Chapter 7:

Introduction to SQL

Objectives

- Definition of terms
- Interpret history and role of SQL
- Define a database using SQL data definition language
- Write single table queries using SQL
- Establish referential integrity using SQL
- Discuss SQL:1999 and SQL:200n standards

SQL Overview

- Structured Query Language
- The standard for relational database management systems (RDBMS)
- RDBMS: A database management system that manages data as a collection of tables in which all relationships are represented by common values in related tables

History of SQL

- 1970–E. Codd develops relational database concept
- 1974-1979–System R with Sequel (later SQL) created at IBM Research Lab
- 1979–Oracle markets first relational DB with SQL
- 1986–ANSI SQL standard released
- 1989, 1992, 1999, 2003–Major ANSI standard updates
- Current–SQL is supported by most major database vendors

Purpose of SQL Standard

- Specify syntax/semantics for data definition and manipulation
- Define data structures
- Enable portability
- Specify minimal (level 1) and complete (level 2) standards
- Allow for later growth/enhancement to standard

Benefits of a Standardized Relational Language

- Reduced training costs
- Productivity
- Application portability
- Application longevity
- Reduced dependence on a single vendor
- Cross-system communication

SQL Environment

- Catalog
  - A set of schemas that constitute the description of a database
- Schema
  - The structure that contains descriptions of objects created by a user (base tables, views, constraints)
- Data Definition Language (DDL)
  - Commands that define a database, including creating, altering, and dropping tables and establishing constraints
- Data Manipulation Language (DML)
  - Commands that maintain and query a database
- Data Control Language (DCL)
  - Commands that control a database, including administering privileges and committing data

Figure 7-1

A simplified schematic of a typical SQL environment, as described by the SQL: 200n standard

