ENTITY/RELATIONSHIP MODELING

Introduction to Database Systems

Mahdi Akhi
Sharif University of Technology

IN THIS LECTURE

- ➤ Entity/Relationship models
  - ➤ Entities and Attributes
  - ➤ Relationships
  - ➤ Attributes
  - ➤ E/R Diagrams
- ➤ For more information
  - ➤ Connolly and Begg chapter 11
  - ➤ Ullman and Widom chapter 2

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?

- ➤ **Conceptual design**
  - ➤ Build a model independent of the choice of DBMS

- ➤ **Logical design**
  - ➤ Create the database in a given DBMS

- ➤ **Physical design**
  - ➤ How the database is stored in hardware

ENTITY/RELATIONSHIP MODELING

➤ E/R Modeling is used for **conceptual design**

➤ **Entities** - objects or items of interest

➤ **Attributes** - facts about, or properties of, an entity

➤ **Relationships** - links between entities

➤ Example

➤ In a University database we might have entities for Students, Courses and Lecturers. Students might have attributes such as their ID, Name, and Fields, and could have relationships with Courses (enrollment) and Lecturers (tutor/tutee)

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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
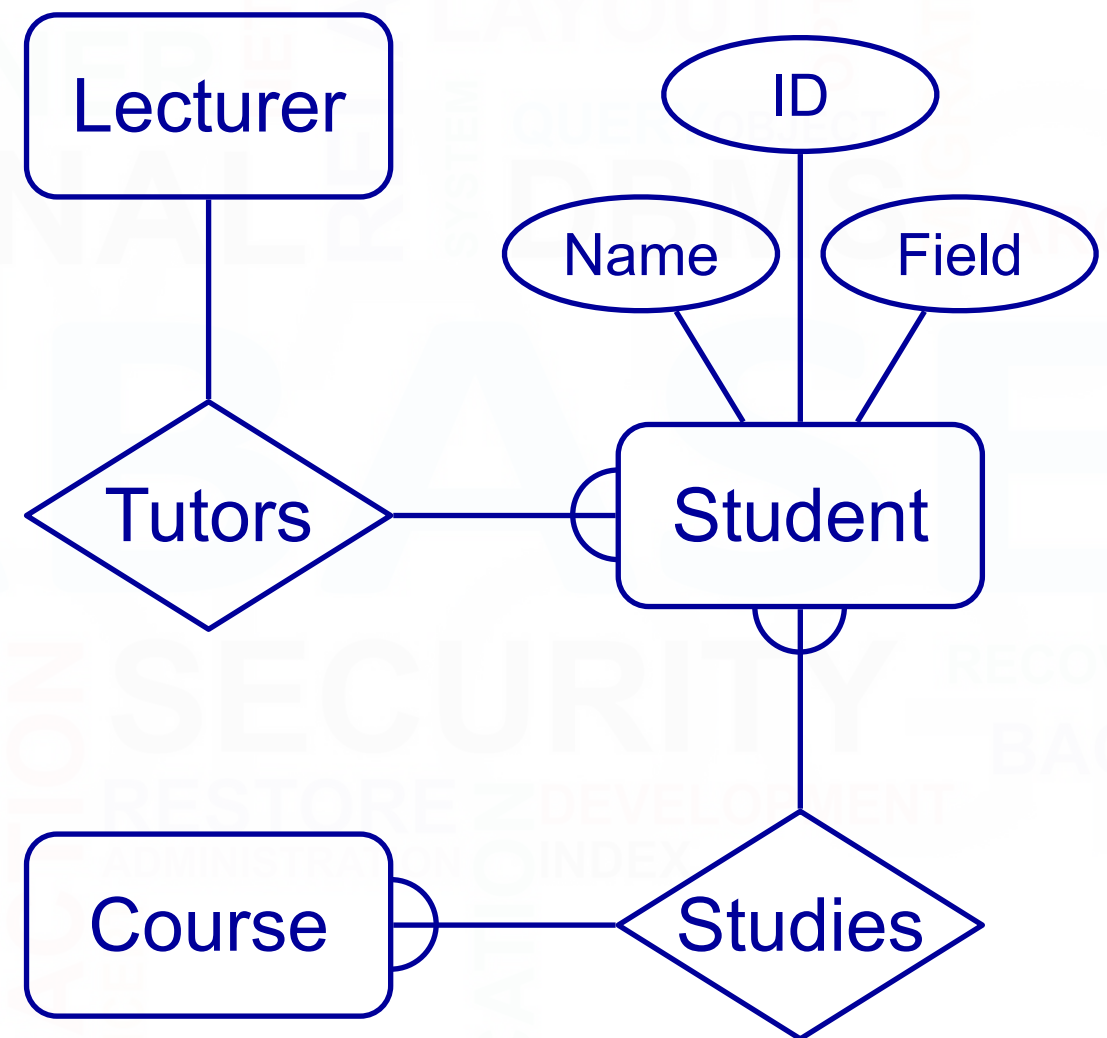
ENTITIES

- Entities represent objects or things of interest
  - **Physical** things like students, lecturers, employees, products
  - More **abstract** things like courses, orders, fields, projects

- Entities have
  - A general type or class, such as Lecturer or Course
  - Instances of that particular type, such as Mahdi Akhi, Mahdi Samiei are instances of Lecturer
  - Attributes (such as name, email address)

DIAGRAMMING ENTITIES

➤ In an E/R Diagram, an entity is usually drawn as a box with rounded corners

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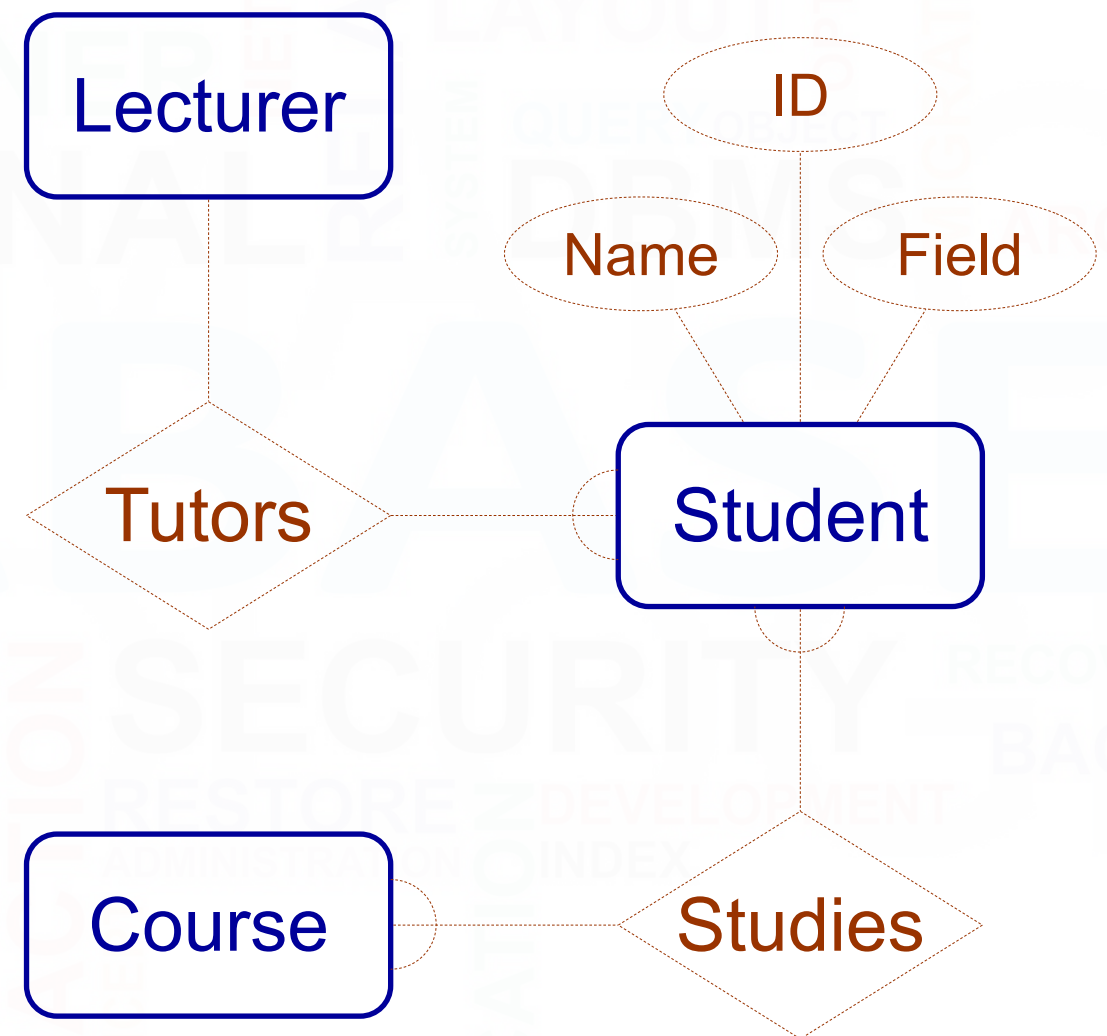
ATTRIBUTES

- ➤ Attributes are facts, aspects, properties, or details about an entity
  - ➤ Students have IDs, names, fields, addresses, …
  - ➤ Courses have codes, titles, credit weights, levels, …

- ➤ Attributes have
  - ➤ A name
  - ➤ An associated entity
  - ➤ Domains of possible values
  - ➤ Values from the domain for each instance of the entity they are belong to

DIAGRAMMING ATTRIBUTES

➤ In an E/R Diagram attributes may be drawn as ovals

➤ Each attribute is linked to its entity by a line

➤ The name of the attribute is written in the oval
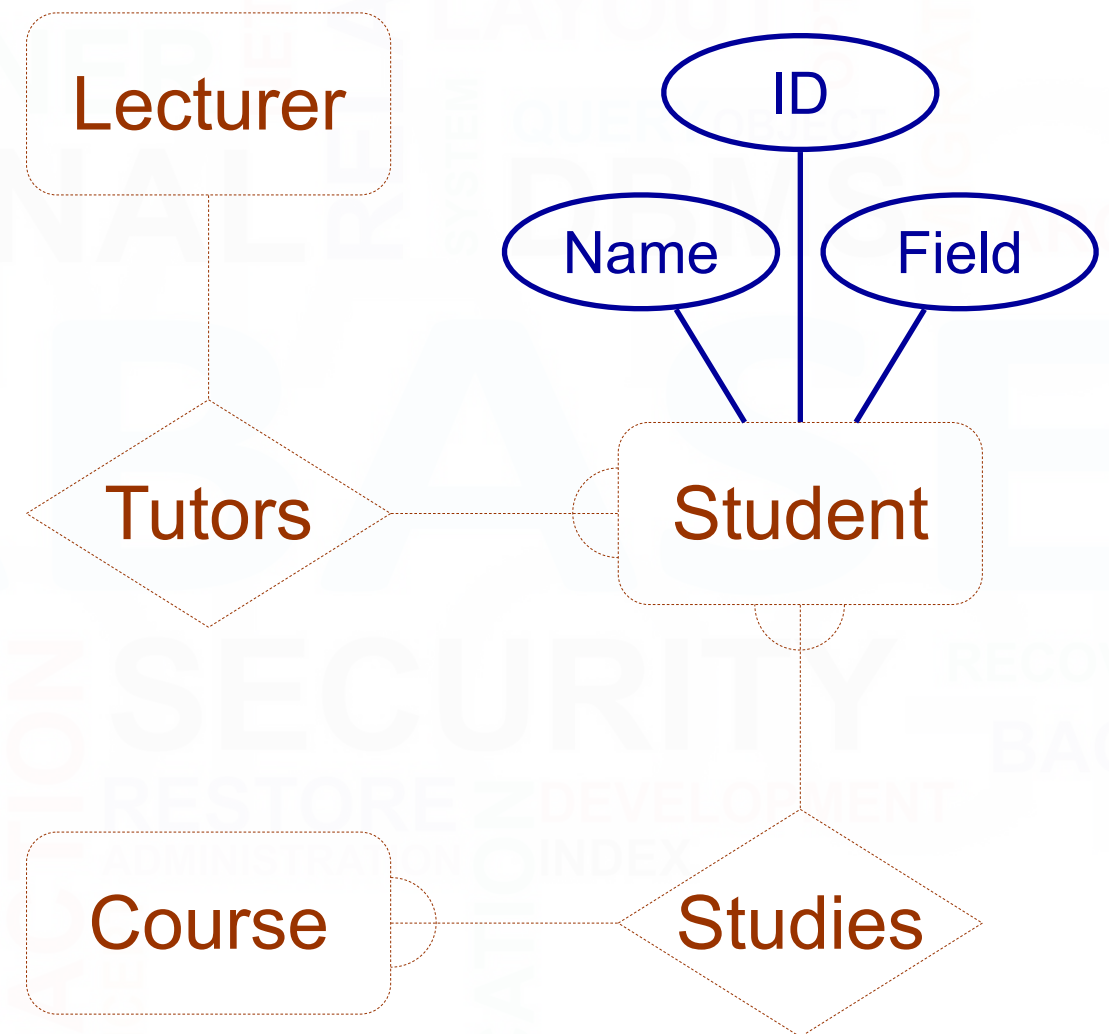
RELATIONSHIPS

