Relational Algebra
Query Execution Trees

Relational Algebra Operators

- Projection **π**
- Selection **σ**
- Duplicate elimination **δ**
- Sorting **τ**
- GroupBy aggregations **γ**
- Set operations **U, ∩, -**
- Product **x**
- Join **⋈**

- Every operator takes as input one or two tables and generates as output a table
  - Schema
  - Tuples
- Operators are composable
  - The output of one operator is the input of another operator

Relational Algebra Expressions

- Sequence of relational algebra operators
  - Input is a set of tables
  - Output is the result table
- Relational algebra expression = Query

- $S_1(M,S,R,H,Sc,P) = \sigma_{H>=100}(Laptop(M,S,R,H,Sc,P))$

  $S_2(Ma,M,T,S,R,H,Sc,P) = Product(Ma,M,T) \bowtie S_1(M,S,R,H,Sc,P)$

  $R(maker) = \pi_{Ma}(S_2(Ma,M,T,S,R,H,Sc,P))$
- $R(maker) = \pi_{maker}(Product \bowtie \sigma_{hd>=100}(Laptop))$

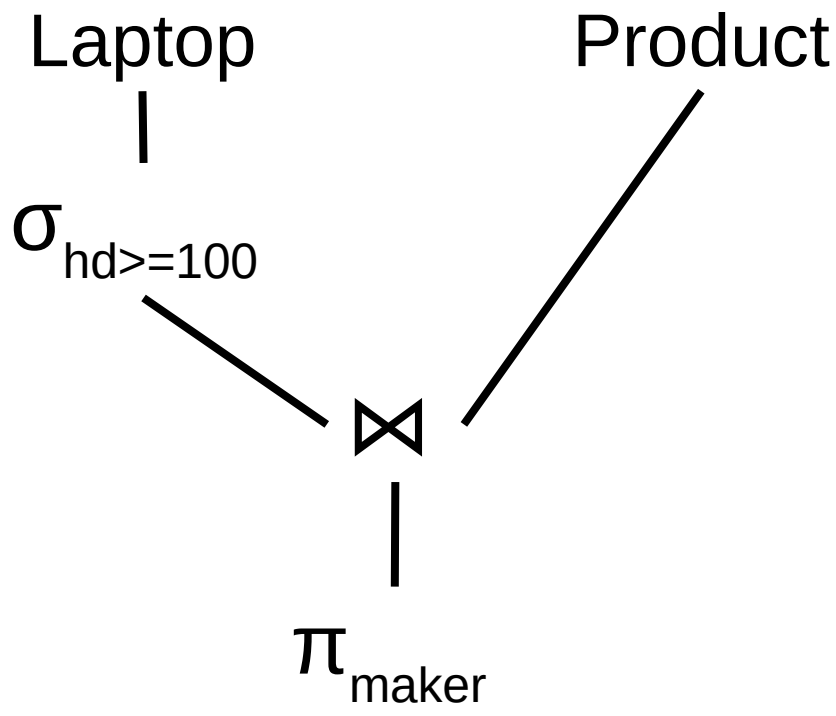
Relational Algebra Expressions ↔ Query Execution Trees

