

TUTORIAL 2 WITH ANSWERS

Exercise 1 Consider the database whose tables are created by the following statements:

- *CREATE TABLE Product (maker VARCHAR(25), model VARCHAR(15) PRIMARY KEY, type CHAR(25)).*
- *CREATE TABLE PC (model VARCHAR(15) PRIMARY KEY, speed DECIMAL(4,2), ram INTEGER, hd INTEGER, price DECIMAL(7,2)).*
- *CREATE TABLE Laptop (model VARCHAR(15) PRIMARY KEY, speed DECIMAL(4,2), ram INTEGER, hd INTEGER, screen DECIMAL(3,1), price DECIMAL(7,2)).*
- *CREATE TABLE Printer (model VARCHAR(15) PRIMARY KEY, color BOOLEAN, type CHAR(10), price DECIMAL(7,2)).*

The tables for these relations are shown in the next page.

For each of the following queries write an expression of relational algebra to answer the query and write the tuples of the result of the query.

1. What PC models have a speed of at least 3.00?
2. Which manufacturers make laptops with a hard disk of at least 100GB?
3. Find the model number and price of all products (of any type) made by manufacturer B.
4. Find the model numbers of all color laser printers.
5. Find those manufacturers that sell Laptops, but not PC's.
6. Find those hard-disk sizes that occur in two or more PC's.
7. Find those pairs of PC models that have both the same speed and RAM. A pair should be listed only once; e.g., list (i, j) but not (j, i) .

Remark. In order to simplify the notation you could write complicated expressions in multiple steps instead of a single line. For example the expression

$$\pi_{title, year}(\sigma_{length \geq 100}(Movies) \cap \sigma_{studioName = 'Fox'}(Movies))$$

can be written as:

$$R_1 = \sigma_{length \geq 100}(Movies), \quad R_2 = \sigma_{studioName = 'Fox'}(Movies),$$

$$R_3 = R_1 \cap R_2, \quad R_4 = \pi_{title, year}(R_3).$$

Or the expression

$$\pi_{title, year}(\sigma_{(length \geq 100 \text{ AND } studioName = 'Fox')}(Movies)).$$

can be written as: $C = (length \geq 100 \text{ AND } studioName = 'Fox')$,

$$R_1 = \sigma_C(Movies), \quad R_2 = \pi_{title, year}(R_1).$$

<i>maker</i>	<i>model</i>	<i>type</i>
A	1001	pc
A	1002	pc
A	1003	pc
A	2004	laptop
A	2005	laptop
A	2006	laptop
B	1004	pc
B	1005	pc
B	1006	pc
B	2007	laptop
C	1007	pc
D	1008	pc
D	1009	pc
D	1010	pc
D	3004	printer
D	3005	printer
E	1011	pc
E	1012	pc
E	1013	pc
E	2001	laptop
E	2002	laptop
E	2003	laptop
E	3001	printer
E	3002	printer
E	3003	printer
F	2008	laptop
F	2009	laptop
G	2010	laptop
H	3006	printer
H	3007	printer

<i>model</i>	<i>speed</i>	<i>ram</i>	<i>hd</i>	<i>price</i>
1001	2.66	1024	250	2114
1002	2.10	512	250	995
1003	1.42	512	80	478
1004	2.80	1024	250	649
1005	3.20	512	250	630
1006	3.20	1024	320	1049
1007	2.20	1024	200	510
1008	2.20	2048	250	770
1009	2.00	1024	250	650
1010	2.80	2048	300	770
1011	1.86	2048	160	959
1012	2.80	1024	160	649
1013	3.06	512	80	529

(a) Sample data for relation PC

<i>model</i>	<i>speed</i>	<i>ram</i>	<i>hd</i>	<i>screen</i>	<i>price</i>
2001	2.00	2048	240	20.1	3673
2002	1.73	1024	80	17.0	949
2003	1.80	512	60	15.4	549
2004	2.00	512	60	13.3	1150
2005	2.16	1024	120	17.0	2500
2006	2.00	2048	80	15.4	1700
2007	1.83	1024	120	13.3	1429
2008	1.60	1024	100	15.4	900
2009	1.60	512	80	14.1	680
2010	2.00	2048	160	15.4	2300

(b) Sample data for relation Laptop

<i>model</i>	<i>color</i>	<i>type</i>	<i>price</i>
3001	true	ink-jet	99
3002	false	laser	239
3003	true	laser	899
3004	true	ink-jet	120
3005	false	laser	120
3006	true	ink-jet	100
3007	true	laser	200

