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:
   πPID (σName = "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:
   πName1, Name2 (σS1.PID < S2.PID ^ S1.Address = S2.Address (ρS1 (Students) × ρS2 (Students)));
   Here we use σS1.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:
   πDeptName (σPreReqDeptName ≠ 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:
   πNumber, DeptName (σNumber = PreReqNumber ^ DeptName = PreReqDeptName (PreReq));

5. What are the names and addresses of the students who are taking “CS4604”?
   SQL:
SELECT Name, Address
FROM Students, Take
WHERE Number = 4604 AND PID = StudentPID AND DeptName = "CS";

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:
\[ \pi_{\text{Name}, \text{DeptName}} (\sigma_{\text{ChairPID} = \text{ProfessorPID} \land \text{Name} = \text{"CS"}} (\text{Departments} \times \text{Teach})) \]

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 \#\# DeptName AND ChairPID = PID;

Relational Algebra:
\[ \pi_{\text{PID}, \text{Name}} (\sigma_{\text{ChairPID} = \text{ProfessorPID} \land \text{D.Name} \neq \text{DeptName} \land \text{ChairPID} = \text{PID}} (\text{Departments} \times \text{Teach})) \]

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 S.PID, S.Name, Number, DeptName
       FROM Departments, Teach NATURAL JOIN Take, Students S
       WHERE ChairPID = ProfessorPID AND StudentsPID = S.PID) T1,
       (SELECT S.PID, S.Name, Number, DeptName
       FROM Departments, Teach NATURAL JOIN Take, Students S
       WHERE ChairPID = ProfessorPID AND StudentsPID = S.PID) T2
WHERE T1.PID = T2.PID AND T1.Name = T2.Name AND (T1.Number \#\# T2.Name OR T1.DeptName \#\# T2.DeptName);

Relational Algebra:
\[ \pi_{\text{T1.PID}, \text{T1.Name}} \left( \sigma_{\text{T2.PID} = \text{T1.PID} \land \text{T1.Name} = \text{T2.Name} \land \text{T1.DeptName} = \text{T2.DeptName}} \left( \sigma_{\text{ChairPID} = \text{ProfessorPID} \land \text{StudentsPID} = \text{S.PID}} (\text{Departments} \times \text{Teach} \Join \text{Take} \Join \text{Students})) \right) \times \sigma_{\text{T1.PID} = \text{T2.PID} \land \text{T1.Name} = \text{T2.Name} \land \text{T1.DeptName} = \text{T2.DeptName}} (\text{Departments} \times \text{Teach} \Join \text{Take} \Join \text{Students})) \right) \]

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

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:
\[ \pi_{\text{PID, Name, DepartmentName}} (\sigma_{\text{Salary > maxchairsalary}} (\gamma_{\text{MAX}} (\sigma_{\text{ChairPID = PID}} (\text{Departments} \times \text{Professors}))))\];

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)
NATURAL JOIN Professors
WHERE Salary = maxsalary;
Relational Algebra:
\[ \pi_{\text{PID, Name, DepartmentName}} (\sigma_{\text{Salary = maxsalary}} (\gamma_{\text{DepartmentName, MAX(Salary)}} (\text{Professors} \bowtie \text{Professors})))\];

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:
\[ \gamma_{R1.A \times COUNT(*)+1} (\sigma_{R1.A < R2.A} (\rho_{R1}(R) \times \rho_{R2}(R))); \]

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.
\[ \pi_{Name} (\sigma_{Number = 4604} (Professors \bowtie PID = ProfessorPID Teach) \cap \sigma_{DeptName = “CS”} (Professors \bowtie PID = ProfessorPID Teach)); \]