Entity Relationship Modelling

DBI - Databases and Interfaces

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This Lecture

- Entity/Relationship models
  - Entities and Attributes
  - Relationships
  - E/R Diagrams

- Further Reading
  - Database Systems, Connolly & Begg, Chapter 12

Database Design

- Before we look at how to create and use a database we'll look at how to design one
- Need to consider
  - What tables, keys, and constraints are needed?
  - What is the database going to be used for?
- Designing your database is important
  - We can create a database design that is independent of DBMS
  - Often results in a more efficient and simpler queries once the database has been created

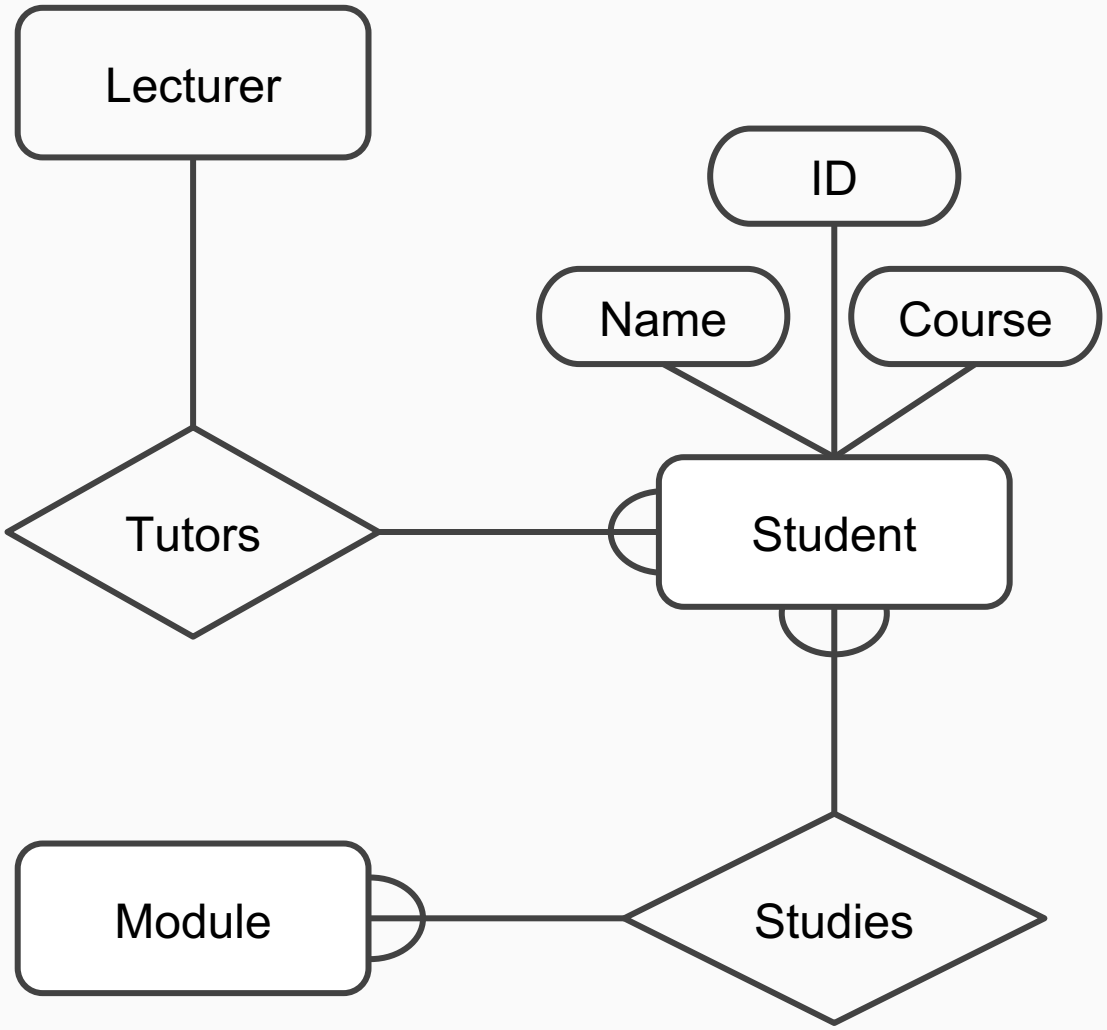
Entity/Relationship Modelling

- E/R Modelling is used for conceptual design
  - Entities
    - objects or items of interest
  - Attributes
    - properties of an entity
  - Relationships
    - links between entities

- For example, in a University database we might have entities for Students, Modules and Lecturers
  - Students might have attributes such as their ID, Name, and Course
  - Students could have relationships with Modules (enrolment) and Lecturers (tutor/tutee)

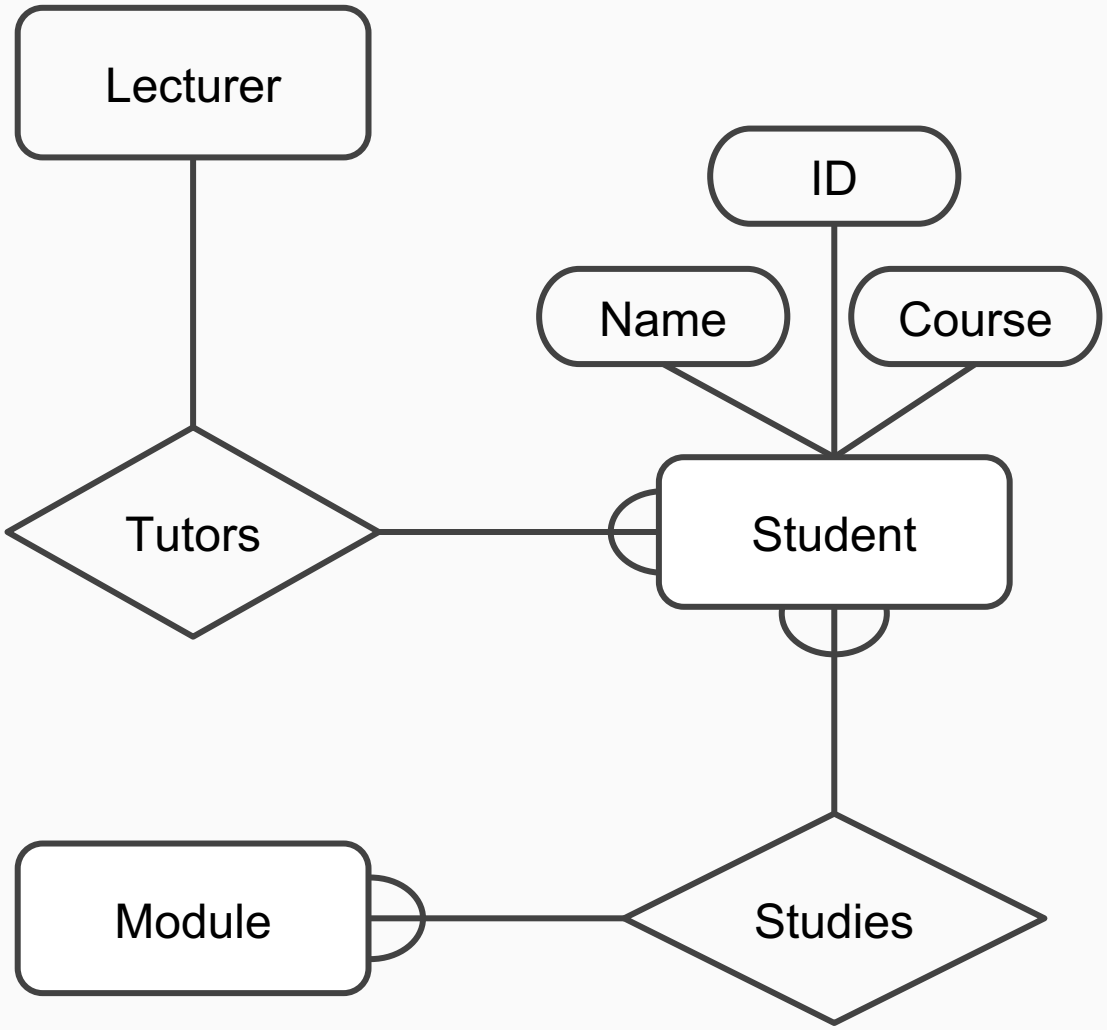
Entity/Relationship Diagrams

- E/R Models are often represented as E/R diagrams that
  - Give a conceptual view of the database
  - Are independent of the choice of DBMS
  - Can identify some problems in a design



E/R: Diagram Conventions

- There are various notations for representing E/R diagrams
- These specify the shape of the various components, and the notation used to represent relationships
- For this introductory module, we will use **simplified** notation