- $S_1(M,S,R,H,Sc,P) = \sigma_{H>=100}(Laptop(M,S,R,H,Sc,P))$

  $S_2(Ma,M,T,S,R,H,Sc,P) = Product(Ma,M,T) \bowtie S_1(M,S,R,H,Sc,P)$

  $R(maker) = \pi_{Ma}(S_2(Ma,M,T,S,R,H,Sc,P))$

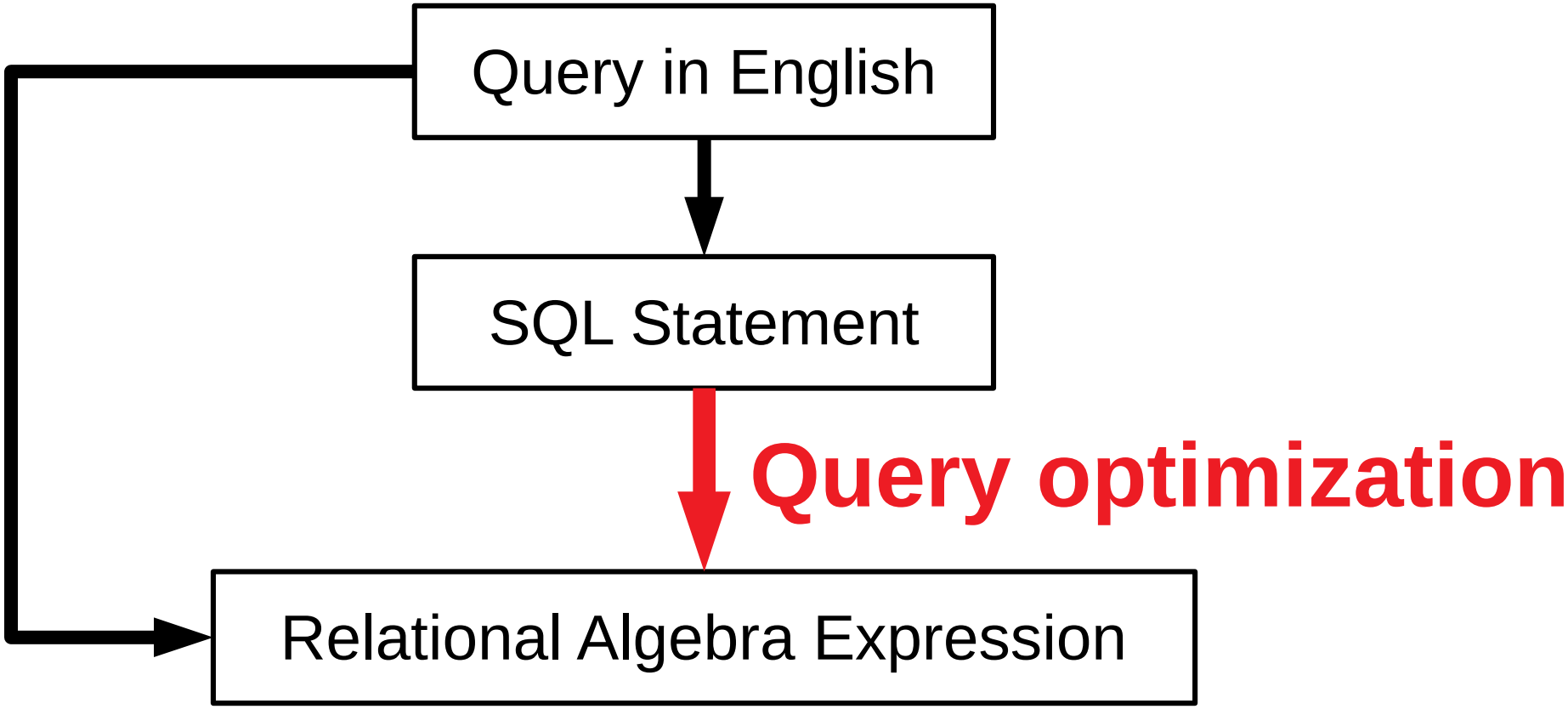
- $R(maker) = \pi_{maker}(Product \bowtie \sigma_{hd>=100}(Laptop))$



Relational Algebra ↔ SQL

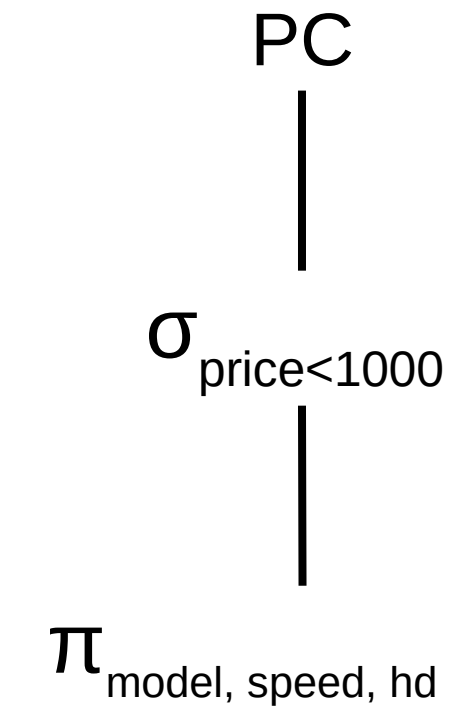
- SELECT ↔ Projection π
- FROM ↔ Input tables
- WHERE ↔ Selection σ, Join predicates
- DISTINCT ↔ Duplicate elimination δ
- ORDER BY ↔ Sorting τ
- GROUP BY ↔ GroupBy aggregations γ
- UNION, INTERSECT, EXCEPT ↔ Set operations U, ∩, -
- JOIN ↔ Join

