



**INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR**

Stamp / Signature of the Invigilator

EXAMINATION (End 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 = 4x15 = 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.

1.(a) Define and explain with an example the notion of a foreign key in a relation.

[2]

ANS:

A foreign key is a set of attributes in a table that refers to the primary key of another table, linking these two tables. In the context of relational databases, a foreign key is subject to an inclusion dependency constraint that the tuples consisting of the foreign key attributes in one relation, R, must also exist in some other (not necessarily distinct) relation, S; furthermore, those attributes must also be a candidate key in S. In other words, a foreign key is a set of attributes that references a candidate key.

For example, a table called TEAM may have an attribute, MEMBER_NAME, which is a foreign key referencing a candidate key, PERSON_NAME, in the PERSON table. Since MEMBER_NAME is a foreign key, any value existing as the name of a member in TEAM must also exist as a person's name in the PERSON table; in other words, every member of a TEAM is also a PERSON.

1.(b) We want to represent the organizational structure of our institute. It consists of various Departments. Each department has a unique name, a unique number, and may have several locations. A particular Employee is Chair of the department. We keep track of the start date when that employee began managing the department as chair. An employee can manage only one department. We also execute several industrial Projects in our institute. A department controls a number of projects, each of which has a unique name, a unique number, and a single location. Each department has several employees. We store each employee's name, ID number, address, salary, gender, and birth date. An employee is assigned to one department, but may work on several projects, which are not necessarily controlled by the same department. We store the current number of hours per week that an employee works on each project. We also keep track of the supervisor of each employee (who is another employee). We keep track of the dependents of each employee for insurance purposes. We keep each dependent's first name, gender, birth date, and relationship to the employee. Draw the ER diagram. Mark the possible primary keys, the weak entity/relationship sets. Indicate the cardinality and participation constraints.

[10]

2. In a drive-way restaurant, there are three counters - order, pay, and pickup. Usually when a car enters to the drive-way, a cctv camera notes down the entry time. At the order counter, the customer (driver or passenger of the car) place the order based on the availability or stock of the order item. In the pay counter the customer pays the amount and picks up from the delivery counter. The entire business is maintained in a simple database with following tables. The keys are underlined. For the given schema, please write down the Relational Algebra and SQL of each of the following query.

Stock(itemid, item name, quantity, unit cost, unit profit)

For each item with an item id this table will store the stock (quantity), item name, unit price, and profit from unit sell.

Order(orderid, orderitem, quantity, drivewayin, orderplaced)

For each customer, this table will assign one orderid, ordered item, quantity of the item, time stamp of the cctv at the front gate and the order time stamp.

Pay(transactionid, orderid, amount, paymenttime)

For each order, this table will store the transaction id, payment amount and time of payment corresponding to each order.

Delivery(deliveryid, transactionid, orderid, delivered)

For each orderid, when transaction is done, it will deliver the ordered item and note down the delivery time.

(a). At the end of a day, the manager wishes to know the average wait time in each counter.

RA:

ANS:

SQL

ANS:

(b). At the end of a day, the manager wishes to know, total amount of sell.

RA:

ANS:

SQL:

ANS:

(c). At the end of a day, the manager wishes to know which item is giving more profit?

RA:

ANS:

SQL:

ANS:

(d). At the end of a day, the manager wishes to know which item is out of stock.

RA:

ANS:

SQL:

ANS:

(e). Update the tables after order (check the availability of the item in the stock before you place an order payment and the completing of delivery to a customer.

RA:

ANS:

SQL:

ANS:

3.(a) Functional dependency set F holds on $R(ABCDEF)$: $F = \{AD \rightarrow B, A \rightarrow E, C \rightarrow E, DEF \rightarrow A, F \rightarrow D\}$. What are the candidate keys of R ? Justify your answer. [3]

ANS: FC

Notice that FC is not on the right-hand side of any of the given FDs. This means that any key of R must contain FC. Find the closure of FC to see that $FC \rightarrow R$. Thus, FC is a candidate key. Any other key would be superkey, since a key must contain FC.

3.(b) Functional dependency set F holds on $R(ABCDEFG)$: $F = \{AD \rightarrow F, AE \rightarrow G, DF \rightarrow BC, E \rightarrow C, G \rightarrow E\}$. Derive the following dependencies from F using Armstrong's axioms. [2]

(i) FD1: $G \rightarrow C$

ANS: $G \rightarrow E, E \rightarrow C$

(ii) FD2: $ADC \rightarrow B$

ANS: $AD \rightarrow F, AD \rightarrow DF, DF \rightarrow BC, AD \rightarrow BC, ADC \rightarrow BC, ADC \rightarrow B$

3.(c) Functional dependency set F holds on $R(ABCDEFGH)$: $F = \{BC \rightarrow GH, AD \rightarrow E, A \rightarrow H, E \rightarrow BCF, G \rightarrow H\}$. Decompose R into BCNF by decomposing in the order of the given FDs. Show your work. [3]

ANS:

ADE, BCEF, GH, BCG

BC \rightarrow GH violates BCNF, decompose. Relations: ABCDEF, BCGH

AD \rightarrow E does not violate BCNF because AD is a superkey, skip.

