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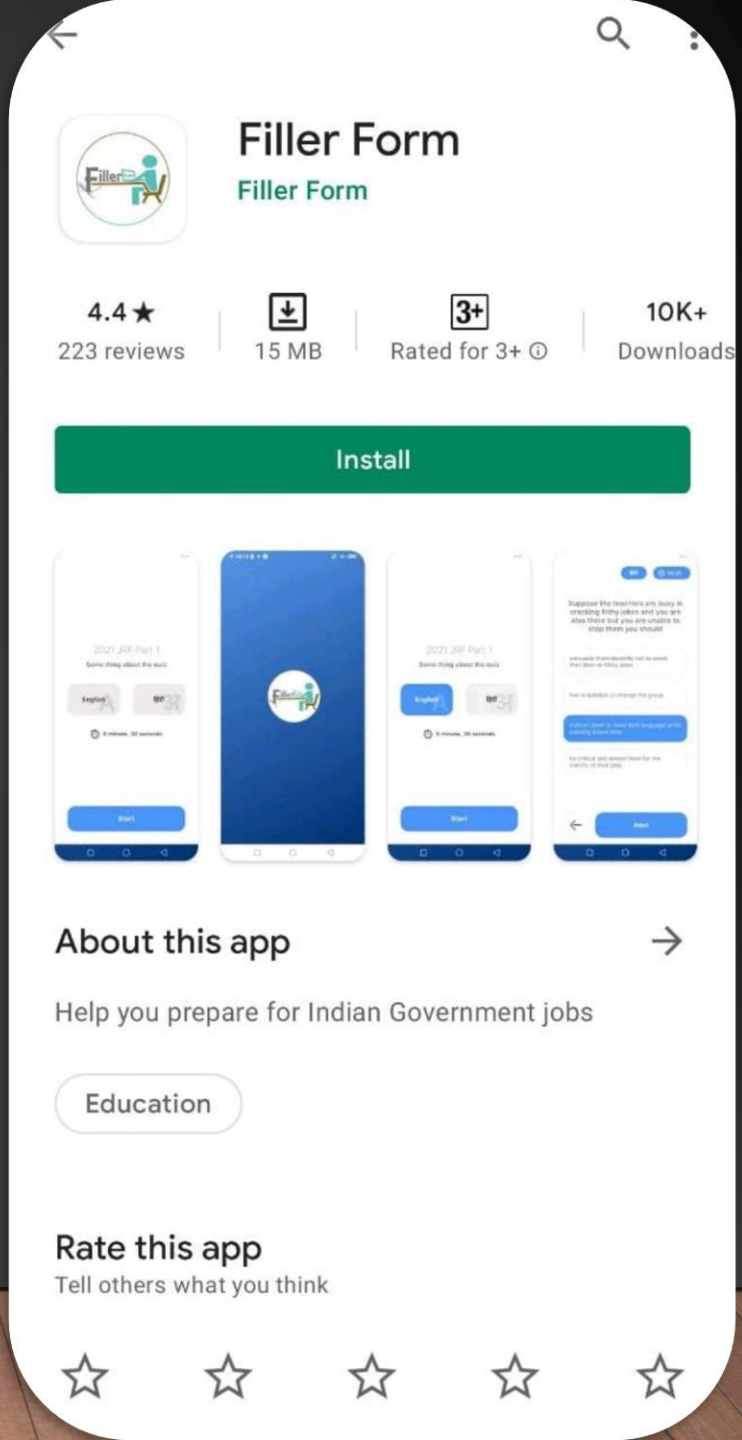

# ❑ Discrete Structure and Optimization

Content:

1) Set & Relations (Part – 2)

2) Relations

3) Types of Relation

4) Equivalence Relation

# ❖ Relation

## Definition and Properties

A binary relation R from set x to y (written as $xRy$ or $R(x, y)$ ) is a subset of the Cartesian product $x \times y$ . If the ordered pair of G is reversed, the relation also changes.

Let us consider two sets A and B
where A = {A1, A2, A3}
B = {B1, B2, B3}
then the cartesian products of A and B is
**A x B** = {(A1, B1), (A1, B2), (A1, B3), (A2, B1), (A2, B2), (A2, B3), (A3, B1), (A3, B2), (A3, B3)}
Consider any subset of A x B Say R= {(A1, B2), (A2, B3), (A3, B1)}

# ❖ Binary Relation

A Binary Relation R from Set A and Set B is a ordered Pair From A to B

- 1st element from 1st Set
- 2nd element from 2nd Set

(i) Let A = {a, b, c}

B = {r, s, t}

Then R = {(a, r), (b, r), (b, t), (c, s)}

is a relation from A to B.

(ii) Let A = {1, 2, 3} and B = A

R = {(1, 1), (2, 2), (3, 3)}

is a relation (equal) on A.

# Types of Relations

**1. Reflexive Relation:** A relation R on set A is said to be a reflexive if **(a, a)** ∈ **R** for every **a** ∈ A.

**Example:** If A = {1, 2, 3, 4} then R = {(1, 1) (2, 2), (1, 3), (2, 4), (3, 3), (3, 4), (4, 4)}. Is a relation reflexive?

**Solution:** The relation is reflexive as for every a ∈ A. (a, a) ∈ R, i.e. (1, 1), (2, 2), (3, 3), (4, 4) ∈ R.

**2. Irreflexive Relation:** A relation R on set A is said to be **irreflexive if (a, a) ∉ R** for every **a ∈ A**.

**Example:** Let A = {1, 2, 3} and R = {(1, 2), (2, 2), (3, 1), (1, 3)}. Is the relation R reflexive or irreflexive?

**Solution:** The relation R is not reflexive as for every a ∈ A, (a, a) ∉ R, i.e., (1, 1) and (3, 3) ∉ R. The relation R is not irreflexive as (a, a) ∉ R, for some a ∈ A, i.e., (2, 2) ∈ R.

**3. Symmetric Relation:** A relation R on set A is said to be symmetric iff (a, b) ∈ R ⇔ (b, a) ∈ R.

**Example:** Let A = {1, 2, 3} and R = {(1, 1), (2, 2), (1, 2), (2, 1), (2, 3), (3, 2)}. Is a relation R symmetric or not?

**Solution:** The relation is symmetric as for every (a, b) ∈ R, we have (b, a) ∈ R, i.e., (1, 2), (2, 1), (2, 3), (3, 2) ∈ R but not reflexive because (3, 3) ∉ R.

**Example of Symmetric Relation:**

1. Relation ⊥r is symmetric since a line a is ⊥r to b, then b is ⊥r to a.
2. Also, Parallel is symmetric, since if a line a is ‖ to b then b is also ‖ to a.

Example R1= {(1,1), (2,2), (3,3), (4,4)} is symmetric.

**Antisymmetric Relation:** A relation R on a set A is antisymmetric iff (a, b) ∈ R and (b, a) ∈ R then a = b.

**Example1:** Let A = {1, 2, 3} and R = {(1, 1), (2, 2)}. Is the relation R antisymmetric?

**Solution:** The relation R is antisymmetric as a = b when (a, b) and (b, a) both belong to R.

**Example2:** Let A = {4, 5, 6} and R = {(4, 4), (4, 5), (5, 4), (5, 6), (4, 6)}. Is the relation R antisymmetric?

**Solution:** The relation R is not antisymmetric as 4 ≠ 5 but (4, 5) and (5, 4) both belong to R.

**5. Asymmetric Relation:** A relation R on a set A is called an Asymmetric Relation if for every (a, b) ∈ R implies that (b, a) does not belong to R.

**6. Transitive Relations:** A Relation R on set A is said to be transitive iff (a, b) ∈ R and (b, c) ∈ R ⇔ (a, c) ∈ R.

**Example1:** Let A = {1, 2, 3} and R = {(1, 2), (2, 1), (1, 1), (2, 2)}. Is the relation transitive?

**Solution:** The relation R is transitive as for every (a, b) (b, c) belong to R, we have (a, c) ∈ R i.e, (1, 2) (2, 1) ∈ R ⇒ (1, 1) ∈ R.

