
```

The `initializeDB()` method (lines 42–62) loads the MySQL driver (line 45), connects to the MySQL database on host `liang.armstrong.edu` (lines 50–55), and creates a statement (line 57).

security hole

Note

There is a *security hole* in this program. If you enter `1' or true or '1` in the `SSN` field, you will get the first student's score, because the query string now becomes

```
select firstName, mi, lastName, title, grade
from Student, Enrollment, Course
where Student.ssn = '1' or true or '1' and
      Enrollment.courseId = ' ' and
      Enrollment.courseId = Course.courseId and
      Enrollment.ssn = Student.ssn;
```

You can avoid this problem by using the `PreparedStatement` interface, which will be discussed in the next section.

Check Point

34.4.1 What are the advantages of developing database applications using Java?

34.4.2 Describe the following JDBC interfaces: `Driver`, `Connection`, `Statement`, and `ResultSet`.

34.4.3 How do you load a JDBC driver? What are the driver classes for MySQL, Oracle, and Java DB?

34.4.4 How do you create a database connection? What are the URLs for MySQL, Oracle, and Java DB?

34.4.5 How do you create a `Statement` and execute an SQL statement?

34.4.6 How do you retrieve values in a `ResultSet`?

34.4.7 Does JDBC automatically commit a transaction? How do you set autocommit to false?

34.5 PreparedStatement

`PreparedStatement` enables you to create parameterized SQL statements.

Once a connection to a particular database is established, it can be used to send SQL statements from your program to the database. The `Statement` interface is used to execute static SQL statements that don't contain any parameters. The `PreparedStatement` interface, extending `Statement`, is used to execute a precompiled SQL statement with or without parameters. Since the SQL statements are precompiled, they are efficient for repeated executions.

A `PreparedStatement` object is created using the `prepareStatement` method in the `Connection` interface. For example, the following code creates a `PreparedStatement` for an SQL `insert` statement:

```
PreparedStatement preparedStatement = connection.prepareStatement
  ("insert into Student (firstName, mi, lastName) " +
   "values (?, ?, ?)");
```

This `insert` statement has three question marks as placeholders for parameters representing values for `firstName`, `mi`, and `lastName` in a record of the `Student` table.

As a subinterface of `Statement`, the `PreparedStatement` interface inherits all the methods defined in `Statement`. It also provides the methods for setting parameters in the object of `PreparedStatement`. These methods are used to set the values for the parameters before executing statements or procedures. In general, the setter methods have the following name and signature:

```
setX(int parameterIndex, X value);
```

where *X* is the type of the parameter, and `parameterIndex` is the index of the parameter in the statement. The index starts from `1`. For example, the method `setString(int parameterIndex, String value)` sets a `String` value to the specified parameter.

The following statements pass the parameters `"Jack"`, `"A"`, and `"Ryan"` to the placeholders for `firstName`, `mi`, and `lastName` in `preparedStatement`:

```
preparedStatement.setString(1, "Jack");
preparedStatement.setString(2, "A");
preparedStatement.setString(3, "Ryan");
```

After setting the parameters, you can execute the prepared statement by invoking `executeQuery()` for a SELECT statement and `executeUpdate()` for a DDL or update statement.

The `executeQuery()` and `executeUpdate()` methods are similar to the ones defined in the `Statement` interface except that they don't have any parameters, because the SQL statements are already specified in the `prepareStatement` method when the object of `PreparedStatement` is created.

Using a prepared SQL statement, Listing 34.2 can be improved as in Listing 34.3.

Listing 34.3 FindGradeUsingPreparedStatement.java

```
import javafx.application.Application;
import javafx.scene.Scene;
import javafx.scene.control.Button;
import javafx.scene.control.Label;
import javafx.scene.control.TextField;
import javafx.scene.layout.HBox;
import javafx.scene.layout.VBox;
import javafx.stage.Stage;
import java.sql.*;

```

```
public class FindGradeUsingPreparedStatement extends Application {
  // PreparedStatement for executing queries
  private PreparedStatement preparedStatement;
  private TextField tfSSN = new TextField();
  private TextField tfCourseId = new TextField();
  private Label lblStatus = new Label();

  @Override // Override the start method in the Application class
  public void start(Stage primaryStage) {
    // Initialize database connection and create a Statement object
    initializeDB();

    Button btShowGrade = new Button("Show Grade");
    HBox hBox = new HBox(5);
    hBox.getChildren().addAll(new Label("SSN"), tfSSN,
      new Label("Course ID"), tfCourseId, (btShowGrade));

    VBox vBox = new VBox(10);
    vBox.getChildren().addAll(hBox, lblStatus);

    tfSSN.setPrefColumnCount(6);
    tfCourseId.setPrefColumnCount(6);
    btShowGrade.setOnAction(e -> showGrade());

```

prepare statement