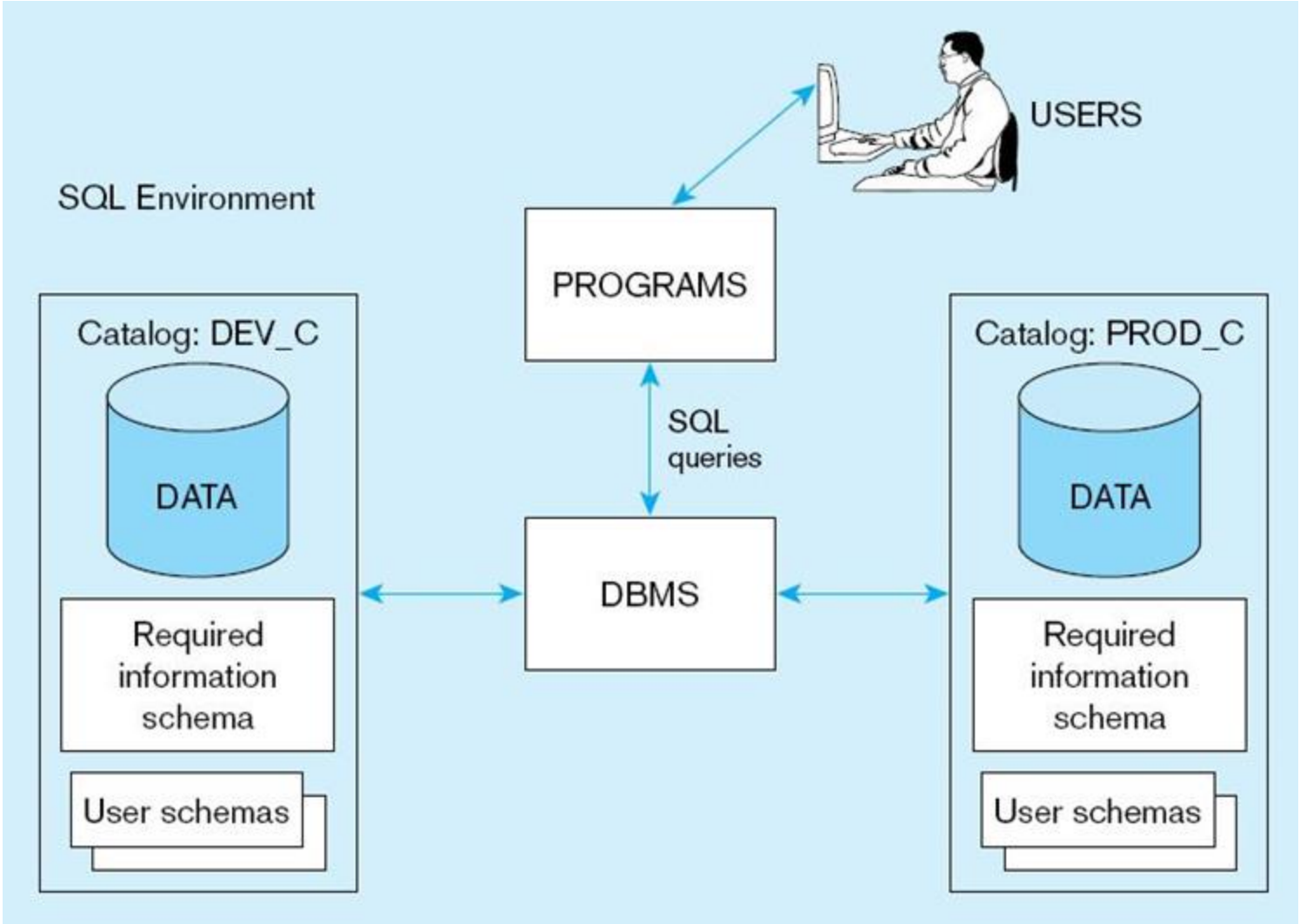
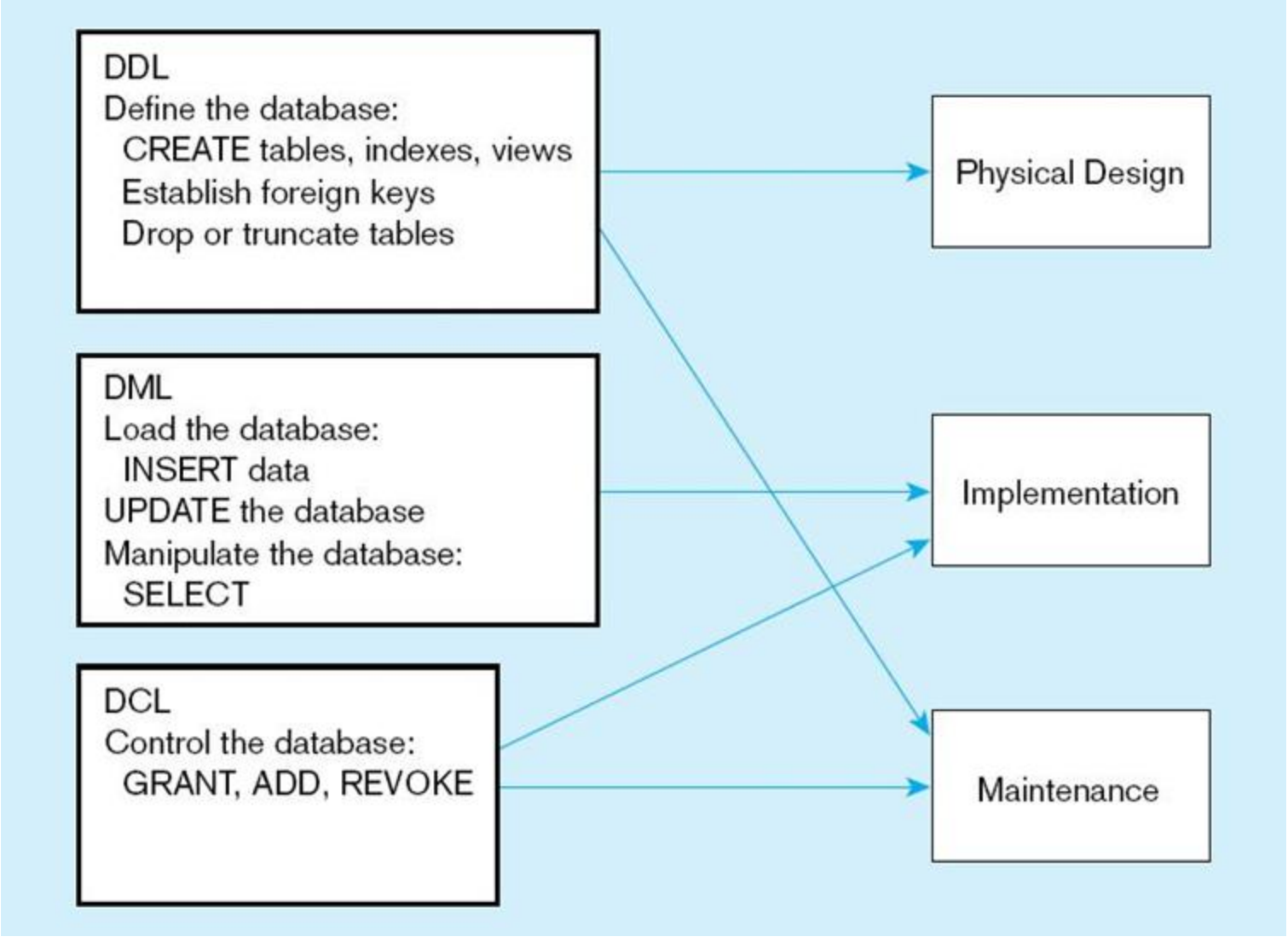