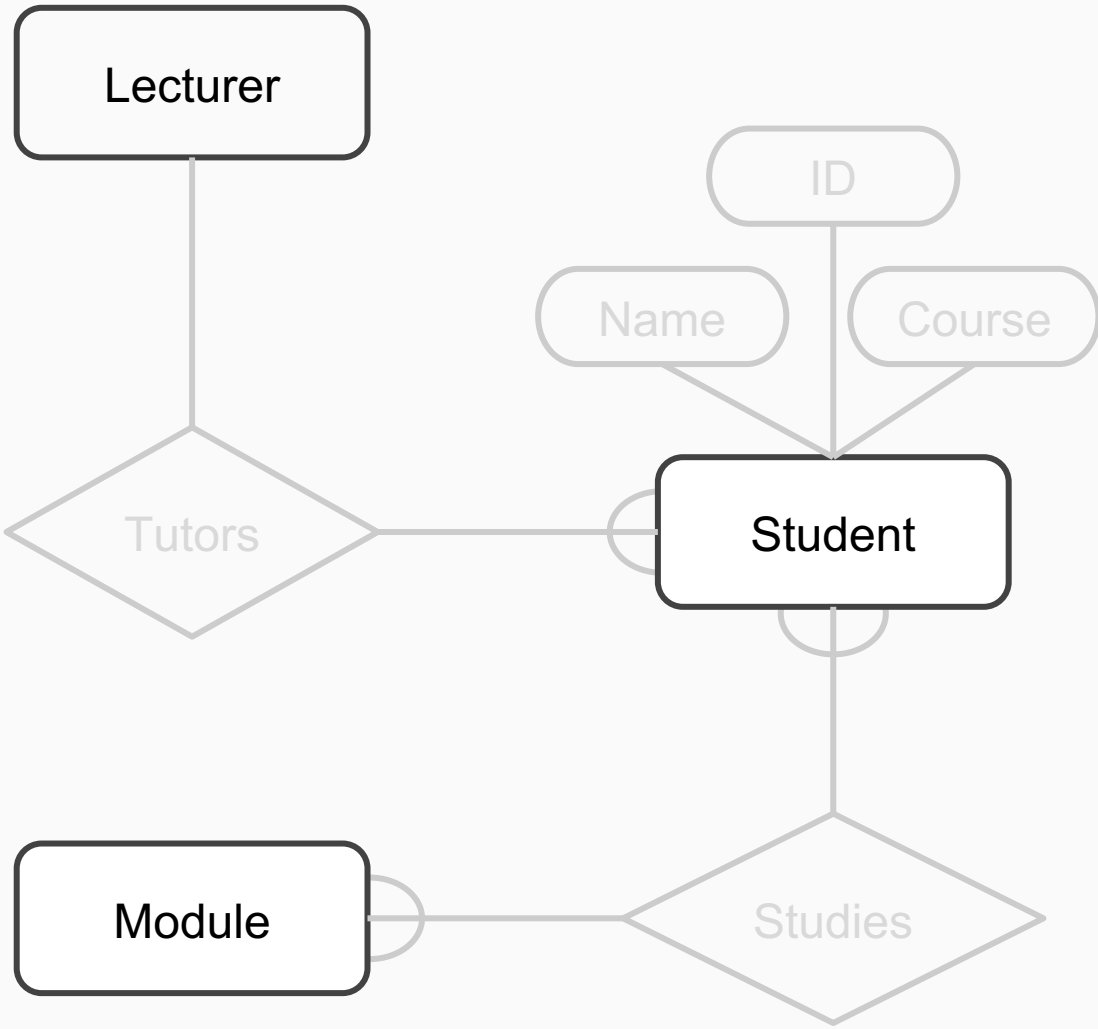
Entities

- Entities represent objects or things of interest
  - Physical things like students, lecturers, employees, products
  - More abstract things like modules, orders, courses, projects
- Entities have
  - A general type or class, such as Lecturer or Module
  - Instances of that particular type. E.g. Paul Dempster and Guoping Qiu are instances of Lecturer
  - Attributes (such as name, email address)

E/R: Diagramming Entities

- In E/R Diagrams, we will represent Entities as boxes with rounded corners

- The box is labelled with the name of the class of objects represented by that entity

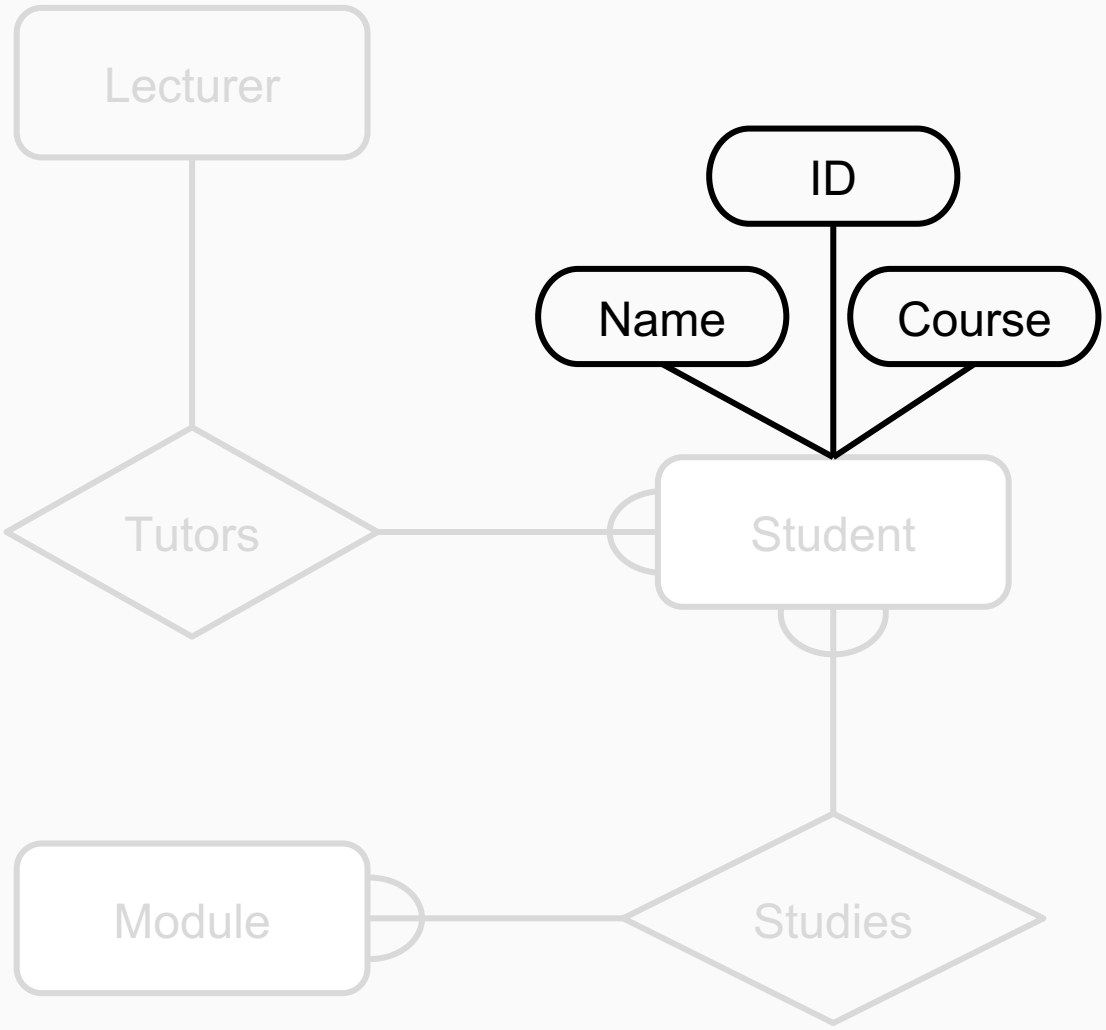


Attributes

- Attributes are facts, aspects, properties, or details about an entity
  - Students have IDs, names, courses, addresses, …
  - Modules have codes, titles, credit weights, levels, …
- Attributes have
  - A name
  - An associated entity
  - Domains of possible values
  - For each instance of the associated entity, a value from the attributes domain

E/R: Diagram Attributes

- In an E/R Diagram attributes are drawn as ovals
- Each attribute is linked to its entity by a line
- The name of the attribute is written in the oval



Relationships

- Relationships are an association between two or more entities
  - Each Student takes several Modules
  - Each Module is taught by a Lecturer
  - Each Employee works for a single Department
- Relationships have
  - A name
  - A set of entities that participate in them
  - A degree
    - the number of entities that participate (most have degree 2)
  - A cardinality ratio

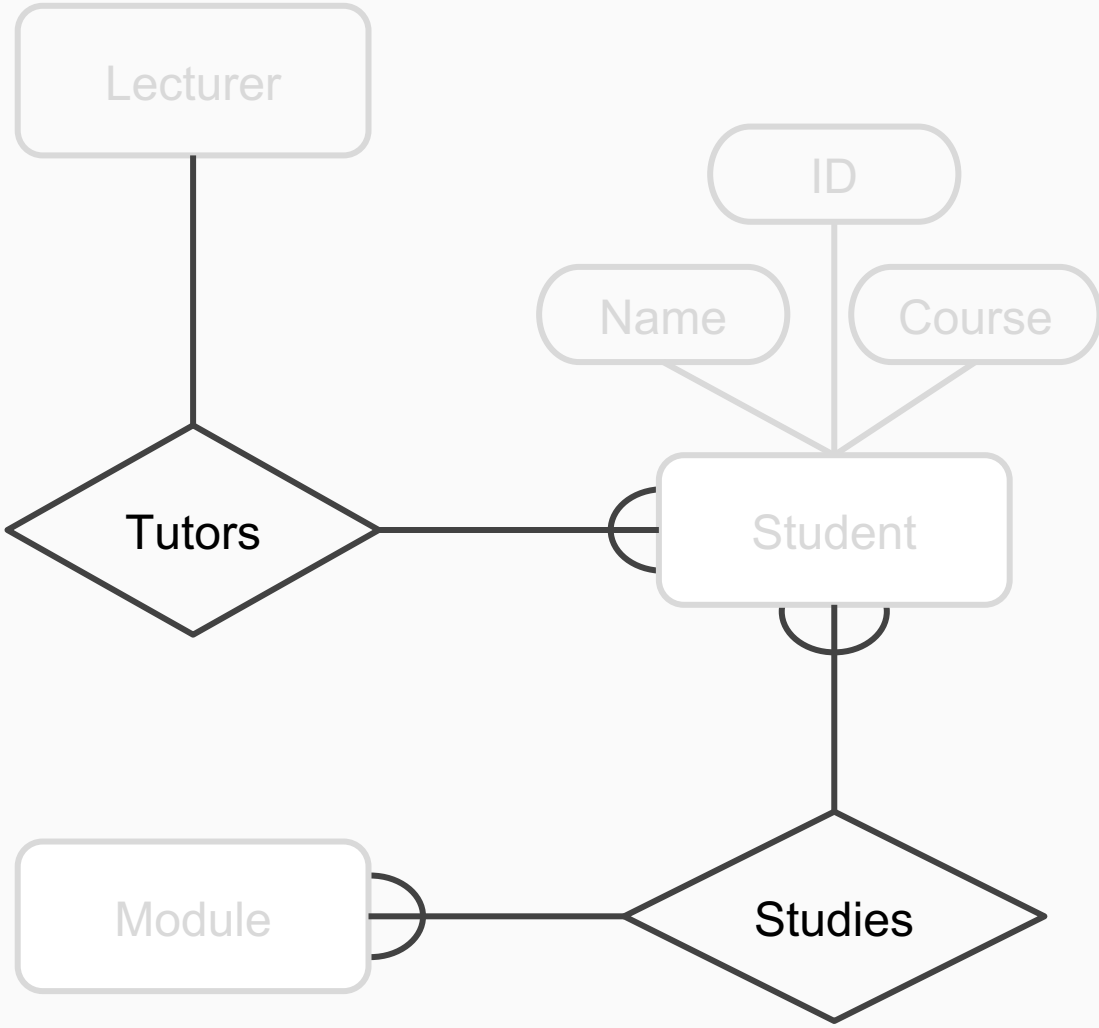
Cardinality Ratios

- Each entity in a relationship can participate in zero, one, or more than one instances of that relationship
- We won't be dealing with optional (zero instances) of relationships
- This leads to 3 types of relationship...

