

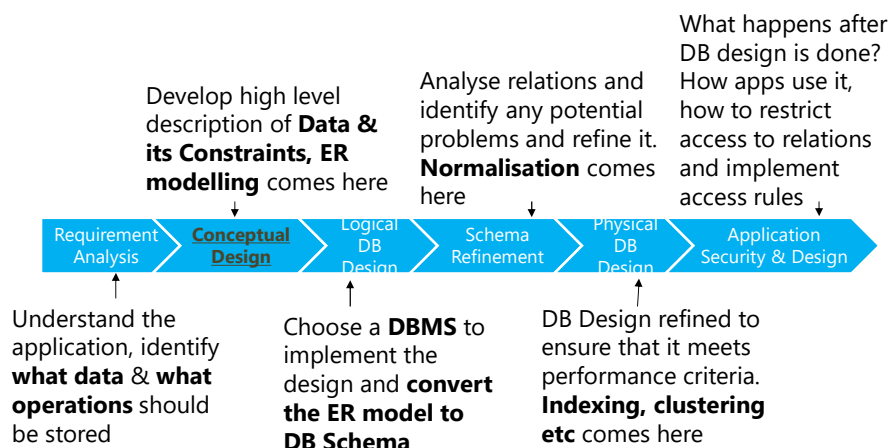
So far- from ACCA4023

- Understand the concept – DBMS
- Identify different types of databases
- Components of DBMS
- DBMS system Architecture
- Benefits of DBMS
- Implementation using MS Access

Objectives

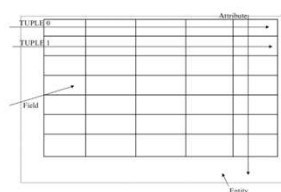
- **Entity, Entity Set and Entity Type**
- **Kinds of Entities**
- **Types of Attributes**
- **Types of Keys**
- **Types of Relationships**
- **Mapping of ERD to tables**

Database Design Process



Relational Database Model

Keys, Domain, Attribute, Degree, Cardinality



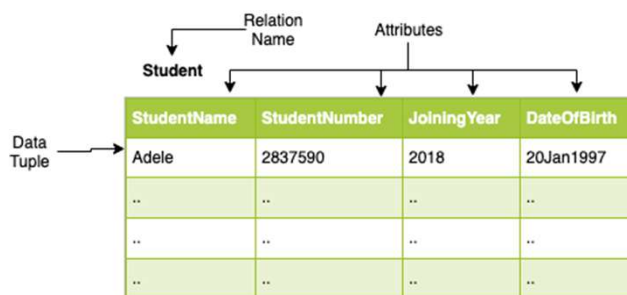
- Relations must have a **key**. Keys can be a set of attributes.
- For each column of a table there is a set of possible values called its **domain**. The domain contains all possible values that can appear under that column.
- Domain is the set of valid values for an attribute.
- **Degree** of the relation is the number of attributes (columns) in the relation.
- **Cardinality** of the relation is the number of tuples (rows) in the relation.

Example - Relation

Book Name	Author	Category	Votes
The Testaments	Margaret Atwood	Fiction	98,291
The Silent Patient	Alex Michaelides	Mystery & Thriller	68,821
Daisy Jones & The Six	Taylor Jenkins Reid	Historical Fiction	82,483
Ninth House	Leigh Bardugo	Fantasy	3,430
Will My Cat Eat My Eyeballs?	Caitlin Doughty	Science & Technology	29,594

- Cardinality of the relation?
- Degree of the relation?

E/R (Entity/Relationship) Model



Database – MS Access

CourseID	CourseName	Click to Add
BUS1	Business Management	
BUS2	Economics	
COM1	Introduction to Computing	
COM2	Advanced Computing	

