1. (15p) Assume that the following data definition statements are provided to define the COMPANY schema given in page 8.

CREATE TABLE EMPLOYEE (Fname VARCHAR(15), **NOT NULL**, Minit CHAR, Lname VARCHAR(15) **NOT NULL**, Ssn CHAR(9) **NOT NULL**, Bdate DATE, Address VARCHAR(30), Sex CHAR, Salary DOUBLE, Super_ssn CHAR (9), Dno INT **NOT NULL DEFAULT** 1,
PRIMARY KEY (Ssn),
FOREIGN KEY (Super_ssn) **REFERENCES** EMPLOYEE(Ssn)
    ON DELETE SET NULL   **ON UPDATE** CASCADE,
FOREIGN KEY (Dno) **REFERENCES** DEPARTMENT(Dnumber)
    ON DELETE SET DEFAULT   **ON UPDATE** CASCADE);

CREATE TABLE DEPARTMENT (Dname VARCHAR(15) **NOT NULL**, Dnumber INT **NOT NULL**, Mgr_ssn CHAR(9) **NOT NULL DEFAULT** '888665555', Mgr_start_date DATE,
PRIMARY KEY (Dnumber),
FOREIGN KEY (Mgr_ssn) **REFERENCES** EMPLOYEE (Ssn)
    ON DELETE SET DEFAULT   **ON UPDATE** CASCADE);

CREATE TABLE DEPT_LOCATIONS (Dnumber INT **NOT NULL**, Dlocation VARCHAR(15) **NOT NULL**,
PRIMARY KEY (Dnumber, Dlocation),
FOREIGN KEY (Dnumber) **REFERENCES** DEPARTMENT(Dnumber)
    ON DELETE CASCADE   **ON UPDATE** CASCADE);

CREATE TABLE PROJECT (Pname VARCHAR(15) **NOT NULL**, Pnumber INT **NOT NULL**, Plocation VARCHAR(15), Dnum INT **NOT NULL DEFAULT** 1,
PRIMARY KEY (Pnumber),
FOREIGN KEY (Dnum) **REFERENCES** DEPARTMENT (Dnumber)
    ON DELETE SET DEFAULT   **ON UPDATE** CASCADE);

CREATE TABLE WORKS_ON (Essn CHAR(9) **NOT NULL, Pno INT NOT NULL DEFAULT 10, Hours DOUBLE NOT NULL,**
PRIMARY KEY (Essn, Pno),
FOREIGN KEY (Essn) **REFERENCES** EMPLOYEE(Ssn)
    ON DELETE CASCADE   **ON UPDATE** CASCADE);
FOREIGN KEY (Pno) **REFERENCES** PROJECT (Pnumber)
    ON DELETE SET DEFAULT   **ON UPDATE** CASCADE);

CREATE TABLE DEPENDENT (Essn CHAR(9) **NOT NULL**, Dependent_name VARCHAR(15) **NOT NULL**, Sex CHAR, Bdate DATE, Relationship VARCHAR(8),
PRIMARY KEY (Essn, Dependent_name),
FOREIGN KEY (Essn) **REFERENCES** EMPLOYEE(Ssn)
    ON DELETE CASCADE   **ON UPDATE** CASCADE);

Suppose that each of the following update operations is applied directly to the database state given in page 8. Write all constraints violated by each operation if any. Write new state of each table after each operation if the operation is not restricted. Show only the updated tables.

a) **(3p)** Insert <'ProductA',3,'Bellaire',8> into PROJECT
b) **(3p)** Insert <'Production',NULL,'943775543','1998-10-01'> into DEPARTMENT
c) **(3p)** Delete the PROJECT tuple with Pname='ProductZ'
d) **(3p)** Delete the DEPARTMENT tuple with Dnumber=5
e) **(3p)** Modify the Pnumber attribute of the PROJECT tuple with Pnumber=3 to 6.

2. (15p) Show the results of the following operations given in Relational Algebra.

A

a1	a2	a3	a4
2	2	4	5
11	8	12	3
5	6	1	5
6	4	2	3

B

b1	b2	b3
2	4	2
1	12	5
2	7	5

C

c1	c2	c3
4	4	5
8	4	5
5	12	6
14	7	3
7	6	3
5	4	5

D

d1	d2	d3	d4
1	4	3	5
4	12	11	4
4	1	5	3

a) **(3p)** $A - (\pi_{(c1,c3,b1,b3)} (C \bowtie_{c2=b2} B))$

b) **(3p)** $(A \bowtie_{a4=b1} (\pi_{(b1,b2,d1,d2)} (B \bowtie_{b2=d2} D)))$

c) **(3p)** $C \cup (\pi_{(a1, a2, a3)} (\sigma_{a4=5} A))$

d) **(3p)** $(c3 \, \mathfrak{I} \, \text{COUNT } d3, \text{ SUM } d2 \, (C \times D))$

e) **(3p)** $A * (\rho_{(a1, i2, e3)} B)$

3. (15p) Consider the four transactions T_1, T_2, T_3 and T_4 and the schedules S_1 and S_2 given below. Draw the serializability (precedence) graphs for S_1 and S_2, and state whether each schedule is serializable or not. If a schedule is serializable, write down the equivalent serial schedule(s).

