Level: 2nd Year Bachelor's in Computer Science (2025/2026)
MODULE: DATABASES
TD No. 3: Relational Algebra

Exercise 1:

Let the following Sale relation be given:

Sale_ID	Sale_Date	Client_ID	Amount	Payment_Mode	Product
1	2026-02-10	101	25000	Credit Card	Laptop
2	2026-02-12	102	1500	Cash	Wireless Mouse
3	2026-02-14	103	10000	Credit Card	External Hard Drive
4	2026-02-16	104	18000	Bank Transfer	Laser Printer
5	2026-02-17	105	30000	Credit Card	Laptop
6	2026-02-18	106	45000	Credit Card	Laser Printer

What do the following queries return?

1. Π{ Payment_Mode} (Sale)
2. σ{Product='Laptop'}(Sale)
3. Π{Client_ID, Amount}{σ{Payment_Mode='Credit Card'}(Sale)}
4. σ{Amount >20000}(Sale)
5. σ{Sale_Date > '2026-02-15'}(Sale) ∩ σ{Product='Laser Printer'}(Sale)
6. σ{(Amount >20000) ∧ (Payment_Mode = 'Credit Card')}(Sale) ?

Exercise 2

Consider the following relational schema for sales

PRODUCT (**ProductID**, Name, Brand, Price, Quantity_in_Stock)

CLIENT (**ClientID**, F_Name, L_Name, Phone_Number, E-Mail, City)

ORDER (**OrderID**, # ClientID, OrderDate, TotalAmount)

ORDER_LINE (# OrderID, #ProductID, Quantity**)**

Express the following queries using relational algebra:

1- Which **clients** live in the city "Constantine"?

2- What are the **ProductID**, **Name**, and **Price** of all products available in stock?

3- Find the ProductIDs of products from the 'Apple' and 'Samsung' brands using the UNION operation, and then using the OR operator.

4- Find the orders placed in the month of January, 2026 with a total amount greater than 500,000 DZD using the INTESECTION operation, and then usinf the AND operator.

5- List all products that do not exist in the Sony brand

6- Find all orders with the associated client information.

7- Find the ProductID, Name, and Quantity of each product ordered.

8- Find all orders ID that contain 'Printers'.

9- Find the names of clients who have ordered "Apple" products.

10- Find the OrderID, ProductID, and Quantity for each product ordered, but only for orders placed in 2022.

11- Find all clients who have ordered every product from the "Printers" category

12- Express queries (2, 5, 8, 9, and 11) with algebraic trees."

ANSWERS

Exercise 1:

1. **Π{Payment_Mode} (Sale)**
   Returns the distinct list of payment modes:

Payment_Mode
Credit Card
Cash
Bank Transfer

2. **σ{Product='Laptop'}(Sale)**
   Returns sales where the product is 'Laptop':

Sale_ID	Sale_Date	Client_ID	Amount	Payment_Mode	Product
1	2026-02-10	101	25000	Credit Card	Laptop
5	2026-02-17	105	30000	Credit Card	Laptop

3. **Π{Client_ID, Amount} {σ{Payment_Mode='Credit Card'}(Sale)}**
   Returns the client IDs and amounts for sales made with 'Credit Card':

Client_ID	Amount
101	25000
103	10000
105	30000
106	45000

4. **σ{Amount > 20000}(Sale)**
   Returns sales where the amount is greater than 20000:

Sale_ID	Sale_Date	Client_ID	Amount	Payment_Mode	Product
1	2026-02-10	101	25000	Credit Card	Laptop
5	2026-02-17	105	30000	Credit Card	Laptop
6	2026-02-18	106	45000	Credit Card	Laser Printer

5. **σ{Sale_Date > '2026-02-15'}(Sale) ∩ σ{Product='Laser Printer'}(Sale)**
   Returns sales made after '2026-02-15' where the product is 'Laser Printer':

Sale_ID	Sale_Date	Client_ID	Amount	Payment_Mode	Product
4	2026-02-16	104	18000	Bank Transfer	Laser Printer
6	2026-02-18	106	45000	Credit Card	Laser Printer

6. **σ{(Amount > 20000) ∧ (Payment_Mode = 'Credit Card')}(Sale)**
   Returns sales where the amount is greater than 20000 and the payment mode is 'Credit Card':

Sale_ID	Sale_Date	Client_ID	Amount	Payment_Mode	Product
1	2026-02-10	101	25000	Credit Card	Laptop
5	2026-02-17	105	30000	Credit Card	Laptop
6	2026-02-18	106	45000	Credit Card	Laser Printer

Exercise 2

1- Which **clients** live in the city "Constantine"?

$\sigma_{\{City='Constantine'\}}$ (CLIENT)

2- What are the **ProductID**, **Name**, and **Price** of all products available in stock?

$\Pi_{\{ProductID, Name, Price\}}(\sigma_{\{Quantity\_in\_Stock > 0\}}$ (PRODUCT))

3- Find the ProductIDs of products from the 'Apple' and 'Samsung' brands using the UNION operation, and then using the OR operator.

- $\Pi_{\{ProductID\}}(\sigma_{\{Brand = 'Apple'\}}(PRODUCT)) \cup \Pi_{\{ProductID\}}(\sigma_{\{Brand = 'Sumsung'\}}(PRODUCT))$
- $\Pi_{\{ProductID\}}(\sigma_{\{Brand = 'Apple' \vee Brand = 'Sumsung'\}}(PRODUCT))$

4- Find the orders placed in the month of January, 2026 with a total amount greater than 500,000 DZD using the INTESECTION operation, and then usinf the AND operator.

- $\sigma_{\{'01/01/2026' <= OrderDate <= '31/01/2026'\}}(ORDER) \wedge \sigma_{\{TotalAmount > 500000\}}(ORDER)$
- $\sigma_{\{'01/01/2026' <= OrderDate <= '31/01/2026' \wedge TotalAmount > 500000\}}(ORDER)$

5- List all products that do not exist in the Sony brand

- $PRODUCT - \sigma_{\{Brand = 'Sony'\}}(PRODUCT)$

6- Find all orders with the associated client information.

$\Pi_{\{OrderID, ClientID, OrderDate, TotalAmount, F\_Name, L\_Name\}}(ORDER \bowtie CLIENT)$

7- Find the ProductID, Name, and Quantity of each product ordered.

$\Pi_{\{ProductID, Name, Quantity\}}((ORDER\_LINE \bowtie PRODUCT))$

8- Find all orders ID that contain 'Printers'.

$\Pi_{\{OrderID\}}(\sigma_{\{Name = 'Printer'\}}(PRODUCT \bowtie (ORDER\_LINE \bowtie ORDER))$

9- Find the names of clients who have ordered "Apple" products.

$\Pi_{\{F\_Name, L\_Name\}}((CLIENT \bowtie ORDER) \bowtie (\sigma_{\{Brand = 'Apple'\}}(PRODUCT)) \bowtie ORDER\_LINE)$

10- Find the OrderID, ProductID, and Quantity for each product ordered, but only for orders placed in 2022.

$\Pi_{\{OrderID,\ ProductID,\ Quantity\}}(\sigma_{\{OrderDate >= '2022\text{-}01\text{-}01' \wedge OrderDate <= '2022\text{-}12\text{-}31'\}}$

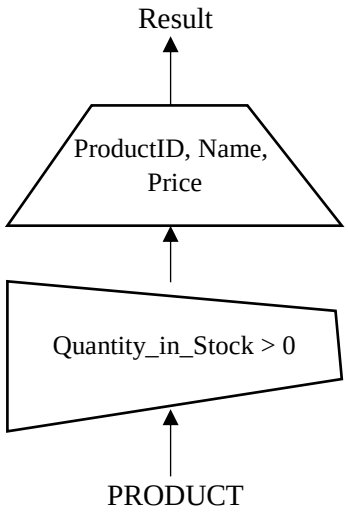
((ORDER⋈ORDER_LINE)⋈PRODUCT))

11- Find all clients who have ordered every product from the "Printers" category

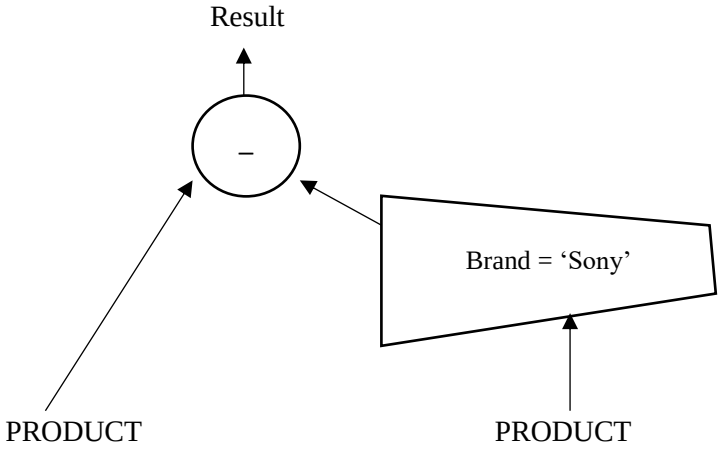
$\Pi_{\{ClientID\}}$(ORDER⋈ (ORDER_LINE÷$\pi_{\{ProductID\}}(\sigma_{\{Brand = 'Printers'\}}$(PRODUCT))))

12- Express queries (2, 5, 8, 9, and 11) with algebraic trees."

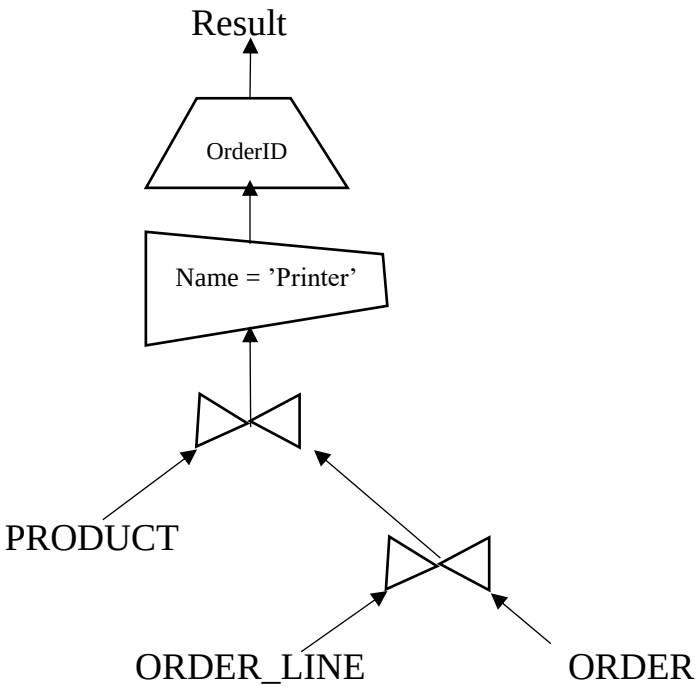
Q2. $\Pi_{\{ProductID,\ Name,\ Price\}}(\sigma_{\{Quantity\_in\_Stock > 0\}}$ (PRODUCT))



Q5. PRODUCT - $\sigma_{\{ Brand = 'Sony'\}}$(PRODUCT)



Q8. $\Pi_{\{OrderID\}}(\sigma_{\{Name = 'Printer'\}}(PRODUCT \bowtie (ORDER\_LINE \bowtie ORDER))$



Request 9 and 11 should be completed by the students