# Database Principles: Fundamentals of Design, Implementation, and Management

**Tenth Edition**

*Chapter 4*

*Relational Model Characteristics*

## Objectives

In this chapter, students will learn:

- That the relational database model offers a logical view of data
- About the relational model's basic component: relations
- That relations are logical constructs composed of rows (tuples) and columns (attributes)
- That relations are implemented as tables in a relational DBMS

# Objectives (cont'd.)

- About relational database operators, the data dictionary, and the system catalog
- How data redundancy is handled in the relational database model
- Why indexing is important





# A Logical View of Data

- Relational model
  - View data logically rather than physically
- Table
  - Structural and data independence
  - Resembles a file conceptually
- Relational database model is easier to understand than hierarchical and network models

# Tables and Their Characteristics

- Logical view of relational database is based on relation
  - Relation thought of as a table
- Table: two-dimensional structure composed of rows and columns
  - Persistent representation of logical relation
- Contains group of related entities (entity set)





TABLE 4.1 **Characteristics of a Relational Table**

| | |
|---|---|
| 1 | A table is perceived as a two-dimensional structure composed of rows and columns. |
| 2 | Each table row (**tuple**) represents a single entity occurrence within the entity set. |
| 3 | Each table column represents an attribute, and each column has a distinct name. |
| 4 | Each intersection of a row and column represents a single data value. |
| 5 | All values in a column must conform to the same data format. |
| 6 | Each column has a specific range of values known as the **attribute domain**. |
| 7 | The order of the rows and columns is immaterial to the DBMS. |
| 8 | Each table must have an attribute or combination of attributes that uniquely identifies each row. |

**FIGURE 4.1** STUDENT table attribute values

Table name: STUDENT — Database name: Ch04_TinyCollege

| STU_NUM | STU_LNAME | STU_FNAME | STU_INIT | STU_DOB | STU_HRS | STU_CLASS | STU_GPA | STU_TRANSFER | DEPT_CODE | STU_PHONE | PROF_NUM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 321452 | Bowser | William | C | 12-Feb-1975 | 42 | So | 2.84 | No | BIOL | 2134 | 205 |
| 324257 | Smithson | Anne | K | 15-Nov-1981 | 81 | Jr | 3.27 | Yes | CIS | 2256 | 222 |
| 324258 | Brewer | Juliette | | 23-Aug-1969 | 36 | So | 2.26 | Yes | ACCT | 2256 | 228 |
| 324269 | Oblonski | Walter | H | 16-Sep-1976 | 66 | Jr | 3.09 | No | CIS | 2114 | 222 |
| 324273 | Smith | John | D | 30-Dec-1958 | 102 | Sr | 2.11 | Yes | ENGL | 2231 | 199 |
| 324274 | Katinga | Raphael | P | 21-Oct-1979 | 114 | Sr | 3.15 | No | ACCT | 2267 | 228 |
| 324291 | Robertson | Gerald | T | 08-Apr-1973 | 120 | Sr | 3.87 | No | EDU | 2267 | 311 |
| 324299 | Smith | John | B | 30-Nov-1986 | 15 | Fr | 2.92 | No | ACCT | 2315 | 230 |

STU_NUM = Student number
STU_LNAME = Student last name
STU_FNAME = Student first name
STU_INIT = Student middle initial
STU_DOB = Student date of birth
STU_HRS = Credit hours earned
STU_CLASS = Student classification
STU_GPA = Grade point average
STU_TRANSFER = Student transferred from another institution
DEPT_CODE = Department code
STU_PHONE = 4-digit campus phone extension
PROF_NUM = Number of the professor who is the student's advisor

SOURCE: Course Technology/Cengage Learning





# Keys

- Each row in a table must be uniquely identifiable
- Key: one or more attributes that determine other attributes
  - Key's role is based on determination
    - If you know the value of attribute A, you can determine the value of attribute B
  - Functional dependence
    - Attribute B is functionally dependent on A if all rows in table that agree in value for A also agree in value for B

TABLE 4.2 **Student Classification**

| HOURS COMPLETED | CLASSIFICATION |
|---|---|
| Less than 30 | Fr |
| 30–59 | So |
| 60–89 | Jr |
| 90 or more | Sr |





# Types of Keys

- Composite key
  - Composed of more than one attribute
- Key attribute
  - Any attribute that is part of a key
- Superkey
  - Any key that uniquely identifies each row
- Candidate key
  - A superkey without unnecessary attributes

# Types of Keys (cont'd.)

- Entity integrity
  - Each row (entity instance) in the table has its own unique identity
- Nulls
  - No data entry
  - Not permitted in primary key
  - Should be avoided in other attributes




