CONTENTS

CHAPTER 1 - COURSE INTRODUCTION

COURSE OBJECTIVES

- Describe the features of a Relational Database.
- Interact with a Relational Database Management System.
- Use SQL*Plus to connect to an Oracle database and submit SQL statements.
- Write SQL queries.
- Use SQL functions.
- Use a query to join together data items from multiple tables.
- Write nested queries.
- Perform summary analysis of data in a query.
- Add, change, and remove data in a database.
- Manage database transactions.
- Work in a multi-user database environment.
- Create and manage tables and other database objects.
- Control access to data.
- Create triggers on database tables.
- Use PL/SQL's datatypes for database and program data.
- Use program stucture and control flow to design and write PL/SQL programs.
- Create PL/SQL stored procedures and functions.

- Write robust programs that handle runtime exceptions.
- Use PL/SQL's collection datatypes.
- Use cursors to work with database data.
- Use the packages supplied with Oracle.
- Design and write your own packages.
- Maintain and evolve your PL/SQL programs.
- Manage the security of your stored PL/SQL programs.

COURSE OVERVIEW

- **Audience:** This course is designed for database application developers.
- **Prerequisites:** Familiarity with relational database concepts.
- **Student Materials:**
  - Student workbook
- **Classroom Environment:**
  - One workstation per student
  - Oracle 11*g*

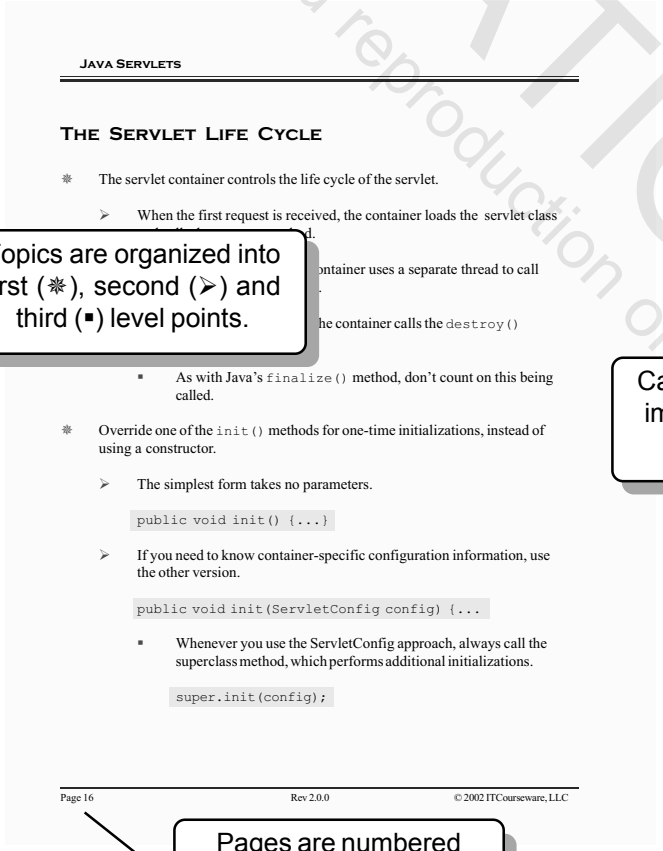
USING THE WORKBOOK

This workbook design is based on a page-pair, consisting of a Topic page and a Support page. When you lay the workbook open flat, the Topic page is on the left and the Support page is on the right. The Topic page contains the points to be discussed in class. The Support page has code examples, diagrams, screen shots and additional information. Hands On sections provide opportunities for practical application of key concepts. Try It and Investigate sections help direct individual discovery.

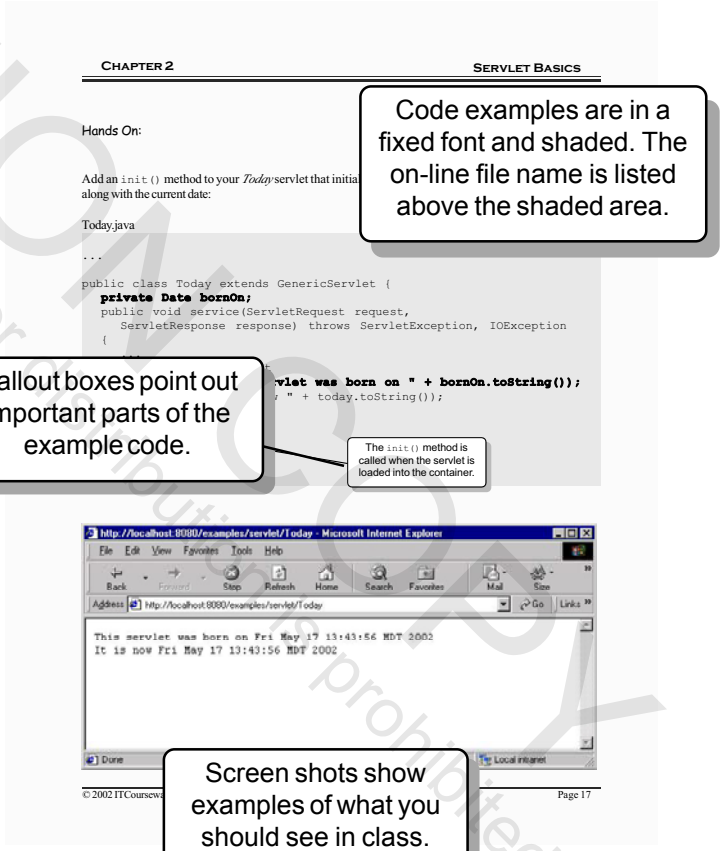
In addition, there is an index for quick look-up. Printed lab solutions are in the back of the book as well as on-line if you need a little help.

The Topic page provides the main topics for classroom discussion.

The Support page has additional information, examples and suggestions.



Topics are organized into first (❋), second (➢) and third (▪) level points.



Code examples are in a fixed font and shaded. The on-line file name is listed above the shaded area.

Callout boxes point out important parts of the example code.

Screen shots show examples of what you should see in class.

Pages are numbered sequentially throughout the book, making lookup easy.

SUGGESTED REFERENCES

Beaulieu, Alan. 2009. ***Learning SQL***. O'Reilly & Associates, Sebastopol, CA. ISBN 0596520823

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Gennick, Jonathan. 2004. ***Oracle Sql*Plus Pocket Reference, Third Edition***. O'Reilly & Associates, Sebastopol, CA. ISBN 0596008856

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Loney, Kevin. 2008. ***Oracle Database 11g: The Complete Reference***. McGraw-Hill Osborne Media, ISBN 0071598758

Mishra, Sanjay. 2009. ***Mastering Oracle SQL, Second Edition***. O'Reilly & Associates, Sebastopol, CA. ISBN 0596006322

Pribyl, Bill, Feuerstein, Steven. 2001. ***Learning Oracle PL/SQL***. O'Reilly and Associates, Sebastopol, CA. ISBN 0596001800

http://tahiti.oracle.com
http://www.dbasupport.com
http://www.orafaq.com
http://asktom.oracle.com
http://www.oracle.com
http://www.searchdatabase.com
http://www.toadworld.com

Your single most important reference is the ***SQL Language Reference*** book, which is part of the *Oracle Database Online Documentation Library*. You may have received this on CD-ROM with your Oracle distribution. If not, you can access it online at Oracle's web site. This is the official, complete description of Oracle's implementation of SQL. It includes many examples and discussions.

