



**INDIAN INSTITUTE OF TECHNOLOGY  
KHARAGPUR**

Stamp / Signature of the Invigilator

EXAMINATION ( Mid Semester )

SEMESTER ( Spring )

Roll Number										Section		Name		
Subject Number	C	S	3	0	2	0	2			Subject Name	Database Management Systems			
Department / Center of the Student													Additional sheets	

**Important Instructions and Guidelines for Students**

1. You must occupy your seat as per the Examination Schedule/Sitting Plan.
2. Do not keep mobile phones or any similar electronic gadgets with you even in the switched off mode.
3. Loose papers, class notes, books or any such materials must not be in your possession, even if they are irrelevant to the subject you are taking examination.
4. Data book, codes, graph papers, relevant standard tables/charts or any other materials are allowed only when instructed by the paper-setter.
5. Use of instrument box, pencil box and non-programmable calculator is allowed during the examination. However, exchange of these items or any other papers (including question papers) is not permitted.
6. Write on both sides of the answer script and do not tear off any page. **Use last page(s) of the answer script for rough work.** Report to the invigilator if the answer script has torn or distorted page(s).
7. It is your responsibility to ensure that you have signed the Attendance Sheet. Keep your Admit Card/Identity Card on the desk for checking by the invigilator.
8. You may leave the examination hall for wash room or for drinking water for a very short period. Record your absence from the Examination Hall in the register provided. Smoking and the consumption of any kind of beverages are strictly prohibited inside the Examination Hall.
9. Do not leave the Examination Hall without submitting your answer script to the invigilator. **In any case, you are not allowed to take away the answer script with you.** After the completion of the examination, do not leave the seat until the invigilators collect all the answer scripts.
10. During the examination, either inside or outside the Examination Hall, gathering information from any kind of sources or exchanging information with others or any such attempt will be treated as '**unfair means**'. Do not adopt unfair means and do not indulge in unseemly behavior.

**Violation of any of the above instructions may lead to severe punishment.**

Signature of the Student

*To be filled in by the examiner*

Question Number	1	2	3	4	5	6	7	8	9	10	Total
Marks Obtained											
Marks obtained (in words)				Signature of the Examiner				Signature of the Scrutineer			