```
    // Create a scene and place it in the stage
    Scene scene = new Scene(vBox, 420, 80);
    primaryStage.setTitle("FindGrade"); // Set the stage title
    primaryStage.setScene(scene); // Place the scene in the stage
    primaryStage.show(); // Display the stage
  }

  private void initializeDB() {
    try {
      // Load the JDBC driver
```

load driver

```
      Class.forName("com.mysql.jdbc.Driver");
//      Class.forName("oracle.jdbc.driver.OracleDriver");
      System.out.println("Driver loaded");

      // Establish a connection
```

connect database

```
      Connection connection = DriverManager.getConnection
        ("jdbc:mysql://localhost/javabook", "scott", "tiger");
//    ("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl",
//     "scott", "tiger");
      System.out.println("Database connected");

      String queryString = "select firstName, mi, " +
        "lastName, title, grade from Student, Enrollment, Course " +
```

placeholder

```
        "where Student.ssn = ? and Enrollment.courseId = ? " +
        "and Enrollment.courseId = Course.courseId";

      // Create a statement
      preparedStatement = connection.prepareStatement(queryString);
    }
    catch (Exception ex) {
      ex.printStackTrace();
    }
  }

  private void showGrade() {
    String ssn = tfSSN.getText();
```

```
71      String courseId = tfCourseId.getText();
72      try {
73        preparedStatement.setString(1, ssn);
74        preparedStatement.setString(2, courseId);
75        ResultSet rset = preparedStatement.executeQuery();
76
77        if (rset.next()) {
78          String lastName = rset.getString(1);
79          String mi = rset.getString(2);
80          String firstName = rset.getString(3);
81          String title = rset.getString(4);
82          String grade = rset.getString(5);
83
84          // Display result in a label
85          lblStatus.setText(firstName + " " + mi +
86            " " + lastName + "'s grade on course " + title + " is " +
87            grade);
88        } else {
89          lblStatus.setText("Not found");
90        }
91      }
92      catch (SQLException ex) {
93        ex.printStackTrace();
94      }
95    }
96  }
```

execute statement

show result

This example does exactly the same thing as Listing 34.2 except that it uses the prepared statement to dynamically set the parameters. The code in this example is almost the same as in the preceding example. The new code is highlighted.

A prepared query string is defined in lines 56–59 with `ssn` and `courseId` as parameters. An SQL prepared statement is obtained in line 62. Before executing the query, the actual values of `ssn` and `courseId` are set to the parameters in lines 73–74. Line 75 executes the prepared statement.

Check Point

34.5.1 Describe prepared statements. How do you create instances of `PreparedStatement`? How do you execute a `PreparedStatement`? How do you set parameter values in a `PreparedStatement`?

34.5.2 What are the benefits of using prepared statements?

34.6 CallableStatement

Key Point

`CallableStatement` enables you to execute SQL stored procedures.

The `CallableStatement` interface is designed to execute SQL-stored procedures. The procedures may have `IN`, `OUT`, or `IN OUT` parameters. An `IN` parameter receives a value passed to the procedure when it is called. An `OUT` parameter returns a value after the procedure is completed, but it doesn't contain any value when the procedure is called. An `IN OUT` parameter contains a value passed to the procedure when it is called and returns a value after it is completed. For example, the following procedure in Oracle PL/SQL has `IN` parameter `p1`, `OUT` parameter `p2`, and `IN OUT` parameter `p3`:

IN parameter
OUT parameter
IN OUT parameter

```
create or replace procedure sampleProcedure
  (p1 in varchar, p2 out number, p3 in out integer) is
begin
  /* do something */
end sampleProcedure;
/
```

Note
The syntax of stored procedures is vendor specific. We use both Oracle and MySQL for demonstrations of stored procedures in this book.

A CallableStatement object can be created using the prepareCall(String call) method in the Connection interface. For example, the following code creates a CallableStatement cstmt on Connection connection for the procedure sampleProcedure:

```
CallableStatement callableStatement = connection.prepareCall(
  "{call sampleProcedure(?, ?, ?)}");
```

{call sampleProcedure(?, ?, ...)} is referred to as the *SQL escape syntax*, which signals the driver that the code within it should be handled differently. The driver parses the escape syntax and translates it into code that the database understands. In this example, sampleProcedure is an Oracle procedure. The call is translated to the string begin sampleProcedure(?, ?, ?); end and passed to an Oracle database for execution.

You can call procedures as well as functions. The syntax to create an SQL callable statement for a function is:

```
{? = call functionName(?, ?, ...)}
```

CallableStatement inherits PreparedStatement. Additionally, the CallableStatement interface provides methods for registering the OUT parameters and for getting values from the OUT parameters.

Before calling an SQL procedure, you need to use appropriate setter methods to pass values to IN and IN OUT parameters, and use registerOutParameter to register OUT and IN OUT parameters. For example, before calling procedure sampleProcedure, the following statements pass values to parameters p1 (IN) and p3 (IN OUT) and register parameters p2 (OUT) and p3 (IN OUT):

