

Chapter 4

Entity Relationship (ER) Modeling

Learning Objectives

- In this chapter, you will learn:
 - The main characteristics of entity relationship components
 - How relationships between entities are defined, refined, and incorporated into the database design process
 - How ERD components affect database design and implementation
 - That real-world database design often requires the reconciliation of conflicting goals

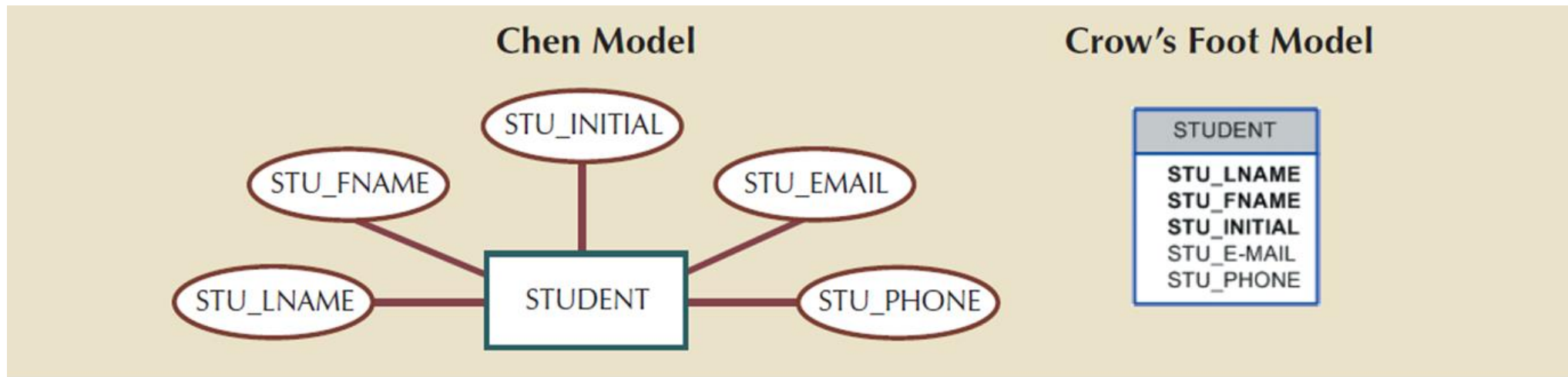
Entity Relationship Model (ERM)

- Basis of an entity relationship diagram (ERD)
- ERD depicts the:
 - Conceptual database as viewed by end user
 - Database's main components
 - Entities
 - Attributes
 - Relationships
- Entity - Refers to the entity set and not to a single entity occurrence

Attributes (1 of 3)

- Characteristics of entities
- **Required attribute:** Must have a value, cannot be left empty
- **Optional attribute:** Does not require a value, can be left empty
- Domain - Set of possible values for a given attribute
- **Identifiers:** One or more attributes that uniquely identify each entity instance

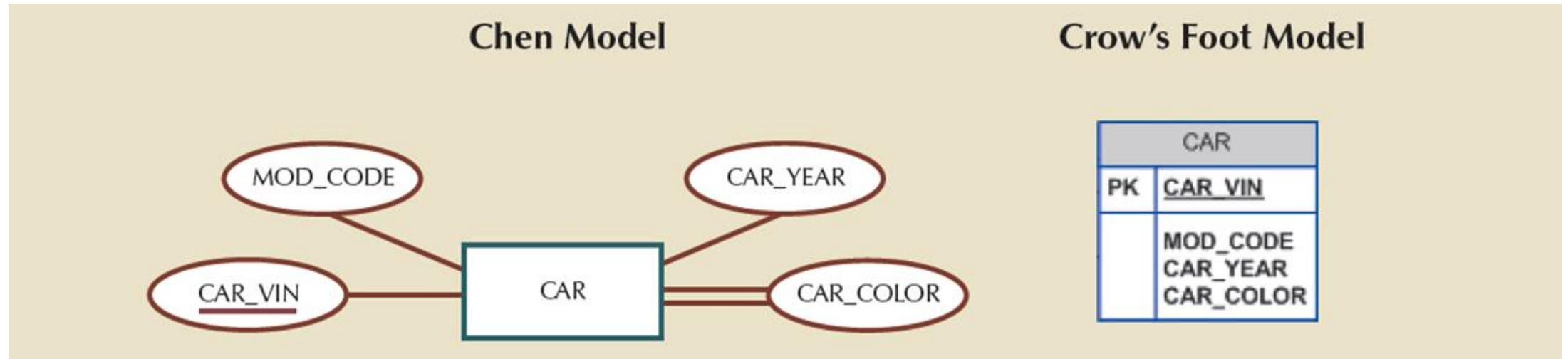
Figure 4.1 - The Attributes of the Student Entity: Chen and Crow's Foot



Attributes (2 of 3)

- **Composite identifier:** Primary key composed of more than one attribute
- **Composite attribute:** Attribute that can be subdivided to yield additional attributes
- **Simple attribute:** Attribute that cannot be subdivided
- **Single-valued attribute:** Attribute that has only a single value
- **Multivalued attributes:** Attributes that have many values

Figure 4.3 - A Multivalued Attribute in an Entity



Attributes (3 of 3)

- **Multivalued attributes:** Attributes that have many values and require creating:
 - Several new attributes, one for each component of the original multivalued attribute
 - A new entity composed of the original multivalued attribute's components
- **Derived attribute:** Attribute whose value is calculated from other attributes
 - Derived using an algorithm

