Months Wise Calendar for GATE-2023 (Unacademy Plus) (Sanchit Jain)

Month	Morning Class (7:30am – 9:00am)	Evening Class (6:00pm – 8:00pm)
Feb-2022	DS & Programming (16-Feb to 23-Mar) (56 Hours)	**DM (2-Feb to 2-Mar) (50 Hours)**
Mar-2022	Algo (24-Mar to 26-April) (38 Hours)	DBMS (5-Mar to 20-April) (50 Hours)
Apr-2022	CN(29-April to 15-June) (54 Hours)	DE (24-April to 1-June) (40 Hours)
May-2022	TOC (26-May to 05-July) (58 Hours)	COA (23-June to 20-July) (38 Hours)
Jun-2022	Compiler (7-July to 5-Aug) (34 Hours)	OS (21-July to 24-Aug) (58 Hours)
Jul-2022		
Aug-2022	DM (11-Aug to 20-Sept) (50 Hours)	**DS & Programming (25-Aug to 5-Oct) (56 Hours)**
Sep-2022	DBMS (22-Sept to 29-Oct) (50 Hours)	Algo (6-Oct to 20-Oct) (38 Hours)
Oct-2022	DE (3-Nov to 23-Nov) (40 Hours)	CN(24-Oct to 20 Nov) (54 Hours)
Nov-2022	COA (24-Nov to 13-Dec) (38 Hours)	TOC (22-Nov to 20-Dec) (58 Hours)
Dec-2022	OS (15-Dec to 31-Jan) (58 Hours)	Compiler (21-Dec to 3-Feb) (58 Hours)
Jan-2023		
Feb-2023		

Months Wise Calendar for GATE-2023 (Unacademy Plus) (Sanchit Jain)

Month	Morning Class (7:30am – 9:00am)	Evening Class (6:00pm – 8:00pm)
Feb-2022	DS & Programming (16-Feb to 23-Mar) (56 Hours)	**DM (2-Feb to 2-Mar) (50 Hours)**
Mar-2022	Algo (24-Mar to 26-April) (38 Hours)	DBMS (5-Mar to 20-April) (50 Hours)
Apr-2022	CN(29-April to 15-June) (54 Hours)	DE (24-April to 1-June) (40 Hours)
May-2022	TOC (26-May to 05-July) (58 Hours)	COA (23-June to 20-July) (38 Hours)
Jun-2022	Compiler (7-July to 5-Aug) (34 Hours)	OS (21-July to 24-Aug) (58 Hours)
Jul-2022		
Aug-2022	DM (11-Aug to 20-Sept) (50 Hours)	**DS & Programming (25-Aug to 5-Oct) (56 Hours)**
Sep-2022	DBMS (22-Sept to 29-Oct) (50 Hours)	Algo (6-Oct to 20-Oct) (38 Hours)
Oct-2022	DE (3-Nov to 23-Nov) (40 Hours)	CN(24-Oct to 20 Nov) (54 Hours)
Nov-2022	COA (24-Nov to 13-Dec) (38 Hours)	TOC (22-Nov to 20-Dec) (58 Hours)
Dec-2022	OS (15-Dec to 31-Jan) (58 Hours)	Compiler (21-Dec to 3-Feb) (58 Hours)
Jan-2023		
Feb-2023		

Months Wise Calendar for GATE-2022 (Unacademy Plus) (Sanchit Jain)

Month	Morning Class (7:00am – 9:00am)	Evening Class (7:00pm – 9:00pm)
Feb-2021	DS & Programming (15-Feb to 23-Mar) (56 Hours)	DM (22-Feb to 27-Mar) (50 Hours)
Mar-2021	Algo (24-Mar to 26-April) (38 Hours)	DBMS (29-Mar to 30-April) (50 Hours)
Apr-2021	CN(29-April to 15-June) (54 Hours)	DE (7-May to 1-June) (40 Hours)
May-2021	TOC (26-May to 05-July) (58 Hours)	COA (23-June to 20-July) (38 Hours)
Jun-2021	Compiler (7-July to 5-Aug) (34 Hours)	OS (21-July to 24-Aug) (58 Hours)
Jul-2021		
Aug-2021	DM (11-Aug to 20-Sept) (50 Hours)	DS & Programming (25-Aug to 5-Oct) (56 Hours)
Sep-2021	DBMS (22-Sept to 29-Oct) (50 Hours)	Algo (6-Oct to 1-Nov) (38 Hours)
Oct-2021	DE (3-Nov to 23-Nov) (40 Hours)	CN(10-Nov to 5 Jan) (54 Hours)
Nov-2021	COA (24-Nov to 13-Dec) (38 Hours)	**Compiler (12-Jan to 3-Feb) (58 Hours)**
Dec-2021	OS (15-Dec to 11-Jan) (58 Hours)	
Jan-2022	**TOC (12-Jan to 3-Feb) (58 Hours)**	
Feb-2022		

COMPLETED

Discrete Mathematics Schedule For GATE-2023

	Evening				
Date	**Day**	**Subject**	**Topic**	**Time**	**Duration**
02-02-2022	Wednesday	DM	Set Theory Part-1	6:00 pm to 8:00 pm	2-Hours
06-02-2022	Sunday	DM	Set Theory Part-2	6:00 pm to 8:00 pm	2-Hours
07-02-2022	Monday	DM	Set Theory Part-3	6:00 pm to 8:00 pm	2-Hours
08-02-2022	Tuesday	DM	Doubt Clearing Session	6:00 pm to 8:00 pm	2-Hours
09-02-2022	Wednesday	DM	Fundamental and Types of Relation Part-1	6:00 pm to 8:00 pm	2-Hours
10-02-2022	Thursday	DM	Fundamental and Types of Relation Part-2	6:00 pm to 8:00 pm	2-Hours
11-02-2022	Friday	DM	Partial Order Relation Part-1	6:00 pm to 8:00 pm	2-Hours
12-02-2022	Saturday	DM	Doubt Clearing Session	6:00 pm to 8:00 pm	2-Hours
13-02-2022	Sunday	DM	Partial Order Relation Part-2	6:00 pm to 8:00 pm	2-Hours
14-02-2022	Monday	DM	Proposition Part-1	6:00 pm to 8:00 pm	2-Hours
15-02-2022	Tuesday	DM	Proposition Part-2	6:00 pm to 8:00 pm	2-Hours
16-02-2022	Wednesday	DM	Doubt Clearing Session	6:00 pm to 8:00 pm	2-Hours
17-02-2022	Thursday	DM	Proposition Part-3	6:00 pm to 8:00 pm	2-Hours
18-02-2022	Friday	DM	Proposition Part-4	6:00 pm to 8:00 pm	2-Hours
19-02-2022	Saturday	DM	Group Thepry Part-1	6:00 pm to 8:00 pm	2-Hours
21-02-2022	Monday	DM	Doubt Clearing Session	6:00 pm to 8:00 pm	2-Hours
22-02-2022	Tuesday	DM	Group Thepry Part-2	6:00 pm to 8:00 pm	2-Hours
23-02-2022	Wednesday	DM	Graph Theory Part-1	6:00 pm to 8:00 pm	2-Hours
24-02-2022	Thursday	DM	Graph Theory Part-2	6:00 pm to 8:00 pm	2-Hours
25-02-2022	Friday	DM	Doubt Clearing Session	6:00 pm to 8:00 pm	2-Hours
26-02-2022	Saturday	DM	Graph Theory Part-3	6:00 pm to 8:00 pm	2-Hours
27-02-2022	Sunday	DM	Graph Theory Part-4	6:00 pm to 8:00 pm	2-Hours
28-02-2022	Monday	DM	Graph Theory Part-5	6:00 pm to 8:00 pm	2-Hours
01-03-2022	Tuesday	DM	Functions	6:30 pm to 8:00 pm	2-Hours
02-03-2022	Wednesday	DM	Doubt Clearing Session	6:30 pm to 8:00 pm	2-Hours

GATE & ESE | Plus | All courses | All languages | All topics

HINGLISH CS & IT

Foundation Course on Compiler for GATE 2022

Lesson 15 • Feb 1, 2022 6:30 PM

Sanchit Jain

HINGLISH CS & IT

Foundation Course on Theory of Computation for GATE 2022

Lesson 21 • Feb 3, 2022 8:00 AM

Sanchit Jain

HINDI CS & IT

Foundation Course on Discrete Mathematics for GATE

Starts on Feb 2, 2022 • 25 lessons

Sanchit Jain

HINGLISH CS & IT

Complete Course on Operating System for GATE

Ended on Jan 11, 2022 • 28 lessons

Sanchit Jain

HINGLISH ELECTRICAL ENGINEERING

Complete Course on Computer Architecture for GATE

Ended on Dec 13, 2021 • 19 lessons

Sanchit Jain

HINGLISH CS & IT

Complete Course on Computer Networks for GATE

Ended on Jan 7, 2022 • 27 lessons

Sanchit Jain

HINDI CS & IT

Complete Course on Digital Electronics for GATE

Ended on Nov 23, 2021 • 18 lessons

Sanchit Jain

HINGLISH PRACTICE & STRATEGY

FAQ Handbook for GATE

Ended on Nov 26, 2021 • 7 lessons

Ravindrababu Ravula

HINDI CS & IT

Complete Course on Algorithms for GATE

Ended on Nov 9, 2021 • 19 lessons

Sanchit Jain

HINGLISH CS & IT

Complete Course on DBMS for GATE

Ended on Oct 28, 2021 • 25 lessons

Sanchit Jain

HINDI CS & IT

Complete Course on Programming & Data Structures for GATE

Ended on Oct 12, 2021 • 28 lessons

Sanchit Jain

HINDI CS & IT

Complete Course on Discrete Mathematics for GATE

Ended on Oct 10, 2021 • 27 lessons

Sanchit Jain

Educator highlights

- Works at **Knowledge Gate**
- Studied at **Delhi Technological University**
- Have qualified gate Have experience of more than 8 years Have a YouTube channel with 5 lakh follower
- Lives in **Ghaziabad, Uttar Pradesh, India**
- Unacademy Educator since **19th July, 2019**
- **844,388 live minutes** taught in last 30 days
- Knows **Punjabi, Hinglish, Hindi and English**

Sanchit Jain

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Legend in GATE & ESE

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Sweta Kumari

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Vishvadeep Gothi

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- GATE AIR-19, 119, 440, 682 - ME from IISc, - MTech BITS Pilani (Data Science) - 14 years teaching experience

10M Watch mins | **1M** Watch mins (last 30 days) | **10K** Followers | **1K** Dedications

Venkata Rao M

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Expert

I am having 13+ years of experience teaching GATE Aspirants...Ex-Made Easy faculty.

8M Watch mins | **692K** Watch mins (last 30 days) | **4K** Followers | **455** Dedications

What if i Miss Live Class?

Completed courses

Completed Courses

What About Non-Tech Sub?

Engineering Mathematics

Ongoing | All courses | All languages

ENGLISH ENGINEERING MATHEMATICS

Comprehensive Course on Engineering Mathematics

Lesson 7 • Today, 12:00 PM

Karumudi Umamaheswara Rao

ENGLISH ENGINEERING MATHEMATICS

Course on Calculus for GATE CSE 2022/2023

Lesson 3 • Today, 6:00 PM

Karumudi Umamaheswara Rao

HINDI ENGINEERING MATHEMATICS

Detailed Course on Engineering Mathematics - Part III

Lesson 16 • Today, 2:00 PM

PALLAV GOUR

HINDI ENGINEERING MATHEMATICS

Detailed Course on Engineering Mathematics - Part I

Lesson 11 • Aug 31, 2021 9:00 AM

PALLAV GOUR

HINGLISH ENGINEERING MATHEMATICS

Comprehensive Course on General Aptitude - Part II

Lesson 7 • Today, 5:00 PM

Sanga N L N Sarma

General Aptitude

Ongoing | All courses | All languages

HINGLISH GENERAL APTITUDE

Course on General Aptitude for GATE 2022-23

Lesson 9 · Started at 9:00 AM

Saurabh Thakur

HINGLISH GENERAL APTITUDE

Practice Course on General Aptitude for GATE 2022

Lesson 9 · Nov 10, 2021 9:30 AM

Aman Raj

HINGLISH GENERAL APTITUDE

Comprehensive Course on General Aptitude - Part II

Lesson 7 · Today, 5:00 PM

Sanga N L N Sarma

ENGLISH GENERAL APTITUDE

Complete Course on General English for GATE 2022 & 2023

Lesson 29 · Today, 12:30 PM

Shreyas A

ENGLISH GENERAL APTITUDE

Comprehensive Course on Numerical Aptitude

Lesson 9 · Dec 1, 2021 5:00 PM

Venkatadri Vaka

HINGLISH GENERAL APTITUDE

Course on Reasoning & Aptitude

Lesson 57 · Today, 12:00 PM

Syed Asif Haider

Test Series

GATE & ESE Test series

Ongoing

Topic-wise tests for GATE CS & IT by Ravindrababu Ravula

Test 40 • Aug 27, 6:00 PM

Subject-wise tests for GATE CS & IT by Ravindrababu Ravula

Test 11 • Sep 11, 6:00 PM

Ignite for GATE 2022 (CS & IT)

FREE

Test 6 • Aug 26, 6:30 PM

Let's Crack BARC 2021 (CS & IT)

FREE

Test 3 • Aug 28, 10:00 AM

Pick a specific topic

Practice Question

Digital Logic
7 concepts • 287 questions

Computer Network
15 concepts • 262 questions

Database Management System
15 concepts • 245 questions

Theory of Computation
14 concepts • 325 questions

COA
15 concepts • 394 questions

Compiler Design
8 concepts • 248 questions

Programming & Data Structure
7 concepts • 362 questions

Algorithms
7 concepts • 290 questions

Operating System
14 concepts • 311 questions

Discrete Mathematics
8 concepts • 195 questions

ASK-A-DOUBT BY UNACADEMY

GATE

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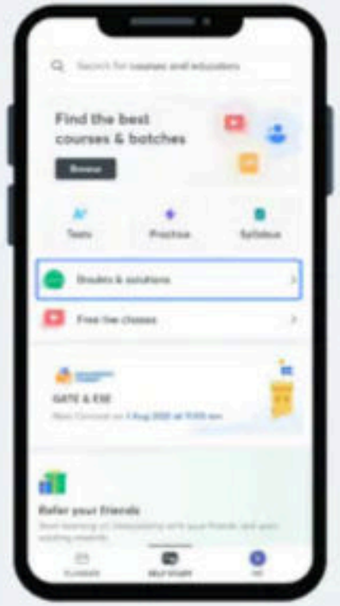
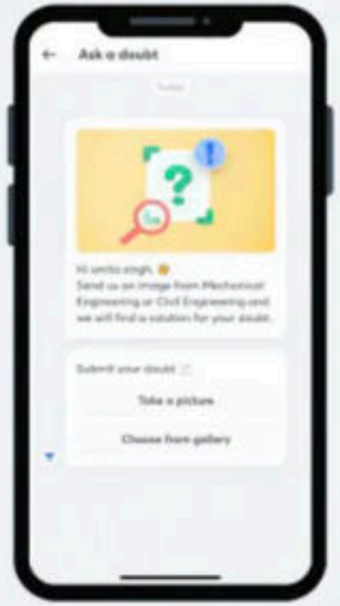
1. Go to the "Doubts & Solutions" feature on your home screen.

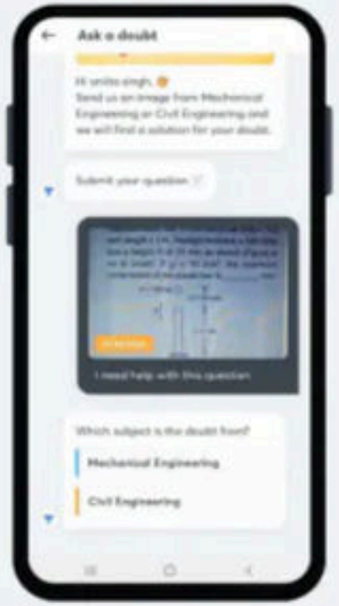


2. Click on "Ask-A-Doubt" & upload your doubt image.



3. Crop the image and highlight the question

4. Choose the subject that the question falls under



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A faster and better way to solve doubts!

GATE & ESE

Whats new?

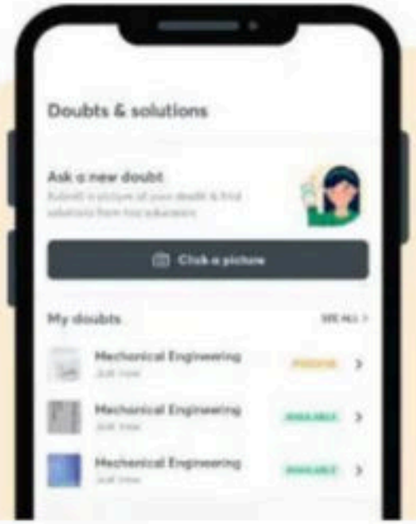
Upload upto three doubts at a go.

You can post 2 additional doubts while waiting for your solution

Get solutions in your preferred language

Select the language you want your question to be answered in

Simply **Click, Crop and Submit** your question!



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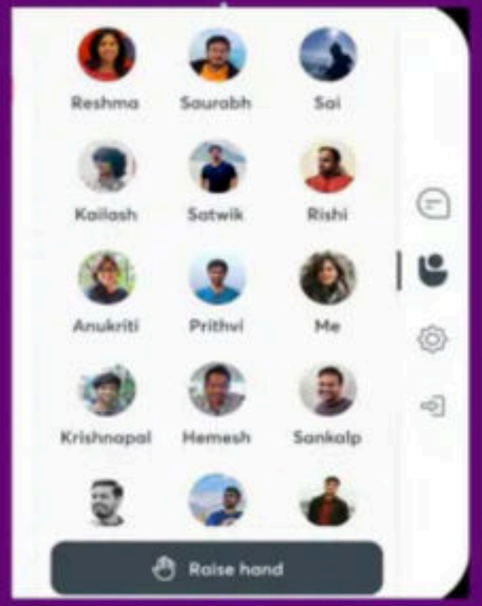
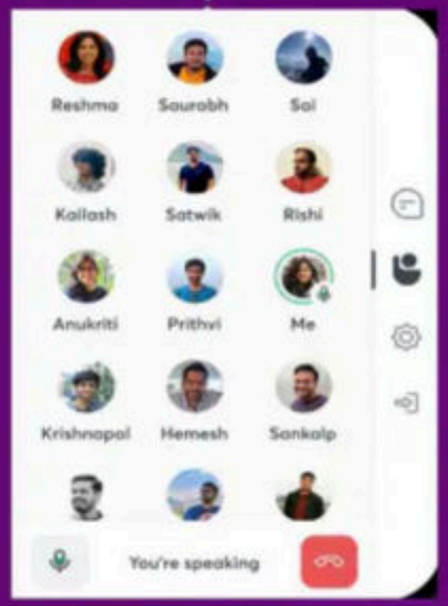
RAISE-A-HAND

Talk with your Favourite Educators in live class and clear your doubts!



