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200
1822 - 2022

# *Entity Relationship modelling*

*Man Geni Addysg Uwch yng Nghymru*
*Where Higher Education Began in Wales*

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# So far

- Understand the concept – DBMS
- Identify different types of databases
- Components of DBMS
- DBMS system Architecture
- Relational Keys

# Today's lesson

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

# Database Design Process

What happens after DB design is done? How apps use it, how to restrict access to relations and implement access rules

Analyse relations and identify any potential problems and refine it. **Normalisation** comes here

Develop high level description of **Data & its Constraints, ER modelling** comes here

Requirement Analysis → **Conceptual Design** → Logical DB Design → Schema Refinement → Physical DB Design → Application Security & Design

Understand the application, identify **what data** & **what operations** should be stored

Choose a **DBMS** to implement the design and **convert the ER model to DB Schema**

DB Design refined to ensure that it meets performance criteria. **Indexing, clustering etc** comes here

# E-R Data Model

- **Three** principal element types:

| Entity | Attributes | Relationships |
| --- | --- | --- |
| • Entity-abstract object of some sort<br>• Entity Sets-a collection of similar entities | • Properties of the entities in that set<br>• 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 ?

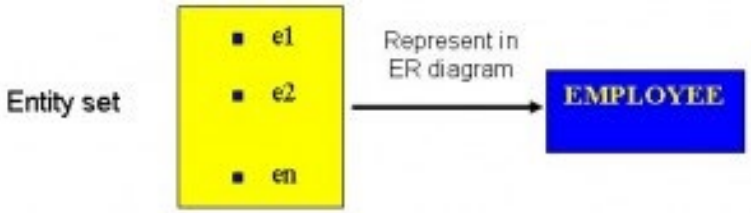
# Entity

- If you are building a data model for a small retail store, then the potential entities may be
    - Products
    - Suppliers
    - Customers
    - Employees
    - Inventory
    - Orders
    - Promotions/Discounts

# Entity, Entity Set

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 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.

Notation for an 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

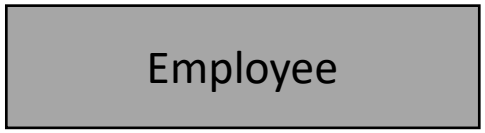
## Regular Entities

- 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




Notation for a Weak Entity

# 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 |

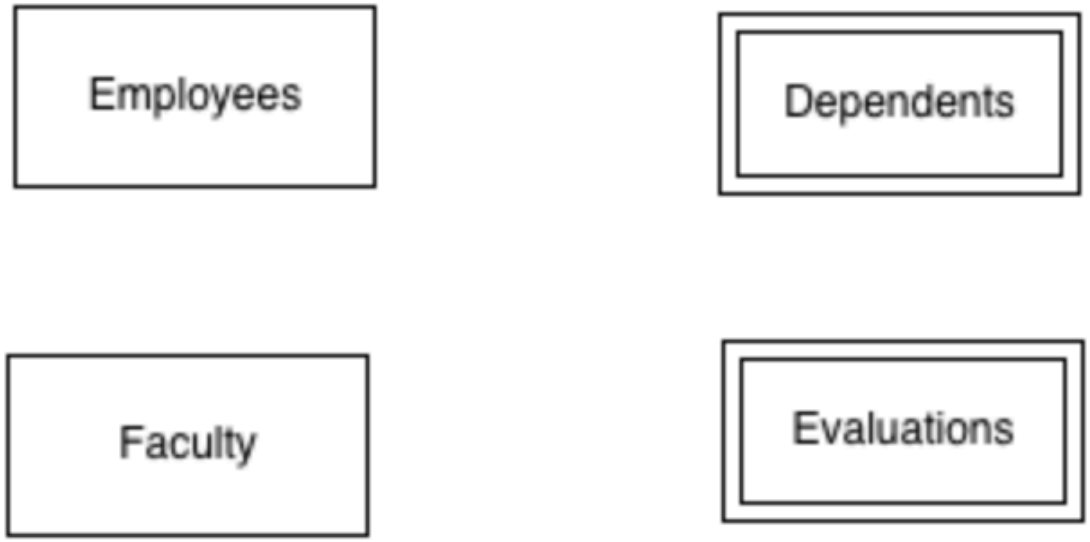
### Course Table:

| 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

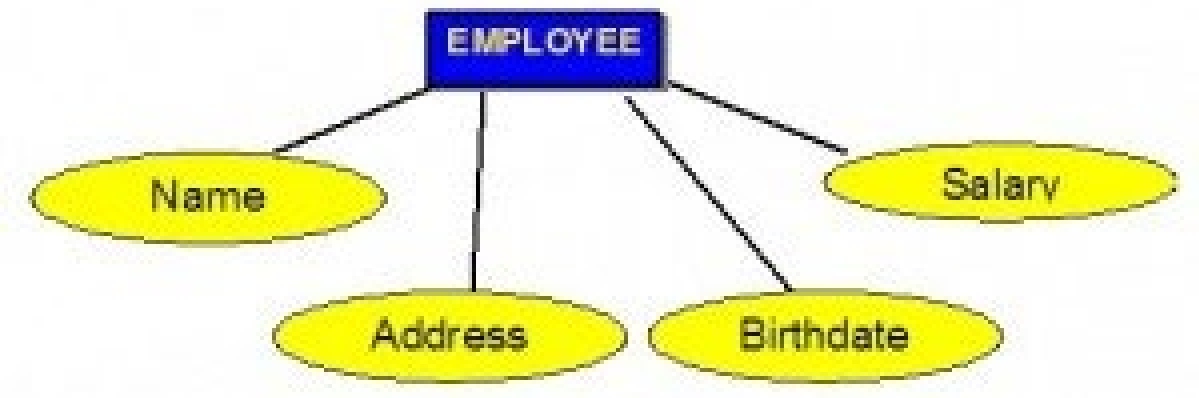
https://forms.office.com/e/KGnQsAxqmt

# Attributes

In the entity, shown below, what are the attributes that define ‘Employee’ entity?

# Attributes

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



# Attribute Types

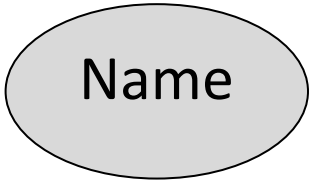
- Each entity has attributes – **properties that describe it.**
- A particular entity will have values for its attributes.
- E.g. an employee entity may have name, age, home address, home phone etc as their attributes.

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

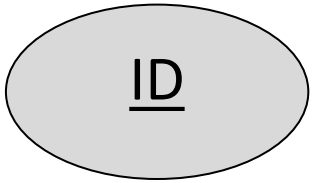
# Attributes Notation

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

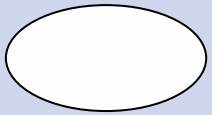
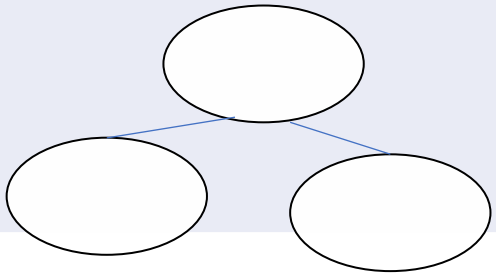
Notation for an Attribute



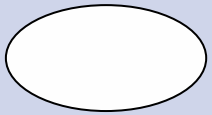
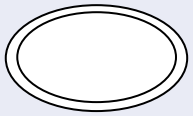

Notation for a **Key** Attribute



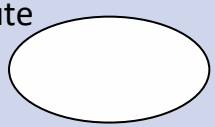
# Attribute Types - 1

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

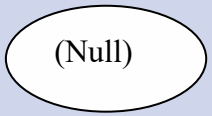
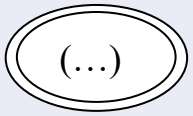
# Attribute Types - 2

| Type | Description | Example |
|---|---|---|
| Single Valued Attribute  | An attribute that holds a single value for each occurrence of an entity type. | Employee entity:<br>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:<br>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:<br>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:<br>Age → can be derived from dateOfBirth and currentDate. |

# Attribute Types - 4

| Type | Description | Example |
|---|---|---|
| NULL Attribute<br>  <br> | An attribute that means either the value is unknown or inapplicable. It does not mean zero. | Employee entity:<br>Commission → can be NULL |
| Complex Attribute<br>  <br> | 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:<br>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.