# Equivalence Relations

A relation R on a set A is called an equivalence relation if it satisfies following three properties:

1. Relation R is Reflexive, i.e. aRa $\forall$ a$\in$A.
2. Relation R is Symmetric, i.e., aRb $\Longrightarrow$ bRa
3. Relation R is transitive, i.e., aRb and bRc $\Longrightarrow$ aRc.

**Example:** Let A = {1, 2, 3, 4} and R = {(1, 1), (1, 3), (2, 2), (2, 4), (3, 1), (3, 3), (4, 2), (4, 4)}.

Show that R is an Equivalence Relation.

**Reflexive:** Relation R is reflexive as (1, 1), (2, 2), (3, 3) and (4, 4) ∈ R.

**Symmetric:** Relation R is symmetric because whenever (a, b) ∈ R, (b, a) also belongs to R.

**Example:** (2, 4) ∈ R ⟹ (4, 2) ∈ R.

**Transitive:** Relation R is transitive because whenever (a, b) and (b, c) belongs to R, (a, c) also belongs to R.

**Example:** (3, 1) ∈ R and (1, 3) ∈ R ⟹ (3, 3) ∈ R.

So, as R is reflexive, symmetric and transitive, hence, R is an Equivalence Relation.

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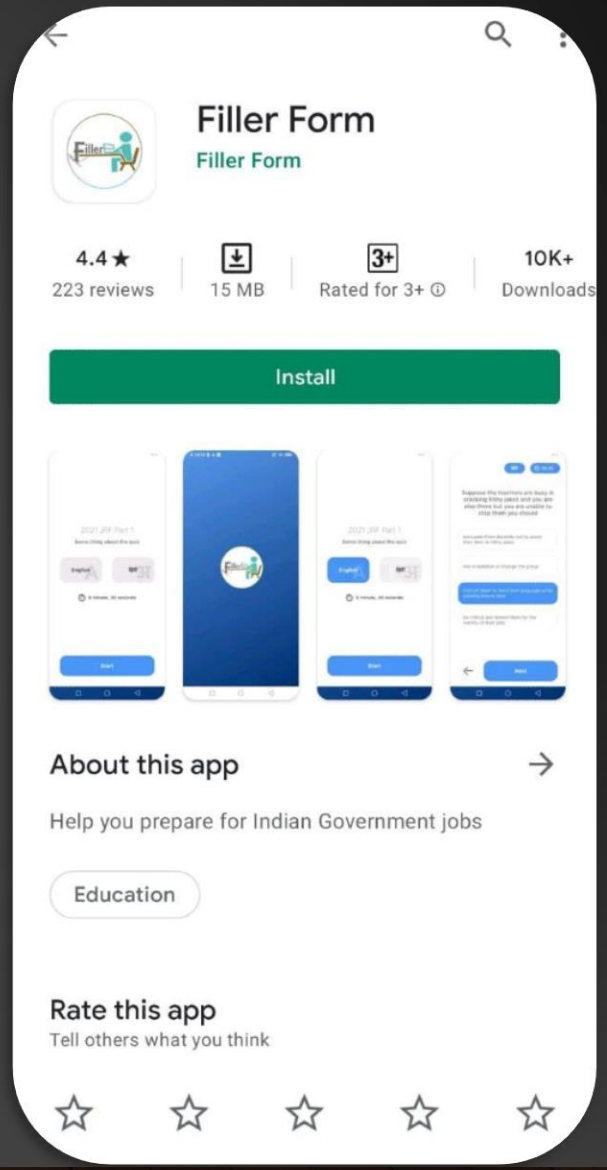