- Click on the Raise a Hand icon from the vertical tab and click on Raise hand



- Talk to the Educator in a Live Class

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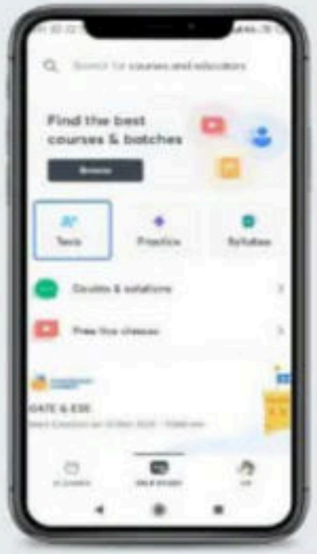
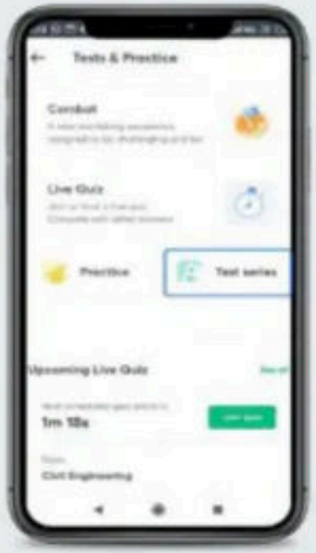
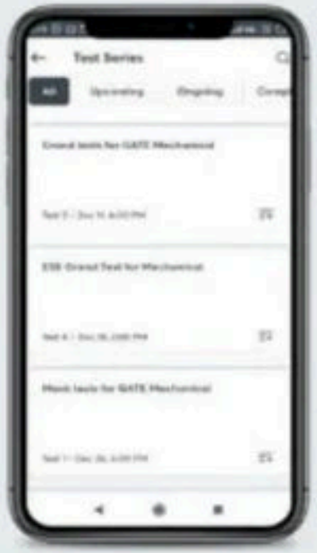


2. Click on the "Test Series" button



3. Enroll and take the test of your choice



Test Series available on the platform

- Topic Wise Tests
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- Monthly batch tests
- Mock Tests (Upcoming)

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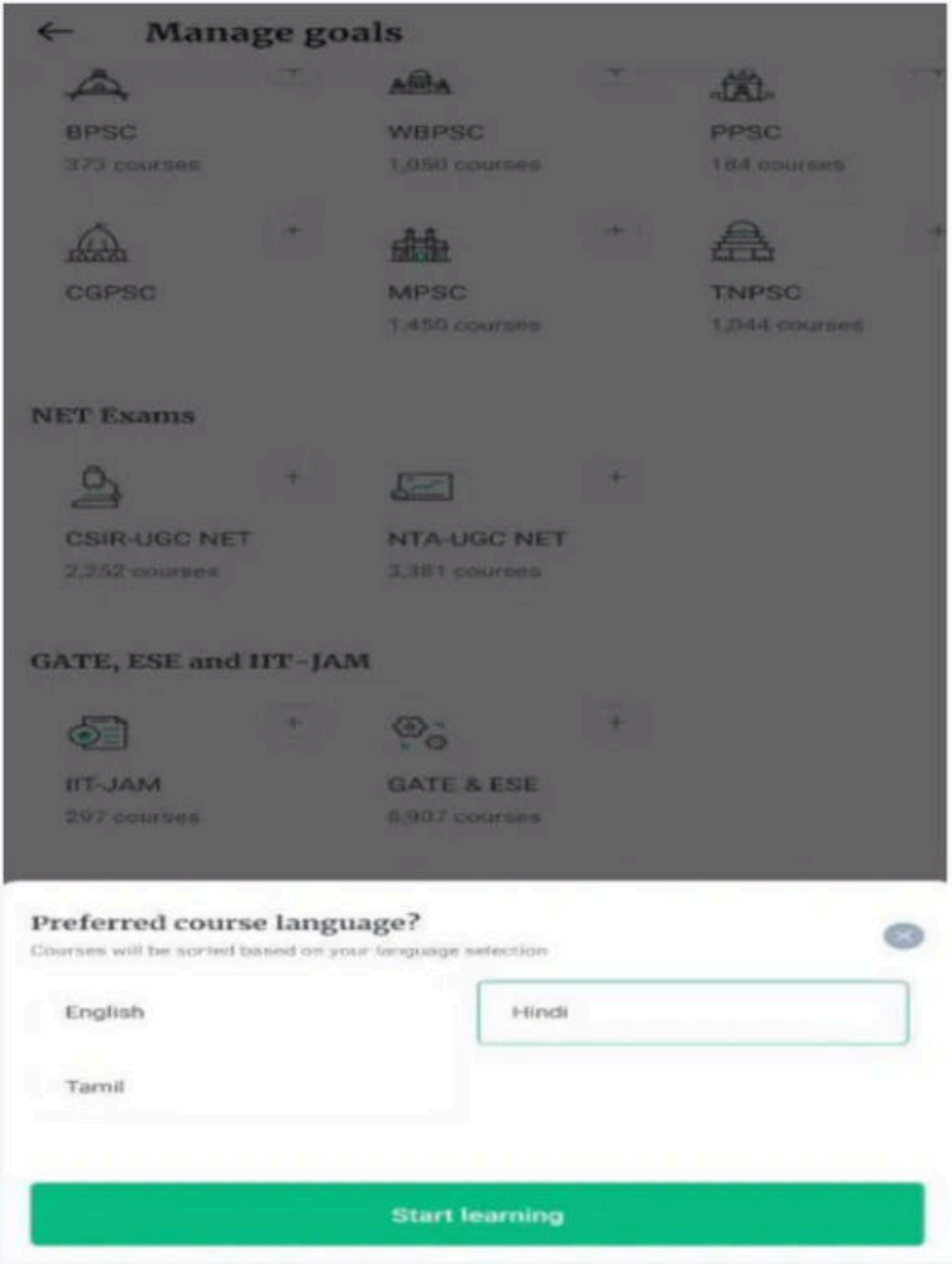
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PPSC
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CGPSC
MPSC
1,450 courses
TNPSC
1,044 courses
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CSIR-UGC NET
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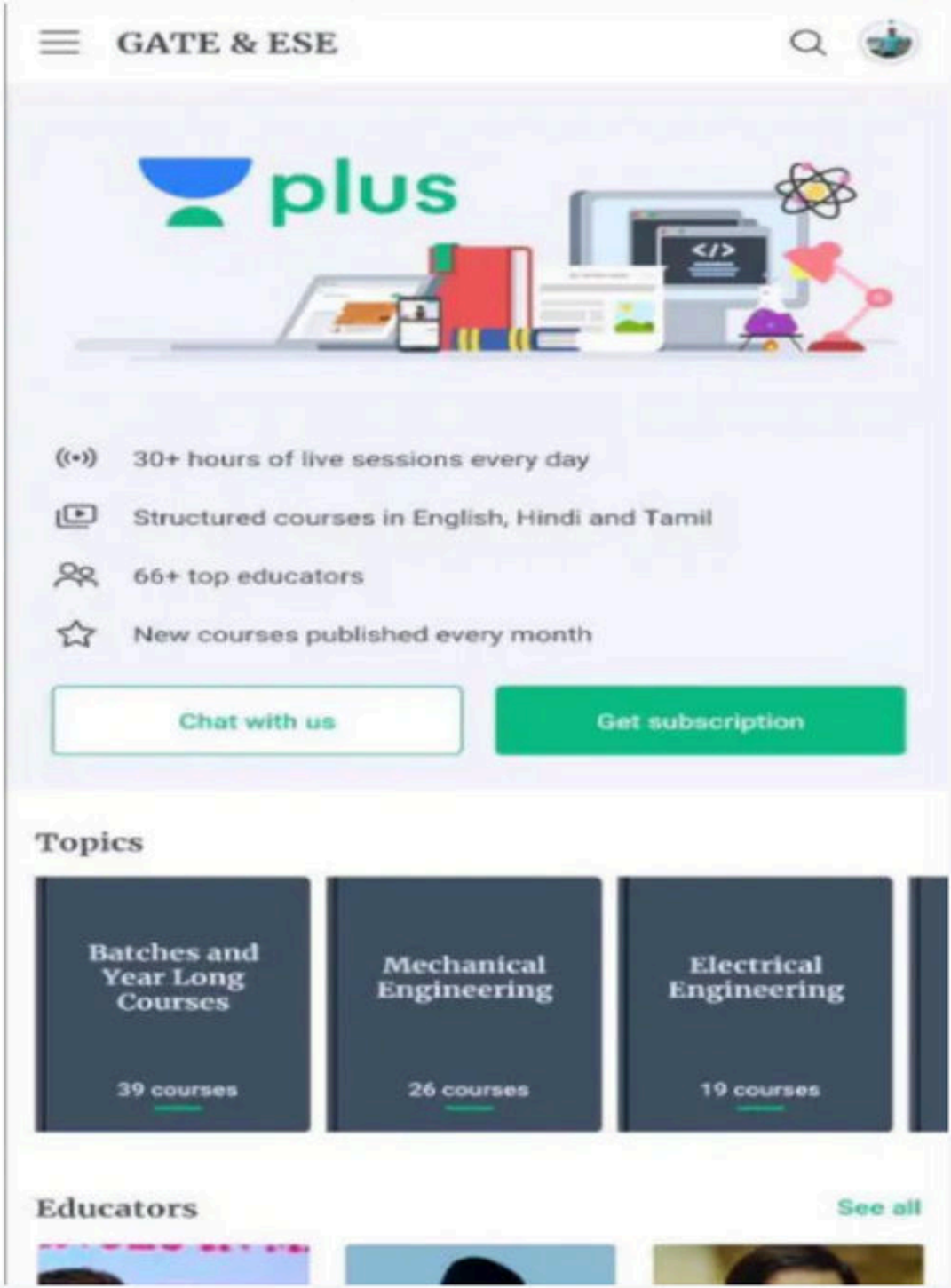
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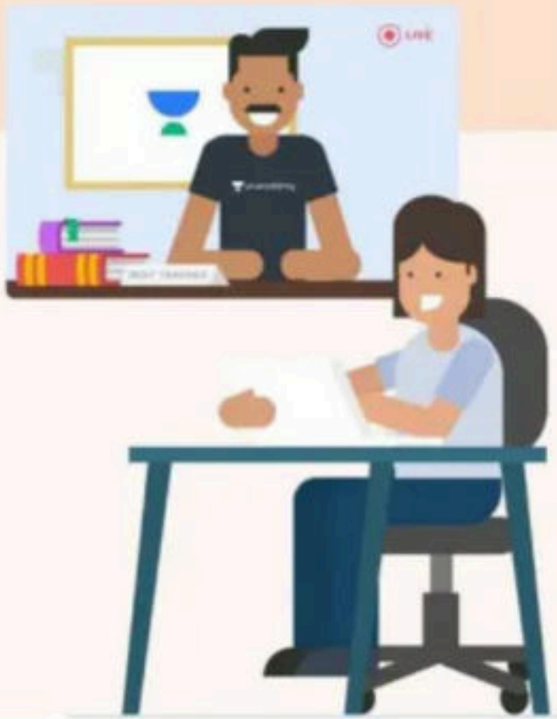

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Verbal Ability

TOPIC	CONCEPTS
Verbal Ability	• Grammar / Basics • Grammar / Question Types • Vocabulary / Question Types
Reading Comprehension	• Fundamentals / RC • Types of Questions • Structure & Usage

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Numerical Ability

TOPIC	CONCEPTS	
Arithmetic Reasoning	• Number System • HCF & LCM of Numbers	• Simplification • Logarithms
Quantitative Apptitude-1	• Averages • Percentages • Profit and Loss • Ratio and Proportion • Partnership • Chain Rule • Pipes and Cisterns • Time and Work	• Speed, Time and Distance • Boats and Streams • Problems and Trains • Mixtures and Alligations • Simple Interest • Compound Interest • True Discount • Bankers Discount
Quantitative Apptitude-2	• 2-D Mensuration • 3-D Mensuration • Heights and Distances	• Probability • Permutations and Combinations • Races and Games
Data Interpretation	• Table Graphs • Bar Graphs • Pie Charts	• Line Graphs • Mixed Graphs

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Reasoning Ability

TOPIC	CONCEPTS	
Logical Reasoning	• Blood Relations • Seating Arrangements • Directions and Distances • Ranking Test • Coding-Decoding • Puzzle Test • Alphabet Test	• Time Sequence Test • Logical Problems • Logical Sequence of Words • Situation Reaction Test • Data Sufficiency • Clocks and Calendars
Arithmetical Reasoning	• Alphanumeric Puzzles • Number Test Series • Inserting the missing character • Calculation-Based Problems	• Problems on Ages • Venn-Diagram Based Questions • Number Analogy • Letter Analogy
Verbal Reasoning	• Logical Venn Diagrams • Syllogisms • Statement and Conclusions • Statement and Courses of Action • Statement and Arguments	• Statement and Assumptions • Decision Making • Critical Reaoning (Conclusions from Passages) • Word Analogy • Classification
Non- Verbal Reasoning	• Series • Analogy • Classification • Mirror Images • Analytical Reasoning • Water Images • Spotting out the Embedded Figure • Completion of Incomplete Pattern	• Figure Matrix • Paper Cutting • Paper Folding • Rule Detection • Grouping of Identical Figures • Cubes and Dices • Dot Situation • Counting of Squares, Triangles, Circles, Rectangles, Lines • Assembling of Images

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TECHNICAL

Programming and Coding

NON-TECHNICAL

Verbal Ability

Numeric Ability

Reasoning Ability

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TECHNICAL - 200 + HOURS

</> Programming and Coding

TOPIC	CONCEPTS
Programming Fundamentals	• Introduction to Programming • Basics Of C Programming • Basics Of Problem Solving • Transition To C++
Data Structure	• Basic Data Structures • Advanced Data Structures And Algorithms
Computer Fundamentals	• Computer Networks • DBMS • OS
Basics Of Web Development	• Introduction to web development
Java	• Basics of Java • Advanced Java
Python	• Basics of Python

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Kotak Mahindra Bank - Credit Card	No Cost EMI*

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CONGRATULATIONS

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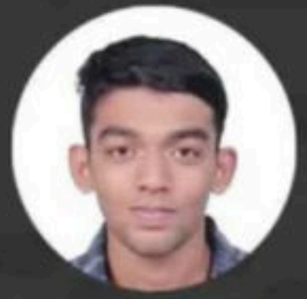
AIR 12

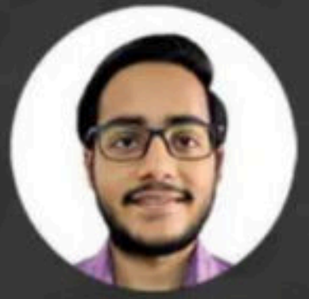
AKASH KUMAR
AIR 20



JAYNIK GAGLANI
AIR 26

ANKIT KURANI
AIR 53

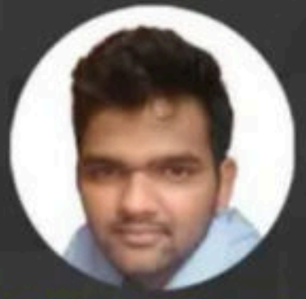
DUVVURI RAVI CHANDRA
AIR 63



ANMOL NAMDEV
AIR 80

SHIVAM GAUTAM
AIR 84

BHARTENDU KUMAR
AIR 84



JIBAN JYOTI DASH
AIR 90

KRITIKA GUPTA
AIR 90

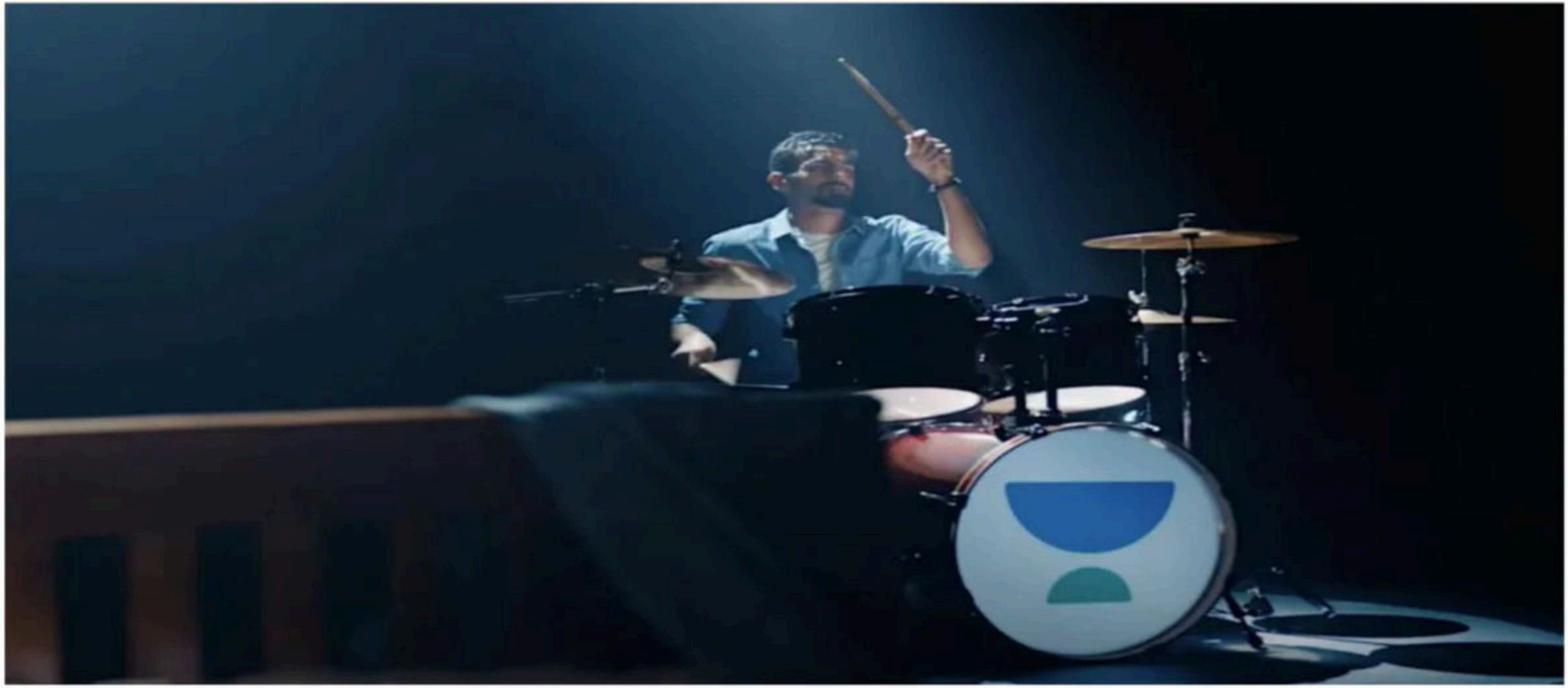
MOHAMMAD UMMAIR
AIR 95

What About Quality and Scale?

Indian edtech Unacademy valued at $3.44 billion in $440 million fundraise

Manish Singh @refsrc / 6:45 AM GMT+5:30 • August 2, 2021

Comment



Conclusion?

- Finding a Perfect Mentor ?
- Discipline (Regular study) (4-6 Hours) ?
- Theory and Numerical of complete syllabus ?
- Less Cost ?
- Safety form Covid ?

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HINGLISH
Discrete Mathematics Problem Solving Part - 4
Sanchit Jain

HINGLISH CS & IT
Discrete Mathematics Problem Solving Part - 3
Starts on Aug 28, 9:00 AM
Sanchit Jain

HINDI PROGRAMMING
Basics of Link List
Starts on Aug 27, 3:00 PM
Sanchit Jain

HINGLISH CS & IT
OS Problem Solving Part - 7
Starts on Aug 27, 8:00 AM
Sanchit Jain

HINDI PROGRAMMING
Basics of Stack
Starts on Aug 25, 3:00 PM
Sanchit Jain

HINGLISH CS & IT
OS Problem Solving Part - 6
Ended on Aug 24, 2021
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HINDI PROGRAMMING
Basics of Array
Ended on Aug 23, 2021
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HINDI COMPUTER FUNDAMENTALS
Understanding Data Strucutre
Ended on Aug 21, 2021
Sanchit Jain

HINGLISH CS & IT
OS Problem Solving Part - 5
Ended on Aug 21, 2021
Sanchit Jain

HINDI COMPUTER FUNDAMENTALS
Data Link Layer in detail
Ended on Aug 20, 2021
Sanchit Jain

HINGLISH CS & IT
Discrete Mathematics Problem Solving Part - 2
Ended on Aug 20, 2021
Sanchit Jain

HINDI COMPUTER FUNDAMENTALS
Basics of Transmission media
Ended on Aug 18, 2021
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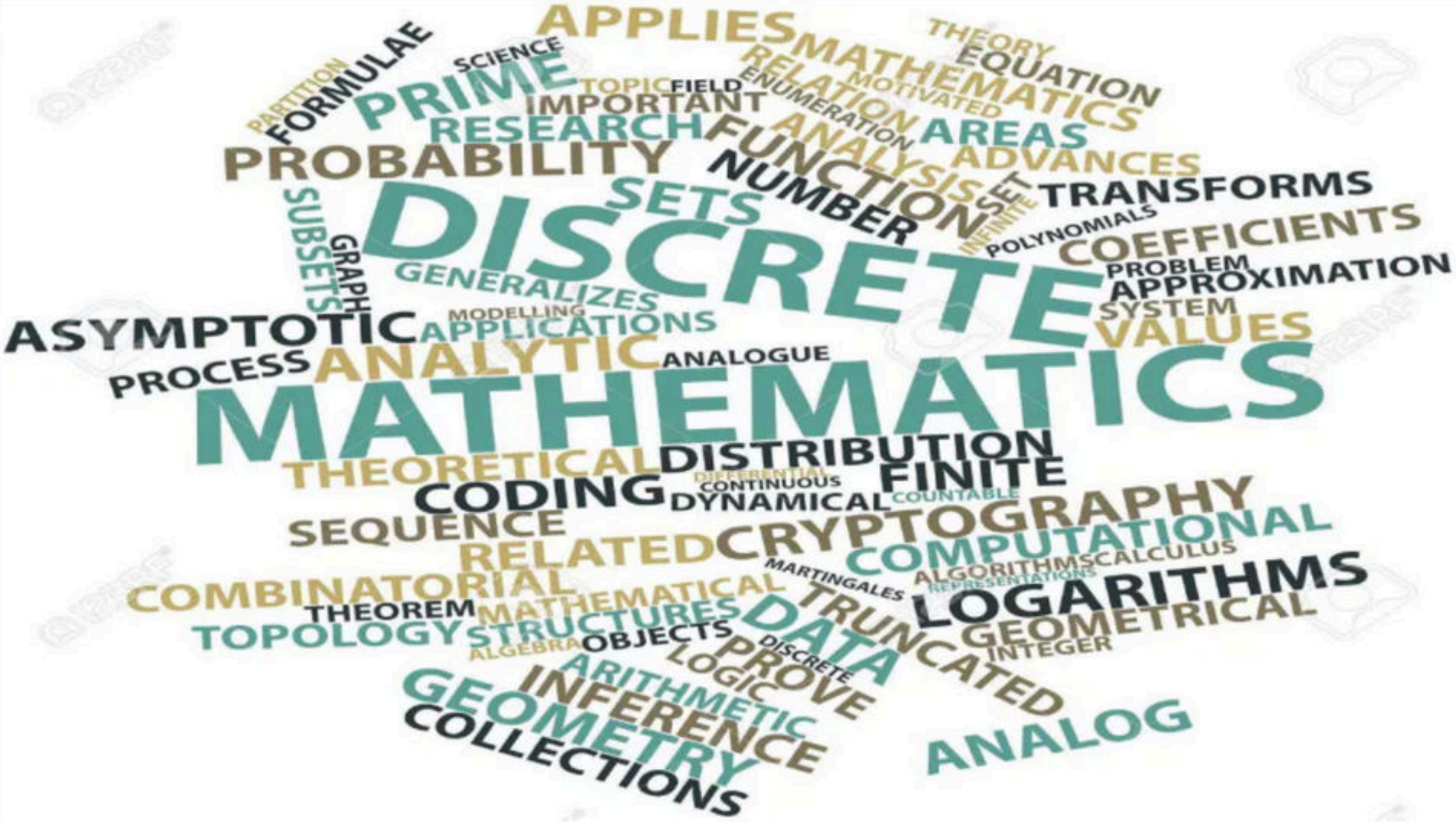
*TERMS AND CONDITIONS APPLY

Fundamental and Types of Relation - Part I

Foundation Course on Discrete Mathematics for GATE

Sanchit Jain • Lesson 5 • Feb 9, 2022



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- Discrete mathematics is a core subject of theoretical computer science. It is not a directly application-oriented subject, but it provides tolls and mathematical models, which are applied to different areas in computer science.