Figure 7-4

DDL, DML, DCL, and the database development process



SQL Database Definition

- Data Definition Language (DDL)
- Major CREATE statements:
  - CREATE SCHEMA–defines a portion of the database owned by a particular user
  - CREATE TABLE–defines a table and its columns
  - CREATE VIEW–defines a logical table from one or more views

Table Creation

Figure 7-5 General syntax for CREATE TABLE

```
CREATE TABLE tablename
( {column definition   [table constraint] } . , . .
[ON COMMIT {DELETE | PRESERVE} ROWS] );

where column definition ::=
column_name
        {domain name | datatype [(size)] }
        [column_constraint_clause . . .]
        [default value]
        [collate clause]

and table constraint ::=
        [CONSTRAINT constraint_name]
        Constraint_type [constraint_attributes]
```

Steps in table creation:

1. Identify data types for attributes
2. Identify columns that can and cannot be null
3. Identify columns that must be unique (candidate keys)
4. Identify primary key–foreign key mates
5. Determine default values
6. Identify constraints on columns (domain specifications)
7. Create the table and associated indexes

The following slides create tables for this enterprise data model

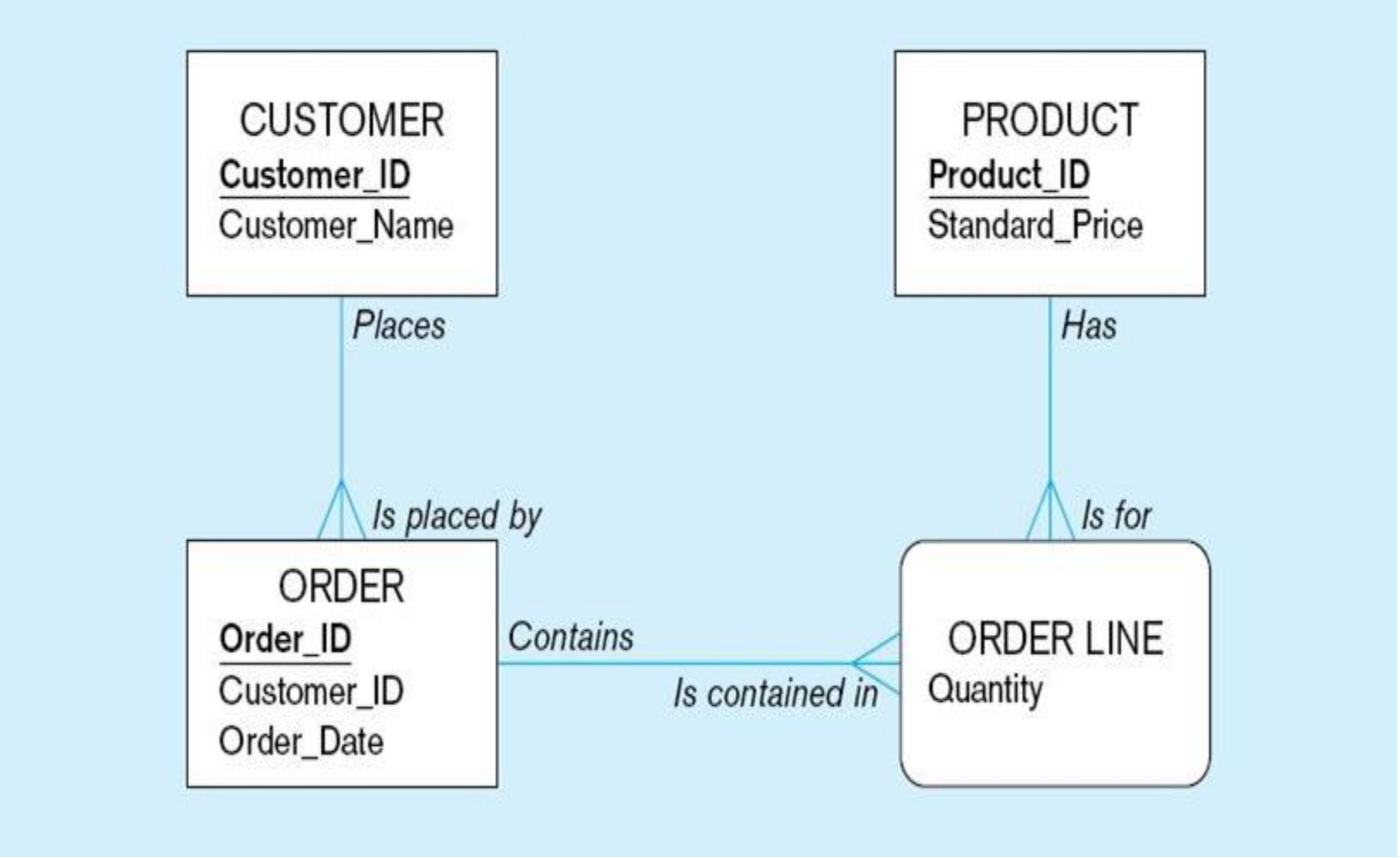


Figure 7-6 SQL database definition commands for Pine Valley Furniture

```
CREATE TABLE CUSTOMER_T
              (CUSTOMER_ID              NUMBER(11, 0) NOT NULL,
               CUSTOMER_NAME            VARCHAR2(25)  NOT NULL,
               CUSTOMER_ADDRESS         VARCHAR2(30),
               CITY                     VARCHAR2(20),
               STATE                    VARCHAR2(2),
               POSTAL_CODE              VARCHAR2(9),
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID));
```

Overall table definitions

```
CREATE TABLE ORDER_T
              (ORDER_ID                 NUMBER(11, 0) NOT NULL,
               ORDER_DATE               DATE DEFAULT SYSDATE,
               CUSTOMER_ID              NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));
```

```
CREATE TABLE PRODUCT_T
              (PRODUCT_ID               INTEGER        NOT NULL,
               PRODUCT_DESCRIPTION      VARCHAR2(50),