# Types of Keys (cont'd.)

  - Can represent:
    - An unknown attribute value
    - A known, but missing, attribute value
    - A "not applicable" condition
  - Can create problems when functions such as COUNT, AVERAGE, and SUM are used
  - Can create logical problems when relational tables are linked

# Types of Keys (cont'd.)

- Controlled redundancy
  - Makes the relational database work
  - Tables within the database share common attributes
    - Enables tables to be linked together
  - Multiple occurrences of values not redundant when required to make the relationship work
  - Redundancy exists only when there is unnecessary duplication of attribute values





**FIGURE 4.2** An example of a simple relational database

Table name: PRODUCT
Primary key: PROD_CODE
Foreign key: VEND_CODE

Database name: Ch04_SaleCo

| PROD_CODE | PROD_DESCRIPT | PROD_PRICE | PROD_ON_HAND | VEND_CODE |
|---|---|---|---|---|
| 001278-AB | Claw hammer | 12.95 | 23 | 232 |
| 123-21UUY | Houselite chain saw, 16-in. bar | 189.99 | 4 | 235 |
| QER-34256 | Sledge hammer, 16-lb. head | 18.63 | 6 | 231 |
| SRE-657UG | Rat-tail file | 2.99 | 15 | 232 |
| ZZX/3245Q | Steel tape, 12-ft. length | 6.79 | 8 | 235 |

link

Table name: VENDOR
Primary key: VEND_CODE
Foreign key: none

| VEND_CODE | VEND_CONTACT | VEND_AREACODE | VEND_PHONE |
|---|---|---|---|
| 230 | Shelly K. Smithson | 608 | 555-1234 |
| 231 | James Johnson | 615 | 123-4536 |
| 232 | Annelise Crystall | 608 | 224-2134 |
| 233 | Candice Wallace | 904 | 342-6567 |
| 234 | Arthur Jones | 615 | 123-3324 |
| 235 | Henry Ortozo | 615 | 899-3425 |

SOURCE: Course Technology/Cengage Learning

# Types of Keys (cont'd.)

- Foreign key (FK)
  - An attribute whose values match primary key values in the related table
- Referential integrity
  - FK contains a value that refers to an existing valid tuple (row) in another relation
- Secondary key
  - Key used strictly for data retrieval purposes





TABLE 4.3 **Relational Database Keys**

| KEY TYPE | DEFINITION |
|---|---|
| Superkey | An attribute or combination of attributes that uniquely identifies each row in a table |
| Candidate key | A minimal (irreducible) superkey; a superkey that does not contain a subset of attributes that is itself a superkey |
| Primary key | A candidate key selected to uniquely identify all other attribute values in any given row; cannot contain null entries |
| Foreign key | An attribute or combination of attributes in one table whose values must either match the primary key in another table or be null |
| Secondary key | An attribute or combination of attributes used strictly for data retrieval purposes |

# Integrity Rules

- Many RDBMs enforce integrity rules automatically
- Safer to ensure that application design conforms to entity and referential integrity rules
- Designers use flags to avoid nulls
  - Flags indicate absence of some value





TABLE 4.4 **Integrity Rules**

| ENTITY INTEGRITY | DESCRIPTION |
|---|---|
| Requirement | All primary key entries are unique, and no part of a primary key may be null. |
| Purpose | Each row will have a unique identity, and foreign key values can properly reference primary key values. |
| Example | No invoice can have a duplicate number, nor can it be null. In short, all invoices are uniquely identified by their invoice number. |
| **REFERENTIAL INTEGRITY** | **DESCRIPTION** |
| Requirement | A foreign key may have either a null entry, as long as it is not a part of its table's primary key, or an entry that matches the primary key value in a table to which it is related. (Every non-null foreign key value *must* reference an *existing* primary key value.) |
| Purpose | It is possible for an attribute *not* to have a corresponding value, but it will be impossible to have an invalid entry. The enforcement of the referential integrity rule makes it impossible to delete a row in one table whose primary key has mandatory matching foreign key values in another table. |
| Example | A customer might not yet have an assigned sales representative (number), but it will be impossible to have an invalid sales representative (number). |

TABLE 4.5 **A Dummy Variable Value Used as a Flag**

| AGENT_CODE | AGENT_AREACODE | AGENT_PHONE | AGENT_LNAME | AGENT_YTD_SLS |
|---|---|---|---|---|
| -99 | 000 | 000-0000 | None | $0.00 |