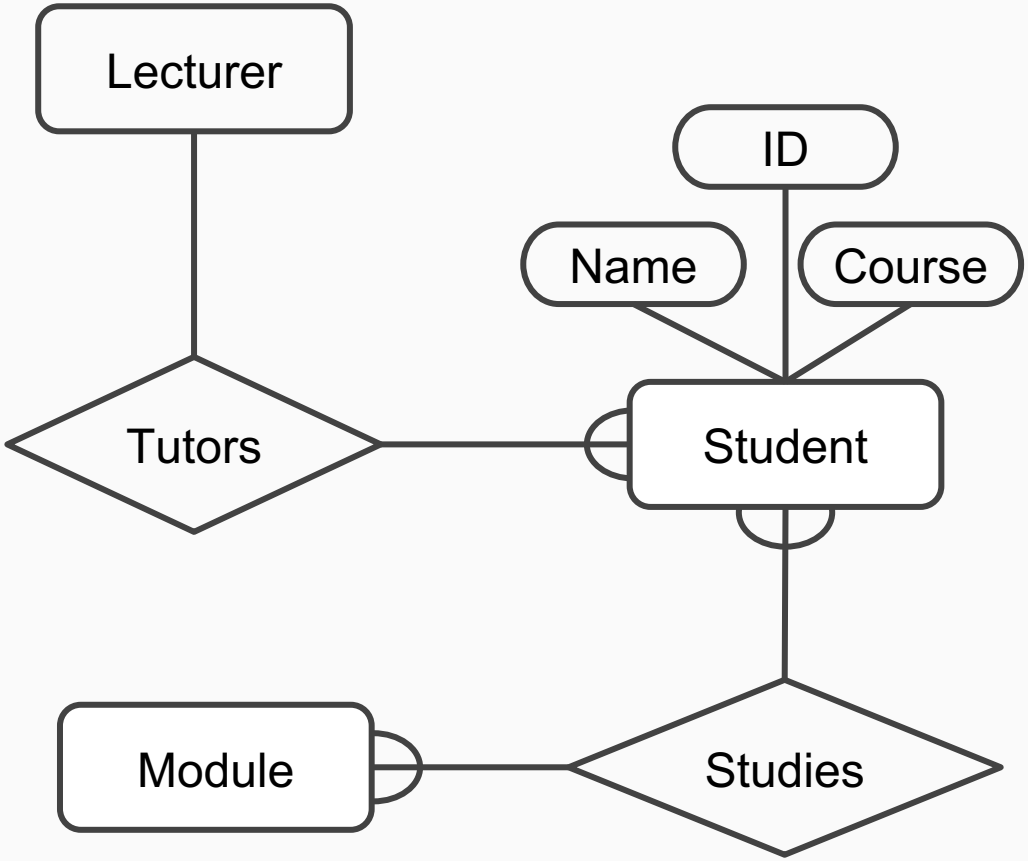
- One to one (1:1)
  - Each lecturer has a unique office & offices are single occupancy
- One to many (1:M)
  - A lecturer may tutor many students, but each student has just one tutor
- Many to many (M:M)
  - Each student takes several modules, and each module is taken by several students

E/R: Diagram Relationships

- Relationships are shown as links between two entities
- The name is given in a diamond box
- The ends of the link show cardinality



Final Diagram



Making E/R Models

- To make an E/R model you need to identify
  - Entities
  - Attributes
  - Relationships
  - Cardinality ratios
- We obtain these from a problem description

- General guidelines
  - Since entities are things or objects they are often nouns in the description
  - Attributes are facts or properties, and so are often nouns also
  - Verbs often describe relationships between entities

Nouns and Verbs

- A **noun** is a part of speech that denotes a person, animal, place, thing, or idea
    - Student
    - Staff
    - Module

- A **verb** is a word used to describe an action, state, or occurrence, and forming the main part of the predicate of a sentence, such as hear, become, happen.
    - Studies
    - Tutors

Example

A university consists of a number of departments. Each department offers several courses. A number of modules make up each course. Students enrol in a particular course and take modules towards the completion of that course. Each module is taught by a lecturer from the appropriate department (several lecturers work in the same department), and each lecturer tutors a group of students. A lecturer can teach more than one module but can work only in one department.

Example - Entities

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Entities – Department, Course, Module, Student, Lecturer

Example - Relationships

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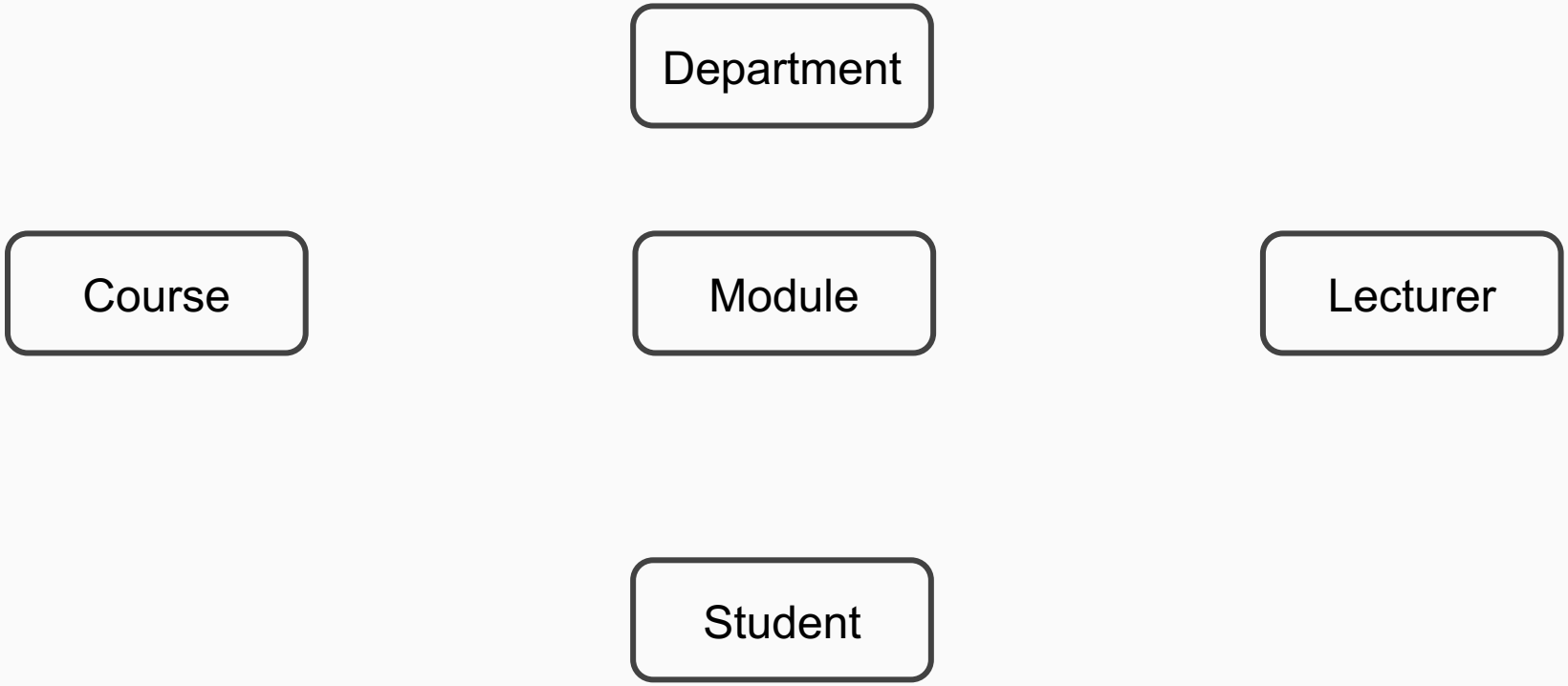
Entities – Department, Course, Module, Student, Lecturer

