Handout 1 Solution

Note: There may be more than one right answer

1. What are the PIDs of the students whose name is "Suri"?
   SQL:
   SELECT PID
   FROM Students
   WHERE Name = "Suri";
   Relational Algebra:
   \( \pi_{PID}(\sigma_{Name = "Suri"}(Students)) \);

2. Which pairs of students live at the same address? It is enough to return the names of such student pairs.
   SQL:
   SELECT S1.Name, S2.Name
   FROM Students S1, Students S2
   WHERE S1.PID < S2.PID AND S1.Address = S2.Address;
   Relational Algebra:
   \( \pi_{S1.Name, S2.Name}(\sigma_{S1.PID < S2.PID} \land S1.Address = S2.Address)(\rho_{S1}(Students) \times \rho_{S2}(Students)) \);
   Here we use \( \sigma_{S1.PID < S2.PID} \) to eliminate duplicates.

3. Which departments have courses that have pre-requisites in other departments?
   SQL:
   SELECT DISTINCT DeptName
   FROM PreReq
   WHERE PreReqDeptName <> DeptName;
   Relational Algebra:
   \( \pi_{DeptName}(\sigma_{PreReqDeptName \neq DeptName}(PreReq)) \);

4. Compute the set of all courses that are their own pre-requisites. The purpose of this query is to ensure that the constraint "A course cannot be a pre-requisite for itself" holds in the database. Your query needs to return only the course number and department name.
   SQL:
   SELECT Number, DeptName
   FROM PreReq
   WHERE Number = PreReqNumber AND DeptName = PreReqDeptName;
   Relational Algebra:
   \( \pi_{Number, DeptName}(\sigma_{PreReqNumber = Number \land DeptName = PreReqDeptName}(PreReq)) \);

5. What are the names and addresses of the students who are taking “CS4604”?
6. What are the courses (specified by course number and department name) that the head of the CS department is teaching?

**SQL:**
```
SELECT Number, DeptName
FROM Departments, Teach
WHERE ChairPID = ProfessorPID AND Name = "CS";
```

**Relational Algebra:**
```
π_{Number, DeptName}(σ_{ChairPID = ProfessorPID ^ Name = "CS"}(Departments \times Teach));
```

7. Return the PID and names of any department head who teaches a course in another department?

**SQL:**
```
SELECT P.Name, DISTINCT PID
FROM Departments D, Professors P, Teach
WHERE ChairPID = ProfessorPID AND D.Name \neq DeptName AND ChairPID = PID;
```

**Relational Algebra:**
```
π_{PID, P.Name}(σ_{ChairPID = ProfessorPID ^ D.Name \neq DeptName ^ ChairPID = PID}(ρ_{D}(Departments) \times ρ_{P}(Professors) \times Teach));
```

8. Are there any students who are taking at least two courses taught by department heads? Identify these students by their PID and name.

**SQL:**
```
SELECT T1.PID, T1.Name
FROM (SELECT T1.PID, T1.Name, Number, DeptName
      FROM Departments, Teach NATURAL JOIN Take, Students T1
      WHERE ChairPID = ProfessorPID AND StudentsPID = T1.PID) T1,
      (SELECT T2.PID, T2.Name, Number, DeptName
      FROM Departments, Teach NATURAL JOIN Take, Students T2
      WHERE ChairPID = ProfessorPID AND StudentsPID = T2.PID) T2
WHERE T1.PID = T2.PID AND T1.Name = T2.Name AND (T1.Number \neq T2.Number OR T1.DeptName \neq T2.DeptName);
```

**Relational Algebra:**
```
π_{T1.PID, T1.Name}(σ_{T1.PID = T2.PID ^ T1.Name = T2.Name ^ T1.Number \neq T2.Number ^ T1.DeptName \neq T2.DeptName}(ρ_{T1.PID, Name, Number, DeptName}(σ_{ChairPID = ProfessorPID ^ StudentsPID = PID}(Departments \times (Teach \bowtie Take) \times Students))) \bowtie \pi_{T1.PID, Name, Number, DeptName}(ρ_{T1.PID, Name, Number, DeptName}(σ_{ChairPID = ProfessorPID ^ StudentsPID = PID}(Departments \times (Teach \bowtie Take) \times Students))));
```
9. Does the PreReq relation have cycles?
Can’t write a query for finding cycles of any length. For length 2 we can do the following:
SQL:
SELECT *
FROM PreReq P1, PreReq P2
WHERE P1.PreReqNumber = P2.number AND P1.PreReqDeptName = P2.DeptName
AND P2.PreReqNumber = P1.number AND P2.PreReqDeptName = P1.DeptName;
Relational Algebra:
\[ \sigma_{P1.\text{PreReqNumber} = P2.\text{number} \land P1.\text{PreReqDeptName} = P2.\text{DeptName} \land P2.\text{PreReqNumber} = P1.\text{number} \land P2.\text{PreReqDeptName} = P1.\text{DeptName}} (\rho_P (\text{PreReq}) \times \rho_P (\text{PreReq})) \]