               PRODUCT_FINISH           VARCHAR2(20)
                        CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                'Red Oak', 'Natural Oak', 'Walnut')),
               STANDARD_PRICE           DECIMAL(6,2),
               PRODUCT_LINE_ID          INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

```
CREATE TABLE ORDER_LINE_T
              (ORDER_ID                 NUMBER(11,0)  NOT NULL,
               PRODUCT_ID               NUMBER(11,0)  NOT NULL,
               ORDERED_QUANTITY         NUMBER(11,0),
CONSTRAINT ORDER_LINE_PK PRIMARY KEY (ORDER_ID, PRODUCT_ID),
CONSTRAINT ORDER_LINE_FK1 FOREIGN KEY(ORDER_ID) REFERENCES ORDER_T(ORDER_ID),
CONSTRAINT ORDER_LINE_FK2 FOREIGN KEY (PRODUCT_ID) REFERENCES PRODUCT_T(PRODUCT_ID));
```

Defining attributes and their data types

```
CREATE TABLE PRODUCT_T
        (PRODUCT_ID             INTEGER         NOT NULL,
         PRODUCT_DESCRIPTION    VARCHAR2(50),
         PRODUCT_FINISH         VARCHAR2(20)
                        CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                'Red Oak', 'Natural Oak', 'Walnut')),
         STANDARD_PRICE         DECIMAL(6,2),
         PRODUCT_LINE_ID        INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

Non-nullable specification

```
CREATE TABLE PRODUCT_T
    (PRODUCT_ID             INTEGER      NOT NULL,
     PRODUCT_DESCRIPTION    VARCHAR2(50),
     PRODUCT_FINISH         VARCHAR2(20)
                CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                       'Red Oak', 'Natural Oak', 'Walnut')),
     STANDARD_PRICE         DECIMAL(6,2),
     PRODUCT_LINE_ID        INTEGER,
CONSTRAINT PRODUCT_PK PRIMARY KEY (PRODUCT_ID));
```

Primary keys can never have NULL values

Identifying primary key

Non-nullable specifications

```
CREATE TABLE ORDER_LINE_T
        (ORDER_ID            NUMBER(11,0) NOT NULL,
         PRODUCT_ID          NUMBER(11,0) NOT NULL,
         ORDERED_QUANTITY    NUMBER(11,0),
CONSTRAINT ORDER_LINE_PK PRIMARY KEY (ORDER_ID, PRODUCT_ID),
CONSTRAINT ORDER_LINE_FK1 FOREIGN KEY(ORDER_ID) REFERENCES ORDER_T(ORDER_ID),
CONSTRAINT ORDER_LINE_FK2 FOREIGN KEY (PRODUCT_ID) REFERENCES PRODUCT_T(PRODUCT_ID));
```

