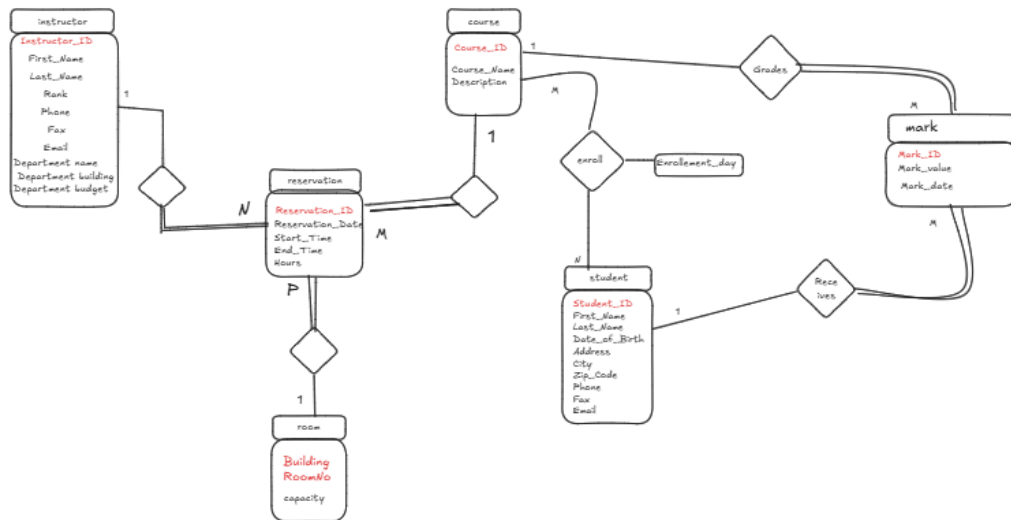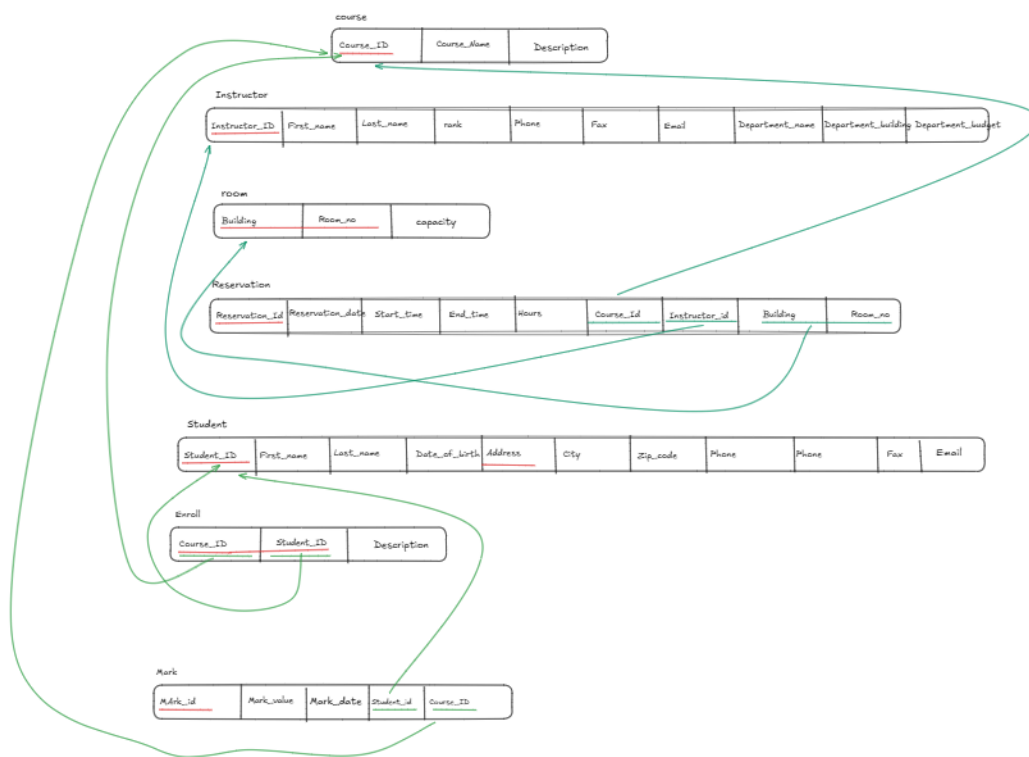# ERD design and Normalization