Figure 4.4 – Splitting the Multivalued Attributes into New Attributes

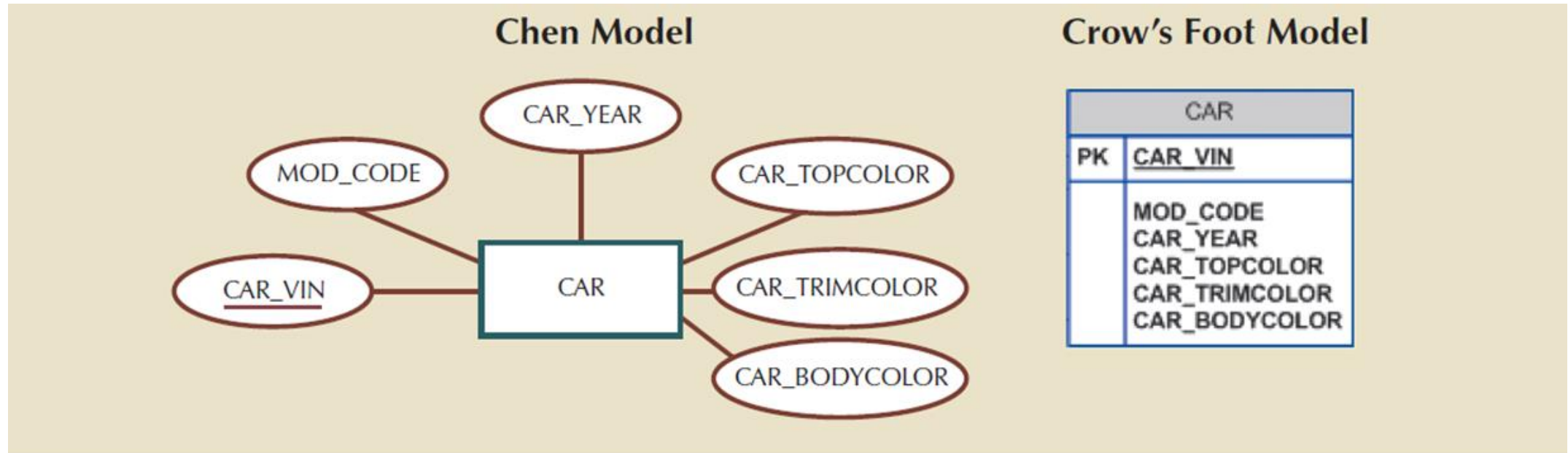


Figure 4.6 - Depiction of a Derived Attribute

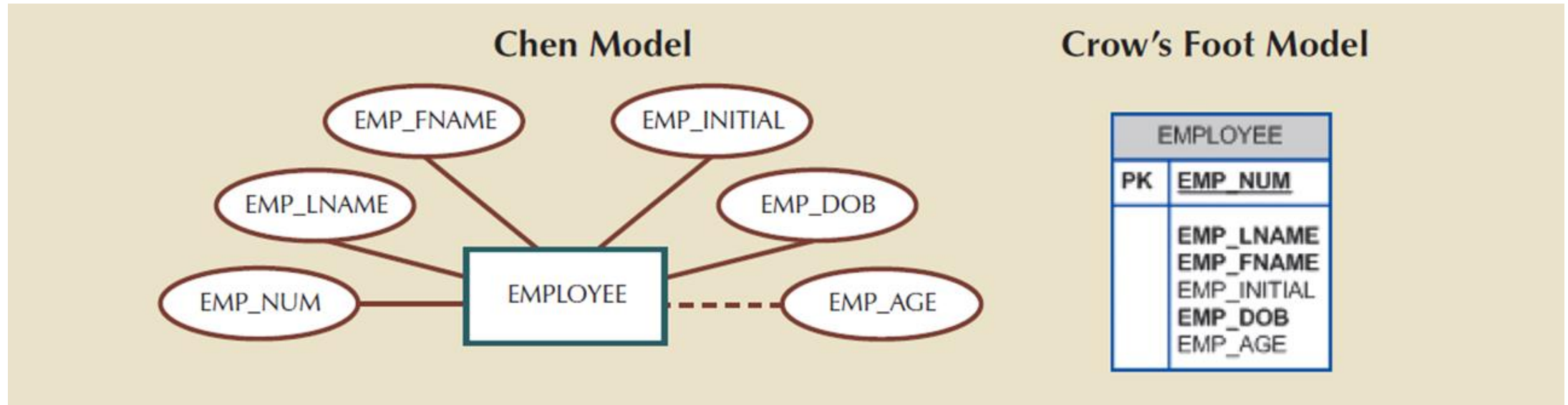


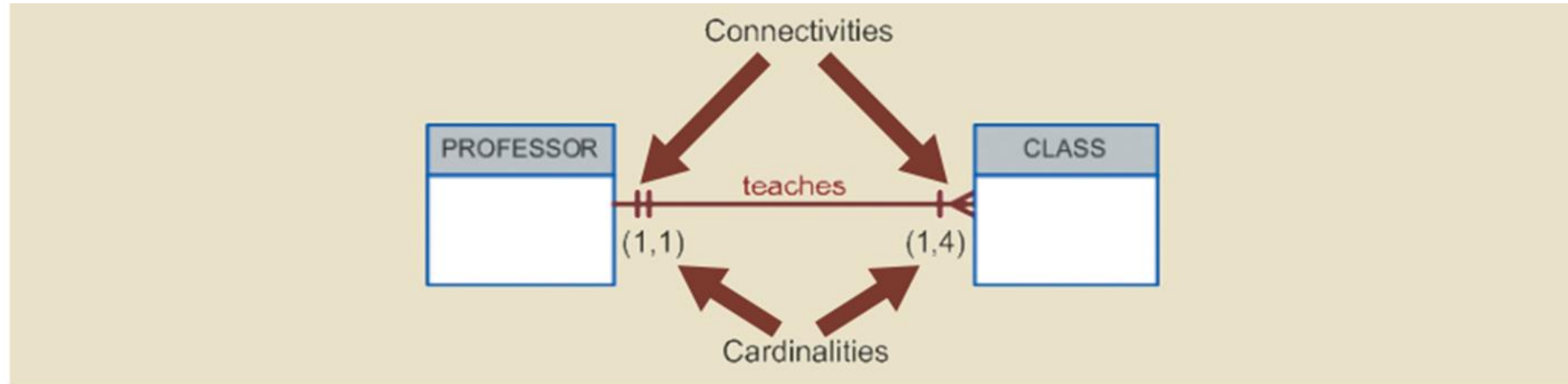
Table 4.2 - Advantages and Disadvantages of Storing Derived Attributes

	DERIVED ATTRIBUTE FOR STORED	DERIVED ATTRIBUTE FOR NOT STORED
Advantage	<ul style="list-style-type: none">Saves CPU processing cyclesSaves data access timeData value is readily availableCan be used to keep track of historical data	<ul style="list-style-type: none">Saves storage spaceComputation always yields current value
Disadvantage	<ul style="list-style-type: none">Requires constant maintenance to ensure derived value is current, especially if any values used in the calculation change	<ul style="list-style-type: none">Uses CPU processing cyclesIncreases data access timeAdds coding complexity to queries

Relationships

- Association between entities that always operate in both directions
- **Participants:** Entities that participate in a relationship
- **Connectivity:** Describes the relationship classification
- **Cardinality:** Expresses the minimum and maximum number of entity occurrences associated with one occurrence of related entity

Figure 4.7 - Connectivity and Cardinality in an ERD



Existence Dependence

Existence dependence

- Entity exists in the database only when it is associated with another related entity occurrence

Existence independence

- Entity exists apart from all of its related entities
- Referred to as a **strong entity** or **regular entity**

Relationship Strength

- **Weak (non-identifying) relationship**
 - Primary key of the related entity does not contain a primary key component of the parent entity
- **Strong (identifying) relationships**
 - Primary key of the related entity contains a primary key component of the parent entity