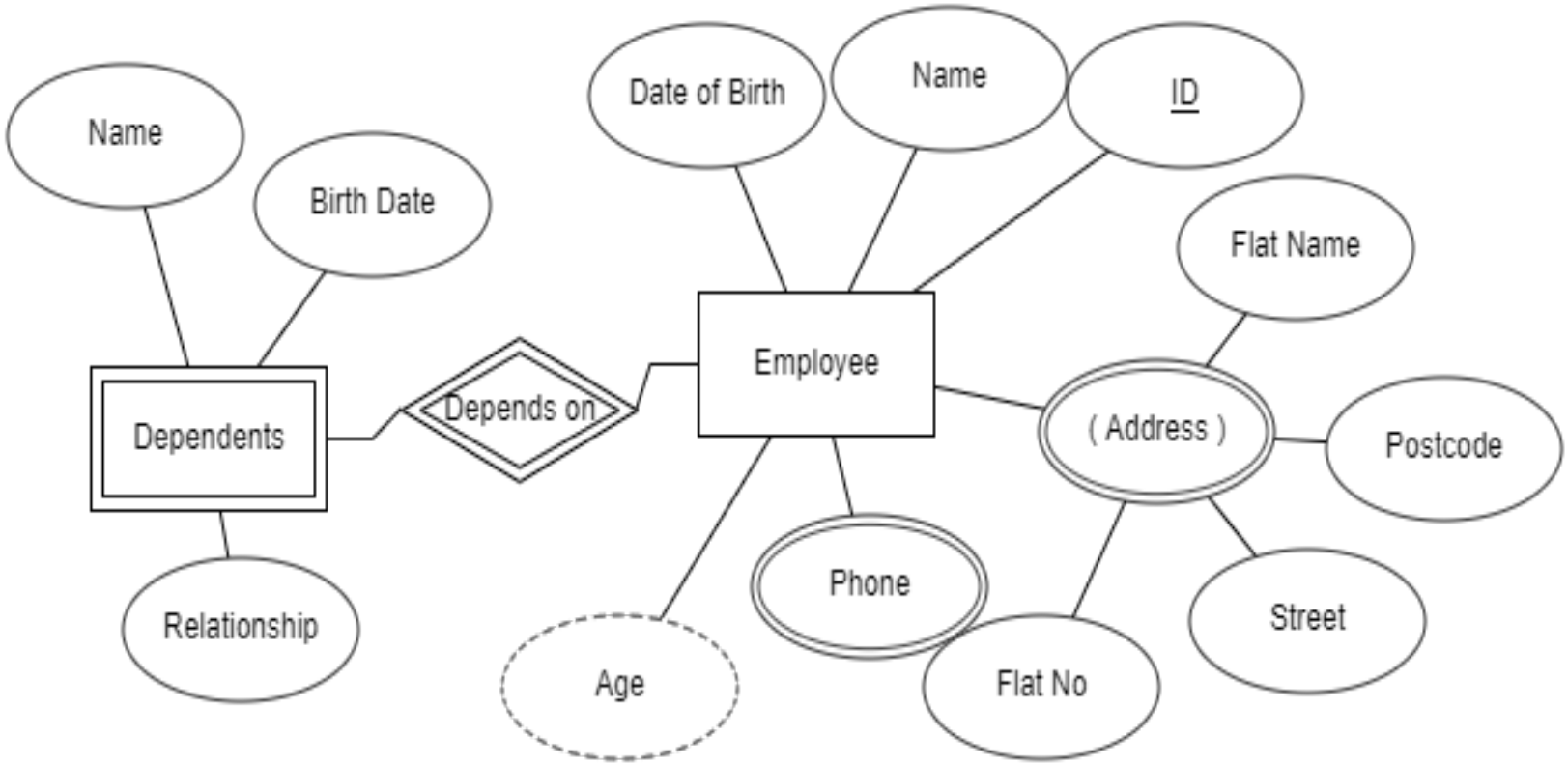
**Salary_tbl**

| 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

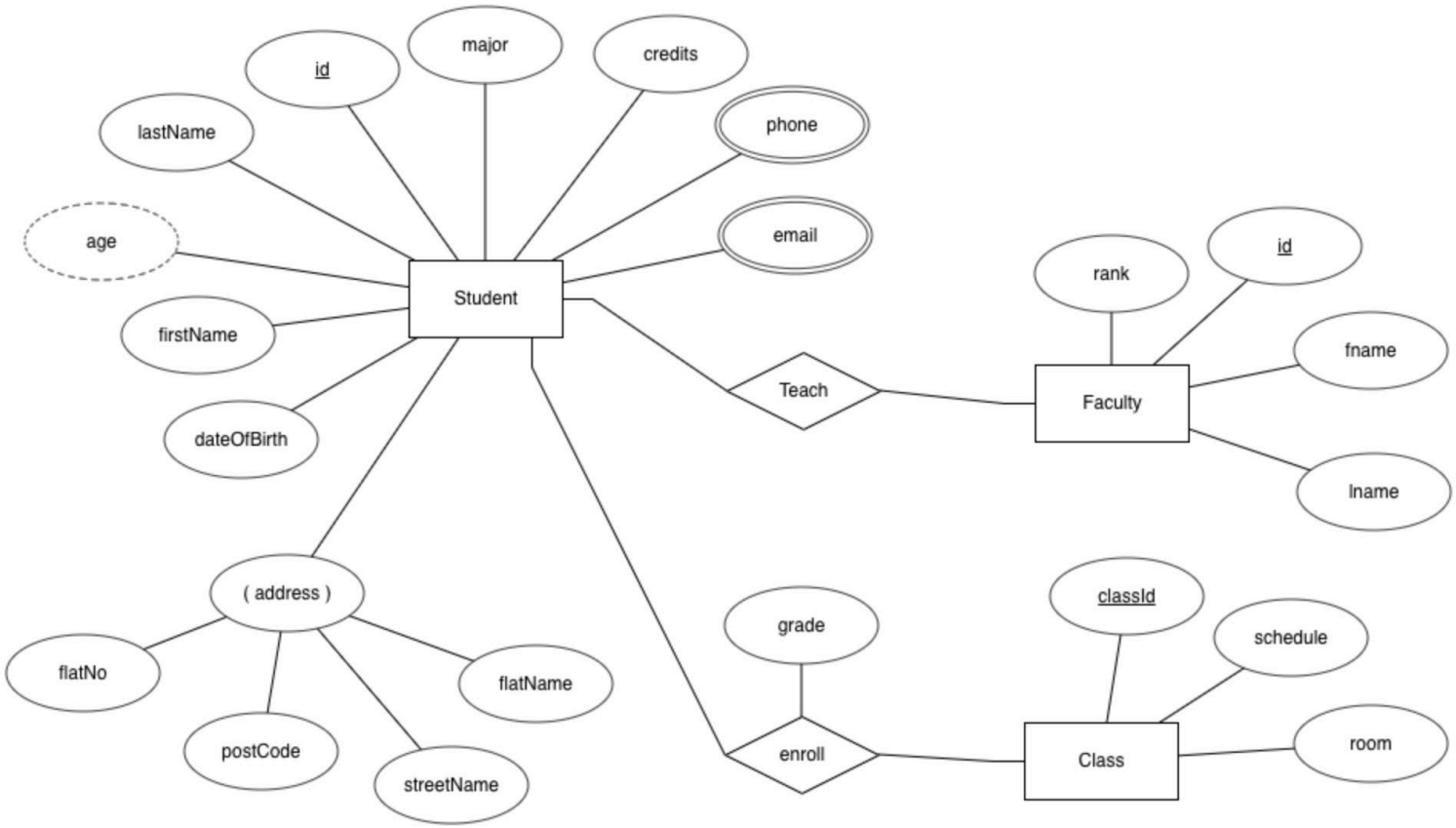
# Entity, Attributes & Relationship



# Entity, Attributes & Relationship

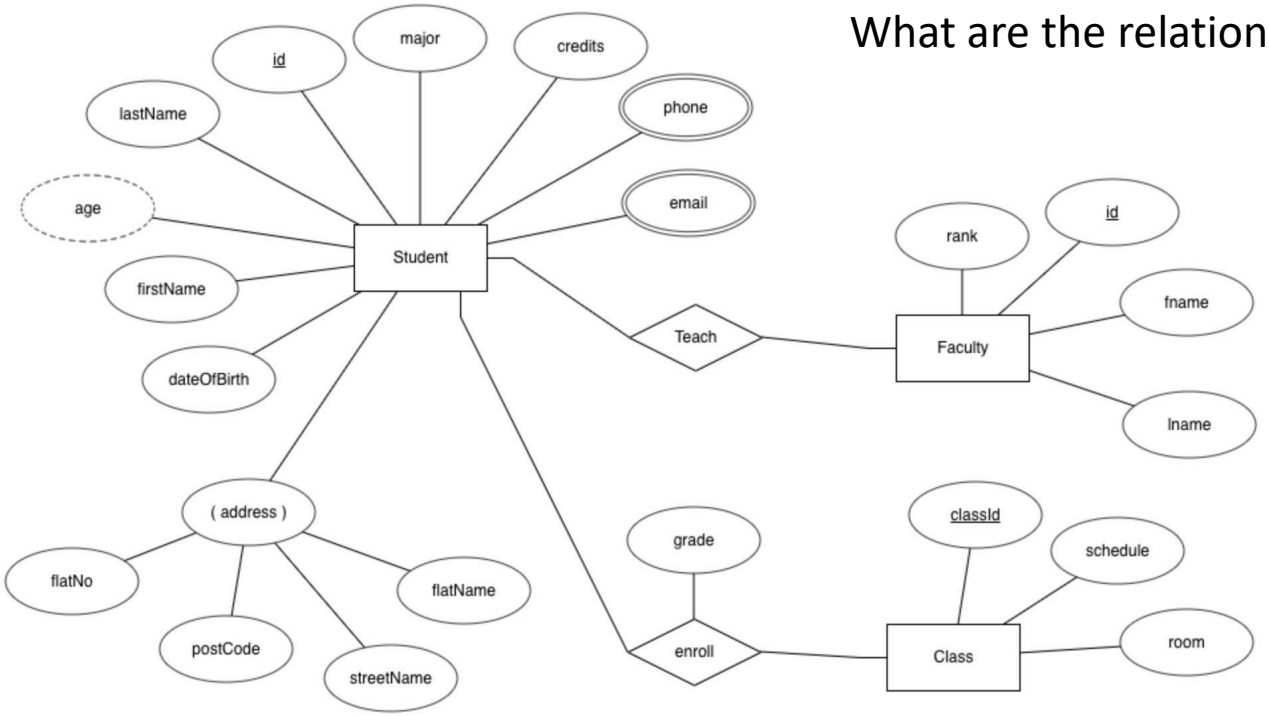
- Identify the entities, attributes and possible relation for simple University Database and represent it in ERD

# Entity & Attributes



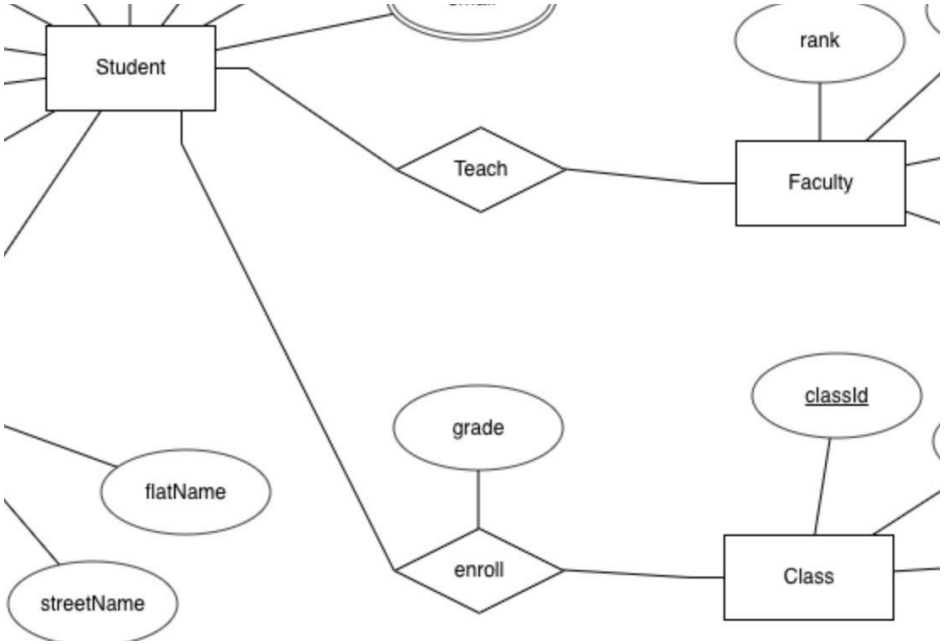