Primary key

Some primary keys are composite–
composed of multiple attributes

Controlling the values in attributes

```
CREATE TABLE ORDER_T
        (ORDER_ID           NUMBER(11, 0) NOT NULL,
         ORDER_DATE         DATE          DEFAULT SYSDATE,
         CUSTOMER_ID        NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));

CREATE TABLE PRODUCT_T
        (PRODUCT_ID         INTEGER       NOT NULL,
         PRODUCT_DESCRIPTION VARCHAR2(50),
         PRODUCT_FINISH     VARCHAR2(20)
                CHECK (PRODUCT_FINISH IN ('Cherry', 'Natural Ash', 'White Ash',
                                          'Red Oak', 'Natural Oak', 'Walnut')),
         STANDARD_PRICE     DECIMAL(6,2),
         PRODUCT_LINE_ID    INTEGER,
```

Default value

Domain constraint

Identifying foreign keys and establishing relationships

```
CREATE TABLE CUSTOMER_T
        (CUSTOMER_ID            NUMBER(11, 0) NOT NULL,
         CUSTOMER_NAME          VARCHAR2(25) NOT NULL,
         CUSTOMER_ADDRESS       VARCHAR2(30),
         CITY                   VARCHAR2(20),
         STATE                  VARCHAR2(2),
         POSTAL_CODE            VARCHAR2(9),
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID));

CREATE TABLE ORDER_T
         (ORDER_ID              NUMBER(11, 0) NOT NULL,
          ORDER_DATE            DATE          DEFAULT SYSDATE,
          CUSTOMER_ID           NUMBER(11, 0),
CONSTRAINT ORDER_PK PRIMARY KEY (ORDER_ID),
CONSTRAINT ORDER_FK FOREIGN KEY (CUSTOMER_ID) REFERENCES CUSTOMER_T(CUSTOMER_ID));
```

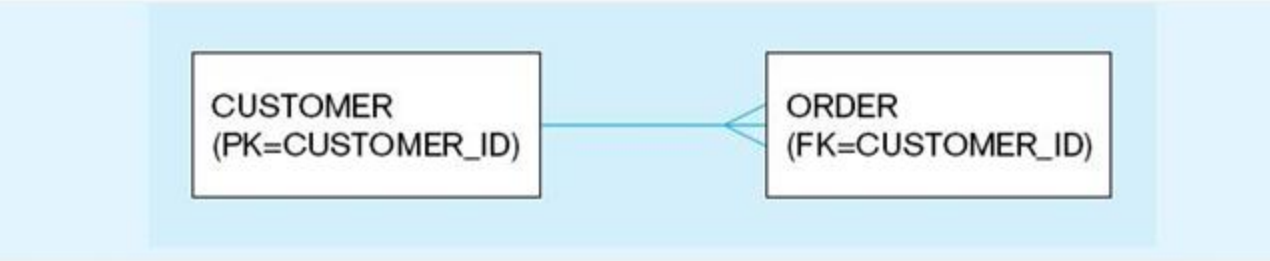
Primary key of parent table

Foreign key of dependent table

Data Integrity Controls

- Referential integrity–constraint that ensures that foreign key values of a table must match primary key values of a related table in 1:M relationships
- Restricting:
  - Deletes of primary records
  - Updates of primary records
  - Inserts of dependent records

Figure 7-7 Ensuring data integrity through updates



Restricted Update: A customer ID can only be deleted if it is not found in ORDER table.

```
CREATE TABLE CUSTOMER_T
                (CUSTOMER_ID          INTEGER DEFAULT 'C999'   NOT NULL,
                 CUSTOMER_NAME        VARCHAR(40)              NOT NULL,
                 . . .
CONSTRAINT CUSTOMER_PK PRIMARY KEY (CUSTOMER_ID),
ON UPDATE RESTRICT);
```

Cascaded Update: Changing a customer ID in the CUSTOMER table will result in that value changing in the ORDER table to match.

```
. . . ON UPDATE CASCADE);
```

Set Null Update: When a customer ID is changed, any customer ID in the ORDER table that matches the old customer ID is set to NULL.

```
. . . ON UPDATE SET NULL);
```

Set Default Update: When a customer ID is changed, any customer ID in the ORDER tables that matches the old customer ID is set to a predefined default value.

```
. . . ON UPDATE SET DEFAULT);
```

Relational integrity is enforced via the primary-key to foreign-key match

Changing and Removing Tables

- ALTER TABLE statement allows you to change column specifications:
  - ALTER TABLE CUSTOMER_T ADD (TYPE VARCHAR(2))
- DROP TABLE statement allows you to remove tables from your schema:
  - DROP TABLE CUSTOMER_T

