Introduction to Oracle 10g SQL Programming

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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.
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 10g
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.
Suggested References


www.dbasupport.com
www.hot-oracle.com
www.oracle.com
www.toadworld.com
www.searchdatabase.com
tahiti.oracle.com
Your single most important reference is the SQL Reference book, which is part of the Oracle Database Online Documentation. 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:

\textit{http://tahiti.oracle.com/}

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

If you have web access in the classroom, open a browser now and find the SQL Reference. Set a browser bookmark, and have the SQL Reference at hand throughout this class.
Chapter 2 - Relational Database and SQL Overview

Objectives

* Describe the features of a Relational Database.
* Describe the features of a Relational Database Management System.
* Work with the standard Oracle datatypes.
* Review Oracle history and versions
* Distinguish between a database server program and a client application program.
* Connect to and disconnect from a database.
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) is a set of ordinary 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.
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

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

user_tables.sql

```sql
SELECT table_name FROM user_tables;
```
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 SQL-99 or SQL:2003 and have added extensions for greater functionality.
SQL statements can be placed in two main categories:

Data Manipulation Language (DML):

Query: \texttt{SELECT}

Data Manipulation: \texttt{INSERT} \texttt{UPDATE} \texttt{DELETE}

Transaction Control: \texttt{COMMIT} \texttt{ROLLBACK}

Data Definition Language (DDL):

Data Definition: \texttt{CREATE} \texttt{ALTER} \texttt{DROP}

Data Control: \texttt{GRANT} \texttt{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.
Oracle Versioning and History

- The original "Oracle," named Software Development Laboratories, was founded in 1977, which then changed its name to Relational Software in 1979.
  - There was no Version 1 for marketing purposes.
  - Version 2 supported just basic SQL functionality.

- The i in Oracle versions stands for 'internet.'
  - The database has features that make it more accessible over the World Wide Web.
  - A Java Virtual Machine was embedded into the database.

- The g in Oracle versions stands for 'grid.'
  - Databases can be managed remotely by a web accessible tool, the Oracle Enterprise Manager (OEM).
    - The OEM comes in Database Control and Grid Control versions, depending on whether you are managing a single database, or a grid of systems.
The American National Standards Institute (ANSI) published the accepted standard for a database language, SQL, in 1986 (X3.135-1986). This standard was updated in 1989 (also called SQL89 or SQL1) and included referential integrity and column constraints (X3.135-1989). The 1992 standard (also called SQL2) offers a larger and more detailed definition of the SQL-89 standard. SQL-92 is almost 600 pages in length, while SQL-89 is about 115 pages. SQL-92 adds additional support capabilities, extended error handling facilities, better security features, and a more complete definition of the SQL language overall.

A new standard was published in 1999. Some critical features of SQL:1999 include a computationally-complete (that is, procedural) language and support for object-oriented data. Oracle 10g adheres to SQL:1999 standards.

Standards continue to evolve, with SQL:2003 as the successor to SQL:1999.
Logical and Physical Storage Structures

Logical Storage Structures:

* A *tablespace* stores the tables, views, indexes, and other schema objects.
  - It is the primary logical storage structure of an Oracle database.
* Each tablespace can contain one or more *segments*, which are made up of *extents*, which consist of *database blocks*.
* Each *database object*, such as a table or index, has its own segment storage.
  - When an object runs out of space, Oracle allocates another extent to the object.
* Each extent is made up of adjacent database blocks, the smallest logical storage unit.

Physical Storage Structures:

* A *tablespace* is comprised of one or more *datafiles*.
  - A datafile is a binary file whose name usually ends in *.dbf*.
* Datafiles consist of *operating system blocks*, which are not the same as database blocks.
  - A database block may consist of many operating system blocks.
* A *database* is the set of datafiles, as well as files containing configuration and management information, necessary to run an RDBMS.
  - An Oracle database includes a *SYSTEM* tablespace, as well as others.
  - The *SYSTEM* tablespace contains the Data Dictionary.
Disk Blocks
(sectors)

Database Block

Extent

Segment

Extent

Datafile

Tablespace
An Oracle instance is a set of background processes and memory which coordinate efficient access to a database.

- An instance must be running in order for you to access the database.

A server process is a program that uses both the instance and the datafiles to give you access to the database.

- All access to the data is performed by the server process.
- Together, we sometimes refer to the instance and server process as the database server or engine.

A user process, or client, is the program you run that uses database data.

