# COP 4710: Database Systems
# Spring 2007

## Chapter 5 – Introduction To SQL – Part 1


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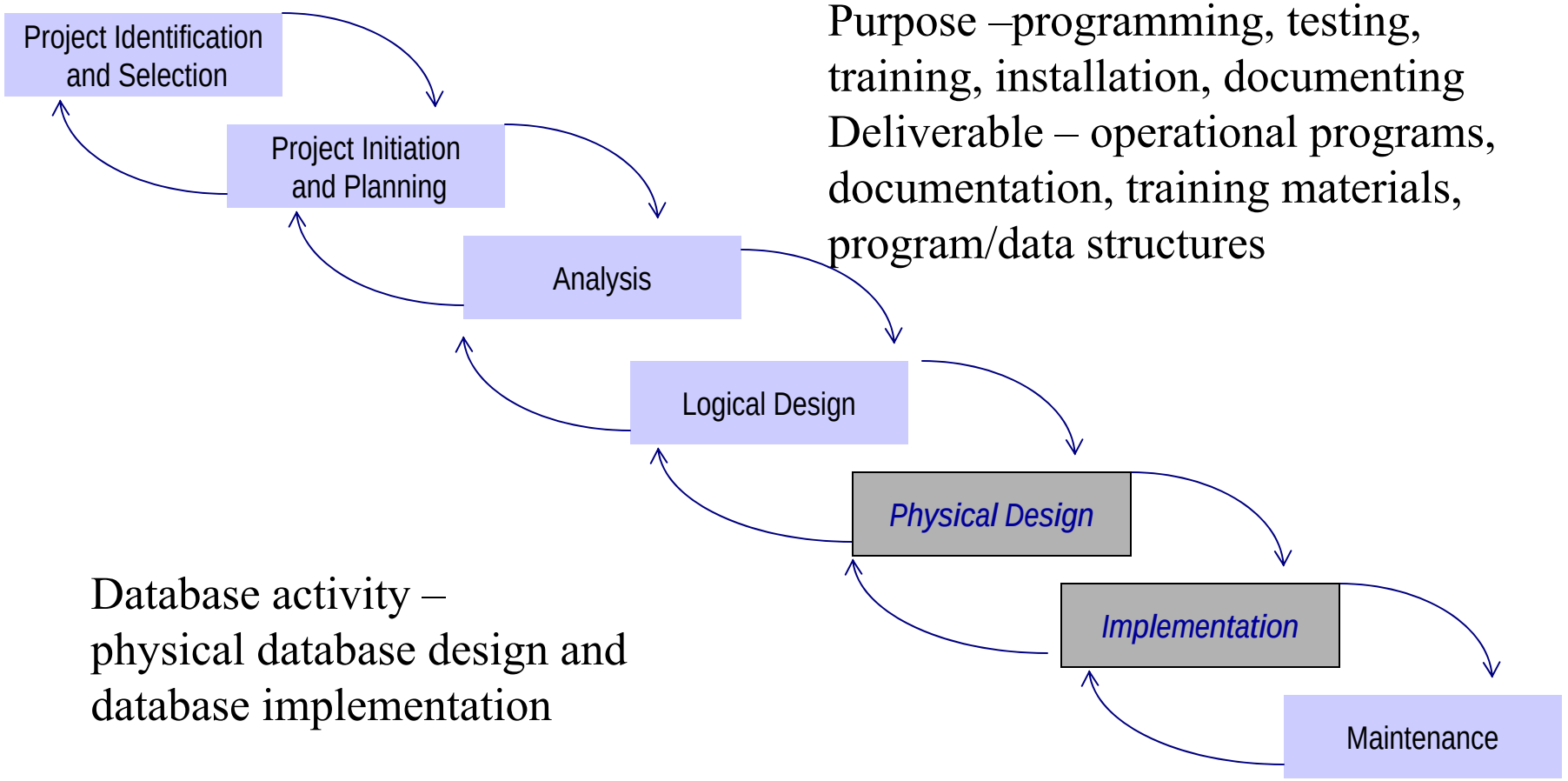
# The Physical Design Stage of SDLC




Purpose –programming, testing, training, installation, documenting
Deliverable – operational programs, documentation, training materials, program/data structures

Database activity – physical database design and database implementation



# SQL Overview

- SQL ≡ Structured Query Language.
- The standard for relational database management systems (RDBMS).
- SQL-99 and SQL: 2003 Standards – Purpose:
  - 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