Insert Statement

- Adds data to a table
- Inserting into a table
  - INSERT INTO CUSTOMER_T VALUES (001, 'Contemporary Casuals', '1355 S. Himes Blvd.', 'Gainesville', 'FL', 32601);
- Inserting a record that has some null attributes requires identifying the fields that actually get data
  - INSERT INTO PRODUCT_T (PRODUCT_ID, PRODUCT_DESCRIPTION,PRODUCT_FINISH, STANDARD_PRICE, PRODUCT_ON_HAND) VALUES (1, 'End Table', 'Cherry', 175, 8);
- Inserting from another table
  - INSERT INTO CA_CUSTOMER_T SELECT * FROM CUSTOMER_T WHERE STATE = 'CA';

Delete Statement

- Removes rows from a table
- Delete certain rows
  - DELETE FROM CUSTOMER_T WHERE STATE = 'HI';
- Delete all rows
  - DELETE FROM CUSTOMER_T;

Update Statement

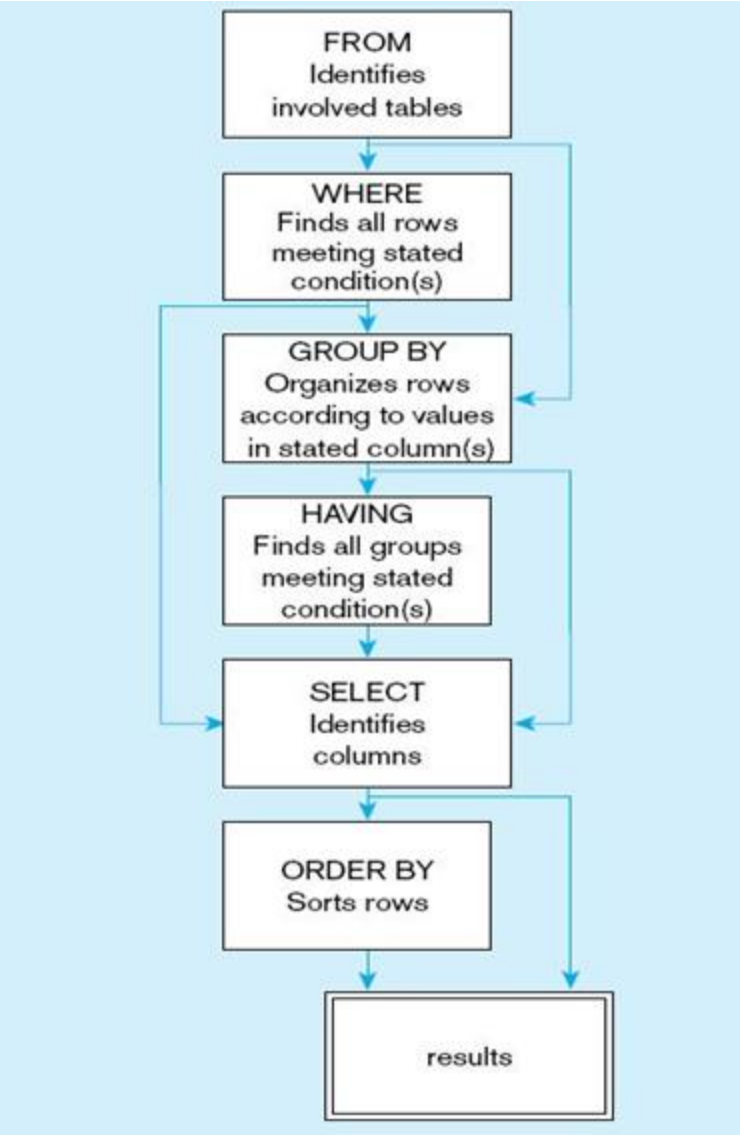
- Modifies data in existing rows

- UPDATE PRODUCT_T SET UNIT_PRICE = 775
  WHERE PRODUCT_ID = 7;

SELECT Statement

- Used for queries on single or multiple tables
- Clauses of the SELECT statement:
  - SELECT
    - List the columns (and expressions) that should be returned from the query
  - FROM
    - Indicate the table(s) or view(s) from which data will be obtained
  - WHERE
    - Indicate the conditions under which a row will be included in the result
  - GROUP BY
    - Indicate categorization of results
  - HAVING
    - Indicate the conditions under which a category (group) will be included
  - ORDER BY
    - Sorts the result according to specified criteria

Figure 7-10
SQL statement processing order (adapted from van der Lans, p.100)



