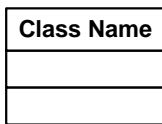# 1 Class Diagrams and Entity Relationship Diagrams (ERD)

Class diagrams and ERDs both model the structure of a system. Class diagrams represent the dynamic aspects of a system: both the structural and behavioural features. ERDs, depicting only structural features provide a static view of the system.
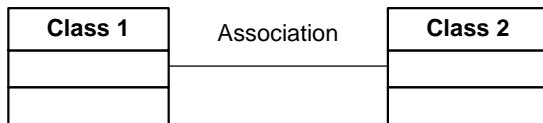
2 Class Diagrams

2.1 Elements of a class diagram:

2.1.1 class

A class is a general concept (represented as a square box). A class defines the structural attributes and behavioural characteristics of that concept. Shown as a rectangle labeled with the class name.
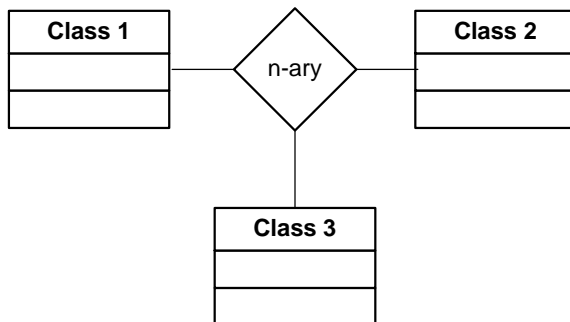
2.1.2 association

A (semantic) relationship between classes. A line that joins two classes.

2.1.2.1 binary

Simple association between two classes. A solid triangle with the association name indicates the direction in which the association is meant to be read.

2.1.2.2 n-ary

n-ary Association expresses an association between multiple classes

2.1.2.3 Aggregation

"has-a" relationship
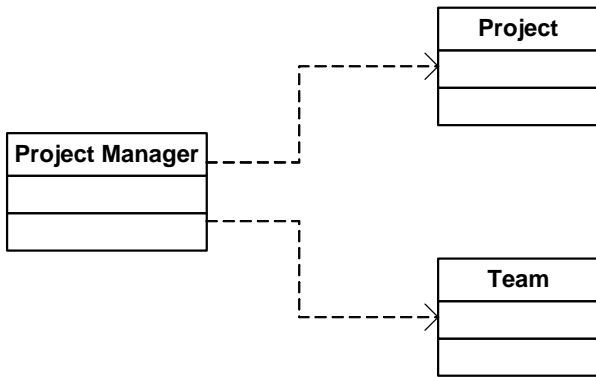
2.1.2.4 Composition

| Car | | Engine |

"is-composed-of" relationship

2.1.2.5 Generalization

| Car | | Volvo |

"is-a-kind-of" relationship

2.1.2.6 Dependency

| Project |

| Project Manager |

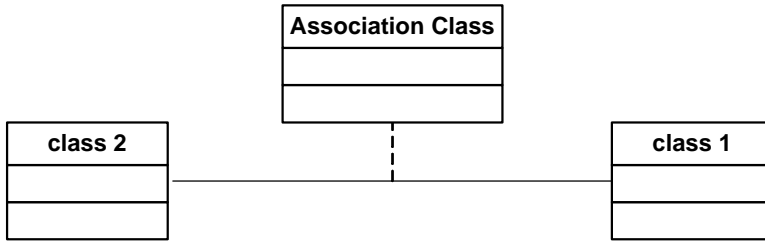| Team |

The source class depends on (uses) the target class. (not used for requirements analysis)

2.1.2.7 Realization

| «datatype» **Human Resources** |

| «datatype» **Project Manager** |

| **Worker** |

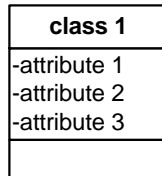| «datatype» **System Administrator** |
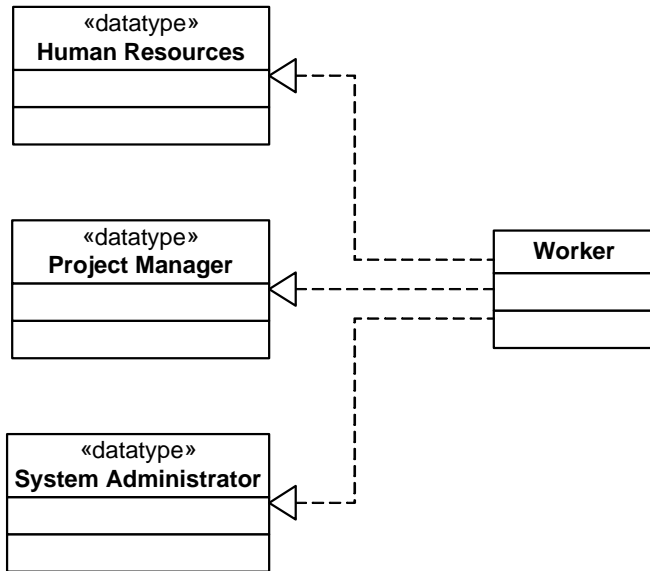
Class supports all operations of target class but not all attributes or associations. (not used for requirements analysis)
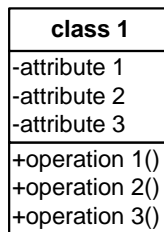
2.1.2.8 Association Classes