A \rightarrow H No relation contains AH, skip.

E \rightarrow BCF violates BCNF, decompose. Relations: ADE, EBCF, BCGH

G \rightarrow H violates BCNF, decompose. ADE, EBCF, BCG, GH

3.(d).(i) Functional dependency set F holds on $R(ABCDEF)$: $F = \{B \rightarrow D, E \rightarrow F, D \rightarrow E, D \rightarrow B, F \rightarrow BD\}$. Is the decomposition of R into $R_1(ABDE)$, and $R_2(BCDF)$ lossless? Justify. [2]

ANS;

No, it is lossy

$ABDE \cap BCDF = BD$

$BD \rightarrow BDEF$, which is not equivalent to either $ABDE$ or $BCDF$

3.(d).(ii) If the above decomposition is not lossless, what additional functional dependency should hold to make it lossless? Justify your answer. [3]

ANS: Any or all of $BDEF \rightarrow$ Any or all of AC

For example some valid answers were: $B \rightarrow C, B \rightarrow A, BEFD \rightarrow AC$, etc. To be lossless, we want $BD \rightarrow ABDE$ or $BD \rightarrow BCDF$. We know that $BD \rightarrow BDEF$, so either want $BD \rightarrow ABDEF$ or $BD \rightarrow CBDEF$ (or both!). This will be satisfied if $BDEF \rightarrow A$ and/or C

3.(d).(iii) Is the above decomposition dependency preserving? Justify your answer. [2]

ANS: It is not dependency preserving since the dependency $E \rightarrow F$ is not preserved.

4.(a) A relation R has $2n$ attributes (n is an integer ≥ 2) which are named A_1, A_2, \dots, A_{2n} . The functional dependency set F having $2n$ number of functional dependencies holds on R . Each functional dependency is of the form: $A_i \rightarrow A_{1+(i+1) \bmod 2n}$, for $i = 1 \dots 2n$. Here mod is the remainder operator. For example, if $n = 2$, the attributes are A_1, A_2, A_3, A_4 then the dependency set $F = \{A_1 \rightarrow A_3, A_3 \rightarrow A_1, A_2 \rightarrow A_4, A_4 \rightarrow A_2\}$.

(i) Suppose $n = 2$. Obtain a lossless-join and dependency-preserving decomposition of R to BCNF. Show the projections of F into each of the decomposed relations. Justify your answer. [3]

ANS:

$R1(A_1A_3), R2(A_2A_4), R3(A_1A_2)$ with respective projections $\{A_1 \rightarrow A_3, A_3 \rightarrow A_1\}, \{A_2 \rightarrow A_4, A_4 \rightarrow A_2\}$, and ϕ .

(ii) For $n > 2$, what is the number of possible keys in R ? Justify your answer. [3]

ANS: n^2

Justification: All "odd" attributes determine each other. All "even" attributes determine each other. No odd attribute determines an even attribute and vice versa. Thus, to get a key, we need 1 odd and 1 even attribute (n choices each). Thus, the number of keys is $n \times n$.

(iii) In any possible lossless-join and dependency-preserving decomposition of R to BCNF, what is the number of relations with no non-trivial FDs in the projection of F^+ on to it? [3]

ANS: 1

Justification: Any relation that has 3 or more attributes will have either 2 odd or 2 even attributes, which means it will have non-trivial FDs. So, the only kind of relation that has no non-trivial FDs is that which has some key of R as its only attributes. Claim: there will be exactly 1 of such kind in the decomposition. If we have more than 1 of such kind, their join will be lossy. If we have none of such kind, the whole decomposition is lossy because no relation with only odd (or only even) attributes can contain a key of R , and any relation that contains a key of R as a strict subset will violate BCNF.

4.(b) State the conditions under which a relation can be in 3NF but not in BCNF? [3]

ANS:

A relation is in 3NF but not BCNF when it contains a non-trivial functional dependency, $X \rightarrow A$, where X is not a superkey, but A is part of a candidate key.

4.(c) Functional dependency set F holds on $R(ABCDEFG)$: $F = \{AD \rightarrow F, AE \rightarrow G, DF \rightarrow BC, E \rightarrow C, G \rightarrow E\}$. Decompose R into three relation $R1, R2$, and $R3$ which are in 3NF but not in BCNF. Justify your answer. [3]

ANS

$R1(ADF) R2(EC) R3(ABDEG)$.

ROUGH WORK