ENSF 608: SQL

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Fall 2021

Textbook: Fundamentals of Database Systems, 7th Ed., Elmasri & Navathe

Learning Objectives

- SQL Data Definition and Data Types
- Specifying Constraints in SQL
- Basic Retrieval Queries in SQL
- `INSERT`, `DELETE`, and `UPDATE` Statements in SQL
- Additional Features of SQL
- More Complex SQL Retrieval Queries
- Specifying Semantic Constraints as Assertions and Actions as Triggers
- Views (Virtual Tables) in SQL
- Schema Modification in SQL

Basic SQL

- SQL language
  - Considered one of the major reasons for the commercial success of relational databases
- SQL
  - The origin of SQL is relational predicate calculus called tuple calculus (see Chapter 8) which was proposed initially as the language SQUARE.
  - SQL Actually comes from the word “SEQUEL” which was the original term used in the paper: “SEQUEL TO SQUARE” by Chamberlin and Boyce. IBM could not copyright that term, so they abbreviated to SQL and copyrighted the term SQL.
  - Now popularly known as “Structured Query language”.
  - SQL is an informal or practical rendering of the relational data model with syntax

SQL Data Definition, Data Types, Standards

- Terminology:
  - **Table**, **row**, and **column** used for relational model terms relation, tuple, and attribute
- `CREATE` statement
  - Main SQL command for data definition
- The language has features for: Data definition, Data Manipulation, Transaction control (Transact-SQL, Ch 20), Indexing (Ch 17), Security specification (Grant and Revoke- see Ch 30), Active databases (Ch 26), Multi-media (Ch 26), Distributed databases (Ch 23) etc.

Schema and Catalog Concepts in SQL (1 of 2)

- We cover the basic standard SQL syntax – there are variations in existing RDBMS systems
- **SQL schema**
  - Identified by a **schema name**
  - Includes an **authorization identifier** and **descriptors** for each element
- **Schema elements** include
  - Tables, constraints, views, domains, and other constructs
- Each statement in SQL ends with a **semicolon**

Schema and Catalog Concepts in SQL (2 of 2)

- `CREATE SCHEMA` statement
  - `CREATE SCHEMA COMPANY AUTHORIZATION ‘Jsmith’;`
- **Catalog**
  - Named collection of schemas in an SQL environment
- SQL also has the concept of a cluster of catalogs.

The CREATE TABLE Command in SQL (1 of 3)

- Specifying a new relation
  - Provide name of table
  - Specify attributes, their types and initial constraints
- Can optionally specify schema:
  - `CREATE TABLE COMPANY.EMPLOYEE ...`

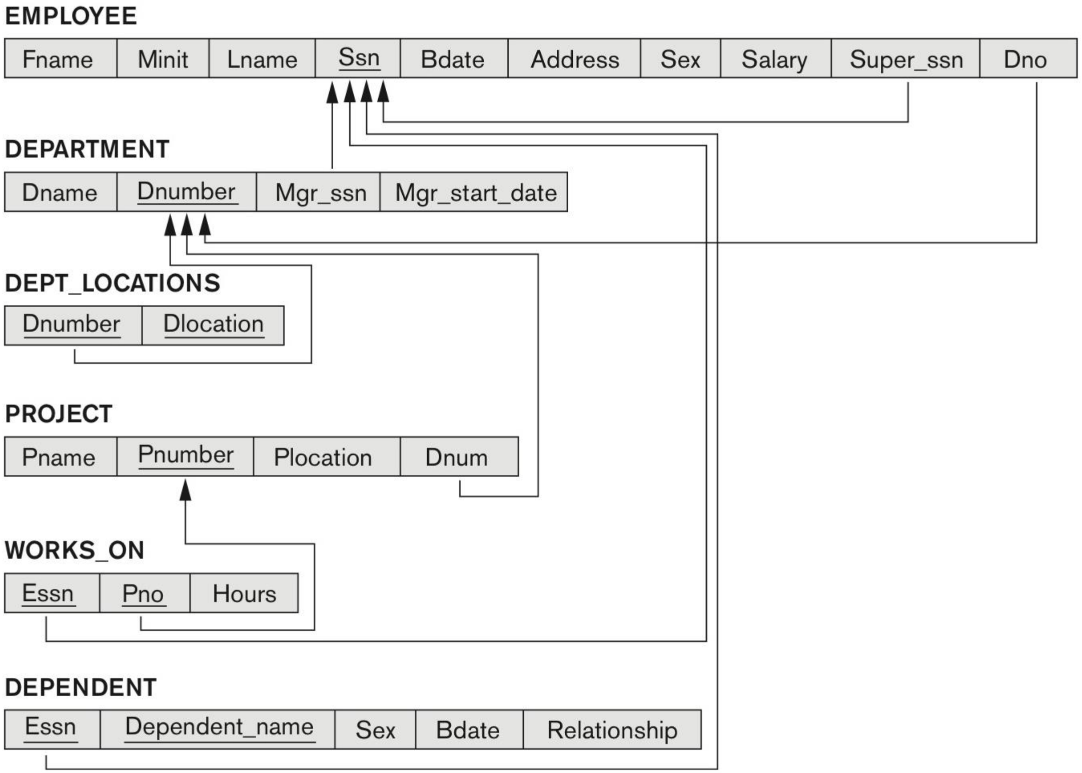
    or
  - `CREATE TABLE EMPLOYEE ...`

The CREATE TABLE Command in SQL (2 of 3)

