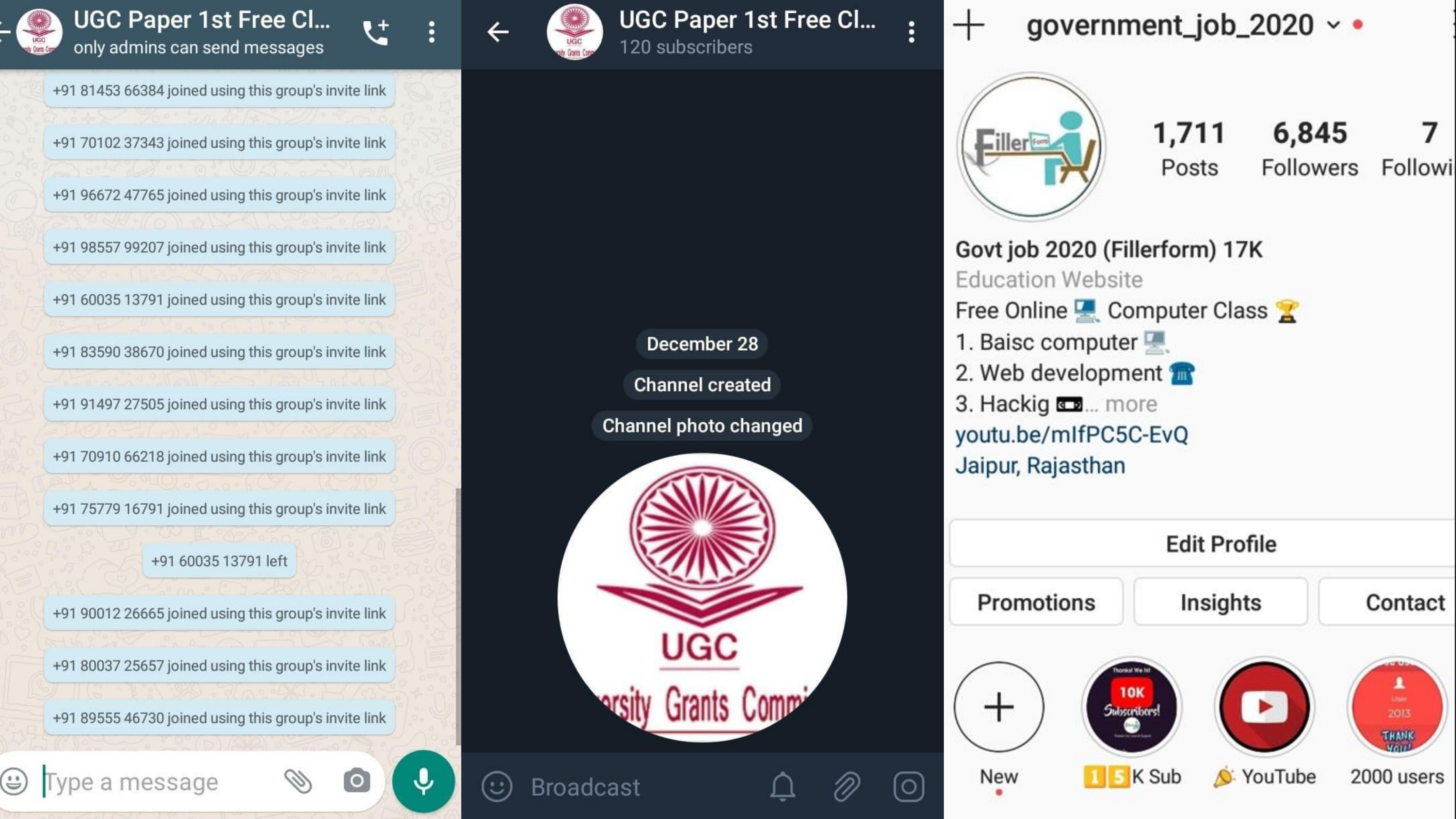
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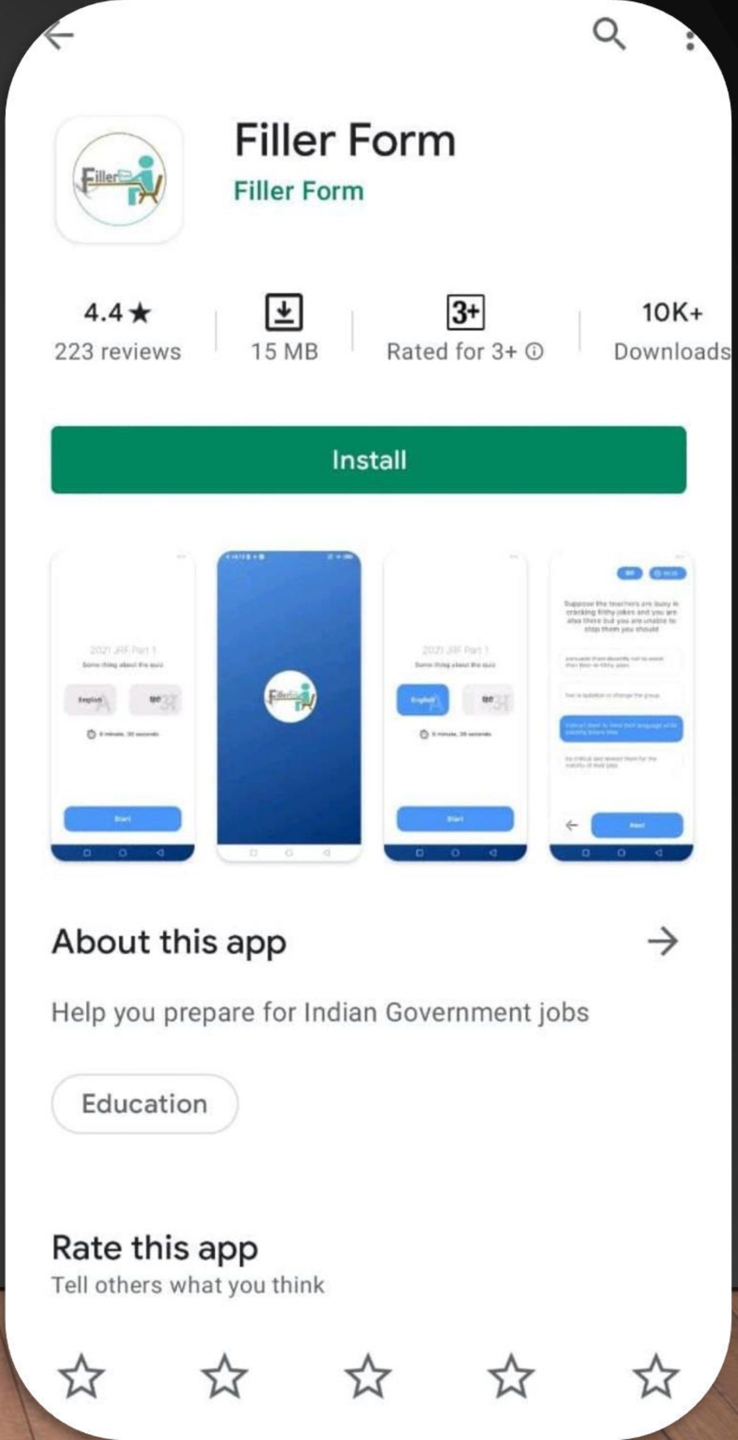