1- **Dropping the department entity**

2- **Adding attributes for instructor entity**

3- **Providing the new ERD**

4-Mapping

course

Course_ID	Course_Name	Description

Instructor

Instructor_ID	First_name	Last_name	rank	Phone	Fax	Email	Department_name	Department_building	Department_budget

room

Building	Room_no	capacity

Reservation

Reservation_Id	Reservation_date	Start_time	End_time	Hours	Course_Id	Instructor_id	Building	Room_no

Student

Student_ID	First_name	Last_name	Date_of_birth	Address	City	Zip_code	Phone	Phone	Fax	Email

Enroll

Course_ID	Student_ID	Description

Mark

Mark_id	Mark_value	Mark_date	Student_id	Course_ID

5-The obtained relational schema is:
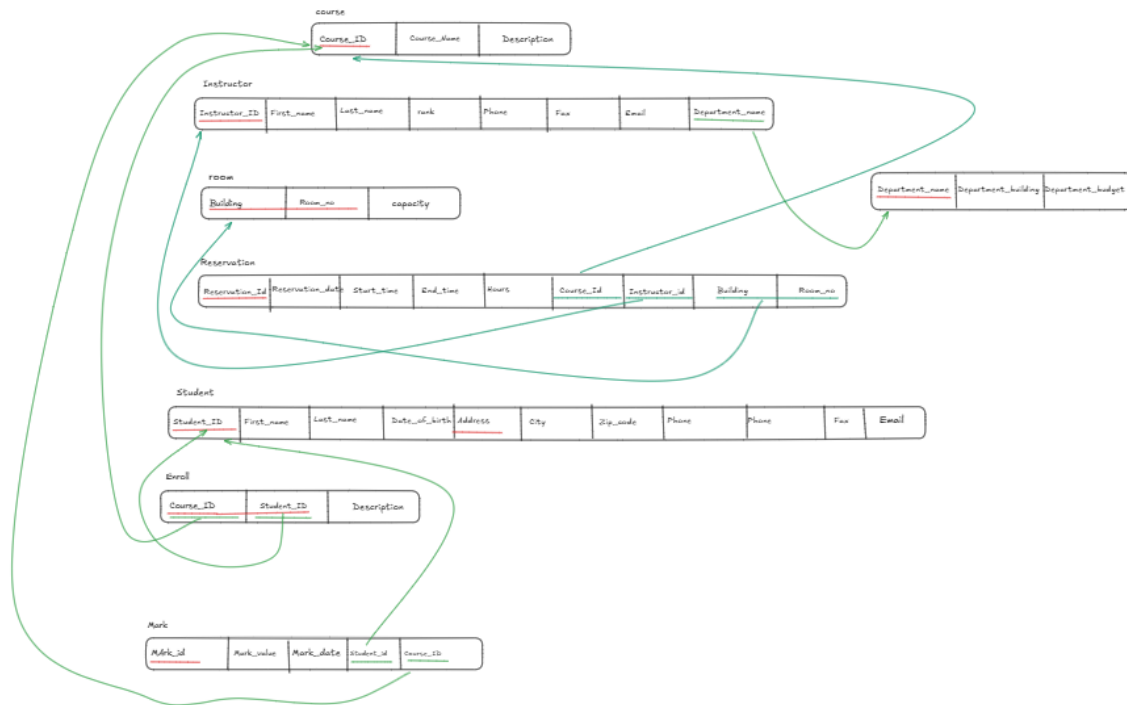
2nf →yes, there is no partial dependency on any relation

3nf→no, if we take Department_name → Department_building, Department_budget,
there is a transitive dependency, so 3nf is violated

Bcnf→ no, the same for Department_name → Department_building, Department_budget,
There is a functional dependency where X→ Y and X aren't a candidate key

Providing a BCNF decomposition:

course

Course_ID	Course_Name	Description

Instructor

Instructor_ID	First_name	Last_name	rank	Phone	Fax	Email	Department_name

room

Building	Room_no	capacity

Department_name	Department_building	Department_budget

Reservation

Reservation_Id	Reservation_date	Start_time	End_time	Hours	Course_Id	Instructor_id	Building	Room_no