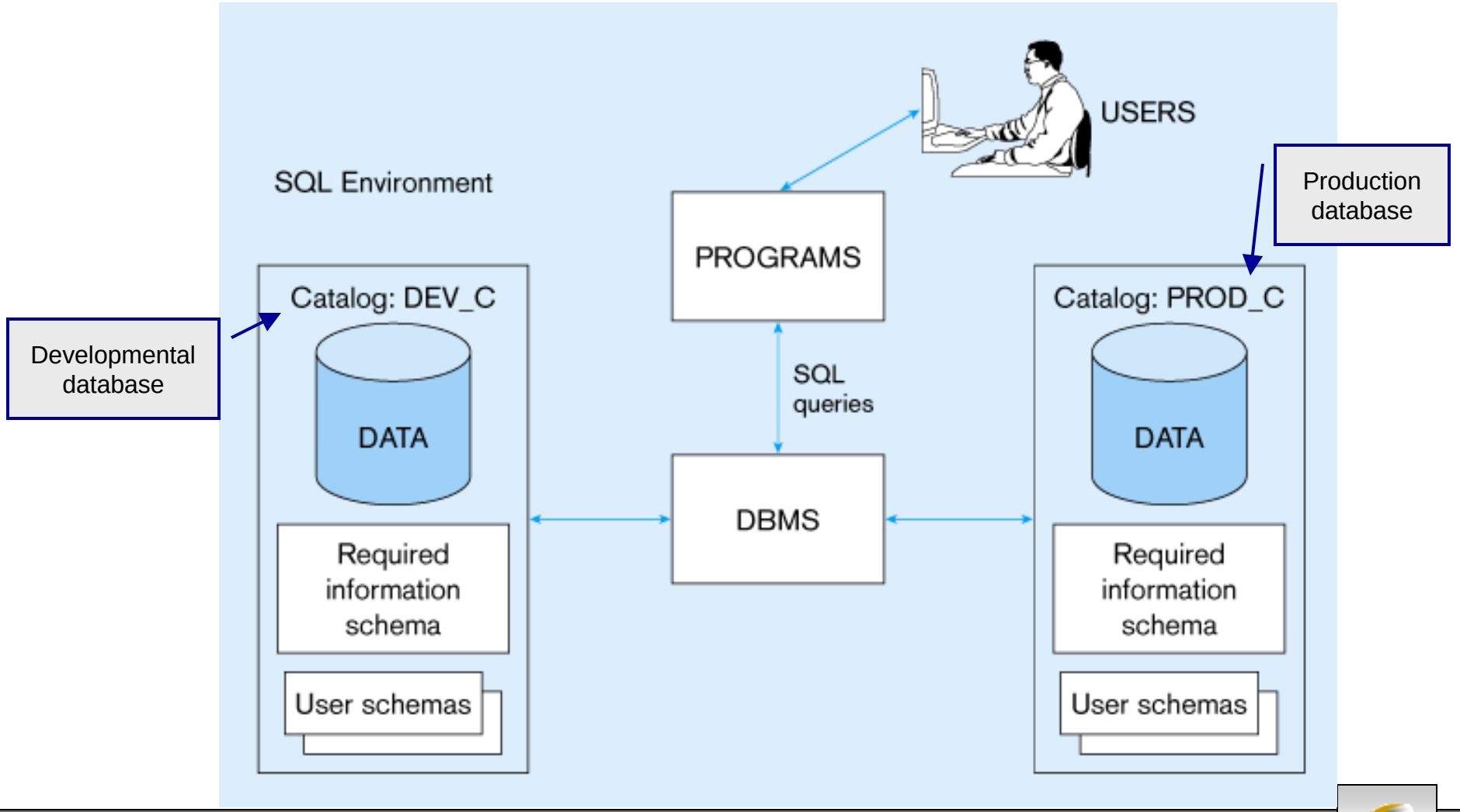


# The SQL Environment

- 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.