❑ Discrete Structure and Optimization

Content:

1) Set & Relations
2) Set Theory
3) Types of Set
4) Operation of Set

Introduction of Sets

A set is defined as a collection of distinct objects of the same type or class of objects. The purposes of a set are called elements or members of the set. An object can be numbers, alphabets, names, etc.

Examples of sets are:

a. A set of rivers of India.

b. A set of vowels.

We broadly denote a set by the capital letter A, B, C, etc. while the fundamentals of the set by small letter a, b, x, y, etc.

If A is a set, and a is one of the elements of A, then we denote it as a ∈ A. Here the symbol ∈ means -"Element of."

Some Important Sets

N – the set of all natural numbers = $\{1, 2, 3, 4, \ldots\ldots\}$

Z – the set of all integers = $\{\ldots\ldots, -3, -2, -1, 0, 1, 2, 3, \ldots\ldots\}$

Z^+ – the set of all positive integers

Q – the set of all rational numbers

R – the set of all real numbers

W – the set of all whole numbers

Sets Representation:

Sets are represented in two forms:-

a) Roster or tabular form: In this form of representation we list all the elements of the set within braces { } and separate them by commas.

Example: If A= set of all odd numbers less then 10 then in the roster from it can be expressed as A={ 1,3,5,7,9}.

b) Set Builder form: In this form of representation we list the properties fulfilled by all the elements of the set. We note as {x: x satisfies properties P}. and read as 'the set of those entire x such that each x has properties P.'

Example: If B= {2, 4, 8, 16, 32}, then the set builder representation will be: B={x: $x=2^n$, where n ∈ N and 1≤ n ≥5}

Standard Notations:

$x \in A$	x belongs to A or x is an element of set A.
$x \notin A$	x does not belong to set A.
$\emptyset$	Empty Set.
U	Universal Set.
N	The set of all natural numbers.
I	The set of all integers.
I_0	The set of all non- zero integers.
I_+	The set of all + ve integers.
C, C_0	The set of all complex, non-zero complex numbers respectively.

Types of Sets

Sets can be classified into many types. Some of which are finite, infinite, subset, universal, proper, singleton set, etc.

Finite Set

A set which contains a definite number of elements is called a finite set.

Example – $S = \{x \mid x \in N \text{ and } 70 > x > 50\}$

Infinite Set

A set which contains infinite number of elements is called an infinite set.

Example – $S = \{x \mid x \in N \text{ and } x > 10\}$

Universal Set

It is a collection of all elements in a particular context or application. All the sets in that context or application are essentially subsets of this universal set. Universal sets are represented as U .

Example – We may define U as the set of all animals on earth. In this case, set of all mammals is a subset of U , set of all fishes is a subset of U , set of all insects is a subset of U , and so on.

Empty Set or Null Set

An empty set contains no elements. It is denoted by $\emptyset$. As the number of elements in an empty set is finite, empty set is a finite set. The cardinality of empty set or null set is zero.

Example – $S = \{x \mid x \in N$ and $7 < x < 8\} = \emptyset$

A = {x : x is a man having age more than 600 years}

I real life, we cannot find any person having age more than 600 years, so A= ∅

Singleton Set or Unit Set

Singleton set or unit set contains only one element. A singleton set is denoted by $\{s\}$.

Example – $S = \{x \mid x \in N,\ 7 < x < 9\}$ = $\{8\}$

Equal Set

If two sets contain the same elements they are said to be equal.

Example – If $A = \{1, 2, 6\}$ and $B = \{6, 1, 2\}$, they are equal as every element of set A is an element of set B and every element of set B is an element of set A.

Equivalent Set

If the cardinalities of two sets are same, they are called equivalent sets.

Example – If $A = \{1, 2, 6\}$ and $B = \{16, 17, 22\}$, they are equivalent as cardinality of A is equal to the cardinality of B. i.e. $|A| = |B| = 3$

Subset

A set X is a subset of set Y (Written as $X \subseteq Y$) if every element of X is an element of set Y.

Example 1 – Let, $X = \{1, 2, 3, 4, 5, 6\}$ and $Y = \{1, 2\}$. Here set Y is a subset of set X as all the elements of set Y is in set X. Hence, we can write $Y \subseteq X$.

Example 2 – Let, $X = \{1, 2, 3\}$ and $Y = \{1, 2, 3\}$. Here set Y is a subset (Not a proper subset) of set X as all the elements of set Y is in set X. Hence, we can write $Y \subseteq X$.

Proper Subset

The term “proper subset” can be defined as “subset of but not equal to”. A Set X is a proper subset of set Y (Written as $X \subset Y$) if every element of X is an element of set Y and $|X| < |Y|$.

Example – Let, $X = \{1, 2, 3, 4, 5, 6\}$ and $Y = \{1, 2\}$. Here set $Y \subset X$ since all elements in Y are contained in X too and X has at least one element is more than set Y .

7 .Power set

The set of all the subsets of a given set A is called the power set of A and it is denoted by P(A).

Please do remember that both ø and A are elements of p(A).

If | A| = n then |P(A)| $=2^n$.