Can be applied to binary or n-ary associations. Used to capture the attributes of an association.

2.1.3 attribute

What is known about each object of this class type. Typical characteristics.

2.1.4 operation

What objects of this class type do. Typical actions that are relevant to the current analysis.

3 Creating a Class Diagram

 Here are some steps to help create a class diagram:

3.1 Identify Classes

These are the abstract or physical "things" in our system which we wish to describe. Find all the nouns and noun phrases in the domain descriptions you have obtained through your analysis. Consider these class candidates.

3.2 Find Associations

Now find the verbs that join the nouns. e.g., The professor (noun) teaches (verb) students (noun). The verb in this case, defines an association between the two nouns. Identify the type of association. Use a matrix to define the associations between classes.

3.3 Draw Rough Class Diagram

Put classes in rectangles and draw the associations connecting the classes.

3.4 Fill in Multiplicity

 Determine the number of occurrences of one class for a single occurrence of the associated class.

3.5 Identify Attributes

Name the information details (fields) which are relevant to the application domain for each class.

3.6 Identify Behaviours -

Specify the operations that are required for each class. (assume getter and setter methods for each attribute.)

3.7 Review your diagram and fine tune it.

Look for inconsistencies and errors. Fix them. Make sure you have captured everything required from the domain you are studying - that your diagram is complete.

4 Entity Relationship Diagrams

4.1 Elements of Entity Relationship Diagrams:

4.1.1 Entity

Entity 1

Entity 1 — Relationship — Entity 2

Key Attribute

Attribute 1

Entity 1

Attribute 2
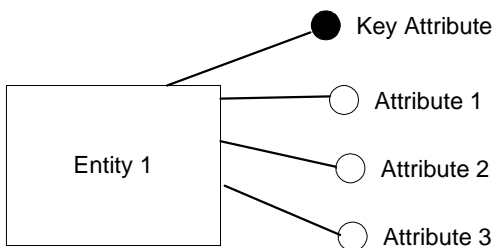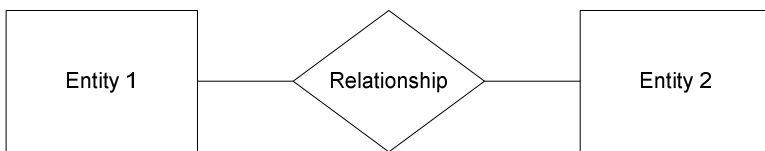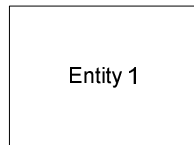
Attribute 3

A data attribute is a property common to an entity.

4.2 Creating an ERD

Here are the steps you may follow to create an entity-relationship diagram.

4.2.1 Identify Entities

Identify the entities. These are typically the nouns and noun-phrases in the descriptive data produced in your analysis. Do not include entities that are irrelevant to your domain.

4.2.2 Find Relationships

Discover the semantic relationships between entities. These are usually the verbs that connect the nouns. Not all relationships are this blatant, you may have to discover some on your own. The easiest way to see all possible relationships is to build a table with the entities across the columns and down the rows, and fill in those cells where a relationship exists between entities.

4.2.3 Draw Rough ERD

Draw the entities and relationships that you have discovered.

4.2.4 Fill in Cardinality

Determine the cardinality of the relationships. You may want to decide on cardinality when you are creating a relationship table.

4.2.5 Define Primary Keys

Identify attribute(s) that uniquely identify each occurrence of that entity.

4.2.6 Draw Key-Based ERD

Now add them (the primary key attributes) to your ERD. Revise your diagram to eliminate many-to-many relationships, and tag all foreign keys .

4.2.7 Identify Attributes

Identify all entity characteristics relevant to the domain being analyzed.

4.2.8 Map Attributes

Determine which to entity each characteristic belongs. Do not duplicate attributes across entities. If necessary, contain them in a new, related, entity.

4.2.9 Draw fully attributed ERD

Now add these attributes. The diagram may need to be modified to accommodate necessary new entities.