➤ Relationships are an association between two or more entities

   ➤ Each Student takes several Courses

   ➤ Each Course 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

➤ This leads to 3 types of relationship…

➤ One to one (**1:1**)

  ➤ Each lecturer has a unique office

➤ 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 course, and each course is taken by several students
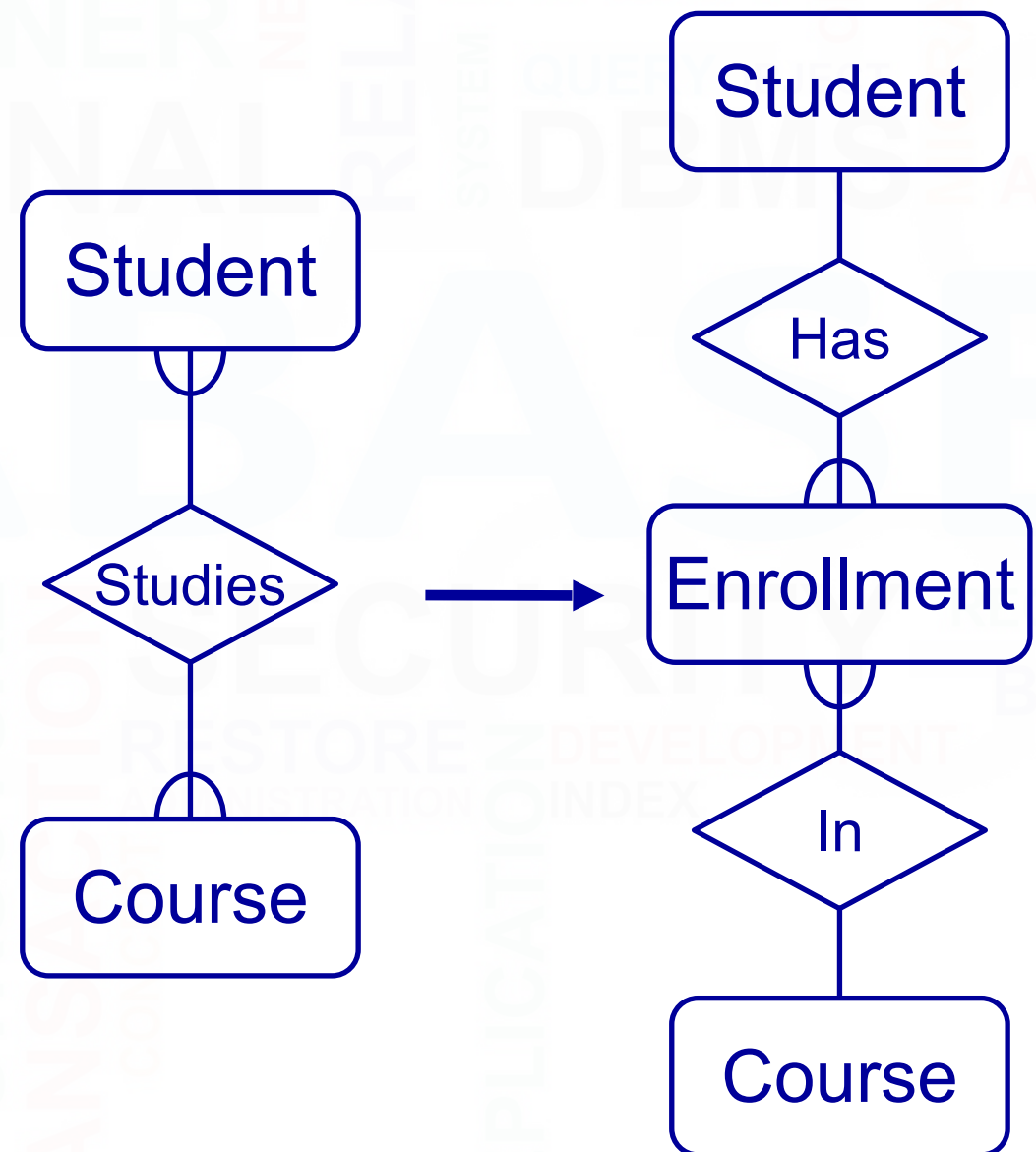
DIAGRAMMING RELATIONSHIPS

➤ Relationships are links between two entities

➤ The name is given in a diamond box

➤ The ends of the link show cardinality
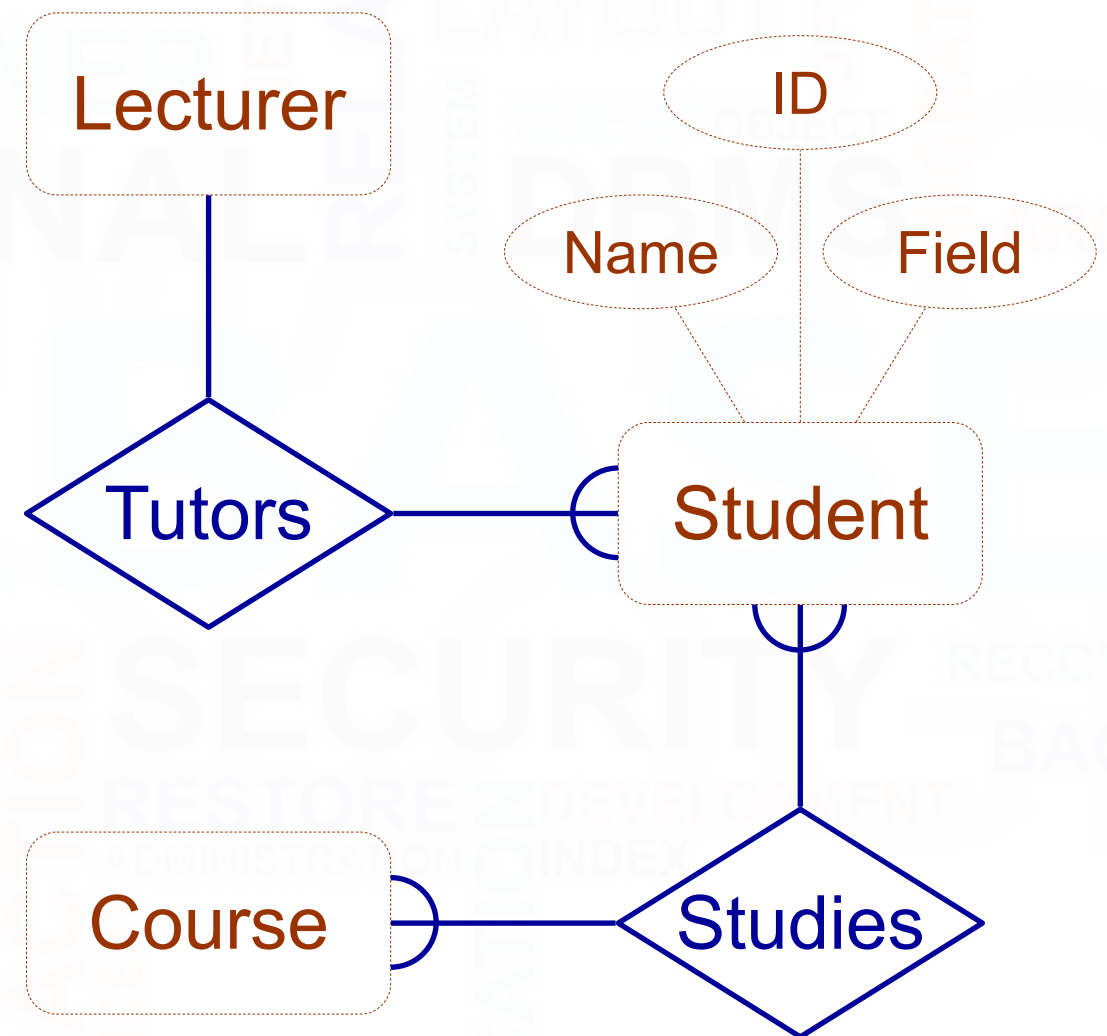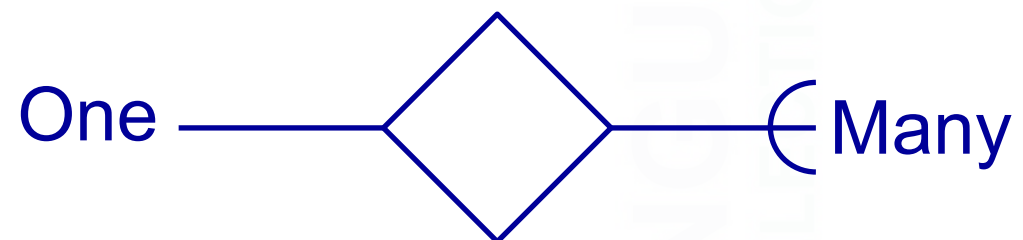
REMOVING M:M RELATIONSHIPS

➤ Many to many relationships are difficult to represent

➤ We can split a many to many relationship into two one to many relationships

➤ An entity represents the M:M relationship

MAKING E/R MODELS

- ➤ To make an E/R model you need to identify
  - ➤ Entities
  - ➤ Attributes
  - ➤ Relationships
  - ➤ Cardinality ratios
- ➤ from a 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

EXAMPLE

A university consists of a number of departments. Each department offers several fields. A number of course make up each fields. Students enroll in a particular field and take courses towards the completion of that field. Each course is taught by a lecturer from the appropriate department, and each lecturer tutors a group of students.
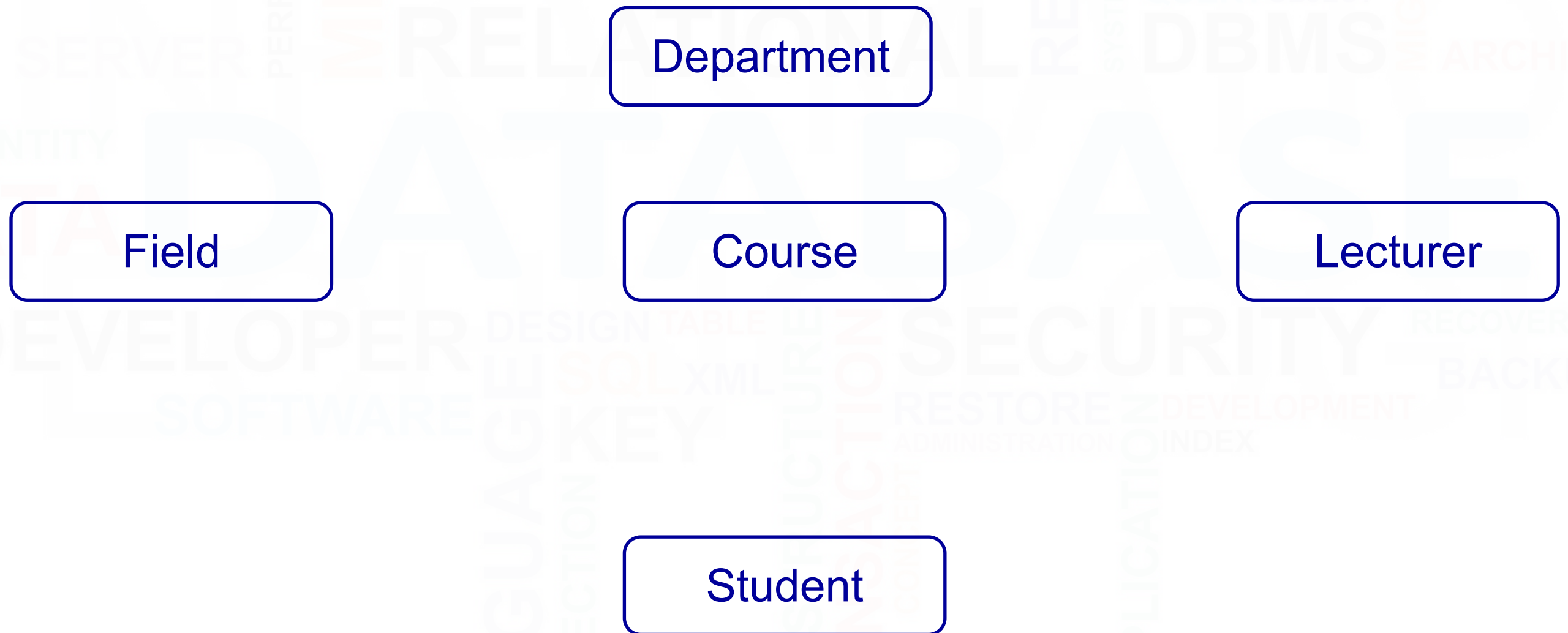
EXAMPLE - ENTITIES