e.g., let A={1, 2}

then |P(A)= {ø, {1}, {2},A}

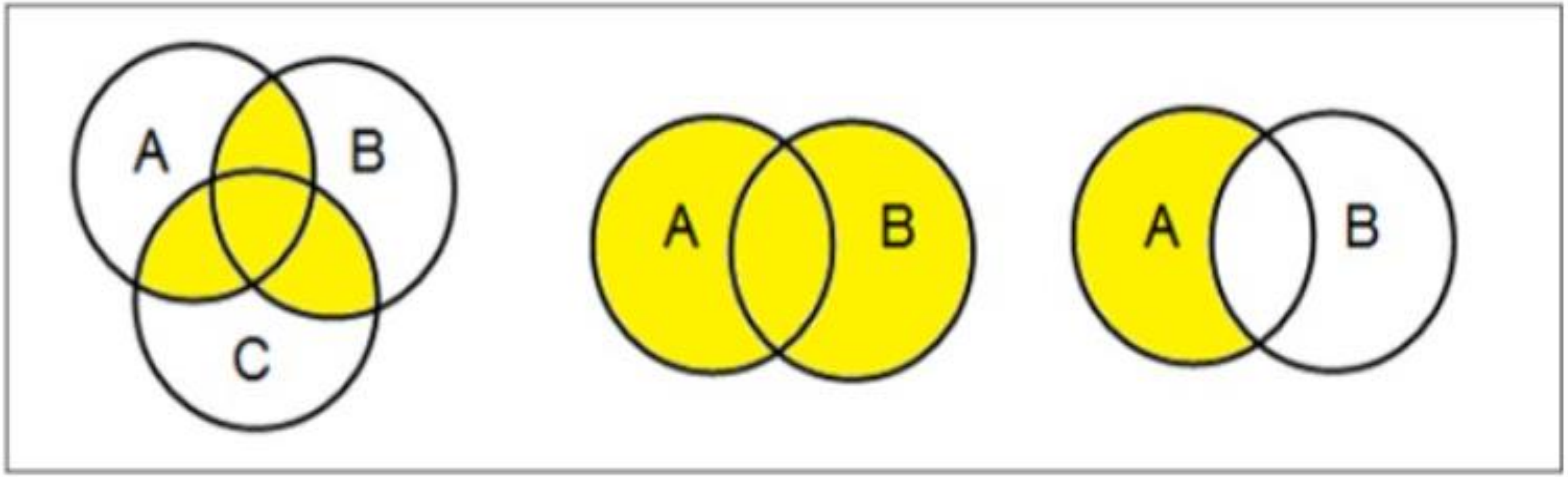
e.g.., A=(A, {b}, }

then P(A) ={ø, {A}, {{B}}, A}

Venn Diagrams

Venn diagram, invented in 1880 by John Venn, is a schematic diagram that shows all possible logical relations between different mathematical sets.

Examples



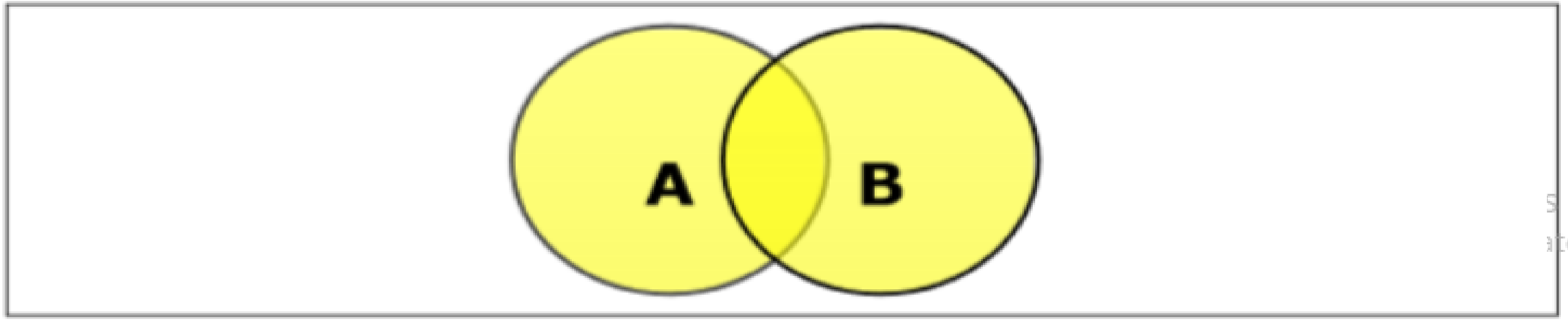
Set Operations

Set Operations include Set Union, Set Intersection, Set Difference, Complement of Set, and Cartesian Product.

Set Union

The union of sets A and B (denoted by $A \cup B$) is the set of elements which are in A, in B, or in both A and B. Hence, $A \cup B = \{x \mid x \in A \; OR \; x \in B\}$.

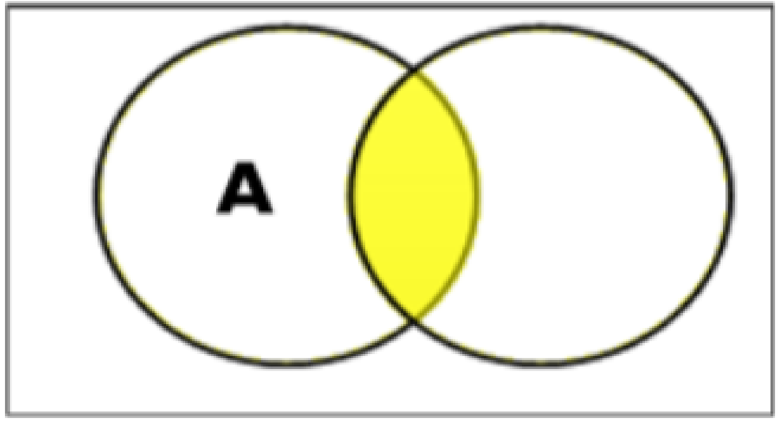
Example − If $A = \{10, 11, 12, 13\}$ and B = $\{13, 14, 15\}$, then $A \cup B = \{10, 11, 12, 13, 14, 15\}$. (The common element occurs only once)



Set Intersection

The intersection of sets A and B (denoted by $A \cap B$) is the set of elements which are in both A and B. Hence, $A \cap B = \{x \mid x \in A \; AND \; x \in B\}$.