FIGURE 4.3 An illustration of integrity rules

**Table name: CUSTOMER** **Database name: Ch04_InsureCo**
**Primary key: CUS_CODE**
**Foreign key: AGENT_CODE**

| CUS_CODE | CUS_LNAME | CUS_FNAME | CUS_INITIAL | CUS_RENEW_DATE | AGENT_CODE |
|---|---|---|---|---|---|
| 10010 | Ramas | Alfred | A | 05-Apr-2012 | 502 |
| 10011 | Dunne | Leona | K | 16-Jun-2012 | 501 |
| 10012 | Smith | Kathy | W | 29-Jan-2013 | 502 |
| 10013 | Olowski | Paul | F | 14-Oct-2012 | |
| 10014 | Orlando | Myron | | 28-Dec-2012 | 501 |
| 10015 | O'Brian | Amy | B | 22-Sep-2012 | 503 |
| 10016 | Brown | James | D | 25-Mar-2013 | 502 |
| 10017 | Williams | George | | 17-Jul-2012 | 503 |
| 10018 | Farriss | Anne | G | 03-Dec-2012 | 501 |
| 10019 | Smith | Olette | K | 14-Mar-2013 | 503 |

**Table name: AGENT (only five selected fields are shown)**
**Primary key: AGENT_CODE**
**Foreign key: none**

| AGENT_CODE | AGENT_AREACODE | AGENT_PHONE | AGENT_LNAME | AGENT_YTD_SLS |
|---|---|---|---|---|
| 501 | 713 | 228-1249 | Alby | 132735.75 |
| 502 | 615 | 882-1244 | Hahn | 138967.35 |
| 503 | 615 | 123-5589 | Okon | 127093.45 |

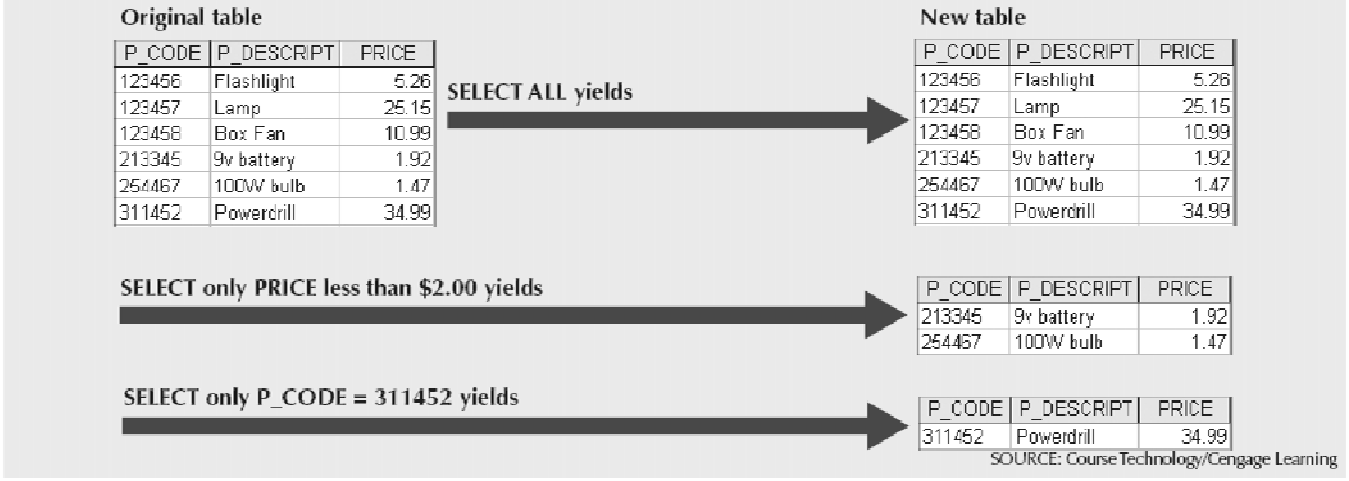
SOURCE: Course Technology/Cengage Learning




# Relational Set Operators

- Relational algebra
  - Defines theoretical way of manipulating table contents using relational operators
  - Use of relational algebra operators on existing relations produces new relations:
    - SELECT
    - PROJECT
    - JOIN
    - INTERSECT
    - UNION
    - DIFFERENCE
    - PRODUCT
    - DIVIDE

