National University of Computer and Emerging Sciences

Lahore Campus

Database Systems (CS2005) Final Exam

Date: May 21st 2025

Course Instructor(s)

IR, ZA, MN, AA, HI, MM, SA

Total Time (Hrs.): 3

Total Marks: 80

Total Questions: 8

SOLUTION

_____ _____ _____

Roll No Section Student Signature

Do not write below this line.

Note: Please ensure that you attempt all questions and their respective parts in the given order.

Consider a detailed DB schema for the various CS competitions held in our university under the society SOFTEC every year.

The participant table stores details about each participant who may take part in competitions. Participants can have mentors, but we only record mentors who are also participants or have been in the past. Teams participate in competitions. A team can have multiple participants and a Team lead (who must be a participant). The Competition table stores information about each competition organized by SOFTEC, including which team won.

Participant

PID	Name	Gender	MentorID
P01	Areeba	F	NULL
P02	Zain	M	P01
P03	Sara	F	P01
P04	Usman	M	P02
P05	Ali	M	NULL
P06	Hamza	M	P04
P07	Sana	F	P03
P08	Bilal	M	P01
P09	Mehak	F	P10
P10	Noor	F	NULL

CompetitionTeam

CID	TeamID
C01	T01
C01	T02
C01	T03
C02	T01
C02	T02
C02	T03
C03	T05
C03	T04
C04	T02
C04	T03
C05	T04
C05	T05

TeamMember

TeamID	PID
T01	P01
T01	P02
T01	P03
T02	P04
T02	P05
T03	P06
T03	P08
T03	P02
T04	P03
T05	P09

Competition

CID	Cname	Venue	Date
C01	Coding Challenge	SHall A	4/27/2025
C02	Hackathon Sprint	CS Lab 3	4/27/2025
C03	Query Master	CS Lab 4	4/26/2025
C04	Data Analysis	Data Lab	4/26/2025
C05	Debug Solo	Online	4/24/2025

Team

TeamID	Name	TeamLeadID
T01	Alpha Coders	P01
T02	Binary Blasters	P04
T03	Code Ninjas	P06
T04	Data Wizards	P03
T05	Solo Master	P09

CLO # 5: Author queries using relational algebra and SQL.

Q. No 1: Consider the database state given above. Give the output for each of the following queries. Also show the intermediate tables. Explain in one sentence what these queries are doing. [9]

a. $R1 \leftarrow \sigma_{Gender='F'}(Participant)$

$Result \leftarrow \pi_{TeamID}(\sigma_{R1.PID = \phi}(TeamMember \bowtie_{TeamMember.PID = R1.PID} R1)$

Ans: Teams with male members T1, T2, T3...; a team with all female members is not included.

b.
```
SELECT DISTINCT ct.CID   FROM CompetitionTeam ct
WHERE EXISTS (SELECT * FROM CompetitionTeam ct1 JOIN TeamMember tm1 ON ct1.TeamID = tm1.TeamID
                    WHERE ct1.CID = ct.CID
                    GROUP BY ct1.TeamID
                    HAVING COUNT(tm1.PID) <> ALL (
                        SELECT COUNT(tm2.PID)
                        FROM CompetitionTeam ct2  JOIN TeamMember tm2 ON ct2.TeamID =
                        tm2.TeamID
                        WHERE ct2.CID = ct.CID
                        GROUP BY ct2.TeamID
                        )
                   );
```

Ans: ***The competitions that allow teams of different numbers of members , null***

c.
```
SELECT DISTINCT p1.PID, p1.Name
FROM Participant p1 JOIN Participant p2 ON p1.PID = p2.MentorID
LEFT JOIN TeamMember tm ON p1.PID = tm.PID
LEFT JOIN CompetitionTeam ct ON tm.TeamID = ct.TeamID
WHERE ct.TeamID IS NULL;
```

Ans: Find participants who are mentors but did not participate in any competition: P10 Noor

CLO # 5: Author queries using relational algebra and SQL.

Q. No 2: Consider the above database. Write **SQL and RA** statements for each of the following problems. [16]

a. List the name of the participant who participated in all the competitions held in 2025.