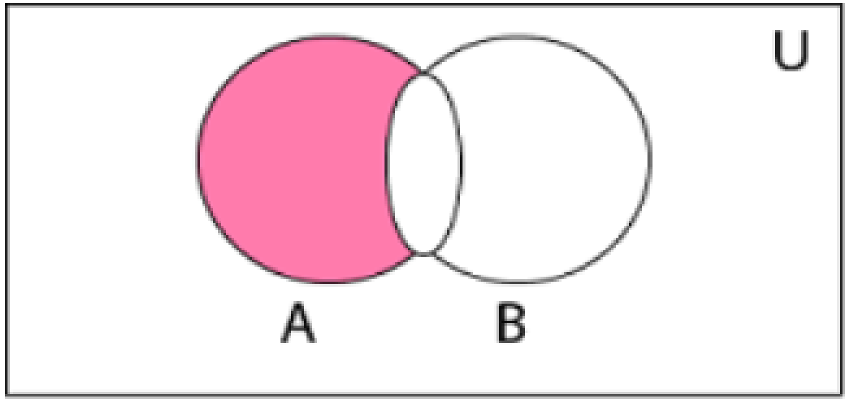
Example – If $A = \{11, 12, 13\}$ and $B = \{13, 14, 15\}$, then $A \cap B = \{13\}$.



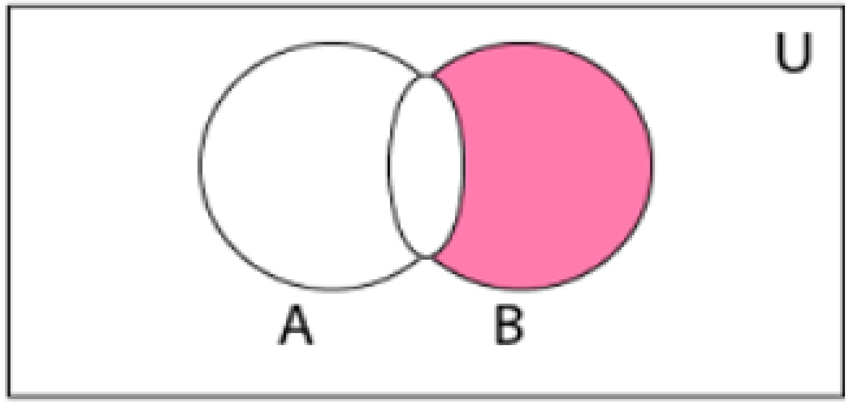
3. Difference of Sets: The difference of two sets A and B is a set of all those elements which belongs to A but do not belong to B and is denoted by A - B.

> A - B = {x: x ∈ A and x ∉ B}

Example: Let A = {1, 2, 3, 4} and B = {3, 4, 5, 6} then A - B = {3, 4} and B - A = {5, 6}



A - B



B - A

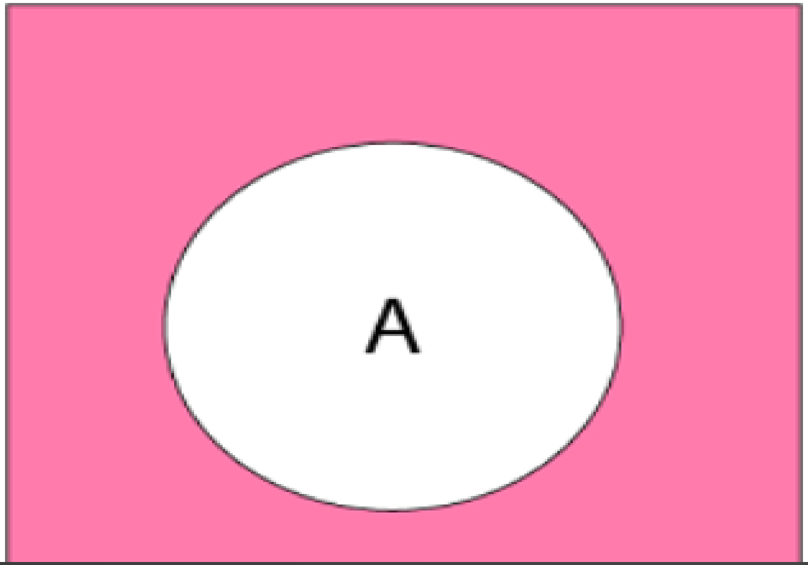
4. Complement of a Set: The Complement of a Set A is a set of all those elements of the universal set which do not belong to A and is denoted by A^C.

$$A^C = U - A = \{x : x \in U \text{ and } x \notin A\} = \{x : x \notin A\}$$

Example: Let U is the set of all natural numbers.