Relationships – Offers, Make Up, Enrol, Take, Taught By, From The, Tutors

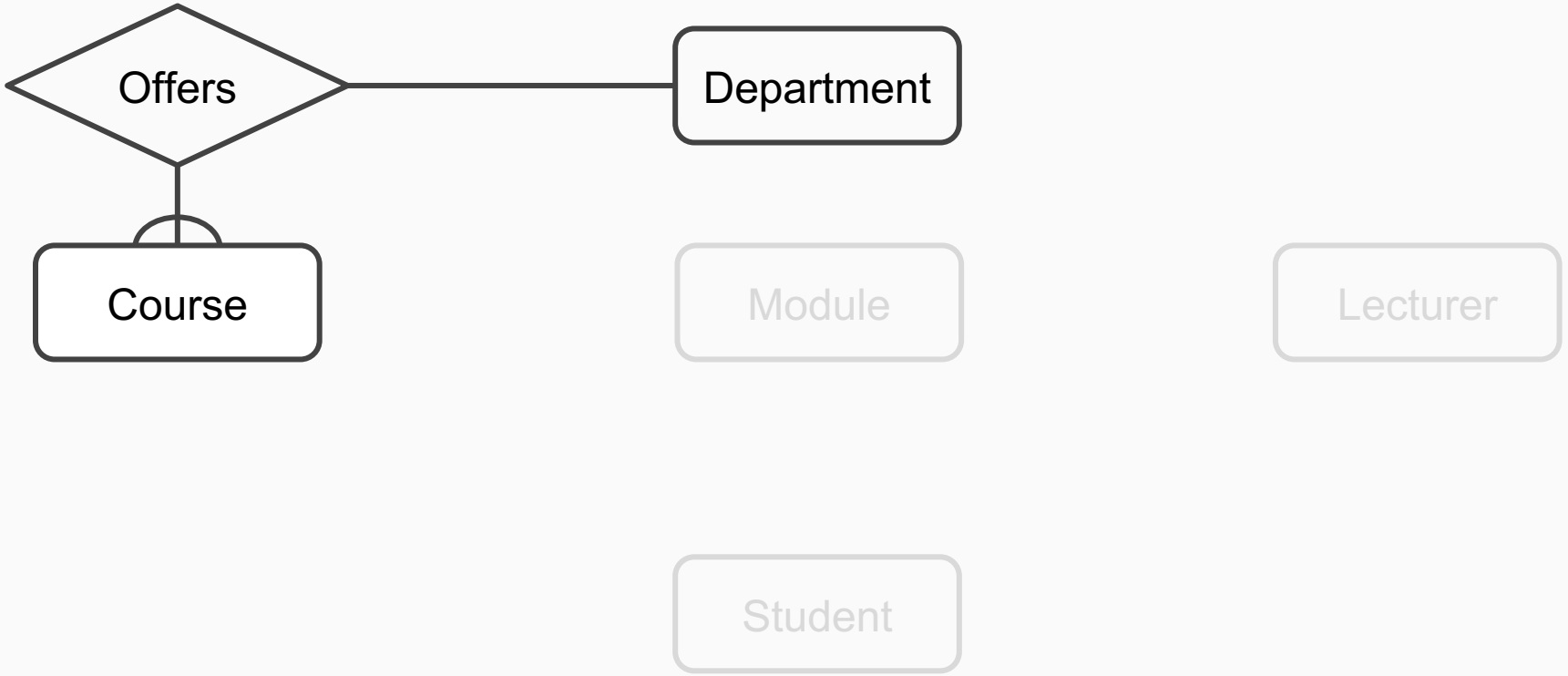
Example - E/R Diagram

Entities – Department, Course, Module, Student, Lecturer



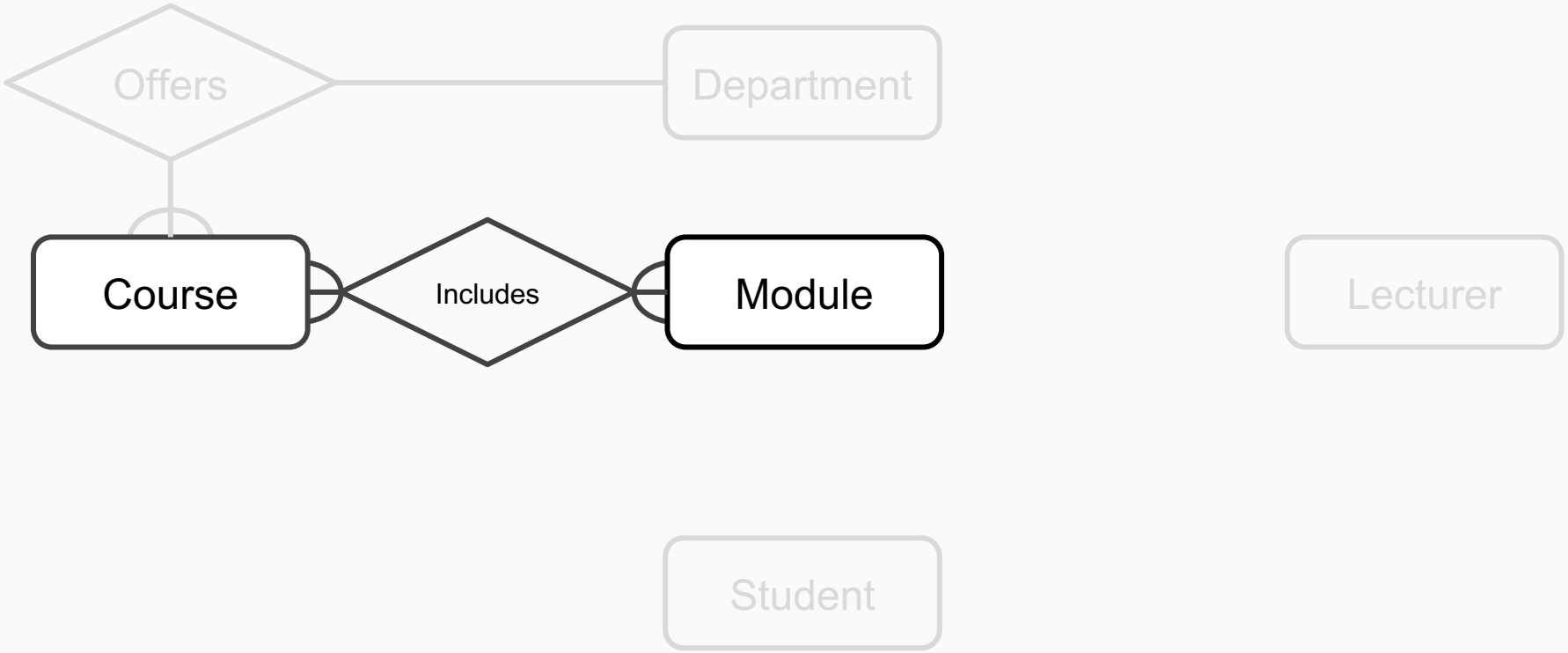
Example - E/R Diagram

Each Department offers several Courses



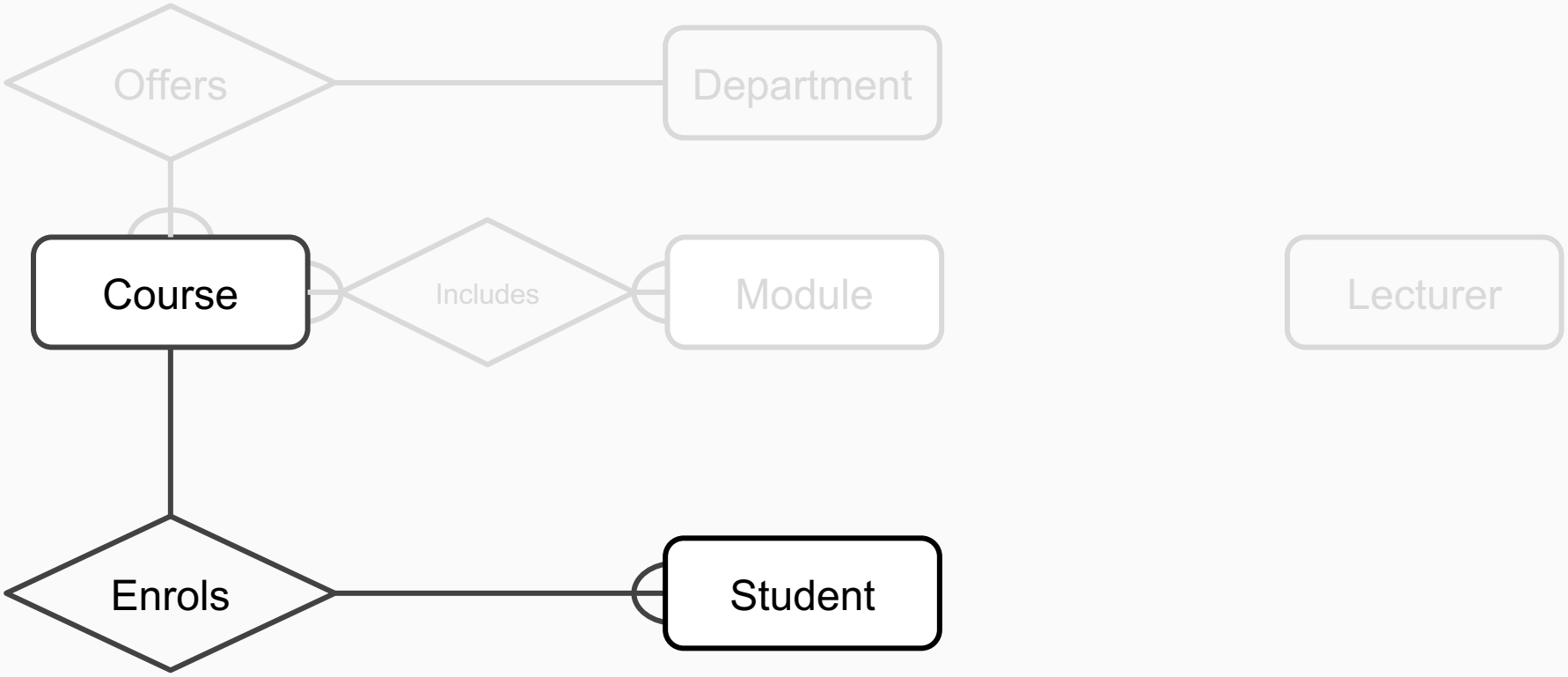
Example - E/R Diagram

A number of modules make up each Course.