An easy way to find it is to go to:

http://tahiti.oracle.com/

Find the documentation for your version of Oracle. Locate the ***SQL Language Reference***, and open the HTML table of contents.

If you have web access in the classroom, open a browser now and find the ***SQL Language Reference***. Set a browser bookmark, and have the ***SQL Language Reference*** at hand throughout this class.

Other important books for Oracle application developers:

* ***Concepts***
* ***Reference***
* ***PL/SQL Language Reference***
* ***PL/SQL Packages and Types Reference***
* ***Advanced Application Developer's Guide***
* ***Error Messages***

CHAPTER 2 - RELATIONAL DATABASE AND SQL OVERVIEW

OBJECTIVES

- Describe the features of a Relational Database.
- Describe the features of a Relational Database Management System.
- Describe the standard SQL datatypes.

REVIEW OF RELATIONAL DATABASE TERMINOLOGY

- Relational Databases:
  - A *Relational Database* consists of *tables*, each with a specific name.
  - A table is organized in *columns*, each with a specific name and each capable of storing a specific *datatype*.
  - A *row* is a distinct set of values, one value for each column (although a column value might be empty (*null*) for a particular row).
  - Each table can have a *primary key*, consisting of one or more columns.
    - The set of values in the primary key column or columns must be unique and not null for each row.
  - One table might contain a column or columns that correspond to the primary key or unique key of another table; this is called a *foreign key*.

A *Relational Database* (RDB) is a database which conforms to Foundation Rules defined by Dr. E. F. Codd. It is a particular method of organizing information.

A *Relational Database Management System* (RDBMS) is a software system that allows you to create and manage a Relational Database. Minimum requirements for such a system are defined by both ANSI and ISO. The most recent standard is named *SQL2*, since most of the standard simply defines the language (SQL) used to create and manage such a database and its data. Some people use the term *SQL Database* as a synonym for *Relational Database*.

Each row (sometimes called a *record*) represents a single entity in the real world. Each column (sometimes called a *field*) in that row represents an attribute of that entity.

Entity Relationship Modeling is the process of deciding which attributes of which entities you will store in your database, and how different entities are related to one another.

The formal word for row is *tuple*; that is, each row in a table that has three columns might be called a *triple* (a set of three attribute values); five columns, a *quintuple*; eight columns, an *octuple*; or, in general, however many attributes describe an entity of some sort, the set of column values in a row that represents one such entity is a tuple. The formal word for column is *attribute*.

RELATIONAL DATABASE MANAGEMENT SYSTEMS

- A *Relational Database Management System* (RDBMS) provides for users.
  - Each *user* is identified by an account name.
    - A user can access data and create database objects based on privileges granted by the database administrator.
  - Users own the tables they create; the set of tables (and other database objects) owned by a user is called a *schema*.
    - Users can grant *privileges* so that other users can access the schema.
- A *session* starts when you connect to the system.
- Once you connect to the database system, all your changes are considered a single *transaction* until you either *commit* or *rollback* your work.
- *SQL* is a standard language for querying, manipulating data, and creating and managing objects in your schema.
- The *Data Dictionary* (also called a *System Catalog* or *Online Catalog*) is a set of ordinary relational tables, maintained by the system, whose rows describe the tables in your schema.
  - You can query a system catalog table just like any other table.
  - Each database vendor has its own system catalog.

You can use the Oracle Enterprise Manager to graphically display database schemas, users, and object details, as well as to perform a variety of administrative tasks. You may also use SQL*Plus to perform many of the same tasks. For example, you can use SQL*Plus to query the Data Dictionary:

dictionary.sql

```
SELECT *
  FROM dictionary
 WHERE table_name LIKE 'USER%';
```

user_tables.sql

```
SELECT table_name FROM user_tables;
```

SQL DATATYPES

- Each column in a table has a specific, predefined datatype.
  - Only values of the correct type can be stored in the column.
  - Many datatype definitions also include a limit on the size of the values that are allowed.
- The details of how data values are stored vary among database vendors.
  - Most database vendors provide similar sets of datatypes, though.
- The most important ANSI/ISO standard datatypes are:
  - **CHARACTER** — Text values of a specific predefined length; the database pads shorter values to the correct length with spaces.
  - **CHARACTER VARYING** — Text values whose length can vary, up to a predefined maximum length for each column.
  - **BIT, BIT VARYING** — Fixed or varying-length bit strings for binary data such as images or documents.
  - **INTEGER** — Whole number values, possibly with predefined precision.
  - **FLOAT, DOUBLE PRECISION FLOAT**— Floating-point numbers.
  - **NUMERIC/DECIMAL** — Fixed-point numbers, with predefined precision and scale.
  - **DATE, TIME, DATETIME, TIMESTAMP** — Calendar date, clock time, combined date/time, date/time with predefined precision.
  - **INTERVAL** — Time interval, perhaps with predefined precision.

While most SQL database vendors provide all the ANSI/ISO standard datatypes in one form or another, they vary widely in their implementation and internal storage format. Examples:

INTEGER:

* MySQL has **TINYINT** (1 byte, signed or unsigned), **SMALLINT** (2 bytes, signed or unsigned), **INT** or **INTEGER** (4 bytes, signed or unsigned), and **BIGINT** (8 bytes, signed or unsigned.)

* Microsoft SQL Server has **TINYINT** (1 byte, unsigned), **SMALLINT** (2 bytes, signed), **INT** (4 bytes, signed), and **BIGINT** (8 bytes, signed).

* Oracle Database has **NUMBER(*p*)**, where *p* specifies precision as the number of decimal digits (up to 38); values stored in a varying length proprietary binary format, consuming only as many bytes as are needed for each number.

CHARACTER VARYING:

* MySQL has **VARCHAR(*n*)** where *n* is the maximum number of characters allowed, up to 65,536.

* Microsoft SQL Server has **VARCHAR(*n*)**, where *n* is either the maximum number of bytes allowed, up to 8,000; or the word **max** indicating strings up to 2GB are allowed.

* Oracle Database has **VARCHAR2(*n*)**, where *n* is the maximum number of bytes allowed, up to 4,000.

DATE, TIME, DATETIME:

* MySQL has **DATE** (calendar date, from 1000-01-01 ad to 9999-12-31 A.D.), **TIME** (clock time), and **DATETIME** (combined date and clock time), all stored in compact binary formats.