From Queries (Through SQL) To Relational Algebra Expressions



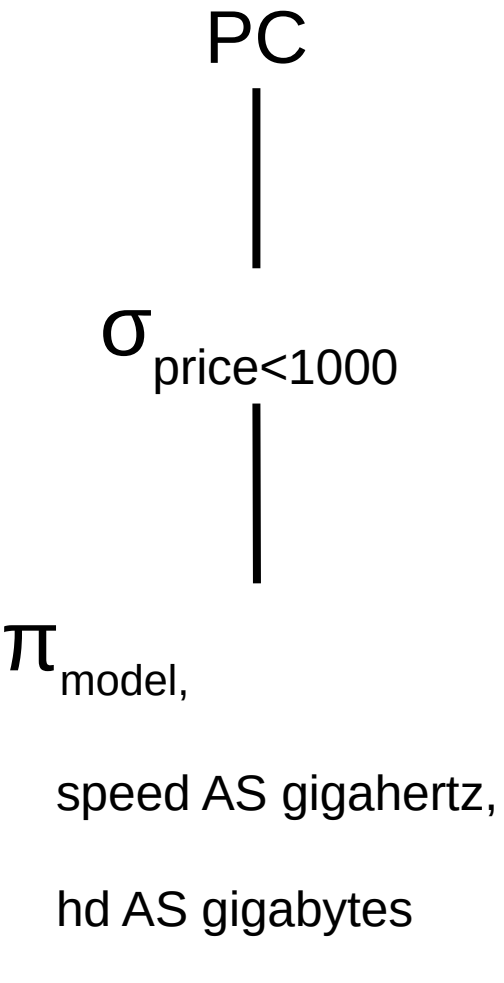
6.1.3 a)

```
select
    model, speed, hd
from pc
where price < 1000
```



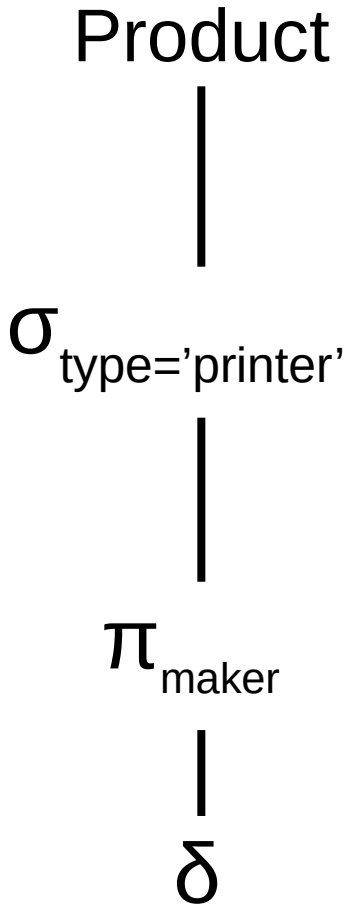
6.1.3 b)

```
select
    model,
    speed as gigahertz,
    hd as gigabytes
from pc
where price < 1000
```



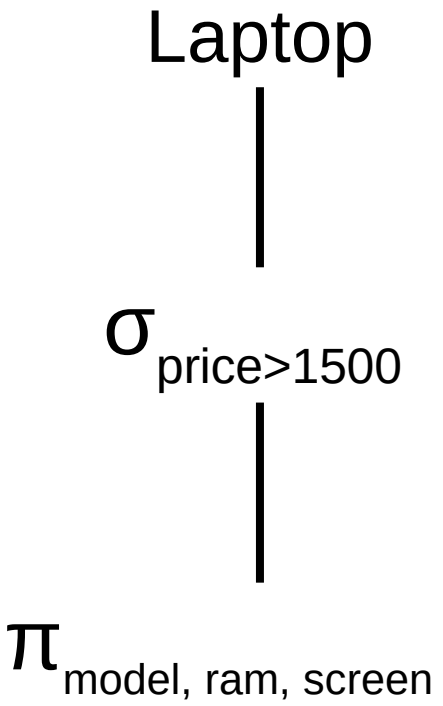
6.1.3 c)

```
select distinct maker
from product
where type = 'printer'
```