Ans:
```
SELECT p.Name
FROM Participant p
JOIN TeamMember tm ON p.PID = tm.PID
JOIN CompetitionTeam ct ON tm.TeamID = ct.TeamID
JOIN Competition c ON ct.CID = c.CID
WHERE YEAR(c.Date) = 2025
GROUP BY p.PID, p.Name
HAVING COUNT(DISTINCT ct.CID) = (
  SELECT COUNT(*)
  FROM Competition
  WHERE YEAR(Date) = 2025
);
```

b. For each team with more than three members, list the name of the Team along with the name of the Team Lead.

Ans: SELECT t.Name AS TeamName, p.Name AS TeamLeadName
FROM Team t
JOIN Participant p ON t.TeamLeadID = p.PID
JOIN (
SELECT TeamID
FROM TeamMember
GROUP BY TeamID
HAVING COUNT(PID) > 3
) tm_count ON t.TeamID = tm_count.TeamID;

CLO # 5: Author queries using relational algebra and SQL.

Q. No 3: Consider the above database. Create a view that finds and lists the ***pairs of Teams*** that have participated in the same set of competitions. [5]

Hint: For the above data, the answer to your query should be

Team1	Team2
T04	T05
T02	T03

Ans:
CREATE VIEW SameCompetitionTeams AS
SELECT DISTINCT ct1.TeamID AS Team1, ct2.TeamID AS Team2
FROM CompetitionTeam ct1 JOIN CompetitionTeam ct2 ON ct1.CID = ct2.CID
WHERE ct1.TeamID < ct2.TeamID
GROUP BY ct1.TeamID, ct2.TeamID
HAVING COUNT(*) = (SELECT COUNT(*) FROM CompetitionTeam c1 WHERE c1.TeamID = ct1.TeamID)
AND COUNT(*) = (SELECT COUNT(*) FROM CompetitionTeam c2 WHERE c2.TeamID = ct2.TeamID);

CLO # 3: Develop a normalized relational design to remove anomalies in a set of relations.

Q. No 4: Consider the relation schema R (A, B, C, D, E), with FDs
F= {A → BC, AB → D, C → D, A → E, EC → B}. Find a minimal cover of *F* (i.e. F_c). [5]
Ans: F_c= {A → CE, C → D, CE → B}

CLO # 3: Develop a normalized relational design to remove anomalies in a set of relations.

Q. No 5: Identify the best normal form of the following relations. Justify your answer. If the given relation is not in BCNF, decompose it into a set of BCNF relations. Please note all parts are independent. [15]

a. Consider the relation R(A, B, C, D), with FDs F= {A → BC, B → D, CD → A}.
b. Consider the relation R(A, B, C, D, E), with FDs F= {AB → C, C → D, D → E, A → B}.
c. Consider the relation R(A, B, C, D), with FDs F= {AB → C, C → D, D → B}.

Ans:

a. Keys are A, BC, and CD. HNF is 3NF as FD2: B→D violates BCNF.
BCNF Schema: R1(A, B, C), R2(B, D); FD3: CD→A is lost.

b. Key is A. HNF is 2NF as FD2: C→D & FD3: D→E violate 3NF.
3NF Schema: R1(A, B, C), R2(C, D, E); FD3: D→E violate BCNF.
BCNF Schema: R1(A, B, C), R21(C, D), R22(D, E); All FDs are preserved.

c. Keys are AB, AC, and AD. HNF is 3NF as FD2: C→D & FD3: D→B violate BCNF.
BCNF Schema: R1(A, C), R2(C, D), R3(D, B); FD1: AB→C is lost.

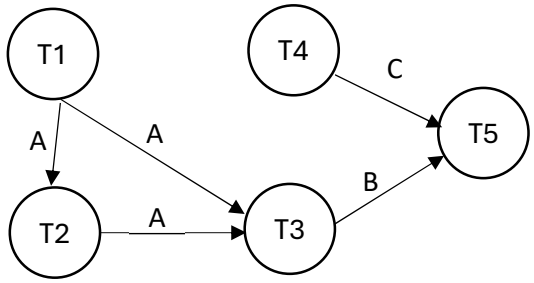
CLO # 3: Develop a normalized relational design to remove anomalies in a set of relations.

Q. No 6: Consider the following schedule: [5]

S: r1(A); w1(A); r2(A); w3(A); w4(D); r4(D); r3(B); w5(B); w4(C); r5(C).