* Microsoft SQL Server has **DATE** (calendar date, from 0001-01-01 to 9999-12-31 A.D.), **TIME** (clock time), **DATETIME** (combined date and time from 1753-01-01 to 9999-12-31 A.D), **DATETIME2** (combined date and time from 0001-01-01 to 9999-12-31 A.D), and **SMALLDATETIME** (combined date and time from 1900-01-01 to 2079-06-06 A.D).

* Oracle Database has **DATE** (combined date and time from 4712-01-01 B.C to 9999-12-31 A.D.), stored in a compact 7-byte binary format.

In addition, each database product has its own rules for presenting and accepting dates as human-readable strings.

INTRODUCTION TO SQL

- SQL is the abbreviation for *Structured Query Language*.
  - It is often pronounced as "sequel."
- SQL was first developed by IBM in the mid-1970s.
- SQL is the international standard language for relational database management systems.
  - SQL is considered a fourth-generation language.
  - It is English-like and intuitive.
  - SQL is robust enough to be used by:
    - Users with non-technical backgrounds.
    - Professional developers.
    - Database administrators.
- SQL is a non-procedural language that emphasizes what to get, but not how to get it.
- Each vendor has its own implementation of SQL; most large vendors comply with the more recent ANSI/ISO standards, and may include proprietary language extensions for greater functionality.

SQL statements can be placed in two main categories:

Data Manipulation Language (DML):

Query:	**SELECT**
Data Manipulation:	**INSERT** **UPDATE** **DELETE**
Transaction Control:	**COMMIT** **ROLLBACK**

Data Definition Language (DDL):

Data Definition:	**CREATE** **ALTER** **DROP**
Data Control:	**GRANT** **REVOKE**

SQL is actually an easy language to learn (many users pick up the basics with no additional instruction). SQL statements look more like natural language than many other programming languages. We can parse them into "verbs," "clauses," and "predicates." Additionally, SQL is a compact language, making it easy to learn and remember. Users and programmers spend most of their time working with only four simple keywords (the Query and DML verbs in the list above). Of course, as we'll learn in this class, you can use them in sophisticated ways.

CHAPTER 8 - DATA MANIPULATION AND TRANSACTIONS

OBJECTIVES

- Add new rows to database tables.
- Modify rows in tables.
- Delete rows from tables.
- Perform tasks consisting of more than one SQL statement.
- Make your changes permanent and visible to other users.
- Undo the effects of SQL statements.
- Access database tables concurrently with other users.
- Prevent other users from interfering with your changes.

THE INSERT STATEMENT

❋ Use the **INSERT** statement to add new rows of data to a table.

```
INSERT INTO table_name [(column_name_list)]
  {VALUES (value_list) | subquery };
```

➢ Use ***column_name_list*** to specify the columns for which you will be providing values.

➢ You must own the table or have **INSERT** privilege on the table.

❋ To add a single row to the table, use the **VALUES** clause.

insert_order.sql
```
INSERT INTO order_header
   (invoice_number, store_number, customer_id,
    order_date, est_delivery_date, amount_due)
  VALUES (3001, 7, 7878, sysdate, sysdate + 4, 0);
```

➢ The order and number of values must match the column list.

❋ To add zero or more rows at once by copying from existing data, use a subquery.

insert_items.sql
```
INSERT INTO order_item
  (SELECT 3001, product_id, 1, .05
     FROM inventory
    WHERE store_number = 7 AND product_id like 'IBM%'
      AND quantity_on_hand > 0);
```

➢ The subquery's **SELECT** list can include column values, expressions, and literals.

▪ You can generate rows in which some column values come from existing records, while others are provided by the statement itself.

❋ Use the **NULL** or **DEFAULT** keywords in place of a value to insert a null, or allow a column to be populated with its default value.

inv.sql
```
INSERT INTO inventory
      VALUES ('BORL0000014', 7, 25, NULL);
```


A company employee may enter a product into the inventory at Store #7 with the following:

inv.sql
```
INSERT INTO inventory
VALUES ('BORL0000014', 7, 25, NULL);
```

This format of the **INSERT** command requires that the number and exact order of all columns in the **inventory_item** table be known. If the table definition should change, this statement would become invalid. A more reliable (and maintainable) format is to specify the order and names of the columns that are being populated:

inv2.sql
```
INSERT INTO inventory (product_id, store_number, quantity_on_hand,
                       quantity_on_order)
VALUES ('BORL0000014', 7, 25, NULL);
```

This format is required when populating only a subset of all columns in a table. Any skipped columns will be automatically assigned the specified default or (if allowed) null value. The **INSERT** below is equivalent to those above:

inv3.sql
```
INSERT INTO inventory (product_id, store_number, quantity_on_hand)
VALUES ('BORL0000014', 7, 25);
```

A subquery can be used to easily populate rows from other data in the database. To add another person to the database with the same address and phone information as an existing person:

person.sql
```
INSERT INTO person (id, lastname, firstname, mi, street, city, state,
                    zip, area_code, phone_number)
       (SELECT 9999, 'Striker', 'Joan', 'R', street, city, state, zip,
               area_code, phone_number
          FROM person
         WHERE id=7881);
```

THE UPDATE STATEMENT

- Use the **UPDATE** statement to change existing data in a single table.

```
UPDATE table_name
  SET column=expression [,column=expression,...]
[WHERE condition];
```

  - You must either own the table or have **UPDATE** privilege.

update_inv.sql

```
UPDATE inventory
   SET quantity_on_hand = 42,
       quantity_on_order = 0
 WHERE store_number = 7
   AND product_id = 'BORL0000014';
```

- The ***expression*** may be a subquery that must return only one row.

update_emp.sql

```
UPDATE employee
   SET supervisor_id = (SELECT manager_id FROM store
                        WHERE store_number = 7)
 WHERE store_number = 7
   AND supervisor_id IS NULL;
```

  - 9*i* and later versions allow you to specify **DEFAULT** to set a value back to the default value specified for this column when the table was created.

```
UPDATE employee SET supervisor_id = DEFAULT
 WHERE id = 6535;
```

    - A **NULL** will be issued if there is no default for this column.

- The **WHERE** clause identifies the rows to be updated.

  - If no **WHERE** clause is used, all rows in ***table_name*** are updated.

With a correlated subquery, we can update each employee based on the store at which they work.

update2.sql
```
UPDATE employee
   SET supervisor_id =
       (SELECT manager_id
          FROM store
         WHERE store_number = employee.store_number)
 WHERE supervisor_id IS NULL;
```

In this example, however, the subquery must be executed once for every row processed by the **UPDATE**, since the value returned by the **SELECT** will depend on the value of the **employee.store_number** in the current row being updated.