4.2.10 Check Results

Is the diagram a consistent and complete representation of the domain.

5 Practice Example

The University of Toronto has several departments. Each department is managed by a chair, and at least one professor. Professors must be assigned to one, but possibly more departments. At least one professor teaches each course, but a professor may be on sabbatical and not teach any course. Each course may be taught more than once by different professors. We know of the department name, the professor name, the professor employee id, the course names, the course schedule, the term/year that the course is taught, the departments the professor is assigned to, the department that offers the course.

5.1 Class Diagram

5.1.1 Identify Classes

These are the abstract or physical "things" in our system which we wish to describe. Find all the nouns and noun phrases in the domain descriptions you have obtained through your analysis. Consider these class candidates.

The class candidates are departments, chair, professor, course, and course section. Since there is only one instance of the University of Toronto, we exclude it from our consideration.

5.1.2 Find Associations

Now find the verbs that join the nouns. e.g., The professor (noun) teaches (verb) students (noun). The verb in this case, defines an association between the two nouns. Identify the type of association. Use a matrix to define the associations between classes.

	department	chair	professor	course
department		managed by	is assigned (aggregate)	offers
chair	manages		is a	
professor	assigned to (aggregate)			teaches
course	offered by		taught by	

5.1.3 Draw Rough Class Diagram

Put classes in rectangles and draw the associations connecting the classes.
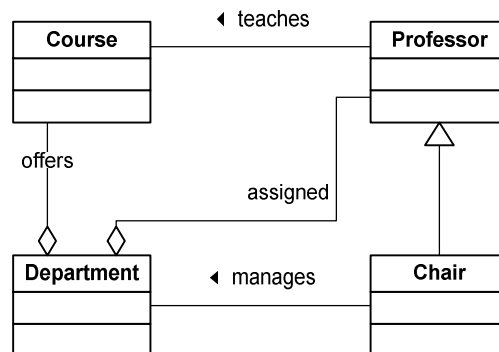
5.1.4 Fill in Multiplicity

Determine the number of occurrences of one class for a single occurrence of the associated class.
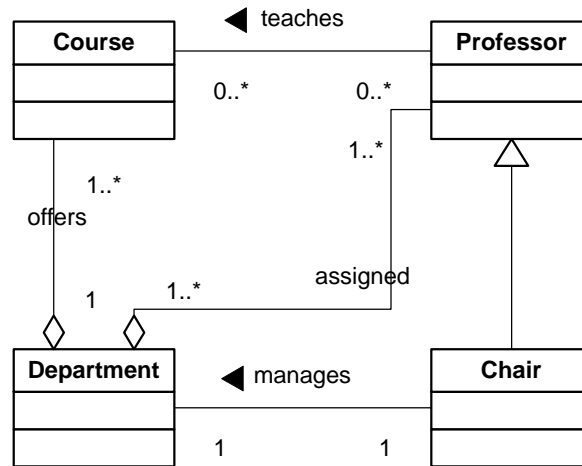
5.1.5 Identify Attributes

Name the information details (fields) which are relevant to the application domain for each class.   Add these attributes.

We have the department name, the professor name, the professor employee id, the course names, the course schedule, the term/year that the course is taught, the departments the professor is assigned to, the department that offers the course.
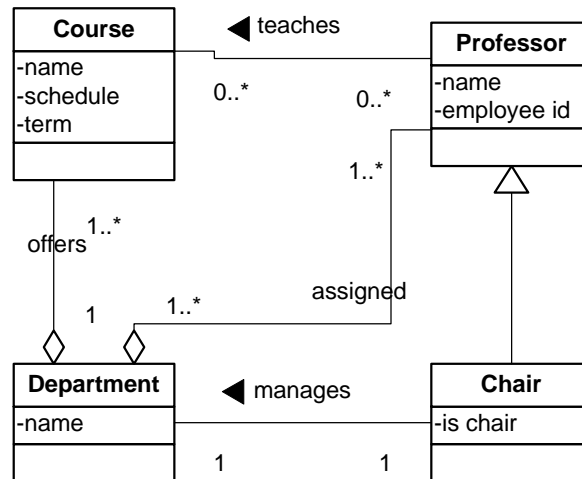
5.1.6 Identify Behaviours