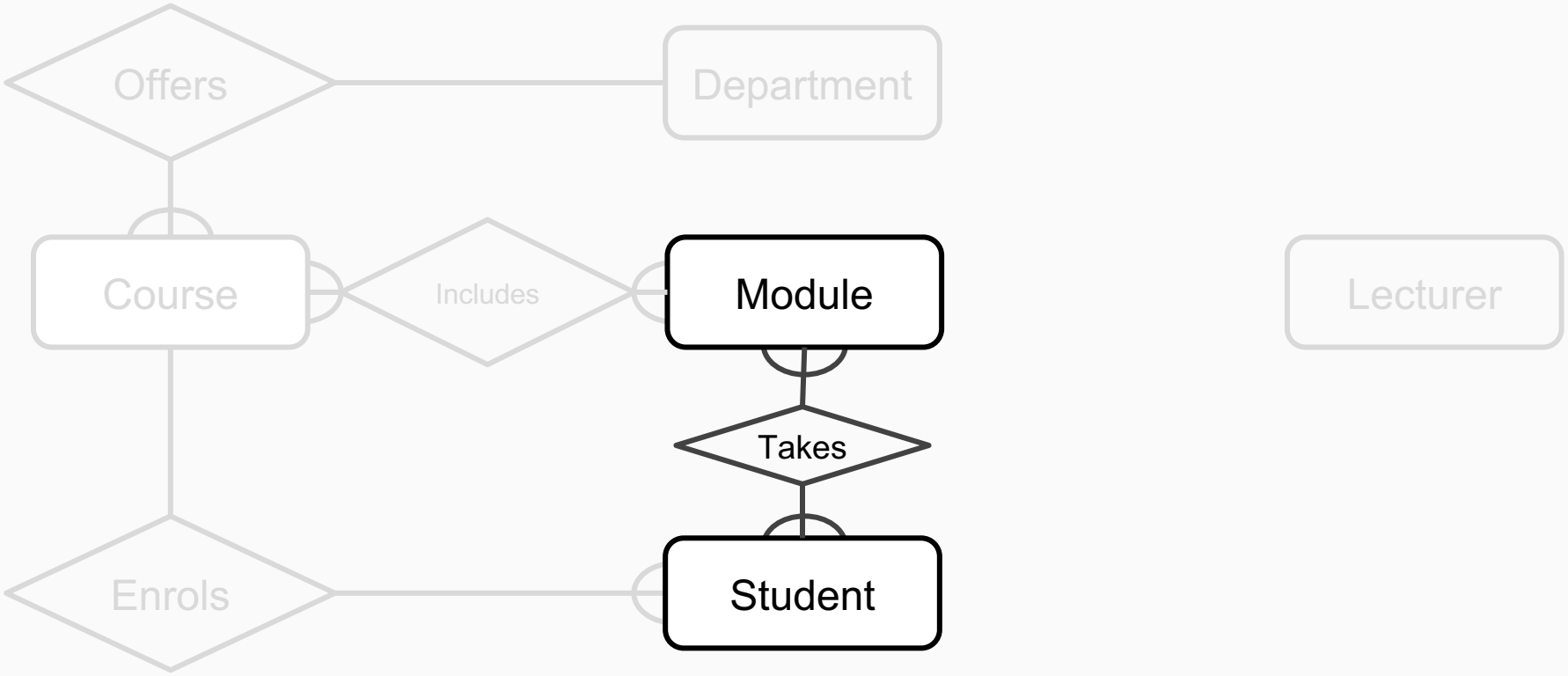
Example - E/R Diagram

Students enrol in a particular course



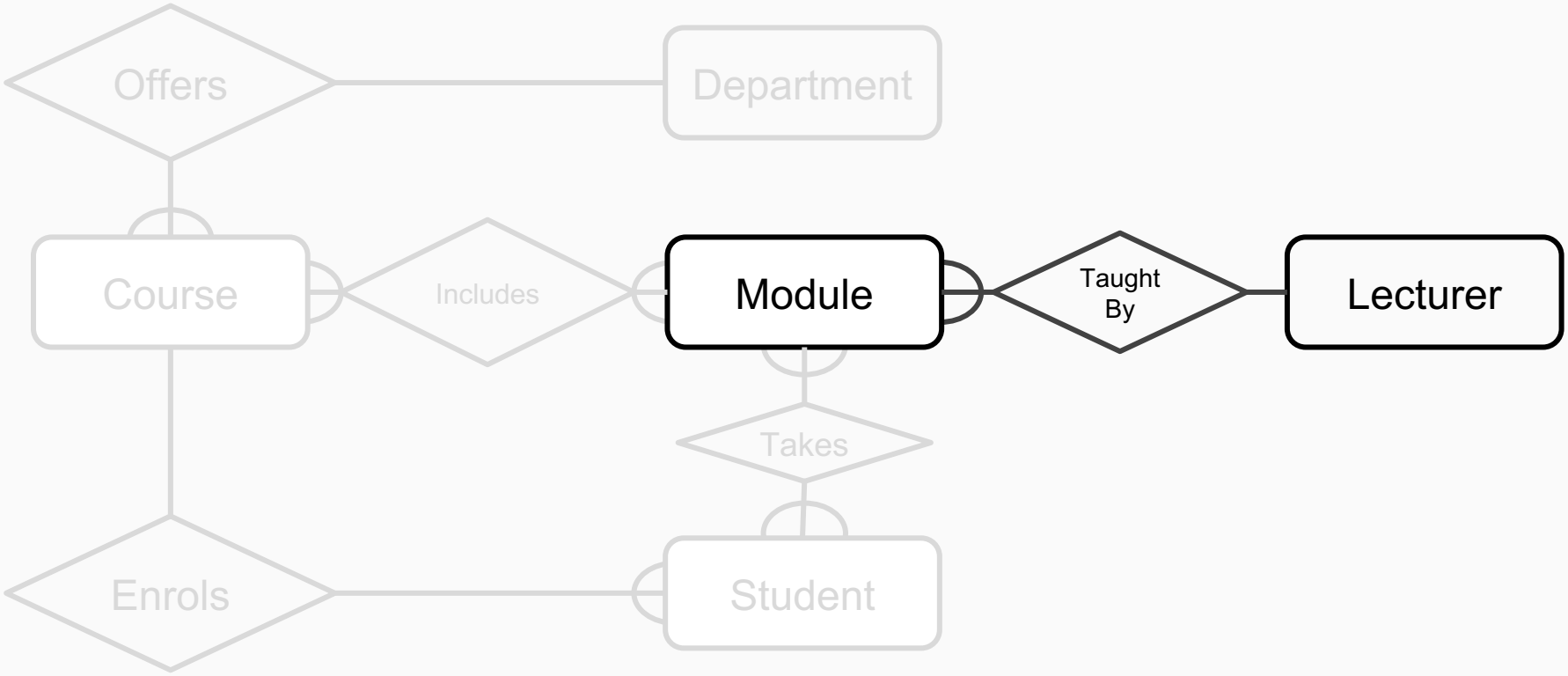
Example - E/R Diagram

Students take several modules



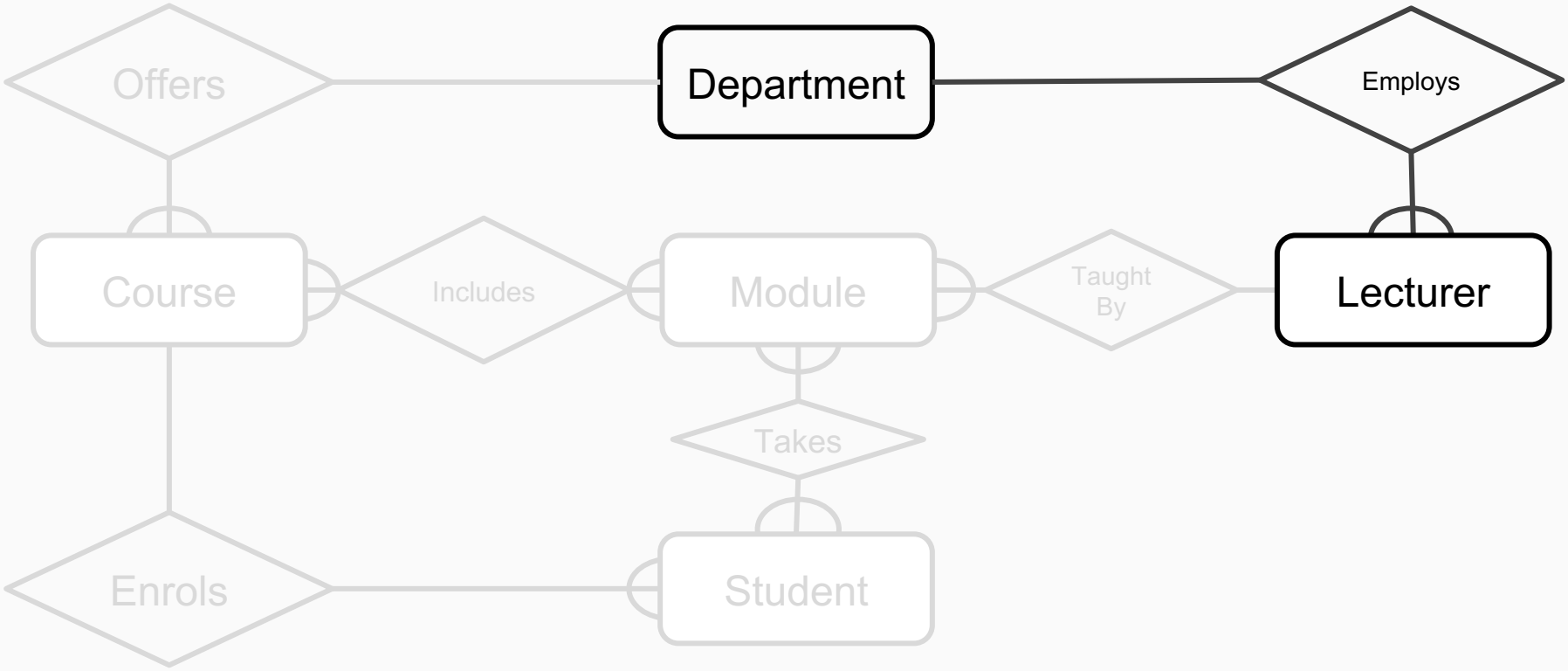
Example - E/R Diagram

Each Module is taught by a Lecturer



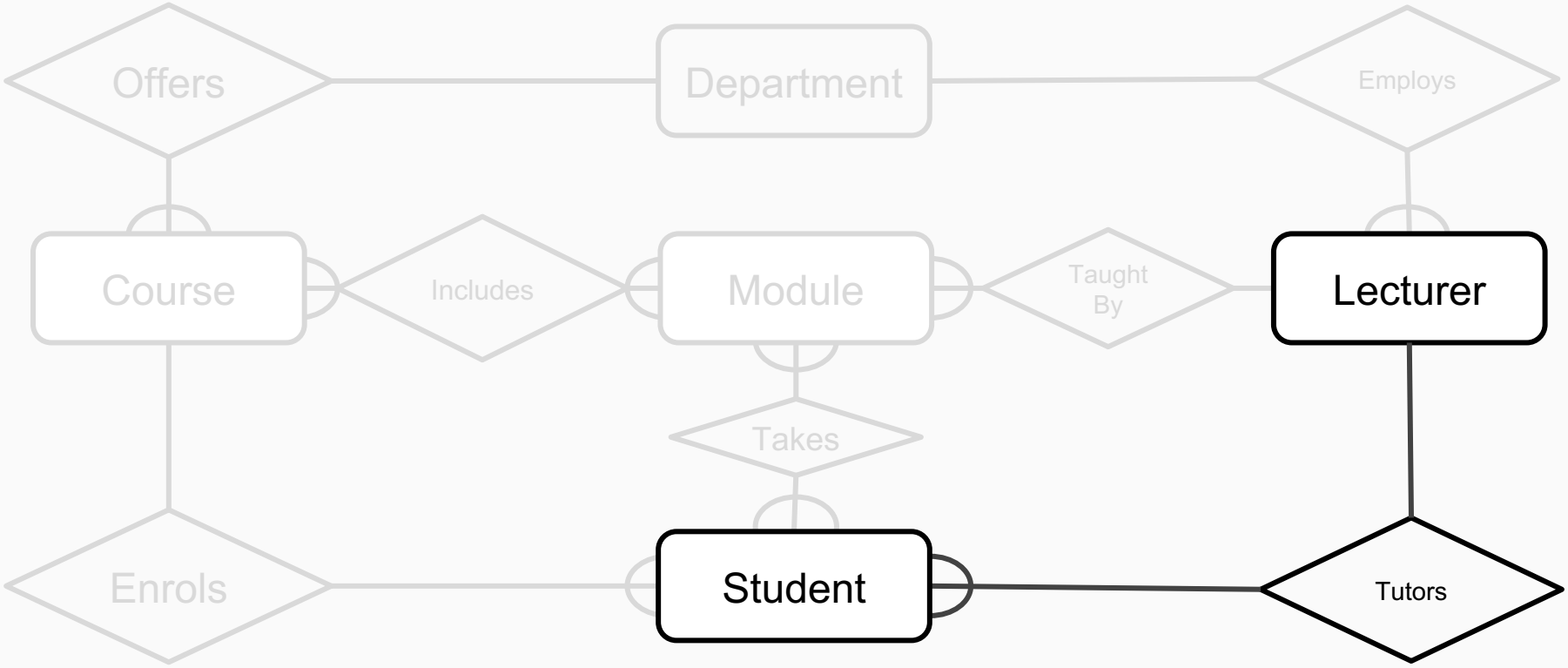
Example - E/R Diagram

Each department employs a number of lecturers



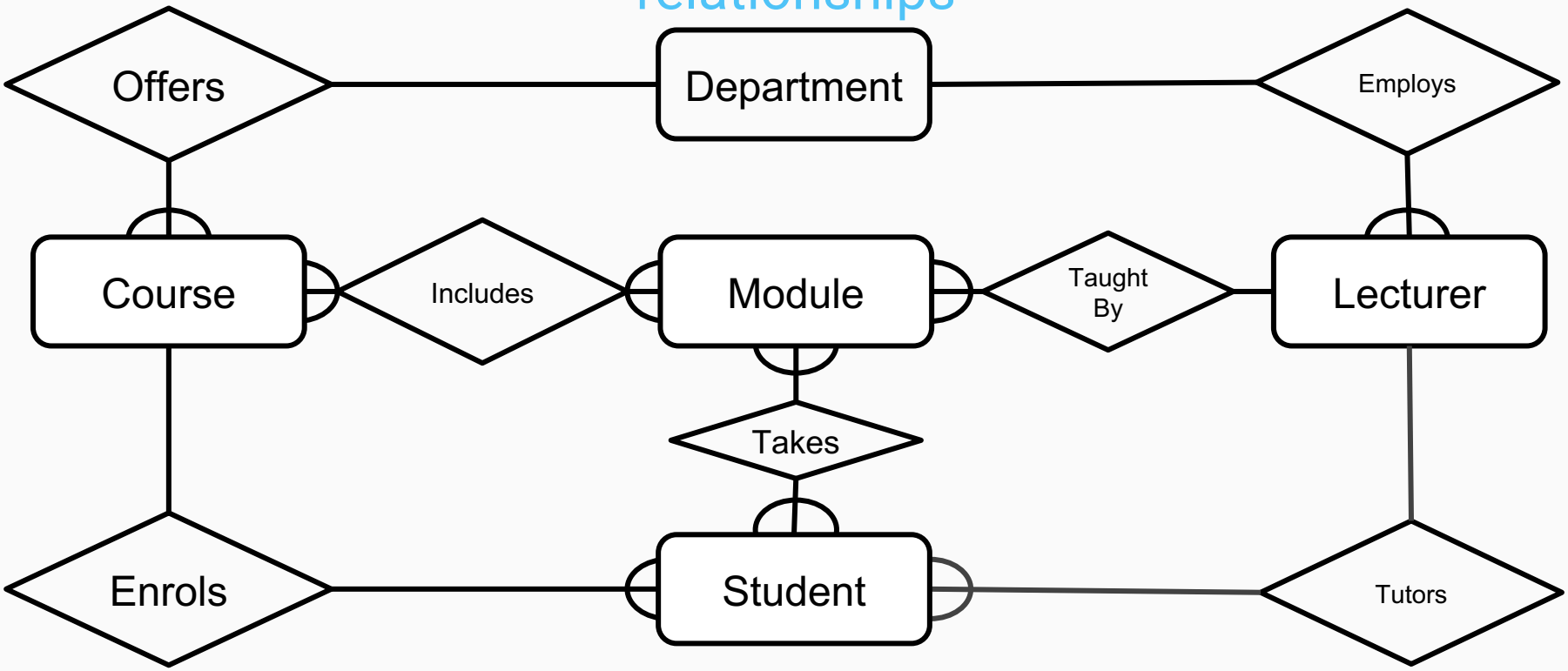
Example - E/R Diagram

Each Lecturer tutors a number of Students



Example - E/R Diagram

The completed diagram. All that remains is to remove M:M relationships



Removing M:M Relationships

Many to many relationships are difficult to represent in a database:

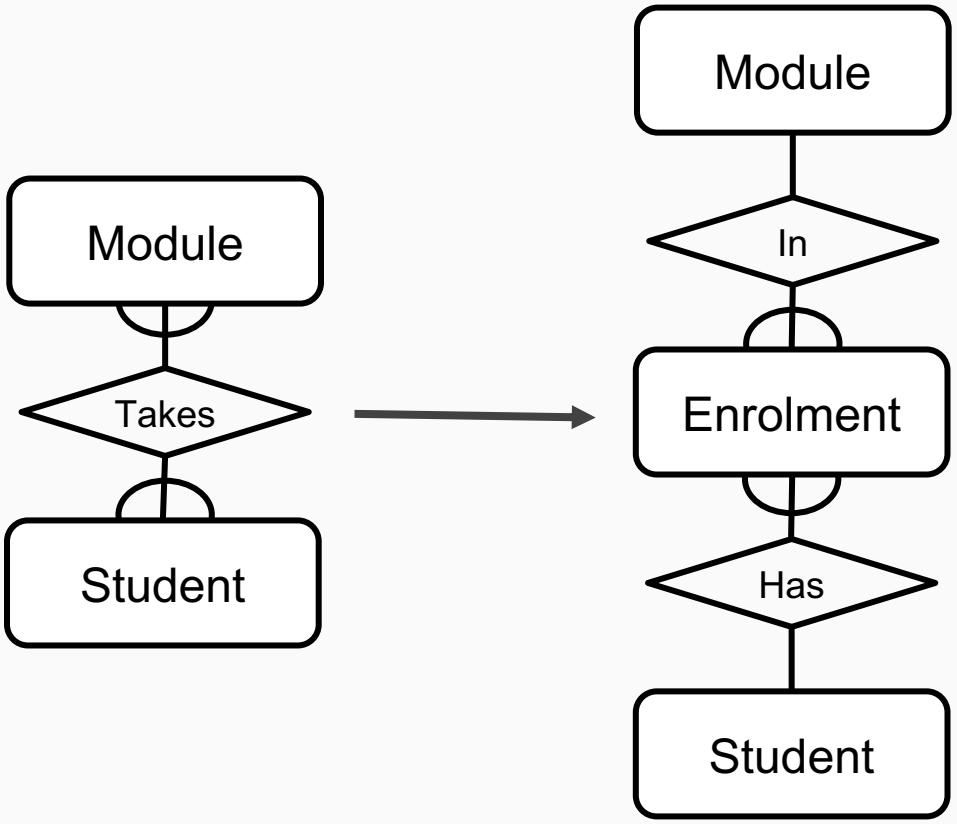
Student		
SID	**sName**	**sMod**
1001	Jack Smith	DBI
1001	Jack Smith	PRG
1001	Jack Smith	IAI
1002	Anne Jones	PRG
1002	Anne Jones	IAI
1002	Anne Jones	Vis

Module	
MID	**mName**
DBI	Databases and Interfaces
PRG	Programming
IAI	AI
VIS	Computer Vision

Student		
SID	**sName**	**sMod**
1001	Jack Smith	DBI, PRG, IAI
1002	Anne Jones	VIS, IAI, PRG

Removing M:M Relationships

- Many to many relationships are difficult to represent in a database
- We can split a many to many relationship into two, one to many relationships
- An additional entity is created to represent the M:M relationship



Entities and Attributes

- Sometimes it is hard to tell if something should be an entity or an attribute
  - They both represent objects or facts about the world
  - They are both often represented by nouns in descriptions
- General guidelines
  - Entities can have attributes but attributes have no smaller parts
  - Entities can have relationships between them, but an attribute belongs to a single entity

Example

We want to represent information about products in a database. Each product has a description, a price and a supplier. Suppliers have addresses, phone numbers, and names. Each address is made up of a street address, a city name, and a postcode.