A university consists of a number of **departments**. Each department offers several **fields**. A number of **course** make up each field. **Students** enroll in a particular field and take courses towards the completion of that field. Each course is taught by a **lecturer** from the appropriate department, and each lecturer tutors a group of students

EXAMPLE - RELATIONSHIPS

➤ A university consists of a number of departments. Each department **offers** several fields. A number of courses **make up** each field. Students **enroll in** a particular field and **take** course towards the completion of that field. Each course is **taught by** a lecturer from the appropriate department, and each lecturer **tutors** a group of students.
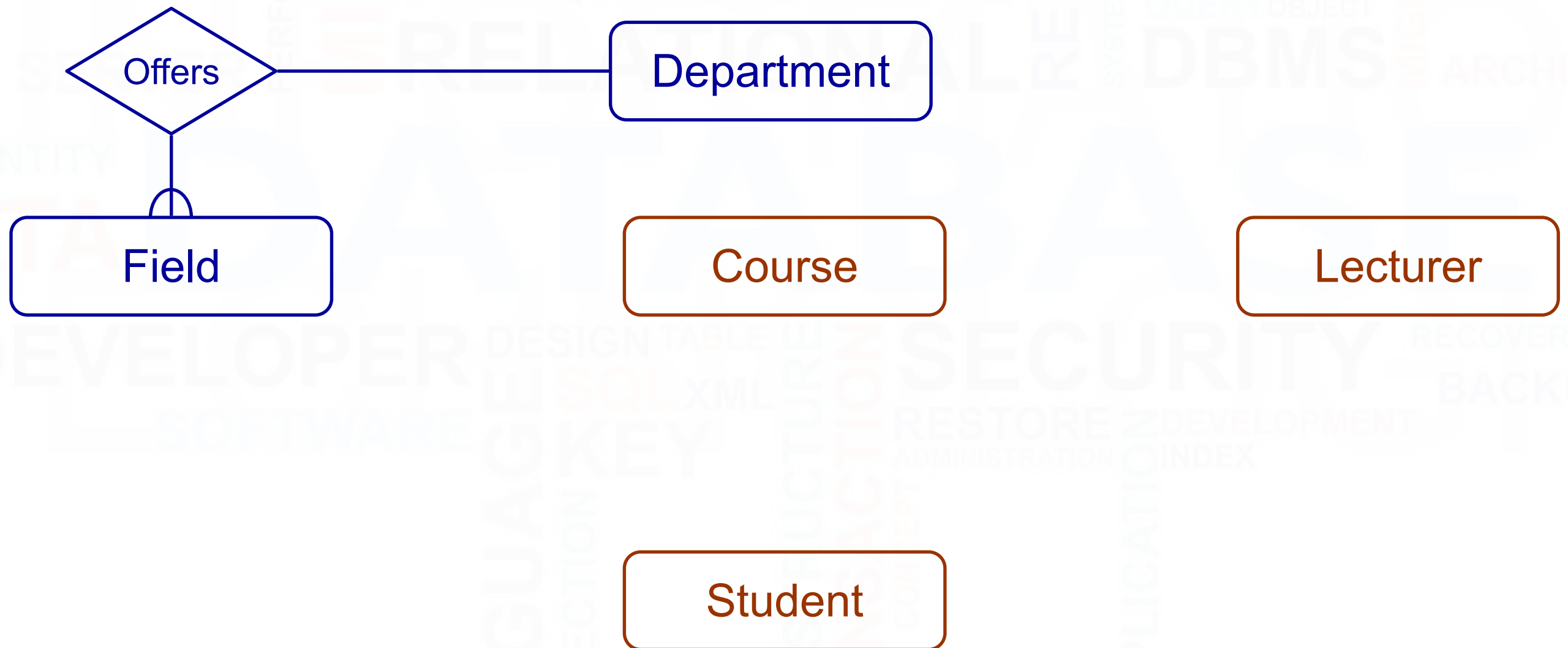
EXAMPLE - E/R DIAGRAM
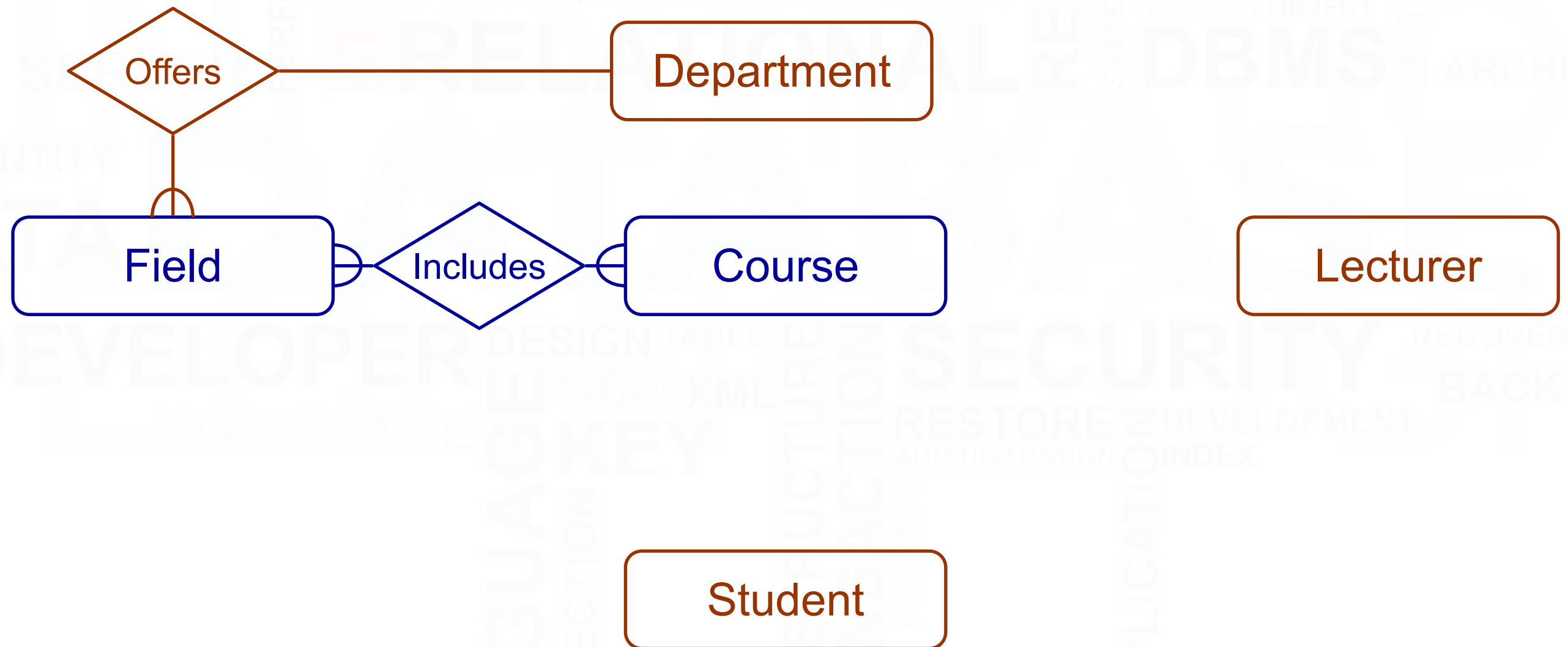
Entities: Department, Field, Course, Lecturer, Student