Oracle also allows several columns to be set with one subquery:

update_person.sql
```
UPDATE person
   SET (area_code, phone_number) =
       (SELECT area_code, phone_number
          FROM store
         WHERE store_number = 7)
 WHERE id = 7881;
```

THE DELETE STATEMENT

- The **DELETE** statement removes rows from a table.
- You must either own the table or have **DELETE** privilege.
- The format of the **DELETE** command is:

```
DELETE FROM table_name
[WHERE condition];
```

- The **WHERE** clause identifies the rows to be deleted.

delete.sql

```
DELETE FROM order_item
  WHERE invoice_number = 2960
    AND product_id = 'ORCL0000014';
```

  - The ***condition*** can be the same as those found in the **SELECT** statement.
  - If no **WHERE** clause is used, all rows in ***table_name*** are deleted!

In addition, Oracle provides the **TRUNCATE** statement. **TRUNCATE** deletes all of the rows in a table. Unlike the **DELETE** statement, you cannot specify any conditions on which rows are to be deleted. The example below will delete the contents of the **person** table:

```
TRUNCATE TABLE person;
```

TRUNCATE is used instead of the **DELETE** statement to free space allocated for the table; and, because each deletion is not logged, the **TRUNCATE** statement is usually faster than **DELETE**. The **TRUNCATE** statement cannot be undone (see **ROLLBACK**) and should, therefore, be used with caution.

TRANSACTION MANAGEMENT

- Once you connect to a database, your statements are all considered to be a single logical unit of work, called a *transaction*.

- At any point in a transaction, you can roll back all of your DML statements.

```
ROLLBACK;
```

  - All of your changes are discarded and a new transaction begins.

- None of your changes are visible in the database until you commit your transaction.

```
COMMIT;
```

  - All your changes are made permanent and a new transaction begins.

- When should you **COMMIT** or **ROLLBACK**?

  - Commit as soon as you have completed the statements making up a logical unit of work.

  - Remember:

    - **COMMIT** commits everything since the last commit or rollback.

    - **ROLLBACK** rolls back everything since the last commit or rollback.

- Add savepoints to your transactions to give yourself a place to partially roll back to - you can set up to five savepoints.

```
SAVEPOINT a;
```

```
ROLLBACK TO a;
```


Transactions help you manage tasks that must succeed as a logical group. To change an employee's id from 8119 to 519, for example, you must also change the corresponding person record:

1. Insert a new person record:

```
INSERT INTO person (SELECT 519, lastname, firstname, mi,
                           street, city, state, zip,
                           area_code, phone_number
                      FROM person
                     WHERE id = 8119 );
```

2. Update the employee record:

```
UPDATE employee SET id = 519 WHERE id = 8119;
```

3. Delete the old person record:

```
DELETE FROM person WHERE id = 8119;
```

4. If all three statements succeed, then commit the work:

```
COMMIT;
```

However, if the **DELETE** statement fails, (for example, if the person has an account or an order record), and we haven't committed yet, then we can roll the work back:

```
ROLLBACK;
```

Note that if we had committed, then the **ROLLBACK** statement would have no effect.

Since the RDBMS must temporarily store enough information to either commit or roll back your entire transaction, it could run out of space if you do not commit often enough. A **DELETE** statement that deletes 100,000 rows from a table may cause the RDBMS to make temporary copies of all those rows. If the system does not have sufficient space for this, the delete will fail. You might have to delete those rows in smaller chunks, committing each time.

CONCURRENCY

- Oracle uses *locks* of various types to coordinate data manipulation, and many other activities, among concurrent sessions.

- When concurrent sessions access the same rows and perform DML statements — **INSERT**s, **UPDATE**s, and **DELETE**s — Oracle isolates each session's work.

  - For example, Oracle assures one session can't update or delete a row another session has already updated, until the other session does a **COMMIT** (or **ROLLBACK**).

- When a session begins manipulating data, it creates an *Exclusive Lock*, and associates all modified rows with that lock.

  - It also creates a second lock associated with the affected table, to prevent others from altering the table's definition until the transaction is done.

- Another session trying to manipulate any of the modified rows will find the lock.

  - By default, the second session will add (*enqueue*) itself to the list of sessions interested in rows controlled by the first session.

    - When the first session commits or rolls back, its lock clears, and the next session in the queue now controls the rows.

  - Your DML statement can include **NOWAIT**, telling Oracle to return an immediate error instead of enqueueing and waiting.

- A deadlock can occur if one transaction requires access to data locked by another in order to complete, while at the same time holding a lock that the other transaction is waiting for.

  - Oracle automatically detects this situation, rolling back the statement that created the deadlock.

Because in normal operation a session *enqueues* (adds itself to the wait list, or queue) on a lock held by another session, the locks themselves are often refered to as "enqueues."

A lock is a data structure created in shared memory (memory that all programs accessing the database can access). Oracle defines different categories and levels of lock, with many individual types of lock with different meanings, for various specific circumstances.

For example, when one session begins performing **INSERT**s, **UPDATE**s, and **DELETE**s, (that is, DML statements), it creates a lock structure representing its current transaction (set of statements that it will **COMMIT** or **ROLLBACK** later). It then marks each row it updates, in such a way that another session accessing that row will be directed to the lock. This lock (known as a *TX* lock) is in the category of DML locks, its level is Row-Level, and its specific type is an *Exclusive Lock*, indicating it has started a transaction and updated rows; other sessions wanting to update any of those same rows must wait for the first session to release the TX lock. However, other sessions can still read those rows (to perform **SELECT** statements). Only another session wanting to update or delete those rows will have to wait.

The session also creates another lock (called a *TM* lock) and associates it with the table itself. This one, a DML-category lock, is a *Table-Level* lock and its specific type is *Row Exclusive* (*RX*), indicating the session has exclusively locked rows in that table. Another session wanting to drop the table, or alter its structure, will have to wait for the first session to clear this lock.

The *Concepts* book, in the Oracle Online Documentation Library, describes concurrency issues, the different types of lock, and the operations that create them.

Locks are created and managed automatically when you perform DML statements. **COMMIT** or **ROLLBACK** ends your current transaction and releases its locks.

EXPLICIT LOCKING

- Exclusive locks are automatically placed whenever you execute **INSERT**, **UPDATE**, or **DELETE** statements.
  - Locks are released by a **COMMIT** or **ROLLBACK**.
- You can explicitly place a lock on an entire table.

```
LOCK TABLE table IN lock-mode MODE [NOWAIT|WAIT seconds];
```

  - **EXCLUSIVE** (or *Write*) *Lock* is a lock mode that does not allow any other user to place any lock on that row or table; other users can still read uncommitted data, however.
  - **SHARE** (or *Read*) *Lock* is a mode in which other users can also place share locks, but no user can obtain an exclusive lock.
- You can place a lock on a subset of rows through a **SELECT** statement.

```
SELECT col1, col2, col3, col4
  FROM table
 WHERE condition
   FOR UPDATE [OF table.col][NOWAIT|WAIT seconds];
```

- The **NOWAIT** option governs what happens if some or all of these records are already locked.
  - If **NOWAIT** is specified, control is returned to the user.
  - Otherwise, the statement will wait for the lock to be released before executing.

lock_person.sql

```
-- Lock records in the person table
SELECT id, lastname, firstname
  FROM person
 WHERE area_code = '303'
   FOR UPDATE;
```

update_person2.sql

```
-- All 303 area_code records are now locked
UPDATE person
   SET area_code = '720'
 WHERE area_code = '303';
```

lock_person2.sql

```
SELECT person.id, lastname, firstname
  FROM person JOIN employee ON person.id = employee.id
 WHERE area_code = '303'
   FOR UPDATE OF person.id;
```

update_person3.sql

```
-- Employee 303 area_code records in person are now locked
-- Corresponding rows in employee are not locked
UPDATE person
   SET area_code = '720'
 WHERE area_code = '303'
   AND id IN (SELECT id FROM employee);
```

lock_person3.sql

```
-- Lock the entire person table
LOCK TABLE person IN EXCLUSIVE MODE NOWAIT;
```


Note:

The option to **WAIT** for a specified number of seconds was added in version 11*g*.