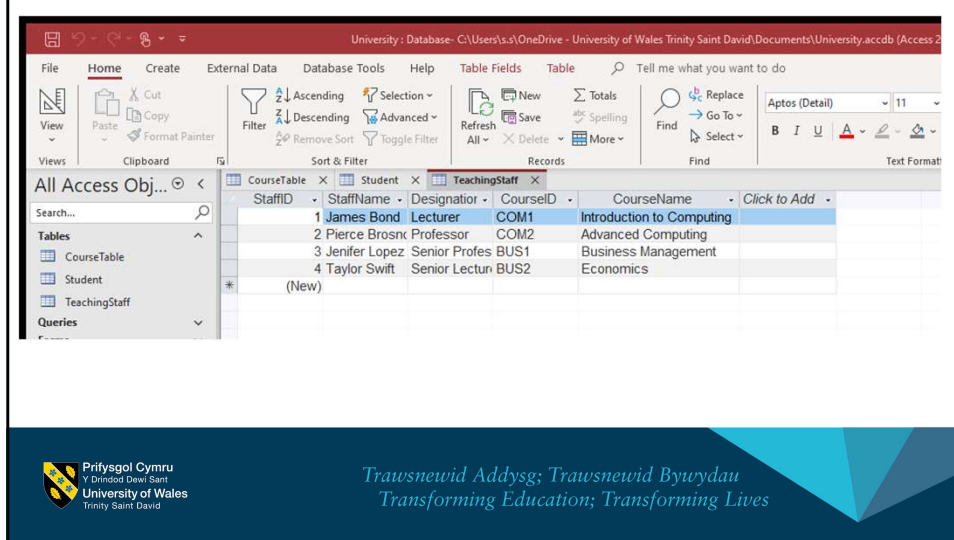
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Database – MS Access

StudentID	StudentName	DateofBirth	CourseID	Click to Add
1	Tom Hanks	05/02/2000	COM1	
2	Tom Hardley	04/07/2003	BUS1	
3	Tom Cruise	04/09/1999	COM1	
4	Jerry Williams	08/07/2001	BUS1	
*	(New)			

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Database – MS Access



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Key

- An attribute or group of attributes, which is used to identify a row in a relation.
- 3 broad classification
 - Super key
 - Candidate key
 - Foreign key



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Super Key

- A **subset of attributes** of an entity-set that **uniquely identifies** the entities.

Super Keys - Prof

{pid}
 {pid, name}
 {pid, dept}
 {pid, rank, sal}

Prof - Relation

Pid	Name	Dept	Rank	Sal
P1	Adam	CS	Asst	6000
P2	Bob	EE	Asso	8000
P3	Calvin	CS	Full	10000
P4	Dorothy	EE	Asst	5000
P5	Emily	EE	Asso	8500
P6	Frank	CS	Full	9000

Candidate Keys

- Candidate key is a **minimal super key**.

Candidate Key - Prof

{pid}
 This is also the **Primary Key**

Prof - Relation

Pid	Name	Dept	Rank	Sal
P1	Adam	CS	Asst	6000
P2	Bob	EE	Asso	8000
P3	Calvin	CS	Full	10000
P4	Dorothy	EE	Asst	5000
P5	Emily	EE	Asso	8500
P6	Frank	CS	Full	9000

Foreign Keys

- Set of fields or attributes in one relation that is used to "refer" to a tuple in another relation.

Prof - Relation

Pid	Name	Dept	Rank	Sal
P1	Adam	CS	Asst	6000
P2	Bob	EE	Asso	8000
P3	Calvin	CS	Full	10000
P4	Dorothy	EE	Asst	5000
P5	Emily	EE	Asso	8500
P6	Frank	CS	Full	9000

Class - Relation

Cid	Title	Dept	Year
C1	Databases	CS	2011
C2	Signal Processing	EE	2012
C1	Databases	CS	2012

Teach - Relation

Pid	Cid	Year
P1	C1	2011
P2	C2	2012
P1	C1	2012

{pid} of Teach → foreign key referencing Prof

{cid, year} of Teach → foreign key referencing Class



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Example

Emp ID	Emp Name	Emp Age	Emp Exp	Emp Salary
123	Abc	25	2	12000
234	Def	39	10	40000
345	Ghi	29	5	22000

Identify the following in the Employee relation

- Super key(s)
- Candidate key(s)
- Primary key(s)



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Identify Superkey, candidate key and primary key

Identify the following in the relation(s)

- Super key(s)
- Candidate key(s)
- Primary key(s)

BookID	Title	Author
1	The Great Gatsby	F. Scott Fitzgerald
2	To Kill a Mockingbird	Harper Lee
3	1984	George Orwell
4	Pride and Prejudice	Jane Austen
5	The Catcher in the Rye	J.D. Salinger

Table: Members

MemberID	Name	Address
1	Alice Johnson	123 Maple St.
2	Bob Smith	456 Oak St.
3	Carol White	789 Pine St.
4	David Brown	101 Elm St.
5	Emily Davis	202 Birch St.