Department

Field

Course

Lecturer

Student

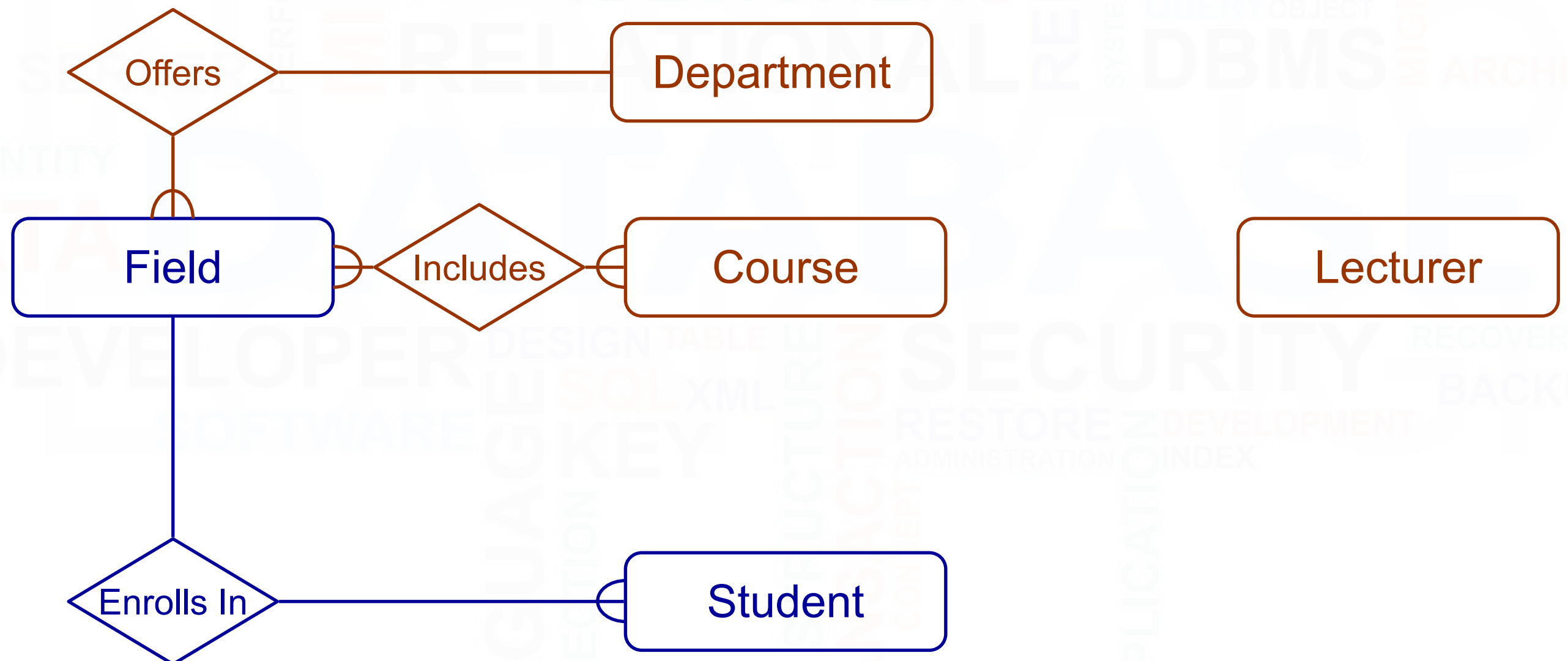# EXAMPLE - E/R DIAGRAM

Each department offers several fields

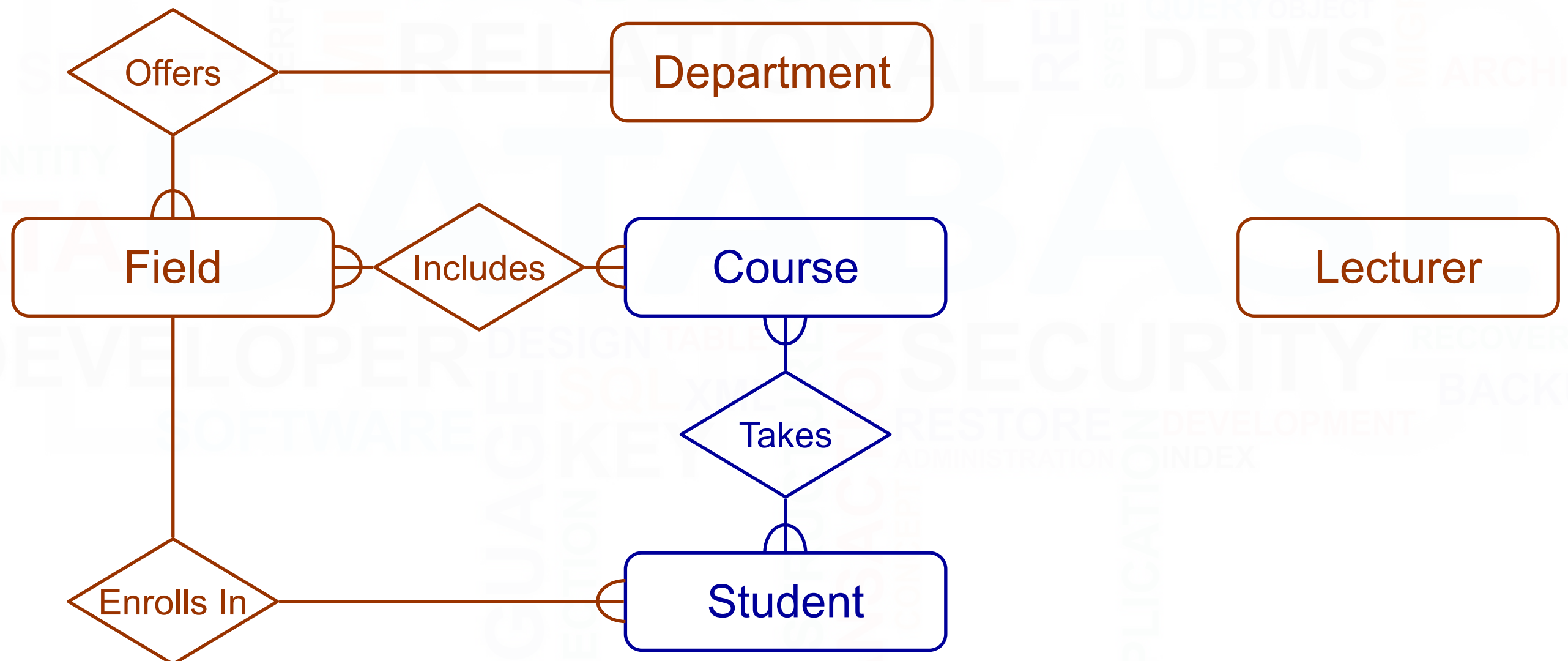# EXAMPLE - E/R DIAGRAM

A number of courses make up each field

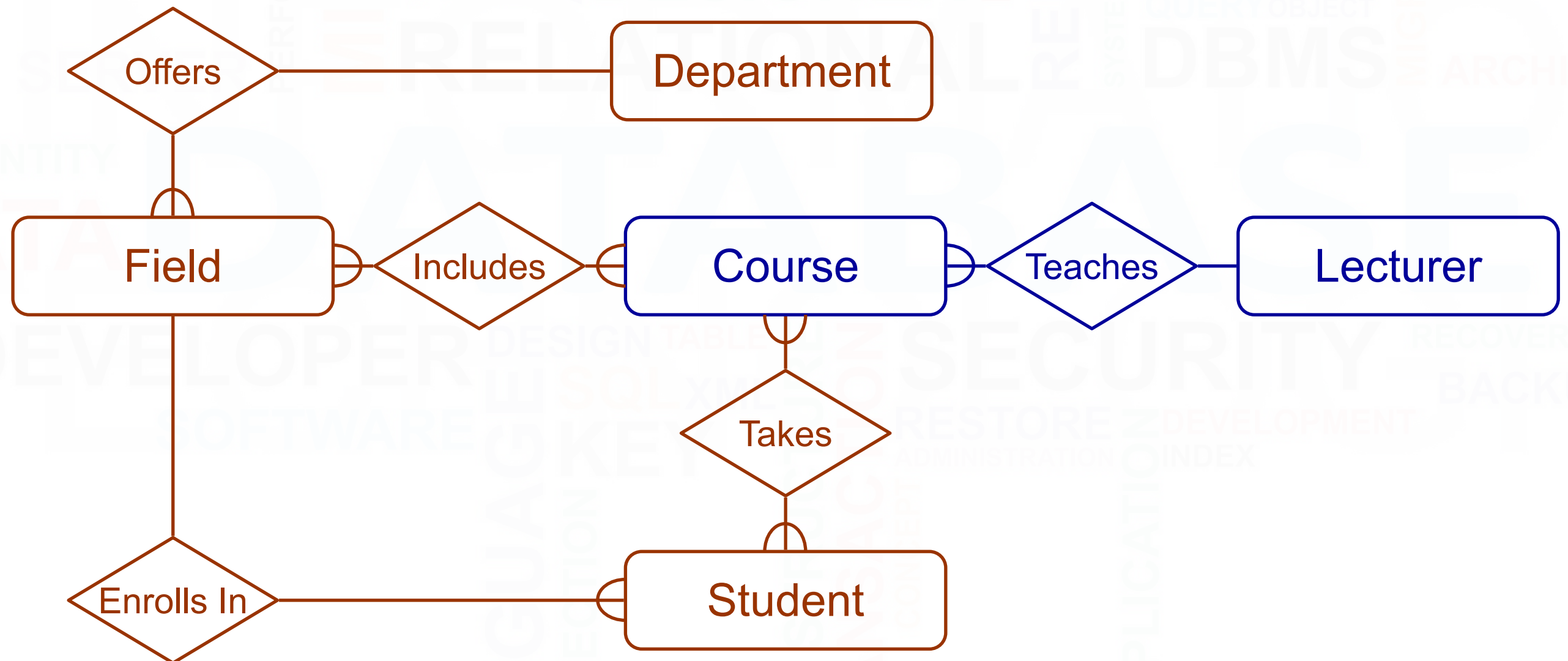# EXAMPLE - E/R DIAGRAM

Students enroll in a particular field
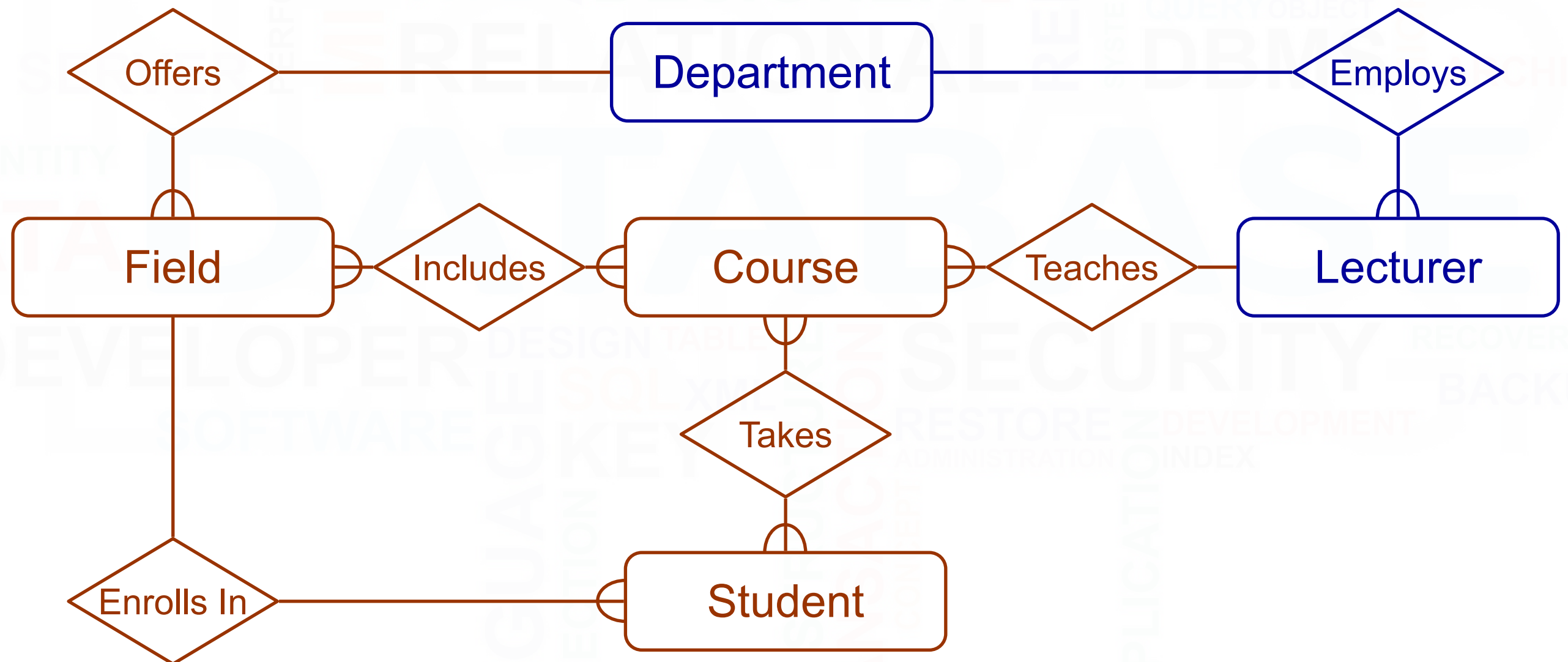
EXAMPLE - E/R DIAGRAM

