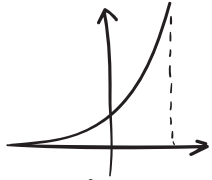


CSAT Formula Book

Last Minute Reading



- LCM and HCF
- Factorials
- Probability
- Venn Diagram
- Quadratic Equation
- Ratios and Proportion
- Surds and Indices
- Calendar
- Clock
- Direction
- Mean, Median and Mode
- Geometry
- Quadrilateral

$$E_n = \frac{kx^2}{2}$$

$$E_k = \frac{mV^2}{2}$$

$$C_y = C_1^{\alpha} (\alpha - \alpha_1)$$

$$T = 2\pi \sqrt{\frac{r}{g}}$$

$$S = V \cdot t$$



$$Y = C_1 P \frac{V^2}{2}$$

$$P = m \cdot V \quad T = 2\pi \sqrt{\frac{r}{g}}$$

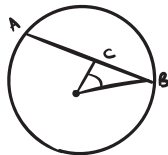
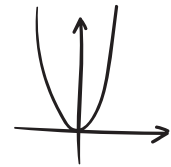
$$E_n = \frac{kx^2}{2}$$

Find HCF $\left(\frac{a \ b \ c}{d \ e \ f}\right) \Rightarrow \frac{\text{HCF}(a, b, c)}{\text{LCM}(d, e, f)}$

Find LCM $\left(\frac{a \ b \ c}{d \ e \ f}\right) \Rightarrow \frac{\text{LCM}(a, b, c)}{\text{HCF}(d, e, f)}$



$$S = V \cdot t$$



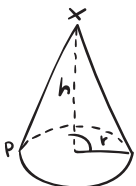
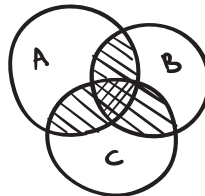
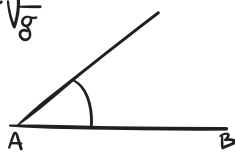
- Divisibility Rules
- Progression
- Geometric Progression
- Harmonic Progression
- Algebraic Formulas
- Time, Speed and Distance
- Simple and Compound Interest
- Profit and Loss
- Averages
- Percentage

$$T = 2\pi \sqrt{\frac{r}{g}}$$

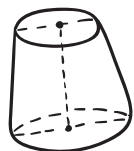
$$E = mc^2$$

$$x + y = a^2 b$$

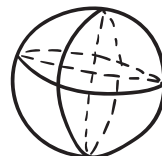
$$E_k = \frac{mV^2}{2}$$



$$Q = U + A$$



$$Y = C_1 P \frac{V^2}{2}$$



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Jagarati Awasthi
UPSC CSE 2020
AIR-02

“

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”



Satyam Gandhi
UPSC CSE 2020
AIR-10

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The Hindu aur Indian Express ek bada challenge ata hai tou usk liye sabse badhya hai apna OnlyIAS ka channel, editorial discussion hota hai usme bus terminology english me use hoti hai baaki sab jo sumit sir hai pura hindi me he bolte hai tou wo aram se aap easily samjh sakte hai.

”



Gaurav Budania
UPSC CSE 2020
AIR-13

Index

CHAPTER NO	CHAPTER NAME	PAGE NO
1	DIVISIBILITY RULES	1
2	PROGRESSION	3
	i. ARITHMETIC PROGRESSION	3
	ii. GEOMETRIC PROGRESSION	4
	iii. HARMONIC PROGRESSION	5
3	IMPORTANT ALGEBRAIC FORMULAS	6
4	TIME, SPEED AND DISTANCE	7
5	SIMPLE AND COMPOUND INTEREST	9
6	PROFIT AND LOSS	10
7	AVERAGES	11
8	PERCENTAGE	12
9	LCM AND HCF	14
10	FACTORIALS	15
11	PROBABILITY	16
12	VENN DIAGRAM	18
13	ROOTS OF QUADRATIC EQUATION	20
14	IMPORTANT SERIES SUM	21
15	RATIOS AND PROPORTIONS	22
16	SURDS AND INDICES	23
17	SQUARES	24
18	CUBES	25
19	CALENDAR	26
20	CLOCK	27
21	DIRECTION	28
22	NUMBERS	30
23	UNIT DIGIT	32
24	MEAN, MEDIAN AND MODE	33
25	GEOMETRY	35
	i. TRIANGLE AND ITS PROPERTIES	35
	ii. IMPORTANT PYTHAGOREAN TRIPLETS	36
	iii. QUADRILATERAL	37
	iv. CIRCLE	38
	v. CUBE	39
	vi. CUBOID	39
	vii. CYLINDER	39
26	TIME AND WORK	40
27	TRIGONOMETRY	41
28	SYLLOGISM DIAGRAMS	42
29	CODING DECODING	44

CH-1 Divisibility Rules

- 2 – Last digit is 0, 2, 4, 6 or 8
- 3 – Sum is divisible by 3
- 4 – Last two digits are divisible by 4
- 5 – Last digit is 0 or 5
- 6 – Number is divisible by 2 and 3
- 7 – Using rule of Triplet, if alternating sum is divisible by 7
- 8 - Last three digits are divisible by 8
- 9 – Sum is divisible by 9
- 10 – Unit digit is 0
- 11 – Difference of odd digits and even digits are 0 or divisible by 11
- 12 – Number divisible by 3 and 4
- 13 - Using rule of Triplet, if alternating sum is divisible by 13

Practice Question – UPSC 2019

Question - An 8 digit number 4252746B leaves remainder 0 when divided by 3. How many values of B are possible?

- A. 2
- B. 3
- C. 4
- D. 6

Solution –

As per rule of divisibility by 3, the sum should be divisible by 3

$$\text{Sum} = 4 + 2 + 5 + 2 + 7 + 4 + 6 + B = 30 + B$$

So, $30 + B$ should be divisible by 3

B can take values of 0, 3, 6 and 9 for the sum to be divisible by 3

So, total 4 values are possible i.e. Option C is correct answer

Practice Question – UPSC 2020

Question - How many 5 digit prime numbers can be obtained by using all the digits 1, 2, 3, 4 and 5 without repetition of digits?

- A. 0
- B. 1
- C. 9
- D. 10

Solution – Digits given are 1, 2, 3, 4 and 5

$$\text{Sum of digits} = 1 + 2 + 3 + 4 + 5 = 15$$

15 is divisible by 3

Any number formed by using all 5 digits will have its sum as 15, which is divisible by 3

As number is always divisible by 3 (using rule of divisibility by 3), formation of prime number is not possible

Thus, no prime number can be formed






Hence, option A is correct answer

STUDENT'S NOTE




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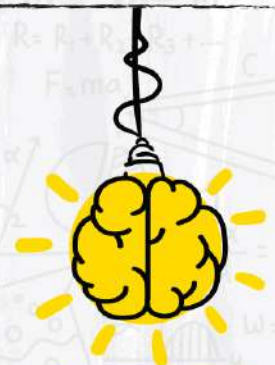


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CH-2 Progression

Arithmetic Progression

- Arithmetic Mean = $\frac{\text{Sum of observations}}{\text{Number of observations}}$
 $= \frac{x_1 + x_2 + \dots + x_n}{n}$

- $T_n = a + (n-1)d$

- $S_n = \frac{n}{2} [2a + (n-1)d]$
 $= \frac{n}{2} (a + l)$

If numbers are consecutive numbers starting from 1 with difference = 1,

Then $a = 1$ and $d = 1$

$$S_n = \frac{n}{2} [2(1) + (n-1)(1)] = \frac{n(n+1)}{2}$$

Where $a =$ First term

$d =$ Common difference

$T_n = n^{\text{th}}$ term

$S_n =$ Sum of n terms

- While solving three unknown terms in an Arithmetic Progression whose sum or product is given should be assumed as $a-d, a, a+d$
- While solving four terms in an Arithmetic Progression whose sum or product is given should be assumed as $a-3d, a-d, a+d, a+3d$

Practice Question – UPSC 2020

Question - One page is torn from a booklet whose pages are numbered in the usual manner starting from the first page as 1. The sum of the numbers on the remaining pages is 195. The torn page contains which of the following numbers

- A. 5, 6
- B. 7, 8
- C. 9, 10
- D. 11, 12

Solution –

The numbers are in Arithmetic Progression starting from 1 and common difference of 1

$$\text{Sum of consecutive numbers} = \frac{n(n+1)}{2} = 195$$

As there is a page which is torn, we need to find value of n where the value on left hand side is just above 195

For value of $n = 20$, $\frac{n(n+1)}{2} = 210$

This implies that sum of two numbers of the torn page must be $210 - 195 = 15$

As the sum should be 15, only option B satisfies this condition

Geometric Progression

- Geometric Mean = $\sqrt[n]{x_1 * x_2 * x_3 * \dots * x_n}$

- $T_n = ar^{n-1}$

- $S_n = \frac{a(r^n - 1)}{r - 1}$ if $r > 1$

- $S_n = \frac{a(1 - r^n)}{1 - r}$ if $r < 1$

- $S_{\text{Infinity}} = \frac{a}{1 - r}$

Where a = First term

r = Common ratio

T_n = n^{th} term

S_n = Sum of n terms

S_{Infinity} = Sum of infinite terms with decreasing common ratio r

- While solving three unknown Term in a G.P whose sum or product is given should be assumed as $(\frac{a}{r})$, a , ar

Practice Question – UPSC 2021

Question - A biology class at high school predicted that a local population of animals will double in size every 12 years. The population at the beginning of the year 2021 was estimated to be 50 animals. If P represents the population after n years, then which one of the following equations represents the model of the class for the population?