DATA INCONSISTENCIES

- When multiple users try to access and manipulate the same data, several data inconsistencies can arise:
  - A *Dirty Read* occurs when a transaction reads uncommitted data by another transaction.
  - A *Non-Repeatable Read* occurs when a user reads rows, another user modifies or deletes the rows and commits, and the first user then tries to read the same rows, getting different data.
  - A *Phantom Read* occurs when a user runs a query, another user inserts rows and commits, then the first user reruns the query, finding the new rows.
- A read-only statement (that is, a **SELECT**) may:
  1. Ignore locks and read data that has been inserted or modified, but not yet committed (Read Uncommitted).
  2. Read only rows that are committed at the time of the read (Read Committed).
  3. Read any rows committed at the time of the read and, possibly, phantom rows added since the last read (Repeatable Read).
  4. The final isolation level (Serializable) is the same as Repeatable Read, except that a re-execution of your **SELECT** will not pick up phantom rows.
- Oracle only supports **READ COMMITTED** and **SERIALIZABLE** on a per-session basis; **READ COMMITTED** is the default.

```
SET TRANSACTION ISOLATION LEVEL {SERIALIZABLE | READ COMMITTED};
```


		Possible Phenomena		
		Dirty Read	Non-Repeatable Read	Phantom Rows
Isolation Level	Read Uncommitted	Yes	Yes	Yes
	Read Committed	No	Yes	Yes
	Repeatable Read	No	No	Yes
	Serializable	No	No	No

These *isolation levels*, defined by SQL92, control which of the data inconsistencies will be prevented during the transaction. For example, in an application where it is highly unlikely that two transactions will attempt to update the same row at the same time, **READ COMMITTED** provides concurrency at the potential cost of data inconsistency. **SERIALIZABLE** transactions, on the other hand, ensure that data will be consistent, but may force another transaction to wait for data access.

Transaction inconsistencies can occur when multiple users are simultaneously updating the same data.

For instance, with Read Committed, if a **SELECT** is performed more than once in the same transaction, another user might have locked some of the rows, modified or deleted them, and then committed; thus, your **SELECT** might have different results at different times in your transaction.

Likewise, with Repeatable Read, if another transaction modifies or deletes rows and commits its changes, a re-execution of your **SELECT** will not see those changes. However, if another transaction adds rows, a repeat of your **SELECT** will see those phantom rows.

LOADING TABLES FROM EXTERNAL SOURCES

- Many systems provide statements or utilities that allow you to load bulk data from external files.
- Oracle's SQL*Loader utility loads rows into a table from external data files, including character and binary formats.
- Oracle provides the export (**exp**) and import (**imp)** utilities to copy or backup database objects and data.

```
exp scott/tiger file=mydata.dmp tables=employee,person,store
```

- Oracle 10*g* introduced Data Pump technology, which is much more efficient than Oracle's original export/import.
  - You invoke the Data Pump **expdp** and **impdp** commands much like the original **exp** and **imp**.
    - The files created by Data Pump are not compatible with files created by the original export/import utilities.
    - The original **exp** and **imp** support all 9*i* features and dataypes, while Data Pump supports 10*g* and higher features.
  - Data Pump requires additional system setup and configuration.
  - Data Pump places all dump and log files on the server's file system.

Oracle provides a standalone utility, SQL*Loader, for loading rows into a table from an external source. SQL*Loader can read a wide variety of data files, parsing records (according to your specifications) into values of the correct types for your table's columns.

empdata.txt

```
ID,SNUM,PAYTYPE,PAYAMT,TITLE
9773,4,H,7,"Clerk"
9777,3,H,7.25,"Customer  Rep"
9785,4,H,7,"Clerk"
9789,3,H,7.25,"Customer  Rep"
7881,3,H,7.25,"Customer  Rep"
9792,5,H,8,"Sales  Rep"
9798,3,H,7.25,"Customer  Rep"
9802,6,H,7.80,"Sales  Rep"
9804,2,H,7.50,"Customer  Rep"
9813,2,H,7.50,"Customer  Rep"
9814,2,H,7.50,"Customer  Rep"
9839,4,H,7,"Clerk"
```

You create a control file that specifies how SQL*Loadhttp://oracle.itags.org/q_oracle_142894.htmler will parse the datafile:

empdata.ctl

```
LOAD DATA
INFILE  'empdata.txt'
BADFILE  'empdata.bad'
DISCARDFILE  'empdata.dsc'
APPEND INTO TABLE employee
WHEN store_number <> '4'
FIELDS TERMINATED BY ',' OPTIONALLY ENCLOSED BY '"' TRAILING NULLCOLS
        (id, store_number, pay_type_code, pay_amount, title)
```

You then run the **sqlldr** command from the operating system command line:

```
sqlldr  CONTROL=empdata.ctl  LOG=empdata.log
```

If you don't include your username/password on the command line, you will be prompted for them.
Records not matching the **WHEN** option will be discarded into **DISCARDFILE**.
Records that can't be parsed, or that cannot be inserted (for example, which would violate an integrity constraint) are copied to **BADFILE**.

LABS

❶ Insert your own name, address, and phone number into the **person** table.
(Solutions: *insert_person.sql, insert_person2.sql*)

❷ Make yourself an employee. Use the store furthest from your actual home. Your starting hourly wage is $8.25.
(Solution: *insert_employee.sql*)

❸ With a single statement, make the store manager of your store your supervisor.
(Solution: *update_emp.sql*)

❹ You must move to the city in which your store is located. Change your address to reflect your store's city, state, and zip; you don't yet know what your street address will be. Be sure to save your changes!
(Solution: *change_address.sql*)

❺ Congratulations — for doing all this, you get a raise to $10 an hour.
(Solution: *pay_increase.sql*)

❻ If our **product** table contains a product for which there is no vendor, we want to delete it.

a. Are there any such products? Retrieve their **product_id** and **description**.
b. If so, can you simply delete them from the **product** table?
c. Take all steps necessary to get rid of any such bogus products.
d. Make sure your changes are made permanent.