Students … take courses

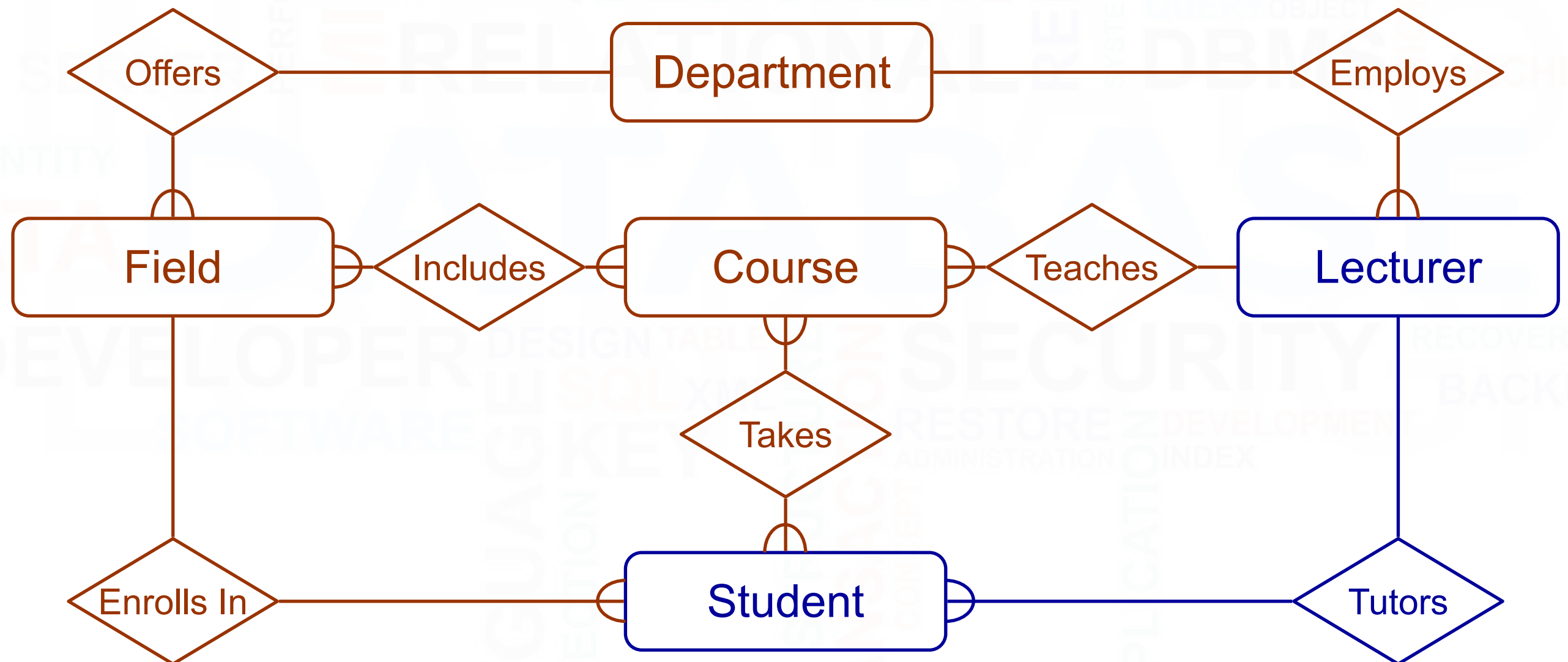# EXAMPLE - E/R DIAGRAM

Each course is taught by a lecturer

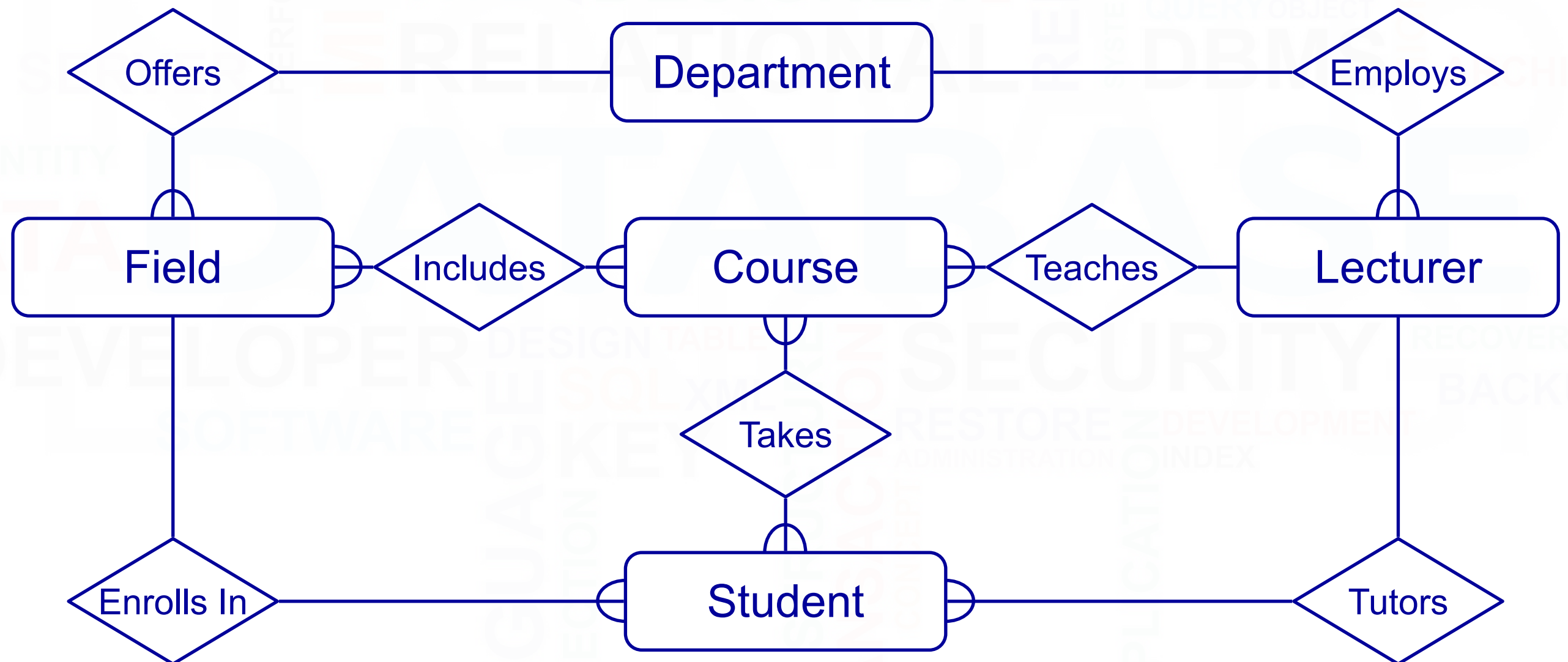a lecturer from the appropriate department

EXAMPLE - E/R DIAGRAM

each lecturer tutors a group of students

EXAMPLE - E/R DIAGRAM

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, and a post-code.
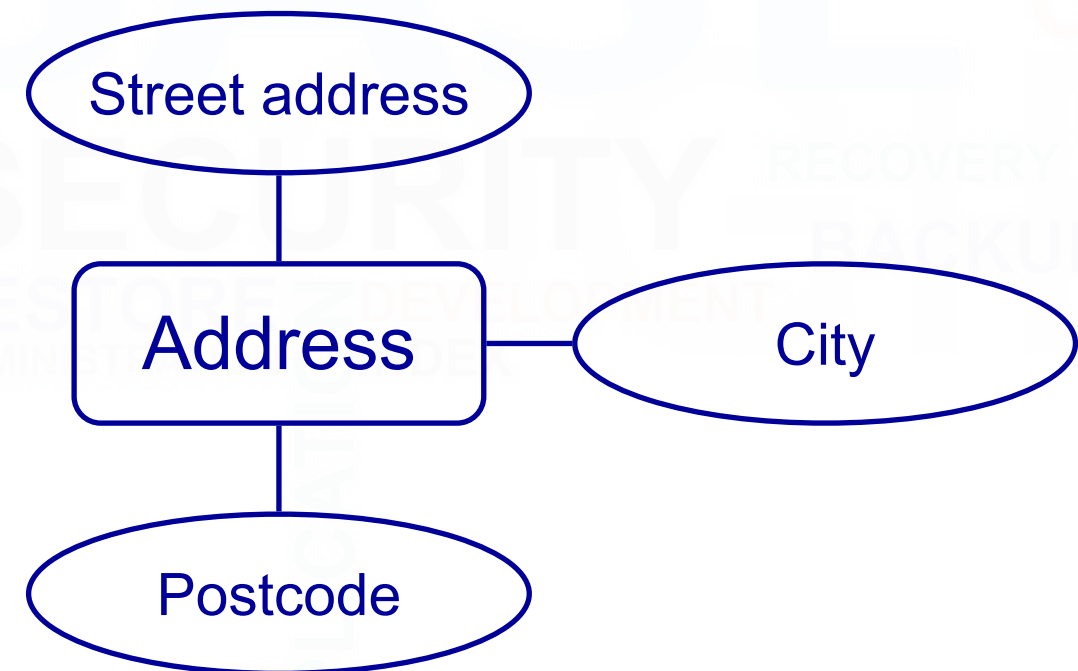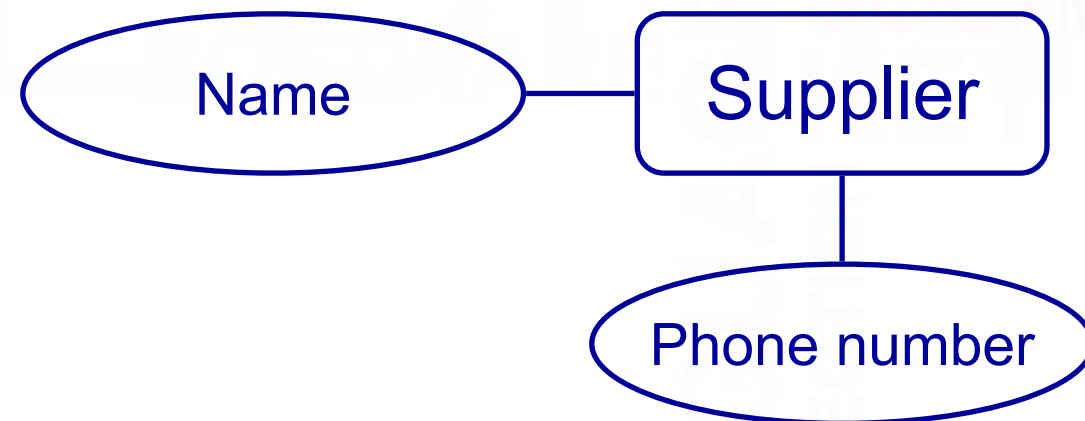
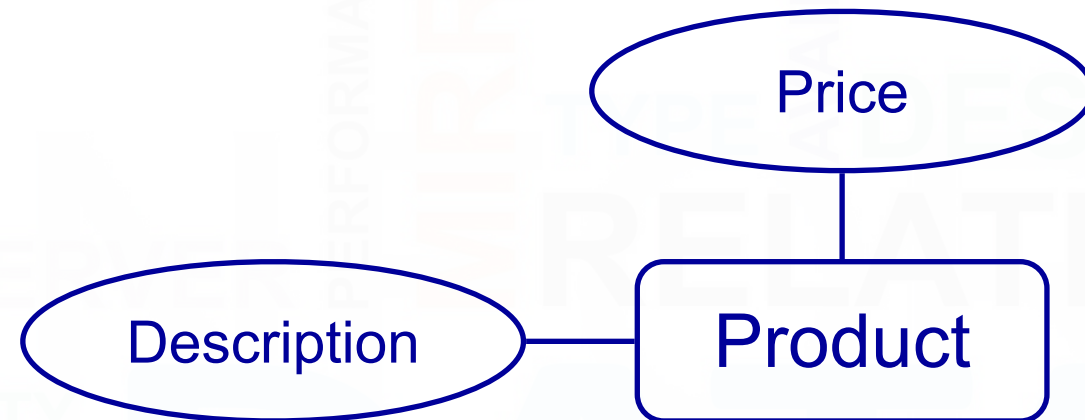# EXAMPLE - ENTITIES/ATTRIBUTES

➤ Entities or attributes:

  ➤ product

  ➤ description

  ➤ price

  ➤ supplier

  ➤ address

  ➤ phone number

  ➤ name

  ➤ street address

  ➤ city

  ➤ postcode

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

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

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EXAMPLE - E/R DIAGRAM
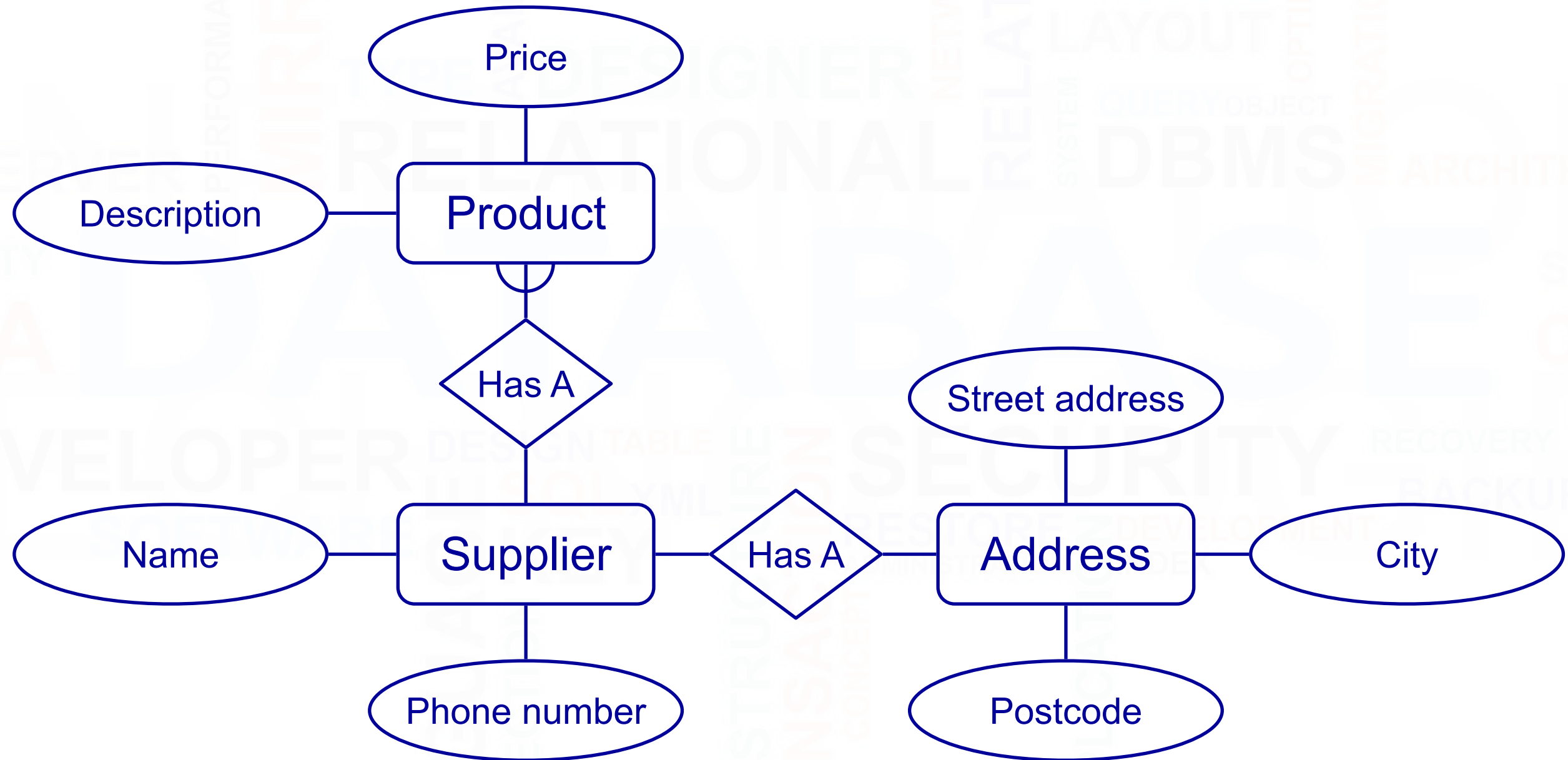
EXAMPLE - RELATIONSHIPS