- The user process sends requests to the server in the form of SQL statements, and gets the resulting data in return.
- The client program and the server program might be running on the same physical machine.
- The client may be on a different machine, communicating with the server over a network.

To begin using the database, your client program must connect to the server, thus starting a session.

- To connect, you must provide a valid database account name (and usually a password).
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 datatypes in Oracle include:
  - **VARCHAR2** — Text values whose length can vary, up to a predefined maximum length for each column.
  - **NUMBER** — Numeric values, possibly with predefined precision and scale.
  - **DATE** — A special value representing a moment in time, with one-second precision.
    - When you retrieve a DATE value from the database, Oracle normally converts it to a string representation of the date value, in a readable format.
  - **CHAR** — Text values of a specific predefined length; if a shorter value is inserted, Oracle automatically pads it to the correct length with spaces.
**VARCHAR2**
When you define a VARCHAR2 column, you specify the maximum number of characters allowed for a value in the column. For example, for U.S. state names, you might define a column as VARCHAR2(14), but for a product description you might define a column as VARCHAR2(200). A VARCHAR2 column can contain no more than 4000 bytes. NVARCHAR2 supports Unicode.

**CHAR**
Use CHAR columns for values that are always the same length — state abbreviations, area codes, phone numbers, etc. It is inconvenient to store varying-length values in a CHAR, because you have to account for space-padding at the end of shorter values. NCHAR supports Unicode.

**DATE vs. TIMESTAMP**
The DATE datatype stores the century, year, month, day, hours, minutes, and seconds of a date. The TIMESTAMP datatype contains that same information, plus milliseconds. Calculating the interval between two dates is much easier if you use timestamps.

**NUMBER (precision, scale)**
Precision refers to the total number of digits, and scale is the number of digits to the right of the decimal point. If precision and scale are not specified, the max values are assumed. If a value exceeds the precision, Oracle returns an error. If the value exceeds the scale, it will be rounded:

<table>
<thead>
<tr>
<th>Definition</th>
<th>Data</th>
<th>Stored Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER</td>
<td>12345.678</td>
<td>12345.678</td>
</tr>
<tr>
<td>NUMBER(3)</td>
<td>1234</td>
<td>error</td>
</tr>
<tr>
<td>NUMBER(5,2)</td>
<td>123.45</td>
<td>123.45</td>
</tr>
<tr>
<td>NUMBER(5,2)</td>
<td>123.45678</td>
<td>123.46</td>
</tr>
<tr>
<td>NUMBER(7,-3)</td>
<td>123432.54</td>
<td>123000</td>
</tr>
<tr>
<td>NUMBER(5,2)</td>
<td>1234.56</td>
<td>error</td>
</tr>
</tbody>
</table>
**SAMPLE DATABASE**

Our company is a hardware/software retailer with stores in several cities.

We keep track of each person's name, address, and phone. In addition, if a person is an employee, we must record the store in which he or she works, the supervisor's ID, the employees's title, pay amount, and compensation type ("Hourly," "Salaried," etc.)

Sometimes a customer will fill out an order, which requires an invoice number. Each invoice lists the store and the customer's ID. We record the quantity of each item on the invoice and any discount for that item. We also keep track of how much the customer has paid on the order.

When a credit account is used for an order, the balance for the account must be updated to reflect the total amount of the invoice (including tax). The salesperson verifies (with a phone call) that the person is a valid user of the account.

Each product we sell has a product ID and description. In addition, we keep track of the vendor from whom we purchase that product, the ID for that product, and the category ("Software," "Peripheral," or "Service"). We also store the address, phone, and sales rep ID for each individual vendor.

We keep track of how many items are on hand at each store and how many each store has on order. When an item is sold, the inventory is updated.

We maintain the address, phone number, and manager ID for each store. Each store has a unique store number. We record the sales tax rate for that store.

When a store runs low on a product, we create a purchase order. Each purchase order in our company has a unique PO number. A PO is sent to a single vendor, from which we might be ordering several items, each at a specific unit cost. The inventory reflects the sale or order of any item in a store.
ACCOUNT
- ACCOUNT_NUMBER
- ACCOUNT_NAME
- ACCOUNT_TYPE_CODE
- CUSTOMER_ID
- CREDIT_LIMIT
- BALANCE
- STREET
- CITY
- STATE