- A. $P = 12 + 50n$
- B. $P = 50 + 12n$
- C. $P = 50 (2)^{12n}$
- D. $P = 50 (2)^{n/12}$

Solution –

The population is getting doubled every 12 years

So, this is a case of Geometric Progression

So, $r = 2$

Also, initial population = 50

Being a case of GP, the population should be in form of ar^{n-1} or $50(2)^t$

Thus, option A and B are eliminated since they are not represented in this particular manner
Check for option C and D by putting value of $n = 12$ for doubling of population, we find that option C gives correct answer
Hence, option C is right choice

Harmonic Progression

- Harmonic Mean = $\frac{n}{\frac{1}{x_1} + \frac{1}{x_2} + \frac{1}{x_3} + \dots + \frac{1}{x_n}}$
- $T_n = \frac{1}{a} + (n-1)d$
- If A, G and H are respectively the arithmetic, geometric and harmonic means, then $A \geq G \geq H$
- $A * H = G^2$, i.e. A, G, H are in GP

Sample Question

Question - What is the minimum value of $a + \frac{1}{a}$?

- A. 0
- B. 1
- C. 2
- D. 20

Solution - Using $AM \geq GM$ of a and $\frac{1}{a}$,

$$\frac{a + \frac{1}{a}}{2} \geq \left(a \cdot \frac{1}{a}\right)^{\frac{1}{2}}$$

After solving,

$$a + \frac{1}{a} \geq 2$$

Thus, minimum value of expression is 2

Hence, option C is correct answer

STUDENT'S NOTE

CH-3 Important Algebraic Formulas

- $(a + b)^2 = a^2 + b^2 + 2ab$
- $(a - b)^2 = a^2 + b^2 - 2ab$
- $a^2 - b^2 = (a + b)(a - b)$
- $(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$
- $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$
- $(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$
- $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$
- $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$

Practice Question - UPSC 2020

Question - How many pairs of natural numbers are there such that the difference of whose squares is 63?

- A. 3
- B. 4
- C. 5
- D. 2

Solution - Let the required natural numbers be a and b

As per statement, $a^2 - b^2 = 63$

Using formula $a^2 - b^2 = (a + b)(a - b)$

$$(a + b)(a - b) = 63$$

$$63 = 9 \times 7$$

$$\text{Or } 63 = 21 \times 3$$

$$\text{Or } 63 = 63 \times 1$$

There will be a total of three possible cases in which product of two numbers is 63

Case 1 :

$$(a + b) = 9 \text{ and } (a - b) = 7$$

Then $a = 8$ and $b = 1$

Case 2 :

$$(a + b) = 21 \text{ and } (a - b) = 3$$

Then $a = 12$ and $b = 9$

Case 3 :

$$(a + b) = 63 \text{ and } (a - b) = 1$$

Then $a = 32$ and $b = 31$

Total three such pair will be there

Hence, option A is correct answer

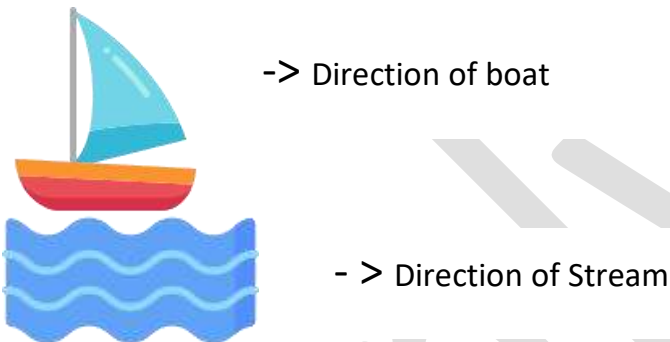
CH-4 Time, Speed and Distance

- $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$
- $\text{Average Speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$
- Relative Speed
 $\text{Time} = \frac{\text{Sum of lengths}}{\text{Relative Speed}}$

$$\text{Time} = \frac{L_1 + L_2}{S_1 \pm S_2}$$

Speeds to be added if two objects are travelling towards each other and subtracted if going away from each other

- $\text{Speed Downstream} = \text{Speed of boat in still water} + \text{Speed of Stream}$



As both are in same direction, speeds will be added

- $\text{Speed Upstream} = \text{Speed of boat in still water} - \text{Speed of Stream}$



As both are in opposite direction, speeds will be subtracted

- $\text{Speed of the boat in still water} = \frac{1}{2} (\text{Downstream speed} + \text{Upstream speed})$
- Conversion from Km/h to m/s -> Multiply by 5/18

- An object covers equal distance at speed S_1 and other equal distance at speed S_2 then his average speed for the distance is $\frac{2(S_1)(S_2)}{S_1+S_2}$

Practice Question – UPSC 2020

Question - A man takes half time in rowing a certain distance downstream than upstream. What is the ratio of the speed in still water to the speed of current?

- A. 1 : 2
- B. 2 : 1
- C. 1 : 3
- D. 3 : 1

Solution –

Let speed of boat in still water = a

Let speed of current = b

Speed downstream = a + b

Speed upstream = a – b

Let total distance = D

As given in question,

Time taken for downstream = $\frac{1}{2}$ * Time taken for upstream

$$\frac{D}{a+b} = \frac{1}{2} * \frac{D}{a-b}$$

After solving, we get

$$a = 3b$$

$$\frac{a}{b} = \frac{3}{1}$$

Hence, option D is right choice

STUDENT'S NOTE

CH-5 Simple and Compound Interest

- Amount = Principal + Interest
- Simple Interest = $\frac{\text{Principal} \times \text{Rate} \times \text{Time}}{100}$
- Compound Interest = $P * \left(1 + \frac{R}{100}\right)^T - P$

Where P = Principal

R = Rate

T = Time

- Doubling of money – Rule of 72 i.e. For doubling of money
Rate * Time = 72 (approx.)
- Tripling of money – Rule of 114 i.e.
Rate * Time = 114 (approx.)
- Quadrupling of money – Rule of 144 i.e.
Rate * Time = 144 (approx.)

Practice Question

Question - A particular sum of money doubles itself in 8 years when interest rate is compounded annually. What is the interest rate?

- A. 6%
- B. 8%
- C. 9%
- D. 12%

Solution –

As money doubles in 8 years,
Using Doubling of money formula,
Rate * time = 72

$$\text{Rate} * 8 = 72$$

$$\text{Rate} = 9\%$$

Hence, option C is correct answer

CH-6 Profit and Loss

- Profit = Selling Price – Cost Price
- Loss = Cost Price – Selling Price
- Profit % = $\frac{\text{Profit}}{\text{Cost Price}} * 100$
- Loss % = $\frac{\text{Loss}}{\text{Cost Price}} * 100$
- Discount = Marked Price – Selling Price
- Discount % = $\frac{\text{Discount}}{\text{Marked Price}} * 100$
- Successive Discount formula = $(x + y - \frac{xy}{100})\%$
Where x and y refer to successive discounts offered

Practice Question – UPSC 2020

Question - A person bought a car and sold it for Rs. 3,00,000. If he incurred a loss of 20%, then how much did he spend to buy the car?

- A. Rs. 3,60,000
- B. Rs. 3,65,000
- C. Rs. 3,70,000
- D. Rs. 3,75,000

Solution –

$$\text{Loss \%} = \frac{\text{Loss}}{\text{Cost Price}} * 100$$

$$\text{Loss \%} = \frac{\text{Cost Price} - \text{Selling Price}}{\text{Cost Price}} * 100$$

Substituting values as given in question

$$20\% = 1 - \frac{300000}{\text{CP}} * 100$$

Solving the equation,

We get CP = 3,75,000

Hence, option D is right choice

STUDENT'S NOTE

CH-7 Averages

- Average = $\frac{\text{Sum of observations}}{\text{Number of observations}}$
- Weighted Average = $\frac{w_1x_1+w_2x_2+\dots+w_nx_n}{x_1+x_2+\dots+x_n}$
- If the value of each unit in a set is increased or decreased by some value x , then the average of the set also increases or decreases respectively by x

Practice Question – UPSC 2020

Question - The average score of a batsman after his 50th innings was 46.4. After 60th innings, his average score increases by 2.6. What was his average score in the last ten innings?