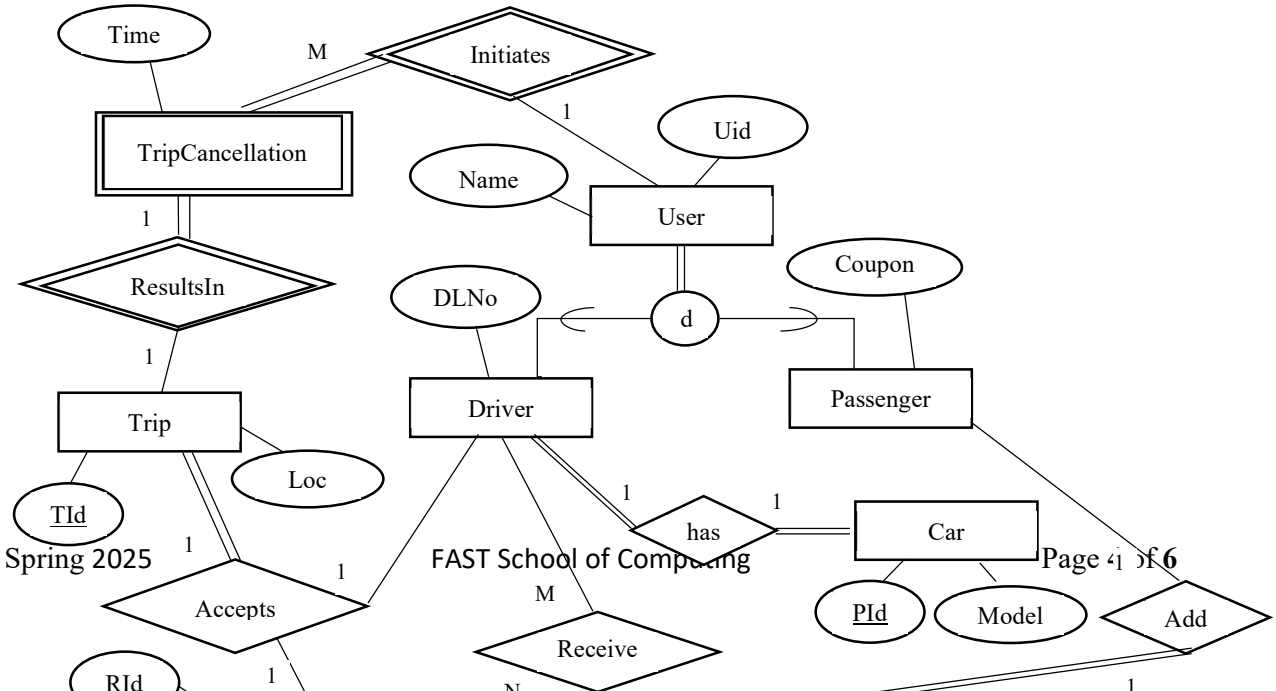
Draw the serializability (precedence) graph for this schedule. State whether this schedule is (conflict) serializable or not. If the schedule is serializable, write down the equivalent serial schedule(s) otherwise explain why it is not.

Ans: It is conflict-serializable and view-serializable. Equivalent serial schedules are T1→T2→T3→T4→T5, T4→T1→T2→T3→T5, & more …



CLO # 2: Design a conceptual model using ER Model for an enterprise.

Q. No 7: Map the following ER/EER Diagram into a relational model and specify all the constraints including primary key, foreign key, not null, and unique. [10]

