CS 261: Database Management Systems
Assignment-1 Solutions

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Note: A question can be answered in several ways depending on your logic and reasoning. Here, I present solutions which are similar to what we had discussed in class. Please do let me know if there are any typos.

Question 1 (Very easy)

Consider the following two relations $R(A, B, C, D)$ and $S(E, F, G, H)$ and the given instances. Write the resultant relation of the following expressions:

R

A	B	C	D
19	60	28	75
21	71	78	15
13	45	77	70
49	54	18	60
51	88	78	63

S

E	F	G	H
69	70	98	75
21	71	48	35
13	55	67	70
49	53	19	40
35	78	78	63
21	71	78	15
13	45	77	70

1. $\pi_{E,H}(\sigma_{(G=78)\vee(F=71)}(S)) - \pi_{B,C}(\sigma_{(A=49)\vee(A=19)}(R))$.

Solution:

E	H
35	63
21	15
21	35

2. $S \bowtie_{F \leq A} R$

Solution:

E	F	G	H	A	B	C	D
13	45	77	70	49	54	18	60
13	45	77	70	51	88	78	63

Question 2 (Easy)

Consider the bank database discussed in class with the same assumptions.

Branch(Name, Assets, City)
Customer(ID, Customer_Name, Street, City)
Loan(Loan_Number, Branch_name, Amount)
Borrower(BC_ID, BL_Number)
Account(Account_Number, AB_name, Balance)
Depositor(DC_ID, A_number)

Write a relational algebraic expression(s) to find the IDs of customers who has the second lowest loan amount.

Solution: To answer this question (regardless of the logic) one has to deal with the relations **Loan** and **Borrower**.

1. Find all the loan numbers (from **Loan** relation) which are not having the lowest loan amount
   $\rho_{TEMP}(Loan\_Amount)(\pi_{Amount}(\textbf{Loan}))$ /* which creates a temporary relation with attribute Loan_Amount */
   $TEMP_1 \leftarrow \sigma_{Amount > Loan\_Amount}(\pi_{Loan\_Number, Amount}(\textbf{Loan}) \times TEMP)$

2. Find the lowest loan amount with loan numbers from $TEMP_1(Loan\_Number, Amount, Loan\_Amount)$ (which is going to be the second lowest loan amount in **Loan**)
   $\rho_{TEMP_2}(Loan\_Amount1)(\pi_{Amount}(TEMP_1))$/* which creates a temporary relation with attribute Loan_Amount1 */
   $TEMP_3 \leftarrow \pi_{Loan\_Number, Amount}(TEMP_1) -$
   $\pi_{Loan\_Number, Amount}(\sigma_{Amount > Loan\_Amount1}(\pi_{Loan\_Number, Amount}(TEMP_1) \times TEMP_2))$

3. Find the all borrower ids
   $\pi_{BC\_ID}(\sigma_{BL\_Number = Loan\_Number}(Borrower \times TEMP_3))$

Question 3 (Hard)

Consider the following relational schema for universities and its affiliated colleges.

University(ID, Name, Address, Website)
Affiliation(University_ID, College_name, City, College_Address, Principal)

Write a TRC expression for the query to *find the ID and Names of all universities with an affiliated college located in every city in which "Delhi University" has an affiliated college.*

Solution: $\{t \mid \exists s \in$ **University**$(t[ID] = s[ID] \wedge t[Name] = s[Name] \wedge (\forall u \in$ **Affiliation**$(u[University\_ID] = s[ID] \wedge s[Name] = "Delhi\ University" \Rightarrow \exists v \in$ **Affiliation**$(u[City] = v[City])))))\}$

Question 4 (Very hard)

For this question, consider our running example of COMPANY database[1] and write a DRC expression for the query: *find the SSNs of employees who belong to "Research" department together with the project numbers of the projects which they work on.*

Solution: We need to use **EMPLOYEE, DEPARTMENT, PROJECT, WORKS_ON** relations to answer the query.

Let $a, b, c, \cdots, r$ denote the attributes (in order) in relations **EMPLOYEE**, followed by **DEPARTMENT**, and so on in the **COMPANY** database. If the attributes in two relations are related via foreign-key constraint, they will be given the same variable name. For example, the attributes DNo and DNumber in **EMPLOYEE** and **DEPARTMENT** will receive the variable j. Thus, the variables associated with attributes SSN, and Pnumber are d, p, respectively. The DRC for the given query is as follows:

$\{< d, p >| \ \exists a, b, c, e, f, g, h, i, j(< a, b, c, d, e, f, g, h, i, j > \in \textbf{EMPLOYEE} \wedge \forall o, q, j(< o, p, q, j > \in \textbf{PROJECT} \wedge \exists k, l, m(< k, j, l, m > \in \textbf{DEPARTMENT} \wedge k = "Research" \Rightarrow \exists r(< d, p, r > \in \textbf{WORKS\_ON})))\}$

[1]Page no. 162, Fundamentals of Database Systems book, 7th edition