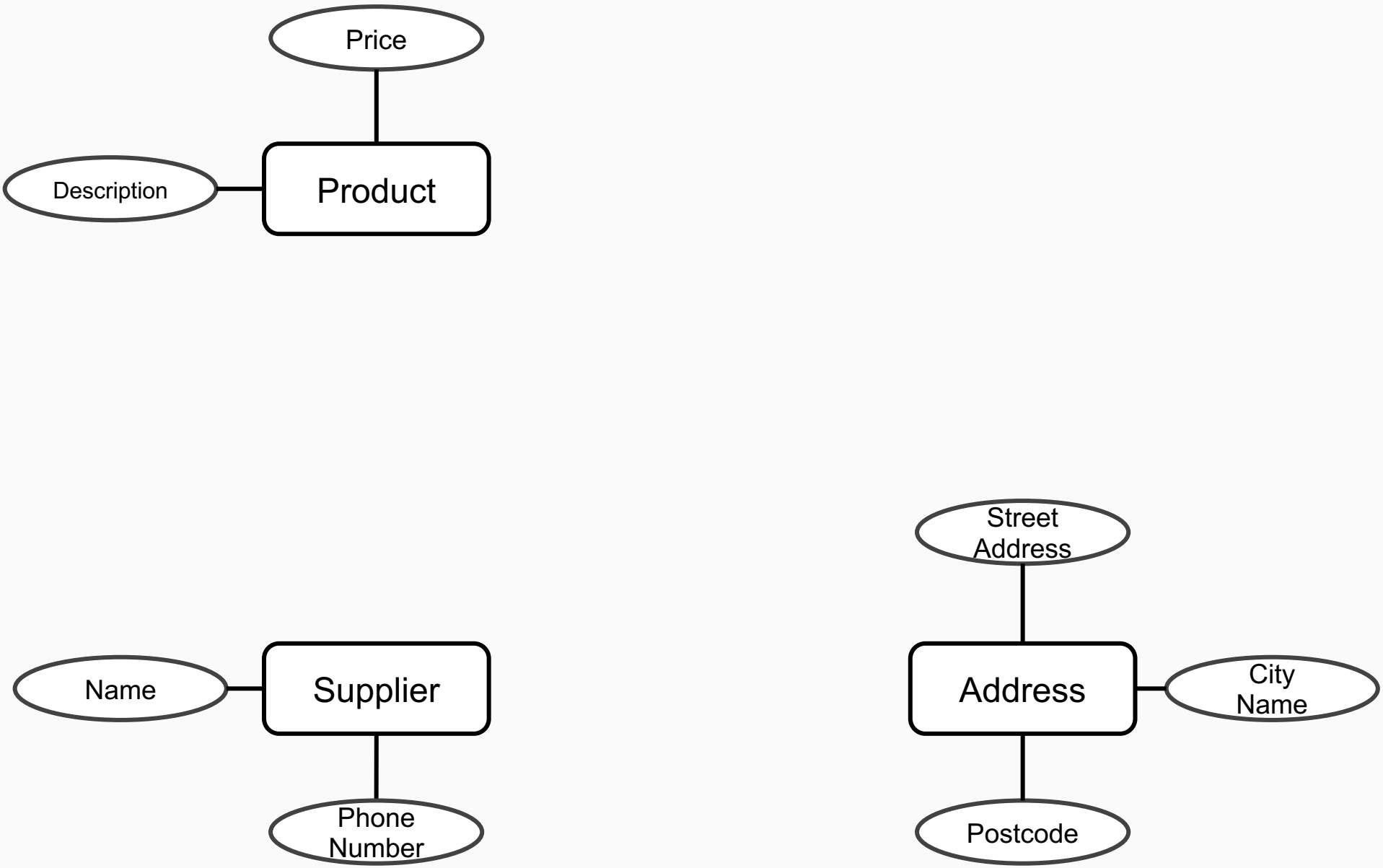
Example - Entities/Attributes

- Entities or attributes:
  - product
  - description
  - price
  - supplier
  - address
  - phone number
  - name
  - street address
  - city name
  - postcode

- Products, suppliers, and addresses all have smaller parts so we make them entities

- The others have no smaller parts and belong to a single entity

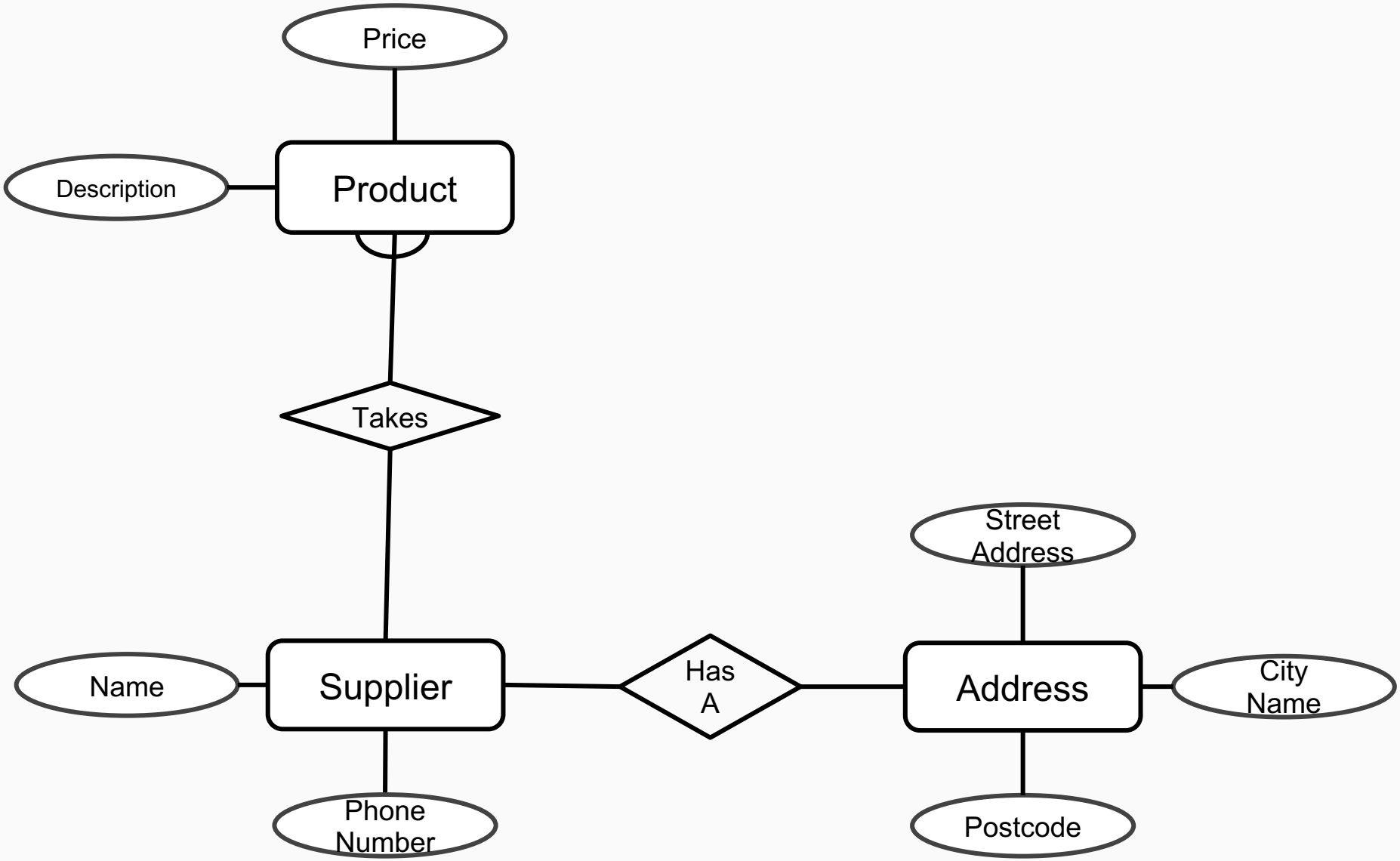
Example - E/R Diagram



Example - Relationships

- Each product has a supplier
  - Each product has a single supplier but there is nothing to stop a supplier supplying many products
  - A many to one relationship
- Each supplier has an address
  - A supplier has a single address
  - It does not seem sensible for two different suppliers to have the same address
  - A one to one relationship