## FIGURE 4.4 SELECT

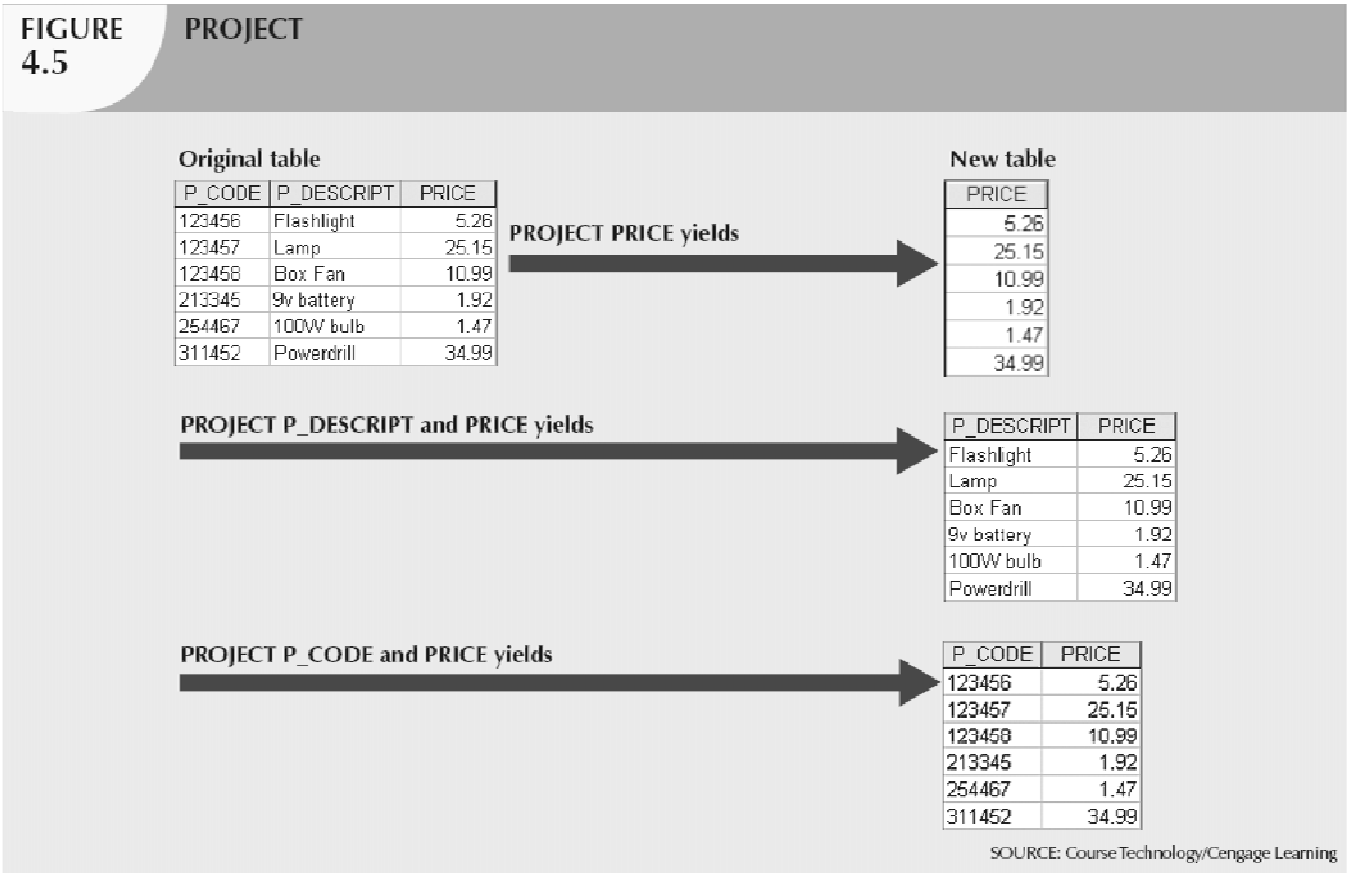



SOURCE: Course Technology/Cengage Learning





## FIGURE 4.5 PROJECT




SOURCE: Course Technology/Cengage Learning

## FIGURE 4.6 UNION

| P_CODE | P_DESCRIPT | PRICE |
|---|---|---|
| 123456 | Flashlight | 5.26 |
| 123457 | Lamp | 25.15 |
| 123458 | Box Fan | 10.99 |
| 213345 | 9v battery | 1.92 |
| 254467 | 100W bulb | 1.47 |
| 311452 | Powerdrill | 34.99 |

UNION

| P_CODE | P_DESCRIPT | PRICE |
|---|---|---|
| 345678 | Microwave | 160.00 |
| 345679 | Dishwasher | 500.00 |
| 123458 | Box Fan | 10.99 |

yields

| P_CODE | P_DESCRIPT | PRICE |
|---|---|---|
| 123456 | Flashlight | 5.26 |
| 123457 | Lamp | 25.15 |
| 123458 | Box Fan | 10.99 |
| 213345 | 9v battery | 1.92 |
| 254467 | 100W bulb | 1.47 |
| 311452 | Powerdrill | 34.99 |
| 345678 | Microwave | 160 |
| 345679 | Dishwasher | 500 |

SOURCE: Course Technology/Cengage Learning

## FIGURE 4.7 INTERSECT

| STU_FNAME | STU_LNAME |
|---|---|
| George | Jones |
| Jane | Smith |
| Peter | Robinson |
| Franklin | Johnson |
| Martin | Lopez |