Table: Loans

LoanID	BookID	MemberID	LoanDate
1	1	3	2024-06-01
2	4	1	2024-06-05
3	2	5	2024-06-10
4	5	2	2024-06-15
5	3	4	2024-06-20

Identify Superkey, candidate key and primary key

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4	5	2	2024-06-15
5	3	4	2024-06-20

Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

Scenario: A university database has a table named Students with columns StudentID, FirstName, LastName, and Email. The StudentID is a unique identifier assigned to each student.

Question: Which of the following can be considered a Primary Key for the Students table?

- A) FirstName
- B) Email
- C) StudentID
- D) Combination of FirstName and LastName



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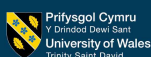
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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

Scenario: In the Employees table, there are columns: EmployeeID, SSN, FirstName, LastName, and Email. Both EmployeeID and SSN are unique for every employee.

Question: Which of the following is not a Candidate Key for the Employees table?

- A) EmployeeID
- B) SSN
- C) Salary
- D) Both A and B



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- C) Salary**
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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

A library database has a Books table with columns BookID, ISBN, Title, and Author. The BookID is an automatically generated unique identifier, and ISBN is the unique identifier for each published book.

What can be said about the keys in this table?

- A) Both BookID and ISBN are primary keys.
- B) Only ISBN can be the primary key, as it's unique for each book.
- C) Both BookID and ISBN are candidate keys, but only one can be chosen as the primary key.
- D) Title should be the primary key because it's the most important piece of information.



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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

In a school database, the Students table has columns StudentID, FirstName, LastName, Email, and NationalID. The StudentID is a unique identifier auto-generated by the system, and the NationalID is unique for each student as well. Which of the following is the best choice for the primary key?

- A) FirstName and LastName combined.
- B) Email because it's unique.
- C) Either StudentID or NationalID can be selected as the primary key.
- D) FirstName should be the primary key.



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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

Scenario: A university database has two tables: Students and Courses. The Students table has StudentID as its Primary Key, and the Courses table has CourseID as its Primary Key. There's a third table called Enrolments which records which students are enrolled in which courses.

Question: In the Enrolments table, which of the following should be used as a Foreign Key?

- A) StudentID
- B) CourseID
- C) Both A and B
- D) Neither A nor B



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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

Scenario: A table ProjectAssignments has columns: EmployeeID, ProjectID, and AssignmentDate. One employee can be assigned to multiple projects, and each project can have multiple employees.

Question: Which of the following is the best Composite Key for the ProjectAssignments table?

- A) EmployeeID
- B) ProjectID
- C) Combination of EmployeeID and ProjectID
- D) AssignmentDate



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Primary Key, Candidate Key, Foreign Key, & Composite Key

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- D) AssignmentDate



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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

A table called Orders has the following columns: OrderID, CustomerID, ProductID, and OrderDate. The OrderID uniquely identifies each order, while both CustomerID and ProductID are required to uniquely identify an ordered product by a customer. What is the best key configuration for this table?

- A) OrderID should be the primary key.
- B) CustomerID should be the primary key.
- C) A composite key of CustomerID and ProductID should be the primary key.
- D) OrderDate should be included in the composite key.



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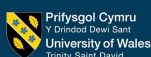
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Quiz

Primary Key, Candidate Key, Foreign Key, & Composite Key

A table StudentCourses stores which courses students are enrolled in, with the columns StudentID, CourseID, EnrollmentDate, and Grade. Each student can enroll in multiple courses, and each course can have multiple students. What is the best key configuration?

- A) StudentID should be the primary key.
- B) CourseID should be the primary key.
- C) A composite key of StudentID and CourseID should be the primary key.
- D) EnrollmentDate should be the primary key.



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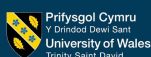
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Lab activity



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Lab activity- Car dealership



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Relationships- Car dealership

Salesperson.SalespersonID → Invoice.SalespersonID
(Left entity) (Right entity)

One salesperson can write multiple invoices, but each invoice is written by only one salesperson.

- **Cardinality:** One-to-Many

Each invoice must reference a salesperson

Salesperson 1 ———< Invoice *

Relationships- Car dealership

Customer.CustomerID → Invoice.CustomerID
(Left entity) (Right entity)

One customer can buy many cars, but each car purchase (invoice) is linked to only one customer.

- **Cardinality:** One-to-Many

A customer may exist without having bought a car

Every invoice must be associated with a customer

Customer 1 ———< Invoice *

Relationships- Car dealership

Car.CarID → Invoice.CarID
(Left entity) (Right entity)

Each car can only be sold once (hence, one invoice),
and each invoice references only one car.