10. A relation R has one numeric attribute A. What is the largest number in R?
SQL:
SELECT MAX(A)
FROM R;
Relational Algebra:
\[ \gamma_{\text{MAX}(A)} (R) \]

11. Which professors (specify PID, Name, and Department) earn salaries more than any department head?
SQL:
SELECT PID, Name, DepartmentName
FROM Professors
WHERE Salary > ALL (SELECT Salary
FROM Departments, Professors
WHERE ChairPID = PID);
Relational Algebra:
\[ \pi_{\text{PID, Name, DepartmentName}} (\sigma_{\text{Salary} > \text{maxchairsalary}} ((\text{Professors}) \times (\gamma_{\text{MAX(Salary)}} \text{maxchairsalary}) \sigma_{\text{ChairPID} = \text{PID}} (\text{Departments} \times \text{Professors}))) ; \]

12. Which professor (specify PID, Name, and Department) earns the highest salary in each department?
SQL:
SELECT PID, Name, DepartmentName
FROM (SELECT DepartmentName, MAX(Salary) as maxsalary
FROM Professors
GROUP BY DepartmentName) N
NATURAL JOIN Professors
WHERE Salary = maxsalary;
Relational Algebra:
\[ \pi_{\text{PID, Name, DepartmentName}} (\sigma_{\text{Salary} = \text{maxsalary}} (\gamma_{\text{DepartmentName, MAX(Salary)}} \text{maxsalary} (\text{Professors} \bowtie \text{Professors})) ; \]
13. A relation R has one numeric attribute A. The rank of a tuple t in R is the number of tuples in R whose value in A is less than the value of t in A. This question deals with computing the ranks of the tuples in R.

(a) What is the median tuple in R, i.e., if R contains n tuple, what is the tuple with rank n/2.
SQL:
SELECT R1.A
FROM R R1, R R2
WHERE R1.A < R2.A
GROUP BY R1.A
HAVING COUNT(*) = (n/2 - 1);
Relational Algebra:
\[ \pi_{R1.A} (\gamma_{R1.A} (\sigma_{R1.A < R2.A} (\rho_{R1}(R) \times \rho_{R2}(R))))];

(b) Compute the rank of each tuple in R.
SQL:
SELECT R1.A, (COUNT(*)+1) AS rank
FROM R R1, R R2
WHERE R1.A < R2.A
GROUP BY R1.A
Relational Algebra:
\[ \gamma_{R1.A} (\pi_{R1.A, (COUNT(*)+1) rank} (\sigma_{R1.A < R2.A} (\rho_{R1}(R) \times \rho_{R2}(R)))); \]

14. Assuming we have a table Numbers with a single attribute containing all the natural numbers < 100:
SQL:
SELECT A.n, B.n, C.n
FROM Numbers as A, Numbers as B, Numbers as C
WHERE C.n <= 10 AND (A.n \times A.n + B.n \times B.n) = (C.n \times C.n);

15. Find the name of the professor who teaches “CS4604.”
(a) Write the query in relational algebra using a natural join.
\[ \pi_{Name} (\sigma_{Number = 4604 \land DeptName = "CS"} (Professors \bowtie_{PID = ProfessorPID} Teach)); \]

(b) Write the query in relational algebra using intersection. This version of the query has a counterpart in SQL that uses sub-queries.
\[ \pi_{Name} (\sigma_{Number = 4604} (Professors \bowtie_{PID = ProfessorPID} Teach) \cap \sigma_{DeptName = "CS"} (Professors \bowtie_{PID = ProfessorPID} Teach)); \]