Figure 4.8 - A Weak (Non-Identifying) Relationship between COURSE and CLASS

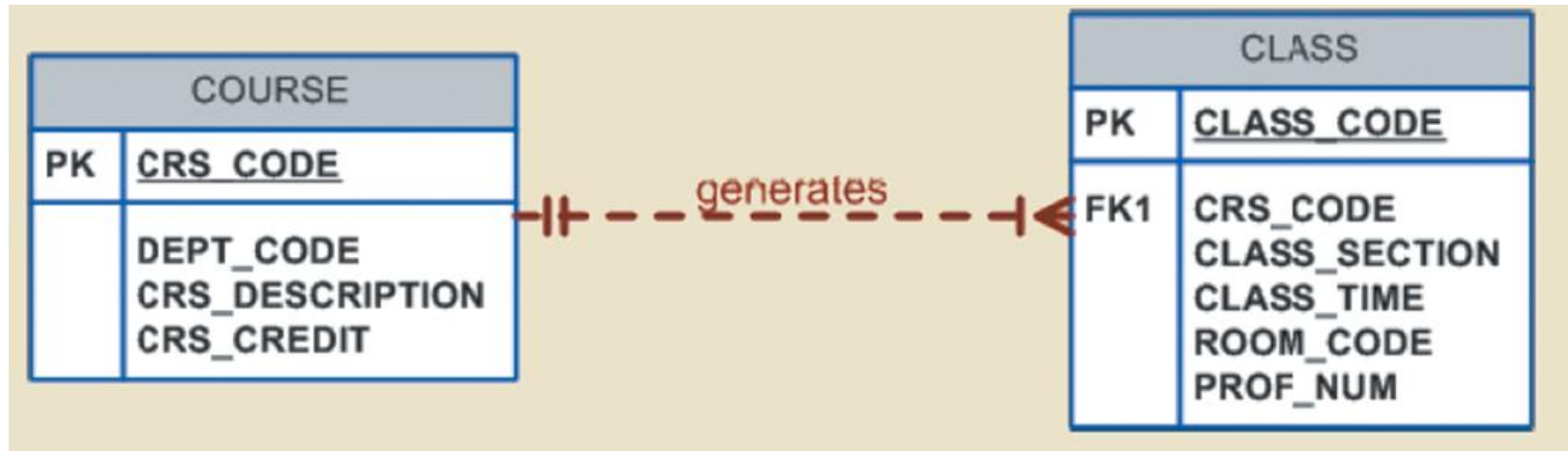
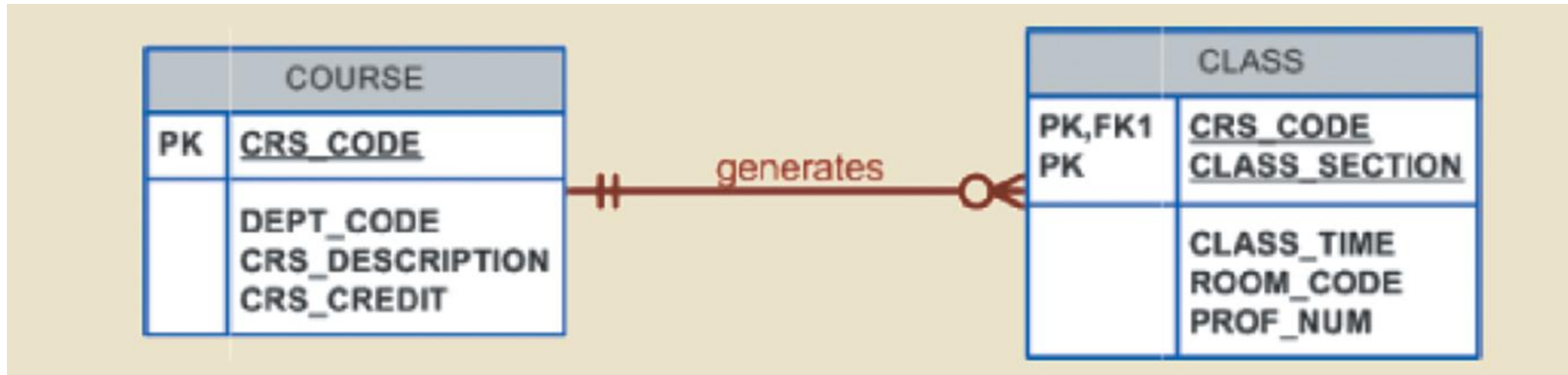


Figure 4.9 - A Strong (Identifying) Relationship between COURSE and CLASS



Weak Entity

- Conditions
 - Existence-dependent
 - Has a primary key that is partially or totally derived from parent entity in the relationship
- Database designer determines whether an entity is weak based on business rules

Figure 4.10 - A Weak Entity in an ERD

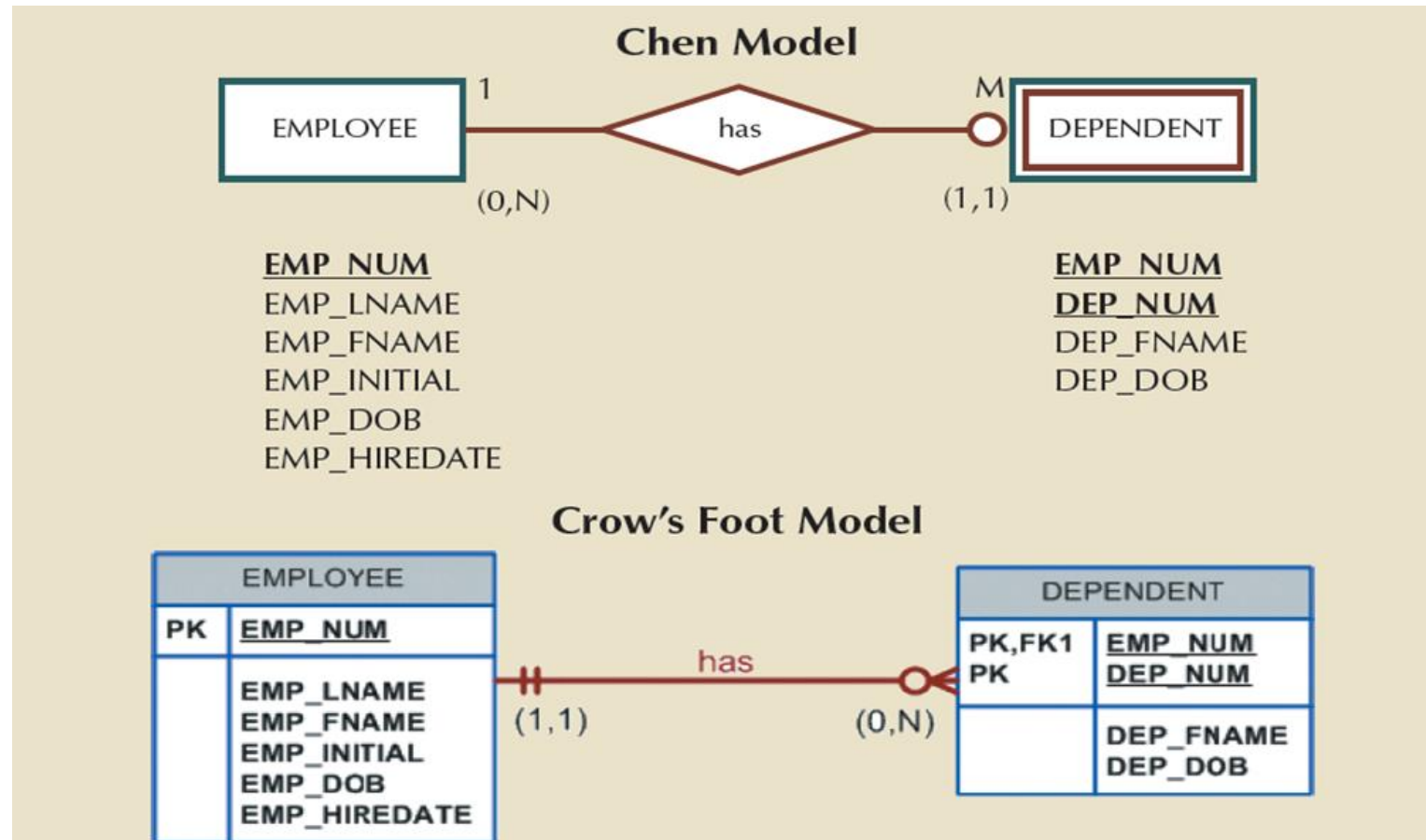


Figure 4.11 - A Weak Entity in a Strong Relationship

Table name: EMPLOYEE

Database name: Ch04_ShortCo

EMP_NUM	EMP_LNAME	EMP_FNAME	EMP_INITIAL	EMP_DOB	EMP_HIREDATE
1001	Callifante	Jeanine	J	12-Mar-64	25-May-97
1002	Smithson	William	K	23-Nov-70	28-May-97
1003	Washington	Herman	H	15-Aug-68	28-May-97
1004	Chen	Lydia	B	23-Mar-74	15-Oct-98
1005	Johnson	Melanie		28-Sep-66	20-Dec-98
1006	Ortega	Jorge	G	12-Jul-79	05-Jan-02
1007	O'Donnell	Peter	D	10-Jun-71	23-Jun-02
1008	Brzenski	Barbara	A	12-Feb-70	01-Nov-03

