1.
Define the following terms:

1. Candidate key [2]

A candidate key is an alternate set of attributes which can uniquely identify tuples in a relation.

1b. Foreign key [2]

A foreign key is an attribute or combination of attributes that constitutes a primary key in some other relation.

1c. Functional dependence [3]

Given two sets of attributes A, B of relation R, B is functionally dependent on A (or A determines B), written A→B, iff each A-value in R has precisely one B-value in R. in other words, any two tuples which agree on A must necessarily agree on B.

1d. Transitive dependence [3]

Transitive dependence refers to dependence among non-key attributes. If A→B and B→C then C is transitively dependent on A.

2.
Give the primary key and the highest normal form of each of the following relations. State any assumptions made and give reasons for your answers.

2a. **Student** {Stud#, Name, Addr, Gender, DoB} [3]

The relation is in 5NF; primary key is [Stud#]: There is no MVD or JD in the relation, and the only FD is based on the primary key.

2b. **Flight** {FlightNo, Date, Seats_Avl, FlightTime, FromCity, ToCity} [3]

The relation is in 1NF; primary key is [FlightNo, Date]: 2NF is violated since FlightNo → FlghtTime, FromCity, ToCity

2c. **Account** {AcctNo, CustNo, CustName, Balance} [3]

The relation is in 1NF; primary key is [Acct#, Cust#]: 2NF is violated since Cust# → CustName.

2d. **Supply** {PartNo, SupplyQty, SupplrNo, SupplrAddr} [3]

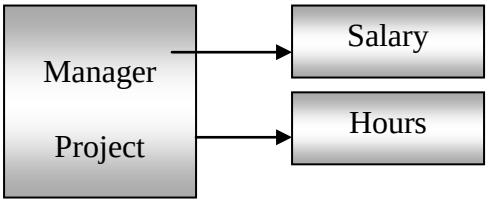
The relation is in 1NF; primary key is [Suplr#, Part#]: 2NF is violated since Suplr# → SupleAddr.

3.
The entity **Participation** consists of the following data elements: **Manager**, **Project**, **Hours** (spent on project(s) per month), and **Salary**. A manager's salary is fixed, and he/she can work on many projects.

3a. Draw an FD diagram for the relation. [3]

FD's are:
Manger → Salary
[Manager, Project]→ Hours

The FD diagram is shown below:



3b. Would you store **Participation** in its current state? Justify your answer. [4]

Rewrite the relation as
Participation {Manager#, ManagerName, Salary, Proj#, ProjName, HoursWorked}
Primary key [Manager#, Proj#]

FDs are
FD1: Manager# → ManagerName, Salary
FD2: Proj# → ProjName
FD3: [Manager#, Proj#] → HoursWorked

The relation is not in 2NF due to FD1 and FD2. It is therefore not prudent to store it as shown.

3c. Provide some sample data for the entity, so that the identified problem(s) is/are highlighted. [4]

This is left as an exercise for you. The sample data must highlight the data duplication that leads to the modification anomalies.

3d. What is the highest normal form of **Participation**? Defend your answer. [3]

The relation is in 1NF only. This is due to FD1, FD2, and FD3 above.

3e. Show how you would design a conceptual schema to store the data mentioned for entity. [11]

Manager {Mgr#, Mgrname, Salary} primary key [Mgr#]
Project {Project#, Project-Name} primary key [Project#]
Project_Team {Project#, Mgr#, Hours} primary key [Project#, Mgr#]

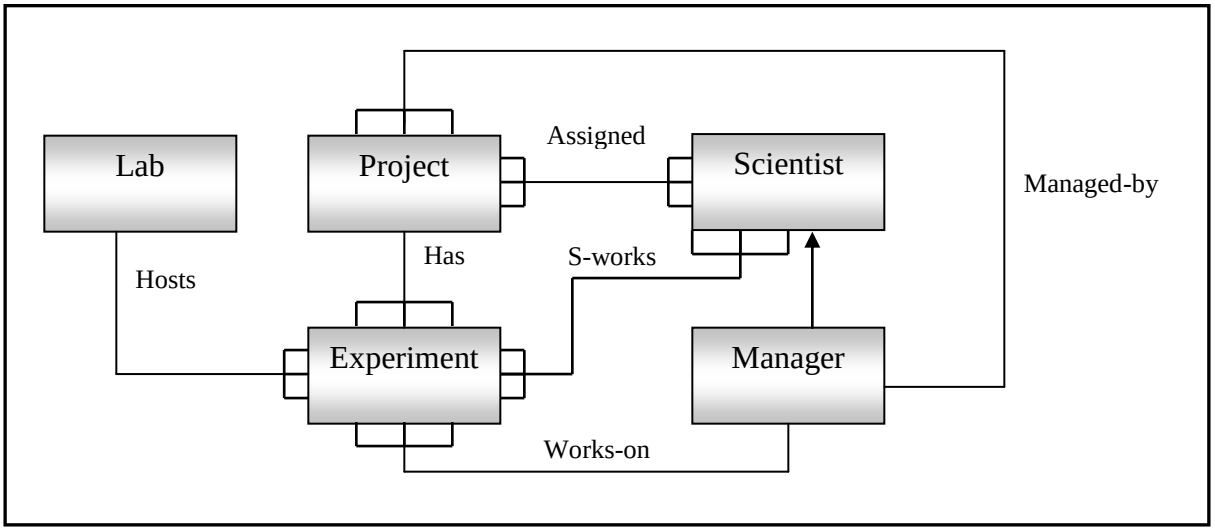
4.
A scientific research establishment organizes its work in projects, each project consisting of several experiments. For each experiment, the following data is recorded:

- Project number
- Project manager
- Project name
- Experiment number
- Experiment name
- Lab in which experiment is to be conducted
- List of scientists to work on the project

Additionally, the following guidelines apply:

- A project manager may manage one or more experiments.
- A scientist may work on more than one experiment.
- An experiment may involve several scientists.
- A manager may manage more than one project.
- All participants (including project managers) are scientists.

4a. Based on the information given, develop an ERD. [12]



4b. Using the XR model as a frame of reference, derive a set of BCNF relations for the system. Use self-explanatory relation and attribute names (you may introduce new attributes). [28]

Kernels are:

Lab {Lab#, LabName…}	primary key [Lab#]
Project {Proj#, ProjName…}	primary key [Proj#]
Scientist {Scientist#, Sc-Name…}	primary key [Scientist#]
Experiment {Exp#, Exp-Name, Exp-Description…}	primary key [Exp#]
Manager {Mgr#, Specialty…}	primary key [Mgr#]

Note: These translate to base relations in the XR model.

No **characteristics** exist in this example.

Manager is a subtype of **Scientist.**

Designations are:

- Lab-Experiment
- Project-Experiment
- Manager-Experiment
- Manager-Project

} Implemented by the introduction of foreign keys

Associations are Scientist-Project and Scientist-Experiment. The former, we will call Proj-Team, and the latter Exp-Team. Their constituent properties are as follows:

Proj-Team {Proj#, Scientist#}	primary key [Proj#, Scientist#]
Exp-Team {Exp#, Scientist#}	primary key [Exp#, Scientist#]

These associations would translate to two (additional) base relations in the model.

Subtypes & Super-types: Manager is a subtype of Scientist (the super-type). To implement this, make the primary key of Scientist (Scientist#) the foreign key and primary key in Manager.

Properties of entities mentioned so far are shown in the following table (primary key attributes are highlighted; foreign keys are italicized)

Entity	**Properties**
Project	**Proj#,** ProjName, ProjDescription, *ProjMgr#*…
Lab	**Lab#,** LabName…
Experiment	**Exp#,** ExpName, ExpDescription, *ExpLab#*, *ExpProj#*, *ExpMgr#*
Scientist	**Scientist#,** ScName…
Manger	**Scientist#,** Specialty…
Proj_Team	***Proj#, ProjScientist#***
Exp_Team	***Exp#, ExpScientist#***

Note: Primary key attributes are highlighted; foreign keys are italicized.

Integrity constraints to be imposed are as outlined in lecture 5 (section 5.5) of the text.

5.
The following relations represent a snapshot of a live database. Primary keys are highlighted. Based on the data, derive an ERD, showing all attributes (state any assumptions made). [10]

Warehouse PK[Wh#]			
Wh#	**City**	**Size**	
WH1	Kingston	37,000	
WH2	Bridgetown	50,000	
WH3	Rosseau	20,000	
WH4	Castries	13,000	
Employee PK [Wh#, Emp#]			
Wh#	**Emp#**	**Salary**	
WH2	E1	45,000	
WH1	E3	42,000	
WH2	E4	48,000	
WH3	E6	52,000	
WH1	E7	51,000	
Supplier PK [Sno]			
Sno	**SName**	**Location**	
S3	Wilson	Jamaica	
S4	Barnes	Barbados	
S6	Jones	St. Lucia	
S7	Lewis	Barbados	
Purch-Ord PK [Emp#, Sno]			
Emp#	**Sno**	**Order#**	**OrderDate**
E3	S7	O67	840623
E1	S4	O73	840728
E7	S4	O76	840525
E6	S6	O77	840619
E3	S4	O79	840623
E1	S6	O80	840729
E3	S6	O90	850622
E3	S3	O91	860713

Answer to Question 5

Observations:

- There is a 1:M relationship between WHOUSE and EMPLOYEE.
- There is a 1:M relationship between EMPLOYEE and PURCH-ORD.
- There is a 1:M relationship between SUPPLIER and PURCH-ORD.

The E-R diagram is shown: