



# Relational Algebra

## Exercise



# Relations - 1

**User**

| Id | Name   | Age | Gender | OccupationId | CityId |
|----|--------|-----|--------|--------------|--------|
| 1  | John   | 25  | Male   | 1            | 3      |
| 2  | Sara   | 20  | Female | 3            | 4      |
| 3  | Victor | 31  | Male   | 2            | 5      |
| 4  | Jane   | 27  | Female | 1            | 3      |

**Occupation**

| OccupationId | OccupationName    |
|--------------|-------------------|
| 1            | Software Engineer |
| 2            | Accountant        |
| 3            | Pharmacist        |
| 4            | Library Assistant |

**City**

| CityId | CityName |
|--------|----------|
| 1      | Halifax  |
| 2      | Calgary  |
| 3      | Boston   |
| 4      | New York |
| 5      | Toronto  |

# Questions - 1

- Solve the following relational expressions for above relations

a.  $\Pi_{\text{Name}} (\sigma_{\text{Age} > 25} (\text{User}))$

b.  $\sigma_{\text{id} > 2 \vee \text{Age} \neq 31} (\text{User})$

c.  $\sigma_{\text{User.OccupationId} = \text{Occupation.OccupationId}} (\text{User} \bowtie \text{Occupation})$

d.  $\text{User} \bowtie \text{Occupation} \bowtie \text{City}$

e.  $\Pi_{\text{Name}, \text{Gender}} (\sigma_{\text{CityName} = \text{"Boston"}} (\text{User} \bowtie \text{City}))$

# Question – 1a

a.  $\Pi_{\text{Name}} (\sigma_{\text{Age} > 25} (\text{User}))$

$\sigma_{\text{Age} > 25} (\text{User})$

User

| Id | Name   | Age | Gender | OccupationId | CityId |
|----|--------|-----|--------|--------------|--------|
| 3  | Victor | 31  | Male   | 2            | 5      |
| 4  | Jane   | 27  | Female | 1            | 3      |

$\Pi_{\text{Name}} (\sigma_{\text{Age} > 25} (\text{User}))$

| Name   |
|--------|
| Victor |
| Jane   |

# Question – 1b

b.  $R_{Id>2 \vee Age!=31}(User)$

| Id | Name   | Age | Gender | OccupationId | CityId |
|----|--------|-----|--------|--------------|--------|
| 1  | John   | 25  | Male   | 1            | 3      |
| 2  | Sara   | 20  | Female | 3            | 4      |
| 3  | Victor | 31  | Male   | 2            | 5      |
| 4  | Jane   | 27  | Female | 1            | 3      |

## ■ Note: Connectives

- ☐ [¬] NOT
- ☐ [∨] OR
- ☐ [^] AND

## Question – 1c

c.  $R_{\text{User.OccupationId=Occupation.OccupationId}}$  (User X Occupation)

| Id | Name   | Age | Gender | OccupationId | CityId | OccupationId | OccupationName    |
|----|--------|-----|--------|--------------|--------|--------------|-------------------|
| 1  | John   | 25  | Male   | 1            | 3      | 1            | Software Engineer |
| 2  | Sara   | 20  | Female | 3            | 4      | 3            | Pharmacist        |
| 3  | Victor | 31  | Male   | 2            | 5      | 2            | Accountant        |
| 4  | Jane   | 27  | Female | 1            | 3      | 1            | Software Engineer |

? Write an equivalent relational algebra expression using

- ☐ A Natural Join
- ☐ An Equi Join
- ☐ A Theta Join

# Question – 1d

d. User ⋈ Occupation ⋈ City

| CityId | OccupationId | Id | Name   | Age | Gender | OccupationName    | CityName |
|--------|--------------|----|--------|-----|--------|-------------------|----------|
| 3      | 1            | 1  | John   | 25  | Male   | Software Engineer | Boston   |
| 4      | 3            | 2  | Sara   | 20  | Female | Pharmacist        | New York |
| 5      | 2            | 3  | Victor | 31  | Male   | Accountant        | Toronto  |
| 3      | 1            | 4  | Jane   | 27  | Female | Software Engineer | Boston   |

? Which of the following is equivalent to the above

- ☐ (User ⋈ Occupation) ⋈ City
- ☐ User ⋈ (Occupation) ⋈ City
- ☐ (User ⋈ City) ⋈ Occupation

## Question – 1e

e.  $P_{\text{Name, Gender}}(R_{\text{CityName}=\text{"Boston"}}(\text{User} \bowtie \text{City}))$

| Name | Gender |
|------|--------|
| John | Male   |
| Jane | Female |

- ? Write an equivalent relational algebra expression using
- A Restriction Operator and a Join

## Relations - 2

*r(author)*

| author_id | first_name | last_name |
|-----------|------------|-----------|
| 1         | John       | McCarthy  |
| 2         | Dennis     | Ritchie   |
| 3         | Ken        | Thompson  |
| 4         | Claude     | Shannon   |
| 5         | Alan       | Turing    |
| 6         | Alonzo     | Church    |
| 7         | Perry      | White     |
| 8         | Moshe      | Vardi     |
| 9         | Roy        | Batty     |