ACCOUNT_TYPE
- ACCOUNT_TYPE_CODE
- ACCOUNT_TYPE_NAME
- INITIAL_DISCOUNT

PERSON
- ID
- LASTNAME
- FIRSTNAME
- MI
- STREET
- CITY
- STATE
- ZIP
- AREA_CODE
- PHONE_NUMBER

EMPLOYEE
- ID
- STORE_NUMBER
- PAY_TYPE_CODE
- PAY_TYPE_NAME
- MINIMUM_WAGE
- TITLE
- SUPERVISOR_ID

PAY_TYPE
- PAY_TYPE_CODE
- PAY_TYPE_NAME
- MINIMUM_WAGE

STORE
- STORE_NUMBER
- MANAGER_ID
- STREET
- CITY
- STATE
- ZIP
- AREA_CODE
- PHONE_NUMBER
- SALES_TAX_RATE

INVOICE
- INVOICE_NUMBER
- STORE_NUMBER
- CUSTOMER_ID
- ACCOUNT_NUMBER
- ORDER_DATE
- EST_DELIVERY_DATE
- DELIVERY_DATE
- AMOUNT_DUE

PRODUCT
- PRODUCT_ID
- DESCRIPTION
- VENDOR_ID
- VENDOR_PART_NUMBER
- PRICE
- REORDER_THRESHOLD
- WARRANTY_TEXT
- PRODUCT_IMAGE