Cardinality: One-to-One

Not every car may be sold (for example, cars that
are just being serviced)

Every invoice must be linked to exactly one car.

Car 1 ——— Invoice 1



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Relationships- Car dealership

Customer – ServiceTicket

Car – ServiceTicket

ServiceTicket – ServiceHistory

Mechanic - ServiceHistory



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Relationships- Car dealership

Customer 1 —< ServiceTicket *

One-to-Many: One customer can have many service tickets.

Car 1 —< ServiceTicket *

One-to-Many: One car can have many service tickets.

ServiceTicket 1 —< ServiceHistory *

One-to-Many: One service ticket can have multiple entries in the service history (for multiple mechanics, parts, etc.).

Mechanic 1 —< ServiceHistory *

One-to-Many: One mechanic can work on many service history records.

E-R Data Model

- **Three** principal element types:

Entity Sets	Attributes	Relationships
• Entity-abstract object of some sort • Entity Sets-a collection of similar entities	• Properties of the entities in that set • Assumptions: attributes are of primitive types, such as strings, integers, or real numbers	• Connections among two or more entity sets

Entity, Entity Set and Entity Type

An **entity** is an object in the real world with an independent existence that can be differentiated from other objects. An entity might be

- An object with physical existence (e.g., a lecturer, a student, a car)
- An object with conceptual existence (e.g., a course, a job, a position)

Entity

Objects in real life that are distinguishable from other objects.

Usually nouns in a scenario description but not every noun becomes an entity – think carefully when you finalize on the entities

Question: If you are building a data model for a **small retail store**, then the potential entities may be ?

Entity

- If you are building a data model for a small retail store, then the potential entities may be ?

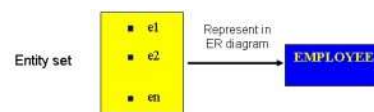
Entity

- If you are building a data model for a small retail store, then the potential entities may be
 - Customer
 - Team
 - Sales Rep
 - Order
 - Item
 - Inventory list

Entity, Entity Set and Entity Type

An **entity set** is a collection of entities of an entity type at a particular point of time. In an entity relationship diagram (ERD), an entity type is represented by a name in a box. For example, the entity is EMPLOYEE.

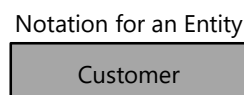
EmployeeID	FirstName	LastName	DateOfBirth	Gender	Position	Department
1	John	Doe	1985-06-15	Male	Software Dev	IT
2	Jane	Smith	1990-09-20	Female	Data Analyst	IT
3	Mike	Brown	1988-12-05	Male	HR Manager	Human Resources
4	Emily	Davis	1992-02-10	Female	Accountant	Finance
5	David	Wilson	1983-11-25	Male	Project Manager	Operations



Entity – Notation

- **Entity Occurrence:** A uniquely identifiable object of an entity type.
- **Entity Instance:** Values associated with the entities. (rows in the table at a given point in time)

Notation: *rectangle* labelled with the name of the entity.



Identify the Entity & entity sets from the data below;

Movie

MovieID	Title	ReleaseDate	Duration	Rating	GenreID	DirectorID
1	Inception	2010-07-16	148	8.8	1	1
2	The Dark Knight	2008-07-18	152	9.0	2	1
3	Interstellar	2014-11-07	169	8.6	1	1
4	Titanic	1997-12-19	195	7.8	3	2

Actor

ActorID	FirstName	LastName	DateOfBirth	Nationality
1	Leonardo	DiCaprio	1974-11-11	American
2	Joseph	Gordon-Levitt	1981-02-17	American
3	Ellen	Page	1987-02-21	Canadian
4	Christian	Bale	1974-01-30	British
5	Kate	Winslet	1975-10-05	British

Kinds of Entities

You should also be familiar with different kinds of entities including independent entities, dependent entities and characteristic entities. These are described below.

Types of Entities

Regular Entities

- Called as Strong Entities.
- Independent Entities
- E.g. Employee

Weak Entities

- Its existence depends on some other entity
- E.g. EmployeeDependants
- If an Employee Instance is deleted, then the dependants too are deleted. They do not exist without the employee.