(c) Sample data for relation Printer

Figure 20: Sample data for Product

Answer.

$$1. R_1 = \sigma_{speed \geq 3.00}(PC), \quad R_2 = \pi_{model}(R_1).$$

<i>model</i>
1005
1006
1013

$$2. R_1 = \sigma_{hd \geq 100}(Laptop), \quad R_2 = Product \bowtie R_1, \\ R_3 = \pi_{maker}(R_2).$$

<i>maker</i>
E
A
B
F
G

$$3. R_1 = \sigma_{maker='B'}(Product \bowtie PC), \quad R_2 = \sigma_{maker='B'}(Product \bowtie Laptop), \\ R_3 = \sigma_{maker='B'}(Product \bowtie Printer), \quad R_4 = \pi_{model, price}(R_1), \\ R_5 = \pi_{model, price}(R_2), \quad R_6 = \pi_{model, price}(R_3) \\ R_7 = R_4 \cup R_5 \cup R_6.$$

<i>model</i>	<i>price</i>
1004	649
1005	630
1006	1049
2007	1429

$$4. C = (color = true \text{ AND } type = 'laser'), \\ R_1 = \sigma_C(Printer), \quad R_2 = \pi_{model}(R_1).$$

<i>model</i>
3003
3007

$$5. R_1 = \sigma_{type='laptop'}(Product), \quad R_2 = \sigma_{type='PC'}(Product), \\ R_3 = \pi_{maker}(R_1), \quad R_4 = \pi_{maker}(R_2) \\ R_5 = R_3 \setminus R_4.$$

<i>maker</i>
F
G

6. $R_1 = \rho_{PC1}(PC)$, $R_2 = \rho_{PC2}(PC)$,
 $C = (PC1.hd = PC2.hd \text{ AND } PC1.model \neq PC2.model)$,
 $R_3 = R_1 \bowtie_C R_2$
 $R_4 = \pi_{hd}(R_3)$.

<i>hd</i>
250
80
160

7. $R_1 = \rho_{PC1}(PC)$, $R_2 = \rho_{PC2}(PC)$,
 $C = (PC1.speed = PC2.speed \text{ AND } PC1.ram = PC2.ram \text{ AND } PC1.model < PC2.model)$,
 $R_3 = R_1 \bowtie_C R_2$
 $R_4 = \pi_{(PC1.model, PC2.model)}(R_3)$.

<i>PC1.model</i>	<i>PC2.model</i>
1004	1012

Exercise 2 Express the following constraints about the relations *Product*, *PC*, *Laptop*, *Printer* seen before. Indicate the tuples that violate these constraints.

- A PC with a processor speed less than 2.00 must not sell for more than \$500.
- A laptop with a screen size less than 15.4 inches must have at least a 100 gigabyte hard disk or sell for less than \$1000.
- No manufacturer of PC's may also make laptops.
- If a laptop has a larger main memory than a PC, then the laptop must also have a higher price than the PC.
- A manufacturer of a PC must also make a laptop with at least as great a processor speed.

Answer.

- a) $C = (speed < 2 \text{ AND } price > 500)$, $\sigma_C(PC) = \emptyset$.

Tuples that violate the constraint:

<i>model</i>
1011

- b) $C = (screen < 15.4 \text{ AND } hd < 100 \text{ AND } price \geq 1000), \quad \sigma_C(Laptop) = \emptyset.$

Tuples that violate the constraint:

<i>model</i>
2004

- c) $\pi_{maker}(\sigma_{type='laptop'}(Product)) \cap \pi_{maker}(\sigma_{type='pc'}(Product)) = \emptyset.$

Tuples that violate the constraint:

<i>maker</i>
A
B
E

- d) $C = (Laptop.ram > PC.ram \text{ AND } Laptop.price \leq PC.price),$

$$\pi_{model}(\sigma_C(PC \times Laptop)) = \emptyset.$$

Tuples that violate the constraint:

<i>model</i>
2002
2006
2008

- e) $R_1 = \pi_{maker,model,speed}(Product \bowtie PC), \quad R_2 = \pi_{maker,speed}(Product \bowtie Laptop),$

$$C = (R_1.maker = R_2.maker \text{ AND } R_1.speed \leq R_2.speed)$$

$$R_3 = \pi_{model}(R_1 \bowtie_C R_2), \quad R_4 = \pi_{model}(PC).$$

The constraint is $R_4 \subset R_3.$

Tuples that violate the constraint:

<i>maker</i>
B
C
D