- ➤ 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
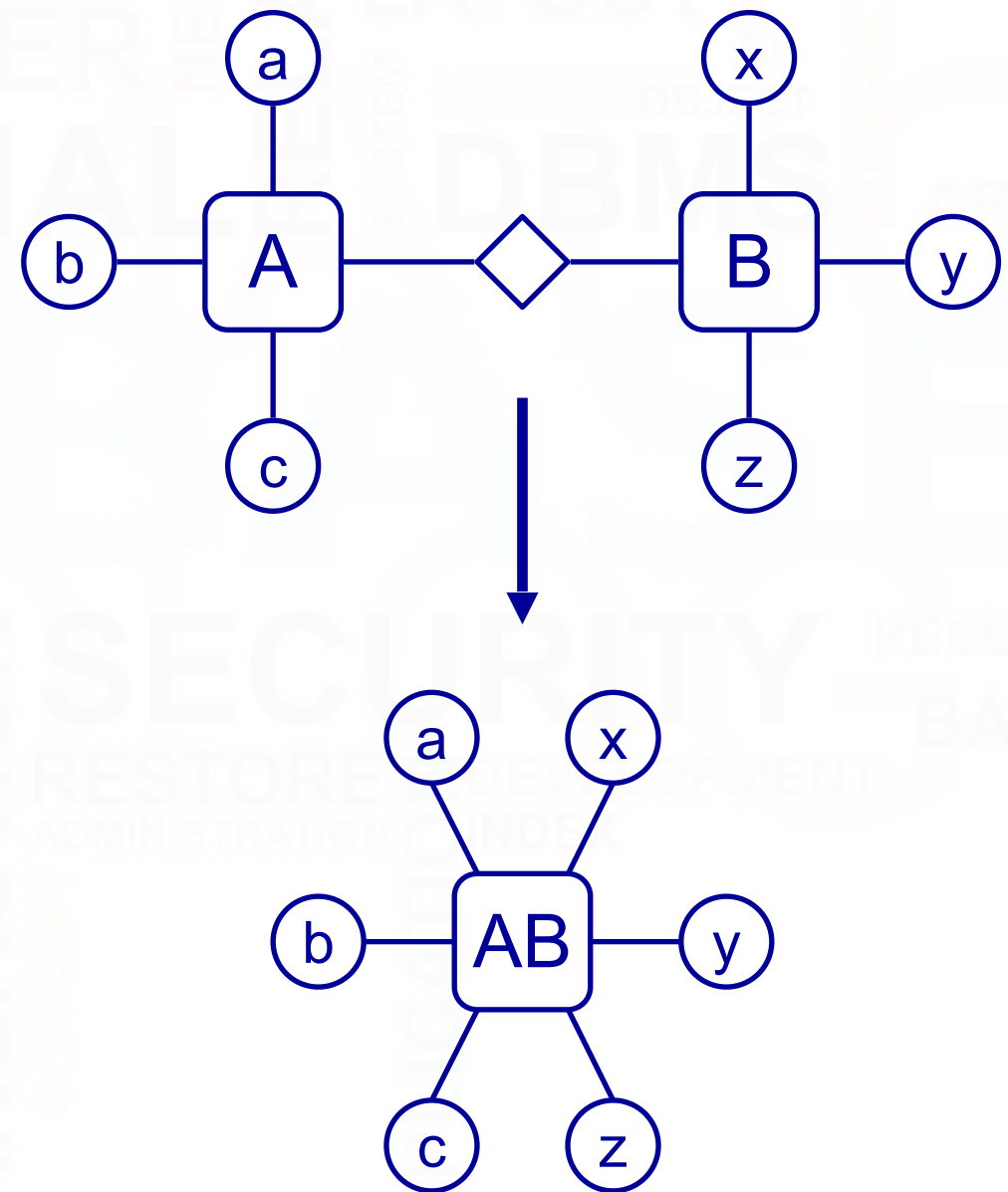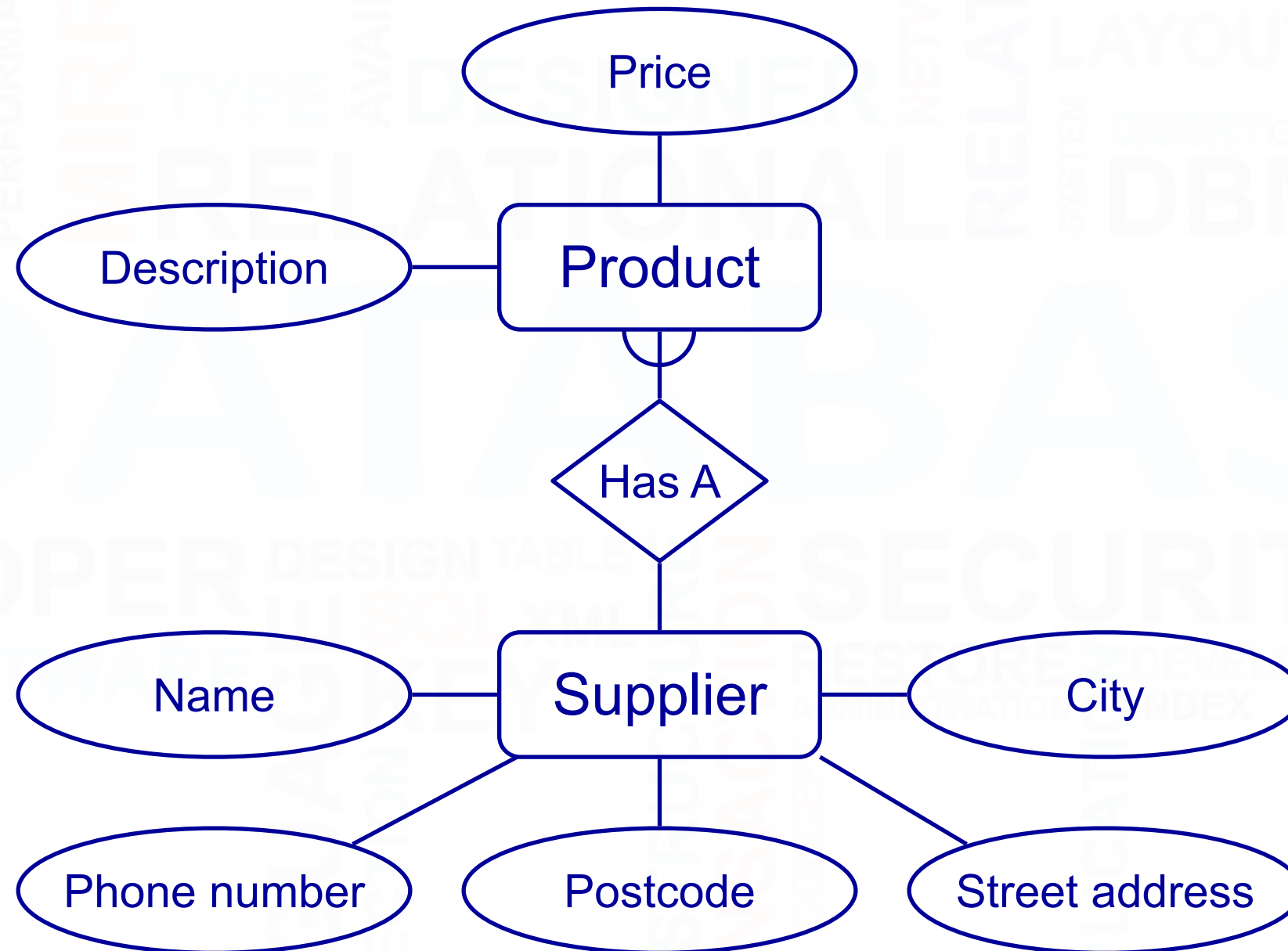
ONE TO ONE RELATIONSHIPS

➤ **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

REDUNDANT 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 one

# EXAMPLE - E/R DIAGRAM

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 might need to be split into two one to many links

DEBUGGING DESIGNS

➤ With a bit of practice E/R diagrams can be used to plan queries

　➤ You can look at the diagram and figure out how to find useful information

　➤ If you can't find the information you need, you may need to change the design

Student

Has

Enrolment

In

Course
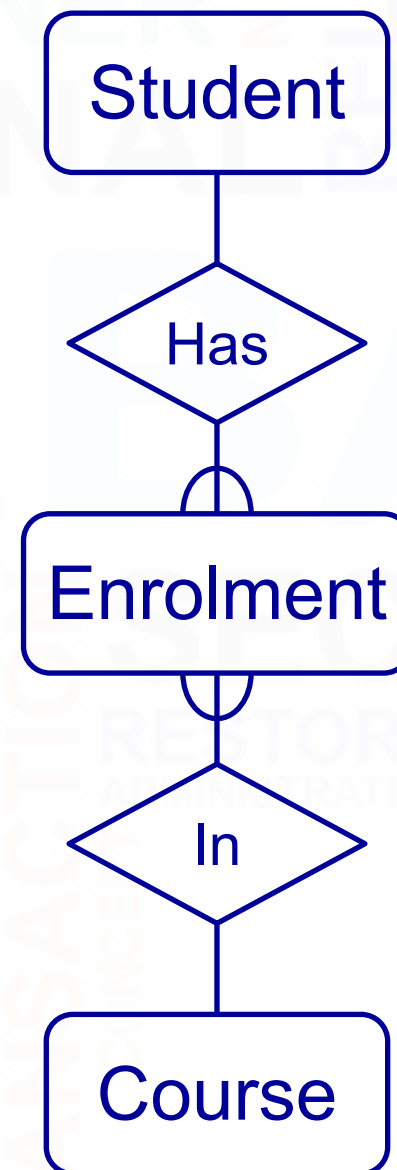
How can you find a list of students who are enrolled in Database systems?