Table name: DEPENDENT

EMP_NUM	DEP_NUM	DEP_FNAME	DEP_DOB
1001	1	Annelise	05-Dec-97
1001	2	Jorge	30-Sep-02
1003	1	Suzanne	25-Jan-04
1006	1	Carlos	25-May-01
1008	1	Michael	19-Feb-95
1008	2	George	27-Jun-98
1008	3	Katherine	18-Aug-03

Relationship Participation

- Optional participation
 - One entity occurrence does not require a corresponding entity occurrence in a particular relationship
- Mandatory participation
 - One entity occurrence requires a corresponding entity occurrence in a particular relationship

Table 4.3 - Crow's Foot Symbols





CROW'S FOOT SYMBOLS	CARDINALITY	COMMENT
	(0,N)	Zero or many; the “many” side is optional.
	(1,N)	One or many; the “many” side is mandatory.
	(1,1)	One and only one; the “1” side is mandatory.
	(0,1)	Zero or one; the “1” side is optional.

Figure 4.13 - CLASS is Optional to COURSE

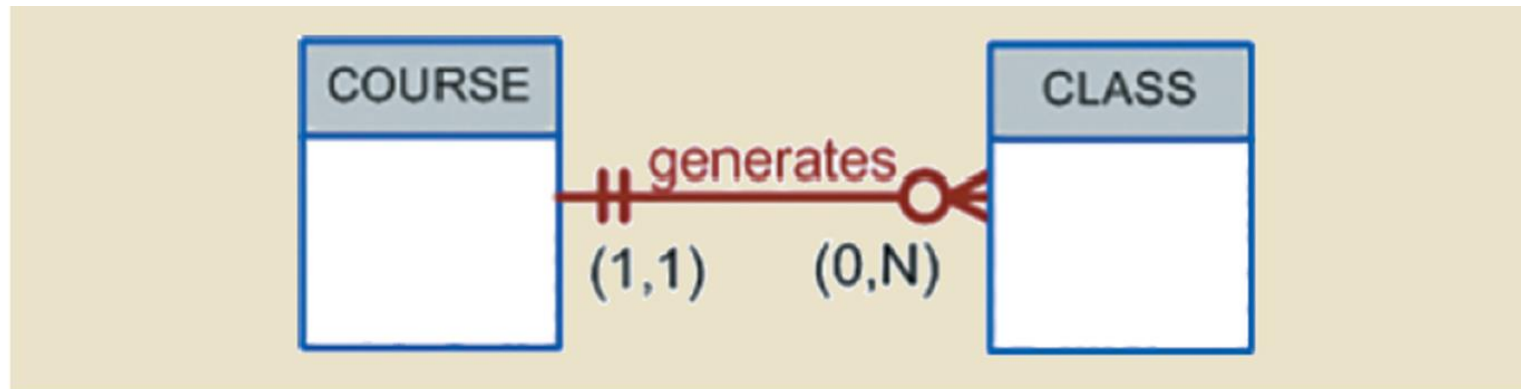
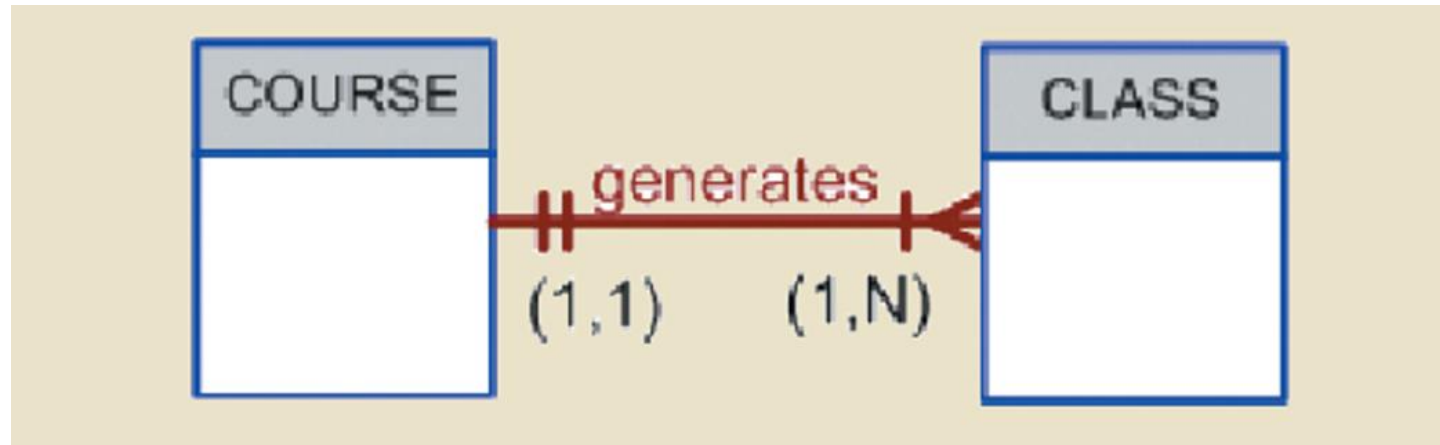


Figure 4.14 - COURSE and CLASS in a Mandatory Relationship



Relationship Degree

- Indicates the number of entities or participants associated with a relationship
- **Unary relationship:** Association is maintained within a single entity
 - **Recursive relationship:** Relationship exists between occurrences of the same entity set
- **Binary relationship:** Two entities are associated
- **Ternary relationship:** Three entities are associated