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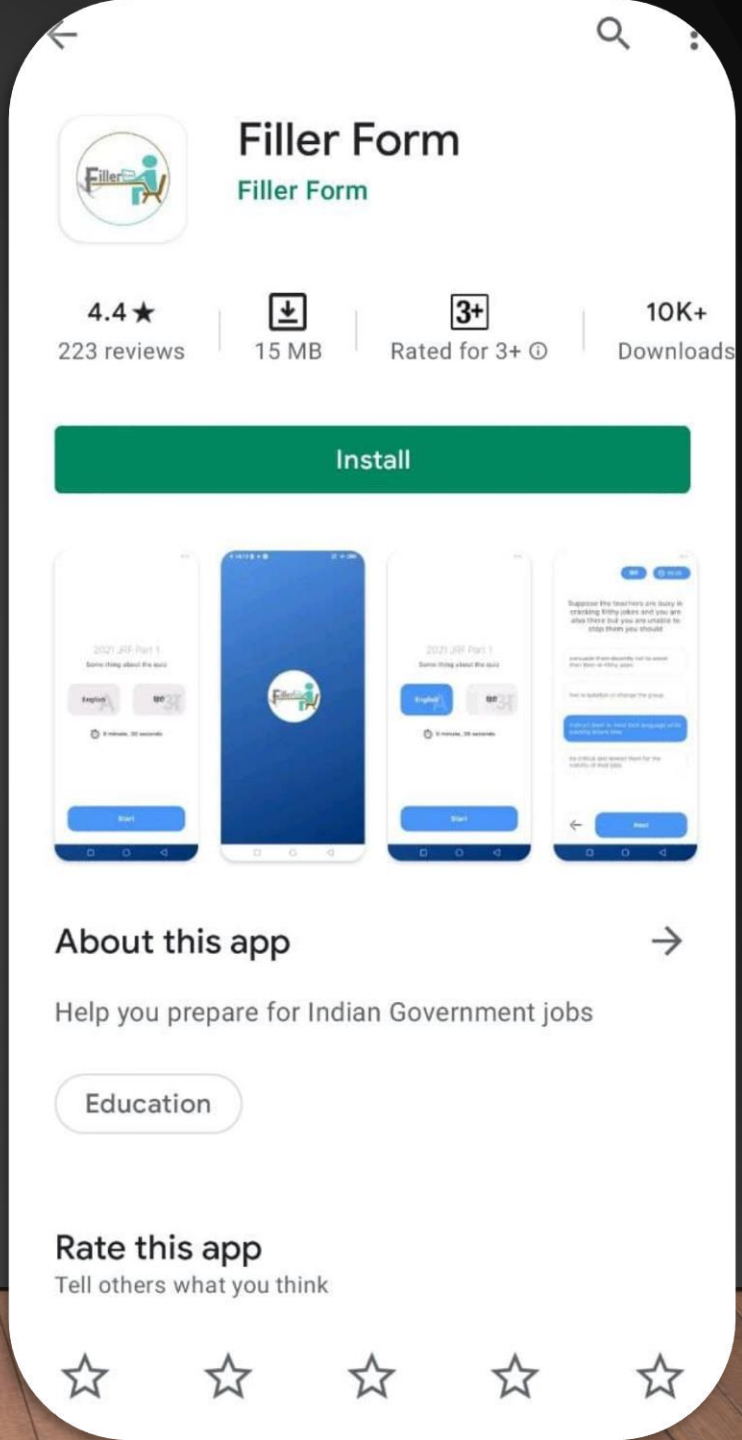

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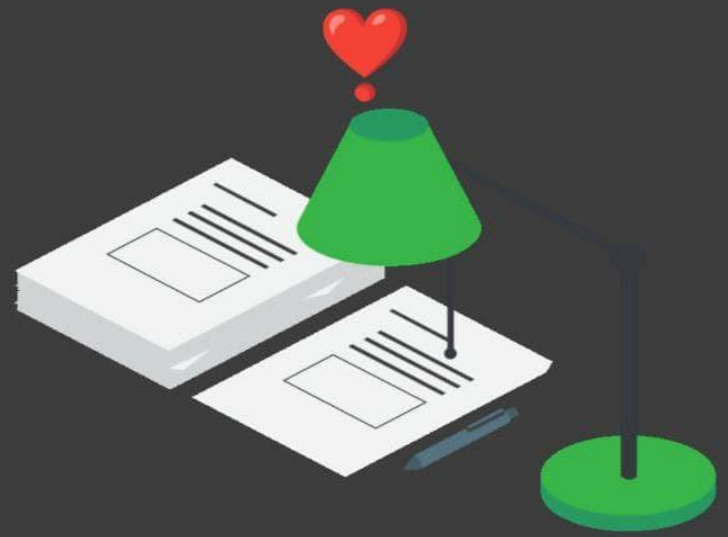

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