- **GATE (7-9 MARKS)**

- Has a good weightage in general all objective and subjective examination.

- Will be asked in Interview for M.Tech, PhD or other government jobs. Not that important in software industry.

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Syllabus (GATE)

- SET THEORY (1-2)
- RELATIONS (1-2)
- FUNCTIONS (1-2)
- GROUP THEORY (1-2)
- PROPOSITIONS & FIRST ORDER LOGIC (2-3)
- GRAPH THEORY (2-3)

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Section 1: Engineering Mathematics

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Monoids, Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability and Statistics: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

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What you can expect from me

- Will take care of theory and numerical both
- Will give more weightage to the topics that are asked more frequently in GATE
- Will not emphasize more than required, on a topic
- Will provide PDF of related books and my PPT

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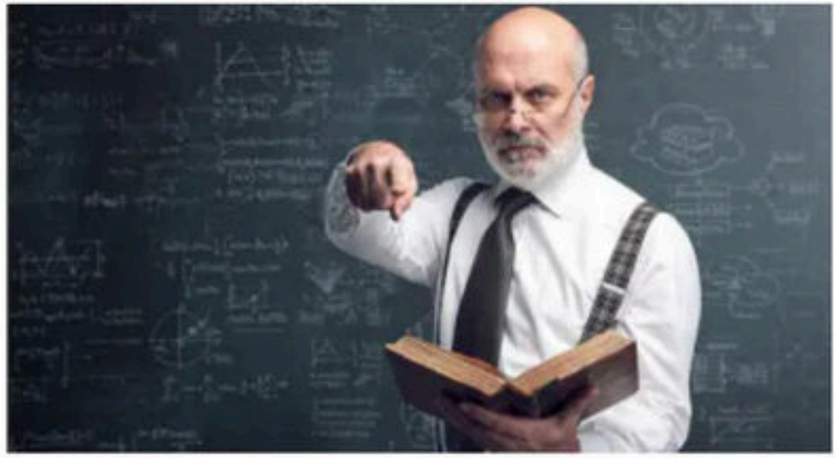
What i expect from you



- There is no hurry, feel free to ask questions any time through out the class, but first listen
- Please revise the entire lecture before and after the class
- Be regular, Consistency is most important
- More you practice, more clarity you will get
- If we follow all the above specified points Success in guaranteed

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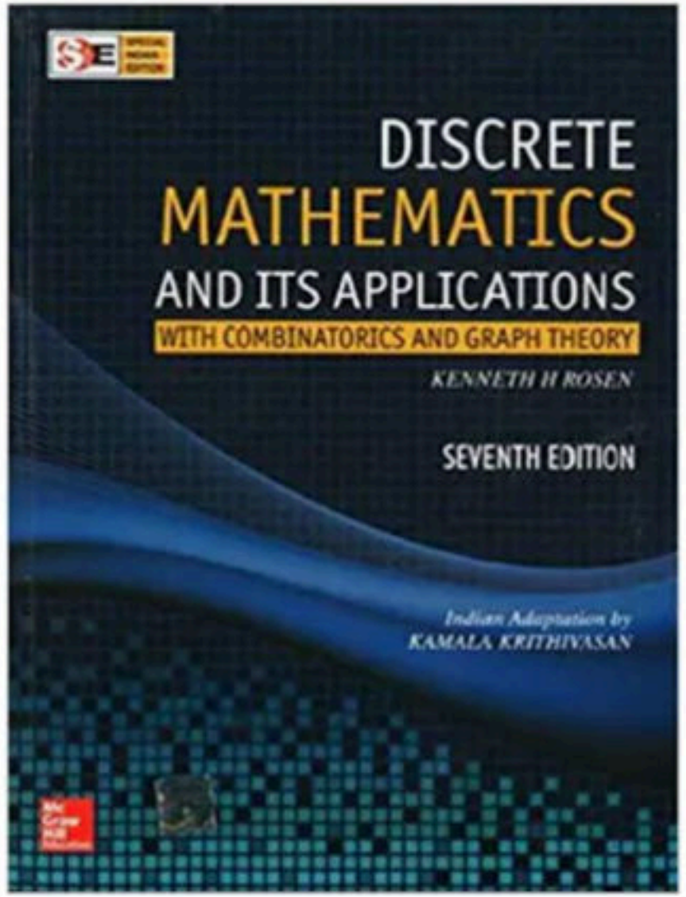
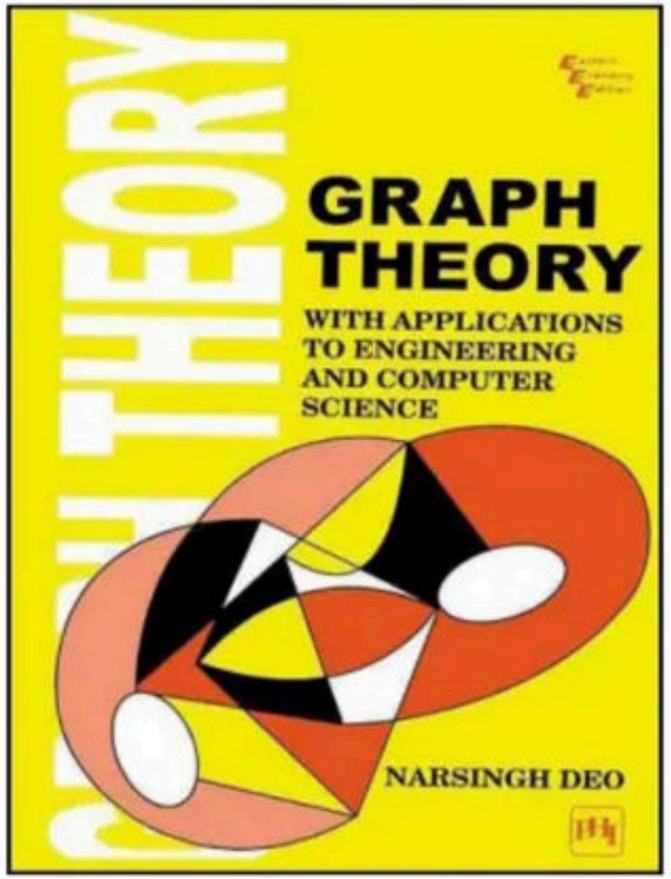
Books to be referred





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Break

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What is a SET

- Set are the fundamental discrete structures on which all the discrete structures are built. Sets are used to group objects together, formally speaking

- "An *unordered ,well-defined*, collection of *distinct* objects (Called elements or members of a set) of same type". Here the type is defined by the one who is defining the set. For e.g.

- A = {0,2,4,6, ---}

- B = {1,3,5, ---}

- C= {x| x ∈ Natural number}

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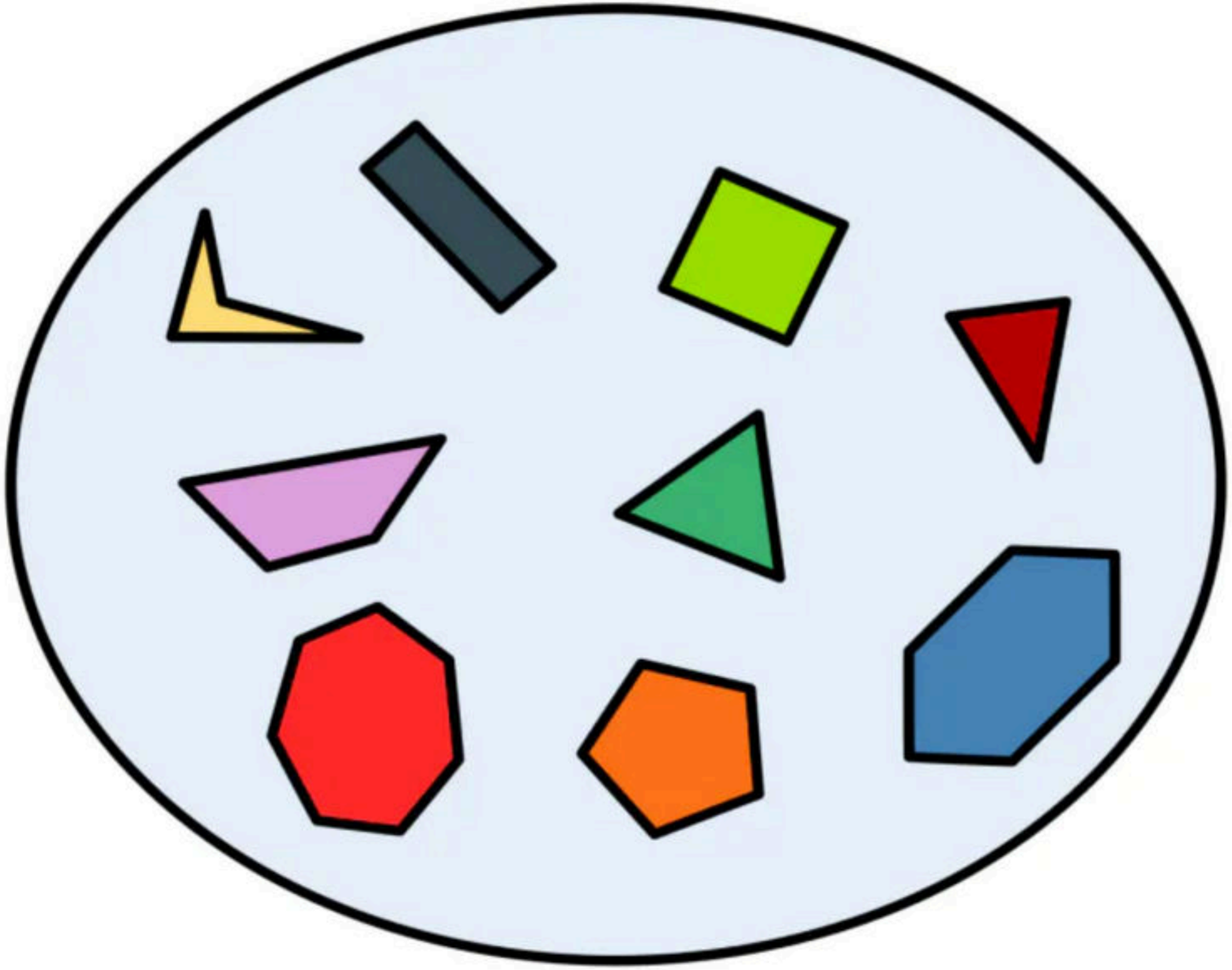

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- A Set is generally denoted usually by capital letter. The objects of a set called the elements, or members of the set.

- A set is said to contain its elements.

- Lower case letters are generally used to denote the elements of the set.

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- $x \in A$, means element x is a member of A

- $x \notin A$ means x is not a member of A

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- **<u>Cardinality of a set</u>** — It is the number of elements present in a Set, denoted like $|A|$.

- For e.g. $A = \{0,2,4,6\}$, $|A| = 4$

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Break

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Representation of set

- **Tabular/Roster representation of set** - here a set is defined by actually listing its members. E.g.

- A = {a, e, i, o, u}

- B = {1, 2, 3, 4}

- C = {---- -4, -2, 0, 2, 4, -----}.

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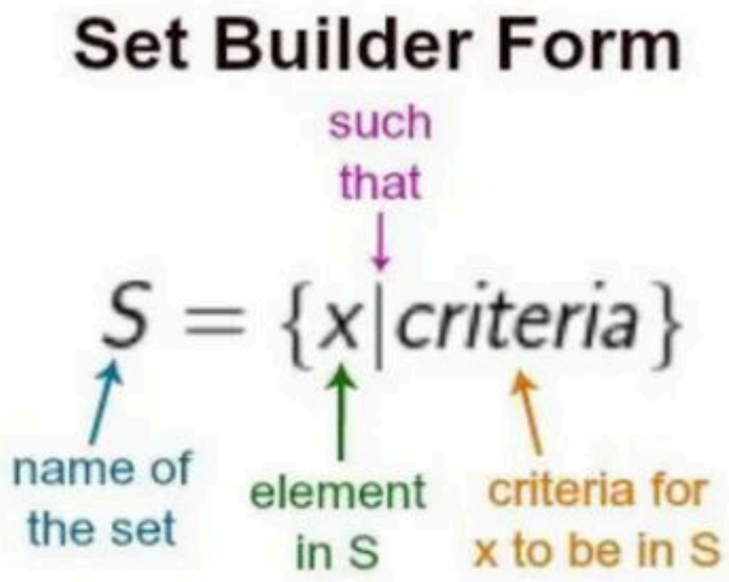
- **<u>Set Builder representations of set</u>**- here we specify the property which the elements of the set must satisfy. E.g.

- A = {x| x is an odd positive number less than 10},

- A = {x | x ϵ English alphabet && x is vowel}

- B = {x | x ϵ N && x <5}

- C = {x | x ϵ Z && x%2 = 0 }



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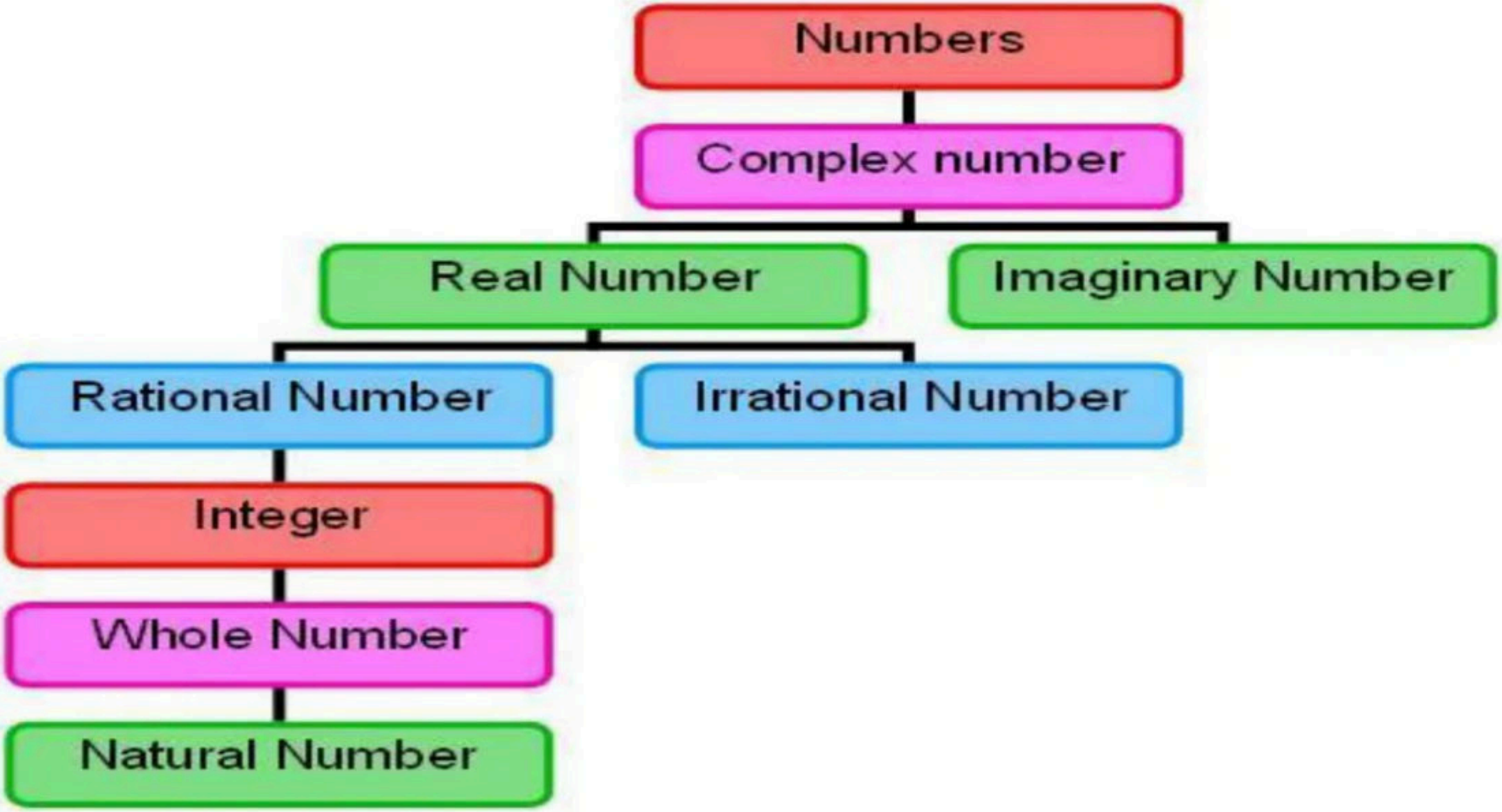

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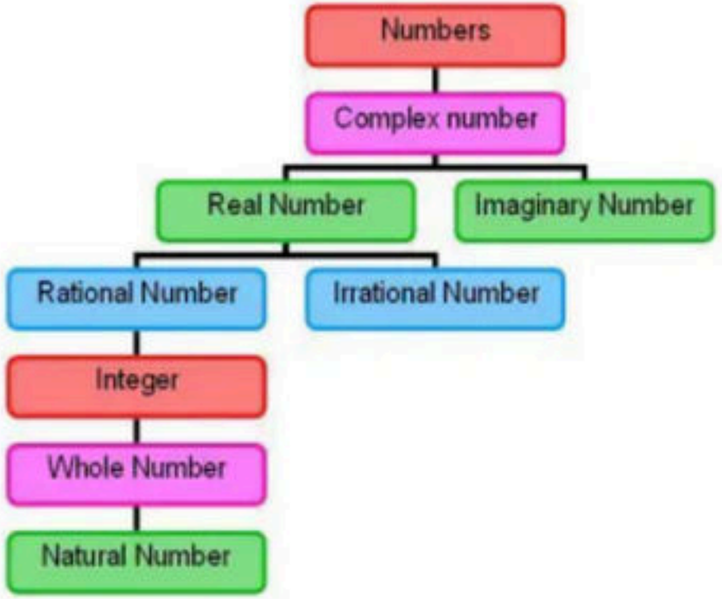
- **<u>Set of all Complex number(C)</u>** - A complex number is a number that can be expressed in the form 'a + bi', where 'a' and 'b' are real numbers and 'i' is the imaginary unit, that satisfies the equation $i^2 = -1$. In this expression, 'a' is the real part and 'b' is the imaginary part of the complex number.