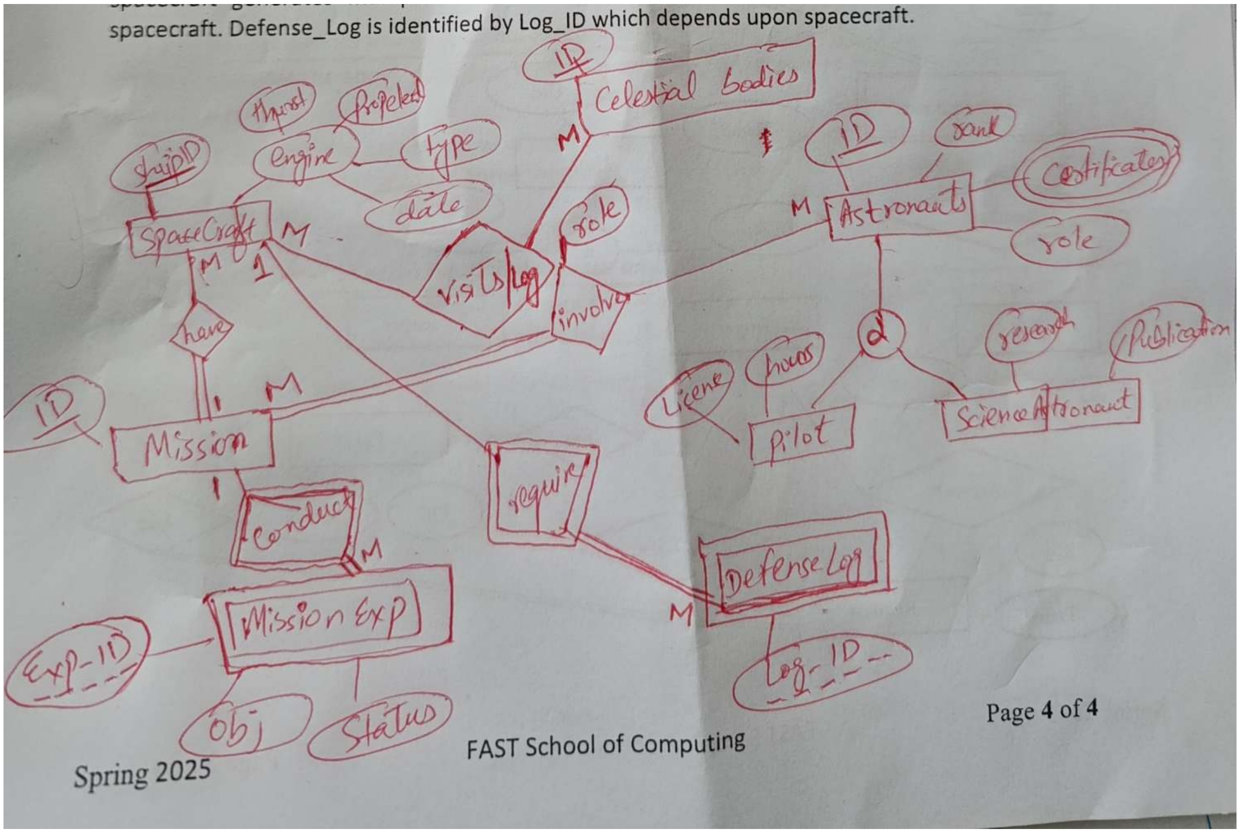


CLO # 2: Design a conceptual model using ER Model for an enterprise.

Q. No 8: Draw an ER/EER diagram (using notation discussed in lectures) for the following requirements of a Deep Space Mission Control System to manage interstellar expeditions, spacecraft, astronauts, and planetary research. Specify all constraints that should hold on to the database and state any assumptions you make. [15]

The system must track **spacecraft** (uniquely identified by Ship_ID) with attributes including model, manufacturer, fuel capacity, backup crew member and engine specifications (thrust level, propellant type, and last maintenance date). Astronauts, identified by their unique Astronaut_ID, operate and control these spacecrafts. Each astronaut's record must include their rank, training certifications, and specialized role. The system categorizes astronauts into two distinct subtypes: Pilot_Astronauts who have tracking flight hours and license number and other is Science_Astronauts who is documenting research fields and publications. An astronaut cannot be both a pilot and scientist. Astronauts can belong to other types as well.

The system regularly conducts **Mission_Experiments** like soil analysis or atmospheric tests, which depend on their parent **Mission** identified by Mission_ID. Each experiment has a partial key Exp_ID and attributes like objective and status. A mission must involve at least one spacecraft and multiple astronauts, while astronauts can participate in multiple missions with different roles. Additionally, spacecraft visits **celestial bodies** (planets, moons), where each celestial body has attributes including *body_ID*, name, mass. These visit records are maintained through an Expedition Log, whenever spacecrafts visit any celestial body/bodies, where celestial bodies may have zero or more record. To address security threats, the system also incorporates **missile defense protocols**. A spacecraft generates multiple defense logs during attacks, and Every defense log requires a spacecraft. Defense_Log is identified by Log_ID which depends upon spacecraft.


spacecraft. Defense_Log is identified by Log_ID which depends upon spacecraft.
ID
Celestial bodies
M
engine
Type
date
shipID
SpaceCraft
M
1
M
visits/Log
role
involve
M
Astronauts
ID
Certificates
role
have
d
Pilot
Science Astronaut
ID
Mission
1
M
require
conduct
M
Defense Log
M
Mission Exp
Exp-ID
Log-ID
Obj
Status
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