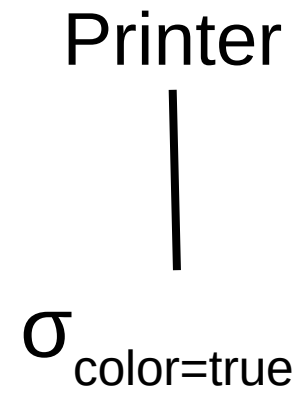
6.1.3 d)

```
select
    model, ram, screen
from laptop
where price > 1500
```



6.1.3 e)

```
select *
from printer
where color = true
```

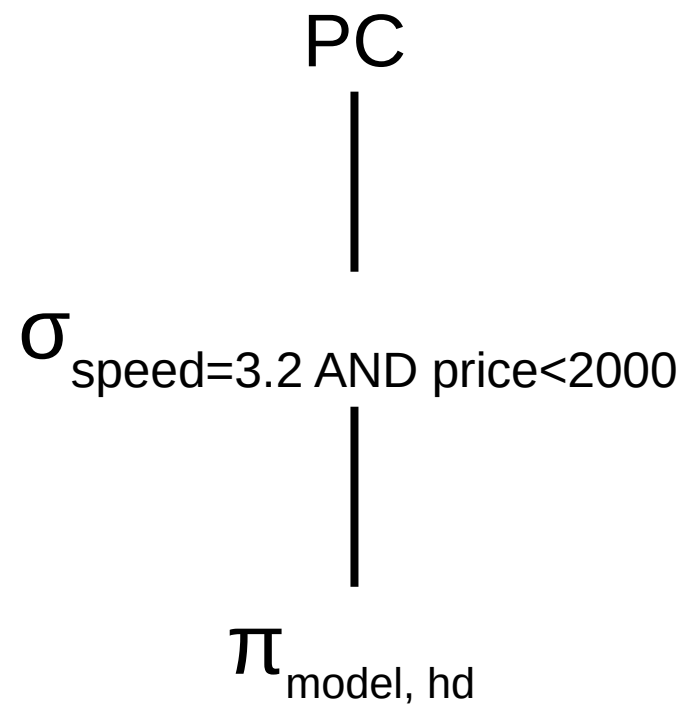


6.1.3 f)