SELECT Example

- Find products with standard price less than $275

```
SELECT PRODUCT_NAME, STANDARD_PRICE
  FROM PRODUCT_V
  WHERE STANDARD_PRICE < 275;
```

Table 7-3: Comparison Operators in SQL

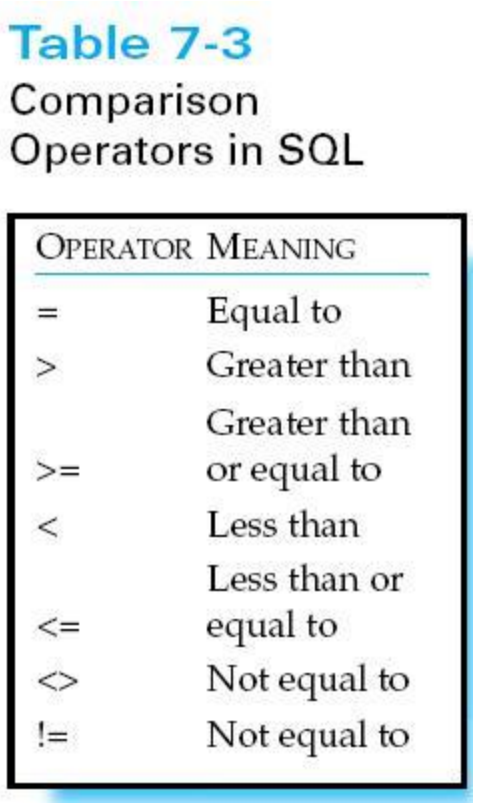


Table 7-3
Comparison Operators in SQL

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

SELECT Example Using Alias

- Alias is an alternative column or table name

```
SELECT CUST.CUSTOMER AS NAME,
       CUST.CUSTOMER_ADDRESS
FROM CUSTOMER_V CUST
       WHERE NAME = 'Home Furnishings';
```

SELECT Example Using a Function

- Using the COUNT ***aggregate function*** to find totals

```
SELECT COUNT(*) FROM ORDER_LINE_V
    WHERE ORDER_ID = 1004;
```

Note: with aggregate functions you can't have single-valued columns included in the SELECT clause