$$\underbrace{a}_{\text{Real part}} + \underbrace{bi}_{\text{Imaginary part}}$$

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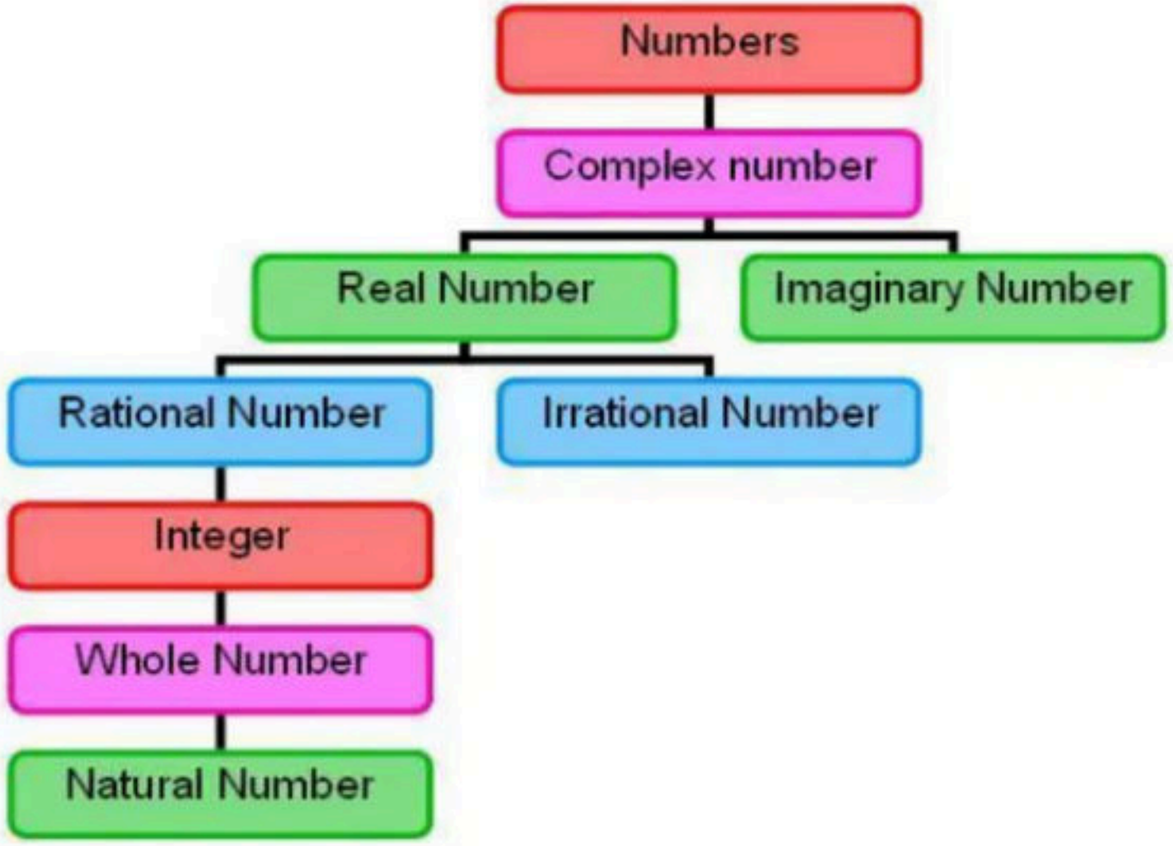
- **<u>Set of all Real number(R)</u>** - A real number is a value that represents a quantity along a continuous line, containing all of the rational numbers and all of the irrational numbers.



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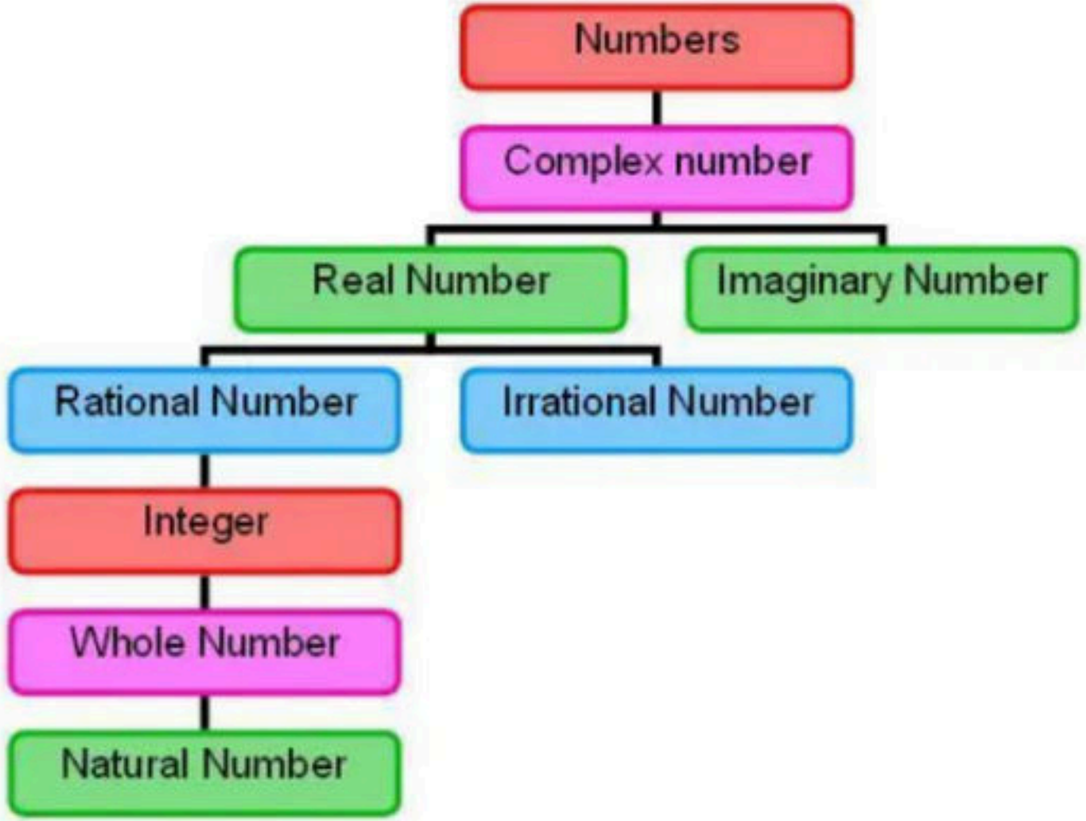
- **<u>Set of all Rational number (Q)</u>** - A rational number is any number that can be expressed as a fraction P/Q of two integers, a numerator P and a non-zero denominator Q.



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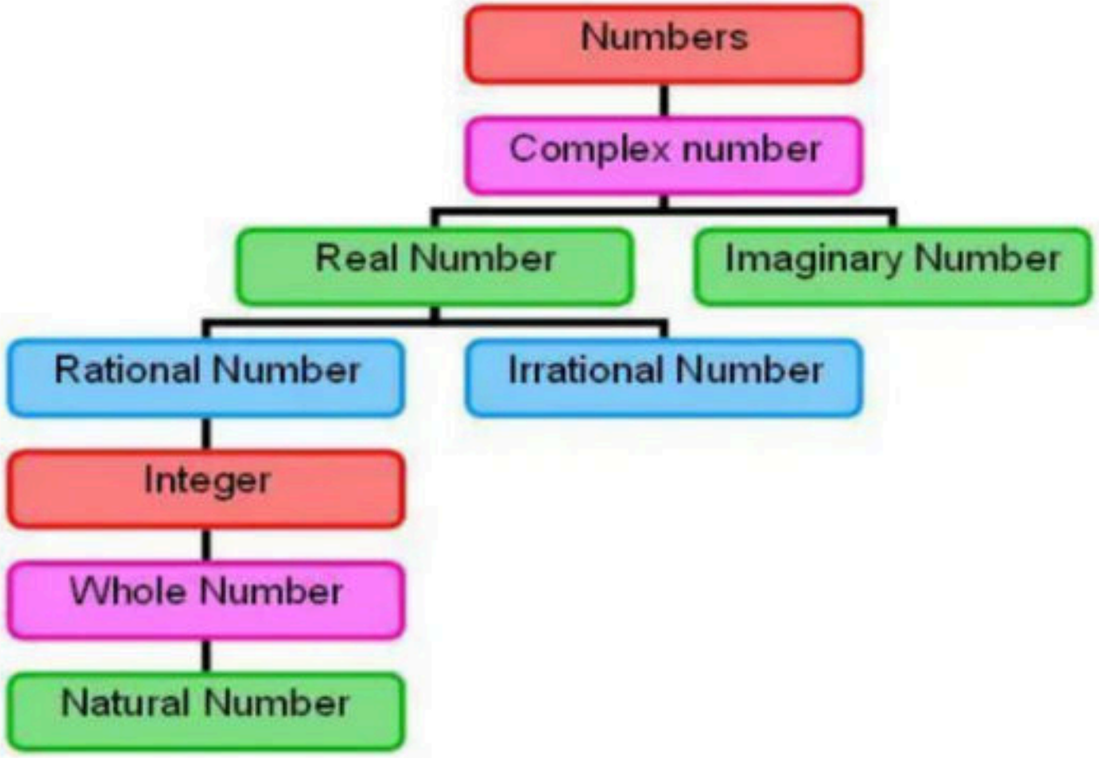
- **<u>Set of all Irrational number (R-Q or R/Q or P)</u>** - An irrational number is a real number that cannot be expressed as a fraction i.e. as a ratio of integers. Therefore, irrational numbers, when written as decimal numbers, do not terminate, nor do they repeat. E.g. root2.



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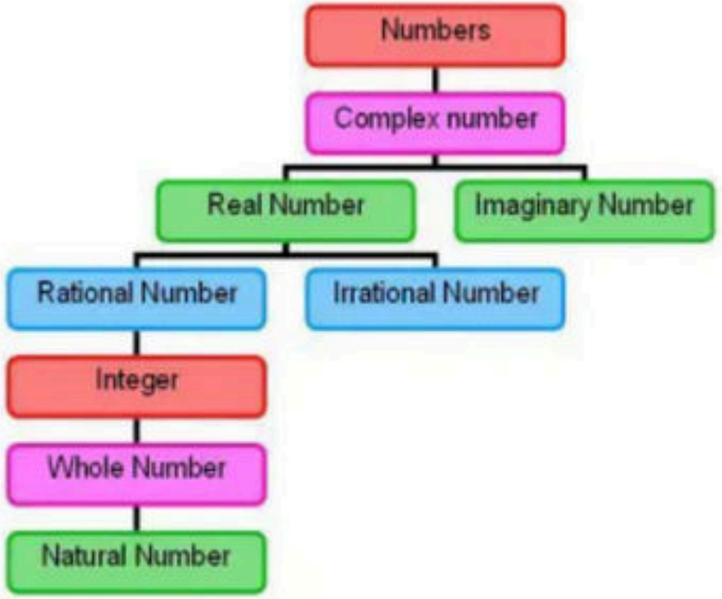
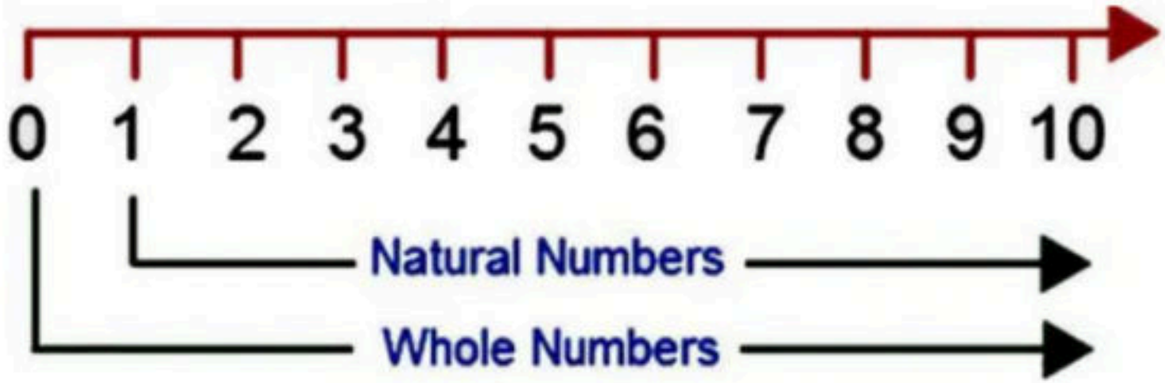
- **<u>Set of all Integer(Z)</u>** - An integer is a number that can be written without a fractional component.
- **<u>Set of all Whole number(W)</u>** - A whole number is a science expanded natural number. Set of natural number and zero





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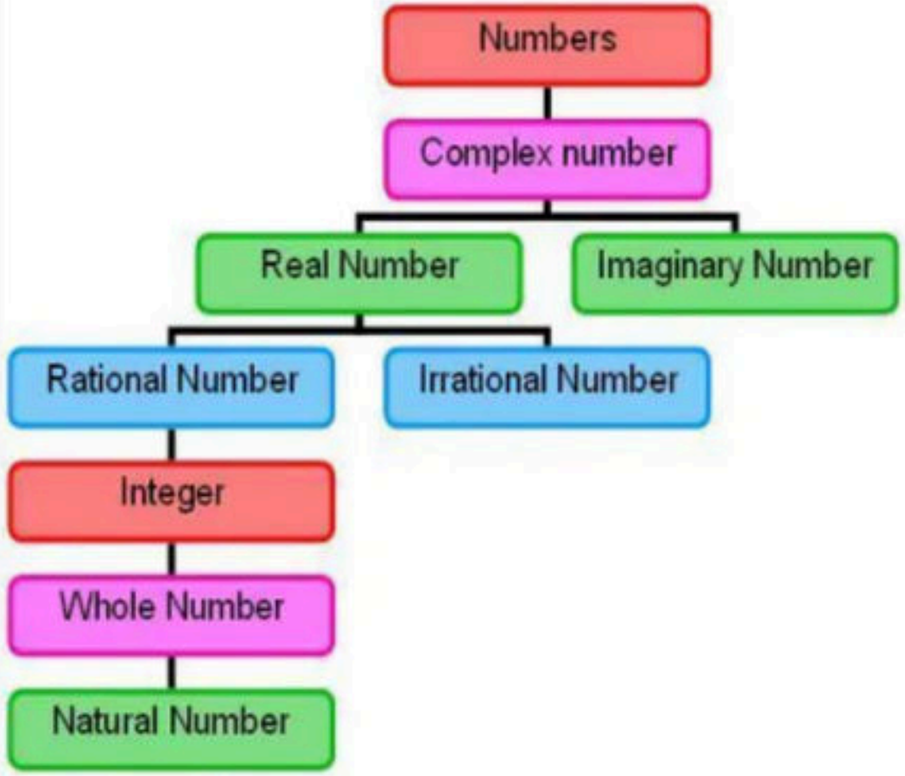
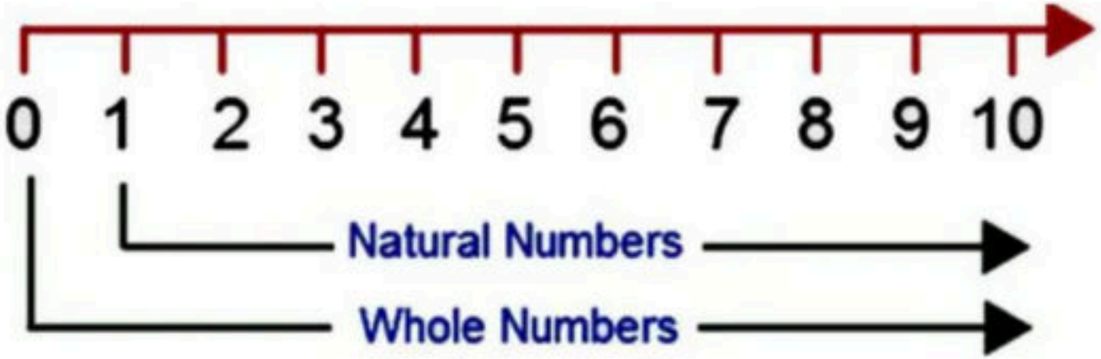
- **<u>Set of all-Natural number(N)</u>** - A natural number is a number that occurs commonly and obviously in nature. The set of natural numbers, can be defined as N = {1,2,3, 4.... ∞}





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Break

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- **<u>Finite set</u>** - If there are exactly '*n*' elements in *S* where '*n*' is a nonnegative integer, we say that *S* is a *finite set.*

- *i.e. if a* set contain specific or finite number of elements is called is called finite set. For e.g. A = {1,2,3,4}

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- **<u>Infinite set</u>** – A set contain infinite number of elements is called infinite set, if the counting of different elements of the set does not come to an end. For e.g. a set of natural numbers.

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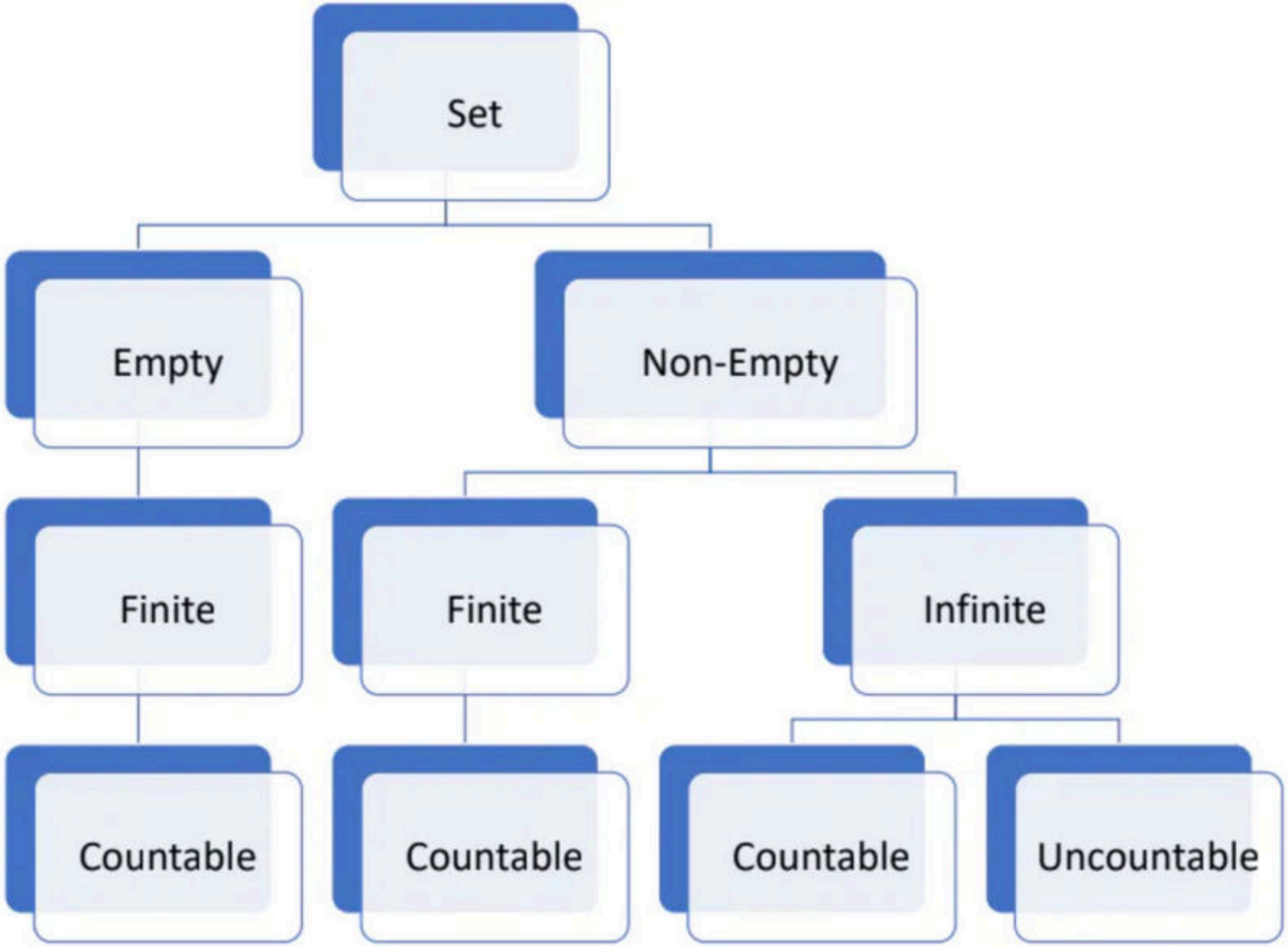

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- **<u>Countable set</u>** – A set is said to be countable if there can be a one to one mapping between the elements of the set and natural numbers. E.g. Set of stars.

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- **<u>Uncountable set</u>** – A set is said to be uncountable if there cannot be a one to one mapping between the elements of the set and natural numbers. E.g. Set of real numbers.

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Q Which of the following is/are not true? **(NET-Dec-2015)**

(a) The set of negative integers is countable.

(b) The set of integers that are multiples of 7 is countable.

(c) The set of even integers is countable.

