Home Work #3

1. Consider the following relational schema for airline flights. **Primary keys** are underlined; **foreign keys** are implied by identically named attributes.

   FLIGHTS (*Flnum*, *Origin*, *Destination*, *Distance*, *Departure*, *Arrival*)
   AIRCRAFT (*AId*, *Range*, *Manufacturer*)
   CERTIFIED (*EId*, *AId*)
   EMPLOYEES (*EId*, *Ename*, *Salary*)

   We are told that the EMPLOYEES relation contains not only pilots but also other kinds of employees. However, only pilots are certified to fly and each pilot is certified for at least one aircraft. The CERTIFIED relation lists, for each pilot, which aircraft(s) he / she is certified for. In FLIGHTS, the attributes are the flight number, the three-letter codes for the origin and destination airports, the distance between those two airports, and finally the departure and arrival times.

   In the AIRCRAFT relation, *range* represents the maximum distance (in miles) the aircraft can fly non-stop; *manufacturer* is the company that has made the aircraft; below, we use the expression *Boeing aircraft* to mean an aircraft whose manufacturer is the *Boeing* company.

   - Write the following queries in relational algebra. You may break up a complex expression by assigning subexpressions to new relation names.
   - You may use non-relational operators **only when** relational operators are inadequate; explain informally why it is necessary to go beyond relational algebra.

§1. Find the names of pilots certified for some (i.e., at least one) Boeing aircraft.

$\pi_{\text{Ename}}(\sigma_{\text{Aircraft.manufacturer=Boeing}}(\text{Aircraft} \bowtie (\text{Certified} \bowtie \text{Employees})))$

§2. List the manufacturers of all aircrafts we know about (in the *Aircraft* relation).

$\pi_{\text{Manufacturer=Boeing}}\text{Aircraft}$

§3. Find the *AIds* of all aircrafts that can be used on non-stop flights from IAD (Washington, D.C.) to DEL (New Delhi).

$\pi_{\text{AId}}(\sigma_{\text{range>Distance}}(\text{Aircraft X }(\pi_{\text{Distance}}(\sigma_{\text{Origin=IAD} \wedge \text{Destination=DEL}}\text{ Flights}))$

§4. Identify the flights (by their *Flnum*) that can be piloted by *every* pilot whose salary is less than $80,000.

$\pi_{\text{Flnum}}((\pi_{\text{Flnum}}(\text{Flights})) \text{ X } (\sigma_{\text{Salary<80,000}}(\text{Certified} \bowtie \text{Employees})))$

§5. Find the *EIds* of employee(s) who earn the highest salary.
Hint: Focus on those who don't.

$\rho_{salary\text{->}salary1}(\pi_{salary1}((\text{Employees x Employees}) - \sigma_{salary1 < salary2}$
$(\pi_{salary\text{->}salary1}(\text{Employees}) \text{ x } \pi_{salary\text{->}salary2}(\text{Employees}))))$

§6. Find the *EIds* of employees who are certified for exactly two aircrafts.
Hint: Can you find those certified for *two or more* and those for *three or more*?

$\pi_{EId}(\sigma_{Count\_AId=2}$ $(\gamma_{EId,\ Count(AId)}\text{Certified}))$
Count operator is needed due to relational algebra not being able to count the number of tuples.

§7. Find the total amount paid to pilots as salaries.

$\gamma_{SUM(Salary)}\text{Employees}$
Necessary due to the addition of salaries that can't be performed in relational algebra.

2. R_1 and R_2 are two relations whose current instances contain N_1 and N_2 tuples respectively, where $N_2 > N_1 > 0$.

- What are the maximum and minimum possible sizes (in number of tuples) for the relation produced by each of the following relational algebra expressions?
- For each, state any assumption you need to make about the schemas of R_1 and R_2 in order to make the expression meaningful.

§1. $R_1 \cup R_2$

Max Size = N1 + N2
Min Size = N1
Assumptions:
R1 Has the same schema as R2

§2. $R_1 - R_2$

Max Size = N1
Min Size = 0

§3. $R_1 \times R_2$

Max size = N1*N2
Min Size = N1

§4. $\sigma_{a>2}(R_1)$

Max Size = N1
Min Size = 0

§5. $R_1 \div R_2$

Max Size = N1
Min Size = 1

3. The current snapshot of relation $R(A, B)$ is the following.

R

A	B
a_1	b_1
a_1	b_2
a_2	b_1
a_3	b_4

Compute the following two join queries on the above snapshot.

(a)

$$R \bowtie R$$

A	B
a_1	b_1
a_1	b_2
a_2	b_1
a_3	b_4

(b)

$$R \underset{A=A}{\bowtie} R$$

A	B
a_1	b_1
a_1	b_2

a_2	b_1
a_3	b_4