Specify the operations that are required for each class. (assume getter and setter methods for each attribute.) In this example - we are not given any behaviours, so we will have to make them up. What are some behaviours of these classes?
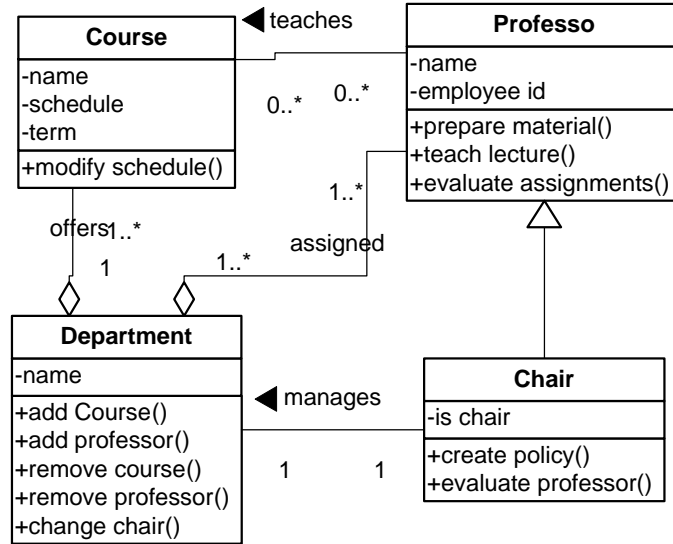
5.1.7 Review your diagram and fine tune it.

Look for inconsistencies and errors. Fix them. Make sure you have captured everything required from the domain you are studying - that your diagram is complete.

5.2 Entity-Relationship Diagram

5.2.1 Identify Entities

Identify the entities. These are typically the nouns and noun-phrases in the descriptive data produced in your analysis. Do not include entities that are irrelevant to your domain.

The entity candidates are departments, chair, professor, course, and course section. Since there is only one instance of the University of Toronto, we exclude it from our consideration.

5.2.2 Find Relationships

Discover the semantic relationships between entities. These are usually the verbs that connect the nouns. Not all relationships are this blatant, you may have to discover some on your own. The easiest way to see all possible relationships is to build a table with the entities across the columns and down the rows, and fill in those cells where a relationship exists between entities.

|	department	chair	professor	course
department		managed by	is assigned	offers
chair	manages		is a	
professor	assigned to			teaches
course	offered by		taught by	

5.2.3 Draw Rough ERD

Draw the entities and relationships that you have discovered.
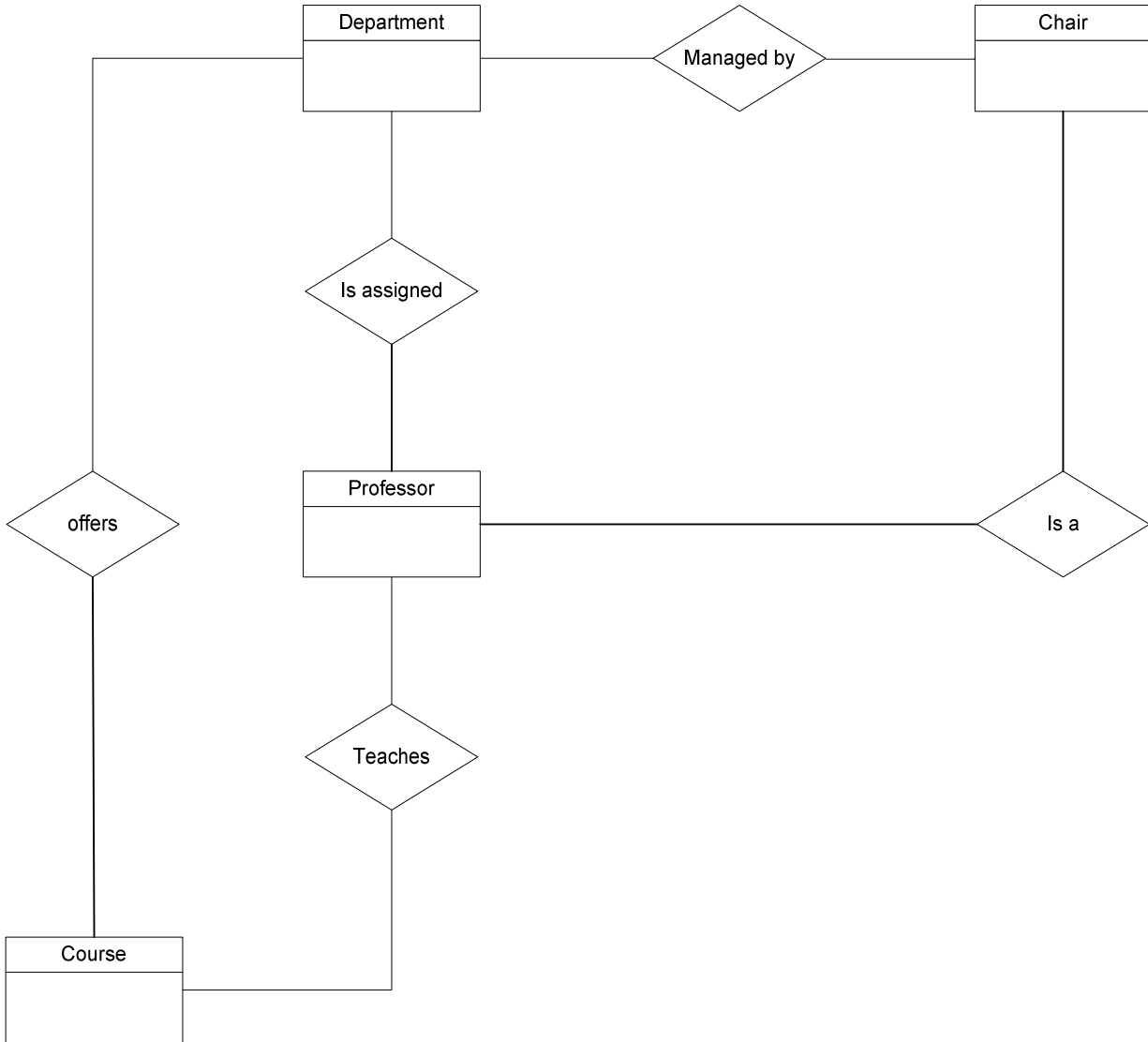
5.2.4 Fill in Cardinality

