

Databases and Information Systems 2025

Mandatory Assignment 2

a.k.a. everything you (n)ever wanted to know about the computer shop

Exercise 1. *Calculus vs. Algebra*

Consider the following three abstract relations, with the following schema:

$P(x:\text{int}, y:\text{int}, z:\text{int}) \quad Q(x:\text{int}, y:\text{int}) \quad R(x:\text{int}, y:\text{int})$

1. For each of the next relational calculus formulas, give an equivalent relational algebra expression:

- | | |
|---|---|
| a) $P(x, y, z) \wedge Q(x, y)$ | e) $Q(x, y) \wedge \neg R(x, y)$ |
| b) $Q(x, y) \wedge R(y, z)$ | f) $P(x, y, z) \wedge \neg R(x, y)$ |
| c) $P(x, y, z) \vee P(z, x, y)$ | g) $Q(x, y) \wedge \neg R(x, x)$ |
| d) $P(x, y, z) \wedge (\exists x. Q(x, z))$ | h) $(\exists x. \exists y. (P(x, y, z) \wedge Q(x, z))) \wedge R(x, y)$ |

2. For each of the next relational algebra expressions, give an equivalent relational calculus formula. If needed, introduce new variable names in formulas to disambiguate different columns that have the same name in the result of the relational algebra expressions.

- | | |
|--------------------------------------|---|
| a) $Q \times R$ | c) $Q \bowtie \rho_{S(y,z)}(\sigma_{x=y}(R))$ |
| b) $\pi_x(\sigma_{x=y \vee x=z}(P))$ | d) $P \cap (\pi_{x,y,x \rightarrow s}(Q \cup R))$ |

Exercise 2. *Relational Algebra*

Consider the familiar database schema of a computer shop that consists of four relations:

```
Product(maker:string, model:int, type:string)
PC(model:int, speed:float, ram:int, hd:int, price:int)
Laptop(model:int, speed:float, ram:int, hd:int, screen:float, price:int)
Printer(model:int, color:bool, type:string, price:int)
```

Formulate (extended) **relational algebra expressions** to answer the following queries. Use the relational algebra calculator (<https://dbis-uibk.github.io/relax/calc/local/uibk/local/3>) to evaluate your expressions. Draw the expression trees for the queries e) and i).

- Find the *overpriced* PCs. Those are PCs that are more expensive and at the same time worse than some other PC in at least two out of three categories (speed, ram, hd; bigger is better).
- Find those PCs that are faster (in terms of speed) than any laptop.
- Find the makers, models, and prices of all offered devices.
- Find the most expensive device manufactured by each maker.
- Find PC-laptop pairs that are equally fast.
- Find laptops that cost more than the average laptop price.
- For every hard disk size (present in the PC table) compute the number of PCs of that size and their average price. Sort the result by the hard disk size (in ascending order).
- For each printer type, find the most and the least expensive model.
- The *body mass index (BMI)* of a computer is its hard disk size divided by the square of its speed. Compute the BMI for each computer (PC and Laptop).

Exercise 3. *SQL Queries*

We continue the exploration of our favorite computer shop now using SQL. Write (and evaluate) **SQL queries** to answer the following queries. To evaluate your queries, download the schema and the example database from Absalon (file `product_p.sql`) and import it into PostgreSQL, e.g., by executing `psql < product_p.sql`.

- a) Find the model number, speed, and hard-disk size for all PCs whose price is under \$1000 where you rename the speed column to GHz and the hd column to GB.
- b) Find the manufacturers of printers.
- c) Find the manufacturer and speed of laptops with a hard disk of at least thirty gigabytes.
- d) Find the model number and price of all products (of any type) made by manufacturer B.
- e) Find those manufacturers that sell Laptops, but not PCs.
- f) Find the laptops whose speed is slower than that of any PC.
- g) Find the maker of the color printer with the lowest price.
- h) Find the model numbers, and the price of the computers (PC or laptop) with the highest speed.
- i) Find for each manufacturer, the average screen size of its laptops.
- j) Find the manufacturers that make at least three different models of PC.
- k) Find for each manufacturer who sells PCs the maximum price of a PC.
- l) Find the average hard disk size of a PC for all those manufacturers that make printers.

Exercise 4. *SQL Modifications*

For the same database schema (and example database), write (and evaluate) the following database modifications, based on the database schema. After executing each of your modifications, you should restore the original database state, e.g., by re-executing `psql < product_p.sql`.

- a) Using two INSERT statements, store in the database the fact that PC model 1100 is made by manufacturer C, has speed 3.2, RAM 1024, hard disk 180, and sells for \$2499.
- b) Delete all PCs with less than 100 gigabytes of hard disk.
- c) Delete all laptops made by a manufacturer that does not make printers.
- d) Manufacturer A acquires manufacturer B. Change all of B's products, so they are now made by A.
- e) For each PC, double the amount of RAM and add 60 gigabytes to the amount of hard disk.
- f) For each laptop made by manufacturer B, add one inch to the screen size and subtract \$100 from the price.
- g) Enough! Delete all products!