Figure 4.15 - Three Types of Relationship Degree

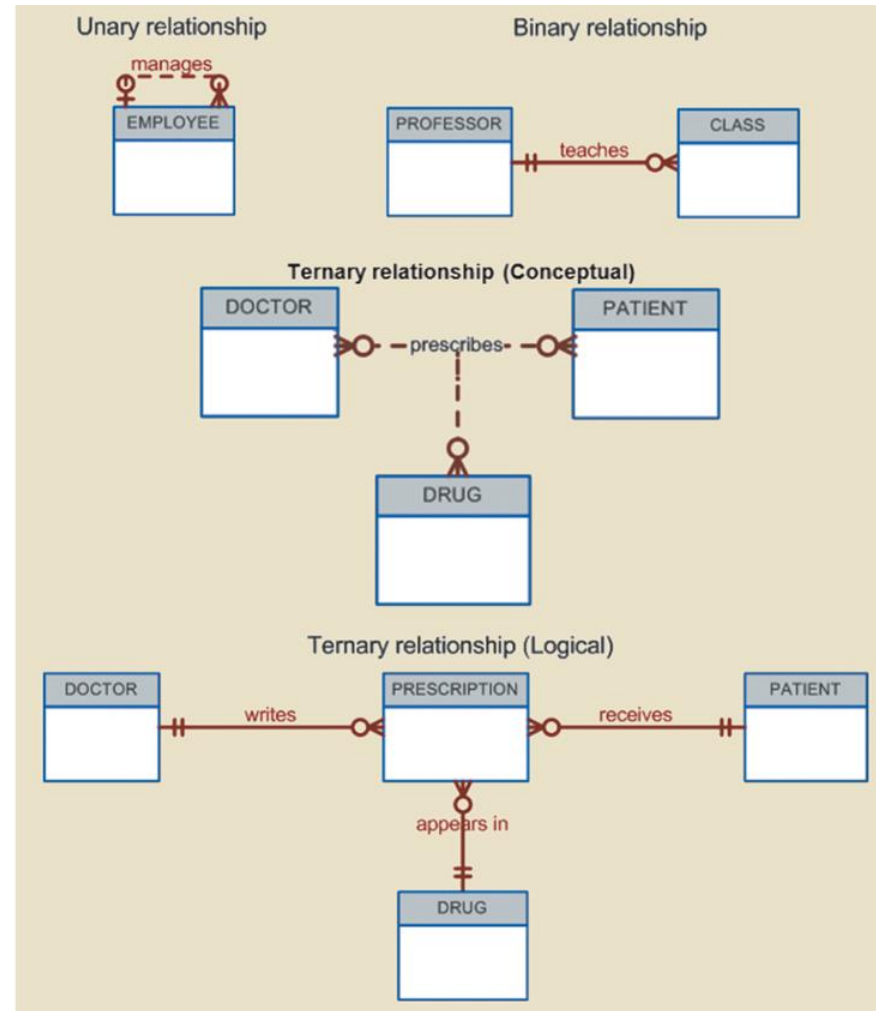
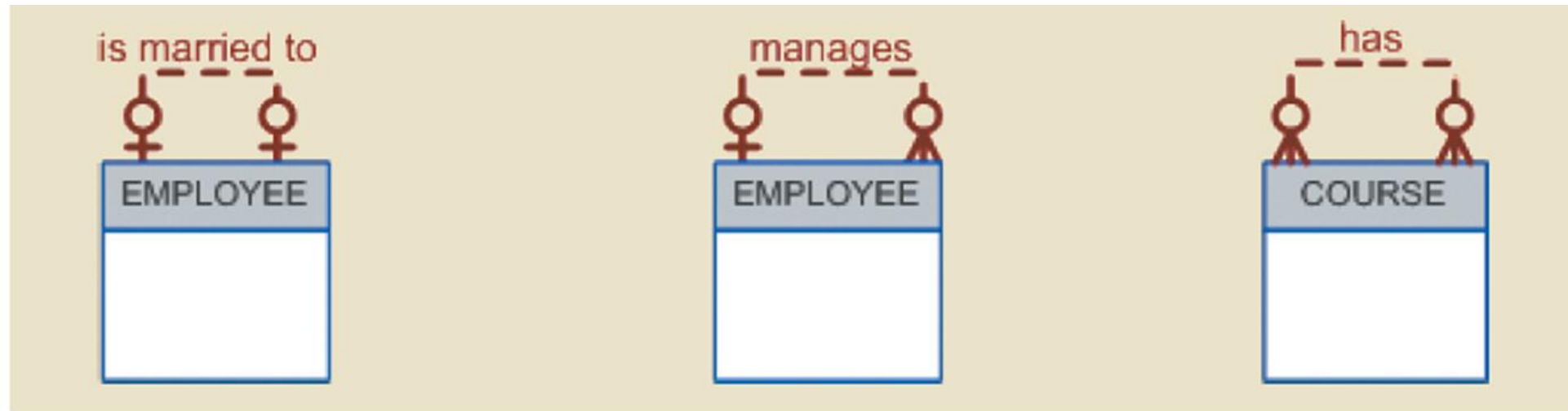


Figure 4.17 - An ER Representation of Recursive Relationships



Associative (Composite) Entities

- Used to represent an M:N relationship between two or more entities
- Is in a 1:M relationship with the parent entities
 - Composed of the primary key attributes of each parent entity
- May also contain additional attributes that play no role in connective process

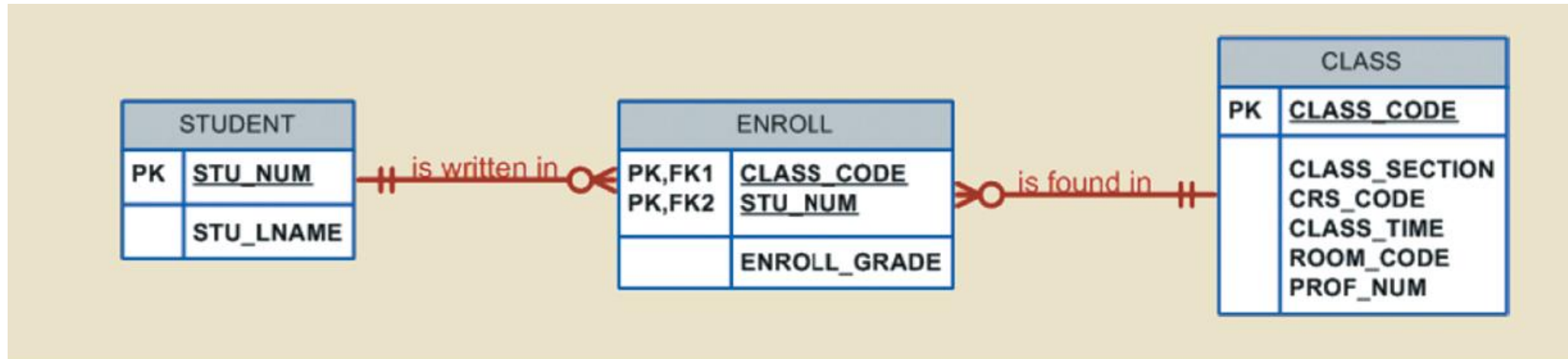
Figure 4.23 - Converting the M:N Relationship into Two 1:M Relationships

Table name: STUDENT		Database name: Ch04_CollegeTry			
STU_NUM	STU_LNAME				
321452	Bowser				
324257	Smithson				

Table name: ENROLL					
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					
CLASS_CODE	CRS_CODE	CLASS_SECTION	CLASS_TIME	ROOM_CODE	PROF_NUM
10014	ACCT-211	3	TTh 2:30-3:45 p.m.	BUS252	342
10018	CIS-220	2	MWF 9:00-9:50 a.m.	KLR211	114
10021	QM-261	1	MWF 8:00-8:50 a.m.	KLR200	114

Figure 4.25 - A Composite Entity in an ERD



Developing an ER Diagram

- Create a detailed narrative of the organization's description of operations
- Identify business rules based on the descriptions
- Identify main entities and relationships from the business rules
- Develop the initial ERD
- Identify the attributes and primary keys that adequately describe entities
- Revise and review ERD