Notation for a Regular Entity

Employee

Notation for a Weak Entity

EmpDependant

Regular and Weak Entities

Example Data:

Student Table:

StudentID	FirstName	LastName	DateOfBirth	Email
1	John	Doe	2000-01-15	john.doe@example.com
2	Jane	Smith	1999-03-22	jane.smith@example.com

Course Table:

CourseID	CourseName	Credits	Department
101	Database Systems	4	Computer Science
102	Calculus I	3	Mathematics

Enrollment Table:

StudentID	CourseID	EnrollmentDate	Grade
1	101	2023-09-01	A
2	101	2023-09-01	B
1	102	2023-09-01	A-

Entities - Examples



Knowledge Check - Entities



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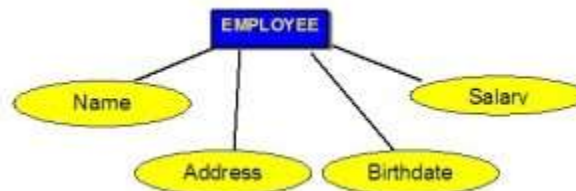
Attributes

In the entity, shown bellow, what are the attributes that define 'Employee' entity?



Attributes

In the entity relationship diagram, shown bellow, each attribute is represented by an oval with a name inside.



Attribute Types

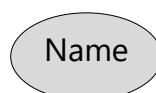
- Each entity has attributes – **properties that describe it**.
- A particular entity will have values for its attributes.
- E.g. an employee entity may have name, age, home address, home phone etc as their attributes.
- **Keys:** Unique value in the context.

Attribute Types			
Simple vs Composite	Single vs Multivalued	Stored vs Derived	Null vs Complex

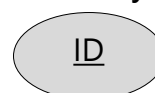
Attributes Notation

- **Attribute Domain:** The set of allowable values for one or more attributes.
- Each attribute is associated with a set of values called a domain.
- **Notation:** Attributes are represented by ovals.

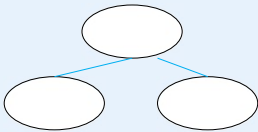
Notation for an Attribute



Notation for an **Key** Attribute



Attribute Types - 1

Type	Description	Example
Simple Attribute 	An attribute composed of a single component with an independent existence. Also called as atomic attributes.	Employee entity: Position, salary etc.
Composite Attribute 	An attribute composed of multiple components, each with an independent existence.	Employee entity: Address → can be made up of <i>street, town, country, postcode</i>

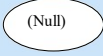
Attribute Types - 2

Type	Description	Example
Single Valued Attribute 	An attribute that holds a single value for each occurrence of an entity type.	Employee entity: Salary → can be only one value. Cannot draw more than one salary.
Multi Valued Attribute 	An attribute that holds multiple values for each occurrence of an entity type.	Employee entity: PhoneNo → A person can have one or more mobile phone number, landline etc.

Attribute Types - 3

Type	Description	Example
Stored Attribute 	An attribute that holds a value provided as is.	Employee entity: Name → can be set by the user as used as is.
Derived Attribute 	An attribute that represents a value that is derivable from the value of a related attribute or set of attributes, not necessarily in the same entity type.	Employee entity: Age → can be derived from dateOfBirth and currentDate.

Attribute Types - 4

Type	Description	Example
NULL Attribute 	An attribute that means either the value is unknown or inapplicable. It does not mean zero or blank.	Employee entity: Commission → can be NULL
Complex Attribute 	An attribute that is formed by nesting composite attributes and multi-valued attributes in arbitrary way. We can say this as the both are in the attribute.	Employee entity: A person can have many phone numbers, many e-mail addresses, home addresses etc. So if there is an attribute in the name of 'Contact detail', it can be a complex attribute.

Nulls

Example of how null can be used

Use the Salary table (Salary_tbl) to follow an example of how null can be used.

Salary_tbl

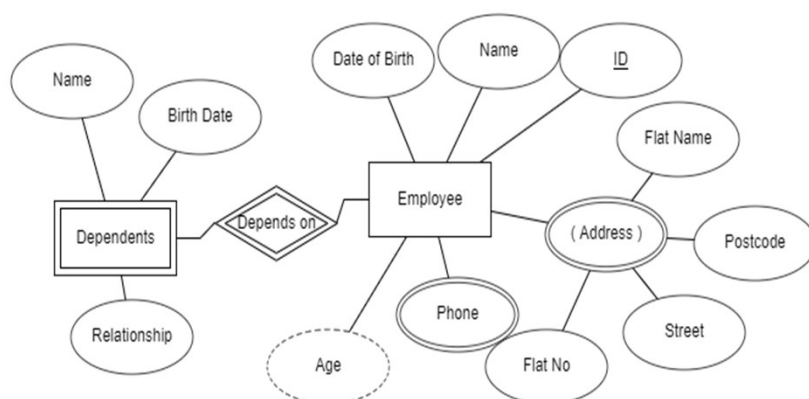
emp#	jobName	salary	commission
E10	Sales	12500	32090
E11	Null	25000	8000
E12	Sales	44000	0
E13	Sales	44000	Null