INTERSECT

| EMP_FNAME | EMP_LNAME |
|---|---|
| Franklin | Lopez |
| William | Turner |
| Franklin | Johnson |
| Susan | Rogers |

yields

| STU_FNAME | STU_LNAME |
|---|---|
| Franklin | Johnson |

SOURCE: Course Technology/Cengage Learning





## FIGURE 4.8 DIFFERENCE

| STU_FNAME | STU_LNAME |
|---|---|
| George | Jones |
| Jane | Smith |
| Peter | Robinson |
| Franklin | Johnson |
| Martin | Lopez |

DIFFERENCE

| EMP_FNAME | EMP_LNAME |
|---|---|
| Franklin | Lopez |
| William | Turner |
| Franklin | Johnson |
| Susan | Rogers |

yields

| STU_FNAME | STU_LNAME |
|---|---|
| George | Jones |
| Jane | Smith |
| Peter | Robinson |
| Martin | Lopez |

SOURCE: Course Technology/Cengage Learning

## FIGURE 4.9 PRODUCT

| P_CODE | P_DESCRIPT | PRICE |
|---|---|---|
| 123456 | Flashlight | 5.26 |
| 123457 | Lamp | 25.15 |
| 123458 | Box Fan | 10.99 |
| 213345 | 9v battery | 1.92 |
| 254467 | 100W bulb | 1.47 |
| 311452 | Powerdrill | 34.99 |

PRODUCT

| STORE | AISLE | SHELF |
|---|---|---|
| 23 | W | 5 |
| 24 | K | 9 |
| 25 | Z | 6 |

yields

| P_CODE | P_DESCRIPT | PRICE | STORE | AISLE | SHELF |
|---|---|---|---|---|---|
| 123456 | Flashlight | 5.26 | 23 | W | 5 |
| 123456 | Flashlight | 5.26 | 24 | K | 9 |
| 123456 | Flashlight | 5.26 | 25 | Z | 6 |
| 123457 | Lamp | 25.15 | 23 | W | 5 |
| 123457 | Lamp | 25.15 | 24 | K | 9 |
| 123457 | Lamp | 25.15 | 25 | Z | 6 |
| 123458 | Box Fan | 10.99 | 23 | W | 5 |
| 123458 | Box Fan | 10.99 | 24 | K | 9 |
| 123458 | Box Fan | 10.99 | 25 | Z | 6 |
| 213345 | 9v battery | 1.92 | 23 | W | 5 |
| 213345 | 9v battery | 1.92 | 24 | K | 9 |
| 213345 | 9v battery | 1.92 | 25 | Z | 6 |
| 311452 | Powerdrill | 34.99 | 23 | W | 5 |
| 311452 | Powerdrill | 34.99 | 24 | K | 9 |
| 311452 | Powerdrill | 34.99 | 25 | Z | 6 |
| 254467 | 100W bulb | 1.47 | 23 | W | 5 |
| 254467 | 100W bulb | 1.47 | 24 | K | 9 |
| 254467 | 100W bulb | 1.47 | 25 | Z | 6 |

SOURCE: Course Technology/Cengage Learning

# Relational Set Operators (cont'd.)

- Natural join
  - Links tables by selecting rows with common values in common attributes (join columns)
- Equijoin
  - Links tables on the basis of an equality condition that compares specified columns
- Theta join
  - Any other comparison operator is used





# Relational Set Operators (cont'd.)

- Inner join
  - Only returns matched records from the tables that are being joined
- Outer join
  - Matched pairs are retained, and any unmatched values in other table are left null

FIGURE 4.10 Two tables that will be used in join illustrations

Table name: CUSTOMER

| CUS_CODE | CUS_LNAME | CUS_ZIP | AGENT_CODE |
|---|---|---|---|
| 1132445 | Walker | 32145 | 231 |
| 1217782 | Adares | 32145 | 125 |
| 1312243 | Rakowski | 34129 | 167 |
| 1321242 | Rodriguez | 37134 | 125 |
| 1542311 | Smithson | 37134 | 421 |
| 1657399 | Vanloo | 32145 | 231 |

Table name: AGENT

| AGENT_CODE | AGENT_PHONE |
|---|---|
| 125 | 6152439887 |
| 167 | 6153426778 |
| 231 | 6152431124 |
| 333 | 9041234445 |