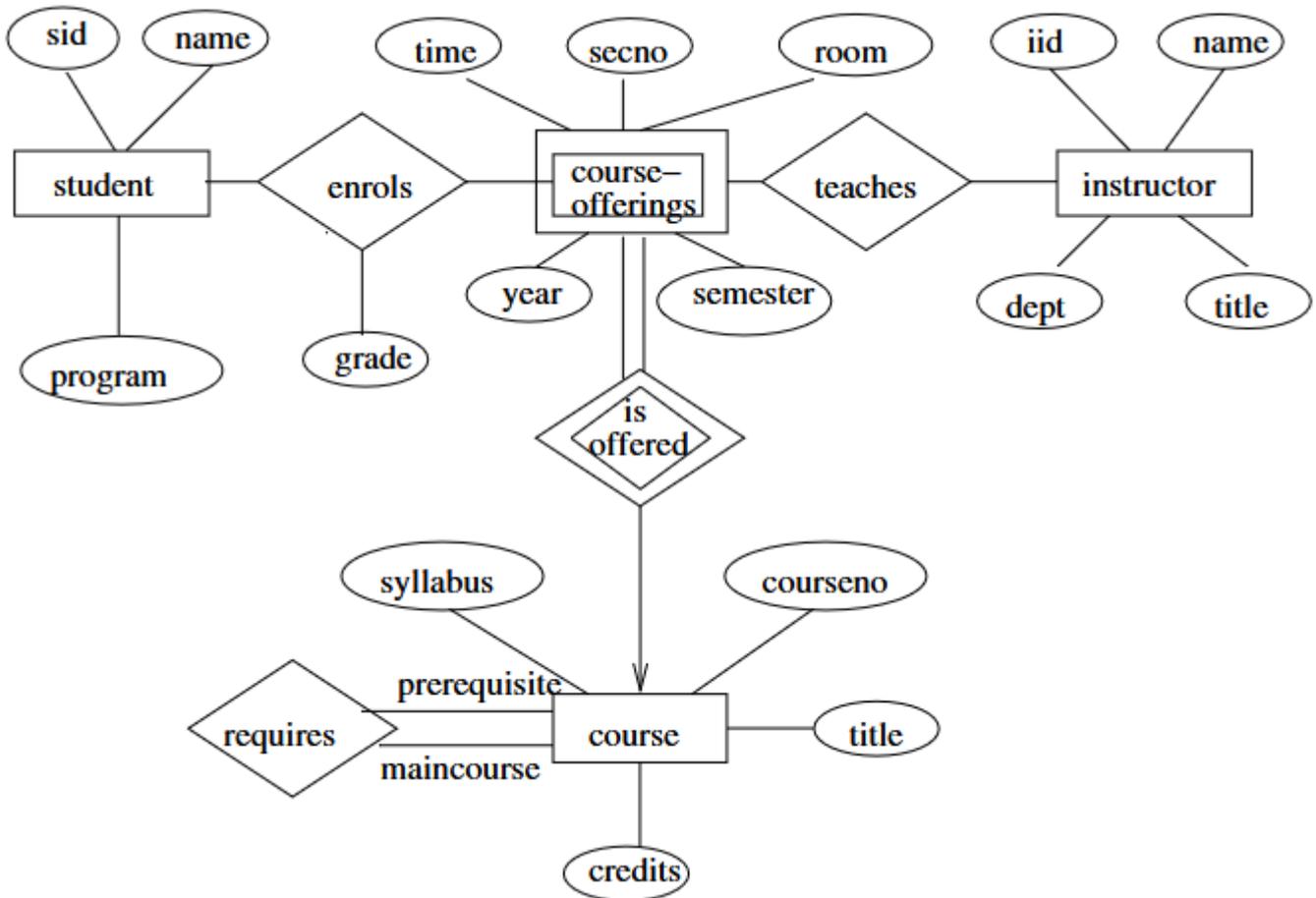
**Instructions:** Answer all FOUR questions. Time = 2hrs. Total marks =  $4 \times 15 = 60$ . Write your answers only in the space provided. Show the solution steps. Answers without explanation will be penalised. The question paper has total 16 pages.

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**ROUGH WORK**

1.(a) The academic module of ERP IITKGP maintains data about the following entities: (a) courses, including number, title, credits, syllabus, and prerequisites; (b) course offerings, including course number, year, semester, section number, instructor(s), timings, and classroom; (c) students, including student-id, name, and program; and (d) instructors, including identification number, name, department, and title. Further, the enrolment of students in courses and grades awarded to students in each course they are enrolled for must be appropriately modelled. The assumptions made are: a class meets only at one particular place and time, and multiple classes may meet at the same place and time. Construct an E-R diagram for the academic module. Indicate the mapping constraints as well as the weak entities in the diagram. [10]

ANS:



(b) Convert the above E-R diagram in to a relational table schema. Underline the key attribute(s). [5]

ANS:

*student* (student-id, name, program)  
*course* (course-no, title, syllabus, credits)  
*course-offering* (course-no, sec-no, year, semester, time, room)  
*instructor* (instructor-id, name, dept, title)  
*enrols* (student-id, course-no, sec-no, semester, year, grade)  
*teaches* (course-no, sec-no, semester, year, instructor-id)  
*requires* (main-course, prerequisite)

2.(a) Given tables  $R(\underline{A}, B)$ ,  $P(\underline{A}, B)$ ,  $S(\underline{B}, C)$ ,  $T(\underline{C}, A)$ , with the primary keys underlined. State if each of the following statement is true/false. If it is false, provide a counter-example of the relevant tables with just one/two tuples, showing that it is false. All the attributes have integer domain. [5]

Statement	True/False	Counter-Example
A is a key for $R \cap P$	True	
A is a key for $R \cup P$	False	$R = \{(1, 2)\}$ , $P = \{(1, 3)\}$
A is a key for $R \bowtie S$	True	
C is a key for $S \bowtie T$	False	$S = \{(1, 3), (2, 3)\}$ , $T = \{(3, 4)\}$
C is a key for $R \bowtie S \bowtie T$	True	

(b) Consider the following relations in an international movie database. Write relational algebra statements to retrieve the results of the queries given below. [2x5=10]

*Actor*(actorId, name, nationality, age);    *Director*(DirectorId, name, nationality);  
*Film*(filmId, title, year, directorId);    *PerformsIn*(actorId, filmId);

(i) ActorId, name, nationality, age, of all actors who have directed a film.