# Entity & Attributes

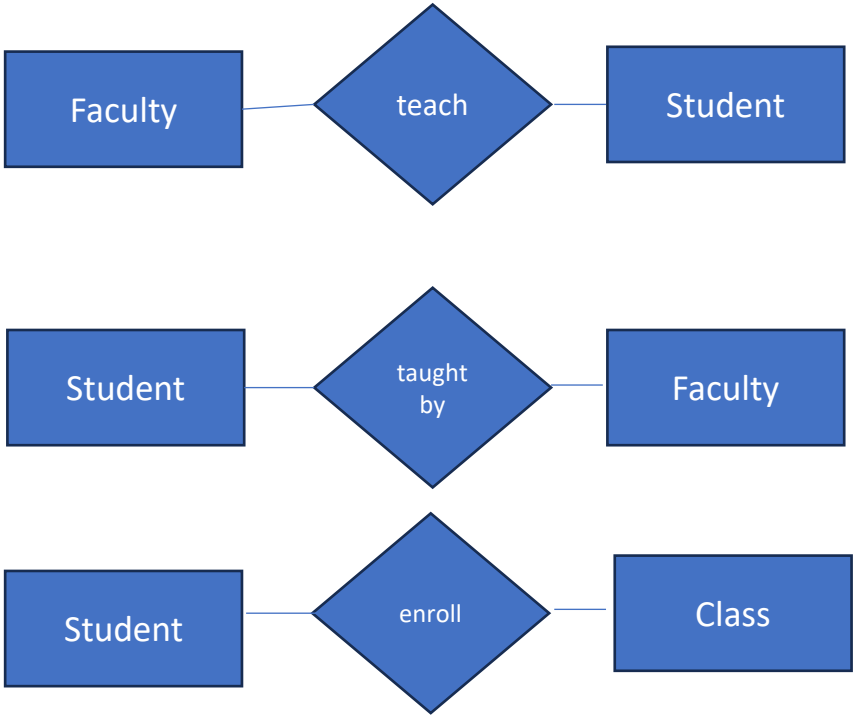
What are the relationships that link the tables?



# Relationships

What are the relationships that link the tables?

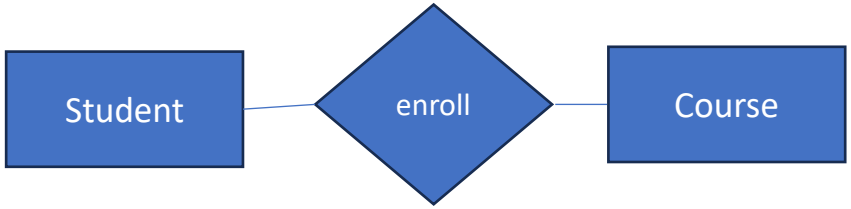


# Relationships

Which one is possibly true?

a) One student enrols to One course
b) One student enrols to many courses
c) Many students enrol in many courses



