Since we didn’t get to cover relational algebra (RA) on a problem set, we’re providing this notebook so you can get some practice in before the final exam. Solutions will be posted in a separate notebook- try doing these on your own first, then take a look at the solutions to check your understanding!

In particular, you should understand:

• How to go from SQL query → RA expression
• How to go from RA expression → SQL query
• How to optimize an RA expression by commuting operators

Note that some of the problems here will be slightly more involved than what would be on the exam!

Consider relations \( R(A,B) \), \( S(B,C) \), \( T(C,D) \) and \( U(D,E) \) for the below examples.

1 SQL → RA

Let’s go through some examples where we’ll translate SQL to Relational Algebra. For each of the below queries, translate them from SQL into RA.

1.1

```sql
SELECT DISTINCT *
FROM R
WHERE R.A = 2;
```

1.2

```sql
SELECT DISTINCT S.B
FROM S
WHERE S.C = 4;
```

1.3

```sql
SELECT DISTINCT R.A, S.C
FROM R, S
WHERE R.B = S.B;
```

1.4

```sql
SELECT DISTINCT R.A, T.D
FROM R, S, T
WHERE R.B = S.B AND S.C = T.C AND R.A = 2 AND S.B = 0;
```
1.5
SELECT DISTINCT R.A
FROM R
WHERE R.B = 0 OR R.B = 2;

1.6
SELECT DISTINCT R.A
FROM R
WHERE R.B <> 2;

1.7
SELECT DISTINCT R.B, U.E
FROM R, S, T, U
WHERE R.B = S.B AND S.C = T.C AND T.D = U.D
AND (S.C = 2 OR T.D = 4) AND U.D <> 2;

2 RA → SQL

Now we’ll go through some examples where we’ll translate Relational Algebra to SQL.

2.1
σ_{B=0}(Π_{B}(S(B,C)))

2.2
Π_{A,E}(σ_{A=2}(σ_{C=0}(R(A,B) \bowtie_{B} (S(B,C) \bowtie_{C} (T(C,D) \bowtie_{D} U(D,E))))))

2.3
Π_{A,C}(((σ_{B=0}(R(A,B))) \bowtie_{B} (S(B,C) \bowtie_{C} (σ_{C=0}(T(C,D))))

2.4
((σ_{A=2}(R(A,B))) \cup (σ_{A=4}(R(A,B)))) \bowtie_{B} ((σ_{C=2}(S(B,C))) - (σ_{B=1}(S(B,C))))

3 Optimization of RA Expressions

In this section, we’ll optimize RA expressions, i.e. reduce the total IO cost of executing them.

3.1
Π_{D}(T(C,D) \bowtie_{D} U(D,E))

3.2
σ_{A=2}(Π_{A,C}(R(A,B) \bowtie_{B} S(B,C))

3.3
σ_{C=0}(Π_{A,C}(σ_{B=0}(( ( R(A,B) ) \bowtie_{B} ( S(B,C) ) ) \bowtie_{C} ( T(C,D) )))))
3.4

\[ \sigma_{C=0}(\Pi_{C}(\sigma_{D=2}(\sigma_{A=3}(( R(A,B) ) \ltimes_{B} (( S(B,C) ) \ltimes_{C} ( T(C,D) ) ))))) \]