T_1: $r_1(X)$; $r_1(Z)$; $w_1(X)$;
T_2: $r_2(Z)$; $r_2(Y)$; $w_2(Z)$; $w_2(Y)$;
T_3: $r_3(X)$; $r_3(Y)$; $w_3(Y)$;
T_4: $r_4(Z)$; $r_4(Y)$; $r_4(X)$; $w_4(Z)$; $w_4(Y)$;

a) (7p) S_1: $r_1(X)$; $r_2(Z)$; $r_1(Z)$; $r_3(X)$; $r_3(Y)$; $r_4(Z)$; $w_1(X)$; $w_3(Y)$; $r_4(Y)$; $r_4(X)$; $r_2(Y)$; $w_2(Z)$; $w_4(Z)$; $w_2(Y)$; $w_4(Y)$

b) (8p) S_2: $r_1(X)$; $r_2(Z)$; $r_3(X)$; $r_1(Z)$; $r_2(Y)$; $r_3(Y)$; $w_1(X)$; $w_2(Z)$; $w_2(Y)$; $w_3(Y)$; $r_4(Z)$; $r_4(Y)$; $r_4(X)$; $w_4(Z)$; $w_4(Y)$

4. (15p)

a) (5p) Suppose, you are given a relation R=(X, <u>Y</u>, <u>Z</u>, W, Q) with the following functional dependencies: {YZ→XWQ, W→Y, Z→Q} Find the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF). Explain briefly. Normalize the relation just one level higher.

b) (5p) Suppose, you are given a relation R = (X, Y, <u>Z</u>, W, <u>Q</u>) with the following functional dependencies: {ZQ →Y, W→Z, X→Q} Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF). Explain briefly. Normalize the relation just one level higher.

c) (5p) Suppose, you are given a relation R = (A, <u>B</u>, C, <u>D</u>) with the following functional dependencies: {C →D, C→A, BD→C} Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF). Explain briefly. Normalize the relation just one level higher.
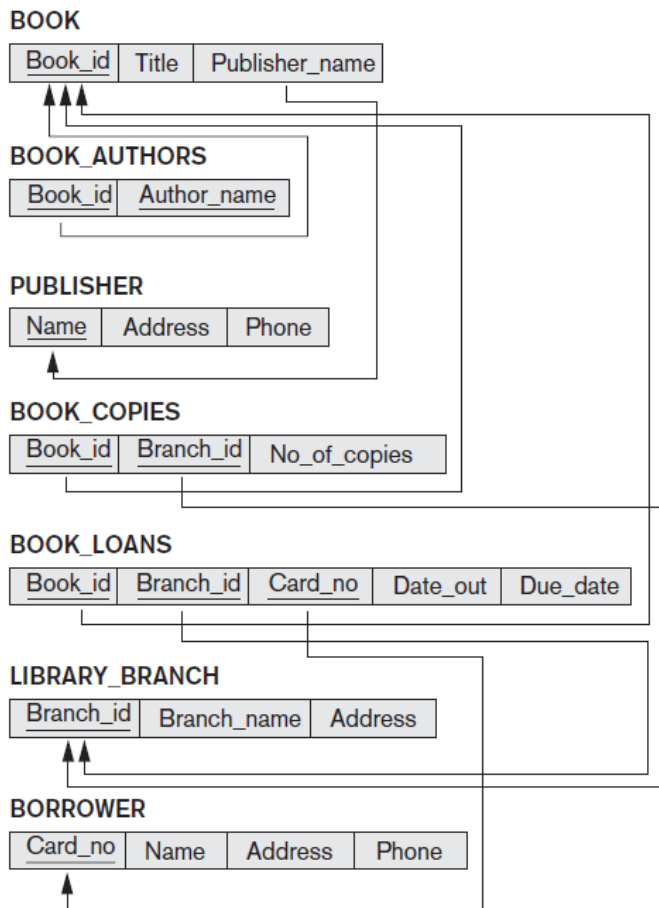
5. (10 p)
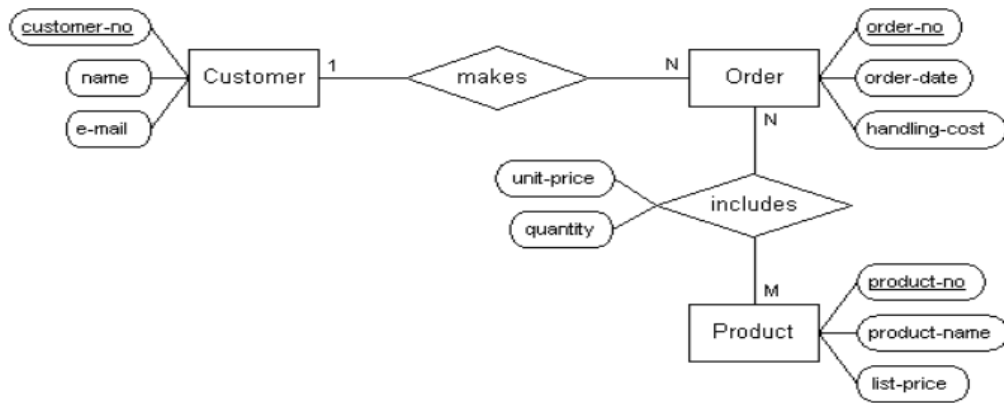
a) (5p) Consider the ER diagram given above. Extract from the ER diagram the requirements and constraints that produced this schema. Try to be as precise as possible in your requirements and constraints specification.