# A simplified schematic of a typical SQL environment, as described by the SQL:2003 standard



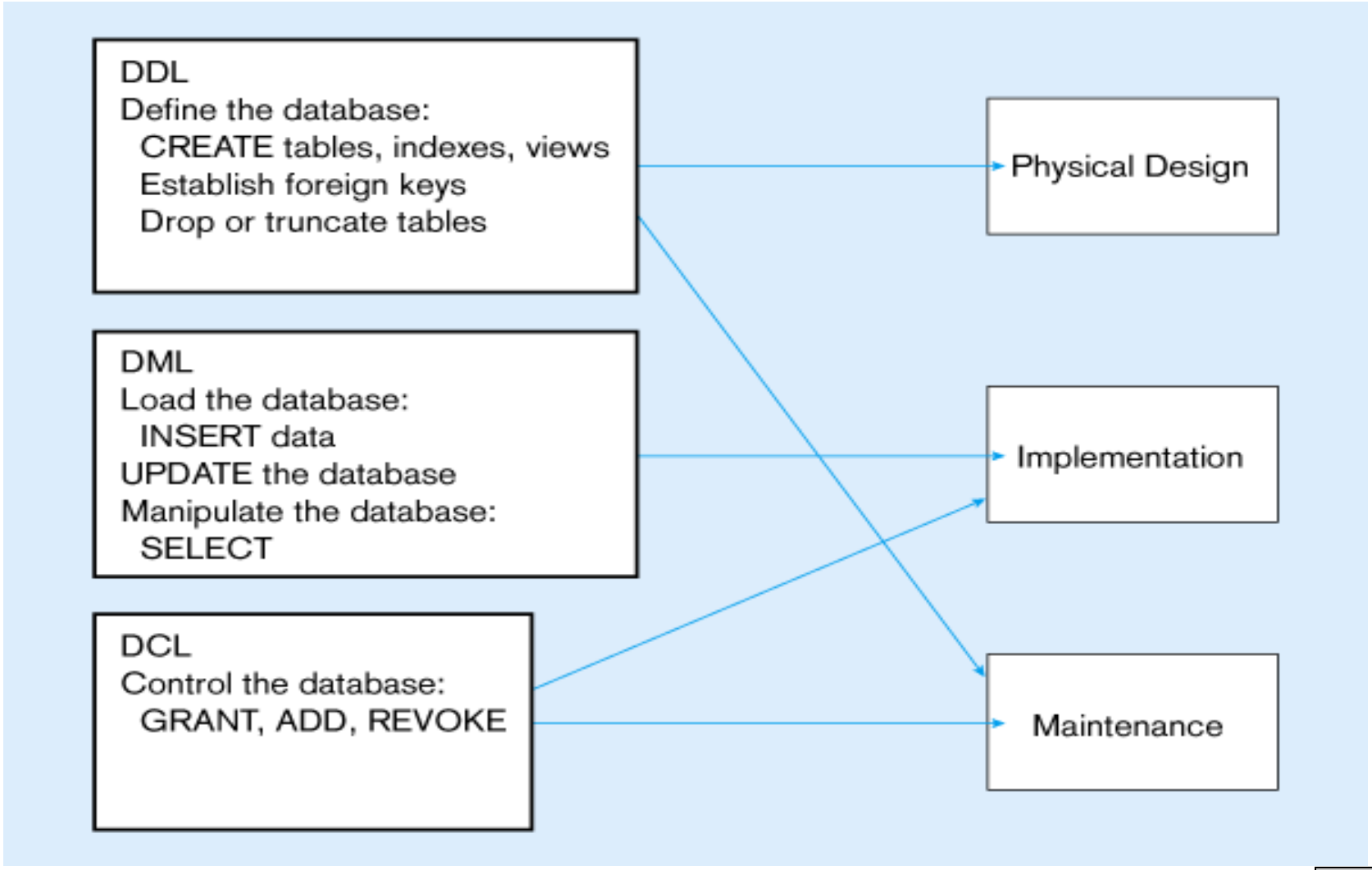



# Some SQL Data Types (from Oracle 9i)

- String types
  - CHAR(n) – fixed-length character data, n characters long Maximum length = 2000 bytes
  - VARCHAR2(n) – variable length character data, maximum 4000 bytes
  - LONG – variable-length character data, up to 4GB. Maximum 1 per table
- Numeric types
  - NUMBER(p,q) – general purpose numeric data type
  - INTEGER(p) – signed integer, p digits wide
  - FLOAT(p) – floating point in scientific notation with p binary digits precision
- Date/time type
  - DATE – fixed-length date/time in dd-mm-yy form



# 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.
- Other CREATE statements: CHARACTER SET, COLLATION, TRANSLATION, ASSERTION, DOMAIN.



# Table Creation

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

# Examples of SQL database definition commands

```
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));
```

```
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));
```

Domain constraint



```
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-null specification

Identifying primary key

Primary keys can never have NULL values



```
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));
```

Non-null specifications

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

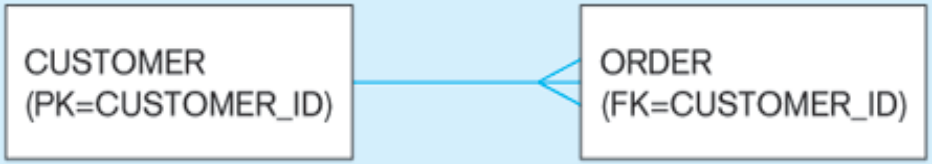
Foreign key of dependent table



# 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.






**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



# Schema Definition

- Control processing/storage efficiency:
  - Choice of indexes
  - File organizations for base tables
  - File organizations for indexes
  - Data clustering
  - Statistics maintenance
- Creating indexes
  - Speed up random/sequential access to base table data
  - Example
    - CREATE INDEX NAME_IDX ON CUSTOMER_T(CUSTOMER_NAME)
    - This makes an index for the CUSTOMER_NAME field of the CUSTOMER_T table



# 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;

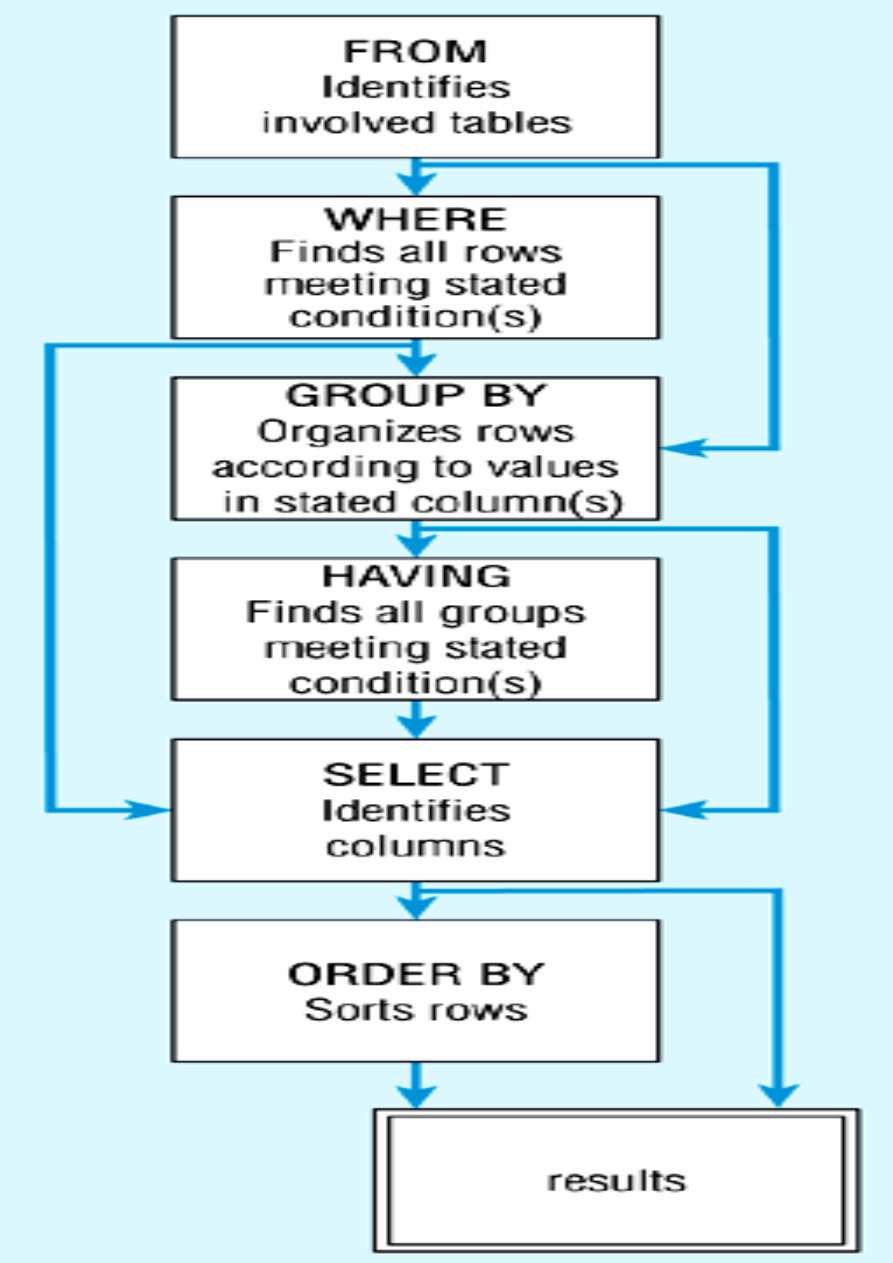


# SELECT Statement

- 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



# SQL statement processing order






# SELECT Example

- Find products with standard price less than $275

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



# 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 UNIT_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



# 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 STATE, COUNT(STATE)
FROM CUSTOMER_V
GROUP BY 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 Category Using the HAVING Clause

- For use with GROUP BY

```
SELECT STATE, COUNT(STATE)
FROM CUSTOMER_V
GROUP BY STATE
HAVING COUNT(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