A = {1, 2, 3}

A^C = {all natural numbers except 1, 2, and 3}.



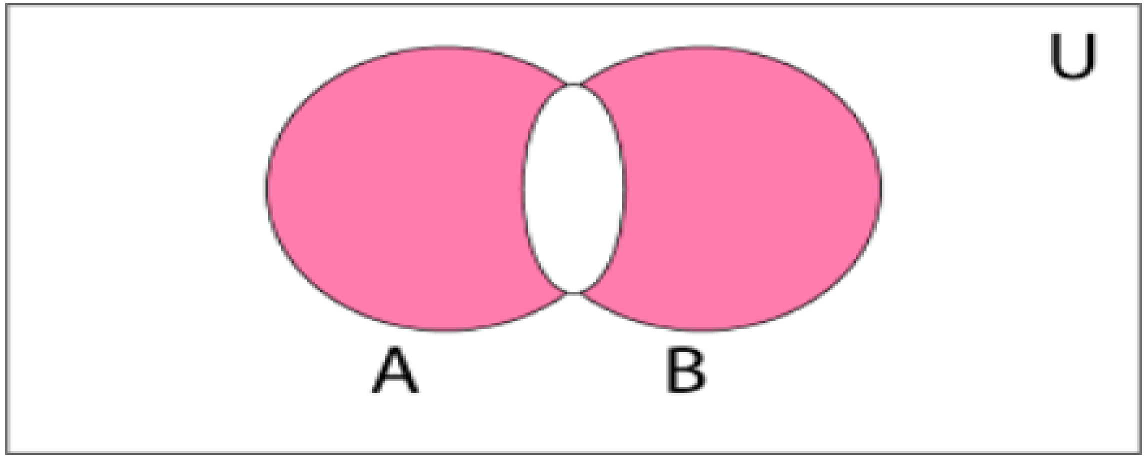
5. Symmetric Difference of Sets: The symmetric difference of two sets A and B is the set containing all the elements that are in A or B but not in both and is denoted by A ⊕ B i.e.

> A ⊕ B = (A ∪ B) - (A ∩ B)

Example: Let A = {a, b, c, d}

B = {a, b, l, m}

A ⊕ B = {c, d, l, m}



Multisets

A multiset is an unordered collection of elements, in which the multiplicity of an element may be one or more than one or zero. The multiplicity of an element is the number of times the element repeated in the multiset. In other words, we can say that an element can appear any number of times in a set.

Example:

A = {l, l, m, m, n, n, n, n}

B = {a, a, a, a, a, c}

Operations on Multisets

1. Union of Multisets: The Union of two multisets A and B is a multiset such that the multiplicity of an element is equal to the maximum of the multiplicity of an element in A and B and is denoted by A ∪ B.

Example:

> Let A = {l, l, m, m, n, n, n, n}
>
> B = {l, m, m, m, n},
>
> A ∪ B = {l, l, m, m, m, n, n, n, n}

2. Intersections of Multisets: The intersection of two multisets A and B, is a multiset such that the multiplicity of an element is equal to the minimum of the multiplicity of an element in A and B and is denoted by A ∩ B.

Example:

> Let A = {l, l, m, n, p, q, q, r}
>
> B = {l, m, m, p, q, r, r, r, r}
>
> A ∩ B = {l, m, p, q, r}.

3. Difference of Multisets: The difference of two multisets A and B, is a multiset such that the multiplicity of an element is equal to the multiplicity of the element in A minus the multiplicity of the element in B if the difference is +ve, and is equal to 0 if the difference is 0 or negative

Example:

Let A = {l, m, m, m, n, n, n, p, p, p}

B = {l, m, m, m, n, r, r, r}

A - B = {n, n, p, p, p}

4. Sum of Multisets: The sum of two multisets A and B, is a multiset such that the multiplicity of an element is equal to the sum of the multiplicity of an element in A and B

Example:

> Let A = {l, m, n, p, r}
>
> B = {l, l, m, n, n, n, p, r, r}
>
> A + B = {l, l, l, m, m, n, n, n, n, p, p, r, r, r}

5. Cardinality of Sets: The cardinality of a multiset is the number of distinct elements in a multiset without considering the multiplicity of an element

Example:

> A = {l, l, m, m, n, n, n, p, p, p, p, q, q, q}

The cardinality of the multiset A is 5.