- **Base tables (base relations)**
  - Relation and its tuples are actually created and stored as a file by the DBMS
- **Virtual relations (views)**
  - Created through the `CREATE VIEW` statement. Do not correspond to any physical file.

COMPANY Relational Database Schema

Figure 5.7 Referential integrity constraints displayed on the COMPANY relational database schema.



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

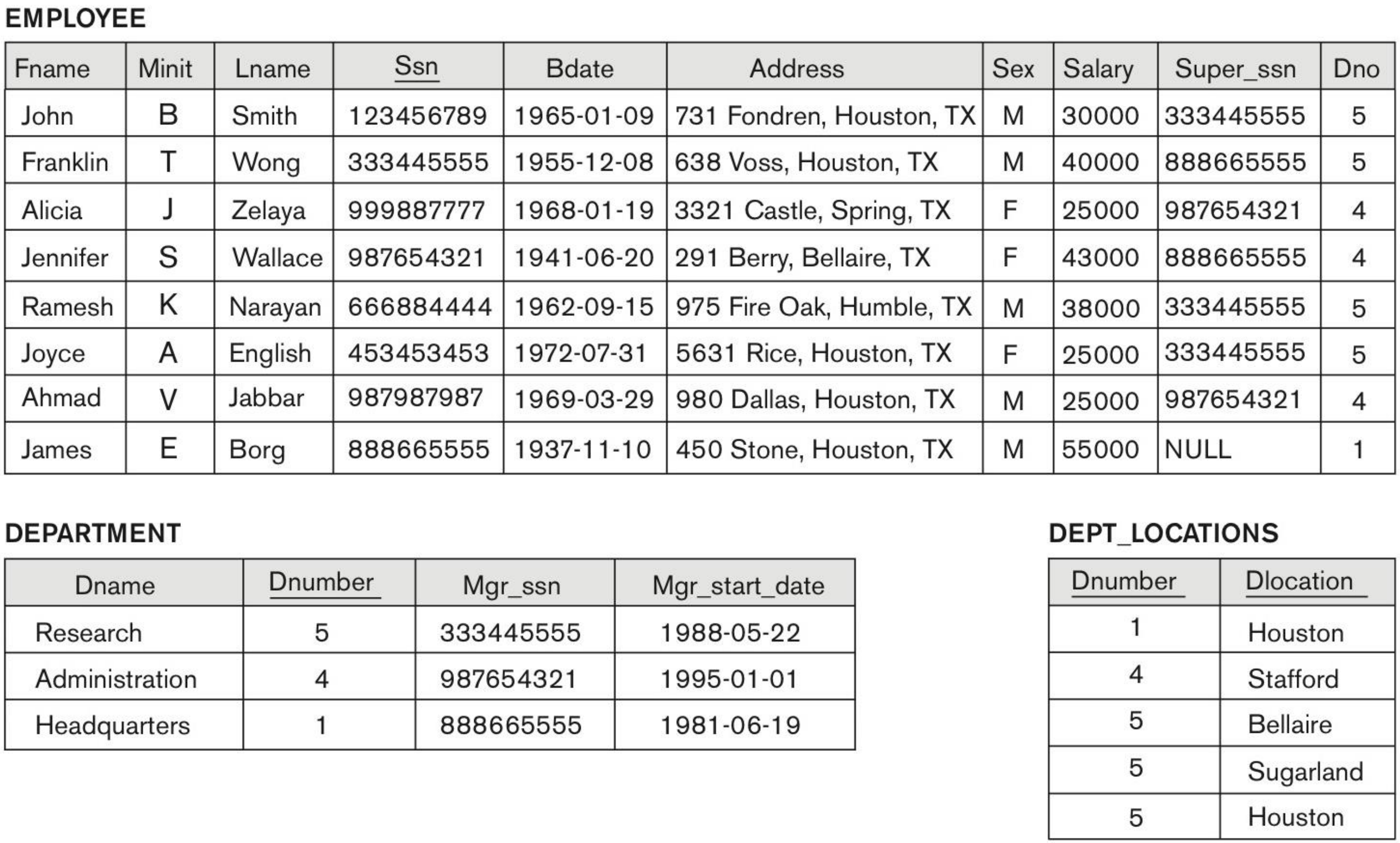
WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Figure 5.6 One Possible Database State for the COMPANY Relational Database Schema (1 of 2)