(Solutions: *product1.sql, product2.sql, product3.sql, product4.sql*)

❼ Delete all the inventory items for your store.
(Solution: *delete_inv.sql*)

❽ What — are you nuts!? Get those inventory items back!
(Solution: *rollback.sql*)

CHAPTER 9 - DATA DEFINITION AND CONTROL STATEMENTS

OBJECTIVES

- Describe the datatypes stored in your database.
- Define your own tables.
- Control the data allowed in your tables.
- Modify the definitions of existing tables and columns.
- Assure the integrity of your database.
- Drop table definitions from your database.
- Control access by other users to your tables.

DATATYPES

- When you create a table, you must choose a datatype for each column within the table.
  - Oracle will issue an error message if you try to **INSERT** or **UPDATE** a value that does not match the column's datatype.
- String types allow you to hold text in several different formats.
  - **CHAR(*size*)** — Fixed length, padded strings; these should only be used when you are certain that all records will have the same length strings.
  - **VARCHAR2(*size*)** — Variable length strings, up to ***size***; these are heavily used to store smaller amounts of text.
  - **CLOB** — Arbitrary length strings; these are used for large amounts of text.
- Numeric types allow you to hold integer and floating point values.
  - **NUMBER(*p*,*s*)** — Integer or floating point values where the precision, ***p***, and scale, ***s***, are optional; these are routinely used to hold dollar amounts and other basic numbers.
  - **BINARY_FLOAT/BINARY_DOUBLE** — 32- or 64-bit floating point values; these are useful for values that need good precision for calculations.
- Binary types allow you to store data in arbitrary formats, such as images, movies, sounds, or compiled programs.
  - **RAW(*size*)** — Small binary values; these are typically icons or other small media values.
  - **BLOB** — Arbitrarily large binary values; these are useful for large media values, program code, and other binary data.
- Date types allow you to hold date/time values.
  - **DATE** — Date/time value with one second granularity; these are general purpose dates that are commonly used in non-globalized databases.
  - **TIMESTAMP** — Date/time value with nanosecond granularity; versions are available to also store time zone information based on the Oracle server or client locale.

String Types	Description	Limits
CHAR(*size*)	Fixed-length character set data of *size* length. Default size is 1.	2000 bytes
NCHAR(*size*)	Fixed-length unicode-only datatype. National character set determines the max length of the column. Default size is 1.	2000 bytes
VARCHAR2(*size*)	Variable-length character string with max size of *size* bytes. Must specify size.	4000 bytes
NVARCHAR2(*size*)	Variable-length character string for national character set with max size of *size* bytes. The national character set determines the max length of the column.	4000 bytes
CLOB	Character Large Object.	4GB*DB_BLOCK_SIZE
NCLOB	National Character Large Object containing Unicode. National character set determines the max length of the column.	4GB*DB_BLOCK_SIZE
LONG (deprecated)	Variable-length character data.Use CLOB instead.	2GB
Numeric Types	**Description**	**Limits**
NUMBER(*p,s)*	Number with precision of *p* and scale of *s*. Must be integer if only *p* is provided.	Precision is 38, Scale is -84 to 127.
BINARY_FLOAT	32-bit, single-precision floating-point number.	Fixed in length - requires 5 bytes of storage.
BINARY_DOUBLE	Double-precision floating-point number, including the bit length. Supports the values infinity and NaN(not a number).	Fixed in length - requires 9 bytes of storage.
Binary Types	**Description**	**Limits**
RAW(*size*)	Binary data of *size* bytes. Size must be specified.	2000 bytes
BLOB	Binary Large Object.	4GB*DB_BLOCK_SIZE
BFILE	Reference to a binary file on disk.	4GB
LONG RAW (deprecated)	Binary data of variable length.Use BLOB instead.	2GB
Date Types	**Description**	**Limits**
DATE	Date range.	From Jan 1, 4712BC to Dec 31, 9999AD.
TIMESTAMP(*fractional_seconds*)	All the information contained in date, plus *fractional_seconds* – the number of digits in the fractional part of the **SECONDS** datetime field.	*fractional_seconds* may be 0-9, default is 6.
TIMESTAMP (*fractional_seconds*) WITH TIME ZONE	Same as above, with timezone displacement value.	0-9, default is 6.
TIMESTAMP (*fractional_seconds*) WITH LOCAL TIME ZONE	Same as **TIMESTAMP WITH TIME ZONE**, except the data is adjusted to database time zone when stored in database. When data is queried, users see data in their session time zone.	0-9, default is 6.
INTERVAL YEAR (*year_precision*) TO MONTH	Period of time in years and months. *year_precision* is number of digits in YEAR datetime field.	0-9, default is 2.
INTERVAL DAY (*day_precision*) TO SECOND (*fractional_seconds*)	Period of time in days, hours, minutes, seconds. *day_precision* is max number of digits in DAY. *fractional_seconds* is max number of digits in SECONDS field.	*day_precision* 0-9, default is 2. *fractional_seconds* 0-9, default is 6.
Miscellaneous Types	**Description**	**Limits**
ROWID (deprecated)	Represents address of row in table.	Only physical ROWIDS
UROWID	Represents address of a row in a table.	

DEFINING TABLES

- Create new tables in your schema with the **CREATE TABLE** statement:

```
CREATE TABLE tablename
(
 colname datatype [DEFAULT value] [NOT NULL],
 ...
 colname datatype [DEFAULT value] [NOT NULL]
);
```

- You must specify a name and datatype, and possibly a data size, for each column.

- The order of the columns in the **CREATE TABLE** statement will be the order in which the columns are stored.

  - The column order is the default order used when issuing a **SELECT *** or **INSERT**.

- **NOT NULL** in a column definition specifies that every row in the table must have a non-**NULL** value for that column.

  - **INSERT**s or **UPDATE**s that attempt to violate this will fail.

- **DEFAULT** specifies a default value to be supplied for a column, if an **INSERT** statement omits a value for the column.

  - Beginning in 9*i*, this value will also be used for an **UPDATE** or **INSERT** where a column is set to **DEFAULT**.

```
UPDATE tablename
   SET columnname = DEFAULT;
```


Physical data storage is managed at different levels. The smallest disk storage space may be a data block or page, which could be as small as 2k-32k (minimum and maximum are often OS-dependent). Contiguous blocks or pages are grouped into extents, which are then used to manage space allocation when creating database objects.

Oracle permits you to specify a number of storage options, such as the tablespace to be used, when you create a table:

pref_cust.sql
```
CREATE TABLE preferred_customer
(
 id NUMBER,
 discount NUMBER(2,2) DEFAULT .05,
 description VARCHAR2(78)
)  TABLESPACE users;
```

If the DBA assigned a default tablespace to you, your database objects will automatically be placed there. Otherwise, they will be placed in the **SYSTEM** tablespace or the database wide **DEFAULT TABLESPACE**. You can find what your default tablespace is with the following query:

```
SELECT default_tablespace
  FROM user_users;
```

DDL statements (such as **CREATE TABLE** or **DROP TABLE**) are not logged. That is, they are not considered to be part of a transaction and, normally, do not need to be committed (and cannot be rolled back).