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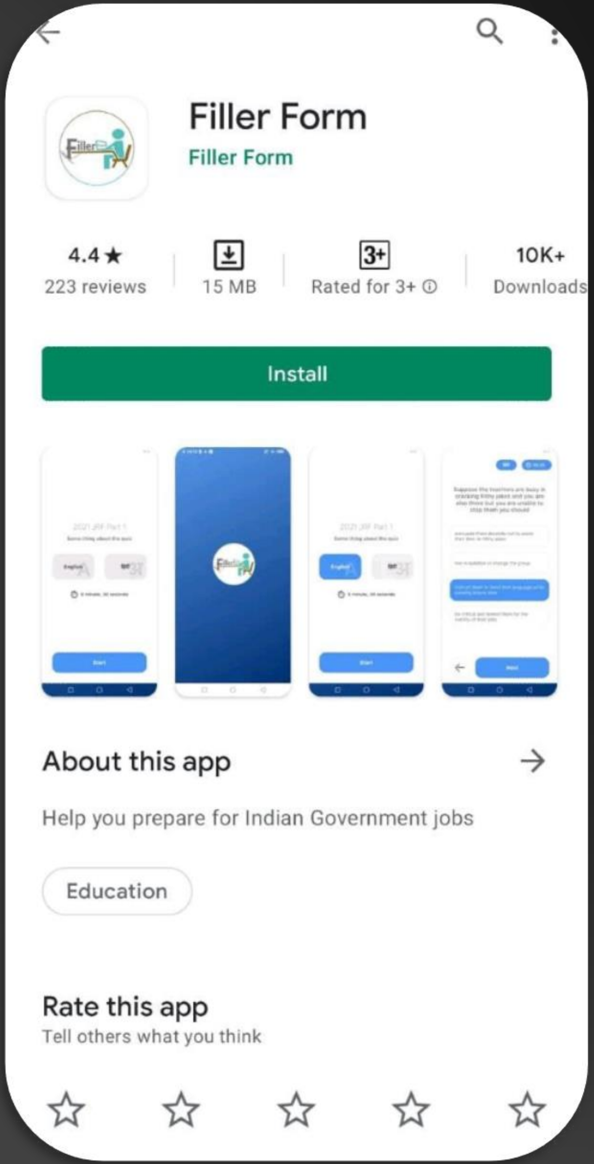