SOURCE: Course Technology/Cengage Learning

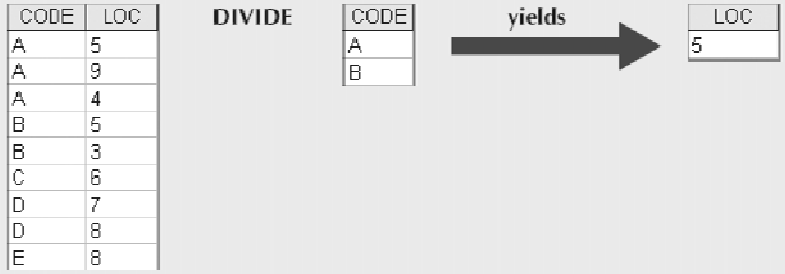




# Relational Set Operators (cont'd.)

- Left outer join
  - Yields all of the rows in the CUSTOMER table
  - Including those that do not have a matching value in the AGENT table
- Right outer join
  - Yields all of the rows in the AGENT table
  - Including those that do not have matching values in the CUSTOMER table

FIGURE 4.16 DIVIDE




SOURCE: Course Technology/Cengage Learning





# The Data Dictionary and System Catalog

- Data dictionary
  - Provides detailed accounting of all tables found within the user/designer-created database
  - Contains (at least) all the attribute names and characteristics for each table in the system
  - Contains metadata: data about data
- System catalog
  - Contains metadata
  - Detailed system data dictionary that describes all objects within the database

TABLE 4.6 A Sample Data Dictionary

| TABLE NAME | ATTRIBUTE NAME | CONTENTS | TYPE | FORMAT | RANGE | REQUIRED | PK or FK | FK REFERENCED TABLE |
|---|---|---|---|---|---|---|---|---|
| CUSTOMER | CUS_CODE | Customer account code | CHAR(5) | 99999 | 10000–99999 | Y | PK | |
| | CUS_LNAME | Customer last name | VARCHAR(20) | Xxxxxxx | | Y | FK | AGENT_CODE |
| | CUS_FNAME | Customer first name | VARCHAR(20) | Xxxxxxx | | Y | | |
| | CUS_INITIAL | Customer initial | CHAR(1) | X | | | | |
| | CUS_RENEW_DATE | Customer insurance renewal date | DATE | dd-mmm-yyyy | | | | |
| | AGENT_CODE | Agent code | CHAR(3) | 999 | | | | |
| AGENT | AGENT_CODE | Agent code | CHAR(3) | 999 | | Y | PK | |
| | AGENT_AREACODE | Agent area code | CHAR(3) | 999 | | Y | | |
| | AGENT_PHONE | Agent telephone number | CHAR(8) | 999-9999 | | Y | | |
| | AGENT_LNAME | Agent last name | VARCHAR(20) | Xxxxxxx | | Y | | |
| | AGENT_YTD_SLS | Agent year-to-date sales | NUMBER(9,2) | 9,999,999.99 | | | | |

FK =Foreign key
PK =Primary key
CHAR =Fixed character length data (1–255 characters)
VARCHAR =Variable character length data (1–2,000 characters)
NUMBER =Numeric data (NUMBER(9,2)) are used to specify numbers with two decimal places and up to nine digits, including the decimal places. Some RDBMSs permit the use of a MONEY or CURRENCY data type.





# The Data Dictionary and System Catalog (cont'd.)

- Homonym
  - Indicates the use of the same name to label different attributes
- Synonym
  - Opposite of a homonym
  - Indicates the use of different names to describe the same attribute

# Relationships within the Relational Database

- 1:M relationship
  - Relational modeling ideal
  - Should be the norm in any relational database design
- 1:1 relationship
  - Should be rare in any relational database design





# Relationships within the Relational Database (cont'd.)

- M:N relationships
  - Cannot be implemented as such in the relational model
  - M:N relationships can be changed into 1:M relationships

# The 1:M Relationship

- Relational database norm
- Found in any database environment

**FIGURE 4.17** The 1:M relationship between PAINTER and PAINTING


SOURCE: Course Technology/Cengage Learning





**FIGURE 4.18** The implemented 1:M relationship between PAINTER and PAINTING

Table name: PAINTER
Primary key: PAINTER_NUM
Foreign key: none

Database name: Ch04_Museum

| PAINTER_NUM | PAINTER_LNAME | PAINTER_FNAME | PAINTER_INITIAL |
|---|---|---|---|
| 123 | Ross | Georgette | P |
| 126 | Itero | Julio | G |

Table name: PAINTING
Primary key: PAINTING_NUM
Foreign key: PAINTER_NUM

| PAINTING_NUM | PAINTING_TITLE | PAINTER_NUM |
|---|---|---|
| 1338 | Dawn Thunder | 123 |
| 1339 | Vanilla Roses To Nowhere | 123 |
| 1340 | Tired Flounders | 126 |
| 1341 | Hasty Exit | 123 |
| 1342 | Plastic Paradise | 126 |