Determine the cardinality of the relationships. You may want to decide on cardinality when you are creating a relationship table.

Department	(1,1)	Managed by	(1,1)		Chair

(1,*) Is assigned (1,*)

(1,*) offers (1,1)

Professor

(0,1) Is a (1,1)

(0,*) Teaches (1,*)

Course
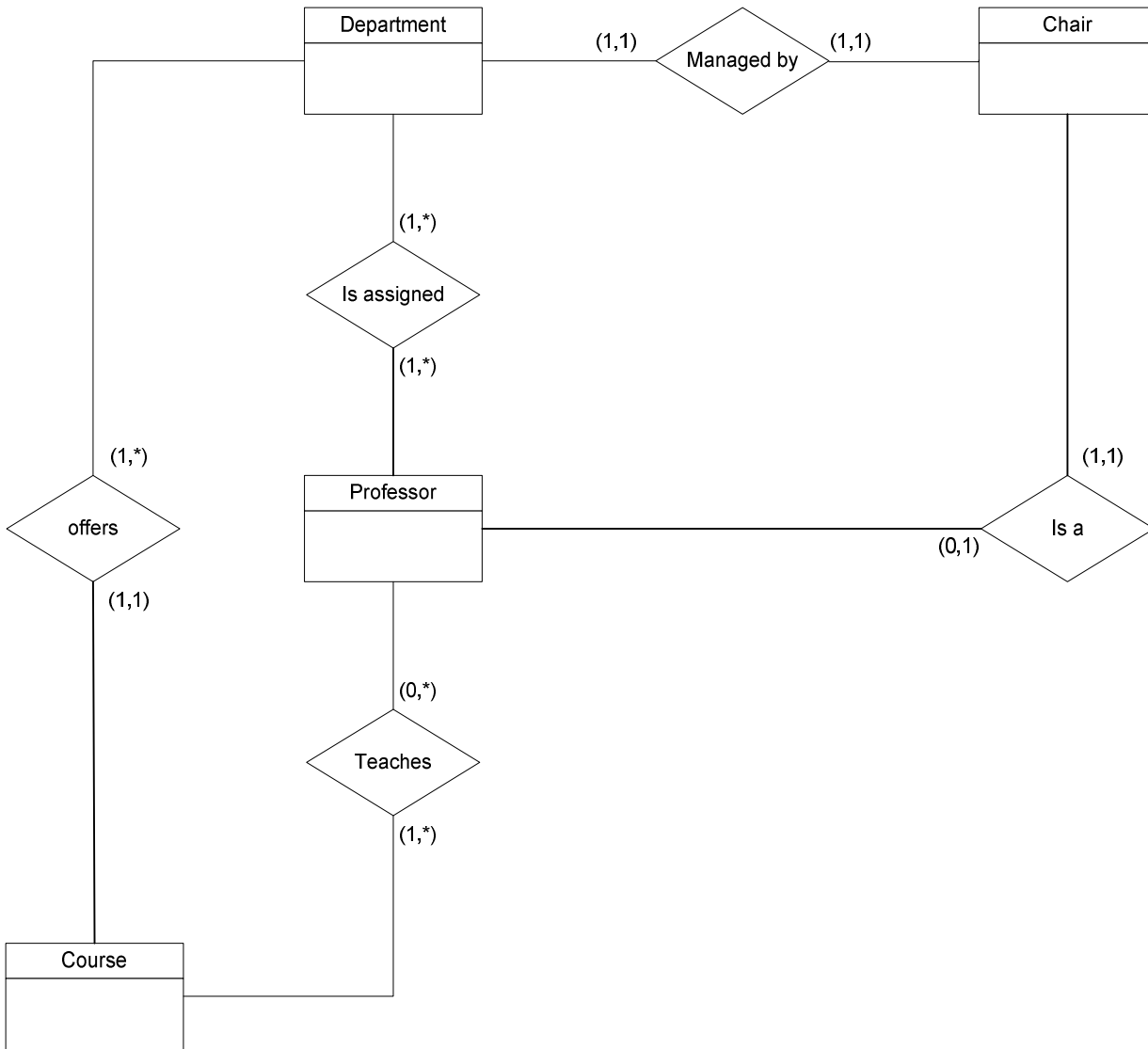
Here we must eliminate many-to-many relationships, and collapse one-to-one relationships where it makes sense. For example, the chair, without any behaviours, is really just an attribute of a department. So we can remove it as an entity and later add it as an attribute.
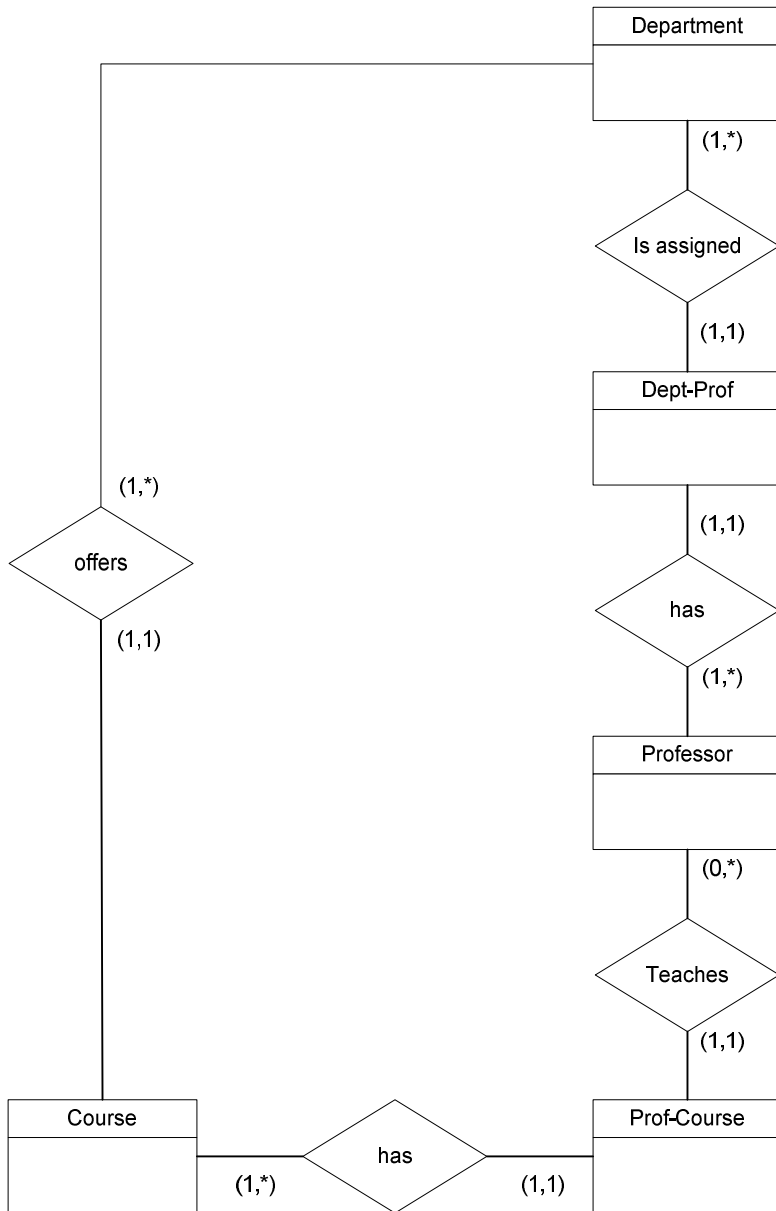
```
                                    ┌──────────────────┐
                                    │   Department     │
                                    ├──────────────────┤
                                    │                  │
                                    └──────────────────┘
                                             │
                                          (1,*)
                                          ◇ Is assigned ◇
                                          (1,1)
                                    ┌──────────────────┐
                                    │   Dept-Prof      │
                                    ├──────────────────┤
                                    │                  │
                                    └──────────────────┘
                                          (1,1)
                                          ◇ has ◇
                                          (1,*)
                                    ┌──────────────────┐
                                    │   Professor      │
                                    ├──────────────────┤
                                    │                  │
                                    └──────────────────┘
                                          (0,*)
                                          ◇ Teaches ◇
                                          (1,1)
```