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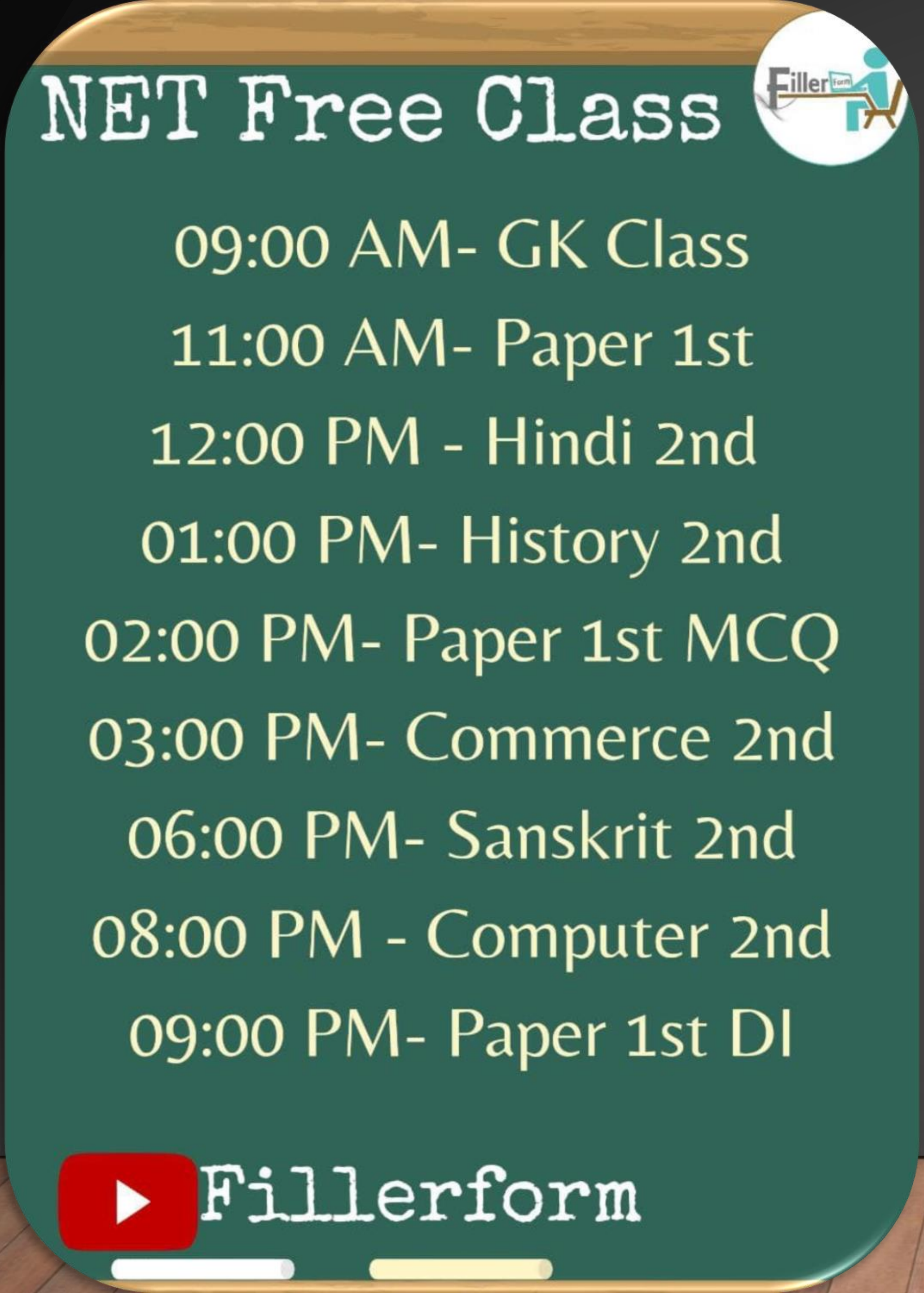
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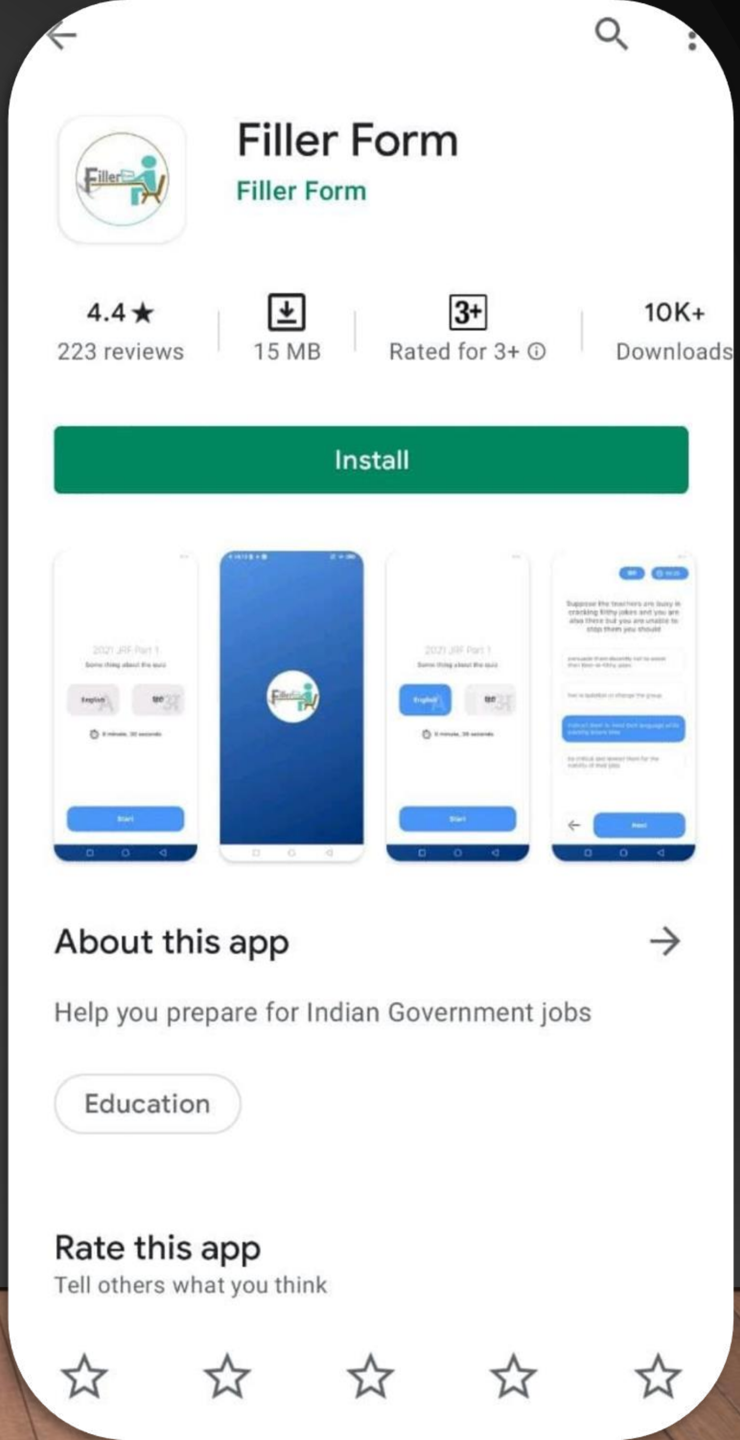
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