Oracle automatically performs a **COMMIT** immediately before and after each DDL statement. This means that if you try to execute a DDL statement within a transaction, your transaction will automatically be committed and you cannot then roll back the transaction.

CONSTRAINTS

- A *constraint* limits the allowed values for a column.
  - **PRIMARY KEY** — Unique value of column(s) in all rows. Nulls not allowed. There can only be one primary key per table.

    ```
    PRIMARY KEY (colname[,colname,...])
    ```

  - **UNIQUE** — Unique value of column(s) in all rows. Nulls allowed.

    ```
    UNIQUE (colname[,colname,...])
    ```

  - **FOREIGN KEY** — Value(s) in foreign key column(s) must match values in the corresponding primary or unique key column(s) of the referenced table.

    ```
    FOREIGN KEY (colname[,colname,...])
     REFERENCES table [(colname[,colname,...])]
      [ON DELETE {CASCADE|SET NULL}];
    ```

    - The primary key columns in the referenced table will be used if not specified.

  - **CHECK** — Value(s) must satisfy the specified condition.

    ```
    CHECK (condition)
    ```

    - **NOT NULL** is similar to a **CHECK** constraint.

      ```
      id NUMBER NOT NULL,
      ```

      ```
      id NUMBER CHECK (id IS NOT NULL)
      ```

- Provide a meaningful constraint name when creating the constraint, otherwise the system will provide a default name that is difficult to read in error messages.

```
[CONSTRAINT name] constraint_definition
```


pref_cust2.sql

```
CREATE TABLE preferred_customer
(
   id NUMBER,
   discount NUMBER(2,2) DEFAULT .05,
   description VARCHAR2(78),
   CONSTRAINT pk_pref_cust PRIMARY KEY (id),
   CONSTRAINT fk_prefcust_person FOREIGN KEY (id)
     REFERENCES person (id),
   CONSTRAINT  ck_prefcust_discount
    CHECK ( discount BETWEEN 0 AND .25 )
);
```

You can query the Data Dictionary for constraint information:

constraints.sql

```
SELECT table_name, constraint_name,
       CASE constraint_type
            WHEN 'R' THEN 'Foreign Key'
            WHEN 'P' THEN 'Primary Key'
            WHEN 'C' THEN 'Check Constraint'
            WHEN 'U' THEN 'Unique Constraint'
       END "Constraint Type"
  FROM user_constraints
 ORDER BY 1, 2;
```

foreign_keys.sql

```
SELECT f.table_name || '(' || fc.column_name || ') references ' ||
       r.table_name  || '(' || rc.column_name || ')' "Foreign keys"
  FROM user_cons_columns fc JOIN user_constraints f
                              ON fc.constraint_name = f.constraint_name
                            JOIN user_constraints r
                              ON f.r_constraint_name = r.constraint_name
                            JOIN user_cons_columns rc
                              ON r.constraint_name = rc.constraint_name
 ORDER BY 1;
```

Graphical development environments, such as SQL Developer, TOAD, or PL/SQL Developer, will automatically query the Data Dictionary for you and display constraint information for your tables.

INLINE CONSTRAINTS

- A constraint involving only one column can be specified in the column definition, using *inline constraint* syntax:

```
colname datatype UNIQUE,

colname datatype PRIMARY KEY,

colname datatype REFERENCES table [(colname)],

colname datatype CHECK (condition),
```

  - Multiple constraints can be placed inline and each can be named.

pref_cust3.sql

```
CREATE TABLE preferred_customer
(
   id NUMBER CONSTRAINT pk_prefcust PRIMARY KEY
     CONSTRAINT fk_prefcust_person
       REFERENCES person (id),
   discount NUMBER(2,2) DEFAULT .05
     CONSTRAINT ck_prefcust_discount
       CHECK ( discount BETWEEN 0 AND .25 ),
   description VARCHAR2(78)
);
```

- Constraint definitions listed at the end of the **CREATE TABLE** statement are *out-of-line constraint* syntax.

  - These syntactic differences for constraint definition have no bearing on the nature of the constraints themselves.

  - Older Oracle documentation referred to inline constraints as "column constraint" syntax, and out-of-line constraints as "table constraint" syntax.

A *foreign key*, or *referential integrity constraint*, is a combination of columns that depends on a primary or unique key in some other table. A *parent row* is a row with foreign key values referencing it; a *parent key* is the referenced primary or unique key in a parent row. A *child row* is the row referencing the parent row. The table containing the parent key is the *parent table* and the table with the foreign key is the *child table*. Before a row is inserted or updated into the child table, the values of the foreign key columns will be checked for rows in the parent table with matching values in the parent key. If there is no match, then the insert will not be allowed. We define this validation of corresponding values as *referential integrity*. Though referential integrity has always been part of the relational model, only recently have RDBMSs begun incorporating primary/foreign key constraints.

To enforce referential integrity, you may determine the action to take on child rows when a parent row value is deleted, the possibilities are:

- **CASCADE** — If the parent row is deleted, delete the child row automatically.
- **SET NULL** — If the parent row is deleted, set the child row's corresponding foreign key values to **NULL**.

Without the **ON DELETE** clause, no action will be taken on the child row. If deleting a parent row will break referential integrity, then the deletion is not allowed. This is the default. The examples opposite use *inline constraint* syntax, which immediately follow the column definition. You may choose instead to use *out-of-line constraint* syntax. Syntactic differences are minor:

- Inline constraints may only refer to one column and are appended directly onto the column definition.
- Out-of-line constraints may refer to one or several columns and are appended onto the end of the table definition.
- Constraints on multiple columns must be out-of-line constraints.
- The **NOT NULL** constraint requires inline constraint syntax.

The example below creates a table tracking office data. An office may have several managers. Each **manager_id** will refer back to a **person** record. If the referenced **person** record is deleted, then the corresponding **office** record is also automatically deleted:

office.sql

```
CREATE TABLE office
(
   office_id NUMBER,
   manager_id NUMBER,
   pager_number CHAR(8) UNIQUE NOT NULL,
   CONSTRAINT fk_office_person FOREIGN KEY (manager_id)
     REFERENCES person (id) ON DELETE CASCADE,
   CONSTRAINT pk_office PRIMARY KEY (office_id, manager_id)
);
```

MODIFYING TABLE DEFINITIONS

❋ **ALTER TABLE** changes the definition of an existing table:

```
ALTER TABLE table_name action
```

❋ ***action*** may be any of the following:

- You may **ADD**, **RENAME**, or **DROP** a column (the **DROP** column feature was added in Oracle 8*i*):

```
ADD columnname column_definition

RENAME COLUMN columnname TO newcolumnname

DROP columnname [RESTRICT | CASCADE]
```

- You may **ADD**, **RENAME**, **DROP**, or **MODIFY** the state of a constraint:

```
ADD out-of-line_constraint_definition

DROP CONSTRAINT cons_name [RESTRICT | CASCADE]
```

- You may **MODIFY** the properties of a column:

```
MODIFY columnname DEFAULT value

MODIFY columnname DEFAULT NULL

MODIFY columnname NOT NULL

MODIFY columnname datatype(size)
```

❋ Several actions may be used in one **ALTER TABLE**, but each action type may appear only once per **ALTER TABLE** statement.