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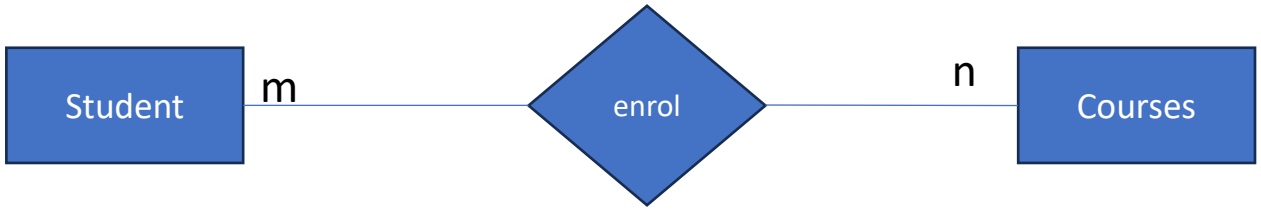


many to many relationship

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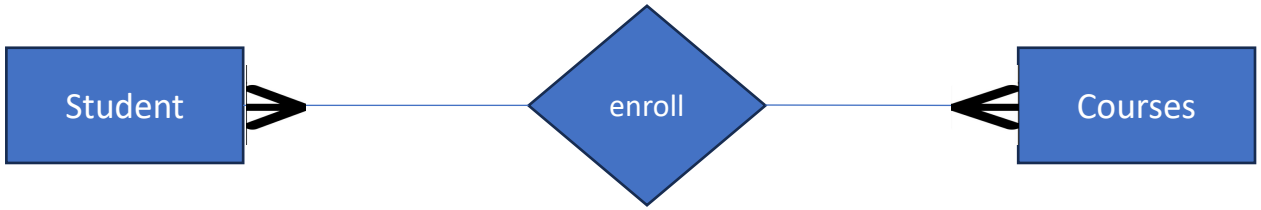
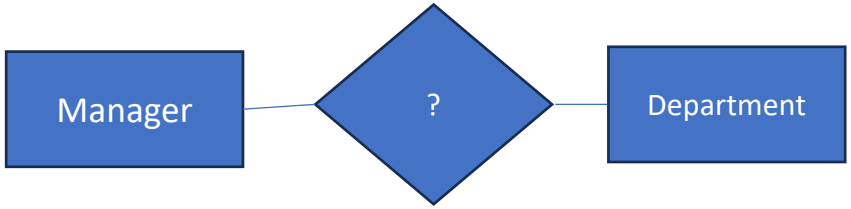



many to many relationship

# Relationships- Manager & Department

What is the relationship?



# 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

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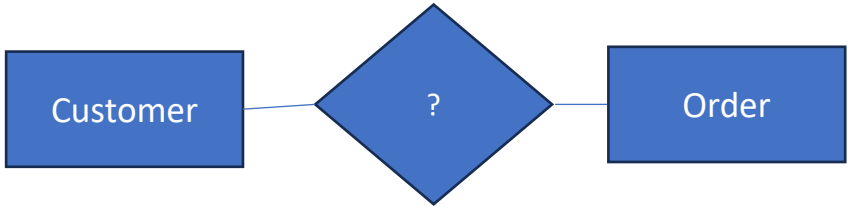
# Relationships- Customer & Order

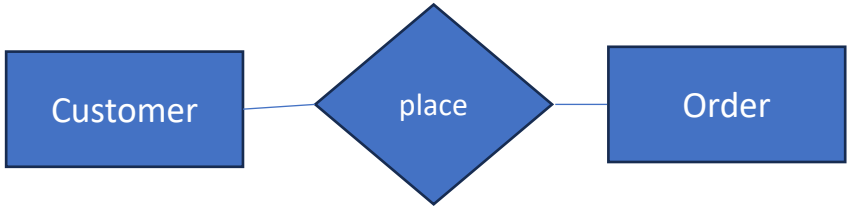
Identify the possible relationship between customer and order



# Relationships- Customer & Order

Which one is possibly true?

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



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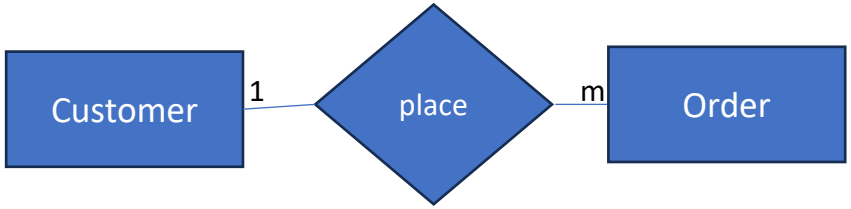

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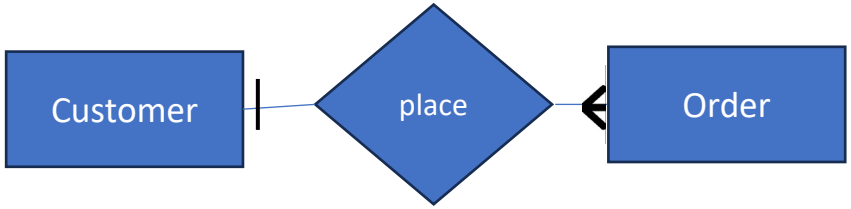

# Relationships- Notations in ERD

one-to-one

one-to-many

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.

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

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What type of relationship is this?

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

# 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
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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) <u>One-to-Many</u>
C) Many-to-One
D) Many-to-Many

# Knowledge Check - Relationships

A university has courses and students. Each student can enrol 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 university has courses and students. Each student can enrol 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) <u>Many-to-Many</u>**

# 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

# 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

# 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

B) **One-to-Many**

C) Many-to-One

D) Many-to-Many

# 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

# 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

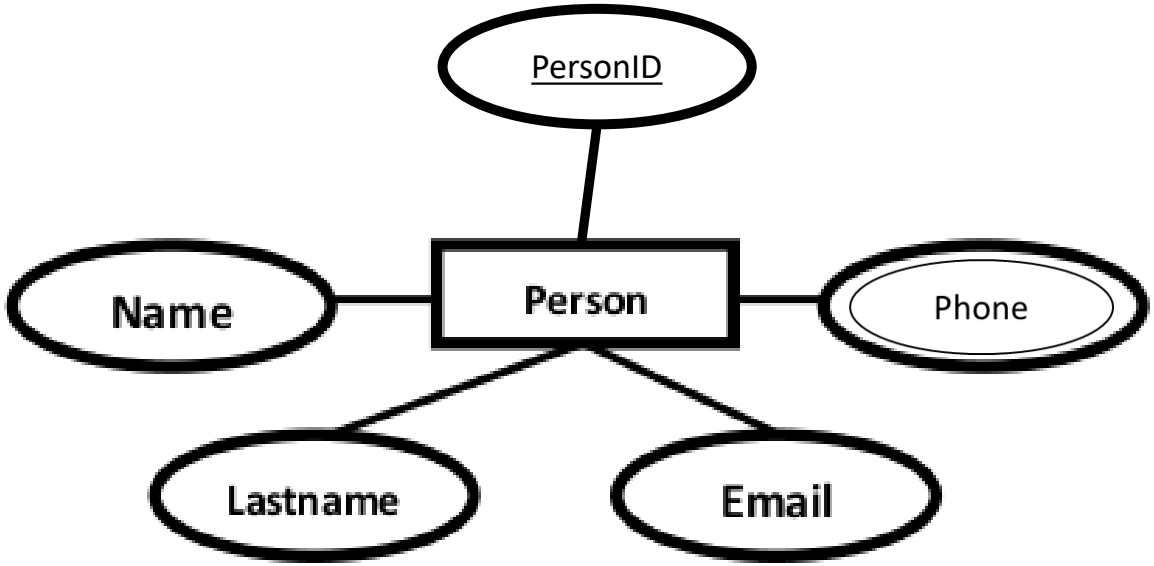
D**) Many-to-Many**

# ERD to Relational Table – Mapping Algorithm

# Mapping Algorithm - Entities and Simple Attributes

Person( personid , name, lastname, email)