```
callableStatement.setString(1, "Dallas"); // Set Dallas to p1
callableStatement.setLong(3, 1); // Set 1 to p3
// Register OUT parameters
callableStatement.registerOutParameter(2, java.sql.Types.DOUBLE);
callableStatement.registerOutParameter(3, java.sql.Types.INTEGER);
```

You can use execute() or executeUpdate() to execute the procedure depending on the type of SQL statement, then use getter methods to retrieve values from the OUT parameters. For example, the next statements retrieve the values from parameters p2 and p3:

```
double d = callableStatement.getDouble(2);
int i = callableStatement.getInt(3);
```

Let us define a MySQL function that returns the number of the records in the table that match the specified firstName and lastName in the Student table.

```
/* For the callable statement example. Use MySQL version 5 */
drop function if exists studentFound;

delimiter //

create function studentFound(first varchar(20), last varchar(20))
  returns int
begin
  declare result int;

  select count(*) into result
```

```
    from Student
    where Student.firstName = first and
      Student.lastName = last;

    return result;
  end;
  //

  delimiter ;
  /* Please note that there is a space between delimiter and ; */
```

If you use an Oracle database, the function can be defined as follows:

```
  create or replace function studentFound
    (first varchar2, last varchar2)
    /* Do not name firstName and lastName. */
    return number is numberOfSelectedRows number := 0;
  begin
    select count(*) into numberOfSelectedRows
    from Student
    where Student.firstName = first and
      Student.lastName = last;

    return numberOfSelectedRows;
  end studentFound;
  /
```

Suppose the function studentFound is already created in the database. Listing 34.4 gives an example that tests this function using callable statements.

LISTING 34.4 TestCallableStatement.java

```
import java.sql.*;

public class TestCallableStatement {
  /** Creates new form TestTableEditor */
  public static void main(String[] args) throws Exception {
    Class.forName("com.mysql.jdbc.Driver");                          load driver
    Connection connection = DriverManager.getConnection(              connect database
      "jdbc:mysql://localhost/javabook",
      "scott", "tiger");
//    Connection connection = DriverManager.getConnection(
//      ("jdbc:oracle:thin:@liang.armstrong.edu:1521:orcl",
//      "scott", "tiger");

    // Create a callable statement
    CallableStatement callableStatement = connection.prepareCall(    create callable statement
      "{? = call studentFound(?, ?)}");

    java.util.Scanner input = new java.util.Scanner(System.in);
    System.out.print("Enter student's first name: ");
    String firstName = input.nextLine();                              enter firstName
    System.out.print("Enter student's last name: ");
    String lastName = input.nextLine();                               enter lastName

    callableStatement.setString(2, firstName);                        set IN parameter
    callableStatement.setString(3, lastName);                         set IN parameter
    callableStatement.registerOutParameter(1, Types.INTEGER);         register OUT parameter
    callableStatement.execute();                                      execute statement
```

get OUT parameter

```
28
29      if (callableStatement.getInt(1) >= 1)
30        System.out.println(firstName + " " + lastName +
31          " is in the database");
32      else
33        System.out.println(firstName + " " + lastName +
34          " is not in the database");
35    }
36  }
```

```
Enter student's first name: Jacob ↵Enter
Enter student's last name: Smith ↵Enter
Jacob Smith is in the database
```

```
Enter student's first name: John ↵Enter
Enter student's last name: Smith ↵Enter
John Smith is not in the database
```

The program loads a MySQL driver (line 6), connects to a MySQL database (lines 7–9), and creates a callable statement for executing the function `studentFound` (lines 15–16).

The function's first parameter is the return value; its second and third parameters correspond to the first and last names. Before executing the callable statement, the program sets the first name and last name (lines 24–25) and registers the `OUT` parameter (line 26). The statement is executed in line 27.

The function's return value is obtained in line 29. If the value is greater than or equal to `1`, the student with the specified first and last name is found in the table.

Check Point

34.6.1 Describe callable statements. How do you create instances of `CallableStatement`? How do you execute a `CallableStatement`? How do you register `OUT` parameters in a `CallableStatement`?

34.7 Retrieving Metadata

Key Point

The database metadata such as database URL, username, and JDBC driver name can be obtained using the `DatabaseMetaData` *interface and result set metadata such as table column count and column names can be obtained using the* `ResultSetMetaData` *interface.*

database metadata

JDBC provides the `DatabaseMetaData` interface for obtaining database-wide information, and the `ResultSetMetaData` interface for obtaining information on a specific `ResultSet`.

34.7.1 Database Metadata

The `Connection` interface establishes a connection to a database. It is within the context of a connection that SQL statements are executed and results are returned. A connection also provides access to database metadata information that describes the capabilities of the database, supported SQL grammar, stored procedures, and so on. To obtain an instance of `DatabaseMetaData` for a database, use the `getMetaData` method on a `Connection` object like this:

```
DatabaseMetaData dbMetaData = connection.getMetaData();
```

If your program connects to a local MySQL database, the program in Listing 34.5 displays the database information statements shown in Figure 34.24.

LISTING 34.5 TestDatabaseMetaData.java

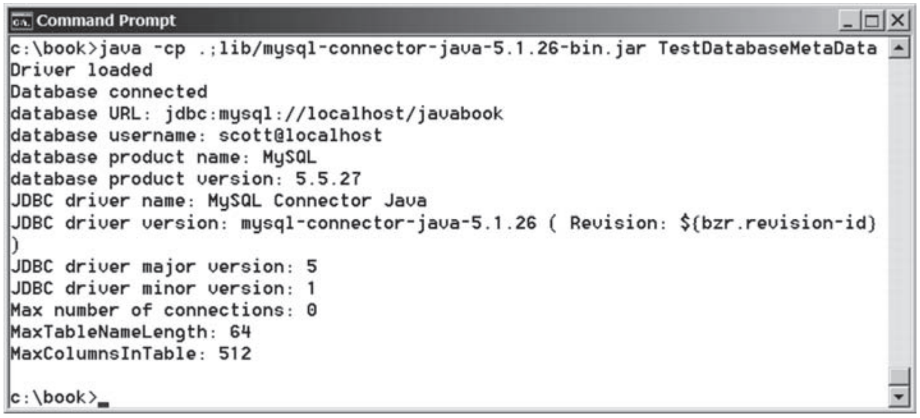
```java
import java.sql.*;

public class TestDatabaseMetaData {
  public static void main(String[] args)
      throws SQLException, ClassNotFoundException {
    // Load the JDBC driver
    Class.forName("com.mysql.jdbc.Driver");
    System.out.println("Driver loaded");

    // Connect to a database
    Connection connection = DriverManager.getConnection
      ("jdbc:mysql://localhost/javabook", "scott", "tiger");
    System.out.println("Database connected");

    DatabaseMetaData dbMetaData = connection.getMetaData();
    System.out.println("database URL: " + dbMetaData.getURL());
    System.out.println("database username: " +
      dbMetaData.getUserName());
    System.out.println("database product name: " +
      dbMetaData.getDatabaseProductName());
    System.out.println("database product version: " +
      dbMetaData.getDatabaseProductVersion());
    System.out.println("JDBC driver name: " +
      dbMetaData.getDriverName());
    System.out.println("JDBC driver version: " +
      dbMetaData.getDriverVersion());
    System.out.println("JDBC driver major version: " +
      dbMetaData.getDriverMajorVersion());
    System.out.println("JDBC driver minor version: " +
      dbMetaData.getDriverMinorVersion());
    System.out.println("Max number of connections: " +
      dbMetaData.getMaxConnections());
    System.out.println("MaxTableNameLength: " +
      dbMetaData.getMaxTableNameLength());
    System.out.println("MaxColumnsInTable: " +
      dbMetaData.getMaxColumnsInTable());

    // Close the connection
    connection.close();
  }
}
```

load driver

connect database

database metadata

get metadata



```
c:\book>java -cp .;lib/mysql-connector-java-5.1.26-bin.jar TestDatabaseMetaData
Driver loaded
Database connected
database URL: jdbc:mysql://localhost/javabook
database username: scott@localhost
database product name: MySQL
database product version: 5.5.27
JDBC driver name: MySQL Connector Java
JDBC driver version: mysql-connector-java-5.1.26 ( Revision: ${bzr.revision-id}
)
JDBC driver major version: 5
JDBC driver minor version: 1
Max number of connections: 0
MaxTableNameLength: 64
MaxColumnsInTable: 512

c:\book>_
```

FIGURE 34.24 The DatabaseMetaData interface enables you to obtain database information.

34.7.2 Obtaining Database Tables

You can identify the tables in the database through database metadata using the `getTables` method. Listing 34.6 displays all the user tables in the javabook database on a local MySQL database. Figure 34.25 shows a sample output of the program.

LISTING 34.6 `FindUserTables.java`

load driver

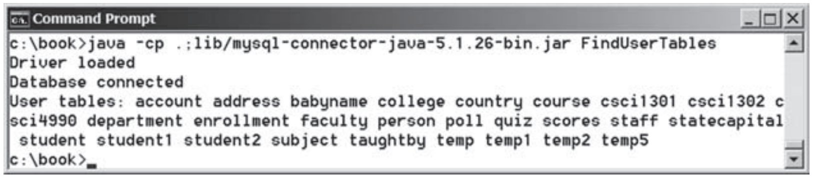
connect database

database metadata

obtain tables

get table names