Student

Student_ID	First_name	Last_name	Date_of_birth	Address	City	Zip_code	Phone	Phone	Fax	Email

Enroll

Course_ID	Student_ID	Description

Mark

Mark_id	Mark_value	Mark_date	Student_id	Course_ID

➔ Is it lossless?
No, because R1 intersect R2 is department_name and it is candidate key for the second relation , the union give all the attributes

6-Rapport :

1. Removal of the Department Entity

In the original ERD, the **Department** entity existed as an independent entity and was referenced by other entities, particularly **Instructor** and **Course**.
As required, the Department entity was **dropped entirely** from the ERD.

All attributes and relationships associated with Department were removed, including:

- Department identifier
- Department building
- Department budget
- All direct relationships between Department and other entities

This change eliminates Department as a separate organizational entity in the database design.

2. Adding Department Attributes to the Instructor Entity

After removing the Department entity, its descriptive attributes were incorporated into the **Instructor** entity to preserve departmental information.

The following attributes were added to Instructor:

- Department_name

- Department_building

- Department_budget

As a result, the Instructor entity now stores both instructor-related and department-related data.

3. New ERD Description

After applying the required changes, the new ERD consists of the following entities:

- Student

- Course

- Instructor

- Room

- Reservation

- Enroll

- Mark

The Instructor entity now directly contains department information instead of referencing a separate Department entity.
All relationships between the remaining entities were preserved to maintain system functionality.

4. Mapping the ERD to a Relational Schema

The proposed ERD was mapped to the following relational schema:

Student

Student(Student_ID, First_name, Last_name, Date_of_birth, Address, City, Zip_code, Phone, Fax, Email)

Course

Course(Course_ID, Course_name, Description)

Instructor

Instructor(Instructor_ID, First_name, Last_name, Rank, Phone, Fax, Email, Department_name, Department_building, Department_budget)

Room

Room(Building, Room_no, Capacity)

Reservation

Reservation(Reservation_ID, Reservation_date, Start_time, End_time, Hours, Course_ID, Instructor_ID, Building, Room_no)

Enroll

Enroll(Course_ID, Student_ID, Description)

Mark

Mark(Mark_ID, Mark_value, Mark_date, Student_ID, Course_ID)

5. Normalization Analysis (2NF, 3NF, BCNF)

Second Normal Form (2NF)

All relations satisfy 2NF because:

- Each relation is in 1NF

- There are no partial dependencies on composite keys

- All non-key attributes depend on the whole primary key

Therefore, the obtained relational schema is in **Second Normal Form (2NF)**.

Third Normal Form (3NF)

The **Instructor** relation violates 3NF due to a transitive dependency:

Instructor_ID → Department_name
Department_name → Department_building, Department_budget

This creates the transitive dependency:

Instructor_ID → Department_name → Department_building, Department_budget

Since non-key attributes depend on another non-key attribute, **Instructor is not in 3NF**.

As a result, the overall schema is **not in Third Normal Form (3NF)**.

Boyce–Codd Normal Form (BCNF)

The schema also violates BCNF because:

- Department_name functionally determines Department_building and Department_budget

- Department_name is not a candidate key

Thus, the Instructor relation violates **BCNF**.

6. BCNF Decomposition and Lossless Join Discussion

BCNF Decomposition

To achieve BCNF, the Instructor relation is decomposed into two relations:

Instructor

Instructor(Instructor_ID, First_name, Last_name, Rank, Phone, Fax, Email, Department_name)

Department

Department(Department_name, Department_building, Department_budget)

Lossless Join Property

The decomposition is **lossless** because:

- The common attribute Department_name is a key in the Department relation

- Joining Instructor and Department on Department_name reconstructs the original Instructor relation without loss of information

Therefore, the BCNF decomposition preserves data integrity and is lossless.

Conclusion

The removal of the Department entity and the integration of its attributes into the Instructor entity simplified the ERD but introduced transitive dependencies.
Although the resulting schema satisfies Second Normal Form, it violates Third Normal Form and BCNF.
Applying a BCNF decomposition resolves these issues and produces a well-structured, normalized database schema with a lossless decomposition.