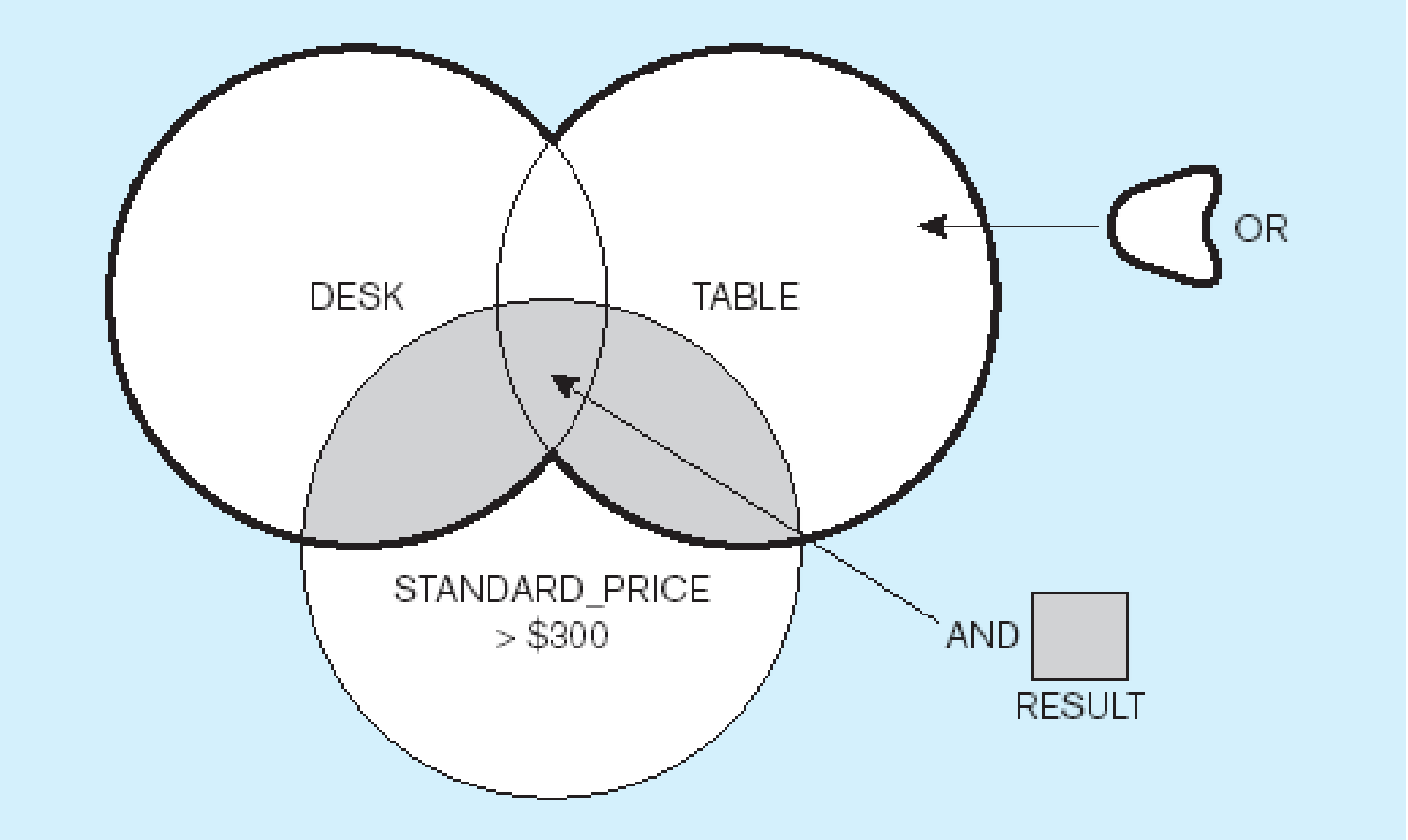
SELECT Example–Boolean Operators

- AND, OR, and NOT Operators for customizing conditions in WHERE clause

```
SELECT PRODUCT_DESCRIPTION, PRODUCT_FINISH, STANDARD_PRICE
FROM PRODUCT_V
   WHERE (PRODUCT_DESCRIPTION LIKE '%Desk'
   OR PRODUCT_DESCRIPTION LIKE '%Table')
   AND STANDARD_PRICE > 300;
```

Note: the LIKE operator allows you to compare strings using wildcards. For example, the % wildcard in '%Desk' indicates that all strings that have any number of characters preceding the word "Desk" will be allowed

Venn Diagram from Previous Query



SELECT Example – Sorting Results with the ORDER BY Clause

- Sort the results first by STATE, and within a state by CUSTOMER_NAME

```
SELECT CUSTOMER_NAME, CITY, STATE
    FROM CUSTOMER_V
    WHERE STATE IN ('FL', 'TX', 'CA', 'HI')
    ORDER BY STATE, CUSTOMER_NAME;
```

Note: the IN operator in this example allows you to include rows whose STATE value is either FL, TX, CA, or HI. It is more efficient than separate OR conditions

SELECT Example– Categorizing Results Using the GROUP BY Clause

- For use with aggregate functions
  - ***Scalar aggregate***: single value returned from SQL query with aggregate function
  - ***Vector aggregate***: multiple values returned from SQL query with aggregate function (via GROUP BY)

```
SELECT CUSTOMER_STATE, COUNT(CUSTOMER_STATE)
    FROM CUSTOMER_V
    GROUP BY CUSTOMER_STATE;
```

Note: you can use single-value fields with aggregate functions if they are included in the GROUP BY clause

SELECT Example– Qualifying Results by Categories Using the HAVING Clause

- For use with GROUP BY

```
SELECT CUSTOMER_STATE, COUNT(CUSTOMER_STATE)
    FROM CUSTOMER_V
    GROUP BY CUSTOMER_STATE
    HAVING COUNT(CUSTOMER_STATE) > 1;
```

Like a WHERE clause, but it operates on groups (categories), not on individual rows. Here, only those groups with total numbers greater than 1 will be included in final result

Using and Defining Views

- Views provide users controlled access to tables
- Base Table–table containing the raw data
- Dynamic View
  - A "virtual table" created dynamically upon request by a user
  - No data actually stored; instead data from base table made available to user
  - Based on SQL SELECT statement on base tables or other views
- Materialized View
  - Copy or replication of data
  - Data actually stored
  - Must be refreshed periodically to match the corresponding base tables

Sample CREATE VIEW

```
CREATE VIEW EXPENSIVE_STUFF_V AS
SELECT PRODUCT_ID, PRODUCT_NAME, UNIT_PRICE
FROM PRODUCT_T
WHERE UNIT_PRICE >300;
```

- View has a name
- View is based on a SELECT statement

Advantages of Views

- Simplify query commands
- Assist with data security (but don't rely on views for security, there are more important security measures)
- Enhance programming productivity
- Contain most current base table data
- Use little storage space
- Provide customized view for user
- Establish physical data independence

Disadvantages of Views

- Use processing time each time view is referenced
- May or may not be directly updateable