(d) The set of real numbers between 0 and ½ is countable.

(A) (a) and (c)

(B) (b) and (d)

(C) (b) only

(D) (d) only

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Break

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- **<u>Null set / empty set</u>** - Is the unique set having no elements. its size or cardinality is zero i.e. $|\phi| = 0$. It is denoted by a symbol ϕ or {}. A set with one element is called singleton set.

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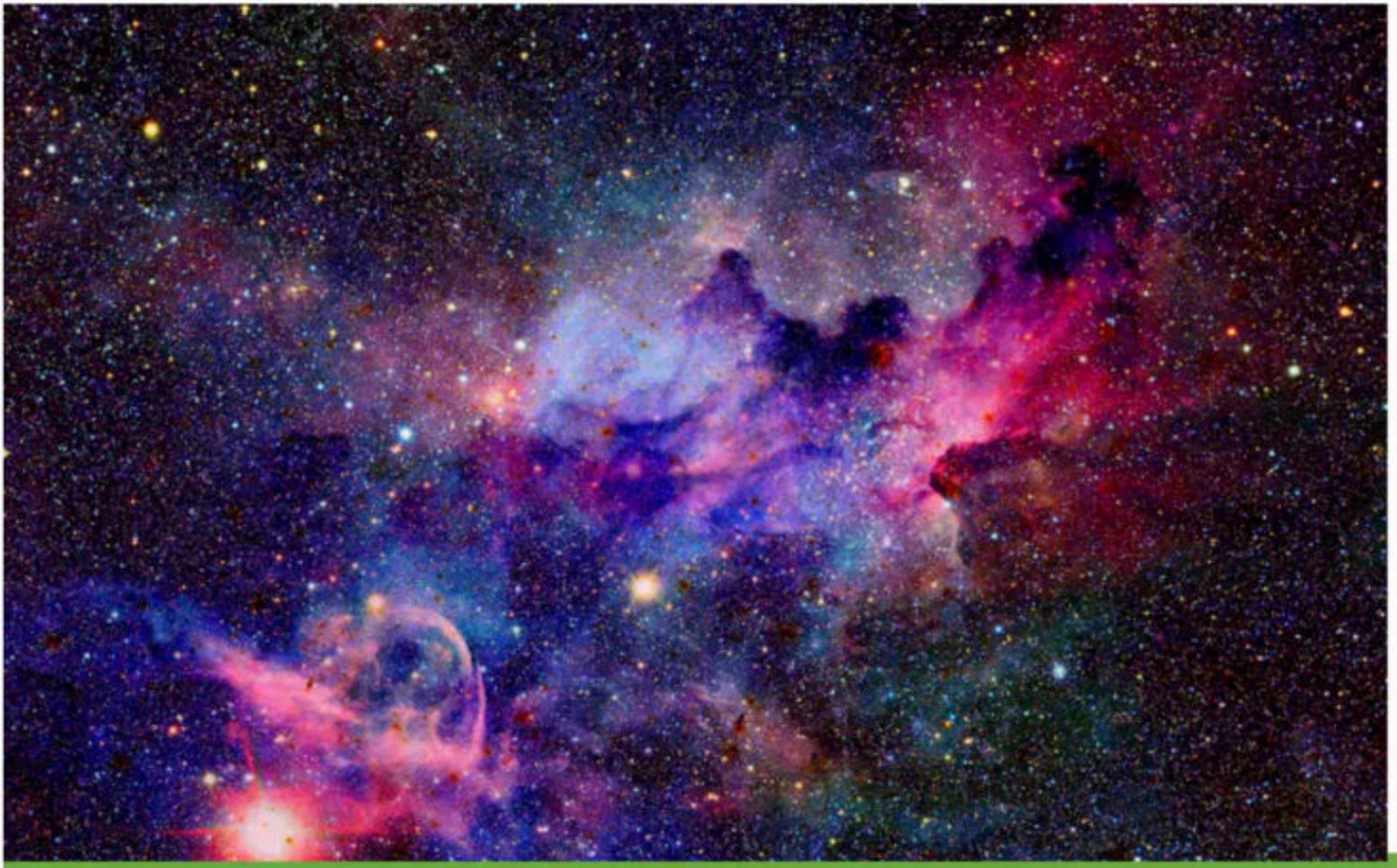
- **<u>Universal set</u>** – if all the sets under investigation are subsets of a fixed set, i.e. the set containing all objects under investigation, in Venn diagram it is represented by a rectangle, and it is denoted by U.



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Break

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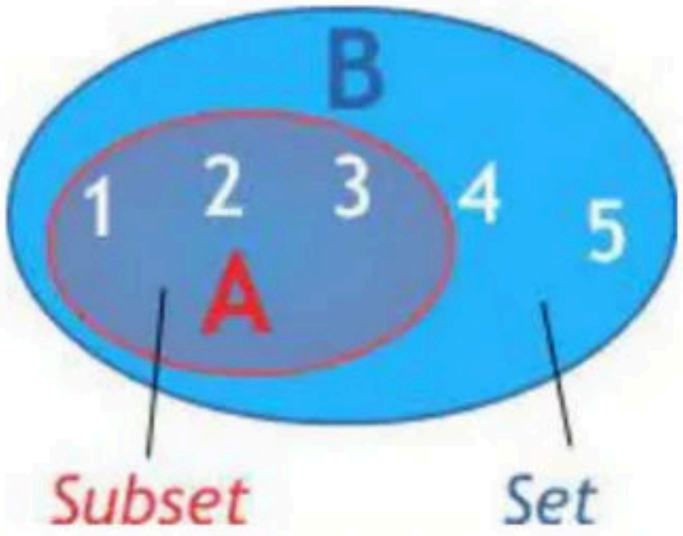
- **<u>Subset of a set</u>** – If every element of set A is also an element of set B i.e.
- $\forall x(x \in A \rightarrow x \in B)$, then A is called subset of B and is written as $A \sqsubseteq B$. B is called the superset of A.

- E.g. A = {1,2,3} B = {1,2,3,4,5}

- Note that to show that *A* is not a subset of *B* we need only find one element $x \in A$ with $x \notin B$. To show that $A \sqsubseteq B$, show that if $x \in A$, then $x \in B$.



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- $\phi \sqsubseteq A$, Empty Set ϕ is a subset for every set
- $A \sqsubseteq U$, Every Set is a subset of Universal set U
- $A \sqsubseteq A$, Every Set is a subset of itself.

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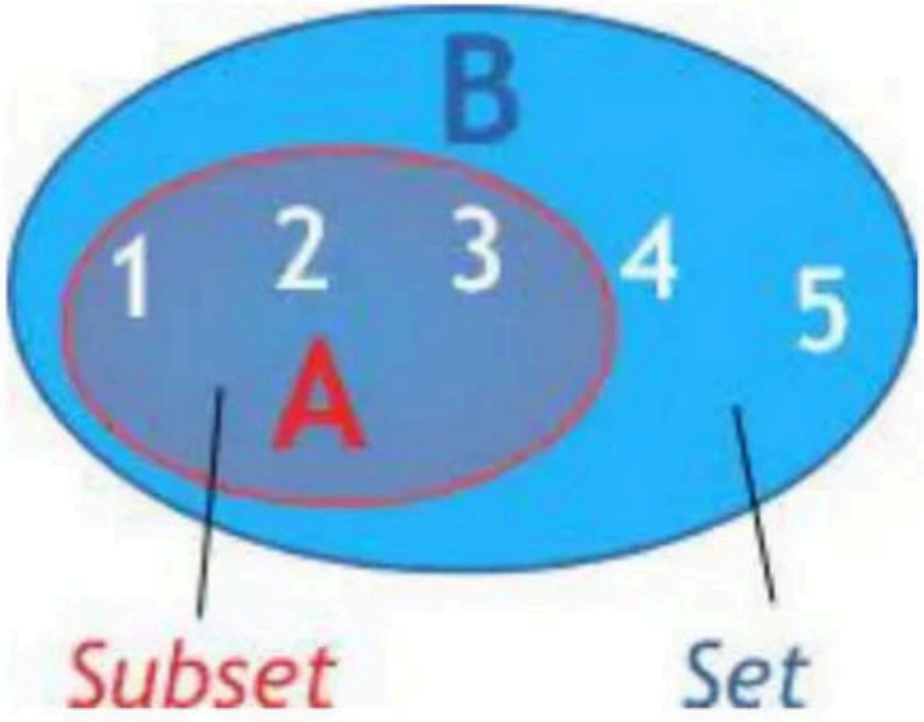
- **<u>Proper subset</u>** – if A is a subset of B and A ≠ B, then A is said to be a proper subset of B, i.e. there is at least one element in B which is not in A. denoted as $A \subset B$.



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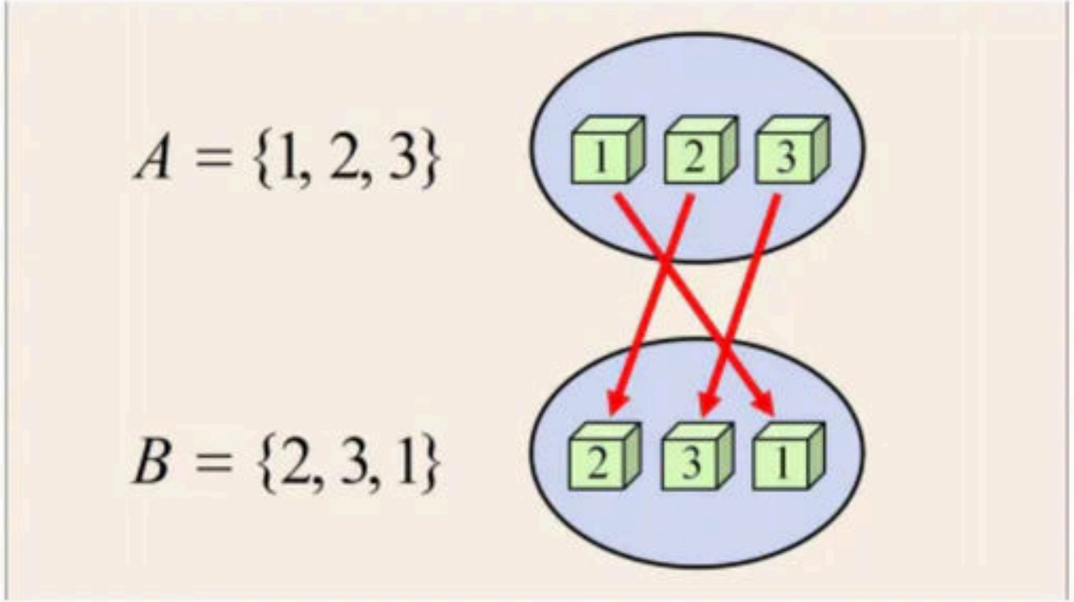
- **<u>Equality of sets</u>** – If two sets A and B have the same element and therefore every element of A also belong to B and every element of B also belong to A, then the set A and B are said to be equal and written as A=B.
- if $A \sqsubseteq B$ and $B \sqsubseteq A$, then A=B
- $\forall x(x \in A \leftrightarrow x \in B)$



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- **<u>Power set</u>** – let A be any set, then the set of all subsets of A is called power set of A and it is denoted by P(A) or 2^A.

- If A= {1,2,3}, then P(A) = {ϕ, {1}, {2}, {3}, {1,2}, {2,3}, {1,3}, {1,2,3}}

- Cardinality of the power set of A is n, $|P(A)| = 2^n$

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Venn Diagram

- Sets can be represented graphically using Venn diagrams, named after the English mathematician John Venn, who introduced their use in 1881. In Venn diagrams the **universal set** *U,* Contains all the objects under consideration, is represented by a rectangle.

- (Note that the universal set varies depending on which objects are of interest.) Inside this rectangle, circles or other geometrical figures are used to represent sets. Sometimes points are used to represent the particular elements of the set. Venn diagrams are often used to indicate the relationships between sets.

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Break

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Q For any Set A, which of the following are true?

1) $\phi \in A$

2) $\phi \sqsubseteq A$

3) $\phi \in 2^A$

4) $\phi \sqsubseteq 2^A$

5) $A \in 2^A$

6) $A \sqsubseteq 2^A$

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Q If ϕ is an empty set. Then $|P(P(P(\phi)))| =$ _____?

a) 1 **b)** 2 **c)** 4 **d)** none of above

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Q The cardinality of the power set of {0, 1, 2 . . ., 10} is _____.
(GATE-2015) (1 Marks)

(A) 1024 **(B)** 1023 **(C)** 2048 **(D)** 2043

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Q For a set A, the power set of A is denoted by 2^A. If A = {5, {6}, {7}}, which of the following options are True. **(GATE-2015) (1 Marks)**

I) $\phi \in 2^A$

II) $\phi \sqsubseteq 2^A$

III) $\{5, \{6\}\} \in 2^A$

IV) $\{5, \{6\}\} \sqsubseteq 2^A$

(A) I and III only

(B) II and III only

(C) I, II and III only

(D) I, II and IV only

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Break

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Q The power set of the set $\{\Phi\}$ is: **(NET-Dec-2012)**

a) $\{\Phi\}$

b) $\{\Phi, \{\Phi\}\}$

c) $\{0\}$

d) $\{0, \Phi, \{\Phi\}\}$

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Q let A be a set with n elements. Let C be a collection of distinct subsets of A such that for any two subsets S_1 and S_2 in C, either S_1 is subset of S_2 or S_2 is subset of S_1. What is the maximum cardinality of C? **(GATE-2005)** **(2 Marks)**

a) n **b)** n+1 **c)** $2^{n-1}+1$ **d)** n!

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Q Let P(S) denotes the power set of set S. Which of the following is always true? **(GATE-2000) (2 Marks)**

a) $P(P(S)) = P(S)$

(b) $P(S) \cap P(P(S)) = \{\phi\}$

(c) $P(S) \cap S = P(S)$

(d) $S \notin P(S)$

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Q The number of elements in the power set P(S) of the set S= {{∅},1, {2,3}} is: **(GATE-1995) (1 Mark)**

a) 2 **b)** 4 **c)** 8 **d)** None of the above

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Q.29 Let S be a set consisting of 10 elements. The number of tuples of the form (A, B) such that A and B are subsets of S, and $A \subseteq B$ is _____.

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Break

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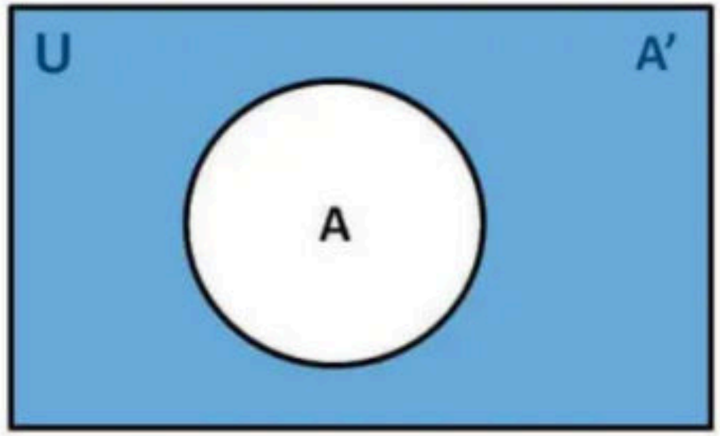
Operation on sets

- **Complement of set** – Set of all x such that $x \notin A$, but $x \in U$.
- $A^c = \{x \mid x \notin A \ \& \ x \in U\}$



$U = \{1, 2, 3, 4, 5, 6\}$

$A = \{2, 3, 6\}$

$A^c = \{ \qquad \}$

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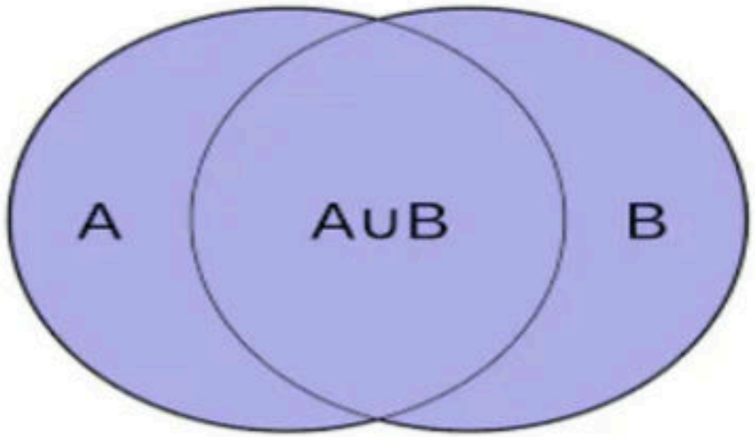
- **<u>Union of sets</u>** – Union of two sets A and B is a set of all those elements which either belong to A or B or both, it is denoted by A U B.
- $A \cup B = \{x \mid x \in A \text{ or } x \in B\}$



$A = \{1, 2, 3, 4\}$

$B = \{3, 4, 5, 6\}$

$A \cup B = \{ \qquad \}$

$|A|+|B|=|A \cup B|$?

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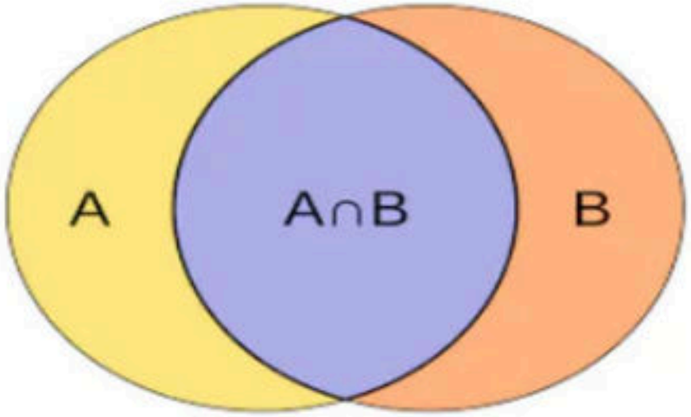
- **<u>Intersection of sets</u>** - Intersection of two sets A and B is a set of all those elements which belong to both A and B, and is denoted by $A \cap B$.
- $A \cap B = \{x \mid x \in A \text{ and } x \in B\}$



$A = \{1, 2, 3, 4\}$

$B = \{3, 4, 5, 6\}$

$A \cap B = \{ \qquad \}$

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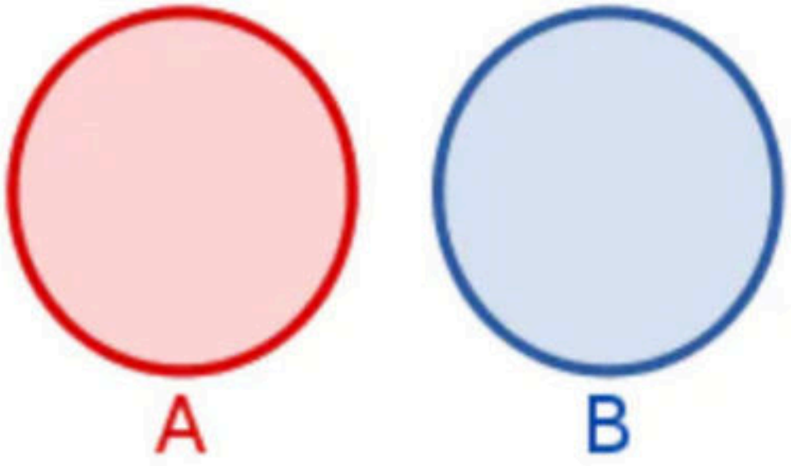
- **<u>Disjoint sets</u>** -- Two sets are said to be disjoint if they do not have a common element, i.e. no element in A is in B and no element in B is in A.