INVENTORY
- PRODUCT_ID
- STORE_NUMBER
- QUANTITY_ON_HAND
- QUANTITY_ON_ORDER

PO_HEADER
- PO_NUMBER
- VENDOR_ID
- STORE_NUMBER
- ORDER_DATE
- TAX_RATE

PO_ITEM
- VENDOR_ID
- UNIT_COST
- PRODUCT_ID

VENDOR
- VENDOR_ID
- NAME
- VENDOR_REP_ID
- STREET
- CITY
- STATE
- ZIP
- COUNTRY

PRODUCT_CATEGORY
- PRODUCT_CATEGORY_CODE
- PRODUCT_CATEGORY_NAME

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<table>
<thead>
<tr>
<th>Table Name</th>
<th>Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSON</td>
<td>ID NUMBER, LASTNAME VARCHAR2(25), FIRSTNAME VARCHAR2(15), MI CHAR(1), STREET VARCHAR2(45), CITY VARCHAR2(25), STATE CHAR(2), ZIP CHAR(9), AREA_CODE CHAR(3), PHONE_NUMBER CHAR(7)</td>
</tr>
<tr>
<td>EMPLOYEE</td>
<td>ID NUMBER, STORE_NUMBER NUMBER, PAY_TYPE_CODE CHAR(1), PAY_TYPE_NAME VARCHAR2(15), MINIMUM_WAGE NUMBER(9,2), TITLE VARCHAR2(15), SUPERVISOR_ID NUMBER</td>
</tr>
<tr>
<td>ACCOUNT</td>
<td>PAY_TYPE_CODE CHAR(1), PAY_TYPE_NAME VARCHAR2(15), MINIMUM_WAGE NUMBER(9,2), ID NUMBER</td>
</tr>
<tr>
<td>ACCOUNT_TYPE</td>
<td>ACCOUNT_TYPE_CODE CHAR(1), ACCOUNT_TYPE_NAME VARCHAR2(15), INITIAL_DISCOUNT NUMBER(3,3)</td>
</tr>
<tr>
<td>ACCOUNT_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ACCOUNT_NAME</td>
<td>VARCHAR2(25)</td>
</tr>
<tr>
<td>ACCOUNT_TYPE_CODE</td>
<td>CHAR(1)</td>
</tr>
<tr>
<td>CREDIT_LIMIT</td>
<td>NUMBER(9,2)</td>
</tr>
<tr>
<td>BALANCE</td>
<td>NUMBER(9,2)</td>
</tr>
<tr>
<td>STREET</td>
<td>VARCHAR2(45)</td>
</tr>
<tr>
<td>CITY</td>
<td>VARCHAR2(25)</td>
</tr>
<tr>
<td>STATE</td>
<td>CHAR(2)</td>
</tr>
<tr>
<td>Zip</td>
<td>CHAR(9)</td>
</tr>
<tr>
<td>AREA_CODE</td>
<td>CHAR(3)</td>
</tr>
<tr>
<td>PHONE_NUMBER</td>
<td>CHAR(7)</td>
</tr>
<tr>
<td>ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>STORE NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>MANAGER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>STREET</td>
<td>VARCHAR2(45)</td>
</tr>
<tr>
<td>CITY</td>
<td>VARCHAR2(25)</td>
</tr>
<tr>
<td>STATE</td>
<td>CHAR(2)</td>
</tr>
<tr>
<td>ZIP</td>
<td>CHAR(9)</td>
</tr>
<tr>
<td>AREA_CODE</td>
<td>CHAR(3)</td>
</tr>
<tr>
<td>PHONE_NUMBER</td>
<td>CHAR(7)</td>
</tr>
<tr>
<td>ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>STORE_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>PRODUCT_ID</td>
<td>VARCHAR2(11)</td>
</tr>
<tr>
<td>STORE_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>QUANTITY_ON_HAND</td>
<td>NUMBER</td>
</tr>
<tr>
<td>QUANTITY_ON_ORDER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>INVOICE_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>STORE_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>CUSTOMER_ID</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ACCOUNT_NUMBER</td>
<td>NUMBER</td>
</tr>
<tr>
<td>ORDER_DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>EST_DELIVERY_DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>DELIVERY_DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>AMOUNT_DUE</td>
<td>NUMBER(9,2)</td>
</tr>
<tr>
<td>ORDER_HEADER</td>
<td>INVOICE_NUMBER NUMBER, STORE_NUMBER NUMBER, CUSTOMER_ID NUMBER, ACCOUNT_NUMBER NUMBER, ORDER_DATE DATE, EST_DELIVERY_DATE DATE, DELIVERY_DATE DATE, AMOUNT_DUE NUMBER(9,2)</td>
</tr>
<tr>
<td>ORDER_ITEM</td>
<td>INVOICE_NUMBER NUMBER, PRODUCT_ID VARCHAR2(11), QUANTITY NUMBER, DISCOUNT NUMBER(3,3)</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>PRODUCT_ID VARCHAR2(11), DESCRIPTION VARCHAR2(75), VENDOR_ID VARCHAR2(4), VENDOR_PART_NUMBER VARCHAR2(20), PRICE NUMBER(9,2), REORDER_THRESHOLD NUMBER, PRODUCT_CATEGORY_CODE CHAR(1), WARRANTY_TEXT CLOB, PRODUCT_IMAGE BLOB</td>
</tr>
<tr>
<td>PRODUCT_CATEGORY</td>
<td>PRODUCT_CATEGORY_CODE CHAR(1), PRODUCT_CATEGORY_NAME VARCHAR2(15)</td>
</tr>
<tr>
<td>STORE</td>
<td>STORE_NUMBER NUMBER, MANAGER_ID NUMBER, STREET VARCHAR2(45), CITY VARCHAR2(25), STATE CHAR(2), ZIP CHAR(9), AREA_CODE CHAR(3), PHONE_NUMBER CHAR(7)</td>
</tr>
<tr>
<td>VENDOR</td>
<td>VENDOR_ID VARCHAR2(4), NAME VARCHAR2(40), VENDOR_REP_ID NUMBER, STREET VARCHAR2(45), CITY VARCHAR2(25), STATE CHAR(2), ZIP CHAR(9), COUNTRY VARCHAR2(15), AREA_CODE CHAR(3), PHONE_NUMBER CHAR(7)</td>
</tr>
</tbody>
</table>

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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

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAR(size)</td>
<td>Fixed-length character set data of size length. Default size is 1.</td>
<td>2000 bytes</td>
</tr>
<tr>
<td>NCHAR(size)</td>
<td>Fixed-length unicode-only datatype. National character set determines the max length of the column. Default size is 1.</td>
<td>2000 bytes</td>
</tr>
<tr>
<td>VARCHAR2(size)</td>
<td>Variable-length character string with max size of size bytes. Must specify size.</td>
<td>4000 bytes</td>
</tr>
<tr>
<td>NVARCHAR2(size)</td>
<td>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.</td>
<td>4000 bytes</td>
</tr>
<tr>
<td>CLOB</td>
<td>Character Large Object.</td>
<td>4GB*DB_BLOCK_SIZE</td>
</tr>
<tr>
<td>NCLOB</td>
<td>National Character Large Object containing Unicode. National character set determines the max length of the column.</td>
<td>4GB*DB_BLOCK_SIZE</td>
</tr>
<tr>
<td>LONG (deprecated)</td>
<td>Variable-length character data. Use CLOB instead.</td>
<td>2GB</td>
</tr>
</tbody>
</table>

