Extended relational algebra

Union: $R \cup S$ (sum of appearances)
Intersection: $R \cap S$ (minimum of appearances)
Difference: R - S (difference of appearances)
Selection: $\sigma_C(R)$ (where C is a condition)
Projection: $\pi_L(R)$ (in L: arithmetic, renaming)
Product: $R \times S$
Join: $R \bowtie S$ ($R \bowtie_\theta S$) (where θ is a condition)
Duplicate elimination: $\delta(R)$
Grouping and aggregation: $\gamma_L(R)$
(in L: grouping expressions and aggregated expressions, plus renaming)
Sorting: $\tau_L(R)$

Examples:

$\pi_{A,B+C->X}(R)$	`SELECT A, B+C AS X FROM R;`
$\delta(R)$	`SELECT DISTINCT * FROM R;`
$R \bowtie S$	`SELECT * FROM R NATURAL JOIN S;`
$R \bowtie_\theta S$	`SELECT * FROM R JOIN S ON (θ);`
$R \times S$	`SELECT * FROM R CROSS JOIN S; or SELECT * FROM R, S;`
$\gamma_{A,SUM(B)}(R)$	`SELECT A, SUM(B) FROM R GROUP BY A;`
$\gamma_{A,COUNT(B)}(\delta \pi_{A,B} R)$	`SELECT A, COUNT(DISTINCT B) FROM R GROUP BY A;`
$\tau_{A, B+C}(R)$	`SELECT * FROM R ORDER BY A, B+C;`

Complex example query in SQL and extended relational algebra:

```
SELECT dname, AVG(sal) + 100 sal_plus
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY dname
HAVING COUNT(empno) > 3
ORDER BY dname;
```

$\tau_{dname}(\pi_{dname,av+100->sal\_plus}(\sigma_{cnt>3}(\gamma_{dname,AVG(sal)->av,COUNT(empno)->cnt}(\sigma_{E.deptno=D.deptno}(Emp \times Dept)))))$

Exercise 1.

We have R(A,B,C) and S(C,D) relations. Rewrite the following extended relational algebra expressions into SQL.

$\gamma_{A,AVG(D)}(\sigma_{B >= 2}(R \times S)$

$\Pi_A (\sigma_{AV > 10}(\gamma_{A,AVG(D)->AV}(R \bowtie S)))$

$\delta (\Pi_A (\sigma_{R.C = S.C} (R \times S)))$

$\tau_A(\Pi_{A,C}(\sigma_{B = 2}(R)$

Exercise 2.

Rewrite the following SQL queries into extended relational algebra.

```
SELECT A, AVG(D) FROM R, S WHERE R.B >=2 GROUP BY A;
SELECT A FROM R NATURAL JOIN S GROUP BY A HAVING AVG(S.D)>10;
SELECT DISTINCT A FROM R, S WHERE R.C = S.C;
SELECT A, C FROM R WHERE B = 2 ORDER BY A;
```

Exercise 3.

List the employees who have maximal salary within their own department. Give the department number, employee name and salary for them. (**deptno, ename, sal**)

T := $\gamma_{deptno,Max(sal)->ms}$(Emp); E:= Emp

$\sigma_{T.deptno=E.deptno\ AND\ E.sal = ms}$(T x E)

```
SELECT e.deptno, ename, sal
FROM emp e, (SELECT deptno, MAX(sal) ms FROM emp GROUP BY deptno) t
WHERE e.deptno = t.deptno and e.sal = ms;
```

Exercise 4.

We have the following relation (multiset meaning).

R(A,B,C): {(X,1,2), (Y,2,3), (Y,3,4), (X,1,5), (Y,3,5), (X,4,2), (X,4,4)}

An equivalent, visually more convenient notation:

R (A, B, C)

A	B	C
X	1	2
Y	2	3
Y	3	4
X	1	5
Y	3	5
X	4	2
X	4	4

Compute the result of the following expressions:

$\gamma_{A,AVG(C)}(\sigma_{B >= 2}R)$ {(X,3), (Y,4)}

$\gamma_{A,B,SUM(C)}(R)$ {(X,1,7), (Y,2,3), (Y,3,9), (X,4,6)}

$\gamma_{A,SUM(B),SUM(C)}(R)$ {(X,10,13), (Y,8,12)}

$\tau_{B,A}\ \Pi_{A,B}(\sigma_{C >= 4}\ R)$ {(X,1), (Y,3), (Y,3), (X,4)}

$\delta(\Pi_{A,B}(\sigma_{B >= 2}\ R))$ {(Y,2), (Y,3), (X,4)}

$\gamma_{A,SUM(E)}(\Pi_{A,B*C->E}\ R)$ {(X,31), (Y,33)}

Exercise 5.

We have the following two relations:

R(A,B): {(0,1), (2,3), (0,1), (2,4), (3,4)}

S(B,C): {(0,1), (2,4), (2,5), (3,4), (0,2), (3,4)}

Compute the result of the following expressions:

a) $\pi_{A+B,A*A,B*B}(R)$

b) $\pi_{B+1,C-1}(S)$

c) $\tau_{B,A}(R)$

d) $\tau_{B,C}(S)$

e) $\delta(R)$

f) $\gamma_{sum(B)}(R)$ {(13)}

g) $\gamma_{A,sum(B)}(R)$ {(0,2), (2,7), (3,4)}

h) $\gamma_{B,avg(C)}(S)$ {(0,1.5), (2,4.5), (3,4)}

!i) $\gamma_{A}(R)$ {(0), (2), (3)}

!j) $\gamma_{A,max(C)}(R \bowtie S)$ {(2,4)}

!k) $\gamma_{sum(E)}(\pi_{A+B->E,A*A->F,B*B->G}(R))$ {(20)}

!l) $\gamma_{G,sum(E)}(\pi_{A+B->E,A*A->F,B*B->G}(R))$ {(1,2), (9,5), (16,13)}