Figure 4.26 - The First Tiny College ERD Segment

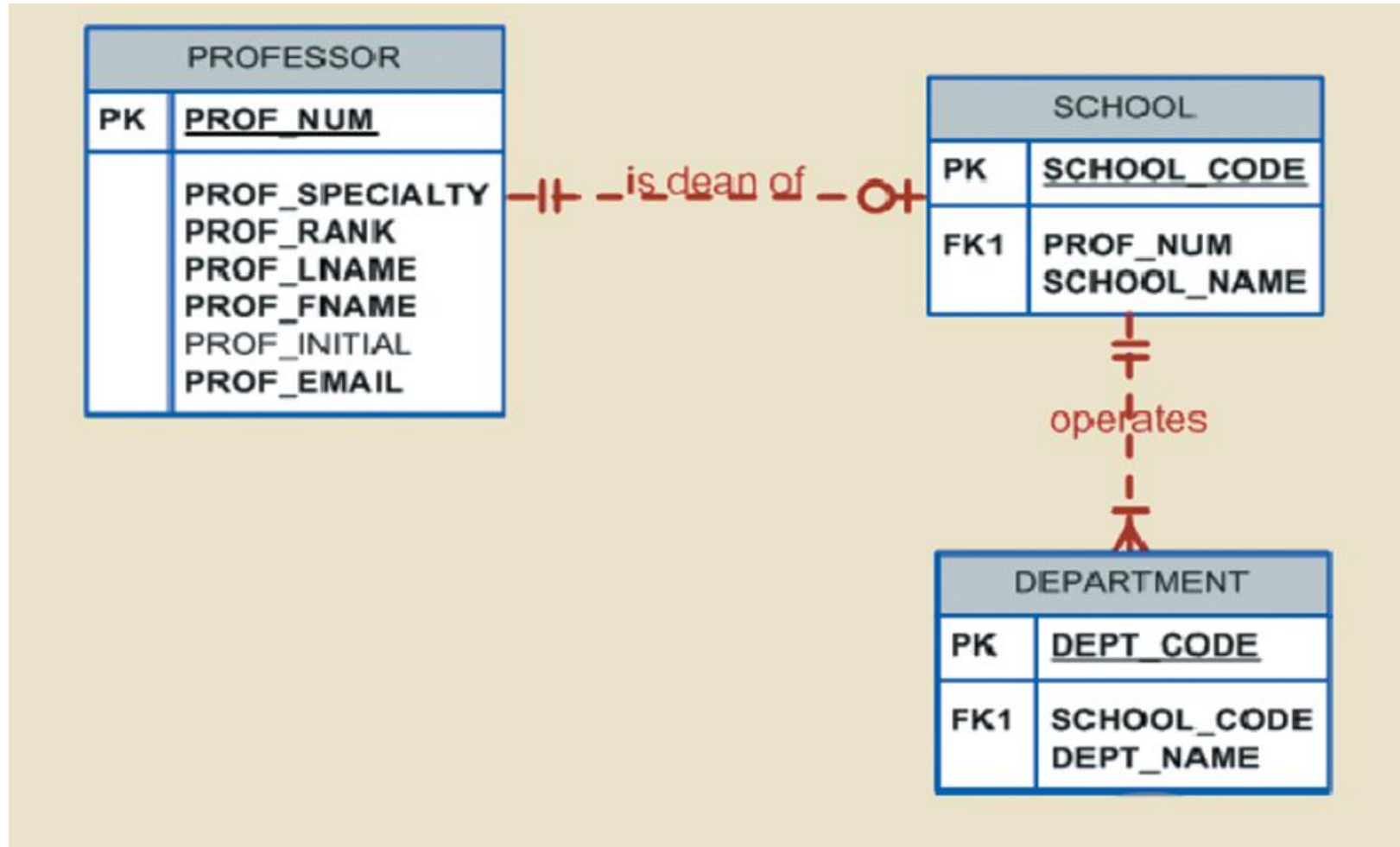


Figure 4.27 - The Second Tiny College ERD Segment



Figure 4.28 - The Third Tiny College ERD Segment

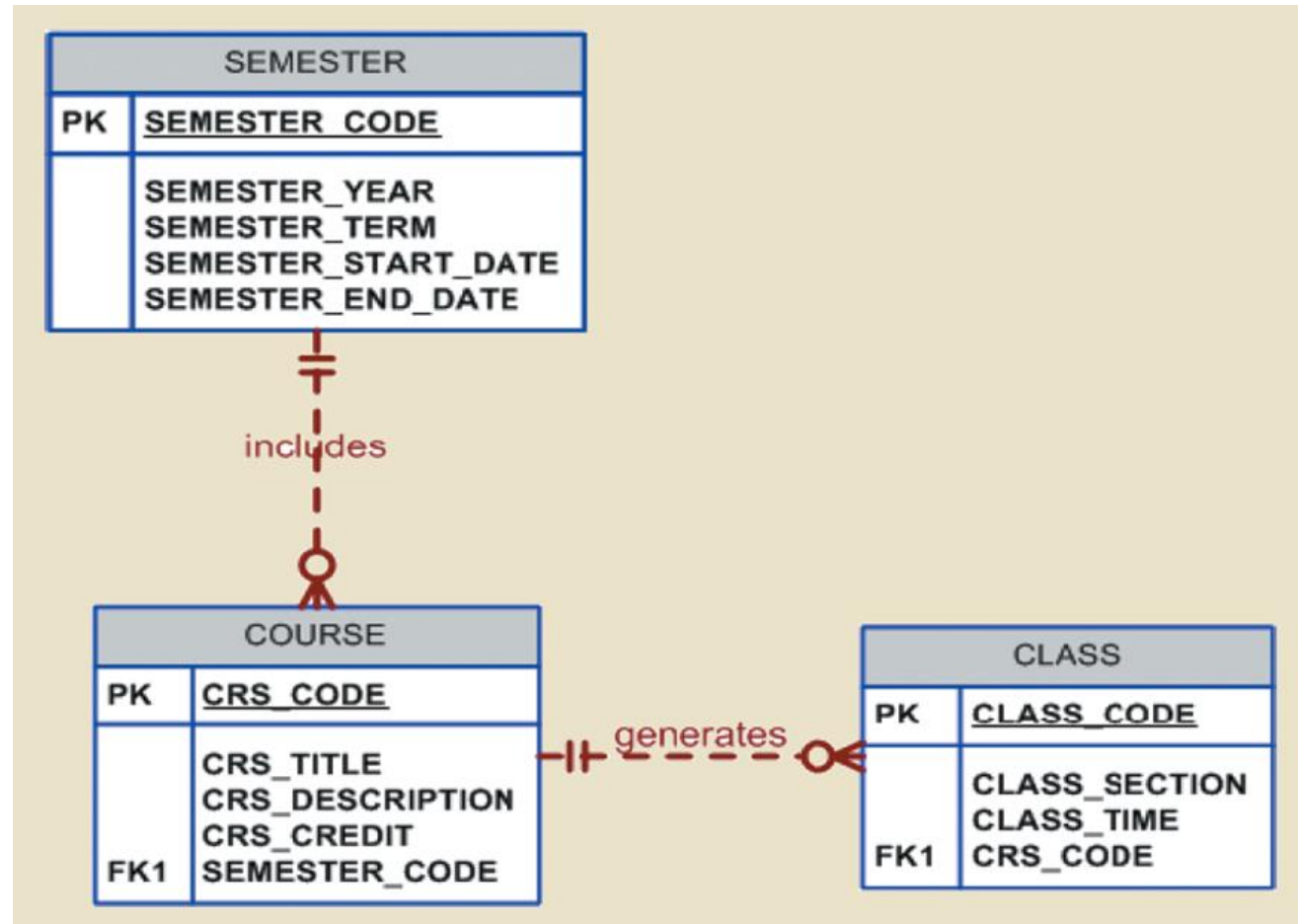


Figure 4.29 - The Fourth Tiny College ERD Segment

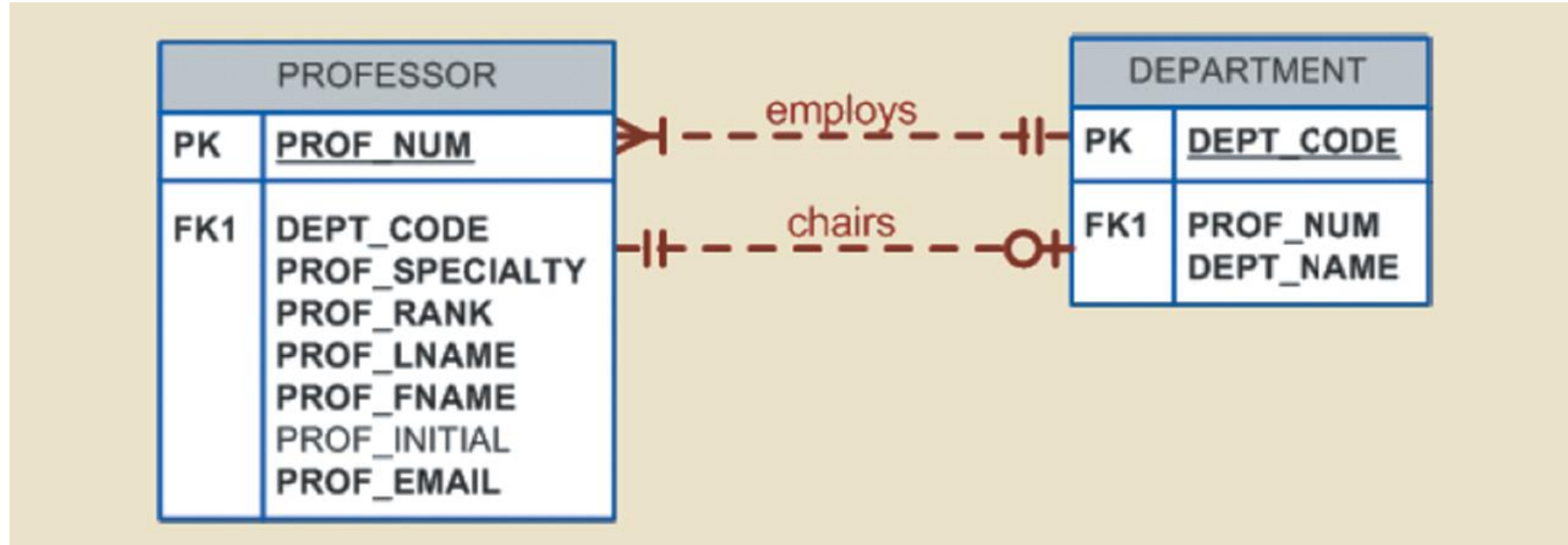


Figure 4.30 - The Fifth Tiny College ERD Segment

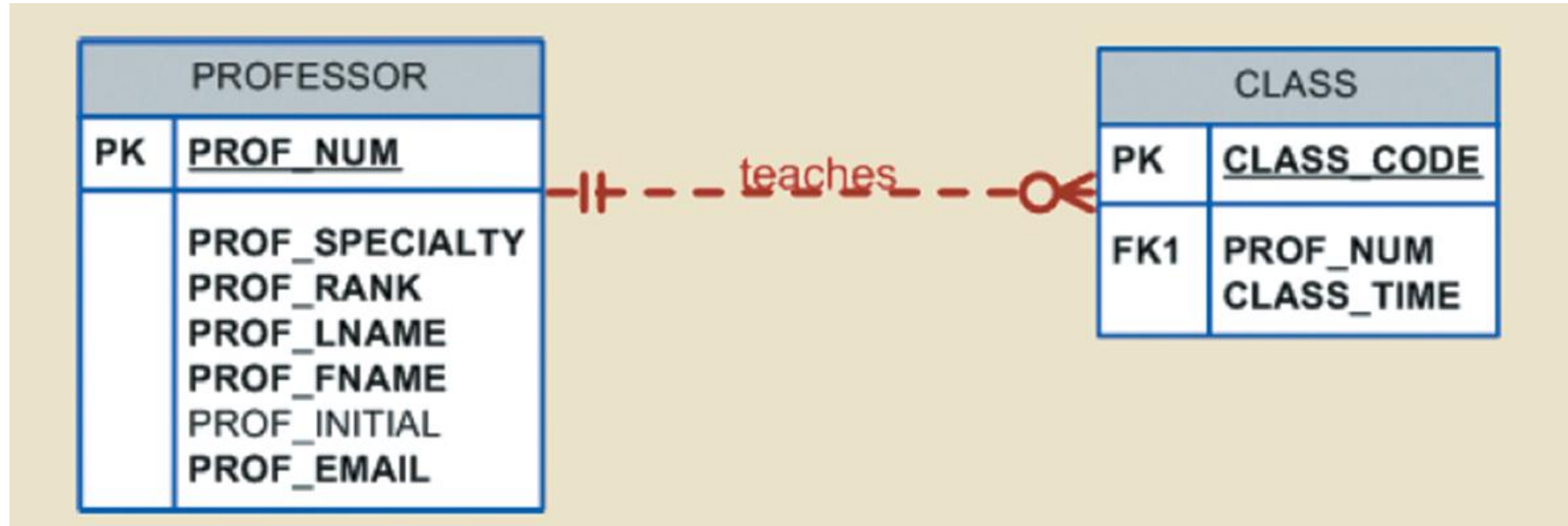


Figure 4.31 - The Sixth Tiny College ERD Segment

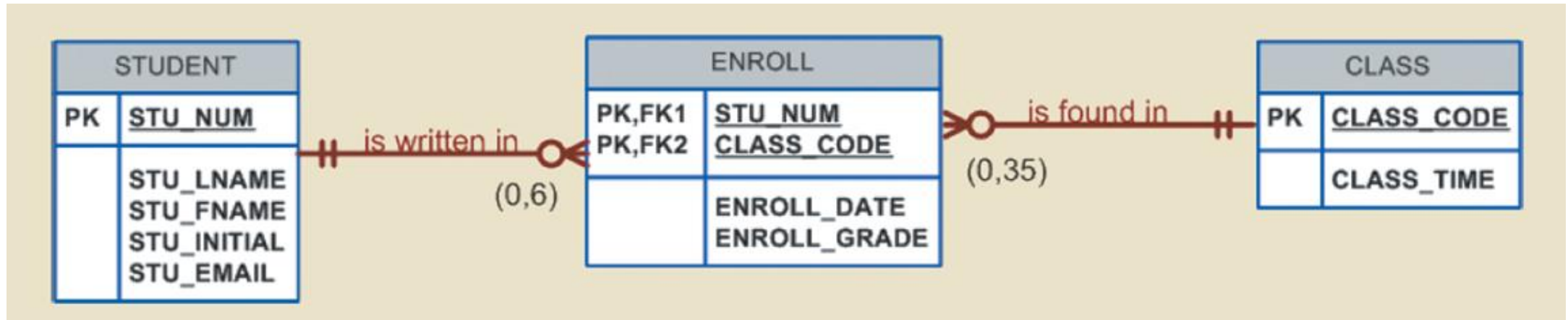


Figure 4.32 - The Seventh Tiny College ERD Segment