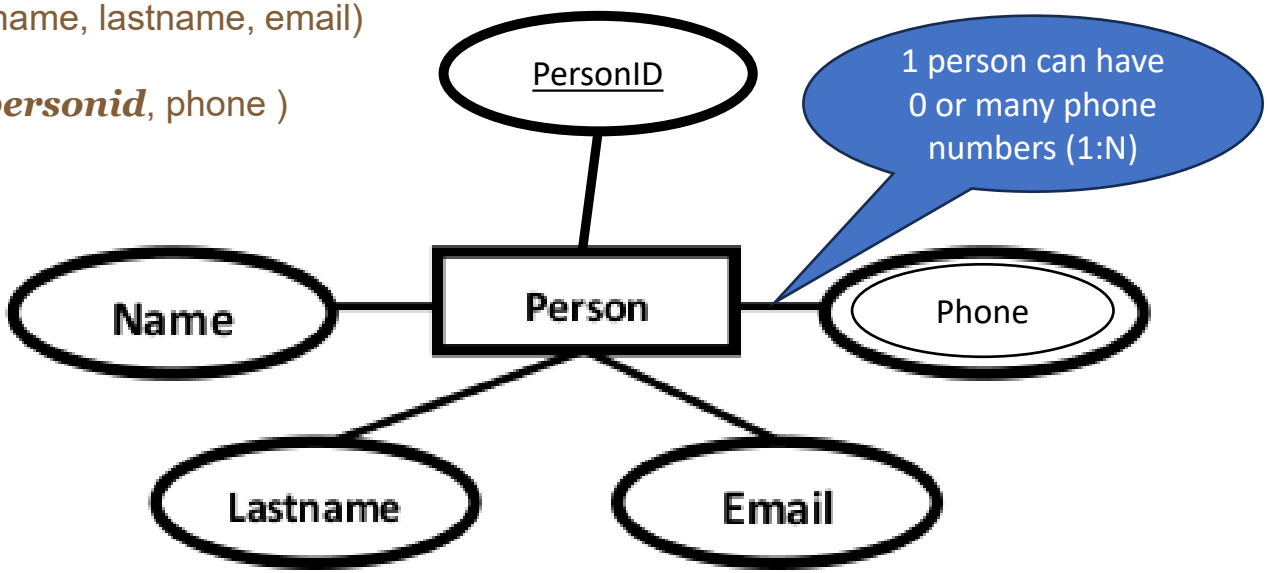
What happens to Phone-multivalued attribute?



# Mapping Algorithm – Multivalued attribute

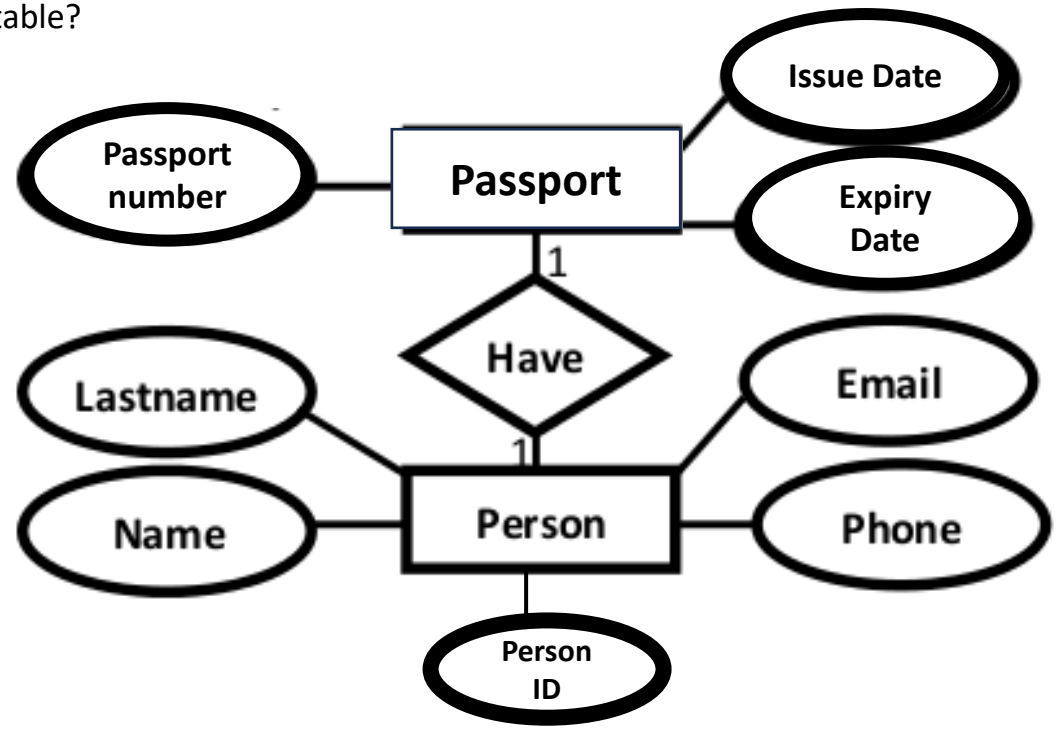
Person( personid , name, lastname, email)

Phone ( phoneid , ***personid***, phone )



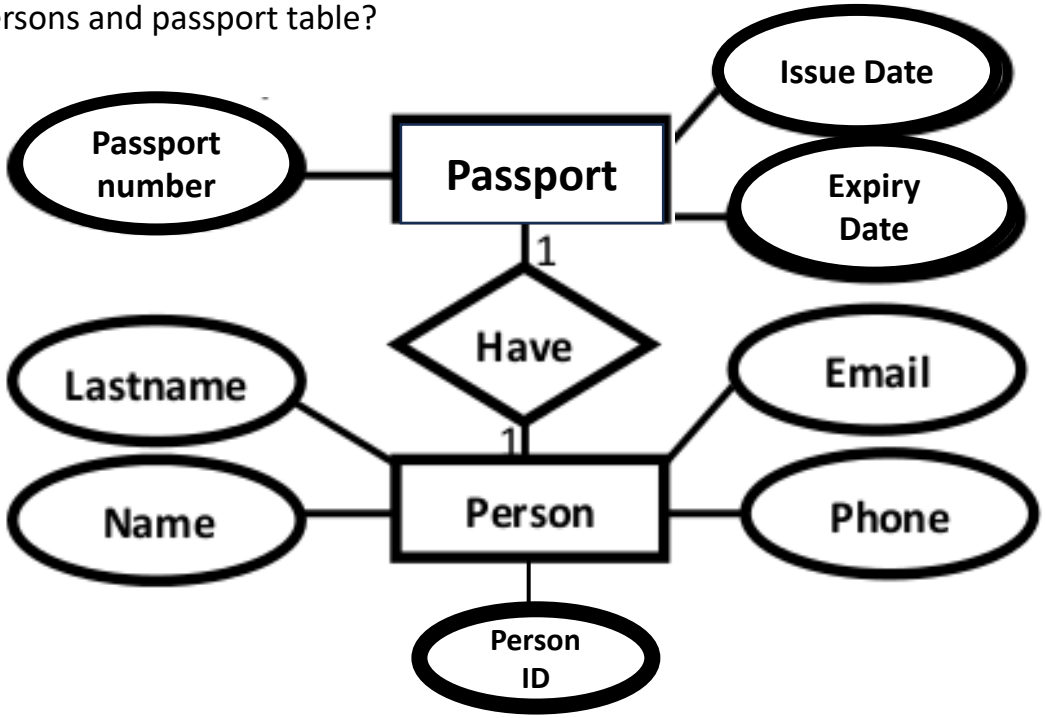
# Mapping Algorithm – 1:1 Relationships

which will be the foreign key creating a reference between Persons and passport table?



# Mapping Algorithm – 1:1 Relationships

which will be the foreign key creating a reference between Persons and passport table?



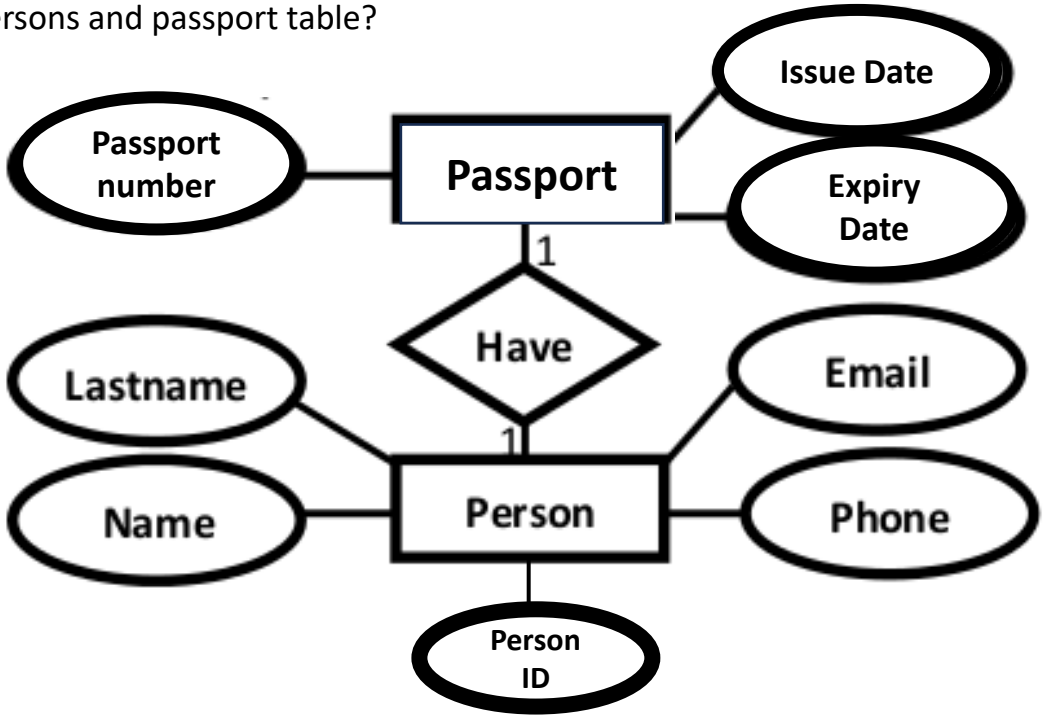

Person (personid{PK},name,lastname,email,passportnumber*{FK}*)

passport ( passportnumber{PK}, issuedate,expirydate)