*r(author\_pub)*

| author_id | pub_id | author_position |
|-----------|--------|-----------------|
| 1         | 1      | 1               |
| 2         | 2      | 1               |
| 3         | 2      | 2               |
| 4         | 3      | 1               |
| 5         | 4      | 1               |
| 5         | 5      | 1               |
| 6         | 6      | 1               |

*r(book)*

| book_id | book_title | month    | year | editor |
|---------|------------|----------|------|--------|
| 1       | CACM       | April    | 1960 | 8      |
| 2       | CACM       | July     | 1974 | 8      |
| 3       | BST        | July     | 1948 | 2      |
| 4       | LMS        | November | 1936 | 7      |
| 5       | Mind       | October  | 1950 | NULL   |
| 6       | AMS        | Month    | 1941 | NULL   |
| 7       | AAAI       | July     | 2012 | 9      |
| 8       | NIPS       | July     | 2012 | 9      |

*r(pub)*

| pub_id | title           | book_id |
|--------|-----------------|---------|
| 1      | LISP            | 1       |
| 2      | Unix            | 2       |
| 3      | Info Theory     | 3       |
| 4      | Turing Machines | 4       |
| 5      | Turing Test     | 5       |
| 6      | Lambda Calculus | 6       |



## Question - 2

- Solve the following relational expressions for above relations

a. How many tuples will the following relational algebra query return?

$$\Pi_{\text{book\_title}} \text{Book}$$

b. What question does the following expression answer?

$$\Pi_{\text{author\_id}} (\text{author}) - \Pi_{\text{editor}} (\text{book})$$

c. Write a relational algebra expression that returns the full names of all authors who are book editors.

d. Write a relational algebra expression that returns the full names of all authors who are **NOT** book editors.

## Question – 2a

a. How many tuples will the following relational algebra query return?

$\Pi_{\text{book\_title}} \text{Book}$

*r(book)*

| book_id | book_title | month    | year | editor |
|---------|------------|----------|------|--------|
| 1       | CACM       | April    | 1960 | 8      |
| 2       | CACM       | July     | 1974 | 8      |
| 3       | BST        | July     | 1948 | 2      |
| 4       | LMS        | November | 1936 | 7      |
| 5       | Mind       | October  | 1950 | NULL   |
| 6       | AMS        | Month    | 1941 | NULL   |
| 7       | AAAI       | July     | 2012 | 9      |
| 8       | NIPS       | July     | 2012 | 9      |

## Question – 2b

b. What question does the following expression answer?

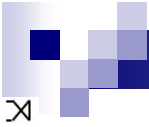
$$\Pi_{\text{author\_id}}(\text{author}) - \Pi_{\text{editor}}(\text{book})$$

*r(author)*

| author_id | first_name | last_name |
|-----------|------------|-----------|
| 1         | John       | McCarthy  |
| 2         | Dennis     | Ritchie   |
| 3         | Ken        | Thompson  |
| 4         | Claude     | Shannon   |
| 5         | Alan       | Turing    |
| 6         | Alonzo     | Church    |
| 7         | Perry      | White     |
| 8         | Moshe      | Vardi     |
| 9         | Roy        | Batty     |

*r(book)*

| book_id | book_title | month    | year | editor |
|---------|------------|----------|------|--------|
| 1       | CACM       | April    | 1960 | 8      |
| 2       | CACM       | July     | 1974 | 8      |
| 3       | BST        | July     | 1948 | 2      |
| 4       | LMS        | November | 1936 | 7      |
| 5       | Mind       | October  | 1950 | NULL   |
| 6       | AMS        | Month    | 1941 | NULL   |
| 7       | AAAI       | July     | 2012 | 9      |
| 8       | NIPS       | July     | 2012 | 9      |



## Question – 2c, 2d

c. Write a relational algebra expression that returns the full names of all authors who are book editors.

**Solution:**  $\pi_{first\_name, last\_name}(author \bowtie_{author\_id=editor} book)$

d. Write a relational algebra expression that returns the full names of all authors who are **NOT** book editors

$\Pi_{first\_name, last\_name}(\sigma_{book\_title = NULL} (author \bowtie_{author\_id = editor} book))$

## Question – 3

- Compute the theta-join of R and S with the condition  
 $R.B = S.B \text{ AND } R.A < S.C$

| R |   |
|---|---|
| A | B |
| 1 | a |
| 7 | t |
| 2 | g |
| 4 | c |
| 9 | t |

| S |   |   |
|---|---|---|
| B | C | D |
| c | 5 | 6 |
| a | 7 | 8 |
| t | 8 | 9 |

$R \bowtie_{R.B = S.B \text{ AND } R.A < S.C} S$

| R.A | R.B | S.B | S.C | S.D |
|-----|-----|-----|-----|-----|
| 1   | a   | a   | 7   | 8   |
| 7   | t   | t   | 8   | 9   |
| 4   | c   | c   | 5   | 6   |