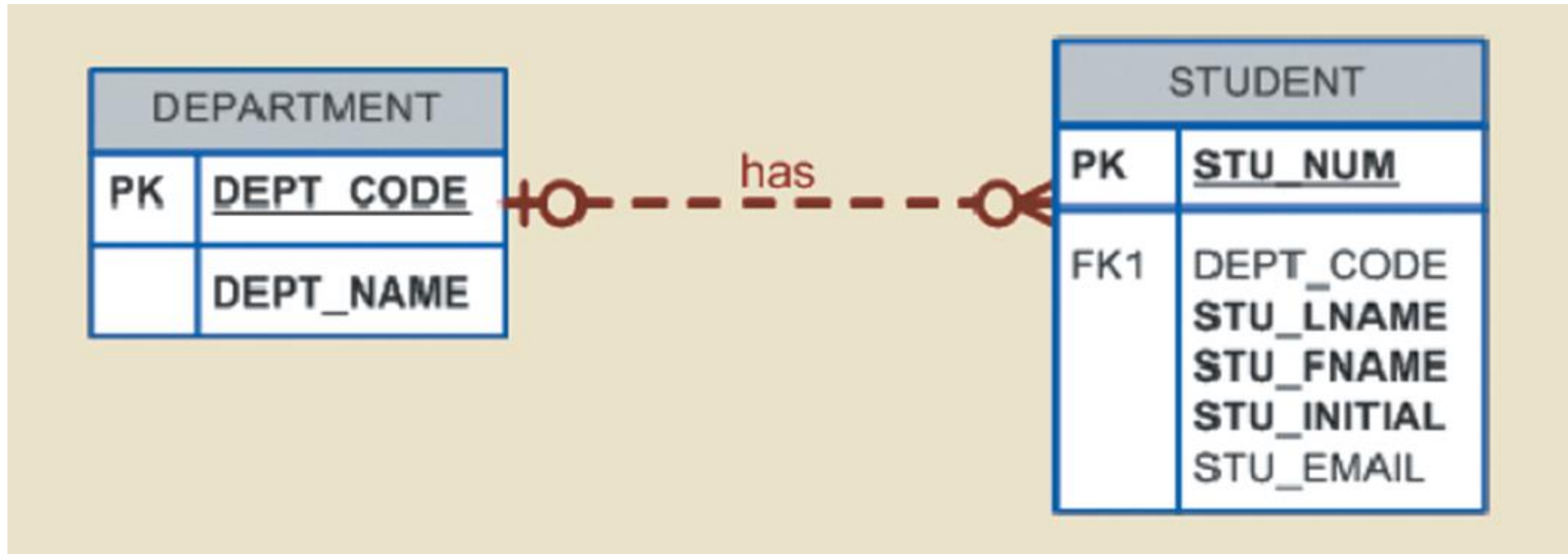


Figure 4.33 - The Eighth Tiny College ERD Segment

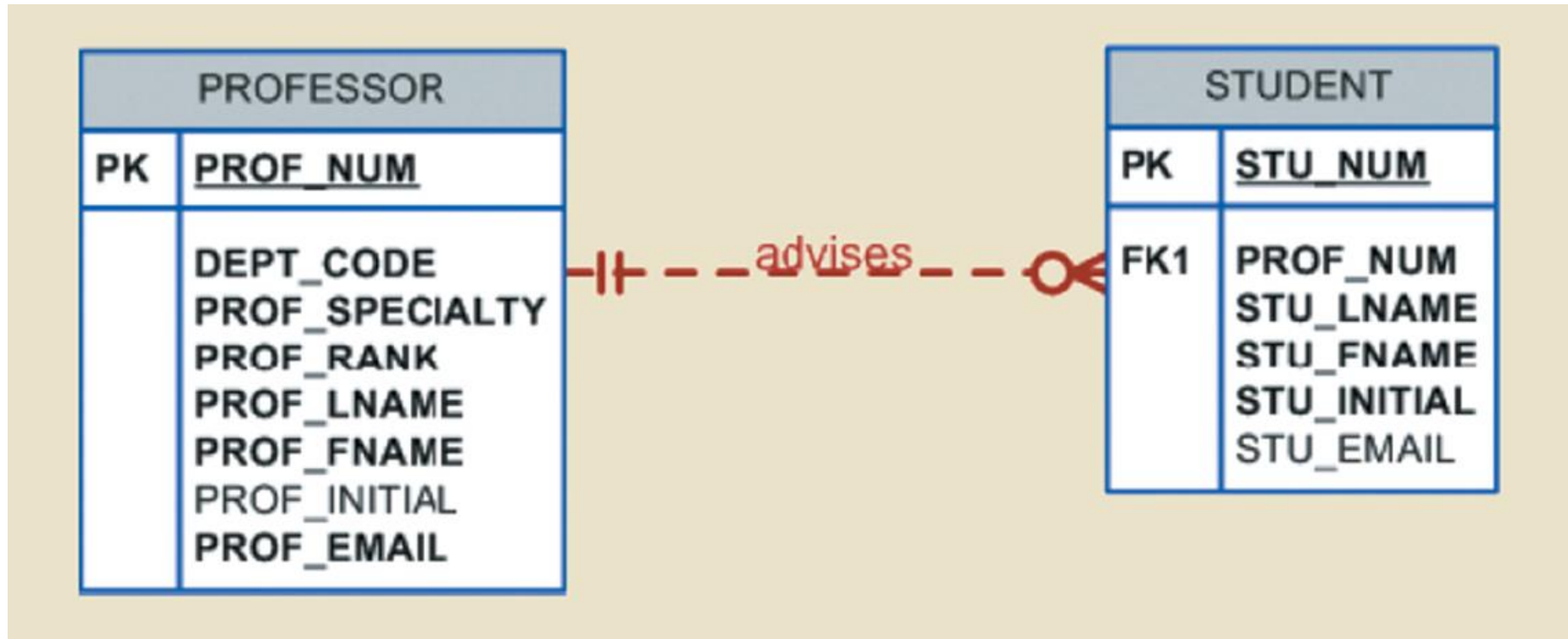


Figure 4.34 - The Ninth Tiny College ERD Segment

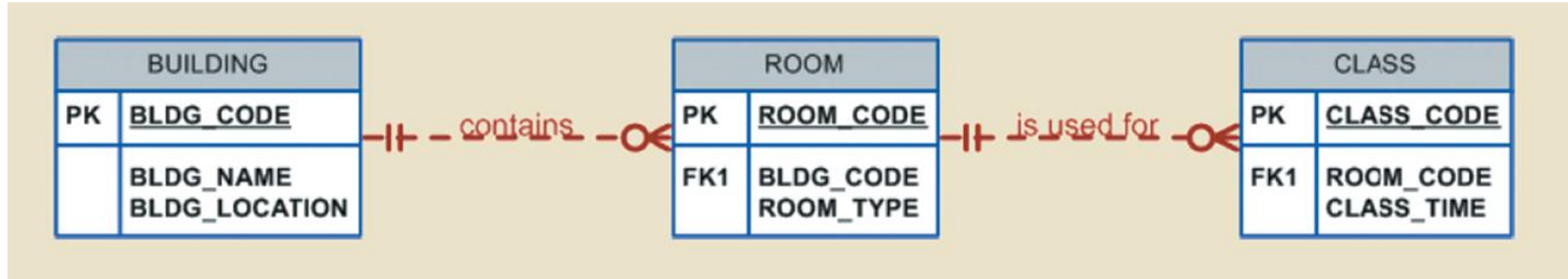


Table 4.4 - Components of the ERM

ENTITY	RELATIONSHIP	CONNECTIVITY	ENTITY
SCHOOL	operates	1:M	DEPARTMENT
DEPARTMENT	has	1:M	STUDENT
DEPARTMENT	employs	1:M	PROFESSOR
DEPARTMENT	offers	1:M	COURSE
COURSE	generates	1:M	CLASS
SEMESTER	includes	1:M	CLASS
PROFESSOR	is dean of	1:1	SCHOOL
PROFESSOR	chairs	1:1	DEPARTMENT
PROFESSOR	teaches	1:M	CLASS
PROFESSOR	advises	1:M	STUDENT
STUDENT	enrolls in	M:N	CLASS
BUILDING	contains	1:M	ROOM
ROOM	is used for	1:M	CLASS

Note: ENROLL is the composite entity that implements the M:N relationship “STUDENT enrolls in CLASS.”

Database Design Challenges: Conflicting Goals

- Database design must conform to design standards
- Need for high processing speed may limit the number and complexity of logically desirable relationships
- Need for maximum information generation may lead to loss of clean design structures and high transaction speed

Figure 4.38 - Various Implementations of the 1:1 Recursive Relationship