DEBUGGING DESIGNS

ID

Student

Name

Has

ID

Enrolment

Code

In
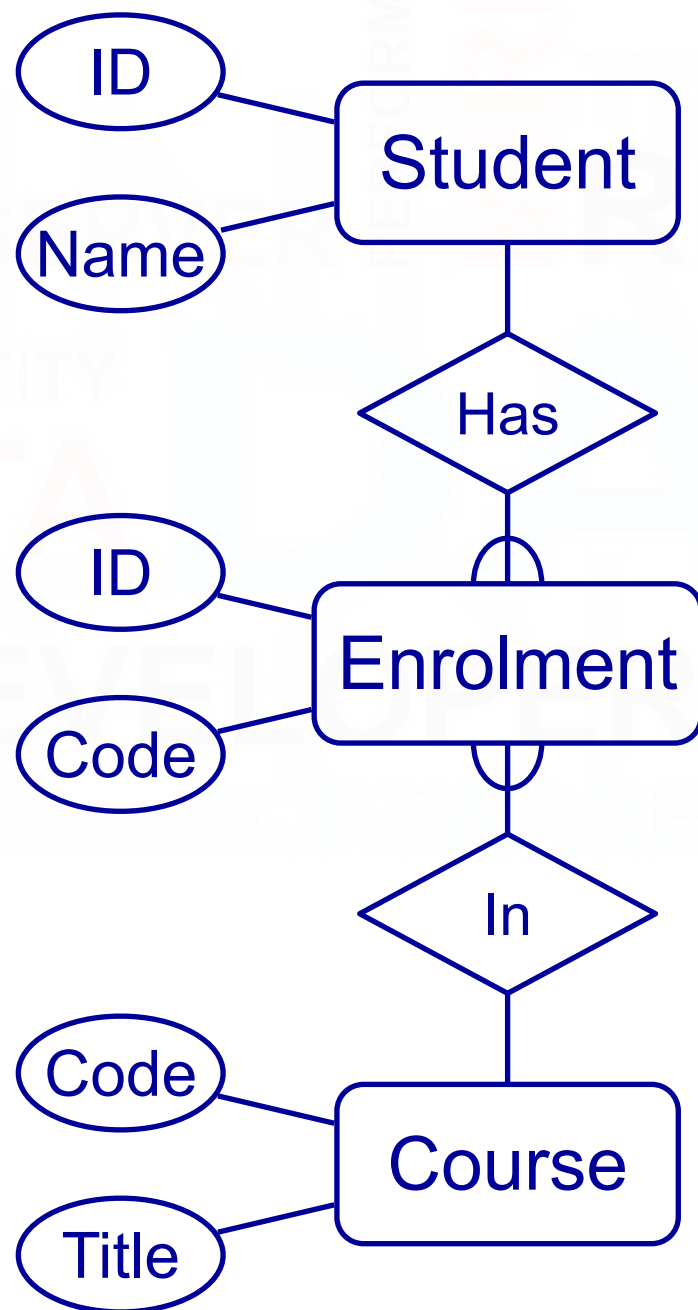
Code

Course

Title

(3) For each instance of Enrolment in the result of (2) find the corresponding Student

(2) Find instances of the Enrolment entity with the same Code as the result of (1)

(1) Find the instance of the Course entity with title 'Database Systems'

E/R IN MORE DETAILED VIEW

➤ **Attributes**

- ➤ **Simple attributes** are atomic values, which cannot be divided further. For example, a student's phone number is an atomic value of 10 digits

- ➤ **Composite attributes** are made of more than one simple attribute. For example, a student's complete name may have first_name and last_name.

- ➤ **Derived attributes** are the attributes that do not exist in the physical database, but their values are derived from other attributes present in the database. For example, average_salary in a department should not be saved directly in the database, instead it can be derived. For another example, age can be derived from data_of_birth.
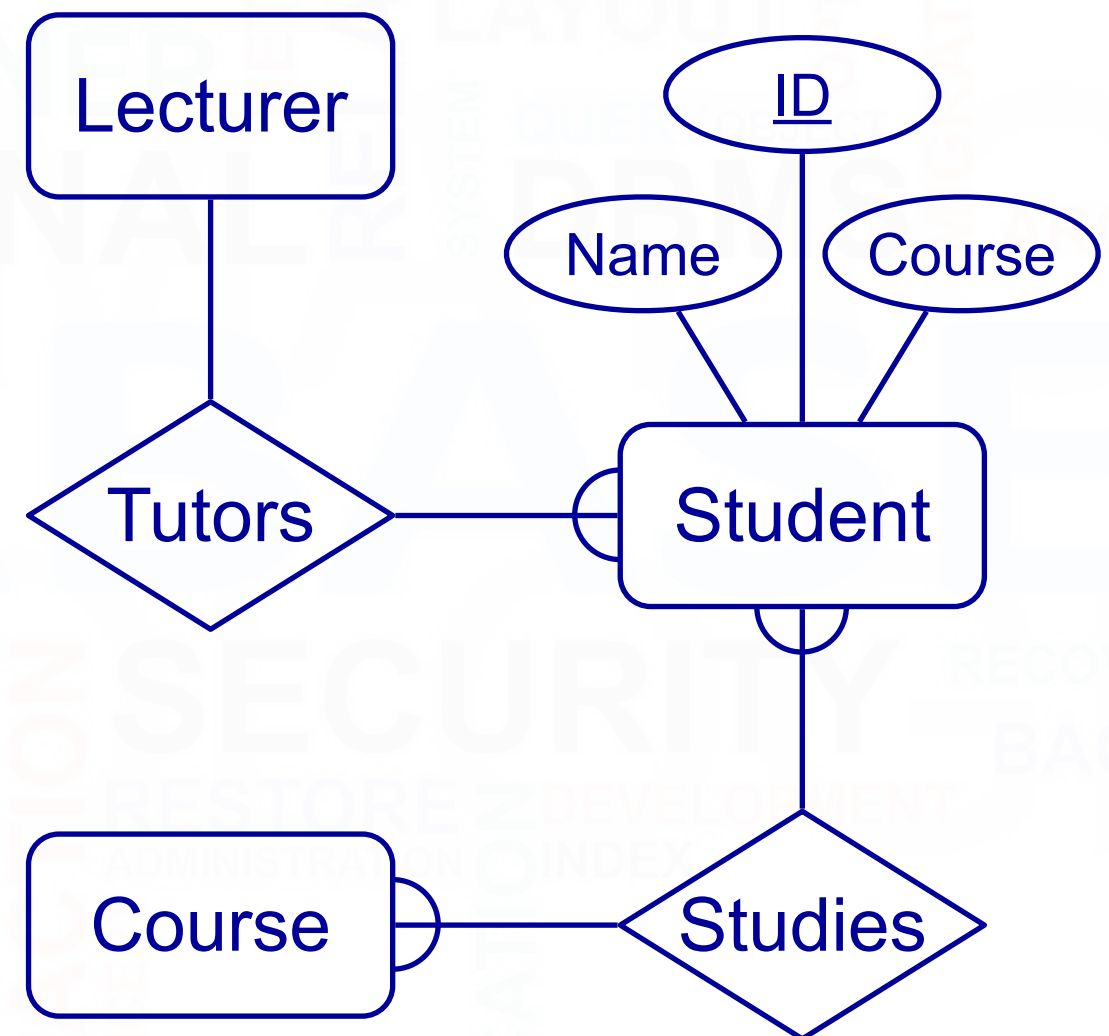
E/R IN MORE DETAILED VIEW

➤ **Attributes**

    ➤ **Single-value attributes** contain single value. For example Social_Security_Number.

    ➤ **Multi-value attribute**s may contain more than one values. For example, a person can have more than one phone number, email_address, etc
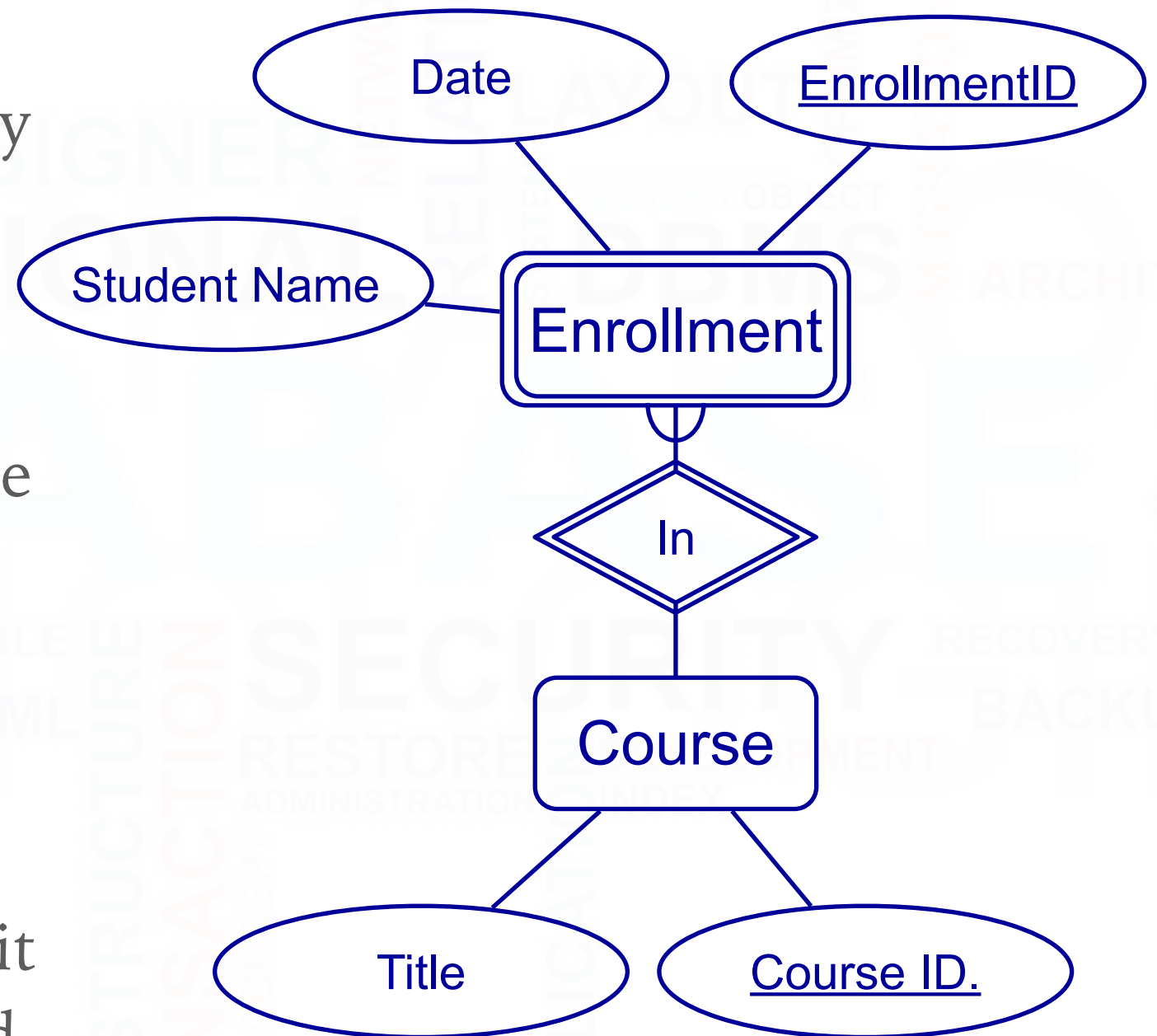
E/R IN MORE DETAILED VIEW

➤ We need a Primary Key to identify a record in an entity

➤ In some cases it could be one of its unique attributes

  ➤ E.g student_number in Student entity

➤ In other cases we need to define new attribute like ID

 ➤ E.g in a enrollment or order

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E/R IN MORE DETAILED VIEW

➤ Strong Vs. Weak entity

   ➤ An entity should have a key attribute which uniquely identifies each record, but there exists some entity type for which key attribute can't be defined. These are called Weak Entity type.

   ➤ A strong entity is one that has a unique identifier among its own attributes; it does not depend on related entities(FK).

Date

EnrollmentID

Student Name

Enrollment

In

Course

Title

Course ID.

E/R IN MORE DETAILED VIEW

➤ Generalization

  ➤ Extracting common properties from a set of entities and creating a generalized entity from it.

