Student Name:_____
Student ID: _____

CSC3170 Introduction to Database Systems (Spring 2015)
Assignment 2

Please answer all the questions below and hand in your answer to the submission box at the 10/F of SHB ***on or before 27th February 2015 4:00pm***

Consider the following relations containing airline flight information:
Flights(*flno*: integer, from: string, to: string, distance: integer, departs: time, arrives: time)
Aircraft(*aid*: integer, aname: string, cruisingrange: integer)
Employees(*eid*: integer, ename: string, salary: integer)
Certified(*eid*: integer, *aid*: integer)

Note that the Employees table describes pilots and other kinds of employees as well; every pilot is certified for some aircraft (otherwise, he or she would not qualify as a pilot), and only pilots are certified to fly.

Write the following queries in relational algebra. Note that some of these queries may not be expressible in relational algebra. For such queries, please informally explain why they cannot be expressed.

1. Find the *eid*s and the enames of pilots certified for some Boeing aircraft.
   $\Pi_{eid,ename}(\sigma_{aname='Boeing'}(Aircraft) \bowtie Certified \bowtie Employee)$

2. Find the *aid*s of all aircraft that can be used on non-stop flights from Bonn to Madrid.
   $\Pi_{aid}(\sigma_{from='Bonn' \wedge to='Madrid'}(Flights) \bowtie_{cruisingrange>distance} Aircraft)$

3. Find the *flno*s of flights that can be piloted by at least one pilot whose salary is more than $100,000.
   This cannot be expressed as there are no relations that link flight and aircraft together directly **OR**

   $\Pi_{flno}(\sigma_{salary>100,000}(Employees) \bowtie Certified \bowtie Aircraft \bowtie_{cruisingrange>distance} Flights)$
   (Assume that there are not indirect flights)

4. Find the *ename*s of pilots who can operate planes with a range greater than 3,000 miles but are not certified on any Boeing aircraft.
   $\rho(R1, \Pi_{eid}(\sigma_{cruisingrange>3,000}(Aircraft) \bowtie Certified))$
   $\rho(R2, \Pi_{eid}(\sigma_{aname='Boeing'}(Aircraft) \bowtie Certified))$
   $\Pi_{ename}((R1 - R2) \bowtie Employees)$

5. Find the *eid*s of employees who make the highest salary.
   $\rho(R1, Employees)$
   $\rho(R2, Employees)$
   $\Pi_{eid}(Employees) - \Pi_{R2.eid}(R1 \bowtie_{R1.salary>R2.salary} R2)$

6. Find the *eid*s of employees who make the second highest salary.

$\rho(R1, Employees)$

$\rho(R2, Employees)$

$\rho(R3, \Pi_{R2.eid,R2.salary}(R1 \bowtie_{R1.salary>R2.salary} R2)$

$\rho(R4, R3)$

$\rho(R5, \Pi_{R4.eid}(R3 \bowtie_{R3.salary>R4.salary} R4)$

$\Pi_{eid}(R3) - R5$

7. Find the *eid*s of employees who are certified for the largest number of aircraft.
This cannot be expressed in relational algebra because there is no operator to count.

8. Find the *eid*s of employees who are certified for exactly three aircraft.

$\rho(R1, Certified)$

$\rho(R2, Certified)$

$\rho(R3, Certified)$

$\rho(R4, Certified)$

$\rho(R5, \sigma_{(R1.eid=R2.eid=R3.eid)\wedge(R1.aid\neq R2.aid\neq R3.aid)}(R1 \times R2 \times R3))$

$\rho(R6, \sigma_{(R1.eid=R2.eid=R3.eid=R4.eid)\wedge(R1.aid\neq R2.aid\neq R3.aid\neq R4.aid)}(R1 \times R2 \times R3 \times R4))$

$\Pi_{eid}(R5) - \Pi_{eid}(R6)$

9. Find the total amount paid to employees as salaries.
This cannot be expressed in relational algebra because there is no operator to sum values.