b) (5p) Map the ER diagram given above into a relational schema. Do not forget to underline the keys.

BOOK

Book_id	Title	Publisher_name

BOOK_AUTHORS

Book_id	Author_name

PUBLISHER

Name	Address	Phone

BOOK_COPIES

Book_id	Branch_id	No_of_copies

BOOK_LOANS

Book_id	Branch_id	Card_no	Date_out	Due_date

LIBRARY_BRANCH

Branch_id	Branch_name	Address

BORROWER

Card_no	Name	Address	Phone

6. (15p) A relational database schema for a LIBRARY database is given. Write the following queries in **SQL**.

   a) (3p) How many different books does each library branch have by the author 'Stephen King'?

   b) (4p) Find the names of library users with multiple borrowed books.

   c) (4p) For each library branch, find the name of this branch and which author has the highest number of books among those borrowed from this branch.

   d) (4p) Find out how many different users have borrowed books from the library branch named 'Central'.

7. (15p) Write the following queries in **SQL**.

RATING

USERID	MOVIEID	RATING
785	140	5
235	170	4
425	140	3
444	170	5
235	435	5
344	435	4
357	186	4
357	189	2
345	190	1
344	182	2
344	190	3
425	186	5
444	140	4
357	170	5

MOVIES

MOVIEID	NUMBEROFVIEWERS	TOTALGROSS	FIRSTWEEKGROSS	GENRE
140	7400000	55000000	5400000	War
170	5300000	43000000	5000000	Crime
182	450000	5200000	200000	Comedy
186	2345000	20000000	3000000	Comedy
189	980000	1000000	75000	Family
190	200000	250000	30000	Crime
435	4450000	39000000	6000000	Adventure
437	3450000	35000000	2500000	Adventure

a) **(2p)** Find the average number of viewers for each genre.

b) **(2p)** Find the average ratings for each genre.

c) **(2p)** Find the number of users who gives ratings to the movies that has first week gross greater than 10% of the total gross.

d) **(3p)** Find the genre of movies that has rating average 4 or greater than 4.

e) **(3p)** Find the number of viewers and average rating values of the movies in which the genre starts with the letter 'C'.

f) **(3p)** Find the users who rate the comedy with the highest number of viewers, or the adventure movie with the highest number of viewers. Give the results in ascending order with respect to user id. Users who fulfill the conditions must be at most once in the results.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Referential integrity constraints displayed on the COMPANY relational database schema.

One possible database state for the COMPANY relational database schema.

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno
John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
Alicia	J	Zelaya	999887777	1968-01-19	3321 Castle, Spring, TX	F	25000	987654321	4
Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	NULL	1

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

WORKS_ON

Essn	Pno	Hours
123456789	1	32.5
123456789	2	7.5
666884444	3	40.0
453453453	1	20.0
453453453	2	20.0
333445555	2	10.0
333445555	3	10.0
333445555	10	10.0
333445555	20	10.0
999887777	30	30.0
999887777	10	10.0
987987987	10	35.0
987987987	30	5.0
987654321	30	20.0
987654321	20	15.0
888665555	20	NULL

PROJECT

Pname	Pnumber	Plocation	Dnum
ProductX	1	Bellaire	5
ProductY	2	Sugarland	5
ProductZ	3	Houston	5
Computerization	10	Stafford	4
Reorganization	20	Houston	1
Newbenefits	30	Stafford	4

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship
333445555	Alice	F	1986-04-05	Daughter
333445555	Theodore	M	1983-10-25	Son
333445555	Joy	F	1958-05-03	Spouse
987654321	Abner	M	1942-02-28	Spouse
123456789	Michael	M	1988-01-04	Son
123456789	Alice	F	1988-12-30	Daughter
123456789	Elizabeth	F	1967-05-05	Spouse