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

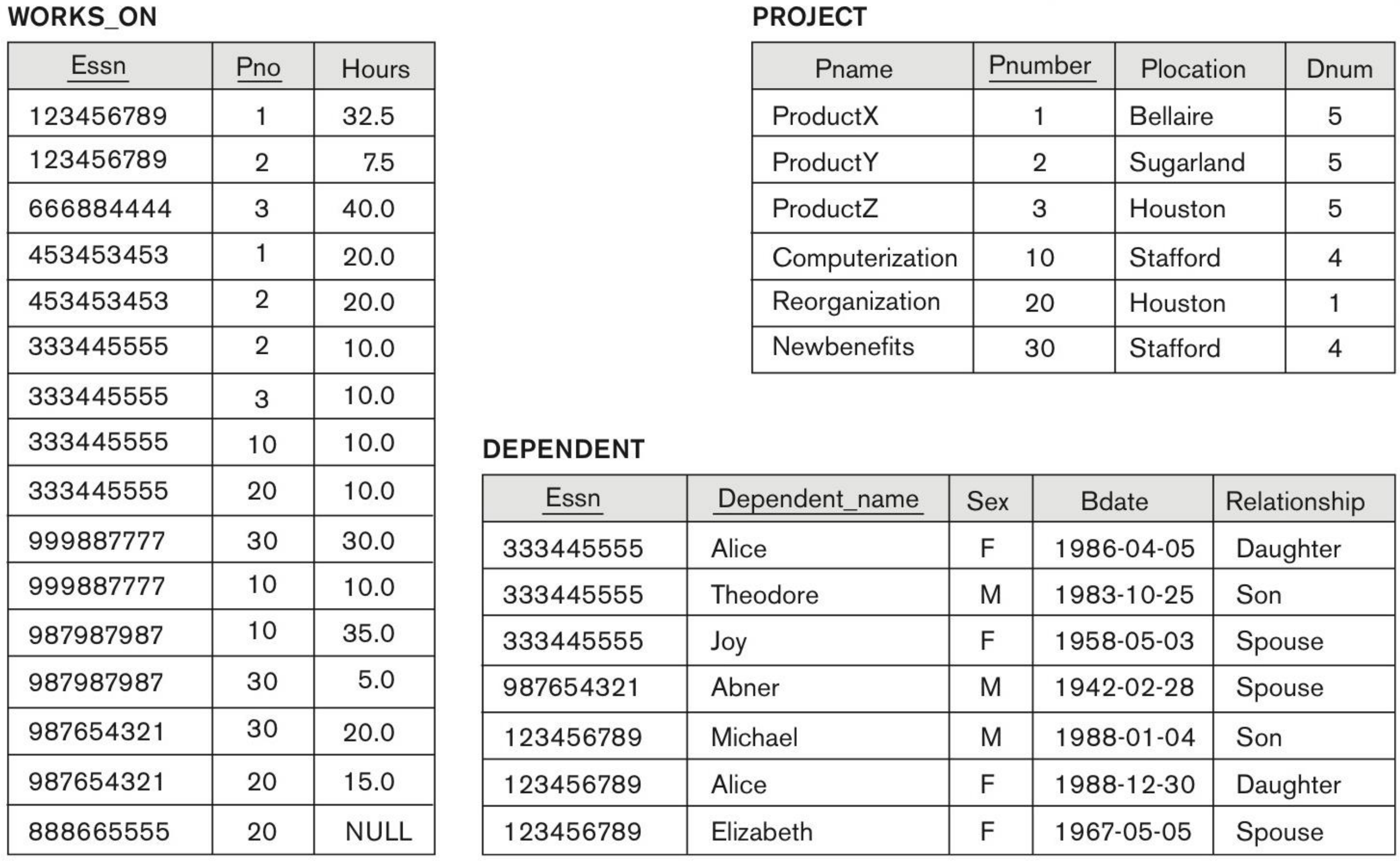
DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

Figure 5.6 One Possible Database State for the COMPANY Relational Database Schema (2 of 2)



WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

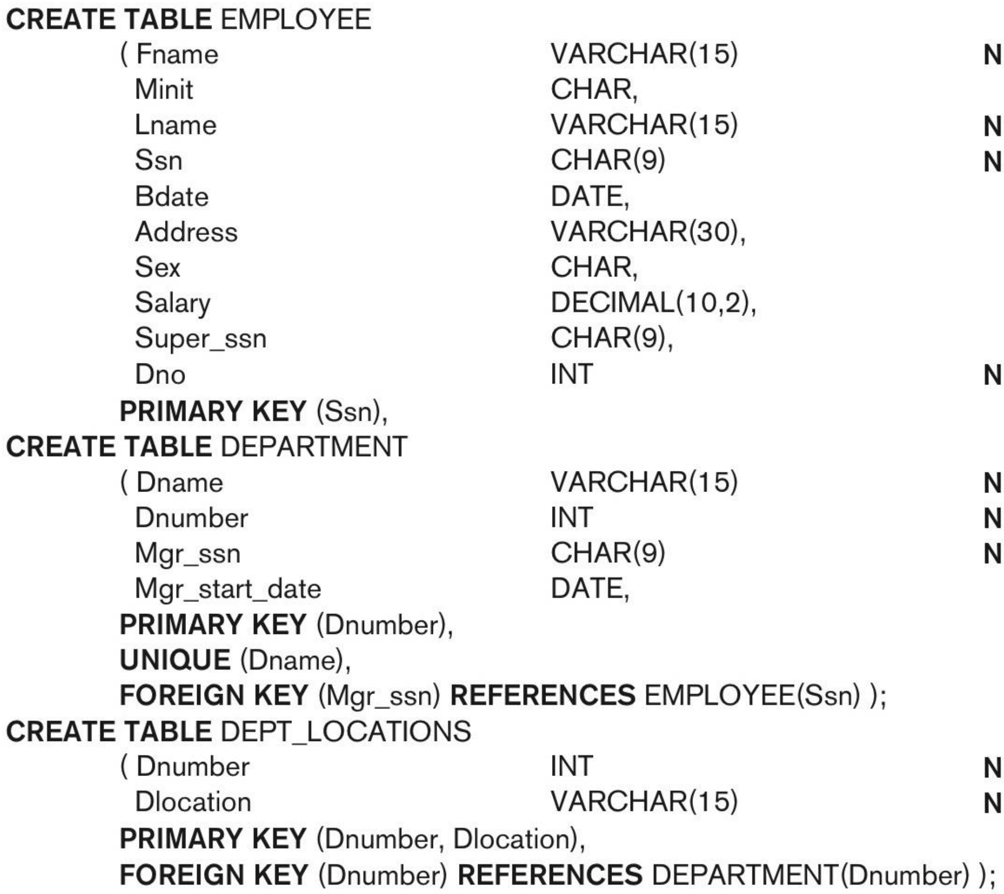
Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse

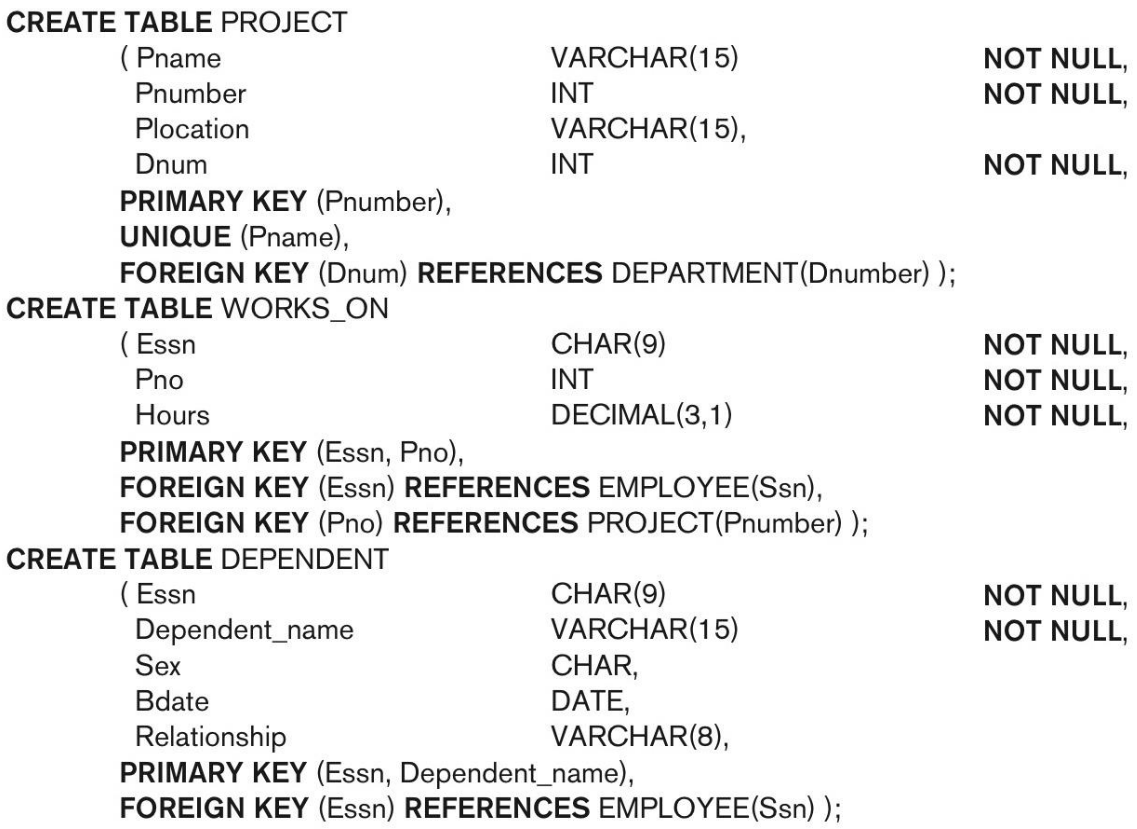
Adapted from Pearson Resources for Fundamentals of Database Systems, 7th Ed.

Figure 6.1 SQL CREATE TABLE Data Definition Statements for Defining the Company Schema from Figure 5.7 (1 of 2)



```
CREATE TABLE EMPLOYEE
          ( Fname                    VARCHAR(15)            NOT NULL,
            Minit                    CHAR,
            Lname                    VARCHAR(15)            NOT NULL,
            Ssn                      CHAR(9)                NOT NULL,
            Bdate                    DATE,
            Address                  VARCHAR(30),
            Sex                      CHAR,
            Salary                   DECIMAL(10,2),
            Super_ssn                CHAR(9),
            Dno                      INT                    NOT NULL,
          PRIMARY KEY (Ssn),
CREATE TABLE DEPARTMENT
          ( Dname                    VARCHAR(15)            NOT NULL,
            Dnumber                  INT                    NOT NULL,
            Mgr_ssn                  CHAR(9)                NOT NULL,
            Mgr_start_date           DATE,
          PRIMARY KEY (Dnumber),
          UNIQUE (Dname),
          FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn) );
CREATE TABLE DEPT_LOCATIONS
          ( Dnumber                  INT                    NOT NULL,
            Dlocation                VARCHAR(15)            NOT NULL,
          PRIMARY KEY (Dnumber, Dlocation),
          FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber) );
```

Figure 6.1 SQL CREATE TABLE Data Definition Statements for Defining the Company Schema from Figure 5.7 (2 of 2)



```
CREATE TABLE PROJECT
        ( Pname                         VARCHAR(15)                 NOT NULL,
          Pnumber                       INT                         NOT NULL,
          Plocation                     VARCHAR(15),
          Dnum                          INT                         NOT NULL,
        PRIMARY KEY (Pnumber),
        UNIQUE (Pname),
        FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE WORKS_ON
        ( Essn                          CHAR(9)                     NOT NULL,
          Pno                           INT                         NOT NULL,
          Hours                         DECIMAL(3,1)                NOT NULL,
        PRIMARY KEY (Essn, Pno),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber) );
CREATE TABLE DEPENDENT
        ( Essn                          CHAR(9)                     NOT NULL,
          Dependent_name                VARCHAR(15)                 NOT NULL,
          Sex                           CHAR,
          Bdate                         DATE,
          Relationship                  VARCHAR(8),
        PRIMARY KEY (Essn, Dependent_name),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn) );
```

The CREATE TABLE Command in SQL (3 of 3)

- Some foreign keys may cause errors
  - Specified either via:
    - Circular references
    - Or because they refer to a table that has not yet been created
  - DBA’s have ways to stop referential integrity enforcement to get around this problem.

Attribute Data Types and Domains in SQL (1 of 4)

- Basic **data types**
  - **Numeric** data types
    - Integer numbers: `INTEGER`, `INT`, and `SMALLINT`
    - Floating-point (real) numbers: `FLOAT` or `REAL`, and `DOUBLE PRECISION`
  - **Character-string** data types
    - Fixed length: `CHAR(`*n*`)`, `CHARACTER(`*n*`)`
    - Varying length: `VARCHAR(`*n*`)`, `CHAR VARYING(`*n*`)`, `CHARACTER VARYING(`*n*`)`

Attribute Data Types and Domains in SQL (2 of 4)

- **Bit-string** data types
  - Fixed length: `BIT(`*n*`)`
  - Varying length: `BIT VARYING(`*n*`)`
- **Boolean** data type
  - Values of `TRUE` or `FALSE` or `NULL`
- **DATE** data type
  - Ten positions
  - Components are `YEAR`, `MONTH`, and `DAY` in the form YYYY-MM-DD
  - Multiple mapping functions available in RDBMSs to change date formats

Attribute Data Types and Domains in SQL (3 of 4)

- Additional data types
  - **Timestamp** data type

    Includes the `DATE` and `TIME` fields

    - Plus a minimum of six positions for decimal fractions of seconds
    - Optional `WITH TIME ZONE` qualifier
  - **INTERVAL** data type
    - Specifies a relative value that can be used to increment or decrement an absolute value of a date, time, or timestamp
  - **DATE, TIME, Timestamp, INTERVAL** data types can be **cast** or converted to string formats for comparison.

Attribute Data Types and Domains in SQL (4 of 4)

- **Domain**
  - Name used with the attribute specification
  - Makes it easier to change the data type for a domain that is used by numerous attributes
  - Improves schema readability
  - Example:
    - `CREATE DOMAIN SSN_TYPE AS CHAR(9);`

Specifying Constraints in SQL

Basic constraints:

- Relational Model has 3 basic constraint types that are supported in SQL:
  - **Key** constraint: A primary key value cannot be duplicated
  - **Entity Integrity** Constraint: A primary key value cannot be null
  - **Referential integrity** constraints: The “foreign key” must have a value that is already present as a primary key, or may be null.