**Can you think of an alternative approach?**

# Mapping Algorithm – 1:1 Relationships

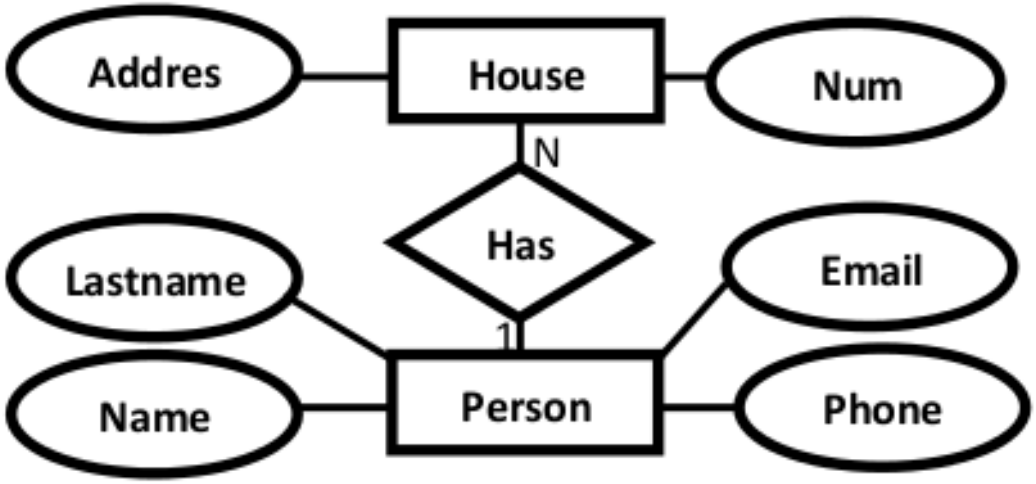
which will be the foreign key creating a reference between Persons and passport table?




Person
(personid{PK},name,lastname,email,)

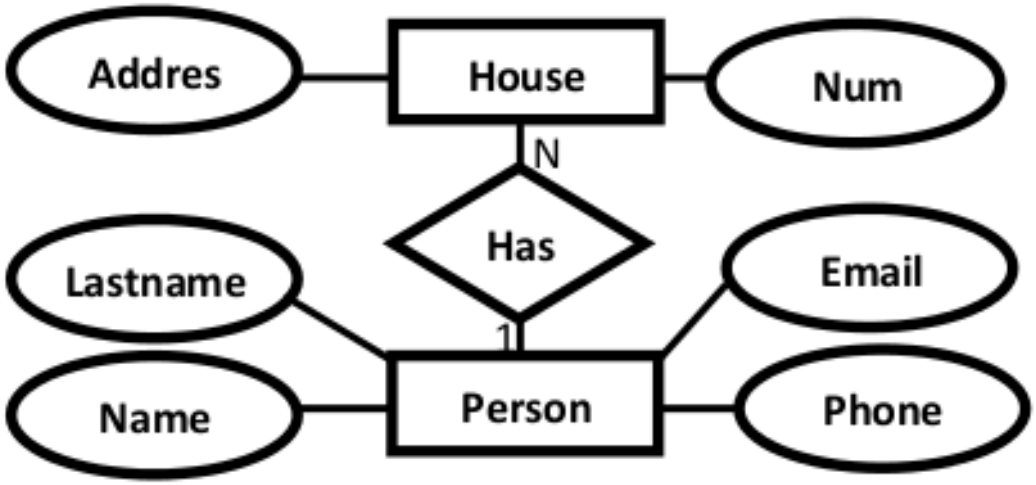
passport
( passportnumber{PK}, issuedate,expirydate, *personid{FK},)*

# Mapping Algorithm – 1:N Relationships




How is this converted to?
*Give a try…*

# Mapping Algorithm – 1:N Relationships



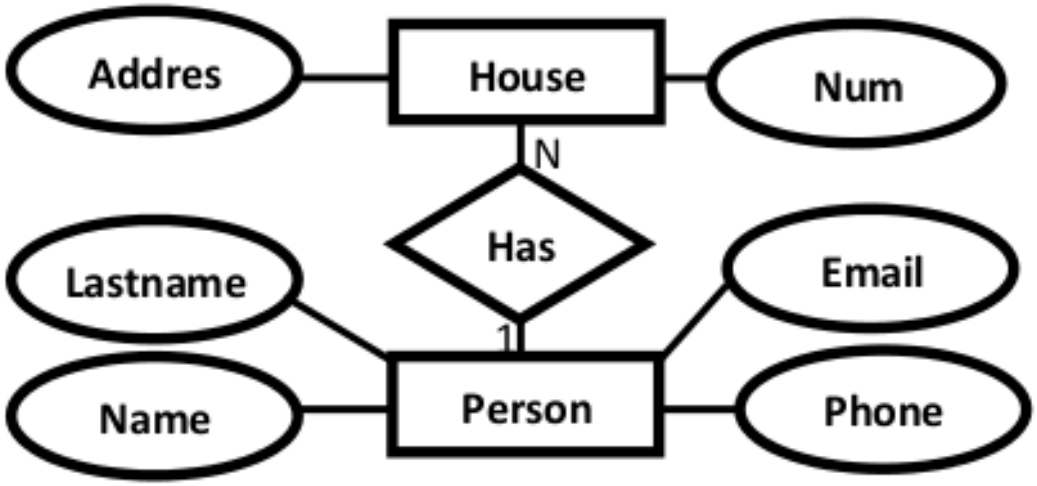

House

| houseid | personid |
|---|---|
| H1 | 1 |
| H2 | 2 |
| H3 | 1 |

person

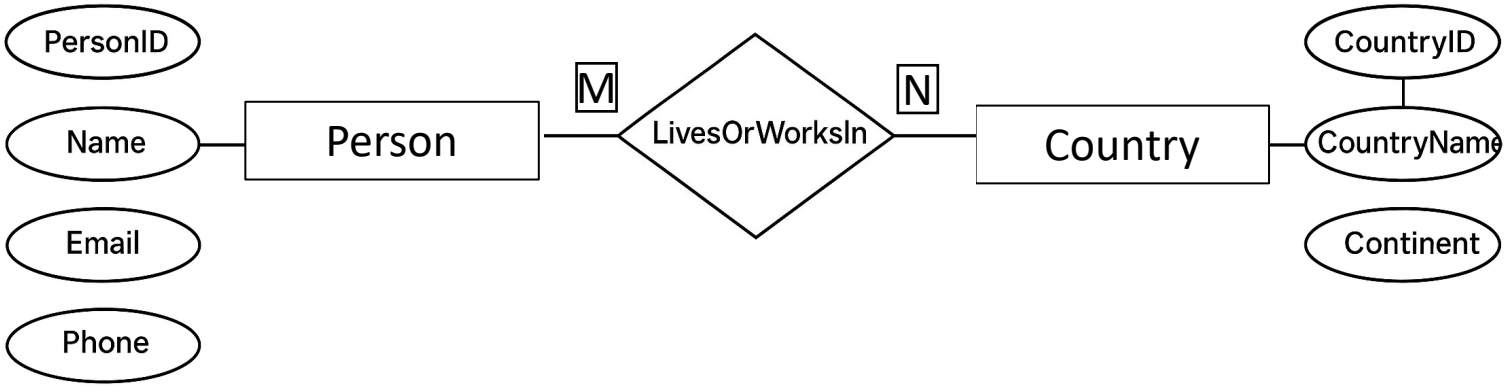
| personid | houseid |
|---|---|
| 1 | H1,H3 |
| 2 | H2 |
| 3 | <null> |