Knowledge Check: Attributes

<https://forms.office.com/e/EkZ8AhrXAx>



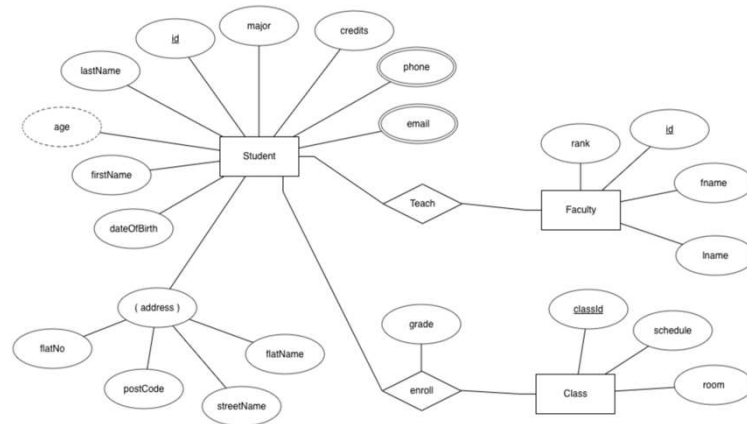
Entity, Attributes & Relationship



Entity, Attributes & Relationship

- Identify the entities, attributes and possible relation for University Database and represent it in ERD

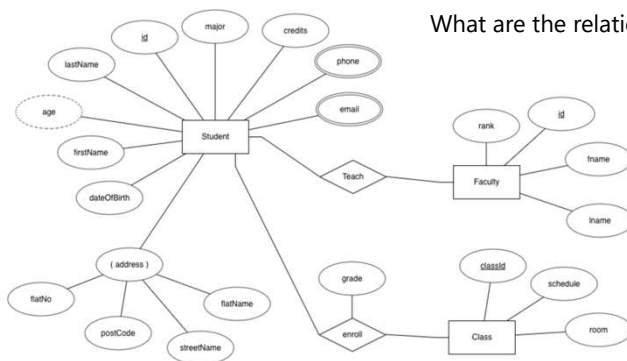
Entity & Attributes



66

Entity & Attributes

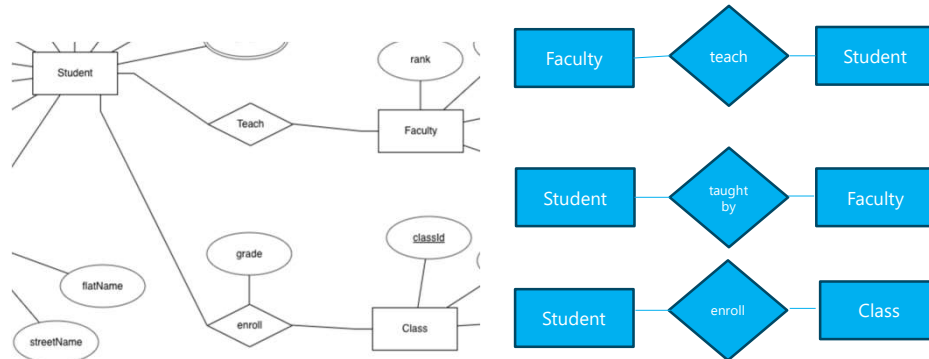
What are the relationships that link the tables?



67

Relationships

What are the relationships that link the tables?

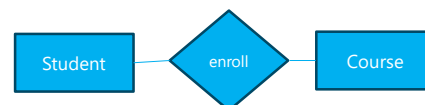


68

Relationships

Which one is possibly true?

- a) One student enrolls to One course
- b) One student enrolls to many courses
- c) Many students enroll in many courses

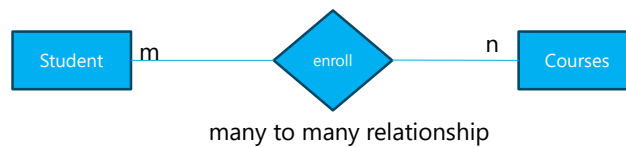


69

Relationships

Which one is possibly true?