Specifying Attribute Constraints

Other Restrictions on attribute domains:

- Default value of an attribute
  - **`DEFAULT`** `<value>`
- NULL is not permitted for a particular attribute (NOT NULL)
- **`CHECK`** clause
  - `Dnumber INT NOT NULL CHECK (Dnumber > 0 AND Dnumber < 21);`

Specifying Key and Referential Integrity Constraints (1 of 2)

- **`PRIMARY KEY`** clause
  - Specifies one or more attributes that make up the primary key of a relation
  - `Dnumber INT PRIMARY KEY;`
- **`UNIQUE`** clause
  - Specifies alternate (secondary) keys (called CANDIDATE keys in the relational model).
  - `Dname VARCHAR(15) UNIQUE;`

Specifying Key and Referential Integrity Constraints (2 of 2)

- **`FOREIGN KEY`** clause
  - Default operation: reject update on violation
  - Attach **referential triggered action** clause
    - Options include `SET NULL`, `CASCADE`, and `SET DEFAULT`
    - Action taken by the DBMS for `SET NULL` or `SET DEFAULT` is the same for both `ON DELETE` and `ON UPDATE`
    - `CASCADE` option suitable for “relationship” relations

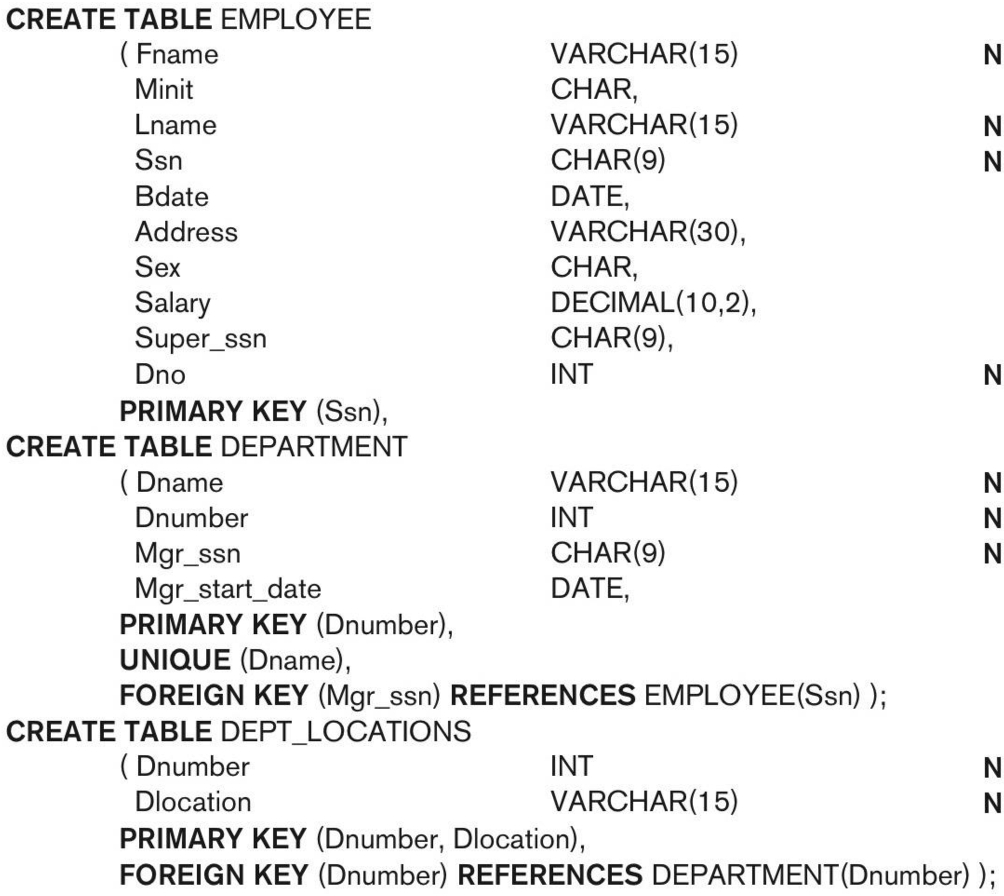
Giving Names to Constraints

- Using the Keyword **`CONSTRAINT`**
  - Name a constraint
  - Useful for later altering