ANS:

$$\pi_{\text{actorId,name,nationality,age}}(\text{Actor} \bowtie_{\text{actorId=directorId}} \text{Director})$$

(ii) Titles of all films in which Leonardo DiCaprio and Kate Winslet have co-acted.

ANS:

$$\pi_{\text{title}}((\pi_{\text{filmId}}(\sigma_{\text{name='Leonardo DiCaprio'}}(\text{Actor}) \bowtie \text{PerformsIn}) \cap \pi_{\text{filmId}}(\sigma_{\text{name='Kate Winslet'}}(\text{Actor}) \bowtie \text{PerformsIn})) \bowtie \text{Film})$$

(iii) Names of all actors that have performed in a film directed by Christopher Nolan.

ANS:

$$\pi_{\text{name}}(\text{Actor} \bowtie \text{PerformsIn} \bowtie \text{Film} \bowtie (\sigma_{\text{name='Christopher Nolan'}}(\text{Director})))$$

(iv) ActorId, name, nationality, age, of all actors who have appeared in the movie titled Inception.

ANS:

$$\pi_{\text{actorId,name,nationality,age}}(\text{Actor} \bowtie (\text{PerformsIn} \bowtie (\sigma_{\text{title='Inception'}}(\text{Film}))))$$

(v) Names of all actors that have played the character of Bruce Wayne, together with the year the corresponding films were released

ANS:

$$\pi_{\text{name,year}}(\text{Actor} \bowtie (\sigma_{\text{character='Bruce Wayne'}}(\text{PerformsIn} \bowtie \text{Film})))$$

3. Given the relational tables related to academic course enrolments:

[5x3=15]

*Student*(Sid, Name, Degree); *Course*(Cid, Cname, Room, Teacher); *Enrolled*(Sid, Cid, Mark)

(i) Write SQL query to obtain the names of the courses in which a MTech student or a BTech student are enrolled.

ANS:

```
SELECT Cname
FROM Student, Course, Enrolled
WHERE Student.Sid = Enrolled.Sid AND Enrolled.Cid = Course.Cid
AND (Degree = "MTech" OR Degree = "BTech")
```

(ii) Write SQL query to obtain the names of the courses in which a MTech student and a BTech student are enrolled.

ANS:

```
SELECT Cname
FROM Student, Course, Enrolled
WHERE Student.Sid = Enrolled.Sid AND Enrolled.Cid = Course.Cid
AND Degree = "MTech" INTERSECT
SELECT Name
FROM Student, Course, Enrolled
WHERE Student.Sid = Enrolled.Sid AND Enrolled.Cid = Course.Cid
AND Degree = "BTech"
```

(iii) Translate the relational algebra statement to a SQL query:

$\pi_{\text{Room, Teacher}}(\text{Course})$

ANS:

```
SELECT (DISTINCT) Room, Teacher
FROM Student
```

(iv) Translate the relational algebra statement to a SQL query without using the SQL JOIN operator:

$\pi_{\text{Sid}}(\text{Enrolled}) - \pi_{\text{Sid}}(\sigma_{\text{Marks} < M1}(\text{Enrolled} \bowtie \pi_{M1}(\rho_{\text{Marks} \rightarrow M1}(\text{Enrolled}))))$

ANS:

```
SELECT Sid
FROM Enrolled
WHERE Sid NOT IN (
    SELECT Sid FROM Enrolled
    WHERE Mark < ANY (SELECT Mark FROM Enrolled))
```

(v) Translate the relational algebra statement to a SQL query without using the SQL JOIN operator:

$\pi_{\text{Name}}(\sigma_{\text{Mark} > 70}(\text{Student} \bowtie \text{Course} \bowtie \text{Enrolled}))$

ANS:

```
SELECT Name
FROM Student, Course, Enrolled
WHERE Student.Sid = Enrolled.Sid AND Enrolled.Cid = Course.Cid
AND Mark > 70
```

4.(a) Consider the relation schema  $R(A, B, C, D, E, F, G, H, I, J)$  with the following set of functional dependencies. What are the candidate keys for  $R$ ? Explain. [2]