- a) One student enrolls to One course
- b) One student enrolls to many courses
- c) **Many students enroll in many courses**

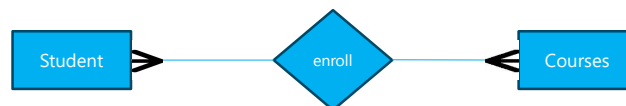


many to many relationship

Relationships

Which one is possibly true?

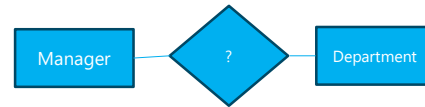
- a) One student enrolls to One course
- b) One student enrolls to many courses
- c) **Many students enroll in many courses**



many to many relationship

Relationships- Manager & Department

What is the relationship?



72

Relationships- Manager & Department

Which one is possibly true?

- a) each manager is assigned to exactly one department
- b) Many managers are assigned to one department



73

Relationships- Manager & Department

Which one is possibly true?

- a) **each manager is assigned to exactly one department**
- b) Many managers are assigned to one department



Relationships- Manager & Department

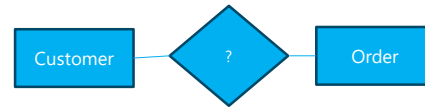
Which one is possibly true?

- a) **each manager is assigned to exactly one department**
- b) Many managers are assigned to one department



Relationships- Customer & Order

Identify the possible relationship between customer and order



Relationships- Customer & Order

Which one is possibly true?

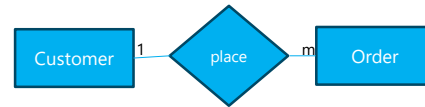
- A customer can place multiple orders
- A customer can place only one order



Relationships- Customer & Order

Which one is possibly true?

- **A customer can place multiple orders**
- A customer can place only one order



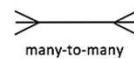
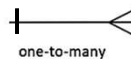
Relationships- Customer & Order

Which one is possibly true?

- **A customer can place multiple orders**
- A customer can place only one order



Relationships- Notations in ERD



Knowledge Check - Relationships

A school has students, and each student is assigned one locker. Each locker is assigned to only one student.

What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many

Knowledge Check - Relationships

A school has students, and each student is assigned one locker. Each locker is assigned to only one student.

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Knowledge Check - Relationships

A company has employees and departments. Each employee is assigned to exactly one department, but each department can have many employees.

What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many



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83

Knowledge Check - Relationships

A company has employees and departments. Each employee is assigned to exactly one department, but each department can have many employees. What type of relationship is this?

- A) One-to-One
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- C) Many-to-One
- D) Many-to-Many



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Knowledge Check - Relationships

A university has courses and students. Each student can enroll in multiple courses, and each course can have multiple students enrolled. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many



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85

Knowledge Check - Relationships

A university has courses and students. Each student can enroll in multiple courses, and each course can have multiple students enrolled. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) **Many-to-Many**

Knowledge Check - Relationships

A library has books and each book has a unique ISBN. Each ISBN is assigned to only one book. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many

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- A) **One-to-One**
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many

Knowledge Check - Relationships

A hospital has patients and doctors. Each patient can be treated by multiple doctors, and each doctor can treat multiple patients. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many

Knowledge Check - Relationships

A hospital has patients and doctors. Each patient can be treated by multiple doctors, and each doctor can treat multiple patients. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) **Many-to-Many**

Knowledge Check - Relationships

A school has classes and teachers. Each class is assigned one teacher, but each teacher can teach multiple classes. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many

Knowledge Check - Relationships

A school has classes and teachers. Each class is assigned one teacher, but each teacher can teach multiple classes. What type of relationship is this?

- A) One-to-One
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- D) Many-to-Many



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92

Knowledge Check - Relationships

A music streaming service has playlists and songs. Each playlist can contain multiple songs, and each song can appear in multiple playlists. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) Many-to-Many



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93

Knowledge Check - Relationships

A music streaming service has playlists and songs. Each playlist can contain multiple songs, and each song can appear in multiple playlists. What type of relationship is this?

- A) One-to-One
- B) One-to-Many
- C) Many-to-One
- D) **Many-to-Many**

Participation in Relationships

Example : National ID Card and Citizen

Relationship: Each citizen has one and only one National ID, and each ID is assigned to one and only one citizen.



Participation in Relationships

Example : National ID Card and Citizen

Relationship: Each citizen has one and only one National ID, and each ID is assigned to one and only one citizen.



Is it mandatory or optional for a citizen to have a National ID?

Is it mandatory or optional for National ID to be assigned to a citizen?