### Numeric Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER(p,s)</td>
<td>Number with precision of p and scale of s. Must be integer if only p is provided.</td>
<td>Precision is 38, Scale is -84 to 127.</td>
</tr>
<tr>
<td>BINARY_FLOAT</td>
<td>32-bit, single-precision floating-point number.</td>
<td>Fixed in length - requires 5 bytes of storage.</td>
</tr>
<tr>
<td>BINARY_DOUBLE</td>
<td>Double-precision floating-point number, including the bit length. Supports the values infinity and NaN(not a number).</td>
<td>Fixed in length - requires 9 bytes of storage.</td>
</tr>
</tbody>
</table>

### Binary Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAW(size)</td>
<td>Binary data of size bytes. Size must be specified.</td>
<td>2000 bytes</td>
</tr>
<tr>
<td>BLOB</td>
<td>Binary Large Object.</td>
<td>4GB*DB_BLOCK_SIZE</td>
</tr>
<tr>
<td>BFILE</td>
<td>Reference to a binary file on disk.</td>
<td>4GB</td>
</tr>
<tr>
<td>LONG RAW (deprecated)</td>
<td>Binary data of variable length. Use BLOB instead.</td>
<td>2GB</td>
</tr>
</tbody>
</table>

### Date Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>Date range.</td>
<td>From Jan 1, 4712BC to Dec 31, 9999AD.</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>All the information contained in date, plus fractional_seconds – the number of digits in the fractional part of the SECONDS datetime field.</td>
<td>fractional_seconds may be 0-9, default is 6.</td>
</tr>
<tr>
<td>TIMESTAMP (fractional_seconds) WITH TIME ZONE</td>
<td>Same as above, with timezone displacement value.</td>
<td>0-9, default is 6.</td>
</tr>
<tr>
<td>INTERVAL YEAR (year_precision) TO MONTH</td>
<td>Period of time in years and months. year_precision is number of digits in YEAR datetime field.</td>
<td>0-9, default is 2.</td>
</tr>
<tr>
<td>INTERVAL DAY (day_precision) TO SECOND (fractional_seconds)</td>
<td>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.</td>
<td>day_precision 0-9, default is 2. fractional_seconds 0-9, default is 6.</td>
</tr>
</tbody>
</table>

### Miscellaneous Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROWID (deprecated)</td>
<td>Represents address of row in table.</td>
<td>Only physical rowids.</td>
</tr>
<tr>
<td>UROWID</td>
<td>Represents address of a row in a table.</td>
<td></td>
</tr>
</tbody>
</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-NOT 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 9i, this value will also be used for an `UPDATE` or `INSERT` where a column is set to `DEFAULT`.

```sql
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:

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

- **UNIQUE** — Unique value of column(s) in all rows. Nulls allowed.
  
  ```sql
  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.
  
  ```sql
  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.
  
  ```sql
  CHECK (condition)
  ```
  
  - NOT NULL is similar to a CHECK constraint.
    
    ```sql
    id NUMBER NOT NULL,
    ```
    
    ```sql
    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.

  ```sql
  [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;
```
**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:

```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:

\[
\text{ALTER TABLE } \text{table}_\text{name} \text{ action}
\]

* action may be any of the following:

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

  \[
  \text{ADD } \text{column}_\text{name} \text{ column}_\text{definition}
  \]

  \[
  \text{RENAME COLUMN } \text{column}_\text{name} \text{ TO } \text{new}_\text{column}_\text{name}
  \]

  \[
  \text{DROP } \text{column}_\text{name} \text{ [RESTRICT | CASCADE]}
  \]

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

  \[
  \text{ADD out-of-line}_\text{constraint}_\text{definition}
  \]

  \[
  \text{DROP CONSTRAINT } \text{cons}_\text{name} \text{ [RESTRICT | CASCADE]}
  \]

- You may MODIFY the properties of a column:

  \[
  \text{MODIFY } \text{column}_\text{name} \text{ DEFAULT value}
  \]

  \[
  \text{MODIFY } \text{column}_\text{name} \text{ DEFAULT NULL}
  \]

  \[
  \text{MODIFY } \text{column}_\text{name} \text{ NOT NULL}
  \]

  \[
  \text{MODIFY } \text{column}_\text{name} \text{ } \text{datatype(size)}
  \]

* 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:

```sql
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.

```sql
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).

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

```sql
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:

```sql
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.

  \[
  \text{DROP TABLE } \text{tablename} \ [\text{CASCADE CONSTRAINTS}] \ [\text{PURGE}];
  \]

- 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 10g, dropped tables are preserved 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

1. 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)

2. 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)

3. 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)

4. 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)

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

6. (Optional) Drop the city table. Can you? How? 
   (Solution: drop_city.sql)
Oracle provides a convenient syntax 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 would 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;
```