- A. 122
- B. 91
- C. 62
- D. 49

Solution –

Average score after 50 innings = 46.4

Total score after 50 innings = Average * Number
= $46.4 * 50 = 2320$

Average after 60 innings = $46.4 + 2.6 = 49$

Total score after 60 innings = Average * Number
= $49 * 60 = 2940$

Runs scored in last 10 innings = Score after 60 innings – Score after 50 innings
= $2940 - 2320$
= 620

Average of last 10 innings = $\frac{\text{Score in last 10 innings}}{10}$
= $\frac{620}{10}$
= 62

Hence, option C is correct answer

STUDENT'S NOTE

CH-8 Percentage

Fraction	Percentage
$\frac{1}{2}$	50%
$\frac{1}{3}$	33.33%
$\frac{1}{4}$	25%
$\frac{1}{5}$	20%
$\frac{1}{6}$	16.66%
$\frac{1}{7}$	14.28%
$\frac{1}{8}$	12.5%
$\frac{1}{9}$	11.11%
$\frac{1}{10}$	10%
$\frac{1}{11}$	9.09%
$\frac{1}{12}$	8.33%
$\frac{1}{13}$	7.69%
$\frac{1}{14}$	7.14%
$\frac{1}{15}$	6.66%
$\frac{1}{20}$	5%
$\frac{1}{24}$	4.16%
$\frac{1}{25}$	4%
$\frac{1}{30}$	3.33%
$\frac{1}{40}$	2.5%
$\frac{1}{50}$	2%
$\frac{1}{100}$	1%

- Percentage Change = $\frac{\text{Final Value} - \text{Initial Value}}{\text{Initial Value}} * 100$

- Successive change of x% and y%

$$\text{Total change in percentage} = \left(x + y + \frac{xy}{100} \right) \%$$

Practice Question – UPSC 2021

Question - If the price of an article is decreased by 20% and then the new price is increased by 25%, then what is the net change in the price?

- A. 0%
- B. 5% increase
- C. 5% decrease
- D. Cannot be determined due to insufficient data

Solution - Total change in percentage = $\left(x + y + \frac{xy}{100} \right) \%$

$$\text{Total change} = (-20) + (25) + \frac{(-20)(25)}{100}$$

$$= 5 - 5 = 0\%$$

Thus, there is no change in price of article

Hence, option A is correct answer

STUDENT'S NOTE



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CH-9 LCM and HCF

- HCF of fraction = $\frac{\text{HCF of Numerator}}{\text{LCM of Denominator}}$
- LCM of fraction = $\frac{\text{LCM of Numerator}}{\text{HCF of Denominator}}$
- LCM * HCF = Product of two numbers
- The least number which when divided by a, b and c leaves a remainder R in each case. Required number = (LCM of a, b, c) + R
- The greatest number which divides a, b and c to leave the remainder R is HCF of (a - R), (b - R) and (c - R)
- The greatest number which divides x, y, z to leave remainders a, b, c is HCF of (x - a), (y - b) and (z - c)

Practice Question – UPSC 2020

Question - What is the greatest length x such that $3\frac{1}{2}$ m and $8\frac{3}{4}$ m are integral multiples of x?

- A. $1\frac{1}{2}$ m
- B. $1\frac{1}{3}$ m
- C. $1\frac{1}{4}$ m
- D. $1\frac{3}{4}$ m

Solution –

The question asks for finding the greatest possible length i.e. HCF of two numbers

$$\text{First number} = 3\frac{1}{2} = \frac{7}{2}$$

$$\text{Second number} = 8\frac{3}{4} = \frac{35}{4}$$

$$\begin{aligned} \text{HCF of fraction} &= \frac{\text{HCF of Numerator}}{\text{LCM of Denominator}} \\ &= \frac{\text{HCF of (7,35)}}{\text{LCM of (2,4)}} \\ &= \frac{7}{4} = 1\frac{3}{4} \text{ m} \end{aligned}$$

Hence, option D is correct answer

CH-10 Factorials

- $n! = 1 * 2 * 3 * 4 * \dots * n$
- $n! = n * (n - 1)!$
- Permutation ${}^n P_r = \frac{n!}{(n-r)!}$
- Combination ${}^n C_r = \frac{n!}{r!(n-r)!}$
- ${}^n C_r = {}^n C_{n-r}$
- ${}^n C_0 + {}^n C_1 + {}^n C_2 + \dots + {}^n C_n = 2^n$
- Total number of Handshakes possible among total n people = ${}^n C_2$
- Total number of Triangles that can be formed by joining sides of polygon of n sides = ${}^n C_3$
- Total number of diagonals of a polygon of n sides = $\frac{n*(n-3)}{2}$
- Total number of circular permutations if clockwise and anti-clockwise are taken as different = $(n-1)!$

Number	Factorial
0	1
1	1
2	2
3	6
4	24
5	120
6	720
7	5040
8	40320
9	362880
10	3628800

STUDENT'S NOTE

CH-11 Probability

- Random Experiment – An experiment whose result cannot be predicted e.g. Dice, coin etc
- Probability of an event always lies between 0 and 1
- $P(\text{Not } A) = 1 - P(A)$
- Probability of an event = $\frac{\text{Number of favourable outcomes}}{\text{Sample space or Total number of outcomes}}$
- Odds in favor of event = $\frac{\text{Number of favourable outcomes}}{\text{Number of unfavourable outcomes}}$
- Odds against an event = $\frac{\text{Number of unfavourable outcomes}}{\text{Number of favourable outcomes}}$

Practice Question – UPSC 2018

Question - A bag contains 15 red balls and 20 black balls. Each ball is numbered either 1 or 2 or 3. 20% of the red balls are numbered 1 and 40% of them are numbered 3. Similarly, among the black balls, 45% are numbered 2 and 30% are numbered 3. A boy picks a ball at random. He wins if the ball is red and numbered 3 or if it is black and numbered 1 or 2. What are the chances of his winning?

- A. $\frac{1}{2}$
- B. $\frac{4}{7}$
- C. $\frac{5}{9}$
- D. $\frac{12}{13}$

Solution –

Total red balls = 15

Total black balls = 20

Red Ball

Probability of picking a random ball is Red = $\frac{15}{35}$

Probability of picking Red and Number 3 = $\frac{15}{35} * \frac{40}{100}$ - Eq 1

(As 40% red balls are Number 3)

Black Ball

Probability of picking a random ball is Black – $\frac{20}{35}$

$$\text{Black and Number 1} = \frac{20}{35} * \frac{25}{100} \quad \text{- Eq 2}$$

(As Black Number 1 balls = 100% - Black Number 2 balls – Black Number 3 balls
= 100% - 45% - 30% = 25%)

$$\text{Black and Number 2} = \frac{20}{35} * \frac{45}{100} \quad \text{- Eq 3}$$

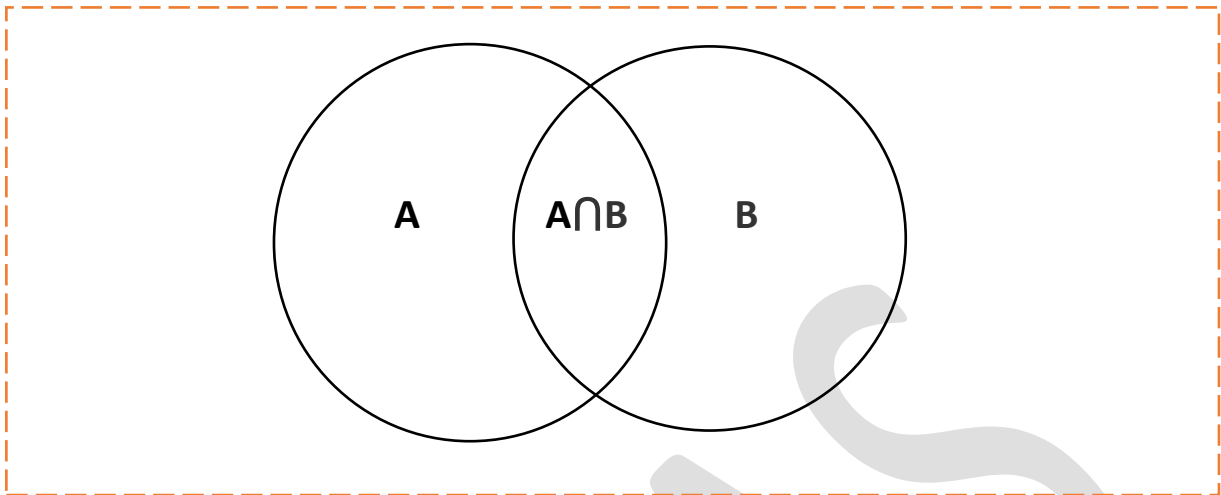
(As 45% black balls are Number 2)

$$\begin{aligned} \text{Total probability} &= \text{Eq 1} + \text{Eq 2} + \text{Eq 3} \\ &= \frac{4}{7} \end{aligned}$$

Hence, option B is correct answer

STUDENT'S NOTE

CH-12 Venn Diagram



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

Practice Question – UPSC 2019

Question - All members of a club went to Mumbai and stayed in a hotel. On the first day, 80% went for shopping and 50% went for sightseeing, whereas 10% took rest in the hotel. Which of the following conclusion(s) can be drawn from the above data?

1. 40% members went for shopping as well as sightseeing.
2. 20% members went for only shopping.

Select the correct answer using the code given below:

- A. 1 only
- B. 2 only
- C. Both 1 and 2
- D. Neither 1 nor 2

Solution –

$n(\text{Shopping})$ or $n(S_1) = 80\%$

$n(\text{Sight Seeing})$ or $n(S_2) = 50\%$

People who took rest = 10%

This implies that rest 90% (100-10) people went either for Shopping or Sight Seeing

So, $n(S_1 \cup S_2) = 90\%$

Using Formula,

$$n(S1 \cup S2) = n(S1) + n(S2) - n(S1 \cap S2)$$

$$90 = 80 + 50 - n(S1 \cap S2)$$

$$n(S1 \cap S2) = 40\%$$

So, 40% members went for shopping as well as sightseeing

Statement 1 is correct.

$$\text{People who went for only Shopping} = n(S1) - n(S1 \cap S2)$$

$$= 80 - 40 = 40\%$$

Statement 2 is incorrect

Hence, option A is correct

STUDENT'S NOTE

CH-13 Roots of Quadratic Equation

The roots of the quadratic equation $ax^2 + bx + c = 0$:

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Practice Question

Question – The roots of the equation $6x^2 - 17x + 12 = 0$ are

- A. $\frac{5}{2}$ and $\frac{3}{2}$
- B. $\frac{3}{2}$ and $\frac{4}{3}$
- C. $\frac{2}{3}$ and $\frac{3}{2}$
- D. $\frac{5}{2}$ and $\frac{3}{4}$

Solution –

Using Formula,

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\text{Roots} = \frac{-(-17) \pm \sqrt{(-17)^2 - 4(6)(12)}}{2 \cdot 6}$$

$$\text{Roots} = \frac{17 \pm 1}{12}$$

$$\text{Roots} = \frac{3}{2} \text{ and } \frac{4}{3}$$

Hence, option B is correct answer

STUDENT'S NOTE

CH-14 Important Series Sum

- Sum of first n Natural numbers = $\frac{n(n+1)}{2}$
- Sum of first n Odd numbers = n^2
- Sum of first n Even numbers = $n(n+1)$
- Sum of squares of first n Natural numbers = $\frac{n(n+1)(2n+1)}{6}$
- Sum of cubes of first n Natural numbers = $\left[\frac{n(n+1)}{2}\right]^2$

Practice Question

Question – The average of all odd numbers upto 100 is

- A. 50
- B. 51
- C. 99
- D. 100

Solution –

Odd numbers are 1, 3, 5, 7, 9, 99

Total number of odd values till 100 = 50

As per formula,

Sum of odd numbers = n^2

Sum of 50 odd numbers till 100 = $(50)^2$

$$\text{Average} = \frac{\text{Sum of values}}{\text{Number of values}}$$

$$\text{Average} = \frac{(50)^2}{50}$$

$$\text{Average} = 50$$

Hence, option A is correct answer

STUDENT'S NOTE

CH-15 Ratios and Proportions

- If $\frac{a}{b} = \frac{c}{d}$ then
 - As per Invertendo law, $\frac{b}{a} = \frac{d}{c}$
 - As per Alternendo law, $\frac{a}{c} = \frac{b}{d}$
 - As per Componendo law, $\frac{a+b}{b} = \frac{c+d}{d}$
 - As per Dividendo law, $\frac{a-b}{b} = \frac{c-d}{d}$
 - As per Componendo and Dividendo, $\frac{a+b}{a-b} = \frac{c+d}{c-d}$
- For a proper fraction $\frac{a}{b}$ i.e. $a < b$, then for a positive quantity c , then

$$\frac{a+c}{b+c} > \frac{a}{b} \text{ and}$$

$$\frac{a-c}{b-c} < \frac{a}{b}$$
- For improper fraction $\frac{a}{b}$ i.e. $a > b$, then for a positive quantity c , then

$$\frac{a+c}{b+c} < \frac{a}{b} \text{ and}$$

$$\frac{a-c}{b-c} > \frac{a}{b}$$

Practice Question UPSC 2019

Question – If the numerator and denominator of a proper fraction are increased by the same positive quantity which is greater than zero, the resulting fraction is

- A. always less than the original fraction
- B. always greater than the original fraction
- C. always equal to the original fraction
- D. such that nothing can be claimed definitely

Solution –

As discussed in formula above,

Proper fraction is one where numerator is less than denominator

For a proper fraction $\frac{a}{b}$ i.e. $a < b$, then for a positive quantity c , then

$$\frac{a+c}{b+c} > \frac{a}{b}$$

(Can also assume values of a , b and c to reach to the answer)

Hence, option B is correct answer

CH-16 Surds and Indices

- $x^0 = 1$
- $x^a * x^b = x^{a+b}$
- $\frac{x^a}{x^b} = x^{a-b}$
- $x^{-a} = \frac{1}{x^a}$
- $\sqrt[a]{x} = (x)^{\frac{1}{a}}$
- $(x)^{\frac{a}{b}} = \sqrt[b]{x^a}$
- $(x^a)^b = x^{ab}$
- $x^a y^a = (xy)^a$
- $\sqrt{a} * \sqrt{b} = \sqrt{ab}$

Practice Question UPSC 2020

Question – What is the largest number among the following?

- A. $(1/2)^{-6}$
- B. $(1/4)^{-3}$
- C. $(1/3)^{-4}$
- D. $(1/6)^{-2}$

Solution –

As discussed in formula above,

$$x^{-a} = \frac{1}{x^a}$$

Option A -> $(\frac{1}{2})^{-6} = 2^6 = 64$

Option B -> $(\frac{1}{4})^{-3} = 4^3 = 64$

Option C -> $(\frac{1}{3})^{-4} = 3^4 = 81$

Option D -> $(\frac{1}{6})^{-2} = 6^2 = 36$

Thus, it is clear that option C has the highest value. Hence, it is the correct answer

CH-17 Squares

Number	Square
1	1
2	4
3	9
4	16
5	25
6	36
7	49
8	64
9	81
10	100
11	121
12	144
13	169
14	196
15	225
16	256
17	289
18	324
19	361
20	400
21	441
22	484
23	529
24	576
25	625
26	676
27	729
28	784
29	841
30	900
31	961
32	1024
33	1089
34	1156
35	1225

CH-18 Cubes

Number	Cube
1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729
10	1000
11	1331
12	1728
13	2197
14	2744
15	3375

STUDENT'S NOTE

CH-19 Calendar

- Normal Year – 365 days or 52 weeks and 1 day
- Leap Year – 366 days or 52 weeks and 2 days
- Century Leap Year – If century year is divisible by 400
e.g. 2000 is leap year , but 1900 is not a leap year
- Leap Years in 400 year time period - 97
- Leap Years in 100 year time period – 24 or 25 depending whether 100 year end is in century leap year or not

Practice Question – UPSC 2021

Question - Which day is 10th October, 2027 if it is Sunday on 10th October, 2021?

- A. Sunday
- B. Monday
- C. Tuesday
- D. Saturday

Solution –

We need to find day after exactly 6 years i.e. $2027 - 2021 = 6$
From 2021 to 2027, there are 5 normal years and 1 year (2024)

Normal year has 52 weeks and 1 extra day

Leap year has 52 weeks and 2 extra days

$$\begin{aligned}\text{So, extra days} &= (\text{Number of normal years} * 1) + (\text{Number of Leap years} * 2) \\ &= (5*1) + (1*2) \\ &= 7\end{aligned}$$

$$\begin{aligned}\text{So, day on 10}^{\text{th}} \text{ October, 2027} &= \text{Day on 10}^{\text{th}} \text{ October, 2021} + \text{Extra days} \\ &= \text{Sunday} + 7 \\ &= \text{Sunday}\end{aligned}$$

Hence, option A is correct answer

CH-20 Clock

- Degrees covered by Minute hand in 1 min = 6°
- Degrees covered by Second hand in 1 second = 6°
- Degrees covered by Hour hand in 1 min = $\frac{1}{2}^\circ$



- Angle between Hour and Minute Hand at a particular time =

$$\frac{60 * \text{Hour} - 11 * \text{Minute}}{2}$$

e.g. If time is 7:30 then angle between Hour and minute hand =

$$\frac{60*7 - 11*30}{2} = 45^\circ$$

- If we wish to find exact minutes when a particular angle will be formed between Hour and Minute Hand, then

$$\frac{2}{11} (A1 \pm A2)$$

Where A1 = smaller hour number * 30 and A2 is the required angle

e.g. At what time between 7 and 8 o'clock are the hands of clock at an angle of 45 degree?

Using Formula,

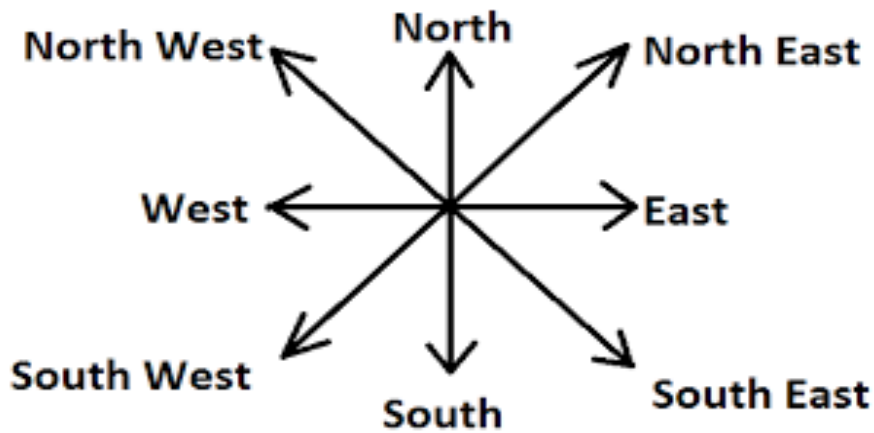
$$\text{Time} = \frac{2}{11} (A1 \pm A2) = \frac{2}{11} (7*30 \pm 45)$$

$$= 30 \text{ and } 46\frac{4}{11}$$

So, 7:30 and 7:46 $\frac{4}{11}$ will be the two times when angles between two hands will be 45°

STUDENT'S NOTE

CH-21 Direction



Practice Question – UPSC 2021

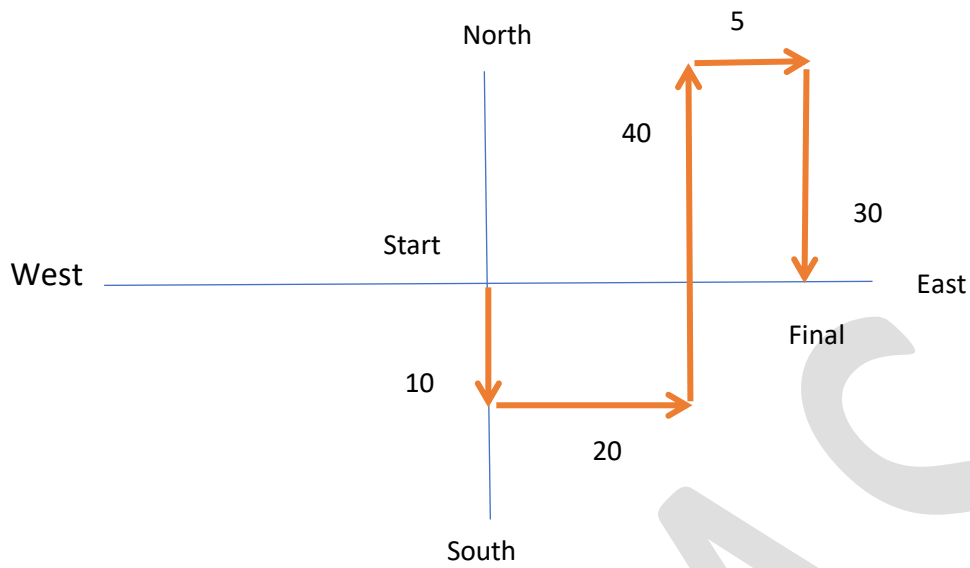
Question - A bank employee drives 10 km towards South from her house and turns to her left and drives another 20 km. She again turns left and drives 40 km, then she turns to her right and drives for another 5 km. She again turns to her right and drives another 30 km to reach her bank where she works. What is the shortest distance between her bank and her house?

- A. 20 km
- B. 25 km
- C. 30 km
- D. 35 km

Solution –

The final direction is as shown in the figure

STUDENT'S NOTE



Total distance between Start and Final point is $20 + 5 = 25$ Km
Hence, option B is correct answer

STUDENT'S NOTE

CH-22 Numbers

- Representation of a Number
 - $ab = 10a + b$
 - $abc = 100a + 10b + c$
 - $abcd = 1000a + 100b + 10c + d$
- Natural Number – Counting numbers containing set of positive integers from 1 to infinity
- Whole Number – Natural numbers with 0 adjoined
- Prime Number – Natural number greater than 1 having only 1 and itself as factors e.g., 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37 etc.
- Odd Number – Numbers not divisible by 2 or having ending in 1, 3, 5, 7 or 9
- Even Number – Numbers divisible by 2 or having ending in 0, 2, 4, 6 or 8
- Rational Number – Can be expressed in term of $\frac{p}{q}$
 - Terminating rational e.g., $\frac{1}{4} = 0.25$
 - Non Terminating rational e.g., $\frac{13}{6} = 2.16666$
- Irrational Number – Cannot be expressed in term of $\frac{p}{q}$
- Integer – Set of all whole numbers with set of negative natural numbers
 - Positive Integer - 1, 2, 3, 4..... is the set of positive integers
 - Negative Integers: -1, -2, -3, -4..... is the set of negative integers
 - Non-Positive and Non-Negative Integers: 0 is neither positive nor negative
- Proper Fraction – Numbers in form of $\frac{p}{q}$ where $p < q$
- Improper Fraction – Numbers in form of $\frac{p}{q}$ where $p > q$
- Co-Prime Numbers – Numbers with HCF 1
- Composite Numbers – Numbers having more than 2 factors
- Twin Prime – Pair of Prime numbers where difference is of two e.g. (5, 7), (11, 13) etc.

Practice Question – UPSC 2020

Question - In the sum $\square + 1\square + 5\square + \square\square + \square 1 = 1\square\square$ for which digit does the symbol \square stand?

- A. 2
- B. 3
- C. 4
- D. 5

Solution –

Using Representation of a number, the above equation becomes

$$(x) + (10 + x) + (50 + x) + (10x + x) + (10x + 1) = 100 + 10x + x$$

$$24x + 61 = 100 + 11x$$

$$13x = 39$$

$$x = 3$$

Hence, option B is correct answer

STUDENT'S NOTE

CH-23 Unit Digit

Unit digit when a number is raised to some power

- 0 – Always 0
- 1 – Always 1
- 2 – 2,4,8,6
- 3 – 3,9,7,1
- 4 – 4, 6
- 5 – Always 5
- 6 – Always 6
- 7 – 7,9,3,1
- 8 – 8,4,2,6
- 9 – 9, 1

Examples –

If we have to find unit digit in $(4167)^{434}$, then simply check for 7 – possibilities are 7, 9, 3 or 1...

As 7 follows a cyclicity of 4, we divide power i.e. 434 by 4 to get remainder of 2

Corresponding to remainder 2, the second number in 7, 9, 3 or 1 is 9

Hence, unit digit will be 9

If we have to find unit digit in $(24163)^{147}$, then simply check for 3 – possibilities are 3, 9, 7 or 1

As 3 follows a cyclicity of 4, we divide power i.e. 147 by 4 to get remainder of 3

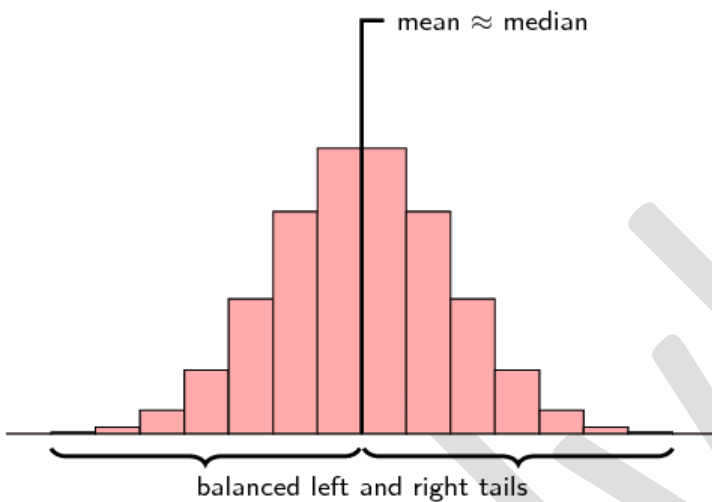
Corresponding to remainder 3, the third number in 3, 9, 7 or 1 is 7

Hence, unit digit will be 7

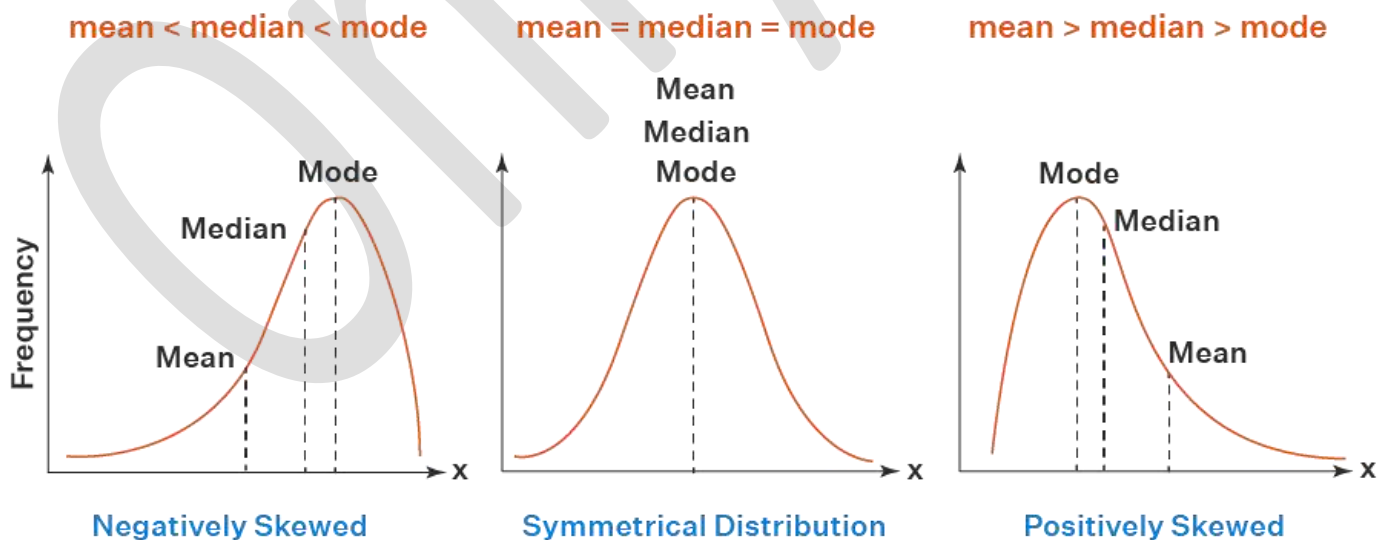
STUDENT'S NOTE

CH-24 Mean, Median and Mode

- Mean = $\frac{\text{Sum of observations}}{\text{Number of observations}}$
- Median = Middlemost observation when data is arranged in ascending order
- Mode = Most frequently occurring value in data set
- $2 \text{ Mean} + \text{Mode} = 3 \text{ Median}$
- Range = Maximum value - Minimum value
- Symmetric Data - Data sets whose values are evenly spread around centre