Example - E/R Diagram

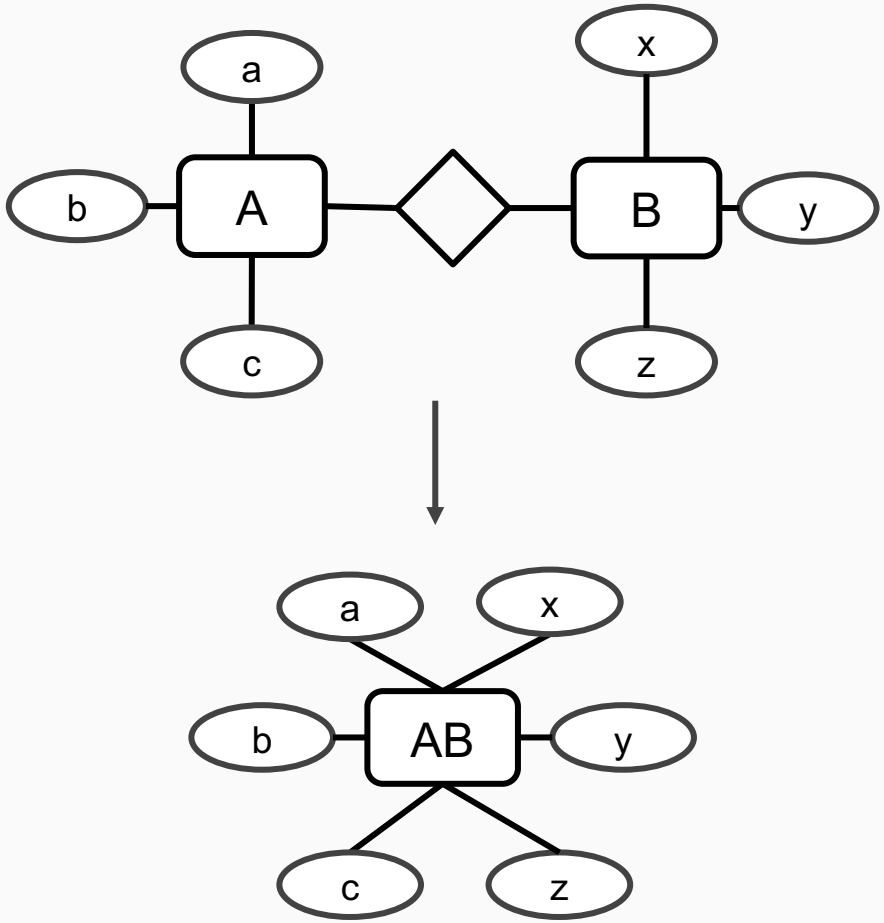


One to One Relationships

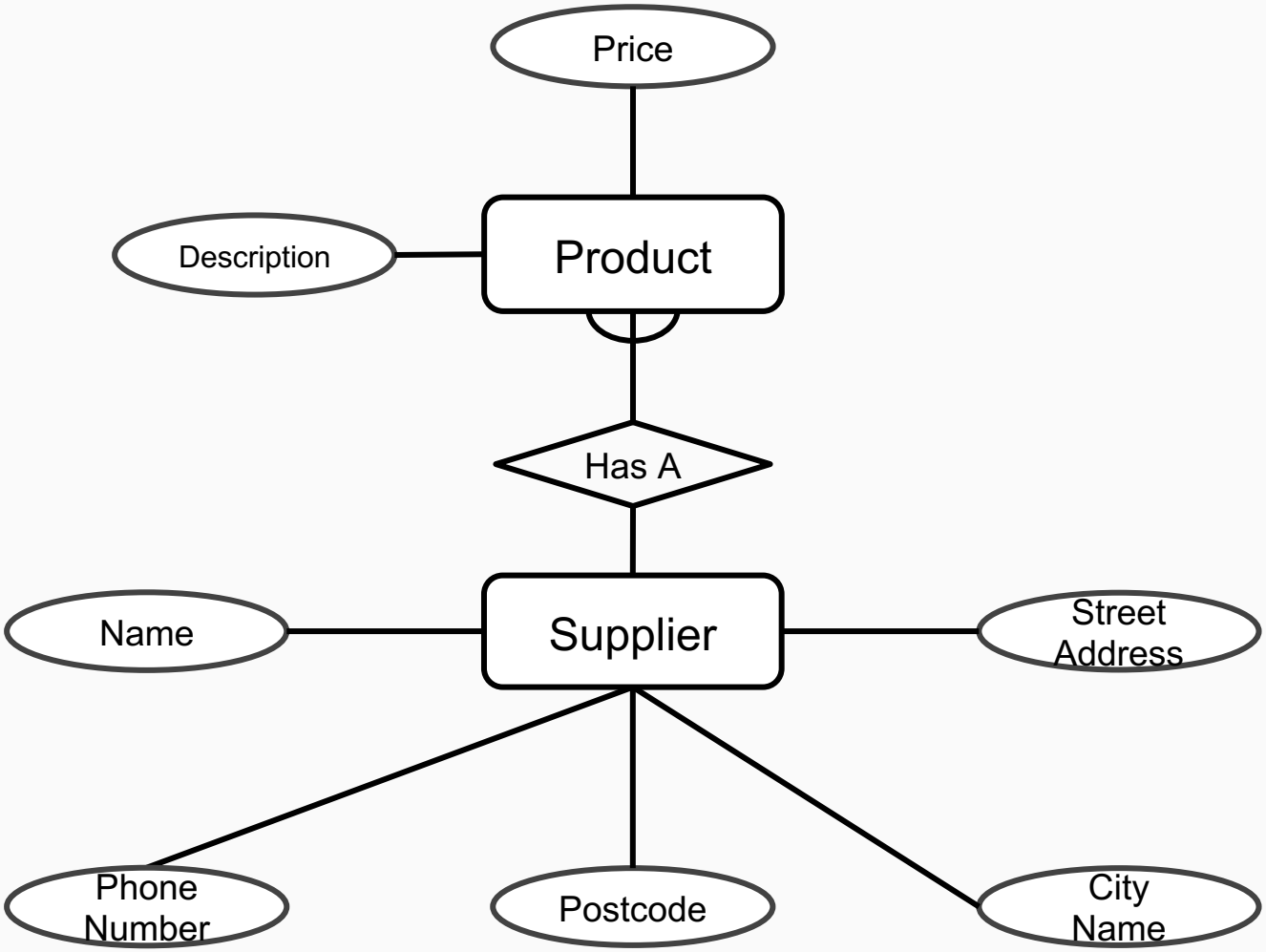
- Some relationships between entities, A and B, might be redundant if
  - It is a 1:1 relationship between A and B
  - Every A is related to a B and every B is related to an A
- Example
  - the supplier-address relationship - Is one to one
  - Every supplier has an address
  - We don't need addresses that are not related to a supplier

One to One Relationships

- We can merge the two entities that take part in a redundant relationship together
  - They become a single entity
  - The new entity has all the attributes of the old ones

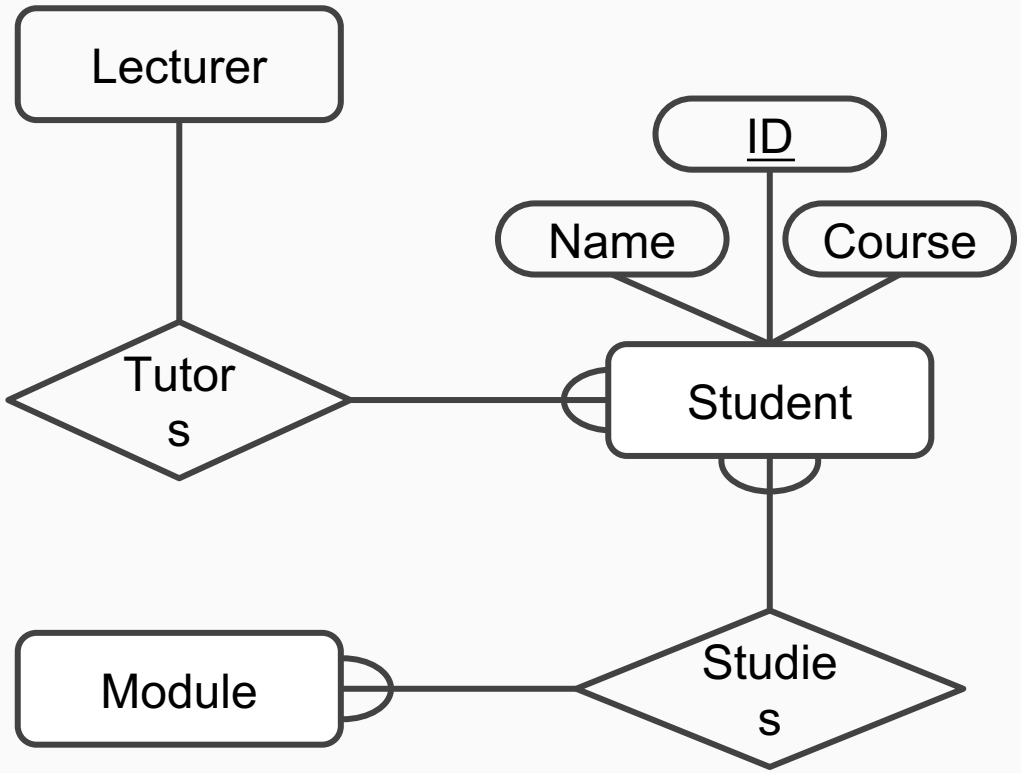


Example - E/R Diagram



Primary Keys

- We often find that we need to specify which attributes will serve as Primary Keys in our ER diagrams
- We do this by underlining the attribute in the relation
  - E.g. ID



Making E/R Diagrams

- From a description of the requirements identify the
  - Entities
  - Attributes
  - Relationships
  - Cardinality ratios of the relationships
- Draw the E/R diagram and then
  - Look at one to one relationships as they might be redundant
  - Look at many to many relationships as they will often need to be split into two one to many links, using an intermediate entity

Exams and Coursework Simplified Example

- Identify the *entities, attributes, relationships,* and *cardinality ratios* from the description.
- Draw an entity-relationship diagram showing the items you identified.
- Many-to-many relationships are hard to represent in database tables. Explain the nature of these problems, and describe how they may be overcome.

Takeaways

1. Database Design
    a. Entity Relationship Modelling
    b. Entity Relationship Diagrams
        i. Entities
        ii. Attributes
        iii. Relationships
            1. Cardinality Ratios (1:1, 1:M, M:M)

Hints

- Be Organised
  - If we can’t read it, how can we mark it?
- Find software you like - now
  - This will save you time during the lab
- Summarise the rules e.g.
  - Entities can have attributes but attributes have no smaller parts
- This is a skill that needs practice
- Rarely will you get it right first time