- $A \cap B = \phi$



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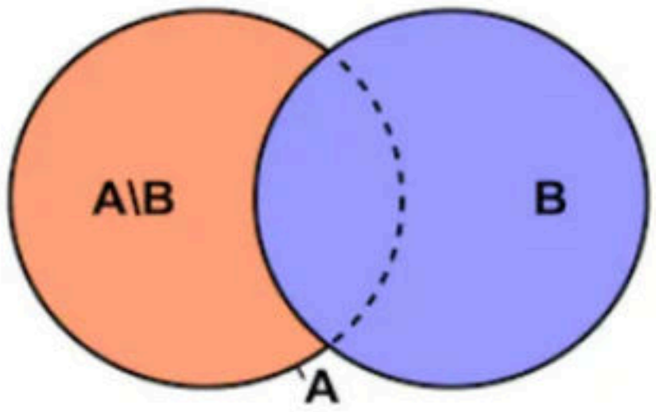
- **<u>Set difference</u>** – the set difference of two sets A and B, is the set of all the elements which belongs to A but do not belong to B.
- $A - B = \{x \mid x \in A \text{ and } x \notin B\}$



A = {1, 2, 3, 4}

B = {3, 4, 5, 6}

A - B = { }

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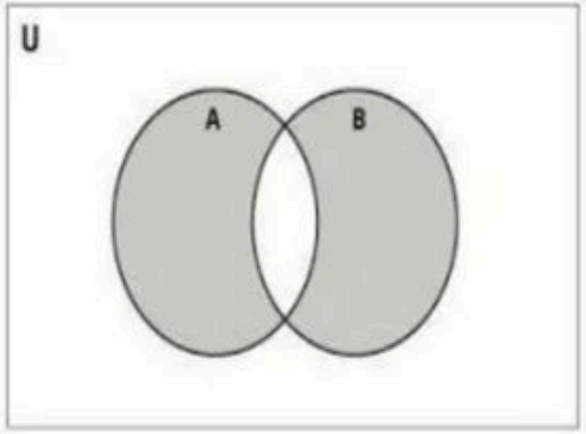
Symmetric difference – the symmetric difference of two sets A and B is the set of all the elements that are in A or in B but not in both, denoted as. $A \oplus B = (A \cup B) - (A \cap B)$



$A \oplus B = \{x \mid (x \in A \text{ and } x \notin B) \text{ or } (x \in B \text{ and } x \notin A)\}$

$A \oplus B = (A - B) \cup (B - A)$

$A = \{1, 2, 3, 4\}$

$B = \{3, 4, 5, 6\}$

$A \oplus B = \{ \qquad \}$

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Q if A_i = {-i, ... -2, -1, 0, 1, 2, ... i} **(NET-July-2018)**

then $\bigcup_{i=1}^{\infty} Ai$ is

a) Z

b) Q

c) R

d) C

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Q The power set of A U B, where A = {2, 3, 5, 7} and B = {2, 5, 8, 9} is **(NET-Dec-2012)**

a) 256

b) 64

c) 16

d) 4

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Break

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Q Consider the following statements?

a) Finite union of finite sets is finite (finite/~~infinite~~) $A_1 \cup A_2 \cup A_3 \ldots \ldots \cup A_n$

b) Finite union of Infinite sets is infinite (~~finite~~/infinite) $A_1 \cup A_2 \ldots A$

c) Infinite union of finite sets is infinite (finite/infinite) $A_1 \cup A_2 \cup A_3 \ldots \cup A_n \cup A_{n+1} \ldots \cup A_\infty$

d) if after finite number of union result is infinite set, then at least of the input set is infinite (T / F)

e) if after finite number of union result is infinite set, then all of the input set is infinite (T / F)

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$A \neq \phi$ $B \neq \phi$

$A \cap B = \phi$

f) Finite intersection of finite sets is finite (finite/~~infinite~~)

g) Finite intersection of Infinite sets is _____(finite/infinite)

$Z_e \cap Z_o = \phi$ (I, I, F)

$Z_2 \cap Z_3 = Z_1$ (I, I, I)

h) If after finite number of intersection result is infinite set, then at least of the input set is infinite (T / F)

i) If after finite number of intersection result is infinite set, then all of the input set is infinite (T / F)

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$$\cancel{\frac{z}{z} = z}$$

$$\frac{3}{2} = 1.5$$

$$\frac{4}{2} = 2$$

Q Let S be an infinite set $S_1, S_2 \ldots\ldots\ldots, S_n$ be Sets such that $S_1 \cup S_2 \cup \ldots \cup S_n = S$ Then,
(GATE-1993) (1 Marks)

(a) ~~At least one of the set S_i is a finite set~~ – 9

(b) ~~Not more than one of the set S_i can be finite~~ – 4

(c) ~~At least one of the sets S_i is an infinite set~~ – 85

(d) ~~Not more than one of the sets S_i can be infinite~~ – 3

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Break

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Q which of the following is not true?

a) $A - B = A \cap B^c$

b) $A - (A - B) = A \cap B$

c) $A - (A \cap B) = A - B$

d) $A - (A - B) = B$

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Q If $A \subset B$, then which of the following is not true?

(a) $A \cup B = B$

(b) $A \cap B = A$

(c) $B^C \subset A^C$

(d) $B - A = \phi$

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Q Which the following in not true?

a) If $A \sqsubseteq \phi$, then $A = \phi$

b) $(A \cap B^C) \cup (A \cap B) = A$

c) $B \cup (A \cap B) = B$

d) $(A \cap B^C) \cup (A \cap B) \cup (A^C \cap B) \cup (A^C \cap B^C) = A \cap B$

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Q Which of the following is true?

(i) $(A - B) - C = A - (C - B)$

(ii) $(A - B) - C = (A - C) - B$

(iii) $(A - B) - C = A - (B \cap C)$

(iv) $(A \cap B) - (B \cap C) = \{A - (A \cap C)\} - (A - B)$

a) i & iii

b) ii & iv

c) i, ii, iv

d) ii & iii

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Break

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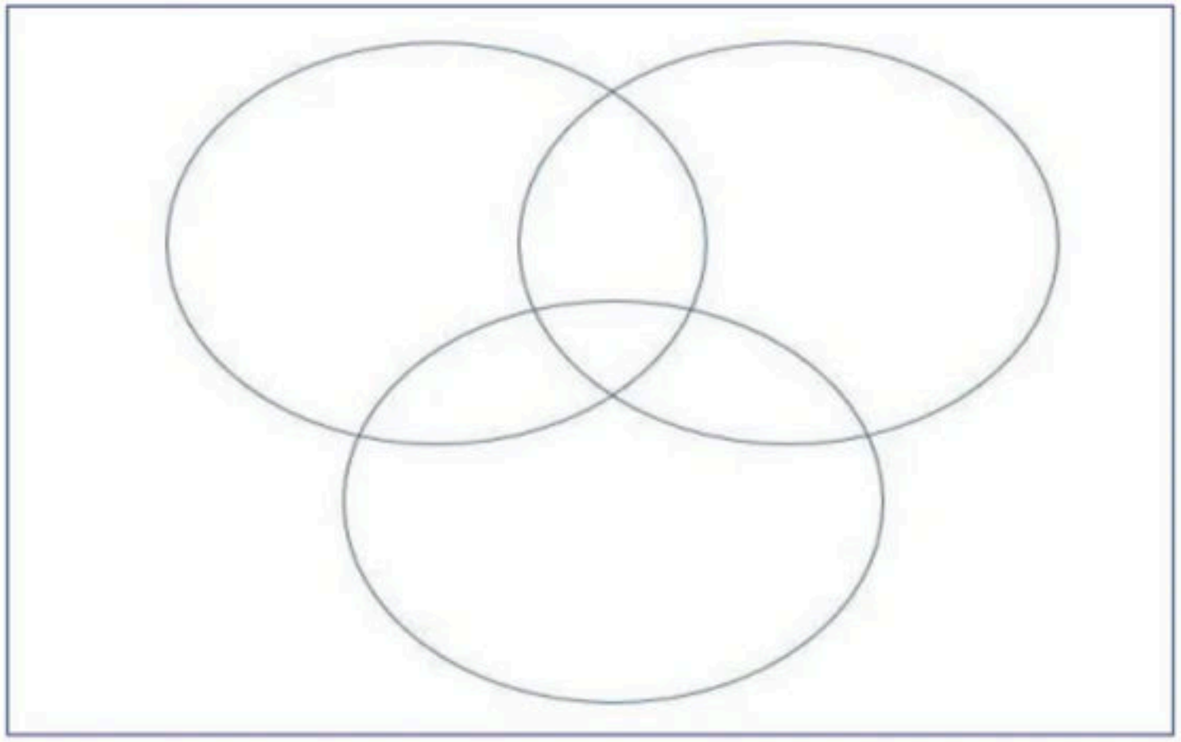
Q In a college, there are three student clubs, Sixty students are only in the Drama club, 80 students are only in the Dance club, 30 students are only in Maths club, 40 students are in both Drama and Dance clubs, 12 students are in both Dance and Maths clubs, 7 students are in both Drama and Maths clubs, and 2 students are in all clubs. If 75% of the students in the college are not in any of these clubs, then the total number of students in the college is _____. **(GATE-2019) (2 Mark)**



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Q The number of integers between 1 and 500 (both inclusive) that are divisible by 3 or 5 or 7 is _____. **(GATE-2017) (1 Marks)**

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Q How many multiples of 6 are there between the following pairs of numbers? **(NET-Jan-2017)**

0 and 100 and –6 and 34

a) 16 and 6

b) 17 and 6

c) 17 and 7

d) 16 and 7

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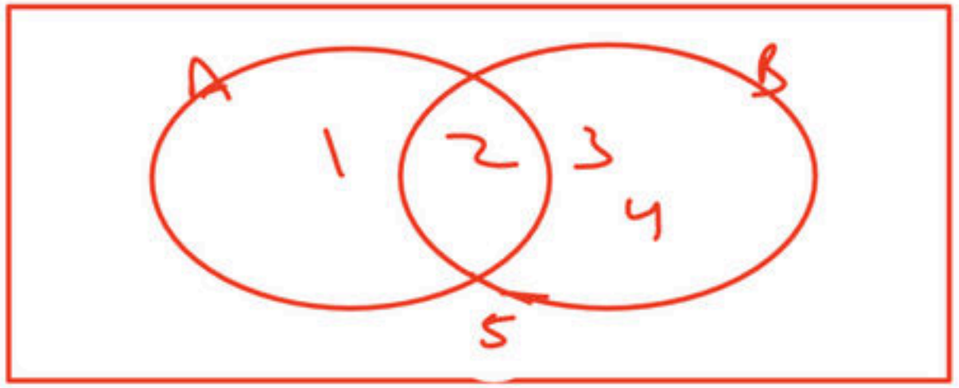
Q Let A and B be sets in a finite universal set U. Given the following: $\cancel{|A - B|}$, $\cancel{|A \oplus B|}$, $|A| + |B|$ and $|A \cup B|$ Which of the following is in order of increasing size? **(NET-Dec-2016)**

a) $|A - B| < |A \oplus B| < |A| + |B| < |A \cup B|$ – 21



b) $|A \oplus B| < |A - B| < |A \cup B| < |A| + |B|$ 9

c) $|A \oplus B| < |A| + |B| < |A - B| < |A \cup B|$ 3

$\lvert A-B\rvert$	$A \oplus B$	$\lvert A\rvert + \lvert B\rvert$	$\lvert A\cup B\rvert$
1	2	4	3

d) $\cancel{|A - B|} < |A \oplus B| < |A \cup B| < |A| + |B|$ – 67

$\cancel{\lvert A-B\rvert}$	$A \oplus B$	$\lvert A\cup B\rvert$	$\lvert A\rvert + \lvert B\rvert$
1	2	3	4

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$A = \{1, 2\}$ $B = \{2, 3, 4\}$

$A + B$

$|A| + |B|$

$2 + 3 = 5$

$A \cup B$

Break

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Q Suppose U is the power set of the set S = {1,2,3,4,5,6}. For any T ∈ U, let |T| denote the number of elements in T and T' denote the complement of T. For any T, R ∈ U, let T\R be the set of all elements in T which are not in R.

(GATE-2015) (2 Marks)

Which one of the following is true?

a) $\forall X \in U, (|X| = |X'|)$

B) $\exists X \in U, \exists Y \in U, (|X| = 5, |Y| = 5 \text{ and } X \cap Y = \varphi)$

C) $\forall X \in U, \forall Y \in U, (|X| = 2, |Y| = 3 \text{ and } X \setminus Y = \varphi)$

D) $\forall X \in U, \forall Y \in U, (X \setminus Y = Y' \setminus X')$

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Q Consider a set A= {1,2, 3, ...,1000}. How many members of A shall be divisible by 3 or by 5 or by both 3 and 5? **(NET-Dec-2014)**

a) 533 **b)** 599 **c)** 467 **d)** 66

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Q Consider the following relation on subsets of the set S of integers between 1 and 2014. For two distinct subsets U and V of S we say U < V if the minimum element in the symmetric difference of the two sets is in U. Consider the following two statements: **(GATE-2014) (2 Marks)**

S_1: There is a subset of S that is larger than every other subset. $= \phi$

$X < \phi$

$S = [2, 3, 4 \ldots \ldots 2013)$

$\boxed{U < V}$

$U = [2, 3, 4, 5]$ $V = [4, 5, 6, 7]$

$U \oplus V = [2, 3, 6, 7]$

$[2, 7, 42, 1024] \oplus \phi$

S_2: There is a subset of S that is smaller than every other subset $= S$

S $S < X$

$[2, 7, 42, 1024]$

X

$[\cancel{5, 207, 785, 1023}] \oplus [2, 3, 4 \ldots 2013)$

$[4, 3, 4, \ldots] = S - X$

Which one of the following is CORRECT?

(A) Both S_1 and S_2 are true — 55

(B) S_1 is true and S_2 is false — 28

(C) S_2 is true and S_1 is false — 16

(D) Neither S_1 nor S_2 is true

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Q If P, Q, R are subsets of the universal set U, then **(GATE-2008) (1 Marks)**

$$(P \cap Q \cap R) \cup (P^C \cap Q \cap R) \cup Q^C \cup R^C$$

(A) $Q^c \cup R^c$

(B) $P \cup Q^c \cup R^c$

(C) $P^c \cup Q^c \cup R^c$

(D) U

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Break

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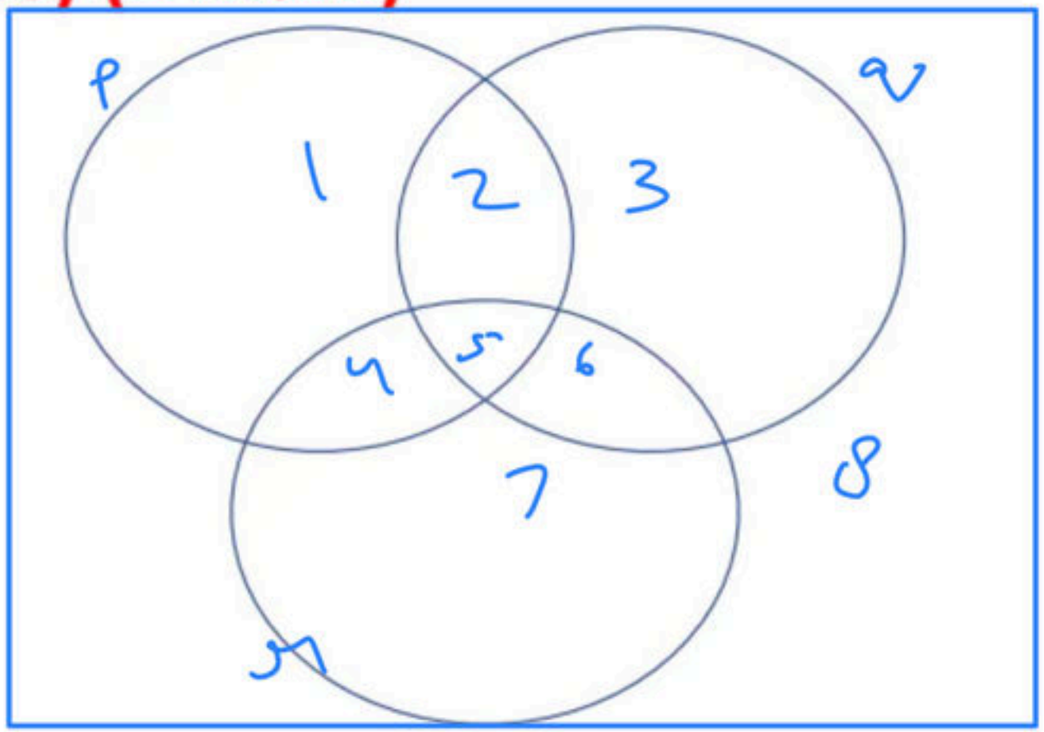
Q let p, q and r be sets let @ denotes the symmetric difference operator defined as

P @ q = (p ∪ q) − (p ∩ q)? **(GATE-2006) (2 Mark)**



I) p @ (q ∩ r) = (p @ q) ∩ (P @ r)

II) p ∩ (q ∩ r) = (p ∩ q) @ (p @ r)

a) I only

b) II only

c) neither I nor II

d) both I and II

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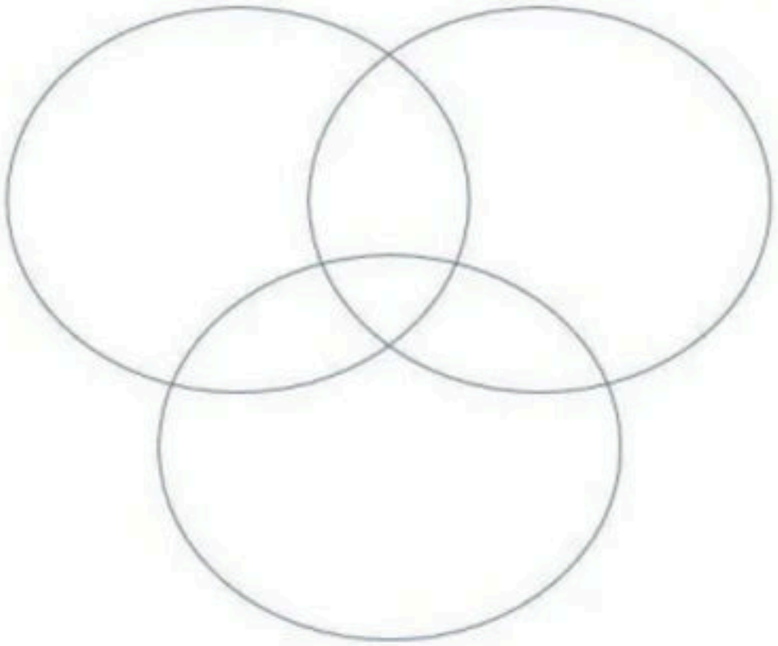
Q Let E, F and G be finite sets.

Let $X = (E \cap F) - (F \cap G)$ and $Y = (E - (E \cap G)) - (E - F)$.

Which one of the following is true? **(GATE-2006) (2 Mark)**

(A) $X \subset Y$ **(B)** $X \supset Y$ **(C)** $X = Y$ **(D)** $X - Y \neq \phi$ and $Y - X \neq \phi$



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Q what is the cardinality of the set of integers X defined below **(GATE-2006) (2 Mark)**

X = {n| 1<=n<=123, n is not divisible by 2,3 or 5}?

a)90

b)33

c)37

d)44

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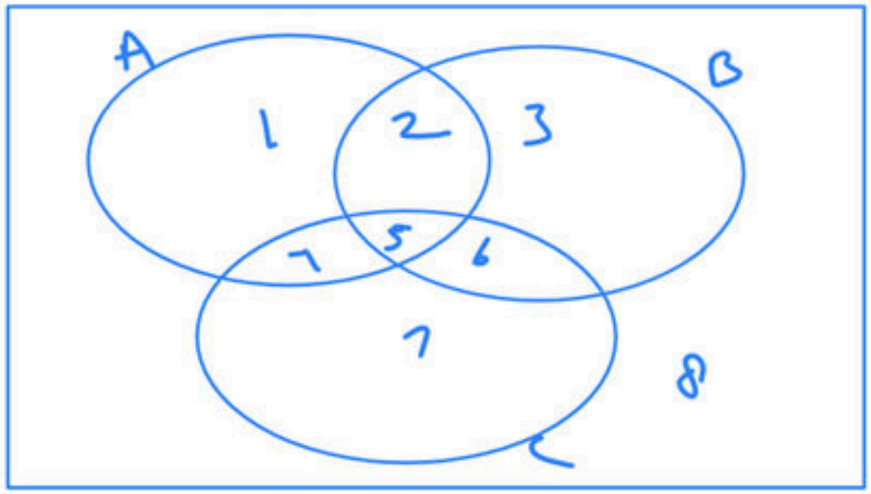
Q Let A, B and C be non-empty sets and let

$X=(A-B)-C$

$Y=(A-C)-(B-C)$



Which one of the following is TRUE? **(GATE-2005) (1 Marks)**

a) $X=Y$ **b)** $X\subset Y$ **c)** $Y\subset X$ **d)** None of these

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Break

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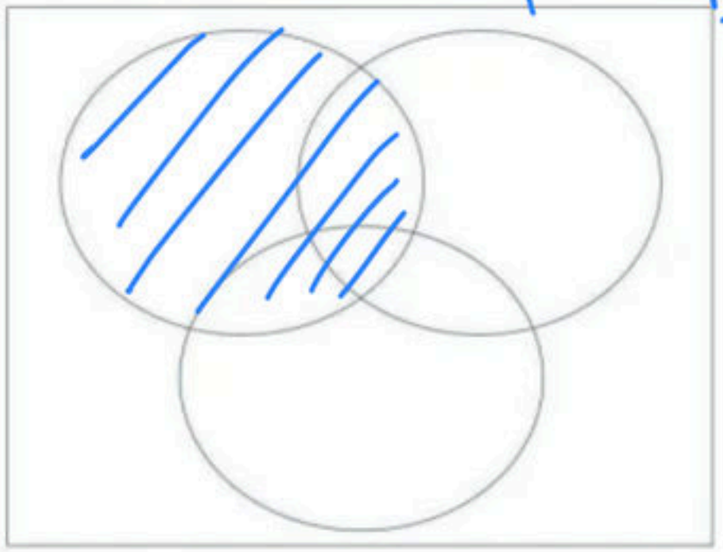
Q In a class of 200 students, 125 students have taken Programming Language course, 85 students have taken Data Structures course, 65 students have taken Computer Organization course; 50 students have taken both Programming Language and Data Structures, 35 students have taken both Data Structures and Computer Organization; 30 students have taken both Programming Language and Computer Organization, 15 students have taken all the three courses. How many students have not taken any of the three courses? **(GATE-2004) (1 Mark)**

(A) 175 — 14 **(B)** 20 — 13 **(C)** 25 — 67 **(D)** 35 — 17

$$|A \cup B \cup C| = \overset{125}{|A|} + \overset{85}{|B|} + \overset{65}{|C|} - \overset{50}{|A \cap B|} - \overset{35}{|B \cap C|} - \overset{30}{|A \cap C|} + \overset{15}{|A \cap B \cap C|}$$

P DS CO



$= 125 + 85 + 65 - 50 - 35 - 30 + 15$

$= \underline{175}$

$200 - 175 = 25$

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Q Consider the following statements:

S_1: There exists infinite sets A, B, C such that $A \cap (B \cup C)$ is finite.