(1,*) offers (1,1)

◇ offers ◇

┌──────────────┐   ◇ has ◇   ┌──────────────┐
│   Course   │ (1,*)   (1,1)   │ Prof-Course │
├──────────────┤   ├──────────────┤
│   │   │   │
└──────────────┘   └──────────────┘

5.2.5 Define Primary Keys

Identify attribute(s) that uniquely identify each occurrence of that entity.

department	name
dept-prof	dept. name employee id
professor	employee id
prof-course	employee id course name
course	course name

5.2.6 Draw Key-Based ERD

Now add them (the primary key attributes) to your ERD. Revise your diagram to eliminate many-to-many relationships, and tag all foreign keys .
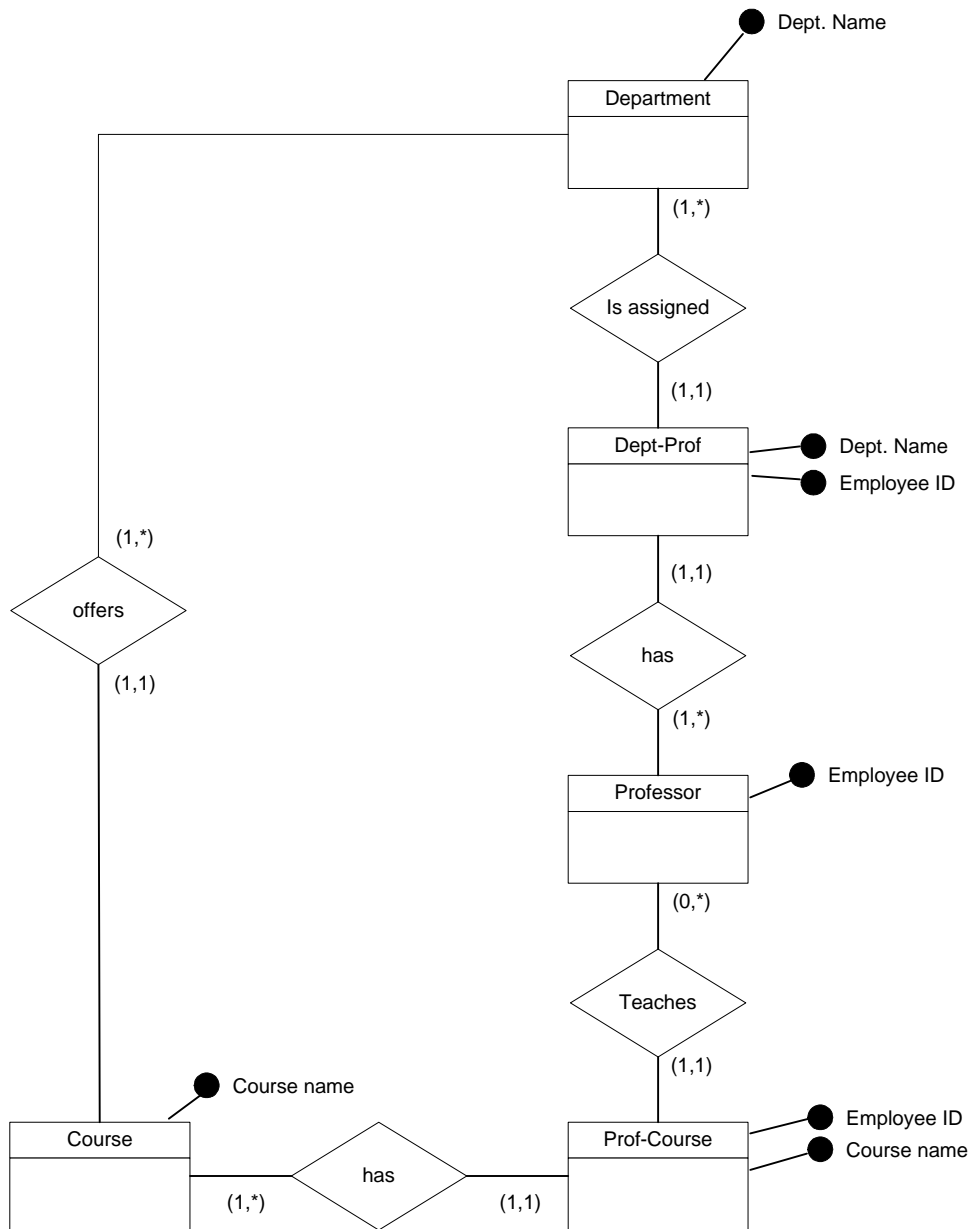
5.2.7 Identify Attributes