Specifying Constraints on Tuples Using CHECK

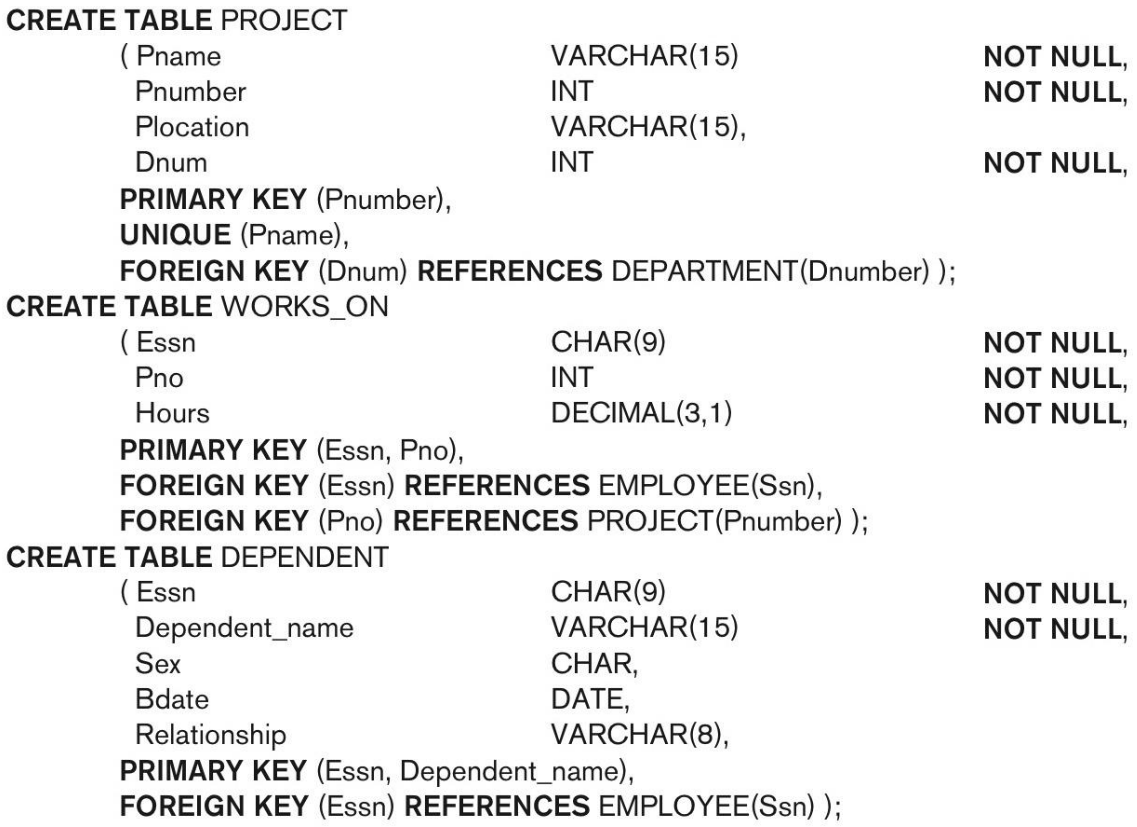
- Additional Constraints on individual tuples within a relation are also possible using CHECK
- `CHECK` clauses at the end of a `CREATE TABLE` statement
  - Apply to each tuple individually
  - `CHECK (Dept_create_date <= Mgr_start_date);`

Figure 6.1 SQL CREATE TABLE Data Definition Statements for Defining the Company Schema from Figure 5.7 (1 of 2)