SOURCE: Course Technology/Cengage Learning

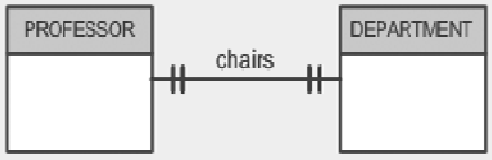
# The 1:1 Relationship

- One entity related to only one other entity, and vice versa
- Sometimes means that entity components were not defined properly
- Could indicate that two entities actually belong in the same table
- Certain conditions absolutely require their use





FIGURE 4.21 The 1:1 relationship between PROFESSOR and DEPARTMENT




SOURCE: Course Technology/Cengage Learning

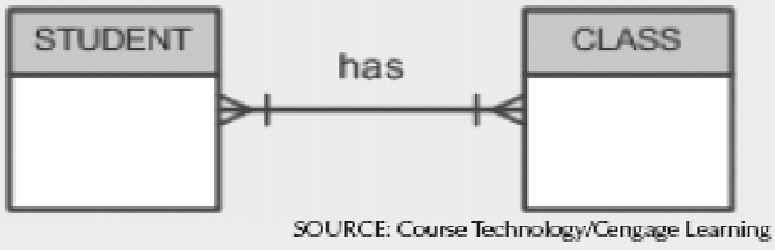
# The M:N Relationship

- Implemented by breaking it up to produce a set of 1:M relationships
- Avoid problems inherent to M:N relationship by creating a composite entity
  - Includes as foreign keys the primary keys of tables to be linked





FIGURE 4.23 The ERM's M:N relationship between STUDENT and CLASS




SOURCE: Course Technology/Cengage Learning

**FIGURE 4.25** Converting the M:N relationship into two 1:M relationships

Table name: STUDENT
Primary key: STU_NUM
Foreign key: none

Database name: Ch04_CollegeTry2

| STU_NUM | STU_LNAME |
|---|---|
| 321452 | Bowser |
| 324257 | Smithson |

Table name: ENROLL
Primary key: CLASS_CODE + STU_NUM
Foreign key: CLASS_CODE, STU_NUM

| CLASS_CODE | STU_NUM | ENROLL_GRADE |
|---|---|---|
| 10014 | 321452 | C |
| 10014 | 324257 | B |
| 10018 | 321452 | A |
| 10018 | 324257 | B |
| 10021 | 321452 | C |
| 10021 | 324257 | C |

Table name: CLASS
Primary key: CLASS_CODE
Foreign key: CRS_CODE

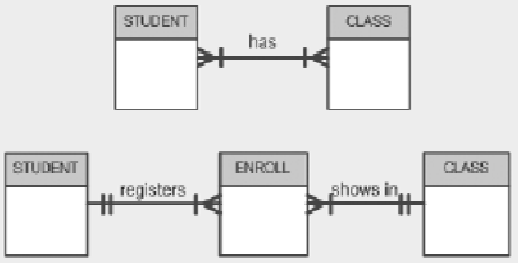
| CLASS_CODE | CRS_CODE | CLASS_SECTION | CLASS_TIME | CLASS_ROOM | PROF_NUM |
|---|---|---|---|---|---|
| 10014 | ACCT-211 | 3 | TTh 2:30-3:45 p.m. | BUS252 | 342 |
| 10018 | CIS-220 | 2 | MWF 8:00-8:50 a.m. | KLR211 | 114 |
| 10021 | QM-261 | 1 | MWF 8:00-8:50 a.m. | KLR200 | 114 |