$\{A, B\} \rightarrow \{C\}$ ,  $\{B\} \rightarrow \{E, F\}$ ,  $\{A, D\} \rightarrow \{G, H\}$ ,  $K \rightarrow \{I\}$ ,  $H \rightarrow \{J\}$

ANS:

$\{ABD\}$

$\{ABD\}^+ = \{ABCDEFGHIJ\} = R$

(b) Consider a schema  $R(A, B, C)$  and following functional dependencies:  $A \rightarrow B$ ;  $B \rightarrow C$ ;  $A \rightarrow B$ ;  $\{AB\} \rightarrow C$ . Find the canonical cover of these set of FDs. Show the steps. [5]

ANS:

$A \rightarrow B$  and  $B \rightarrow C$

Step 1: Minimize the Functional Dependencies

1. Check for Extraneous Attributes:

- We need to check if any attribute on the left-hand side of the functional dependencies can be removed without changing the closure of the functional dependencies.

2. Evaluate  $A \rightarrow BC$  :

- Since A can derive B from  $A \rightarrow B$  and B can derive C from  $B \rightarrow C$  :
- Thus,  $A \rightarrow BC$  is necessary as it allows to derive both attributes.

3. Evaluate  $B \rightarrow C$  :

- This dependency is essential as there is no other dependency that provides C from B .

4. Evaluate  $A \rightarrow B$  :

- This is also essential since it directly connects A to B .

5. Evaluate  $AB \rightarrow C$  :

- This dependency can be removed because  $A \rightarrow B$  and  $B \rightarrow C$  together imply that A alone can derive C through  $A \rightarrow B \rightarrow C$  . Thus,  $AB \rightarrow C$  is redundant.

Step 2: Resulting Functional Dependencies

After evaluating the dependencies, the following remain essential:

1.  $A \rightarrow BC$
2.  $B \rightarrow C$
3.  $A \rightarrow B$

However, since  $A \rightarrow BC$  covers both  $A \rightarrow B$  and  $A \rightarrow C$  , we can simply represent this as:

- $A \rightarrow B$  and  $B \rightarrow C$

Step 3: Determine the Canonical Cover

Thus, the canonical cover for the functional dependencies is:

- $A \rightarrow B$
- $B \rightarrow C$

Conclusion

The correct canonical cover from the options provided is:

- 4)  $A \rightarrow B$  and  $B \rightarrow C$  .

(c) The relation *StudentPerformance*(*name*, *courseNo*, *rollNo*, *grade*) has the following functional dependencies. Explain if the relation is in BCNF and/or 3NF. [3]

$\text{name, courseNo} \rightarrow \text{grade}$   
 $\text{rollNo, courseNo} \rightarrow \text{grade}$   
 $\text{name} \rightarrow \text{rollNo}$   
 $\text{rollNo} \rightarrow \text{name}$

ANS:

Only in 3NF not in BCNF

Say attributes (*name*, *courseNo*, *rollNo*, *grade*) be (A,B,C,D). Then given FDs are as follows:

$AB \rightarrow D$ ,  $CB \rightarrow D$ ,  $A \rightarrow C$ ,  $C \rightarrow A$

Here there are two Candidate keys, AB and CB. Now  $AB \rightarrow D$  and  $CB \rightarrow D$  satisfy BCNF as LHS is superkey in both. But,  $A \rightarrow C$  and  $C \rightarrow A$ , doesn't satisfy BCNF. Hence, we check for 3NF for these 2 FDs. As C and A on RHS of both the FDs are prime attributes, they satisfy 3NF.

(d) Given a relation  $R(A, B, C, D, E, F)$  and an FD set:  $A \rightarrow BCE$ ,  $C \rightarrow D$ ,  $BD \rightarrow F$ ,  $EF \rightarrow B$ ,  $BE \rightarrow A$ . Decompose the relation  $R$  into three relations  $R_1$ ,  $R_2$  and  $R_3$  such that the resulting relations are in 3NF and the decomposition is lossless-join and dependency preserving. Explain why these properties hold for each of these three relations. [5]

ANS:

$R_1(A, B, C, E, F)$ ,  $R_2(C, D)$ ,  $R_3(B, D, F)$

Each relation is in 3NF. Each decomposition is lossless-join and dependency preserving.



ROUGH WORK

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