select model, hd

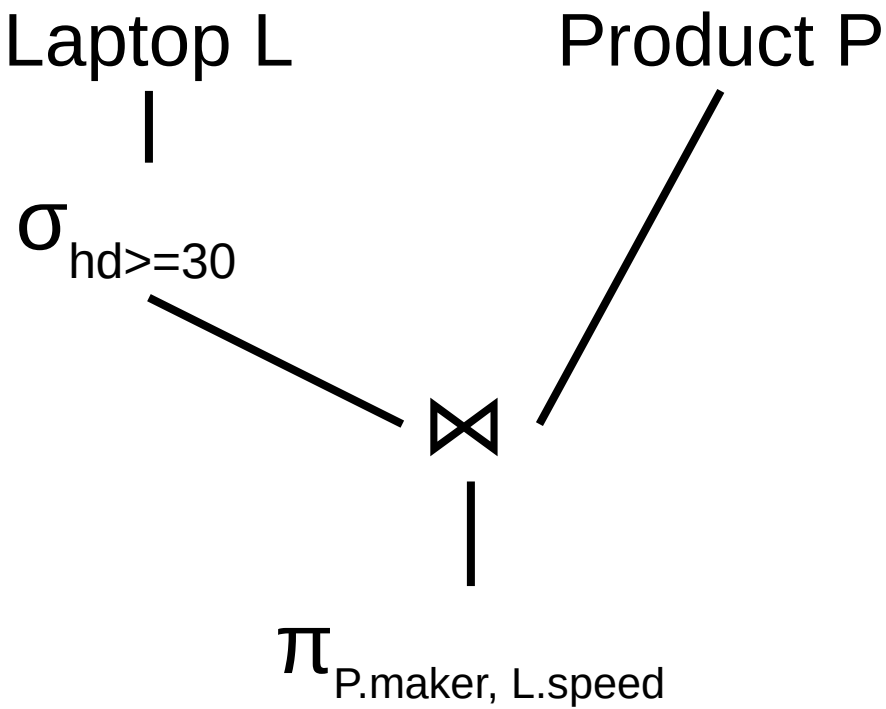
from pc

where speed = 3.2
and price < 2000

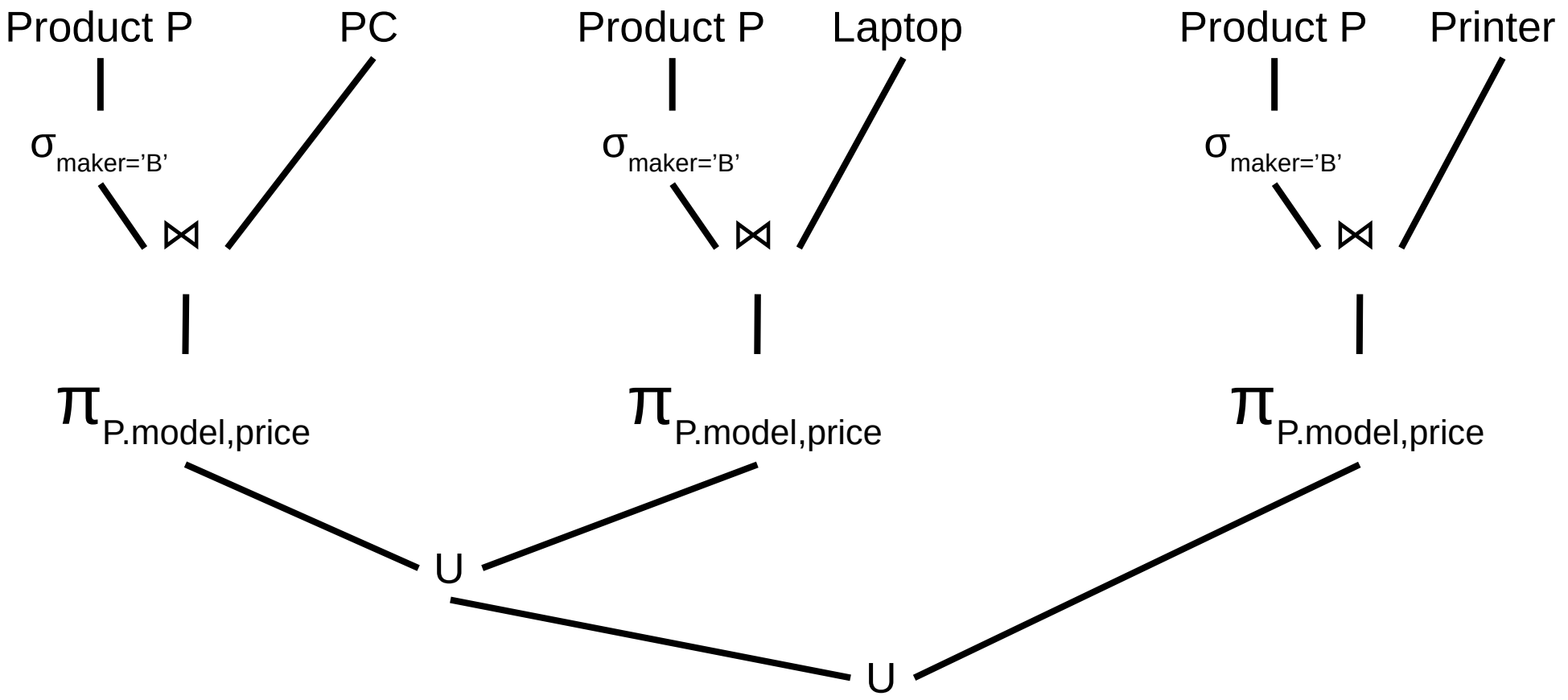


6.2.2 a)

```
select P.maker, L.speed
from Product P, Laptop L
where P.model = L.model
    AND hd >= 30
```