# Mapping Algorithm – 1:N Relationships



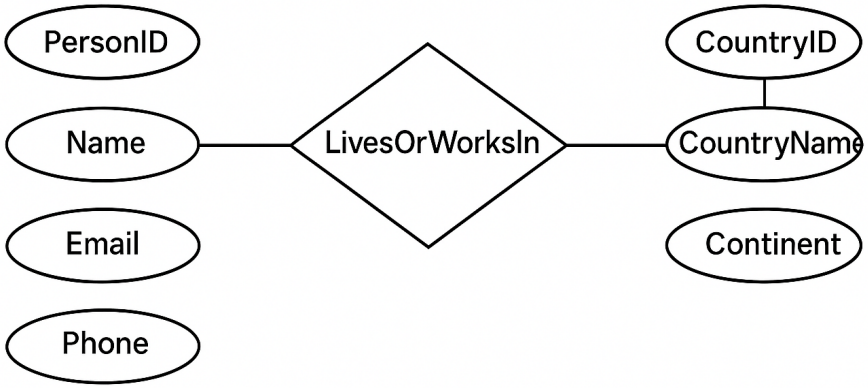

Person( personid[PK] , name, lastname, email )
House ( housed[PK] , num , address, *personid[FK]*)

# Mapping Algorithm – N:N Relationships



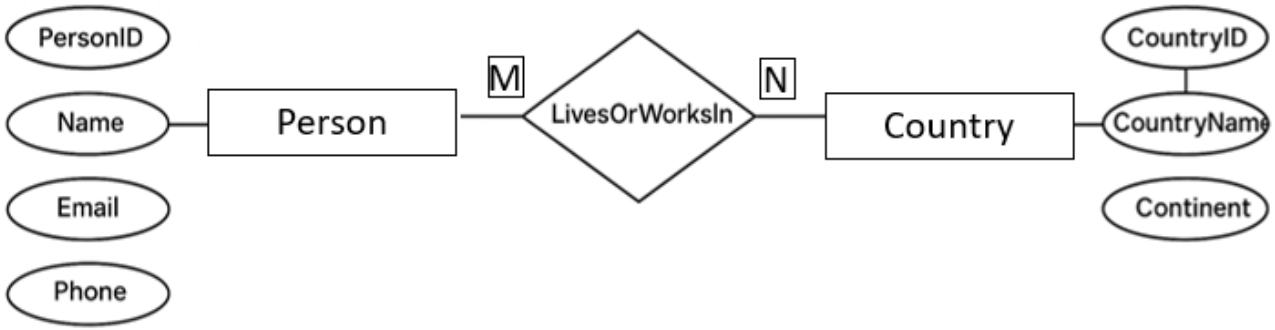

How is this converted?

Give a try…



# Mapping Algorithm – N:N Relationships

The Person can live or work in many countries. Also, a country can have many people.



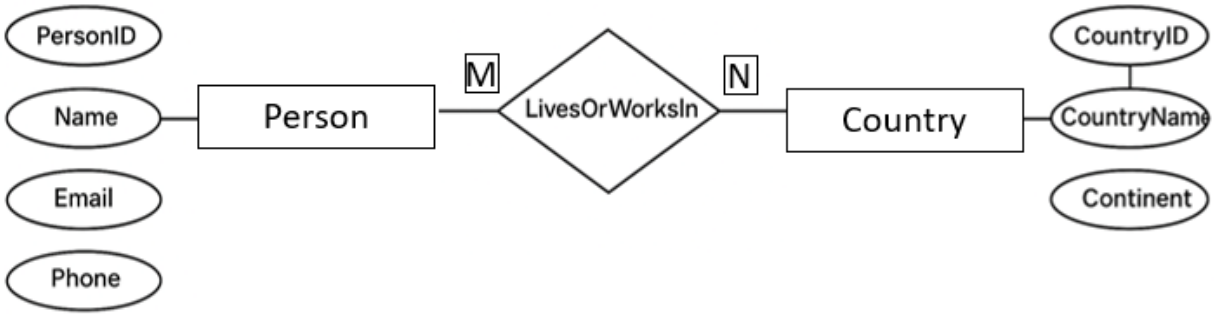

Person

| personid | countryid |
|---|---|
| p1 | c1 |
| p2 | c1 |
| p3 | c1,c2 |

Country

| countryid | personid |
|---|---|
| c1 | p1,p2,p3 |
| c2 | p3 |
| c3 | - |

# Mapping Algorithm – N:N Relationships

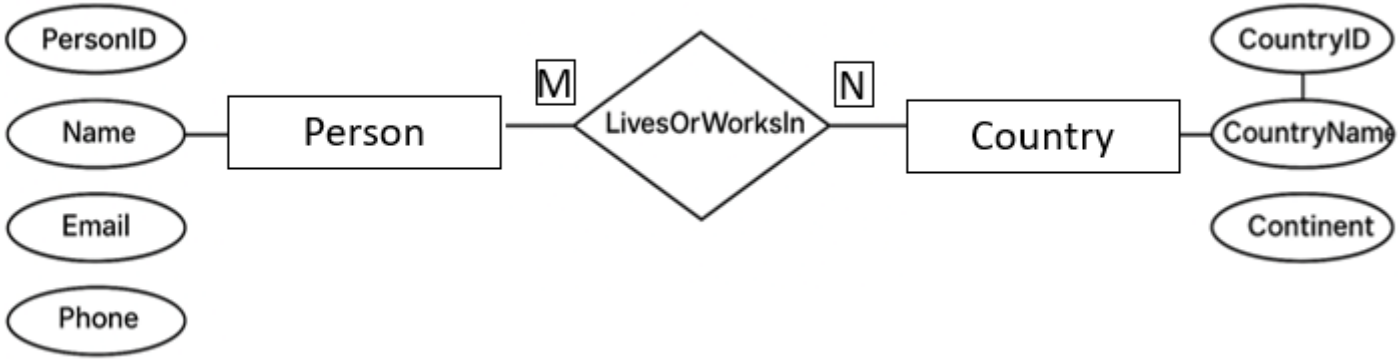



| countryid | personid |
|---|---|
| c1 | p1,p2,p3 |
| c2 | p3 |
| c3 | - |

| personid | countryid |
|---|---|
| p1 | c1 |
| p2 | c1 |
| p3 | c1,c2 |

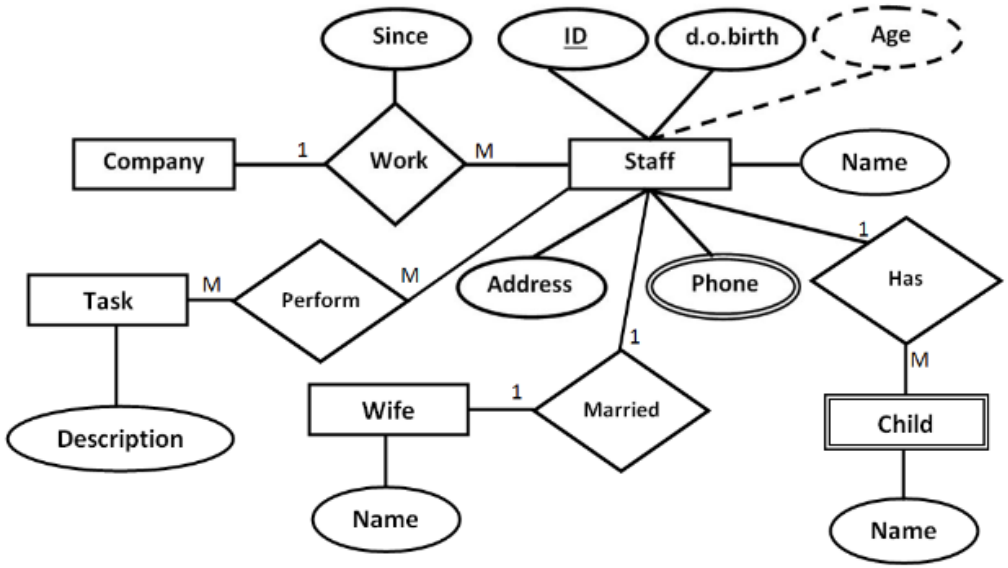
| LivesOrWorksin_id | personid | countryid |
|---|---|---|
| has1 | P1 | C1 |
| has2 | P2 | C1 |
| has3 | p3 | C1 |
| has4 | p3 | c2 |