You can alter an existing table definition.

ALTER TABLE syntax:

The statement below will add a **salesperson_id** column to the **order_header** table:

alter_order_header.sql
```
ALTER TABLE order_header
       ADD salesperson_id NUMBER REFERENCES person;
```

You can use the **MODIFY** clause to change only certain column characteristics:

- The datatype of a column (if existing row values are a compatible datatype or null).
- The maximum length of a character column or precision of a numeric column.
- The **DEFAULT** value of a column.
- The **NOT NULL** constraint of a column.

alter_order_item.sql
```
ALTER TABLE order_item
     MODIFY product_id NOT NULL;
```

The above will work only if all rows currently have non-null **product_id** values.

You can use **ALTER TABLE** to **ADD** or **DROP** constraints. When adding a constraint, you must use out-of-line constraint syntax. To drop a foreign key or check constraint, use the constraint name (from the **USER_CONSTRAINTS** system catalog table).

alter_pref_cust.sql
```
ALTER TABLE preferred_customer
       DROP PRIMARY KEY;
```

alter_employee.sql
```
ALTER TABLE employee
      ADD hire_date DATE;
```

You can also temporarily turn off constraints (instead of permanently removing them) with the **DISABLE**/**ENABLE** clauses:

alter_inventory.sql
```
ALTER TABLE inventory DISABLE PRIMARY KEY;
```

This is typically done for bulk loading of data.

DELETING A TABLE DEFINITION

- **DROP TABLE** removes a table definition, with all of its data, from your schema.

```
DROP TABLE tablename [CASCADE CONSTRAINTS] [PURGE];
```

  - Use **CASCADE CONSTRAINTS** to automatically drop any foreign keys that reference this table.
    - Data in the referencing table is not modified or deleted.
    - Without this option, you must use **ALTER TABLE** to remove all foreign key constraints in referencing tables before this table can be dropped.
  - Starting in Oracle 10*g*, dropped tables are noted in a table called the **recyclebin** and are not actually removed from disk unless the **PURGE** option is specified.
    - You can recover a table from the **recyclebin** with the **FLASHBACK TABLE** statement.
    - Objects are automatically removed from the **recyclebin** when space limites are exceeded.
- All privileges that have been granted on the dropped table are revoked.
- All triggers on the table are dropped.
- Any views, stored procedures, or other objects referencing the dropped table are marked invalid and will be revalidated the next time they are used.

Note:

Every user has a **recyclebin**, which is a Data Dictionary table containing information on the user's dropped objects. You can view it two ways:

```
SELECT * FROM recyclebin;
```

```
SHOW recyclebin;
```

CONTROLLING ACCESS TO YOUR TABLES

- You control access to all tables in your schema by granting or revoking privileges.

```
GRANT privilege(s) ON table TO {user|PUBLIC};
```

- You can grant other users privileges to:
  - **SELECT** data from your tables.
  - **INSERT**, **UPDATE**, and **DELETE** data in your tables.
  - Create and alter tables or otherwise modify your schema.

```
GRANT INSERT, UPDATE ON product TO clerk3;
```

grant_select.sql

```
GRANT SELECT ON inventory TO PUBLIC;
```

- When you grant a privilege to a user, you can allow that user to pass on the same privilege to other users.

```
GRANT UPDATE ON employee TO dobbs
      WITH GRANT OPTION;
```

- Remove privileges with **REVOKE**:

```
REVOKE privilege(s) ON table FROM {user|PUBLIC};
```

- A DBA account (**SYSTEM**, or an account with similar privileges) can control privileges on tables in any user's schema.

Roles

You can group several privileges together as a role. You must have the **CREATE ROLE** privilege to do it:

```
CREATE ROLE rolename;
```

To use roles:

1. Create the role.
2. Grant privileges to the role.
3. Grant the role to those users who need those privileges.

role.sql

```
CREATE ROLE dbtester;

GRANT CREATE SESSION, CREATE TABLE, ALTER ANY TABLE, DROP ANY TABLE
   TO dbtester;

GRANT SELECT ANY TABLE, UPDATE ANY TABLE, DELETE ANY TABLE
   TO dbtester;

GRANT dbtester TO dobbs;
```

LABS

❶ We are creating a preferred customer program.

a. Create a table to maintain the list of preferred customers. Each preferred customer will have a discount (normally 5%). We will want to have a brief description for each one. Each preferred customer must have a record in the person table.
(Solution: *create_pref_cust.sql*)

b. Add a preferred customer record for everyone who has placed an order. For the preferred customer description, use 'Special Order Customer.'
(Solution: *insert_pref_cust.sql*)

❷ Upon examination, the existing definition of our database has several omissions. Make the appropriate changes to the database definition:

a. The database should ensure that every store manager is indeed a current employee.
(Solution: *store_manager.sql*)

b. Each account should have its own discount.
(Solution: *account_discount.sql*)

c. On order headers we need to be able to list the id of the salesperson who took the order.
(Solution: *sales_person.sql*)

❸ Create a table called **city** containing the name of each distinct city and state in the person table. Define a compound primary key for this table.
(Solution: *city.sql*)

❹ Create another table called **calif_person** containing the id, firstname, lastname, city, and state of each person in California. Each person's city and state must exist in the **city** table.
(Solution: *calif_person.sql*)

❺ (Optional) Delete Los Angeles from the **city** table. Can you? How?
(Solution: *delete_la.sql*)

❻ (Optional) Drop the **city** table. Can you? How?
(Solution: *drop_city.sql*)

Oracle provides a convenient operation, called a *Create Table As Select* (CTAS), for creating a table and populating it with data from an existing table:

```
CREATE TABLE table_name AS subquery;
```

The columns of the new table will have the same names and datatypes as the columns in the **SELECT** list of the subquery.

```
CREATE TABLE area_codes AS
  SELECT DISTINCT area_code, state
    FROM person
   WHERE area_code IS NOT NULL;
```

The new table will have no constraints defined, so they will have to be added afterwards:

```
ALTER TABLE area_codes
   ADD CONSTRAINT pk_area_codes PRIMARY KEY (area_code, state);
```

The alternative is to create the table, then copy the rows:

```
CREATE TABLE area_codes (
   area_code CHAR(3),
   state     CHAR(2),
   CONSTRAINT pk_area_codes PRIMARY KEY (area_code, state)
);

INSERT INTO area_codes
   SELECT DISTINCT area_code, state
     FROM person
    WHERE area_code IS NOT NULL;
```