S_2: There exists two irrational numbers x and y such that $(x + y)$ is rational.

Which of the following is true about S_1 and S_2? **(GATE-2001) (2 Mark)**

(a) Only S_1 is correct

(b) Only S_2 is correct

(c) Both S_1 and S_2 are correct

(d) None of S_1 and S_2 is correct

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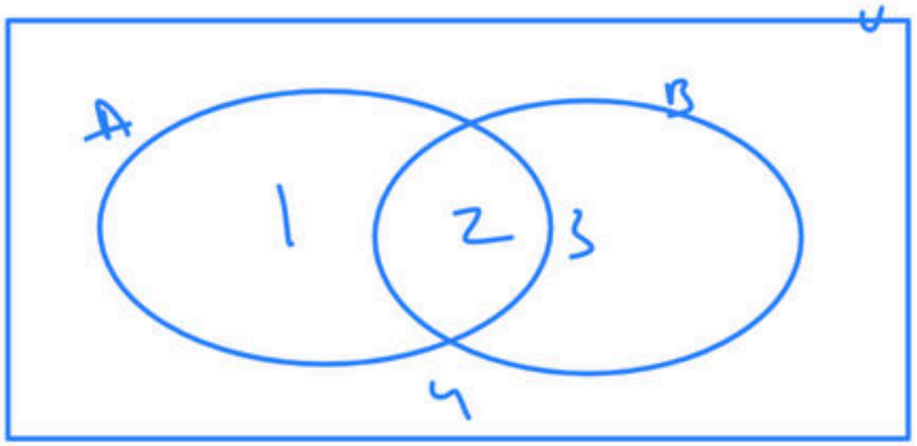
Q Let A and B be sets and let A^c and B^c denote the complements of the sets A and B. the set $(a - b) \cup (b - a) \cup (a \cap b)$ is equal to. **(GATE- 1996)**

(1 Mark)

(a) $A \cup B$ 85 **(b)** $A^c \cup b^c$ 8 **(c)** $A \cap B$ 4 **(d)** $A^c \cap b^c$ 3



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Q The bit string for the sets, A = {1,3,5,7,9} and B = {1,2,3,4,5} are 1010101010 and 1111100000 respectively. If the universal set is U = {1, 2….,10} is represented 1111111111 which of the following is false?

a) A U B = 1111111010

b) A ⋂ B = 1010100000

c) A – B= 0000001010

d) A^C = 0000011111

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Break

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Idempotent law

- $A \cup A = A$
- $A \cap A = A$

Associative law

- $(A \cup B) \cup C = A \cup (B \cup C)$
- $(A \cap B) \cap C = A \cap (B \cap C)$

$a+(b+c) = (a+b)+c$

Commutative law

- $A \cup B = B \cup A$
- $A \cap B = B \cap A$

$a+b = b+a$

$M_1 \times M_2 \neq M_2 \times M_1$

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Distributive law

- $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$ → $a.(b+c) = a.b + a.c$
- $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

De Morgan's law

- $(A \cup B)^C = A^C \cap B^C$
- $(A \cap B)^C = A^C \cup B^C$

$\overline{a+b} = \bar{a} \cdot \bar{b}$

$\overline{a \cdot b} = \bar{a} + \bar{b}$

Identity law

- $A \cup \phi = A$
- $A \cap \phi = \phi$
- $A \cup U = U$
- $A \cap U = A$

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Complement law

- $A \cup A^C = U$
- $A \cap A^C = \phi$
- $U^C = \phi$
- $\phi^C = U$

Involution law

- $((A)^C)^C = A$

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Q.27 Let S be a set consisting of 10 elements. The number of tuples of the form (A, B) such that A and B are subsets of S and $A \subseteq B$ is _____. **(GATE- 2021)**

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Cartesian Product

1. Cartesian Product of two sets A and B in the set of all ordered pairs, whose first member belongs to the first set and second member belongs to the second set, denoted by A × B.

(a,1) (1,a)

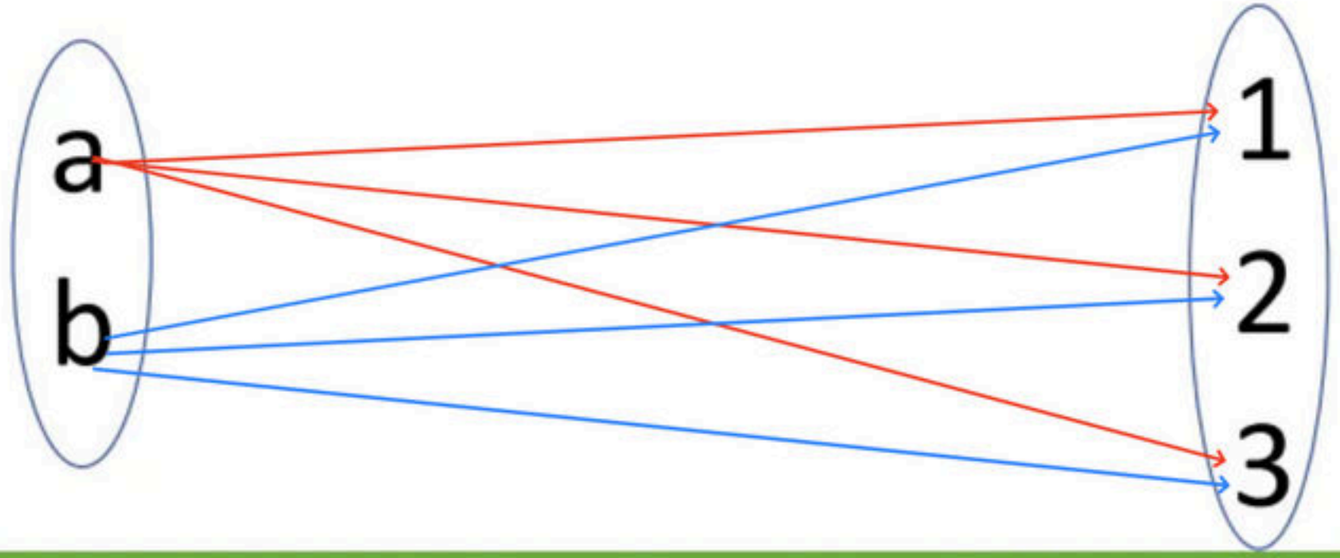
2. For E.g. if A = {a, b}, B = {1, 2, 3}

3. A×B = { (a,1), (a,2), (a,3), (b,1), (b,2), (b,3) }

$R_1 =$ ((a,1), (a,3), (b,2))

$R_3 = [\ ]$

$R_2 = A \times B$



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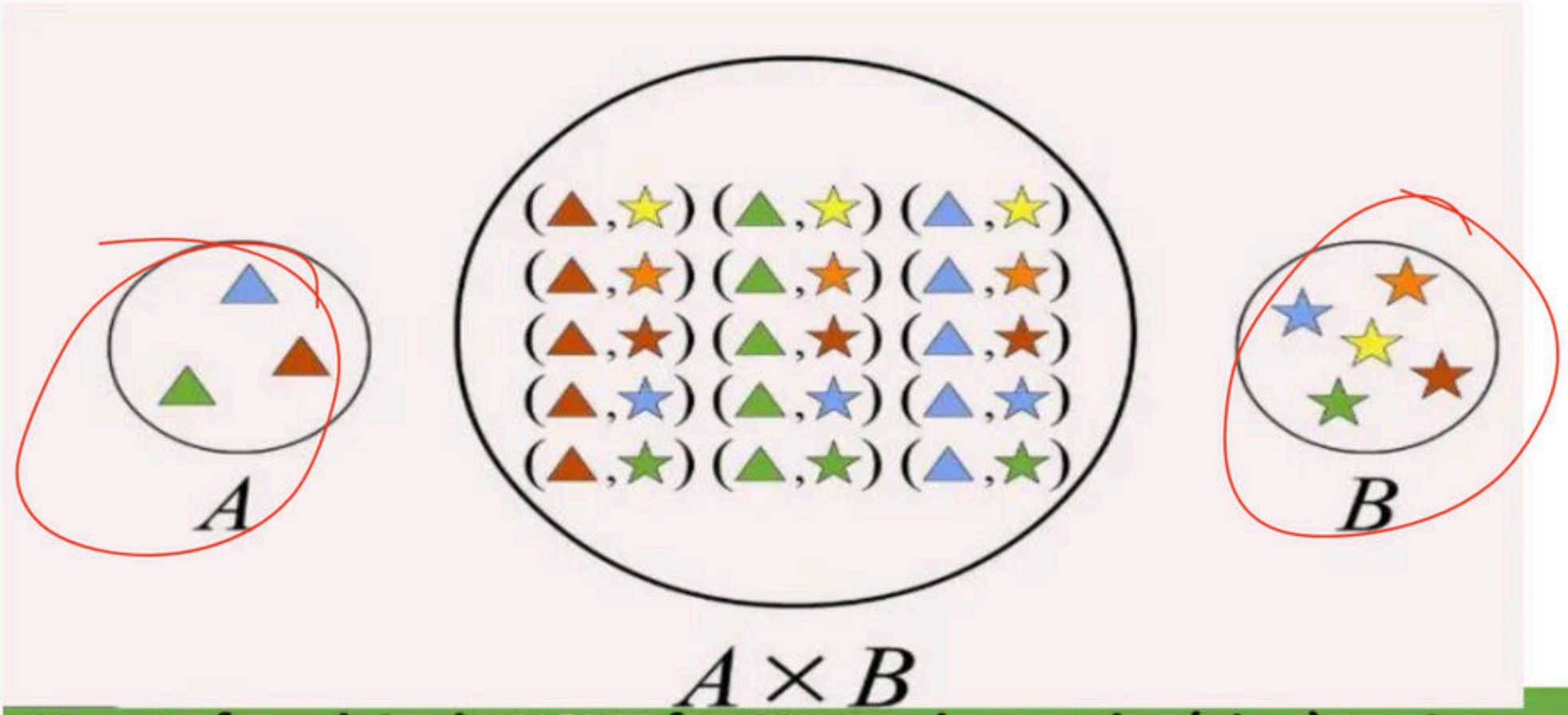
- It is a kind of maximum relation possible, where every member of the first set belong to every member of the second set.

- $A \times B = \{(a, b) \mid a \in A \text{ and } b \in B\}$



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1. In general, commutative law does not hold good $A \times B \mathrel{!=} B \times A$

2. If $|A| = m$ and $|B| = n$ then $|A \times B| =$ $m \cdot n$

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Q The number of binary relations on a set with n elements is: **(GATE-1999) (1 Marks)**

(A) n^2

(B) 2^n

(C) 2^{n^2}

(D) None of the above

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Q Let A be a finite set of size n. The number of elements in the power set of A × A is: **(GATE-1993) (1 Marks)**

a) $2^{(2^n)}$ 13

b) $2^{(n^2)}$ 75

c) 2^n 12

d) None of the above 6

$A \times A = n^2$

$P(A \times A) = 2^{n^2}$

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Break

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Relation

- **Relation**: - Let A and B are sets then every possible subset of 'A×B' is called a relation from A to B.

- If |A| =m and |B| = n then total no of element(pair) will be m*n, every element will have two choice weather to present or not present in the subset(relation), therefore the total number of relation possible is _____

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For E.g. if A = {a, b}, B = {1, 2}

$A \times B = \{ (a,1), (a,2), (b,1) (b,2) \}$

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For E.g. if A = {a, b}, B = {1, 2}, $\boxed{A \times B = \{(a, 1), (a, 2), (b, 1), (b, 2)\}}$

(a , 1)	(a , 2)	(b , 1)	(b , 2)	
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

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For E.g. if A = {a, b}, B = {1, 2}

$|A| = m$ $|B| = n$ $\rightarrow$ mn $\rightarrow$ 2^{mn}

2 2 4 $2^4 \rightarrow 16$

(a , 1)	(a , 2)	(b , 1)	(b , 2)	
0	0	0	0	{ }
0	0	0	1	{(b, 2)}
0	0	1	0	{(b, 1)}
0	0	1	1	{(b, 1), (b, 2)}
0	1	0	0	{(a, 2)}
0	1	0	1	{(a, 2), (b, 2)}
0	1	1	0	{(a, 2), (b, 1)}
0	1	1	1	{(a, 2), (b, 1), (b, 2)}
1	0	0	0	{(a, 1)}
1	0	0	1	{(a, 1), (b, 2)}
1	0	1	0	{(a, 1), (b, 1)}
1	0	1	1	{(a, 1), (b, 1), (b, 2)}
1	1	0	0	{(a, 1), (a, 2)}
1	1	0	1	{(a, 1), (a, 2), (b, 2)}
1	1	1	0	{(a, 1), (a, 2), (b, 1)}
1	1	1	1	{(a, 1), (a, 2), (b, 1), (b, 2)}

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Matrix Representation

	1	2	3
x	$(x,1)$	$(x,2)$	$(x,3)$
y	$(y,1)$	$(y,2)$	$(y,3)$
z	$(z,1)$	$(z,2)$	$(z,3)$

B

A

$A \times B$

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- Largest relation possible will be $A \times B$

- Smallest possible relation will be ϕ

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Break

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- **Complement of a relation**: - Let R be a relation from A to B, then the complement of relation will be denoted by R', R^C or ~~R.~~

- $R' = \{(a, b) \mid (a, b) \in A \times B, (a, b) \in! R\}$

- $R' = (A \times B) - R$

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- For E.g. if A×B = {(a, 1), (a, 2), (a, 3), (b, 1), (b, 2), (b, 3)}
- R= {(a, 1), (a, 3), (b, 2)}
- R' = {(a,2), (b,1), (b,3) }

$A' = U - A$

$R' = (A \times B) - R$

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$R \cup R' =$

$R \cap R' =$

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Break

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- **Inverse of a relation**: - Let R be a relation from A to B, then the inverse of relation will be a relation from B to A, denoted by R^{-1}.

$R: A \longrightarrow B$ / $R^{-1}: B \longrightarrow A$

- $R^{-1} = \{(b, a) \mid (a, b) \in R\}$
- $A \times B = \{(a, 1), (a, 2), (a, 3), (b, 1), (b, 2), (b, 3)\}$
- $R = \{(a, 1), (a, 3), (b, 2)\}$
- $R^{-1} = \{(1, a), (3, a), (2, b)\}$
- $|R| \boxed{=} |R^{-1}|$

$|R| = |R^{-1}|$

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- **<u>Diagonal relation</u>**: - A relation R on a set A is said to be diagonal relation if, R is a set of all ordered pair (x, x), for every $\forall x \in A$, sometimes it is also denoted by $\blacktriangle_A$

- $R = \{(x, x) \mid \forall x \in A\}$

	1	2	3
1	11		
2		22	
3			33

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Break

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Types of a Relation

- To further study types of relations, we consider a set A with n elements, then a cartesian product A×A will have n^2 elements(pairs). Therefore, total number of relation possible is $2^{n * n}$

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- **<u>Reflexive relation</u>**: - A relation R on a set A is said to be reflexive,
- If $\forall x \in A$
  - $(x, x) \in R$

	1	2	3
1	11		
2		22	
3			33

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Q consider a set A = {1,2,3}, find which of the following relations are reflexive and Irreflexive?

	Relation	Reflexive	Irreflexive
1	A×A		
2	ϕ		
3	{(1,1), (2,2), (3,3)}		
4	{(1,2), (2,3), (1,3)}		
5	{(1,1), (1,2), (2,1), (2,2)}		
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}		
7	{(1,3), (2,1), (2,3), (3,2)}		

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1. Smallest reflexive relation is _____

2. Largest reflexive relation is _____

3. Total number of reflexive relations will be _____

4. If two relations R_1 and R_2 are reflexive then their union and intersection will also be reflexive (T / F).

5. Any super set of reflexive relation will also be reflexive(T / F).

6. If a relation is reflexive then its inverse R^{-1} will also be reflexive (T / F).

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1. Smallest reflexive relation is $\blacktriangle_A$

2. Largest reflexive relation is $A \times A$

3. Total number of reflexive relations will be $2^{n(n-1)}$

4. If two relations R_1 and R_2 are reflexive then their union and intersection will also be reflexive.

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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Q What is the possible number of reflexive relations on a set of 5 elements? **(GATE-2010) (1 Marks)**

(A) 2^{10} **(B)** 2^{15} **(C)** 2^{20} **(D)** 2^{25}

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Break

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- **<u>Irreflexive relation</u>**: - A relation R on a set A is said to be Irreflexive,

1. If $\forall x \in A$
2. $(x, x) \notin R$

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Q consider a set A = {1,2,3}, find which of the following relations are reflexive and Irreflexive?

	Relation	Reflexive	Irreflexive
1	A×A	Y	
2	ϕ	N	
3	{(1,1), (2,2), (3,3)}	Y	
4	{(1,2), (2,3), (1,3)}	N	
5	{(1,1), (1,2), (2,1), (2,2)}	N	
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}	Y	
7	{(1,3), (2,1), (2,3), (3,2)}	N	

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1. Smallest irreflexive relation is _____

2. Largest irreflexive relation is _____

3. Total number of irreflexive relation will be _____

4. If two relations R_1 and R_2 are Irreflexive then their union and intersection will also be Irreflexive (T / F).

5. If a relation R on a set A is reflexive, then R^C is Irreflexive, and vice versa (T / F).

6. Any sub set of irreflexive relation will also be irreflexive(T / F).

7. If a relation is irreflexive then its inverse R^{-1} will also be irreflexive (T / F).

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	
0	0	1	0	{(b, a)}
0	0	1	1	
0	1	0	0	{(a, b)}
0	1	0	1	
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

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- Smallest irreflexive relation is ϕ
- Largest irreflexive relation is $(A \times A) - \blacktriangle_A$
- Total number of irreflexive relation will be $2^{n(n-1)}$
- If two relations R_1 and R_2 are Irreflexive then their union and intersection will also be Irreflexive.
- If a relation R on a set A is reflexive, then R^C is Irreflexive

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Q Suppose that R_1 and R_2 are reflexive relations on a set A. Which of the following statements is correct? **(NET-July-2016)**

a) $R_1 \cap R_2$ is reflexive and $R_1 \cup R_2$ is irreflexive.

b) $R_1 \cap R_2$ is irreflexive and $R_1 \cup R_2$ is reflexive.

c) Both $R_1 \cap R_2$ and $R_1 \cup R_2$ are reflexive.

d) Both $R_1 \cap R_2$ and $R_1 \cup R_2$ are irreflexive

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Break

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- **<u>Symmetric relation</u>**: - A relation R on a set A is said to be Symmetric,

If $\forall$ a, b $\in$ A

(a, b) $\in$ R

.....

then (b, a) $\in$ R

.....

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Q consider a set A = {1,2,3}, find which of the following relations are Symmetric, Anti-Symmetric and Asymmetric?