- Skewed Data - Data sets that are not symmetric



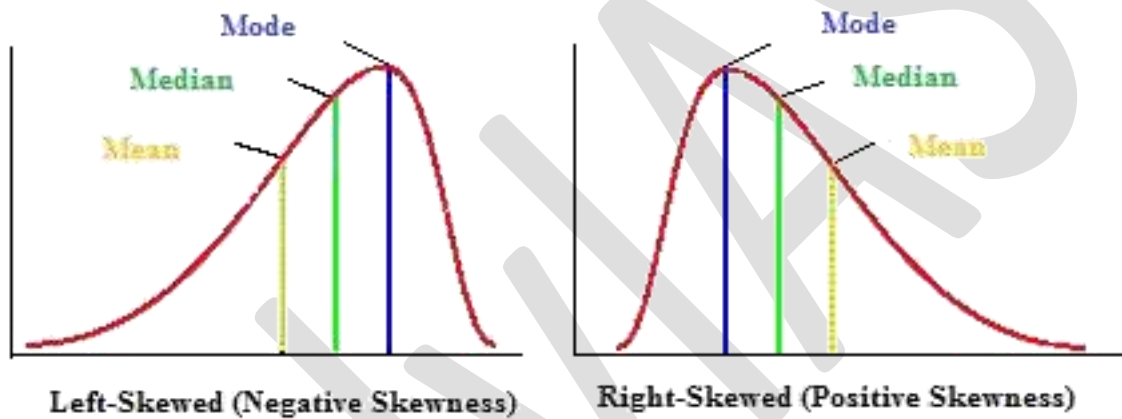
Practice Question – UPSC 2017

Question - If for a sample data $\text{Mean} < \text{Median} < \text{Mode}$ then the distribution is

- A. Symmetric
- B. Skewed to the right
- C. Neither symmetric nor skewed
- D. Skewed to the left

Solution –

As discussed above, when $\text{Mean} < \text{Median} < \text{Mode}$, the distribution is skewed towards left
Hence, option D is correct answer

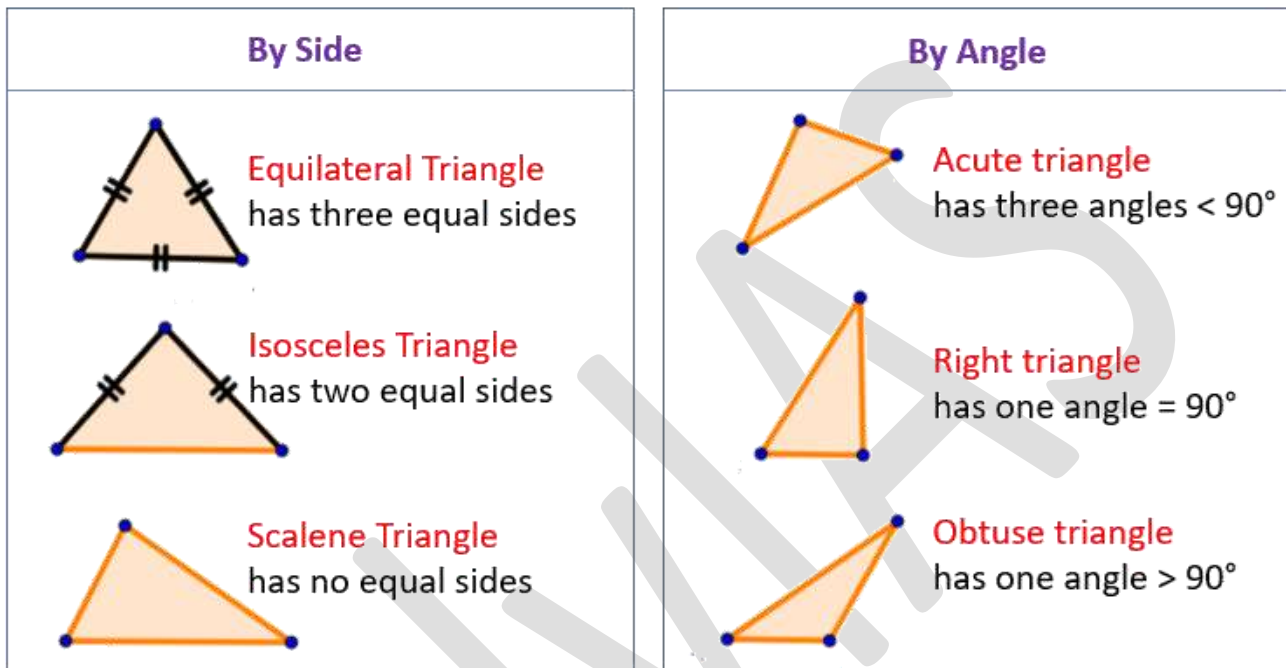


STUDENT'S NOTE

CH-25 Geometry

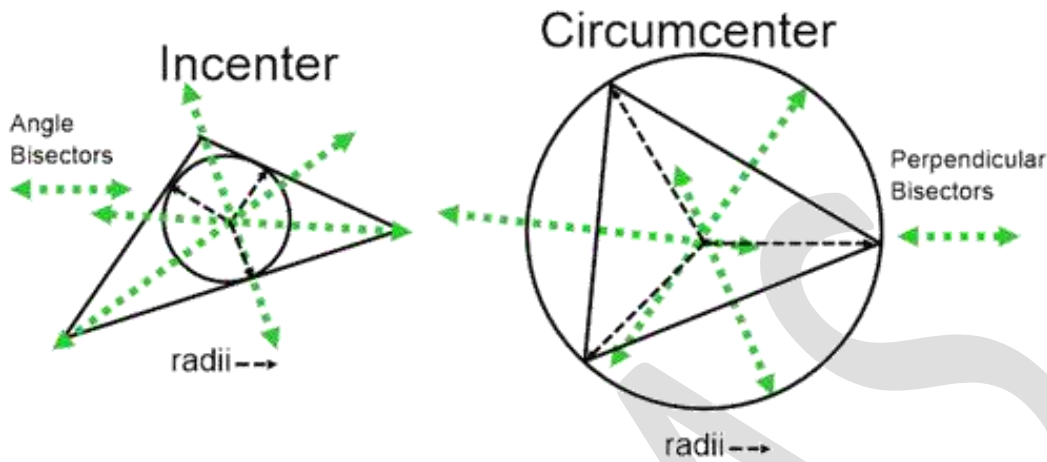
Triangle and its properties

Types of Triangles



- Sum of three angles of triangle = 180°
- Three types of triangles based on angle–
 - I. Acute – All angles less than 90°
 - II. Right – One angle equal to 90° and $P^2 + B^2 = H^2$
 - III. Obtuse – One angle greater than 90°
- Three types of triangles based on sides
 - I. Scalene triangle – no sides are equal
 - II. Isosceles triangle - two sides are equal
 - III. Equilateral – all sides are equal
- Sum of two sides is always greater than third side
- Difference of two sides is always less than third side
- Sum of interior angles = 180°
- Exterior angle is always equal to sum of two opposite angles
- Sum of exterior angles = 360°
- Perimeter of triangle = Sum of sides
- Semi - perimeter $s = \frac{1}{2}$ of perimeter

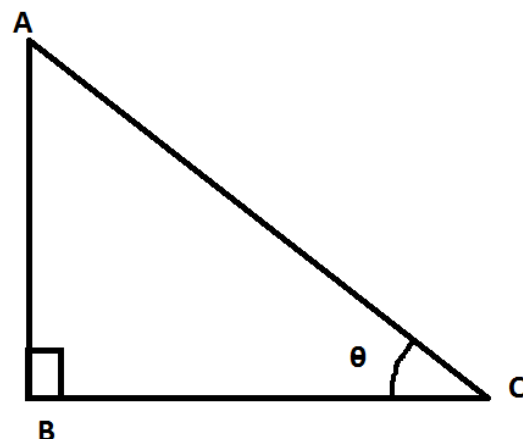
- Area of triangle using Heron's Formula = $\sqrt{(s)(s - a)(s - b)(s - c)}$



- Inradius of triangle = $\frac{\text{Area}}{\text{Semi-Perimeter}}$
- Circumradius = $\frac{a \cdot b \cdot c}{4 \cdot \text{Area}}$, where a, b and c are three sides of triangle
- In a right angle triangle, Circumradius is equal to half of Hypocenter
- Area of Triangle = $\frac{1}{2} \cdot \text{base} \cdot \text{height}$
- Area of Triangle = $\frac{1}{2}ab \sin Q$ where Q is angle between a and b
- Area of equilateral triangle = $\sqrt{\frac{3a^2}{4}}$, where a is side of triangle