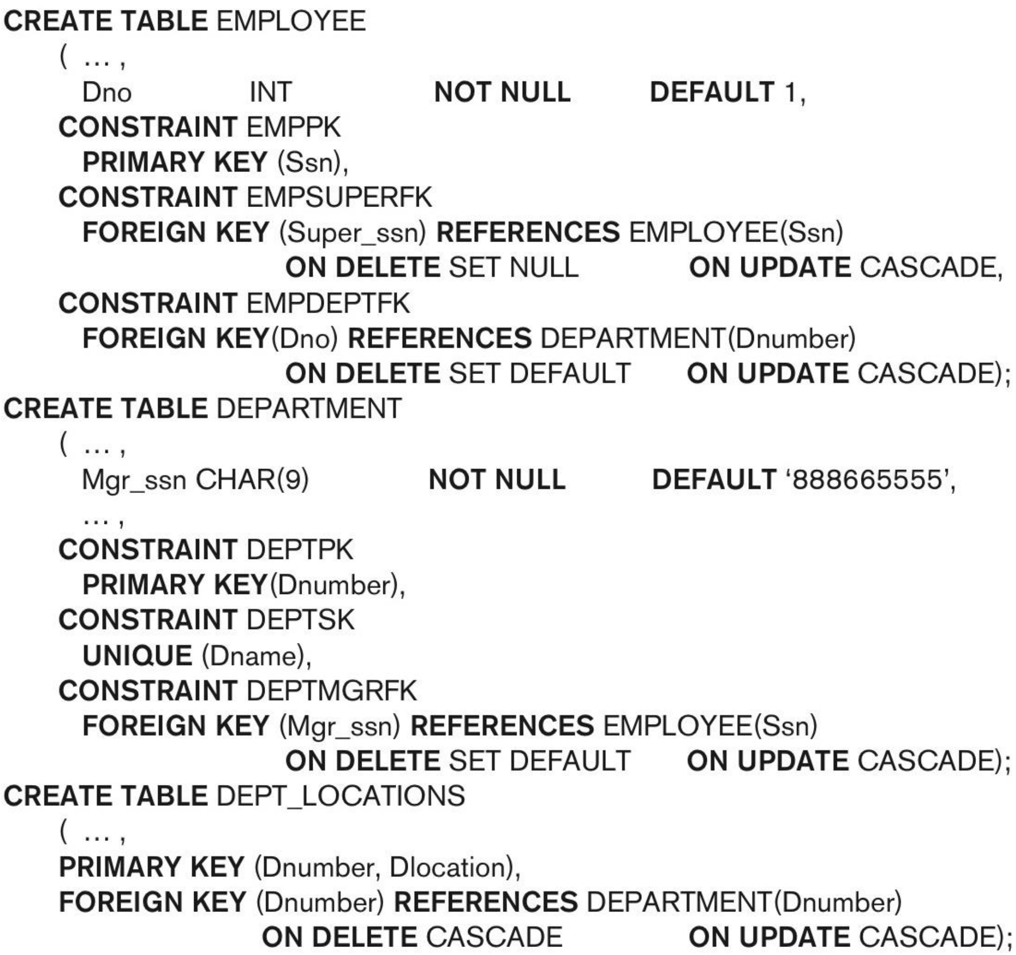
```
CREATE TABLE EMPLOYEE
        ( Fname                 VARCHAR(15)             NOT NULL,
          Minit                 CHAR,
          Lname                 VARCHAR(15)             NOT NULL,
          Ssn                   CHAR(9)                 NOT NULL,
          Bdate                 DATE,
          Address               VARCHAR(30),
          Sex                   CHAR,
          Salary                DECIMAL(10,2),
          Super_ssn             CHAR(9),
          Dno                   INT                     NOT NULL,
        PRIMARY KEY (Ssn),
CREATE TABLE DEPARTMENT
        ( Dname                 VARCHAR(15)             NOT NULL,
          Dnumber               INT                     NOT NULL,
          Mgr_ssn               CHAR(9)                 NOT NULL,
          Mgr_start_date        DATE,
        PRIMARY KEY (Dnumber),
        UNIQUE (Dname),
        FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn) );
CREATE TABLE DEPT_LOCATIONS
        ( Dnumber               INT                     NOT NULL,
          Dlocation             VARCHAR(15)             NOT NULL,
        PRIMARY KEY (Dnumber, Dlocation),
        FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber) );
```

Figure 6.1 SQL CREATE TABLE Data Definition Statements for Defining the Company Schema from Figure 5.7 (2 of 2)



```
CREATE TABLE PROJECT
        ( Pname                          VARCHAR(15)                  NOT NULL,
          Pnumber                        INT                          NOT NULL,
          Plocation                      VARCHAR(15),
          Dnum                           INT                          NOT NULL,
        PRIMARY KEY (Pnumber),
        UNIQUE (Pname),
        FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE WORKS_ON
        ( Essn                           CHAR(9)                      NOT NULL,
          Pno                            INT                          NOT NULL,
          Hours                          DECIMAL(3,1)                 NOT NULL,
        PRIMARY KEY (Essn, Pno),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber) );
CREATE TABLE DEPENDENT
        ( Essn                           CHAR(9)                      NOT NULL,
          Dependent_name                 VARCHAR(15)                  NOT NULL,
          Sex                            CHAR,
          Bdate                          DATE,
          Relationship                   VARCHAR(8),
        PRIMARY KEY (Essn, Dependent_name),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn) );
```

Figure 6.2 Default Attribute Values and Referential Integrity Triggered Action Specification



```
CREATE TABLE EMPLOYEE
    ( … ,
      Dno          INT             NOT NULL        DEFAULT 1,
    CONSTRAINT EMPPK
      PRIMARY KEY (Ssn),
    CONSTRAINT EMPSUPERFK
      FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn)
                        ON DELETE SET NULL          ON UPDATE CASCADE,
    CONSTRAINT EMPDEPTFK
      FOREIGN KEY(Dno) REFERENCES DEPARTMENT(Dnumber)
                        ON DELETE SET DEFAULT       ON UPDATE CASCADE);
CREATE TABLE DEPARTMENT
    ( … ,
      Mgr_ssn CHAR(9)              NOT NULL        DEFAULT '888665555',
      … ,
    CONSTRAINT DEPTPK
      PRIMARY KEY(Dnumber),
    CONSTRAINT DEPTSK
      UNIQUE (Dname),
    CONSTRAINT DEPTMGRFK
      FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn)
                        ON DELETE SET DEFAULT       ON UPDATE CASCADE);
CREATE TABLE DEPT_LOCATIONS
    ( … ,
    PRIMARY KEY (Dnumber, Dlocation),
    FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber)
                      ON DELETE CASCADE             ON UPDATE CASCADE);
```