SOURCE: Course Technology/Cengage Learning



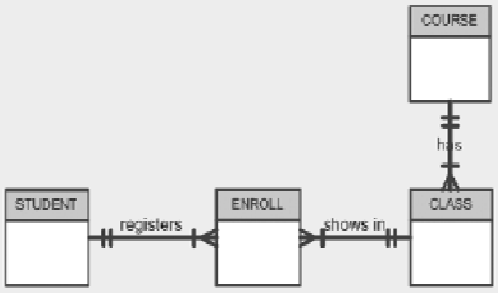


**FIGURE 4.26** Changing the M:N relationship to two 1:M relationships




SOURCE: Course Technology/Cengage Learning

FIGURE 4.27 The expanded entity relationship model

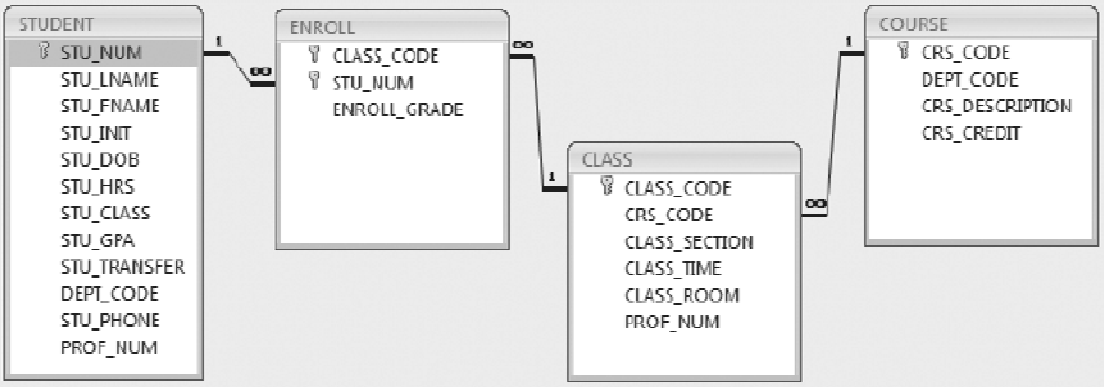



SOURCE: Course Technology/Cengage Learning





FIGURE 4.28 The relational diagram for the Ch04_TinyCollege database




SOURCE: Course Technology/Cengage Learning

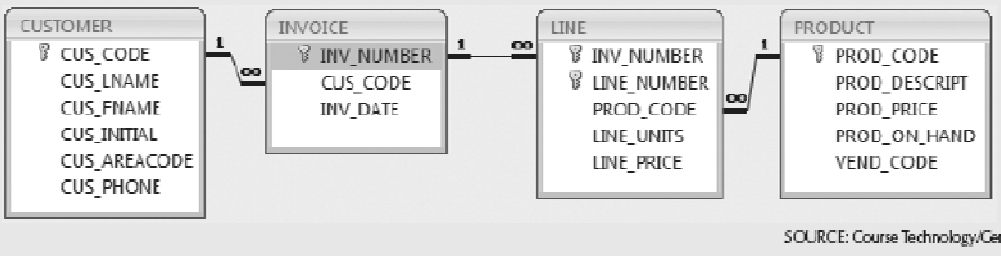
# Data Redundancy Revisited

- Data redundancy leads to data anomalies
  - Can destroy the effectiveness of the database
- Foreign keys
  - Control data redundancies by using common attributes shared by tables
  - Crucial to exercising data redundancy control
- Sometimes, data redundancy is necessary





FIGURE 4.30 The relational diagram for the invoicing system




SOURCE: Course Technology/Cengage Learning

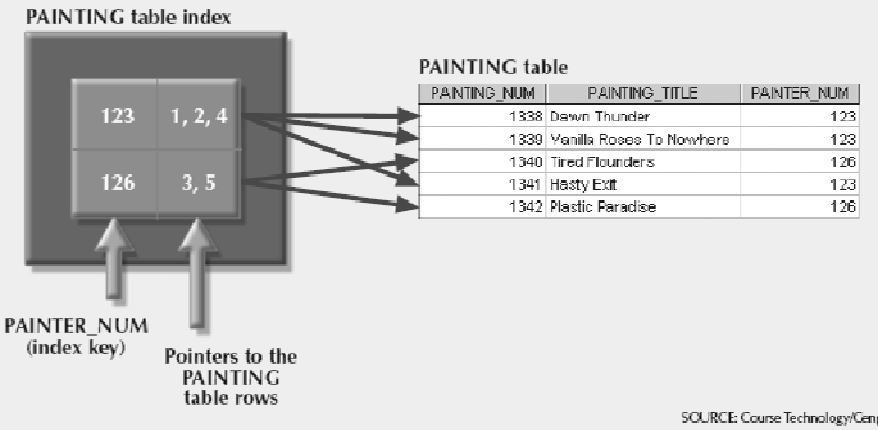
# Indexes

- Orderly arrangement to logically access rows in a table
- Index key
  - Index's reference point
  - Points to data location identified by the key
- Unique index
  - Index in which the index key can have only one pointer value (row) associated with it
- Each index is associated with only one table





FIGURE 4.31 Components of an index




SOURCE: Course Technology/Cengage Learning

# Codd's Relational Database Rules

- In 1985, Codd published a list of 12 rules to define a relational database system
  - Products marketed as "relational" that did not meet minimum relational standards
- Even dominant database vendors do not fully support all 12 rules




# Summary

- Tables are basic building blocks of a relational database
- Keys are central to the use of relational tables
- Keys define functional dependencies
  - Superkey
  - Candidate key
  - Primary key
  - Secondary key
  - Foreign key

# Summary (cont'd.)

- Each table row must have a primary key that uniquely identifies all attributes
- Tables are linked by common attributes
- The relational model supports relational algebra functions
  - SELECT, PROJECT, JOIN, INTERSECT UNION, DIFFERENCE, PRODUCT, DIVIDE
- Good design begins by identifying entities, attributes, and relationships
  - 1:1, 1:M, M:N