# Mapping Algorithm – N:N Relationships



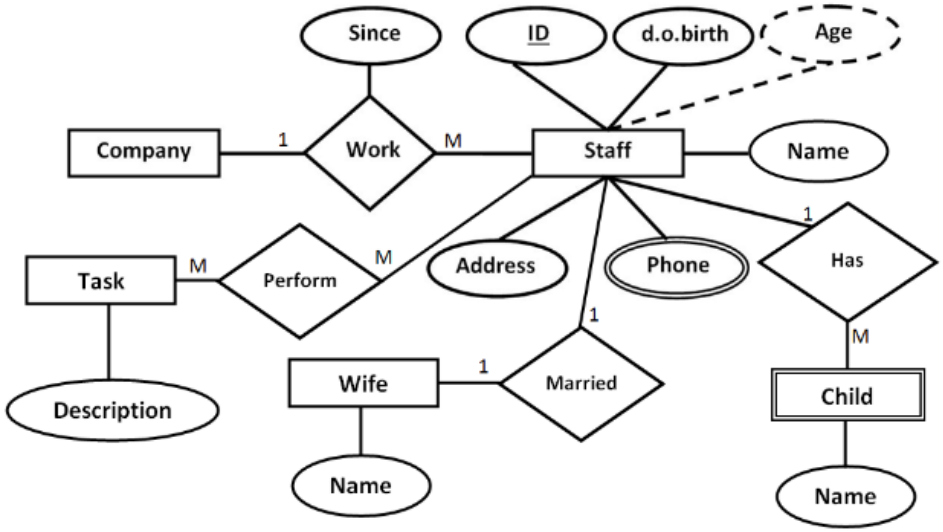

Persons( <u>personid</u> , name, lastname, email )
Country ( <u>countryid</u> , name, code)
LivesOrWorksin( LivesOrWorksin_id, *personid , countryid*)

# Mapping Algorithm – Activity 1




https://forms.office.com/e/3Dzw97CRvA

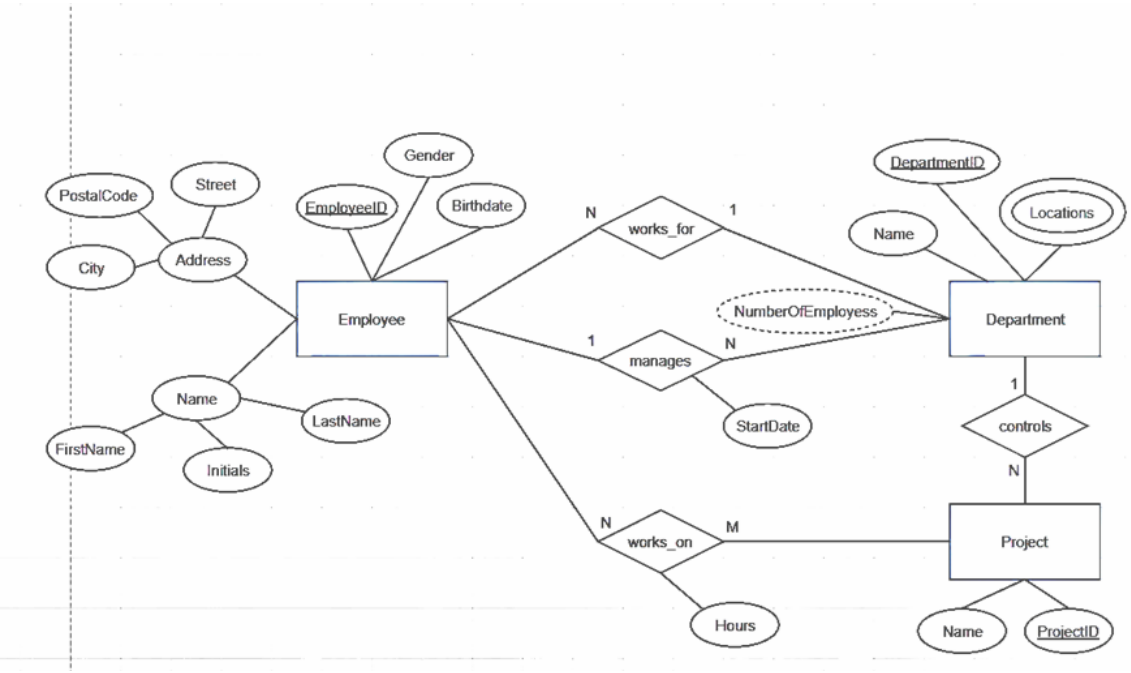
# Mapping Algorithm – Activity 1




https://forms.office.com/e/3Dzw97CRvA

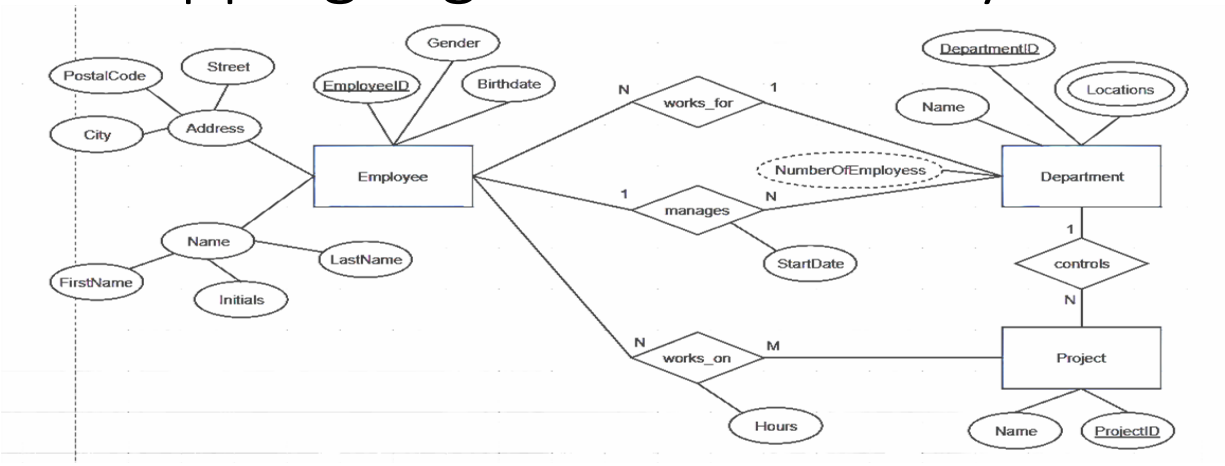
Company( CompanyID , name , address )
Staff( StaffID , dob , address , ***WifeID***)
Child( ChildID , name , ***StaffID*** )
Wife ( WifeID , name )
Phone(PhoneID , phoneNumber , ***StaffID***)
Task ( TaskID , description)
Work(WorkID , ***CompanyID , StaffID*** , since )
Perform(PerformID , ***StaffID , TaskID*** )

# Mapping Algorithm – Activity 2




https://forms.office.com/e/nZnGcYpCEn

# Mapping Algorithm – Activity 2




Employee(**<u>Employeeid,</u>**gender,birthdate,street,postalcode,city,Firstname,Initials,Lastname,*Departmentid*)
Department(**<u>departmentID</u>**,name, *LocationID,employeeid)*
Location(**<u>LocationID,</u>**locationname)
Project(**<u>Projectid,</u>**name,*departmentid)*
Works_on(hours, *employeeid, projectid*)

**Further Reading :**

**Chapter 11 Database Analysis and the DreamHome Case Study**

**Chapter 12: Entity–Relationship Modelling**

**Chapter 13 Enhanced Entity–Relationship Modelling**

Database Systems: A Practical Approach to Design, Implementation, and Management Sixth edition by • Thomas Connolly • Carolyn Begg