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| **National University of Computer and Emerging Sciences, Lahore Campus** | | | | |
| C:\Users\saif\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Word\final design.jpg | **Course Name:** | **Database Systems** | **Course Code:** | **CS2005** |
| **Degree Program:** | **BS(Computer Science)** | **Semester:** | **Spring 2022** |
| **Exam Duration:** | **3 Hours** | **Total Marks:** | **80** |
| **Paper Date:** | **Tue 14-Jun-2022** | **Weight** | **50%** |
| **Section:** | **ALL** | **Page(s):** | **11** |
| **Exam Type:** | **Final Exam** | **Total Questions:** | **7** |

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| **Student : Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Roll No.\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Section:\_\_\_\_\_\_\_** |

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| **Instruction/Notes:** | Scratch sheet can be used for rough work however, all the questions and steps are to be shown on question paper. ***No extra/rough sheets should be submitted with question paper***.  You will not get any credit if you do not show proper working, reasoning and steps as asked in question statements. |

**Q1.** *(6+4= 10 points)* Consider the relation schema *R (A, B, C, D, E, G, H)*, with FDs *F = {AD→BG, CD→EHC, BD→G, E→D, G→C, D→G}*.

1. Find a minimal cover of F (i.e. Fc). Show each step.
2. Determine all possible keys (i.e. minimal of super key). Prove it.

**Q2.** *(10 points)* Consider a relation schema *R (A, B, C, D, E)*, with FDs *F = {AB→C, AB→D, D→A, BC→D, BC→E}*. Suppose *{AB}, {BC},* and *{BD}* are the three possible keys of this relation. Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF). Justify your answer. If R is not in BCNF, decompose it into a set of BCNF relations and show your steps. List clearly complete set of BCNF schema relations with all keys and FDs and also indicate which dependencies are not preserved.

**Q3.** *(5 points)* You are given the relation below. You do not know the functional dependencies for this relation *R*, but you can infer by considering the given state.

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|  | **R** | | |  | |  | |
| **A** | | **B** | **C** | | **D** | | **E** | |
| r | | 222 | 4 | | mg | | i | |
| a | | 444 | 1 | | cs | | z | |
| z | | 111 | 2 | | ee | | a | |
| a | | 333 | 1 | | ds | | n | |

Suppose this relation *R* is decomposed into the following two relations: *R1(A, B, C, D)* and *R2(A, C, E)*. Is this decomposition lossless? Justify your answer.

**Q4.** *(10 points)* CUREMED is a new emerging software house that develops software tools for aiding doctors in the treatment of diseases. Consider the following database of the “Researchers at CUREMED” website. The website keeps track of the different researchers and diseases they work on. Each researcher is identified by a unique username and can work on various tools under development. The database maintains a relation TOOL to record the disease for which a tool is being developed. The fields *Did* in TOOLS relation, *Aid* in WorkAssignment relation, and *Rname* in WorkAssignment relation are foreign keys.

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| |  |  |  |  | | --- | --- | --- | --- | |  | **Researcher** | | | | **Rname** | | **Gender** | **Age** | | | Zahid | | M | 42 | | | Ali | | M | 35 | | | Ahmad | | M | 29 | | | Aliya | | F | 27 | | | Tania | | F | 29 | | | Hamza | | M | 34 | |  |  |  |  | | --- | --- | --- | |  | **Disease** | | | **Did** | | **Dname** | | | 1 | | Cancer | | | 2 | | Aids | | | 3 | | Hepatitis | | | 4 | | Arthritis | | | 5 | | Alzheimer | | | |  |  |  | | --- | --- | --- | | **WorkAssignment** | | | | **Aid** | **Rname** | | 10 | Hamza | | 30 | Hamza | | 30 | Zahid | | 70 | Hamza | | 70 | Zahid | | 10 | Zahid | | 20 | Ali | | 20 | Ahmad | | 70 | Tania |  |  |  |  | | --- | --- | --- | | **TOOL** | |  | | **Tid** | **Tname** | **Did** | | 10 | CancerGraphNets | 1 | | 20 | Memory | 5 | | 40 | HelpInAids | 2 | | 30 | BoneCancer | 1 | | 50 | HepatitisDetector | 3 | | 70 | ‎Leukemia | 1 | |
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Write the result of the following queries for the Database State given above. Also, show the intermediate tables. *Explain in one sentence what these queries are doing.*

1. R1 ← **Π** Rname (**s** Age > 30 Researcher )

R2 ← **Π** Aid, Rname (WorkAssignment)

R3 ← **Aid** **ℱCOUNT (Rname)** (R1 \* R2) *Note: Here \* is a symbol of natural join*

1. SELECT R1.Rname AS Researcher1, R2.Rname AS Researcher2

FROM Researcher R1 JOIN Researcher R2 ON R1.Rname != R2.Rname

WHERE NOT EXISTS (

(SELECT Aid FROM WorkAssignment WHERE Rname=R1.Rname)

INTERSECT

(SELECT Aid FROM WorkAssignment WHERE Rname=R2.Rname)

);

**Q5.** *(20 points)* Consider the above database of *Q#5*, write both **SQL and Relation Algebra Queries** for the following tasks:

1. For each disease, print the number of tools being developed for that disease and number of researchers working on those tools.
2. Print the names of the researchers working on **all** the TOOLS for CANCER treatment.

**Q6.** *(10 points)* Map the following ER/EER Diagram into a relational model and specify all the constraints including primary key, foreign key, not null, and unique.

EMPLOYEE

N

1

COURSE

Offered

COURSE OFFERING

N

STAFF

FACULTY

VISITING

PERMANENT

Offered in

SEMESTER

Taught

N

1

1

Pre-Req

1

N

**Q7.** *(15 points)* ABC express is a new transport company that wants to engage in the transport business in Pakistan. ABC express also wants to digitalize its business, and for this purpose, it has hired you as a database designer. The company will not own any vehicle. Instead, the company will borrow vehicles from other individuals or companies.

ABC express will provide two types of transport services: the passenger transport service and the cargo transport service. In order to provide services, ABC express will use two types of vehicles: the bus and the truck. Each vehicle (whether a bus or a truck) will have a license plate number and a year of manufacture. Each bus will also have information about the luggage capacity and the number of seats. A truck will also have information about tonnage and the number of axles. Each vehicle will be owned either by a person or by a company. If a vehicle is owned by a person, then cnic, name and address of that person will be stored in the database, where cnic will be unique. If a vehicle is owned by a company, then the company’s name, its business type, all locations where its offices are located, and ntn (national tax number) will be stored in the database. A company’s name and ntn will be unique.

ABC express will provide transport services on different routes. For each route, we will store the route id, the starting city and the destination city. The route id will be unique. A service will either be a cargo transport service or a passenger transport service. Each service (whether a cargo transport service or a passenger transport service) will have a unique service id, the start time, and the arrival time. For a cargo transport service, we will store information about freight charges per kilogram. For a passenger transport service, we will store the ticket price. There could be more than one service on the same route. If a service is a cargo service, then we will use a truck for this service. Similarly, if a service is a passenger transport service, then we will use a bus. Each truck and bus can provide multiple services. Each vehicle will be engaged in some service. Furthermore, for each service, there will only be one allocated vehicle.

Draw an ER/EER diagram (using notation discussed in lectures) for the above scenario. Specify all constraints that should hold on the database and state any assumptions you make.