Identify all entity characteristics relevant to the domain being analyzed.
Excluding those keys already identified:
Schedule, Term, Professor name, Department Chair (which is an employee ID, a foreign key to Professor)
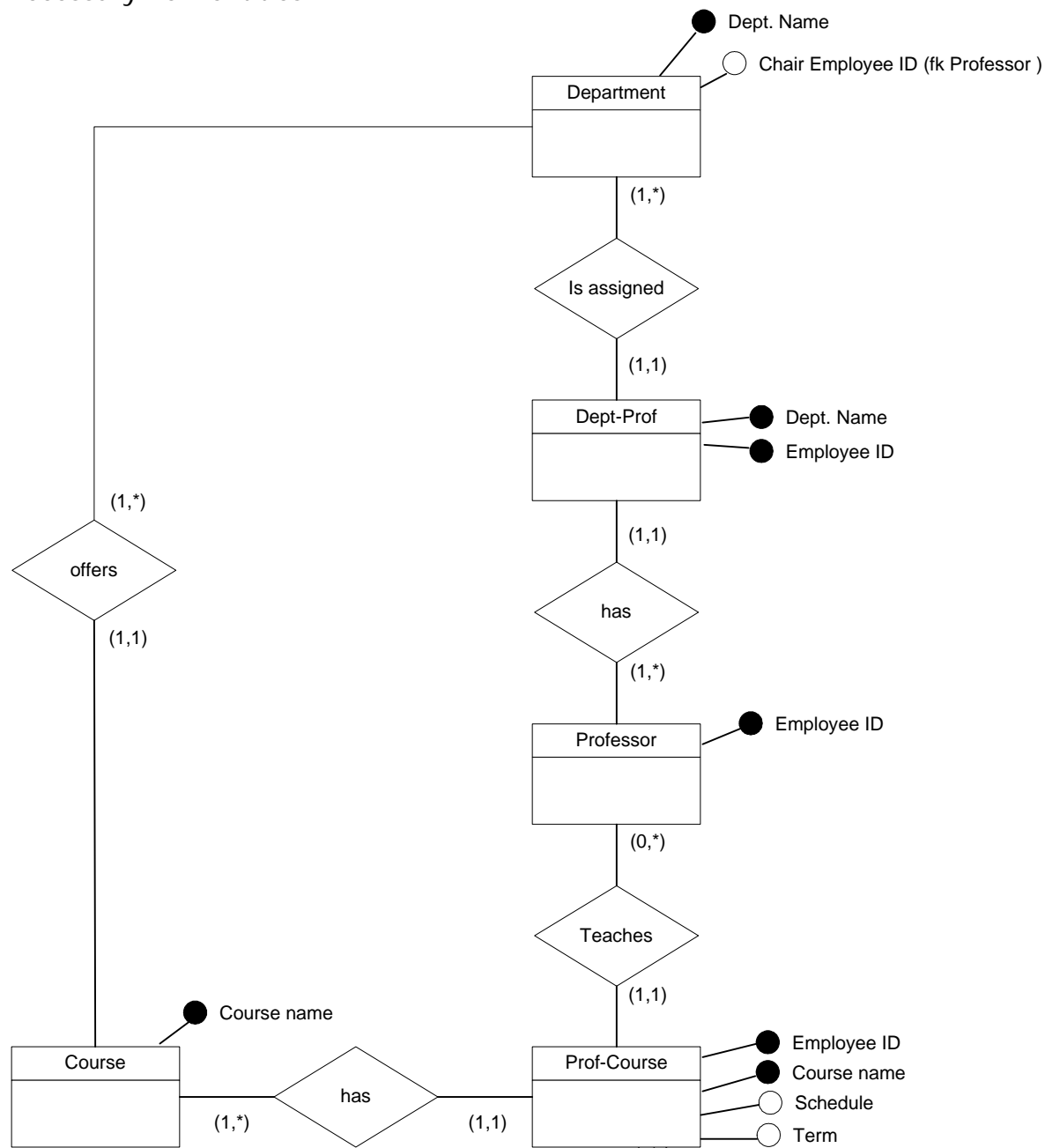
5.2.8 Map Attributes

Determine which to entity each characteristic belongs. Do not duplicate attributes across entities. If necessary, contain them in a new, related, entity.
Schedule → Prof-Course, Term → Prof-Course, Chair → Department

5.2.9 Draw fully attributed ERD

Now add these attributes. The diagram may need to be modified to accommodate necessary new entities.

5.2.10 Check Results

Is the diagram a consistent and complete representation of the domain. If not - fix it.