Participation in Relationships

Example : National ID Card and Citizen

Relationship: Each citizen has one and only one National ID, and each ID is assigned to one and only one citizen.



Mandatory participation – at least 1 must be present in this relationship

Participation in Relationships

Example : Car and ParkingSpace

Relationship: Each car is assigned to one parking space, and each parking space is assigned to one car.

Each car must have a parking space, and each parking space must have a car.



Participation in Relationships

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Participation in Relationships

Example : Car and ParkingSpace

Relationship: Each car is assigned to one parking space, and each parking space is assigned to one car.

Each car may have a parking space, and each parking space must have a car.



Participation in Relationships

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Relationship: Each car is assigned to one parking space, and each parking space is assigned to one car.

Each car may have a parking space, and each parking space must have a car.

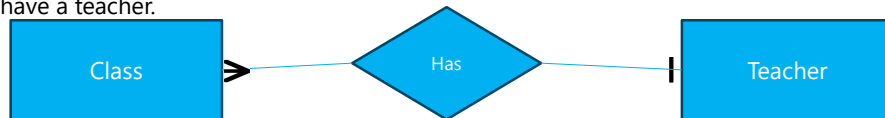


Participation in Relationships

Example : Teacher and Class

Relationship: Each teacher teaches many classes, but each class is taught by only one teacher.

A teacher might not be assigned to any class (e.g., on leave), but each class must have a teacher.



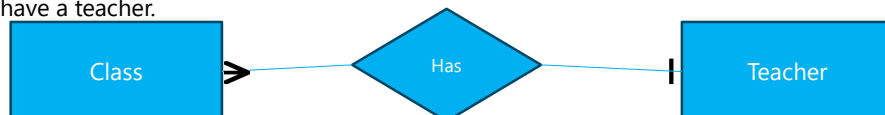
Which is mandatory and which is optional here?

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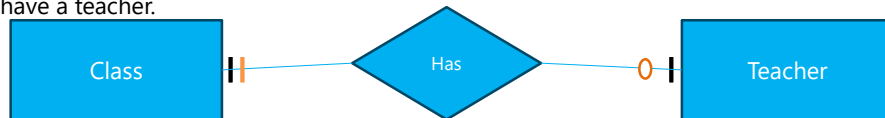
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Here, the relationship between Teacher and Class, is optional for the Teacher but mandatory for the Class.

Participation in Relationships

Example : Customer & Order

Relationship: Each customer can place many orders, but each order is placed by only one customer.

A customer might not have placed any orders yet, but each order must be associated with a customer.



Participation in Relationships

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Relationship: Each customer can place many orders, but each order is placed by only one customer.

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Participation in Relationships

Example : Actor and Movie

Relationship: Each actor can star in multiple movies, and each movie can have multiple actors starring in it.

An actor might not have starred in any movies yet (e.g., new actor), and a movie might not have any actors starring in it yet (e.g., pre-production).



Participation in Relationships

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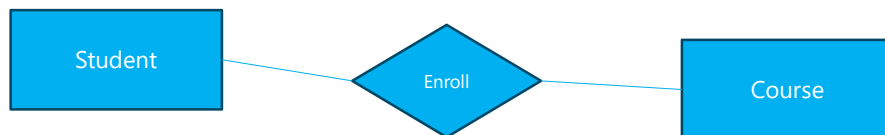
Participation in Relationships

Example : Student and Course

Relationship: Each student must be enrolled in at least one course, and each course must have at least one student enrolled.

Every student (Student) must be enrolled in at least one course (Course).

Every course (Course) must have at least one student enrolled.

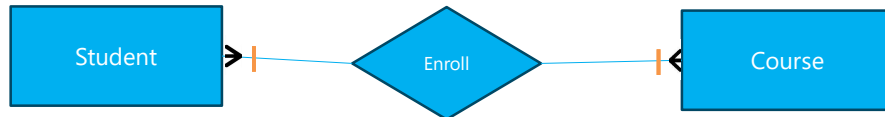


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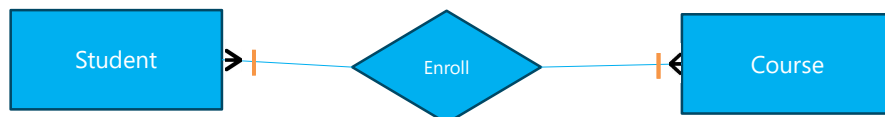


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ERD to Relational Tables: Mapping Algorithm