```java
 1  import java.sql.*;
 2
 3  public class FindUserTables {
 4    public static void main(String[] args)
 5        throws SQLException, ClassNotFoundException {
 6      // Load the JDBC driver
 7      Class.forName("com.mysql.jdbc.Driver");
 8      System.out.println("Driver loaded");
 9
10      // Connect to a database
11      Connection connection = DriverManager.getConnection
12        ("jdbc:mysql://localhost/javabook", "scott", "tiger");
13      System.out.println("Database connected");
14
15      DatabaseMetaData dbMetaData = connection.getMetaData();
16
17      ResultSet rsTables = dbMetaData.getTables(null, null, null,
18        new String[] {"TABLE"});
19      System.out.print("User tables: ");
20      while (rsTables.next())
21        System.out.print(rsTables.getString("TABLE_NAME") + " ");
22
23      // Close the connection
24      connection.close();
25    }
26  }
```



```
c:\book>java -cp .;lib/mysql-connector-java-5.1.26-bin.jar FindUserTables
Driver loaded
Database connected
User tables: account address babyname college country course csci1301 csci1302 c
sci4990 department enrollment faculty person poll quiz scores staff statecapital
 student student1 student2 subject taughtby temp temp1 temp2 temp5
c:\book>_
```

FIGURE 34.25 You can find all the tables in the database.

Line 17 obtains table information in a result set using the `getTables` method. One of the columns in the result set is TABLE_NAME. Line 21 retrieves the table name from this result set column.

34.7.3 Result Set Metadata

The `ResultSetMetaData` interface describes information pertaining to the result set. A `ResultSetMetaData` object can be used to find the types and properties of the columns in a `ResultSet`. To obtain an instance of `ResultSetMetaData`, use the `getMetaData` method on a result set like this:

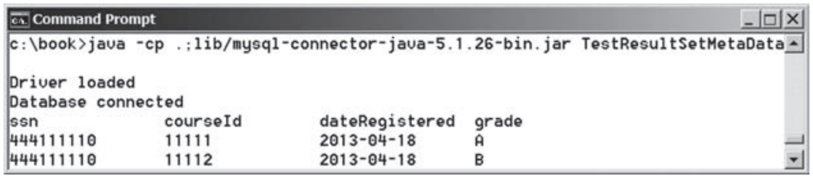
```java
ResultSetMetaData rsMetaData = resultSet.getMetaData();
```

You can use the `getColumnCount()` method to find the number of columns in the result and the `getColumnName(int)` method to get the column names. For example, Listing 34.7 displays all the column names and contents resulting from the SQL SELECT statement *`select * from Enrollment`*. The output is shown in Figure 34.26.

LISTING 34.7 `TestResultSetMetaData.java`

```java
import java.sql.*;

public class TestResultSetMetaData {
  public static void main(String[] args)
      throws SQLException, ClassNotFoundException {
    // Load the JDBC driver
    Class.forName("com.mysql.jdbc.Driver");
    System.out.println("Driver loaded");

    // Connect to a database
    Connection connection = DriverManager.getConnection
      ("jdbc:mysql://localhost/javabook", "scott", "tiger");
    System.out.println("Database connected");

    // Create a statement
    Statement statement = connection.createStatement();

    // Execute a statement
    ResultSet resultSet = statement.executeQuery
      ("select * from Enrollment");

    ResultSetMetaData rsMetaData = resultSet.getMetaData();
    for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
      System.out.printf("%-12s\t", rsMetaData.getColumnName(i));
    System.out.println();

    // Iterate through the result and print the students' names
    while (resultSet.next()) {
      for (int i = 1; i <= rsMetaData.getColumnCount(); i++)
        System.out.printf("%-12s\t", resultSet.getObject(i));
      System.out.println();
    }

    // Close the connection
    connection.close();
  }
}
```

load driver
connect database
create statement
create result set
result set metadata
column count
column name



```
c:\book>java -cp .;lib/mysql-connector-java-5.1.26-bin.jar TestResultSetMetaData