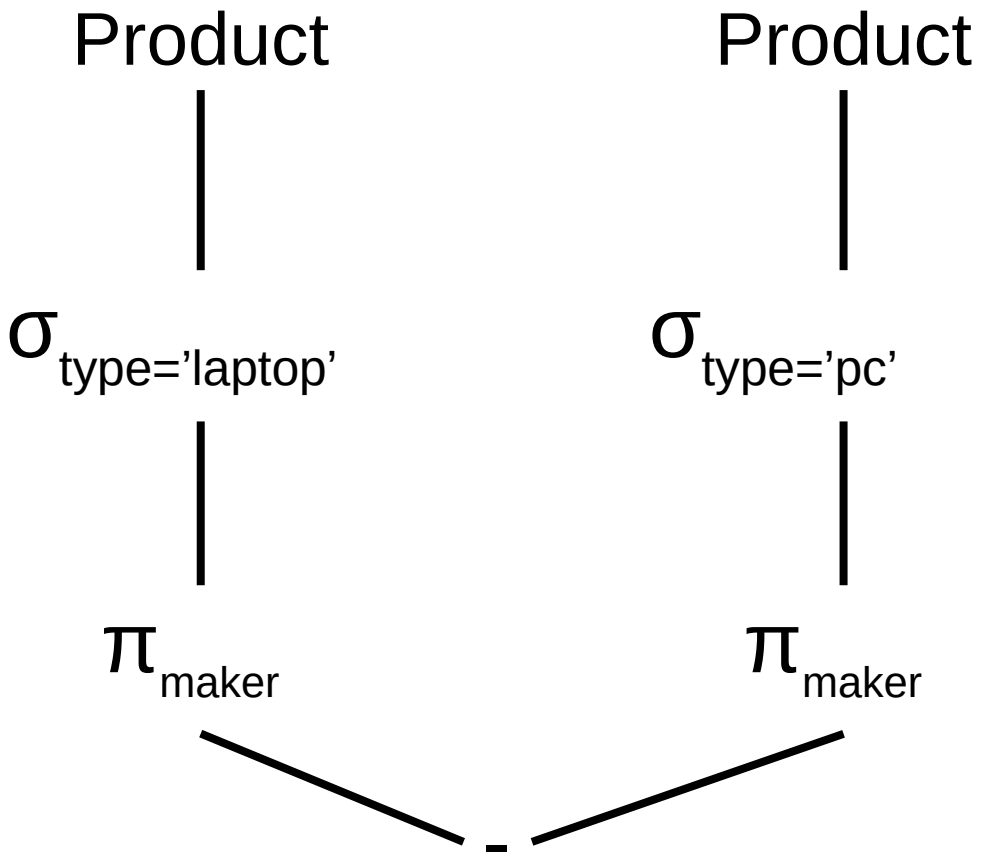


6.2.2 b)


Product P
PC
σ maker='B'
⋈
π P.model,price
Product P
Laptop
σ maker='B'
⋈
π P.model,price
Product P
Printer
σ maker='B'
⋈
π P.model,price
U
U

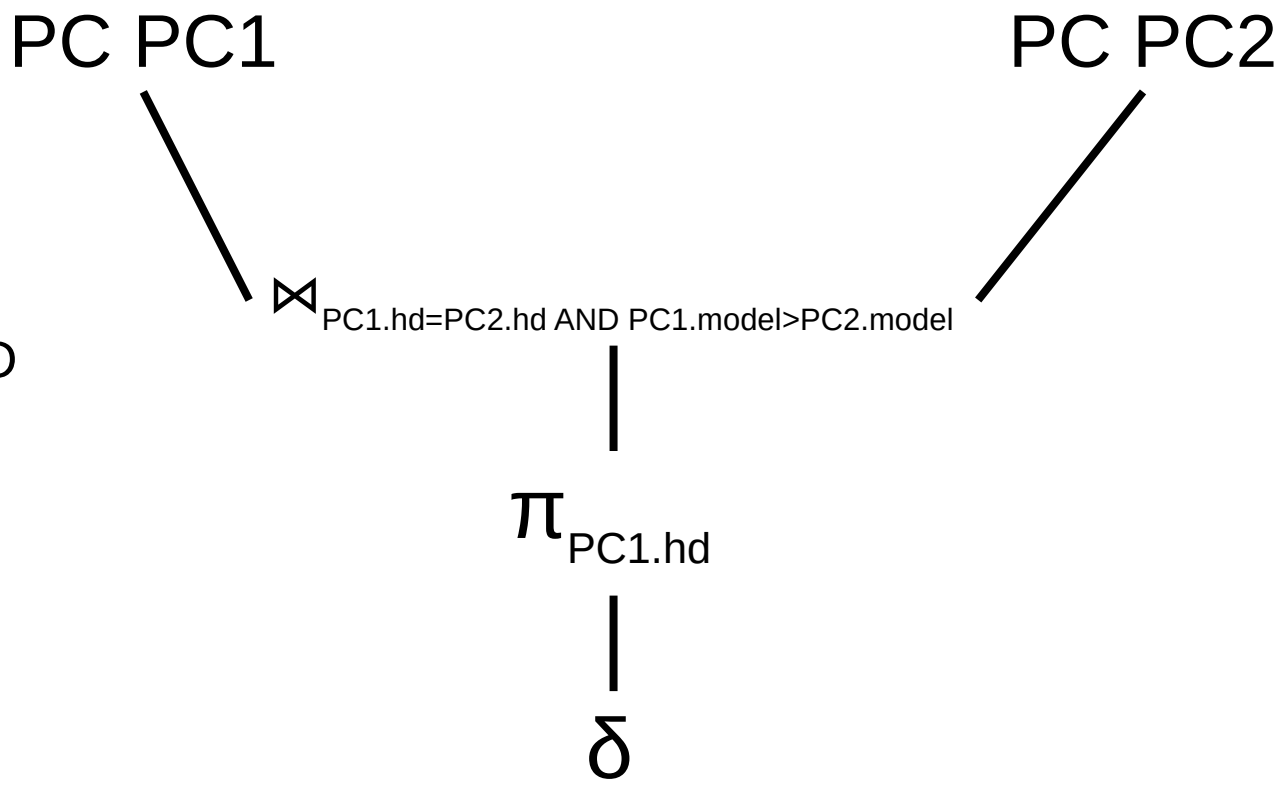
6.2.2 c)

```
select maker
from Product
where type = 'laptop'
EXCEPT
select maker
from Product
where type = 'pc'
```