Important Pythagorean Triplets

- Numbers that follow $P^2 + B^2 = H^2$
- 3,4,5
- 6, 8, 10
- 7, 24, 25
- 5, 12, 13
- 9, 40, 41
- 20, 21, 29



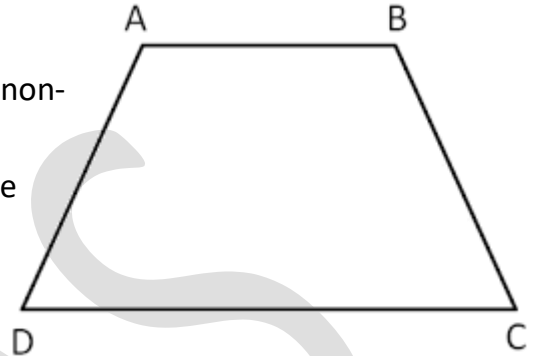
Quadrilateral

- Total number of sides = 4
- Sum of interior angles = 360°
- 5 major types of Quadrilaterals

I. Trapezium

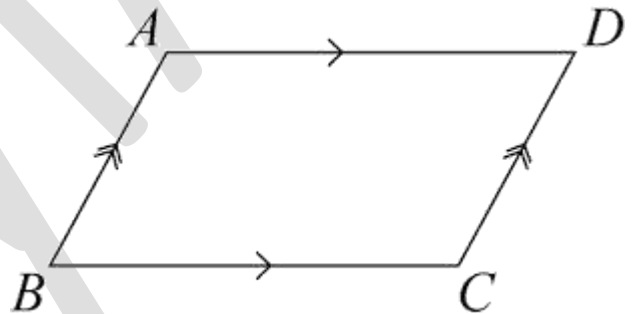
- i. Two sides are parallel and two sides are non-parallel
- ii. Area = $\frac{1}{2} \times$ sum of parallel sides \times distance between parallel sides =

$$= \frac{1}{2} \times (a+b) \times h$$
- iii. Perimeter = $a + b + c + d$



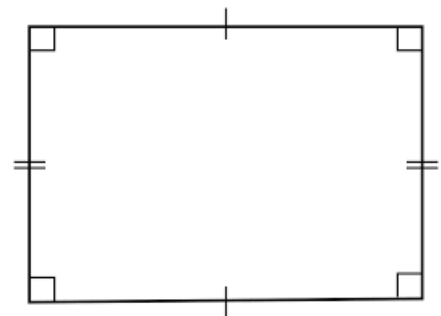
II. Parallelogram

- i. Opposite sides are equal and parallel
- ii. Opposite angles are equal
- iii. Perimeter = $2(a+b)$
- iv. Area = $\frac{1}{2} \times$ product of diagonals $\times \sin Q$
- v. $(D1)^2 + (D2)^2 = 2(a^2 + b^2)$
 Where D1 = Diagonal 1 and D2 = Diagonal 2
 And a = length of one side
 b = length of other unequal side



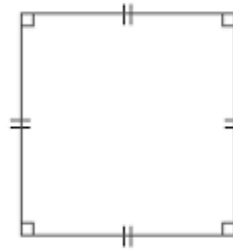
III. Rectangle

- i. Opposite sides are equal, parallel and all angles are of 90°
- ii. Perimeter = $2(l+b)$
- iii. Area = $l \times b$
- iv. Diagonal = $\sqrt{l^2 + b^2}$
- v. Diagonals are equal
 Where l = Length and b = Breadth of rectangle



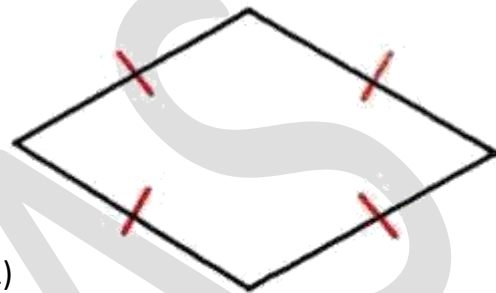
IV. Square

- i. All sides are equal
- ii. All angles are of 90°
- iii. Perimeter = $4a$
- iv. Diagonal = $\sqrt{2} a$
- v. Area = a^2



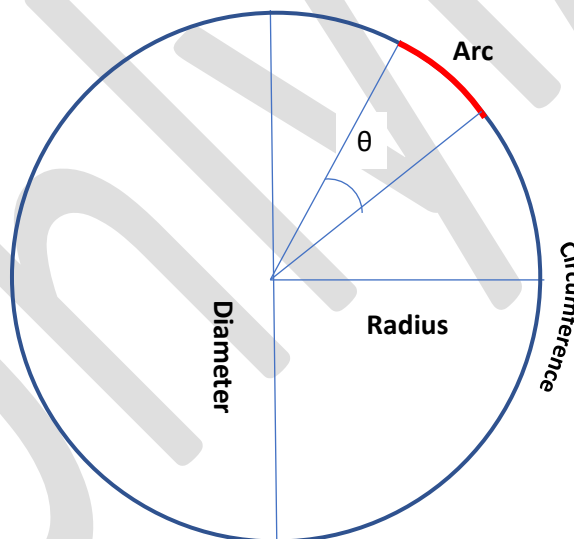
V. Rhombus

- i. All sides are equal
- ii. Opposite angles are equal
- iii. Perimeter = $4a$
- iv. Area = $\frac{1}{2} * \text{product of diagonals}$
 (As angles intersect at 90° , so $\sin Q = 1$)



Rhombus

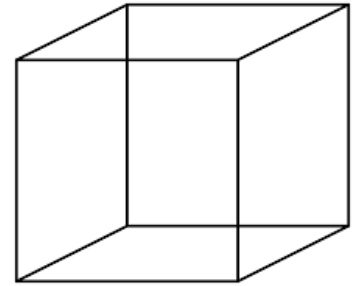
Circle



- Radius = $\frac{\text{Diameter}}{2}$
- Circumference = $2 * \pi * r$
- Area = $\pi * r^2$
- Area of Arc = $\frac{\theta}{360} * \pi * r^2$

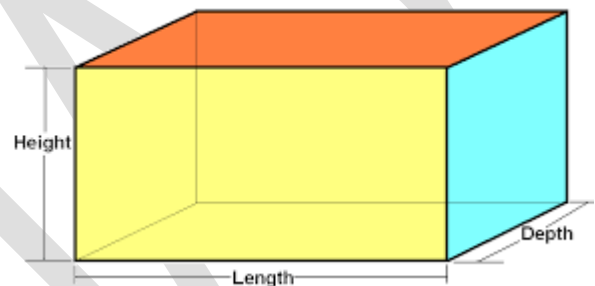
Cube

- All sides are equal with length a
- Base of Cube is a square
- Volume of cube = a^3
- Length of Diagonal = $\sqrt{3} a$
- Lateral surface area = Perimeter of base * Height = $4a^2$
- Total surface area = Lateral Surface Area + 2 Base Area = $6a^2$
- Open area = Lateral Surface Area + Base Area = $5a^2$



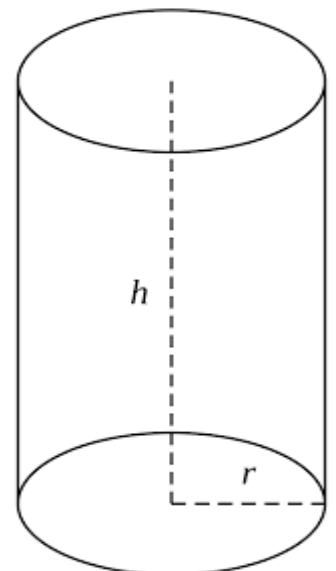
Cuboid

- Base of Cuboid is a rectangle
- Volume = Length * Breadth * Height
- Let Length = l , Breadth = b , Height = h , then
- Length of Diagonal = $\sqrt{l^2 + b^2 + h^2}$
- Lateral Surface Area = $2(l+b) * h$
- Open area = $2(l+b) * h + l * b$
- Total Surface Area = $2(l + b) * h + l * b = 2(lb + bh + lh)$



Cylinder

- Base of cylinder is a circle with radius r and having height h
- Volume = $\pi * r^2 * h$
- Curved Surface Area = $2 * \pi * r * h$
- Total Surface Area = Curved Surface Area + 2 Base area
 $= 2 * \pi * r * h + 2 * \pi * r^2$
 $= 2 * \pi * r (h + r)$



CH-26 Time and Work

- Days required to complete work = $\frac{1}{\text{Work done in 1 day}}$
- Efficiency $\propto \frac{1}{\text{Time taken}}$
- If M1 persons can do W1 work in D1 days working T1 hours each day with E1 efficiency and M2 persons can do W2 work in D2 days working T2 hours each day with E2 efficiency, then



$$\frac{M_1 D_1 T_1 E_1}{W_1} = \frac{M_2 D_2 T_2 E_2}{W_2}$$

Practice Question – UPSC 2020

Question - A person X can complete 20% of work in 8 days and another person Y can complete 25% of the same work in 6 days. If they work together, in how many days will 40% of the work be completed?