Driver loaded
Database connected
ssn             courseId        dateRegistered  grade
444111110       11111           2013-04-18      A
444111110       11112           2013-04-18      B
```

FIGURE 34.26 The `ResultSetMetaData` interface enables you to obtain result set information.

Check Point

34.7.1 What is DatabaseMetaData for? Describe the methods in DatabaseMetaData. How do you get an instance of DatabaseMetaData?

34.7.2 What is ResultSetMetaData for? Describe the methods in ResultSet-MetaData. How do you get an instance of ResultSetMetaData?

34.7.3 How do you find the number of columns in a result set? How do you find the column names in a result set?

Key Terms

candidate key	34-5	integrity constraint	34-4
database system	34-2	primary key	34-5
domain constraint	34-5	relational database	34-5
foreign key	34-5	Structured Query Language (SQL)	34-6
foreign key constraint	34-5	superkey	34-5

Chapter Summary

1. This chapter introduced the concepts of *database systems*, *relational databases*, *relational data models*, *data integrity*, and *SQL*. You learned how to develop database applications using Java.

2. The Java API for developing Java database applications is called *JDBC*. JDBC provides Java programmers with a uniform interface for accessing and manipulating relational databases.

3. The JDBC API consists of classes and interfaces for establishing connections with databases, sending SQL statements to databases, processing the results of SQL statements, and obtaining database metadata.

4. Since a JDBC driver serves as the interface to facilitate communications between JDBC and a proprietary database, JDBC drivers are database specific. If you use a driver, make sure it is in the classpath before running the program.

5. Four key interfaces are needed to develop any database application using Java: Driver, Connection, Statement, and ResultSet. These interfaces define a framework for generic SQL database access. The JDBC driver vendors provide implementation for them.

6. A JDBC application loads an appropriate driver using the Driver interface, connects to the database using the Connection interface, creates and executes SQL statements using the Statement interface, and processes the result using the ResultSet interface if the statements return results.

7. The PreparedStatement interface is designed to execute dynamic SQL statements with parameters. These SQL statements are precompiled for efficient use when repeatedly executed.

8. Database *metadata* is information that describes the database itself. JDBC provides the DatabaseMetaData interface for obtaining database-wide information and the ResultSetMetaData interface for obtaining information on the specific ResultSet.

Quiz

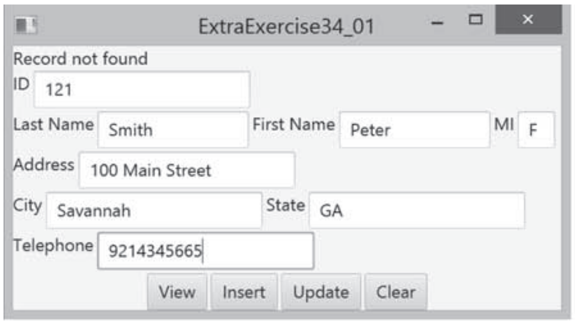
Answer the quiz for this chapter online at the book Companion Website.

Programming Exercises

MyProgrammingLab™

***34.1** (*Access and update a* `Staff` *table*) Write a program that views, inserts, and updates staff information stored in a database, as shown in Figure 34.27a. The *View* button displays a record with a specified ID. The *Insert* button inserts a new record. The *Update* button updates the record for the specified ID. The `Staff` table is created as follows:

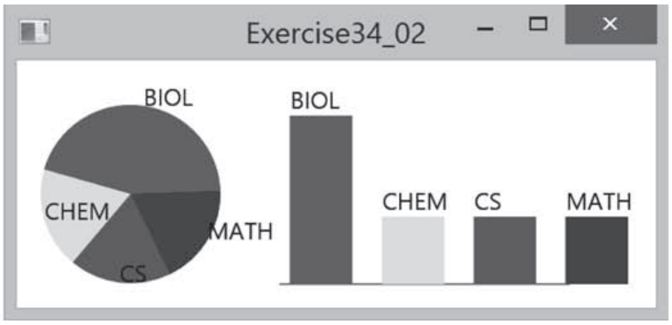
```
create table Staff (
  id char(9) not null,
  lastName varchar(15),
  firstName varchar(15),
  mi char(1),
  address varchar(20),
  city varchar(20),
  state char(2),
  telephone char(10),
  email varchar(40),
  primary key (id)
);
```



Record not found

ID	121
Last Name	Smith
First Name	Peter
MI	F
Address	100 Main Street
City	Savannah
State	GA
Telephone	9214345665

(a)



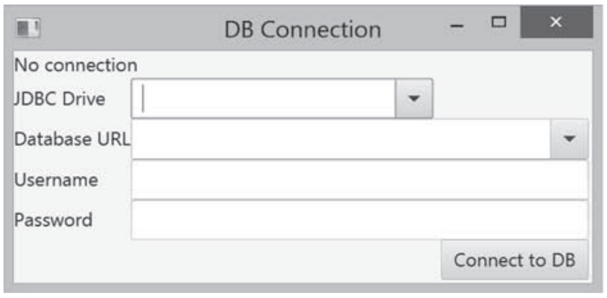
(b)

Figure 34.27 (a) The program lets you view, insert, and update staff information. (b) The `PieChart` and `BarChart` components display the query data obtained from the data module.

****34.2** (*Visualize data*) Write a program that displays the number of students in each department in a pie chart and a bar chart, as shown in Figure 34.27b. The `PieChart` and `BarChart` classes are created in Programming Exercises 14.12 and 14.13. The number of students for each department can be obtained from the `Student` table (see Figure 34.4) using the following SQL statement:

```
select deptId, count(*)
from Student
where deptId is not null
group by deptId;
```

***34.3** (*Connection dialog*) Develop a subclass of `BorderPane` named `DBConnection-Pane` that enables the user to select or enter a JDBC driver and a URL and to enter a username and password, as shown in Figure 34.28. When the *Connect to DB* button is clicked, a `Connection` object for the database is stored in the `connection` property. You can then use the `getConnection()` method to return the connection.



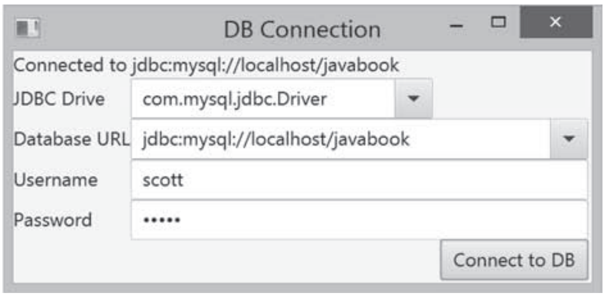
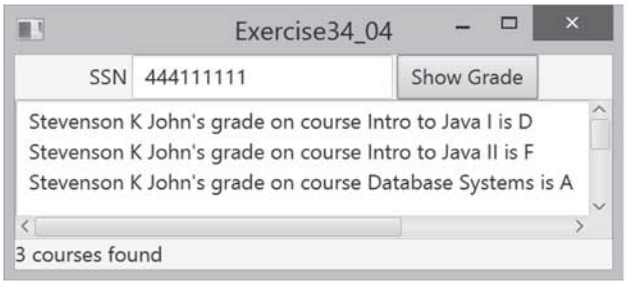
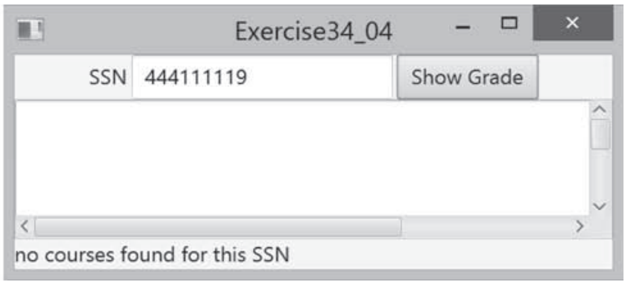


FIGURE 34.28 The `DBConnectionPane` component enables the user to enter database information.

***34.4** (*Find grades*) Listing 34.2, FindGrade.java, presented a program that finds a student's grade for a specified course. Rewrite the program to find all the grades for a specified student, as shown in Figure 34.29.



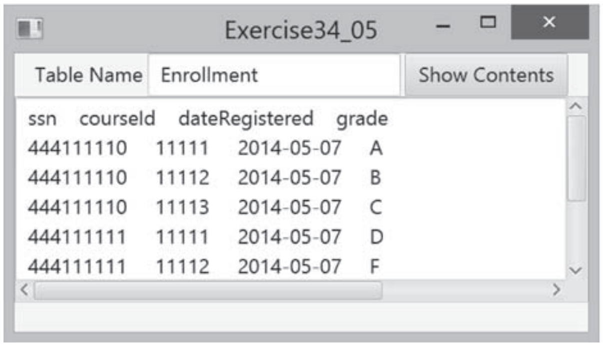
```
Stevenson K John's grade on course Intro to Java I is D
Stevenson K John's grade on course Intro to Java II is F
Stevenson K John's grade on course Database Systems is A
3 courses found
```



```
no courses found for this SSN
```

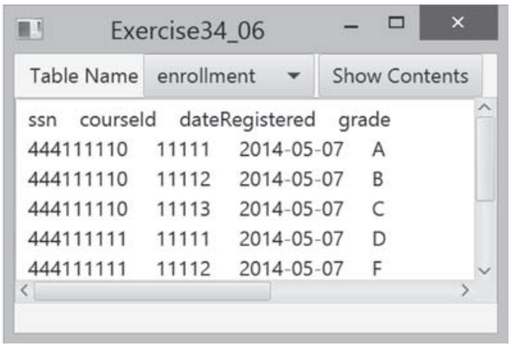
FIGURE 34.29 The program displays the grades for the courses for a specified student.

***34.5** (*Display table contents*) Write a program that displays the content for a given table. As shown in Figure 34.30a, you enter a table and click the *Show Contents* button to display the table contents in the text area.