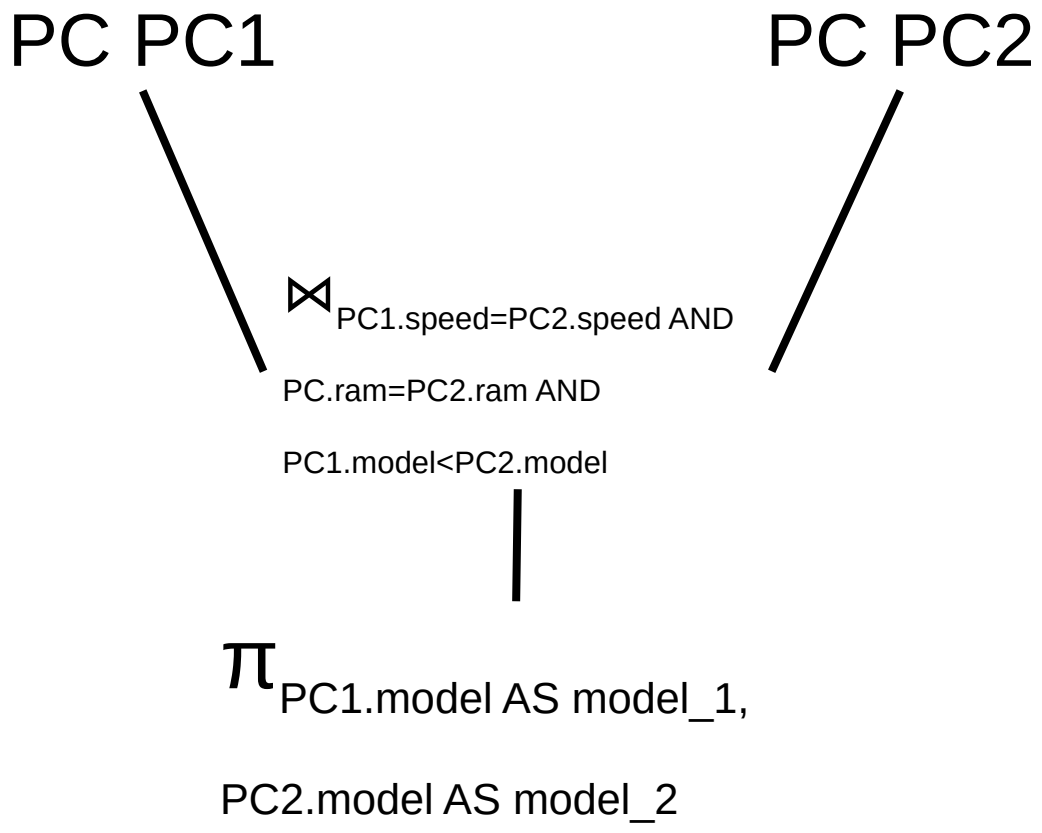
6.2.2 d)

```
select distinct PC1.hd
from PC PC1, PC PC2
where PC1.hd = PC2.hd AND
    PC1.model > PC2.model
```