	Relation	Symmetric	Anti-Symmetric	Asymmetric
1	$A \times A$			
2	ϕ			
3	{(1,1), (2,2), (3,3)}			
4	{(1,2), (2,3), (1,3)}			
5	{(1,1), (1,2), (2,1), (2,2)}			
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}			
7	{(1,3), (2,1), (2,3), (3,2)}			

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1. Smallest symmetric relation is _____

2. Largest symmetric relation is_____

3. Total number of symmetric relation will be _____

4. If a relation on a set A is symmetric then R __ R^{-1}

5. If two relations R_1 and R_2 are symmetric then their Union and Intersection will also be symmetric. (T / F)

6. If a relation is symmetric then its superset and subset will always be symmetric. (T / F)

7. If a relation is symmetric then its complement R^c will always be symmetric. (T / F)

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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1. Smallest symmetric relation is ϕ

2. Largest symmetric relation is $A \times A$

3. Total number of symmetric relation will be $2^{[n(n+1)]/2}$

4. If a relation on a set A is symmetric then $R = R^{-1}$

5. If two relations R1 and R2 are symmetric then their union and intersection will also be symmetric.

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Q Let R be a relation on the set of ordered pairs of positive integers such that $((p, q), (r, s)) \in R$ if and only if $p-s = q-r$. Which one of the following is true about R? **(GATE-2015) (2 Marks)**

(A) Both reflexive and symmetric

(B) Reflexive but not symmetric

(C) Not reflexive but symmetric

(D) Neither reflexive nor symmetric

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Q How many relations are there on a set with n elements that are symmetric and a set with n elements that are reflexive and symmetric? **(NET-Dec-2012)**

A) $2^{n(n+1)/2}$ and $2^{n}.3^{n(n-1)/2}$

B) $3^{n(n-1)/2}$ and $2^{n(n-1)}$

C) $2^{n(n+1)/2}$ and $3^{n(n-1)/2}$

D) $2^{n(n+1)/2}$ and $2^{n(n-1)/2}$

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Break

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- **<u>Anti-Symmetric relation</u>**: - A relation R on a set A with cartesian product A×A is said to be Anti-Symmetric,

If $\forall\, a, b \in A$

$(a, b) \in R$

$(b, a) \in R$

.....

$a = b$

.....

Conclusion: Symmetry is not allowed but diagonal pairs are allowed

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	Relation	Symmetric	Anti-Symmetric	Asymmetric
1	A×A	Y		
2	ϕ	Y		
3	{(1,1), (2,2), (3,3)}	Y		
4	{(1,2), (2,3), (1,3)}	N		
5	{(1,1), (1,2), (2,1), (2,2)}	Y		
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}	N		
7	{(1,3), (2,1), (2,3), (3,2)}	N		

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1. Smallest Anti-symmetric relation is _____

2. Largest Anti-symmetric relation will contain _____elements

3. Total number of Anti-symmetric relation will be _____

4. A relation R on a set A is Anti-Symmetric if $(R \cap R^{-1}) \sqsubseteq \blacktriangle_A$ (T / F)

5. Sub set of a Anti-Symmetric will also be (T / F)

6. Super set of a Anti-Symmetric will also be (T / F)

7. If two relations R_1 and R_2 are Anti-symmetric then their _____need not to be Anti-symmetric but _____ will also be Anti-symmetric.

8. If a relation is Anti-symmetric then its complement R^c will always be Anti-symmetric. (T / F)

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	
0	1	1	1	
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	
1	1	1	1	

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1. Smallest Anti-symmetric relation is ϕ

2. Largest Anti-symmetric relation will contain $n(n+1)/2$ elements

3. Total number of Anti-symmetric relation will be $2^n * 3^{[n(n-1)]/2}$

4. A relation R on a set A is Anti-Symmetric if $(R \cap R^{-1}) \sqsubseteq \blacktriangle_A$

5. Sub set of a Anti-Symmetric will also be Anti-Symmetric

6. If two relations R1 and R2 are Anti - symmetric then their union need not to be Anti-symmetric but intersection will also be Anti-symmetric.

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Q Consider a set A = {a, b, c} and R_1, R_2, R_3 and R_4 are relations on A which of the following is not true?

		Symmetric	Anti-Symmetric	True
1	$R_1 = \{(a, a), (c, c)\}$	Y	Y	
2	$R_2 = \{(a, b), (b, a), (a, c)\}$	N	N	
3	$R_3 = \{(a, b), (b, c), (a, c)\}$	N	Y	
4	$R_4 = \{(a, b), (b, a), (c, c)\}$	Y	N	

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Q Consider the binary relation R = {(x, y), (x, z), (z, x), (z, y)} on the set {x, y, z}. Which one of the following is TRUE? **(GATE-2009) (1 Marks)**

(A) R is symmetric but NOT antisymmetric

(B) R is NOT symmetric but antisymmetric

(C) R is both symmetric and antisymmetric

(D) R is neither symmetric nor antisymmetric

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Break

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- **<u>Asymmetric relation</u>**: - A relation R on a set A is said to be Asymmetric,

If $\forall$ a, b $\in$ A

(a, b) $\in$ R

.....

(b, a) $\notin$ R

.....

Conclusion: Symmetry is not allowed; even diagonal pairs are not allowed

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	Relation	Symmetric	Anti-Symmetric	Asymmetric
1	$A \times A$	Y	N	
2	ϕ	Y	Y	
3	{(1,1), (2,2), (3,3)}	Y	Y	
4	{(1,2), (2,3), (1,3)}	N	Y	
5	{(1,1), (1,2), (2,1), (2,2)}	Y	N	
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}	N	Y	
7	{(1,3), (2,1), (2,3), (3,2)}	N	N	

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1. Smallest Asymmetric relation is _____

2. Largest Asymmetric relation will contain _____elements

3. Total number of Asymmetric relation will be _____

4. Every asymmetric relation is also anti-symmetric (T / F)

5. Sub set of a Asymmetric will also be Asymmetric (T / F)

6. Super set of a Asymmetric will also be Asymmetric(T / F)

7. If two relations R_1 and R_2 are Asymmetric then their Union will also be Asymmetric(T / F).

8. If two relations R_1 and R_2 are Asymmetric then their Intersection will also be Asymmetric(T / F).

9. If a relation is Asymmetric then its complement R^c will always be Asymmetric. (T / F)

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	
0	0	1	0	{(b, a)}
0	0	1	1	
0	1	0	0	{(a, b)}
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

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1. Every asymmetric relation is also anti-symmetric

2. Smallest Asymmetric relation is ϕ

3. Largest Asymmetric relation will contain $n(n-1)/2$ elements

4. Total number of Asymmetric relation will be $3^{[n(n-1)]/2}$

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Break

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- **<u>Transitive relation</u>**: - A relation R on a set A is said to be Transitive,

If $\forall$ a, b, c $\in$ A

(a, b) $\in$ R

(b, c) $\in$ R

.....

(a, c) $\in$ R

.....

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	Relation	Transitive
1	$A \times A$	
2	ϕ	
3	{(1,1), (2,2), (3,3)}	
4	{(1,2), (2,3), (1,3)}	
5	{(1,1), (1,2), (2,1), (2,2)}	
6	{(1,1), (2,2), (3,3), (1,3), (2,1)}	
7	{(1,3), (2,1), (2,3), (3,2)}	
8	{(1,2)}	
9	{(1,3), (2,3)}	
10	{(1,2), (1,3)}	
11	{(2,3), (1,2)}	

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1. Smallest Asymmetric relation is _____

2. Largest Asymmetric relation will contain _____ elements

3. If two relations R_1 and R_2 are Transitive then their _____ need not to be transitive but _____ will also be transitive.

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For E.g. if A = {a, b}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	{(a, b), (b, a)}
0	1	1	1	{(a, b), (b, a), (b, b)}
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	{(a, a), (a, b), (b, a)}
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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For E.g. if A = {a, b}, A×A = {(a, a), (a, b), (b, a), (b, b)}

(a , a)	(a , b)	(b , a)	(b , b)	
0	0	0	0	{ }
0	0	0	1	{(b, b)}
0	0	1	0	{(b, a)}
0	0	1	1	{(b, a), (b, b)}
0	1	0	0	{(a, b)}
0	1	0	1	{(a, b), (b, b)}
0	1	1	0	
0	1	1	1	
1	0	0	0	{(a, a)}
1	0	0	1	{(a, a), (b, b)}
1	0	1	0	{(a, a), (b, a)}
1	0	1	1	{(a, a), (b, a), (b, b)}
1	1	0	0	{(a, a), (a, b)}
1	1	0	1	{(a, a), (a, b), (b, b)}
1	1	1	0	
1	1	1	1	{(a, a), (a, b), (b, a), (b, b)}

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1. Smallest Asymmetric relation is ϕ

2. Largest Asymmetric relation will contain $A \times A$ elements

3. If two relations R_1 and R_2 are Transitive then their union need not to be transitive but intersection will also be transitive.

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$\|A\| = n$	No of transitive relation
0	1
1	2
2	13
3	171
4	3994

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Warshall's Algorithm: -

Q Consider a set A = {1,2,3} and a relation **R** = {(1,1), (1,3), (2,2), (3,1), (3,2)}?

	1	2	3
Column			
Row			

	1	2	3
1			
2			
3			

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Q Consider a set A = {1,2,3,4} and a relation

R = {(1, 1), (2, 1), (2, 2), (2, 3), (2, 4), (3, 1), (3, 2), (3, 3), (3, 4)}?

	1	2	3	4
Column				
Row				

	1	2	3	4
1				
2				
3				
4				

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Warshall's Algorithm: -

Q Consider a set A = {1,2,3} and a relation **R** = {(1,1), (1,3), (2,2), (3,1), (3,2)}?

	1	2	3
Column			
Row			

	1	2	3
1			
2			
3			

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Break

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Q A binary relation R on N x N is defined as follows:

(a, b) R (c, d) if a <= c or b <= d

Consider the following propositions:

P: R is reflexive

Q: R is transitive

Which one of the following statements is TRUE? **(GATE- 2016) (2 Marks)**

(A) Both P and Q are true.

(B) P is true and Q is false.

(C) P is false and Q is true.

(D) Both P and Q are false.

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Q Let R be the relation on the set of positive integers such that a R b if and only if a and b are distinct and have a common divisor other than 1. Which one of the following statements about R is True? **(GATE-2015) (1 Marks)**

(A) R is symmetric and reflexive but not transitive

(B) R is reflexive but not symmetric and not transitive

(C) R is transitive but not reflexive and not symmetric

(D) R is symmetric but not reflexive and not transitive

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Q The relation "divides" on a set of positive integers is _____. **(NET-June-2013)**

a) Symmetric and transitive

b) Anti symmetric and transitive

c) Symmetric only

d) Transitive only

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Q A relation **R** in {1, 2,3,4,5,6} is given by {(1,2), (2,3), (3,4), (4,4), (4,5)}. This relation is: **(NET-Dec-2008)**

a) Reflexive

b) Symmetric

c) Transitive

d) not reflexive, not symmetric and not transitive

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Q the transitive closure of a relation R on a set A whose relation matrix $\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{matrix}$ is:

(NET-June-2005)

a) $\begin{matrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{matrix}$ **b)** $\begin{matrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 0 \end{matrix}$ **c)** $\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$ **d)** $\begin{matrix} 0 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 1 & 1 \end{matrix}$

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Q The binary relation S = ϕ (empty set) on set A = {1,2,3} is **(GATE-2002) (2 Marks)**

(a) Neither reflexive nor symmetric

(b) Symmetric and reflexive

(c) Transitive and reflexive

(d) Transitive and symmetric

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Q The binary relation R= {(1,1), (2,1), (2,2), (2,3), (2,4), (3,1), (3,2), (3,3), (3,4)} on the set A = {1,2,3,4} is **(GATE-1998) (2 Marks)**

(a) reflexive, symmetric and transitive

(b) neither reflexive, nor irreflexive but transitive

(c) irreflexive, symmetric and transitive

(d) irreflexive and antisymmetric

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Q The transitive closure of the relation {(1,2), (2,3), (3,4), (5,4)} on the set {1,2,3,4,5} is _____. **(GATE-1989) (2 Marks)**

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Break

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- **<u>Equivalence Relation</u>**: - A relation R on a set A with cartesian product A×A is said to be Equivalence, if it is

1. **Reflexive**
2. **Symmetric**
3. **Transitive**

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- If two relations R_1 and R_2 are Equivalence then their union need not to be equivalence but intersection will also be Equivalence.

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R_1 : (a, b) iff (a + b) is even over the set of integers

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R_2 : (a, b) iff (a + b) is odd over the set of integers

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R_3 : (a, b) iff a. b > 0 over the set of non-zero rational numbers

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R_4 : (a, b) iff $|a - b| \leq 2$ over the set of natural numbers

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Break

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Q Which of the relations on {0, 1, 2, 3} is an equivalence relation? **(NET-July-2018)**

a) {(0, 0) (0, 2) (2, 0) (2, 2) (2, 3) (3, 2) (3, 3)}

b) {(0, 0) (1, 1) (2, 2) (3, 3)}

c) {(0, 0) (0, 1) (0, 2) (1, 0) (1, 1) (1, 2) (2, 0)}

d) {(0, 0) (0, 2) (2, 3) (1, 1) (2, 2)}

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Q Let S be a set of n elements. The number of ordered pairs in the largest and the smallest equivalence relations on S are **(GATE-2007) (1 Marks)**

(A) n and n

(B) n^2 and n

(C) n^2 and 0

(D) n and 1

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Q Let R and S be any two equivalence relations on a non-empty set A. Which one of the following statements is TRUE? **(GATE-2005) (2 Marks)**

(A) $R \cup S$, $R \cap S$ are both equivalence relations

(B) $R \cup S$ is an equivalence relation

(C) $R \cap S$ is an equivalence relation

(D) Neither $R \cup S$ nor $R \cap S$ is an equivalence relation

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Q Suppose A is a finite set with n elements. The number of elements in the largest equivalence relation of A is? **(GATE-1998)** **(1 Marks)**

(a) n **(b)** n^2 **(c)** 1 **(d)** n + 1

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Q Let R_1 and R_2 be two equivalence relations on a set. Consider the following assertions **(GATE-1998) (1 Marks)**

(i) $R_1 \cup R_2$ is an equivalence relation

(ii) $R_1 \cap R_2$ is an equivalence relation

Which of the following is correct?

a) Both assertions are true

b) Assertions (i) is true but assertions (ii) is not true

c) Assertions (ii) is true but assertions (i) is not true

d) Neither (i) nor (ii) is true

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Q Let R be a non-empty relation on a collection of sets defined by A R B if and only if $A \cap B = \phi$. Then, (pick the true statement) **(GATE-1996) (2 Marks)**

(a) R is reflexive and transitive

(b) R is symmetric and not transitive

(c) R is an equivalence relation

(d) R is not reflexive and not symmetric

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Break

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1. In mathematics, when the elements of some set *S* have a notion of equivalence (formalized as an equivalence relation) defined on them, then one may naturally split the set *S* into **equivalence classes**.

2. These equivalence classes are constructed so that elements *a* and *b* belong to the same **equivalence class** if and only if they are equivalent.

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- **<u>Equivalence Class:</u>** - of an element is denoted by [x].
  $[x] = \{y \mid y \in A \text{ and } (x, y) \in R\}$ for all $x \in A$

- We can have [x] = [y], even if x != y

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Q Consider A = {1, 2, 3, 4, 5} an equivalence relation R on A, R = {(1,1),(2,2),(3,3),(4,4),(5,5),(1,4),(4,1),(2,5),(5,2)} find the partition of a set A, defined by R.

[1] =

[2] =

[3] =

[4] =

[5] =

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<u>Partitions of a Set</u>: - let A be a set, with n elements. Based on our understanding of equivalent classes, a subdivision of A into non-empty and non-overlapping subset is called a partition of A.

$A_1 \cup A_2 \cup A_3 \cup \ldots\ldots\ldots\ldots \cup A_n = A$

$A_1 \cap A_2 \cap A_3 \cap \ldots\ldots\ldots\ldots \cap A_n = \phi$

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Q Consider A = {1, 2, 3, 4, 5} an equivalence relation R on A, R = {(1,1),(2,2),(3,3),(4,4),(5,5),(1,4),(4,1),(2,5),(5,2)} find the partition of a set A, defined by R.

[1] = {1, 4}

[2] = {2, 5}

[3] = {3}

[4] = {1,4}

[5] = {2, 5}

so we have partitions =

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Q Let A = {1,2,3,4,5} is a set having partitions as {1, 4}, {2, 3, 5} , find the equivalence relation from which these partitions are created?

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Q A relation R is defined on the set of integers as x Ry iff (x + y) is even. Which of the following statements is true? **(GATE-2000) (2 Marks)**

(a) R is not an equivalence relation

(b) R is an equivalence relation having 1 equivalence class

(c) R is an equivalence relation having 2 equivalence classes

(d) R is an equivalence relation having 3 equivalence classes

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Break

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Q How many different equivalence relations with exactly three different equivalence classes are there on a set with five elements? **(NET-July-2016)**

(A) 10 **(B)** 15 **(C)** 25 **(D)** 30

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Q The number of equivalence relations of the set {1,2,3,4} is **(GATE-1997) (1 Marks)**

a) 15 **b)** 16 **c)** 24 **d)** 4

Will answer this question after functions

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Break

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- **<u>Partial Order Relation</u>**: - A relation R on a set A with cartesian product A×A is said to be partial order, if it is

1. **Reflexive**
2. **Anti - Symmetric**
3. **Transitive**

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1. In mathematics, especially order theory, a **partially ordered set** (also **poset**) formalizes and generalizes the intuitive concept of an ordering, sequencing, or arrangement of the elements of a set.

2. A poset consists of a set together with a binary relation indicating that, for certain pairs of elements in the set, one of the elements precedes the other in the ordering.

3. The relation itself is called a "partial order." The word *partial* in the names "partial order" and "partially ordered set" is used as an indication that not every pair of elements needs to be comparable.

4. That is, there may be pairs of elements for which neither element precedes the other in the poset. Partial orders thus generalize total orders, in which every pair is comparable.

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- **<u>Partial ordering set (Poset):</u>** - a set A with partial ordering relation R defined on A is called a POSET and is denoted by [A, R]

- For e.g. [A, /], [A, <=], [P(S), ⊑]

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- **<u>Total order relation:</u>** - A Poset [A, R] is called a total order set, if every pair of elements are comparable i.e. either (a, b) or (b, a) $\in$ R, for $\forall$ a, b $\in$ A

- For e.g. A = {1, 2, 3, 6}, then Poset [A,/] is not a total order relation but A = {1,2,4,8} will be

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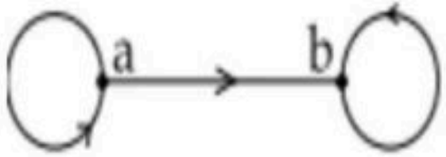
Q Which of the following statements is true? **(NET-July-2018)**

a) $(Z, \leq)$ is not totally ordered

b) The set inclusion relation $\subseteq$ is a partial ordering on the power set of a set S

c) $(Z, \neq)$ is a Poset

d) The directed graph 

is not a partial order

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Q A partial order P is defined on the set of natural numbers as follows. Here x/y denotes integer division. **(GATE-2007) (2 Marks)**

(1) (0,0) ∈ P **(2)** (a, b) ∈ P if and only if a % 10 <= b % 10 and (a/10, b/10) ∈ P.

Consider the following ordered pairs:

(i) (101,22) **(ii)** (22,101) **(iii)** (145,265) **(iv)** (0,153)

a) I & iii **b)** ii & iv **c)** I & iv **d)** iii & iv

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Q A relation R is defined on ordered pairs of integers as follows: (x, y) R (u, v) if x < u and y > v. Then R is **(GATR-2006) (1 Marks)**

(A) Neither a Partial Order nor an Equivalence Relation

(B) A Partial Order but not a Total Order

(C) A Total Order

(D) An Equivalence Relation

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Q let R_1 be a relation from A = {1,3,5,7} to B = {2,4,6,8} and R_2 be another relation from B to C = {1,2,3,4} as defined below **(GATE-2004) (1 Marks)**

(i) an element x in A is related to an element y in B if x + y is divisible by 3

(ii) an element x in B is related to an element y in C if x + y is even but not divisible by 3.

Which is the composite relation R_1R_2 from A to C?

a) {(1,2), (1,4), (3,3), (5,4), (7,3)}

b) {(1,2), (1,3), (3,2), (5,2), (7,3)}

c) {(1,2), (3,2), (3,4), (5,4), (7,2)}

d) {(3,2), (3,4), (5,1), (5,3), (7,1)}

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Q Let R be a symmetric and transitive relation on a set A. Then **(GATE-1995) (1 Marks)**

a) R is reflexive and hence an equivalence relation

b) R is reflexive and hence a partial order

c) R is reflexive and hence not an equivalence relation

d) None of the above

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Q.19 A relation R is said to be circular if aRb and bRc together imply cRa. Which of the following options is/are correct?

(Gate-2021) (1 Marks)

(a) If a relation S is reflexive and circular, then S is an equivalence relation.

(b) If a relation S is circular and symmetric, then S is an equivalence relation.

(c) If a relation S is transitive and circular, then S is an equivalence relation.

(d) If a relation S is reflexive and symmetric, then S is an equivalence relation.

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