```
ssn    courseId  dateRegistered  grade
444111110  11111  2014-05-07  A
444111110  11112  2014-05-07  B
444111110  11113  2014-05-07  C
444111111  11111  2014-05-07  D
444111111  11112  2014-05-07  F
```

(a)



```
ssn    courseId  dateRegistered  grade
444111110  11111  2014-05-07  A
444111110  11112  2014-05-07  B
444111110  11113  2014-05-07  C
444111111  11111  2014-05-07  D
444111111  11112  2014-05-07  F
```

(b)

FIGURE 34.30 (a) Enter a table name to display the table contents. (b) Select a table name from the combo box to display its contents.

***34.6** (*Find tables and showing their contents*) Write a program that fills in table names in a combo box, as shown in Figure 34.30b. You can select a table from the combo box to display its contents in the text area.

****34.7** (*Populate Quiz table*) Create a table named `Quiz` as follows:

```
create table Quiz(
  questionId int,
  question varchar(4000),
  choicea varchar(1000),
  choiceb varchar(1000),
  choicec varchar(1000),
  choiced varchar(1000),
  answer varchar(5));
```

The **Quiz** table stores multiple-choice questions. Suppose the multiple-choice questions are stored in a text file accessible from http://www.cs.armstrong.edu/liang/data/Quiz.txt in the following format:

```
1. question1
a. choice a
b. choice b
c. choice c
d. choice d
Answer:cd

2. question2
a. choice a
b. choice b
c. choice c
d. choice d
Answer:a

...
```

Write a program that reads the data from the file and populate it into the **Quiz** table.

***34.8** (*Populate Salary table*) Create a table named **Salary** as follows:

```
create table Salary(
  firstName varchar(100),
  lastName varchar(100),
  rank varchar(15),
  salary float);
```

Obtain the data for salary from http://cs.armstrong.edu/liang/data/Salary.txt and populate it into the **Salary** table in the database.

***34.9** (*Copy table*) Suppose the database contains a student table defined as follows:

```
create table Student1 (
  username varchar(50) not null,
  password varchar(50) not null,
  fullname varchar(200) not null,
  constraint pkStudent primary key (username)
);
```

Create a new table named **Student2** as follows:

```
create table Student2 (
  username varchar(50) not null,
  password varchar(50) not null,
  firstname varchar(100),
  lastname varchar(100),
  constraint pkStudent primary key (username)
);
```

A full name is in the form of **firstname mi lastname** or **firstname lastname**. For example, **John K Smith** is a full name. Write a program that copies table `Student1` into `Student2`. Your task is to split a full name into `firstname`, `mi`, and `lastname` for each record in `Student1` and store a new record into `Student2`.

***34.10** (*Record unsubmitted exercises*) The following three tables store information on students, assigned exercises, and exercise submission in LiveLab. LiveLab is an automatic grading system for grading programming exercises.

```
create table AGSStudent (
  username varchar(50) not null,
  password varchar(50) not null,
  fullname varchar(200) not null,
  instructorEmail varchar(100) not null,
  constraint pkAGSStudent primary key (username)
);

 create table ExerciseAssigned (
  instructorEmail varchar(100),
  exerciseName varchar(100),
  maxscore double default 10,
  constraint pkCustomExercise primary key
    (instructorEmail, exerciseName)
);

create table AGSLog (
  username varchar(50), /* This is the student's user name */
  exerciseName varchar(100), /* This is the exercise */
  score double default null,
  submitted bit default 0,
  constraint pkLog primary key (username, exerciseName)
);
```

The `AGSStudent` table stores the student information. The `ExerciseAssigned` table assigns the exercises by an instructor. The `AGSLog` table stores the grading results. When a student submits an exercise, a record is stored in the `AGSLog` table. However, there is no record in `AGSLog` if a student did not submit the exercise.

Write a program that adds a new record for each student and an assigned exercise to the student in the `AGSLog` table if a student has not submitted the exercise. The record should have `0` on `score` and `submitted`. For example, if the tables contain the following data in `AGSLog` before you run this program, the `AGSLog` table now contains the new records after the program runs.

AGSStudent

username	password	fullname	instructorEmail
abc	p1	John Roo	t@gmail.com
cde	p2	Yao Mi	c@gmail.com
wbc	p3	F3	t@gmail.com

ExerciseAssigned

instructorEmail	exerciseName	maxScore
t@gmail.com	e1	10
t@gmail.com	e2	10
c@gmail.com	e1	4
c@gmail.com	e4	20

AGSLog

username	exerciseName	score	submitted
abc	e1	9	1
wbc	e2	7	1

AGSLog after the program runs

username	exerciseName	score	submitted
abc	e1	9	1
wbc	e2	7	1
abc	e2		0
wbc	e1		0
cde	e1		0
cde	e4		0

***34.11** (*Baby names*) Create the following table:

```
create table Babyname (
  year integer,
  name varchar(50),
  gender char(1),
  count integer,
  constraint pkBabyname primary key (year, name, gender)
);
```

The baby name ranking data was described in Programming Exercise 12.31. Write a program to read data from the following URL and store into the Babyname table.
`https://liveexample.pearsoncmg.com/data/babynamesranking2001.txt`,

. . .

`https://liveexample.pearsoncmg.com/data/babynamesranking2010.txt`.