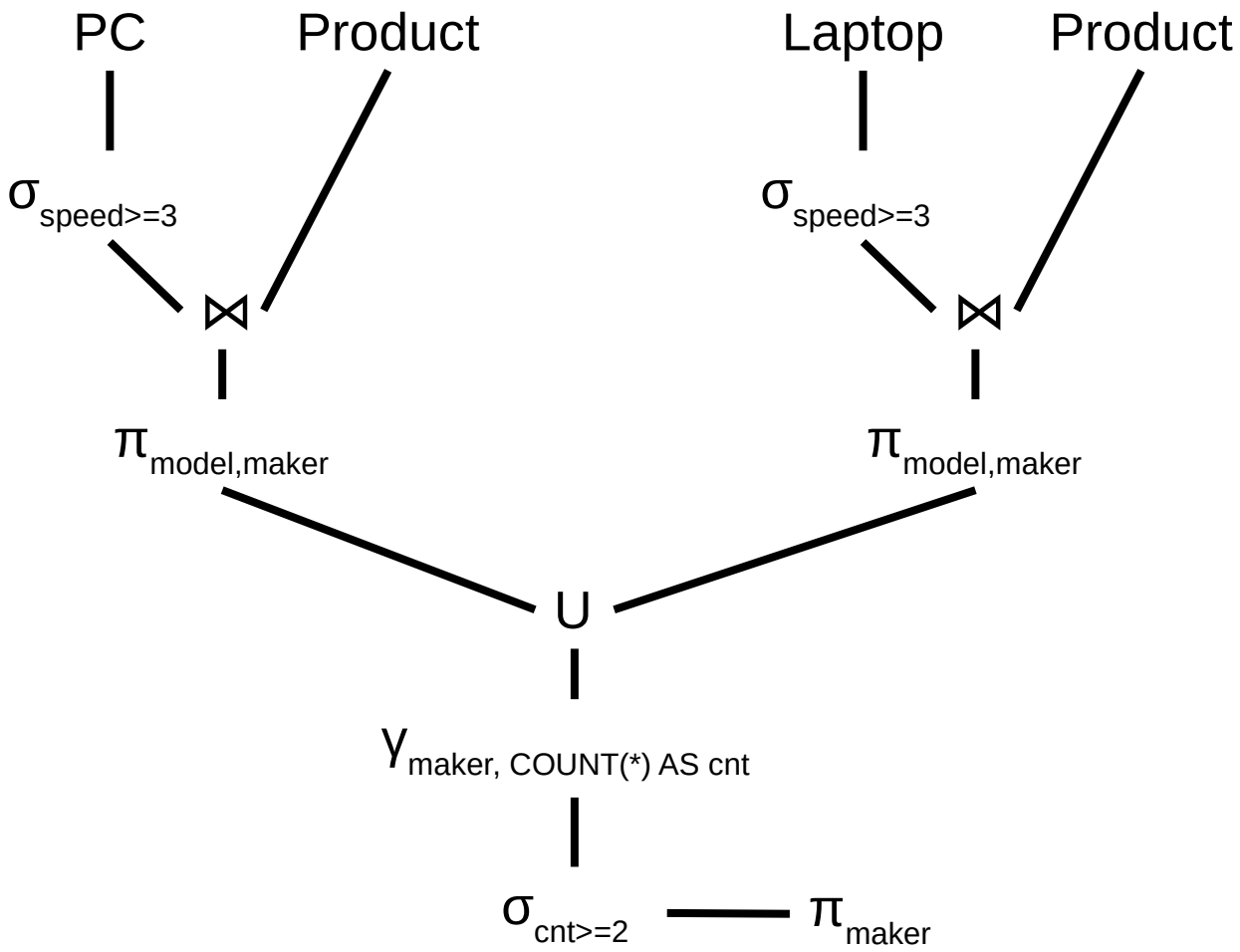


6.2.2 e)

```
select PC1.model as model_1,
PC2.model as model_2

from PC PC1, PC PC2

where PC1.speed = PC2.speed
AND PC1.ram = PC2.ram

AND PC1.model < PC2.model
```



6.2.2 f)



- $S_1(model,maker) = \pi_{model,maker}(Product \bowtie \sigma_{speed>=3}(PC))$

  $S_2(model,maker) = \pi_{model,maker}(Product \bowtie \sigma_{speed>=3}(Laptop))$

  $S_3(model,maker) = S_1 \cup S_2$

  $S_4(maker,cnt) = \gamma_{maker,\ COUNT(*)\ AS\ cnt}(S_3)$

  $S_5(maker,cnt) = \sigma_{cnt>=2}(S_4)$

  $R(maker) = \pi_{maker}(S_5)$