  ➤ It is a bottom-up approach in which two or more entities can be generalized to a higher-level entity if they have some attributes in common.
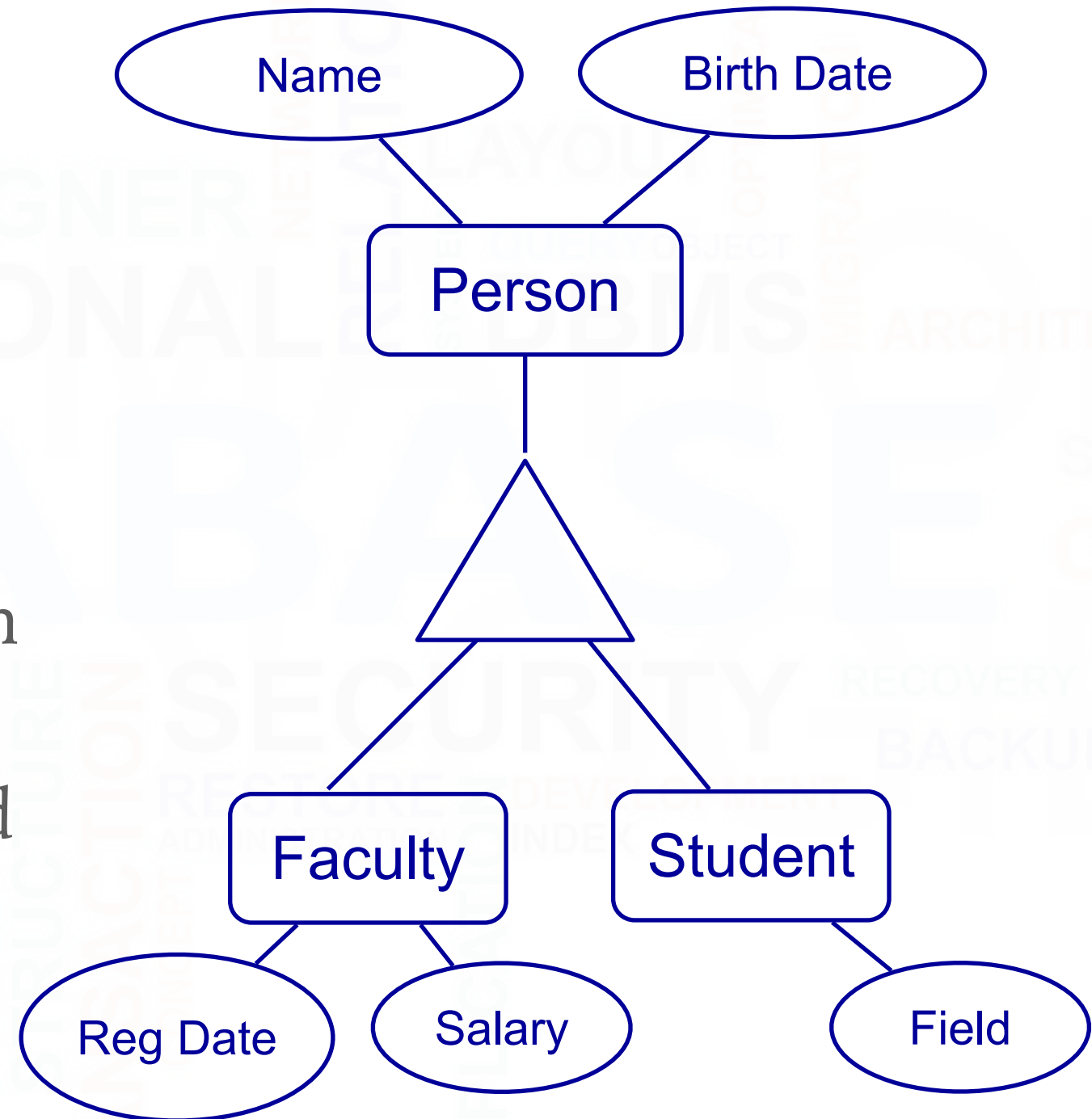
E/R IN MORE DETAILED VIEW

➤ Specialization

   ➤ An entity is divided into sub-entities based on its characteristics.

   ➤ It is a top-down approach where the higher-level entity is specialized into two or more lower-level entities
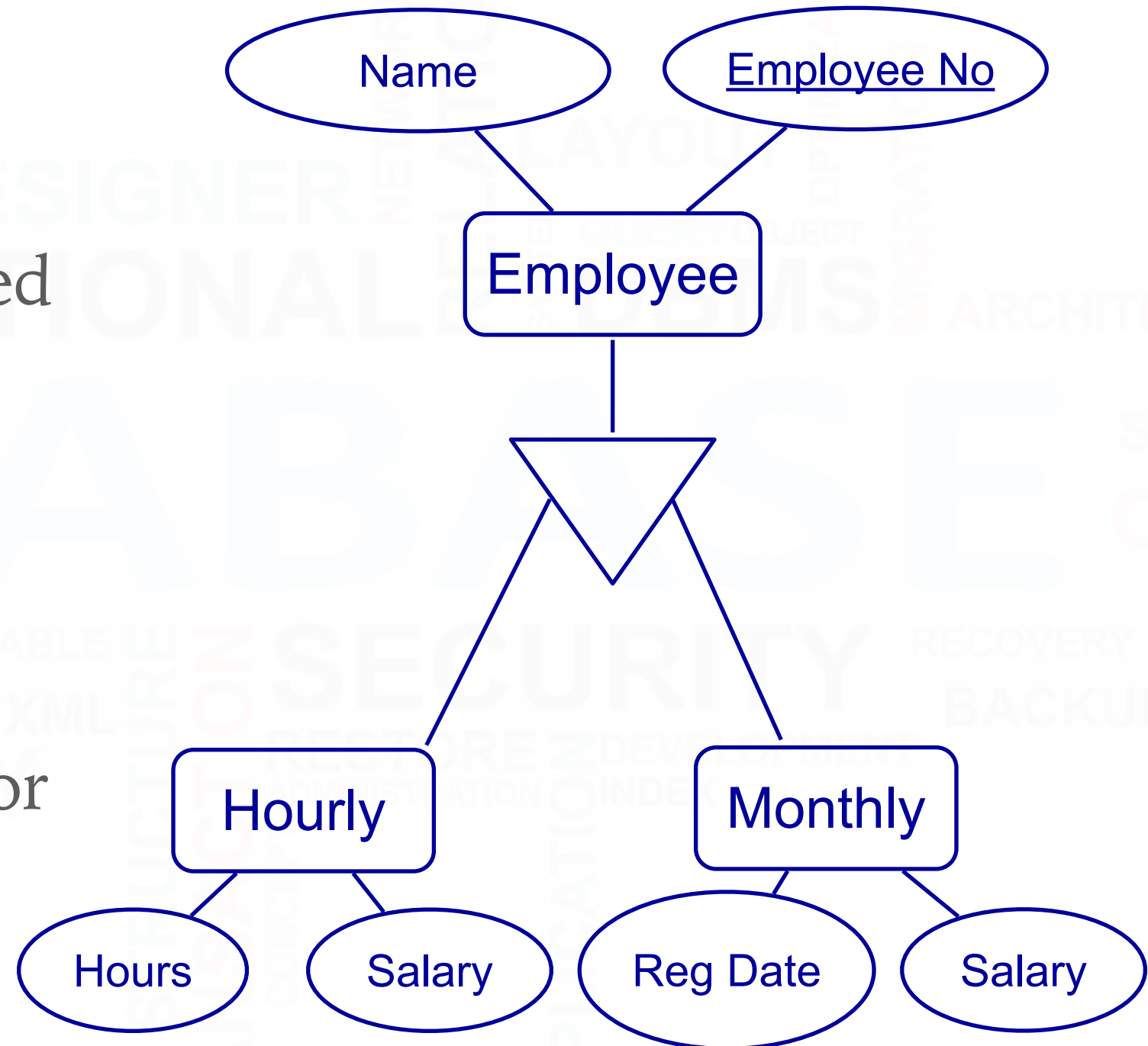
E/R IN MORE DETAILED VIEW

➤ Aggregation

  ➤ Is a process when relation between two entities is treated as a **single entity**.

  ➤ Aggregation is an abstraction through which we can represent relationships as higher-level entity sets.
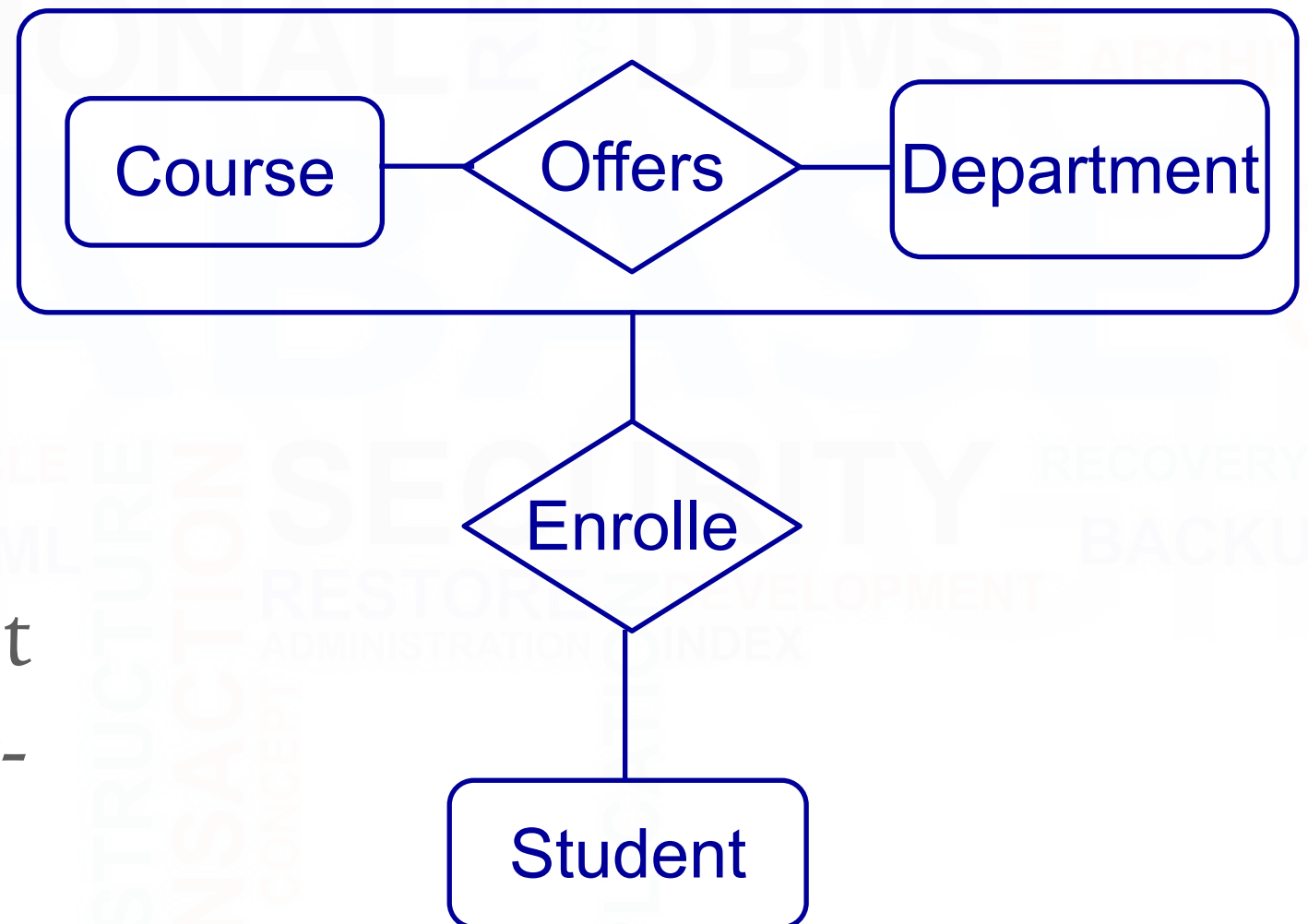
کوییز ۲

▶ پروژه نرم‌افزاری از مجموعه‌ای از زیرپروژه‌ها تشکیل شده است. هر زیر پروژه خود می‌تواند تعدادی زیر پروژه داشته باشد. در نهایت زیر پروژه دارای تعدادی فعالیت است. هر فعالیت به یک گروه از افراد محول می‌شود. هر گروه دارای یک مدیر گروه است که وظیفه راهبری گروه را بر عهده دارد. در یک پروژه نرم‌افزاری هر فعالیت دارای زمان شروع و پایان و هزینه مد نظر برای انجام است. کل پروژه دارای یک مدیر پروژه است که فعالیت افراد مختلف را کنترل می‌کند.

▶ الف) ERD در حالتی که محدودیتی روی فعالیت همزمان گروه‌ها نیست

▶ ب) در صورت امکان! ERD در حالتی که یک گروه می‌تواند در هر زمان تنها یک فعالیت انجام دهد (یعنی دو فعالیت همزمان را نمی‌تواند انجام دهد).

THIS LECTURE IN EXAMS

"A database will be made to store information about patients in a hospital. On arrival, each patient's personal details (name, address, and telephone number) are recorded where possible, and they are given an admission number. They are then assigned to a particular ward (Accident and Emergency, Cardiology, Oncology, etc.). In each ward there are a number of doctors and nurses. A patient will be treated by one doctor and several nurses over the course of their stay, and each doctor and nurse may be involved with several patients at any given time."

THIS LECTURE IN EXAMS

Identify the *entities*, *attributes*, *relationships*, and *cardinality ratios* from the description.

(4 marks)

Draw an entity-relationship diagram showing the items you identified.

(4 marks)

Many-to-many relationships are hard to represent in SQL tables. Explain why many-to-many relationships cause problems in SQL tables, and show how these problems may be overcome.

(4 marks)

END