- A. 6
- B. 8
- C. 10
- D. 12

Solution –

Person X

Time taken to complete 20% work = 8 days

Time taken to complete 100 % work = 40 days

Person Y

Time taken to complete 25% work = 6 days

Time taken to complete 100 % work = 24 days

Both together

$$\text{Amount of work done in 1 day} = \frac{1}{40} + \frac{1}{24} = \frac{1}{15}$$

So, time taken to complete 100% work = 15 days

Time taken to complete 40% work = 6 days

Hence, option A is correct answer

CH-27 Trigonometry

Trigonometry Table

- $\sin \theta = \frac{P}{H}$
- $\cos \theta = \frac{B}{H}$
- $\tan \theta = \frac{P}{B}$
- $\operatorname{Cosec} \theta = \frac{H}{P}$
- $\sec \theta = \frac{H}{B}$
- $\cot \theta = \frac{B}{P}$

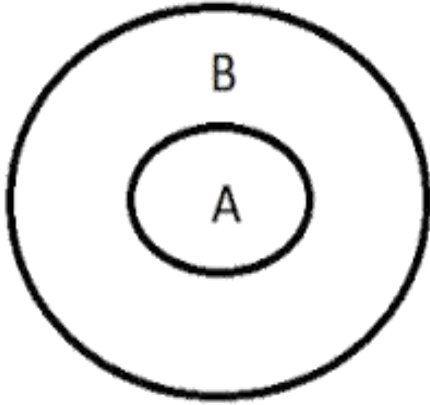
	0°	30°	45°	60°	90°
$\sin \theta$	0	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$	1
$\cos \theta$	1	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$	0
$\tan \theta$	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	Not defined
$\operatorname{cosec} \theta$	Not defined	2	$\sqrt{2}$	$\frac{2}{\sqrt{3}}$	1
$\sec \theta$	1	$\frac{2}{\sqrt{3}}$	$\sqrt{2}$	2	Not defined
$\cot \theta$	Not defined	$\sqrt{3}$	1	$\frac{1}{\sqrt{3}}$	0

Where B = Base
 P = Perpendicular
 H = Hypotenuse

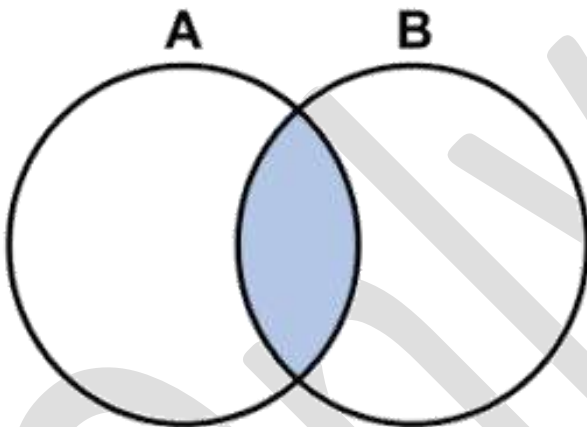
STUDENT'S NOTE

CH-28 Syllogism Diagrams

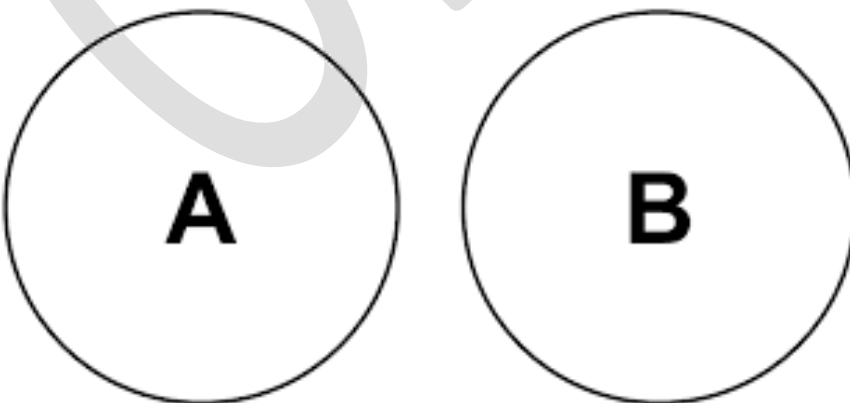
- All A are B



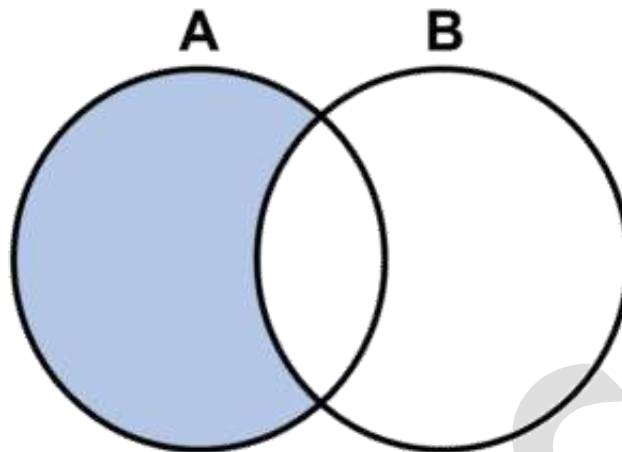
- Some A are B



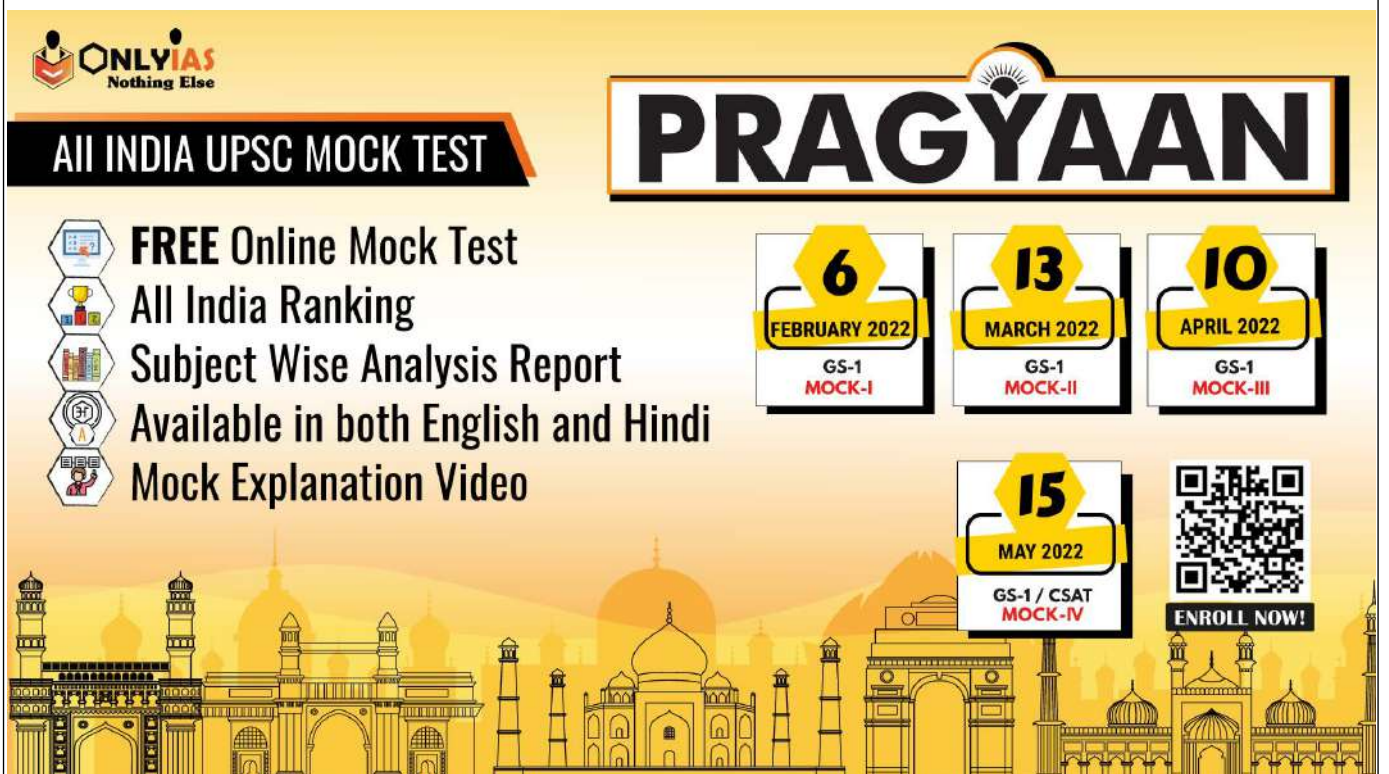
- No A are B




- Some A are not B








STUDENT'S NOTE



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CH-29 Coding Decoding

Alphabet	Code
A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	9
J	10
K	11
L	12
M	13
N	14
O	15
P	16
Q	17
R	18
S	19
T	20
U	21
V	22
W	23
X	24
Y	25
Z	26

- Trick to remember codes - EJOTY word where

E = 5

J = 10

O = 15

T = 20

Y = 25

Practice Question – UPSC 2020

Question - The letters from A to Z are numbered from 1 to 26 respectively.

If GHI = 1578 and DEF = 912, then what is ABC equal to

- A. 492
- B. 468
- C. 262
- D. 246

Solution –

As per the code of alphabets:

$$\text{GHI} = 789$$

$$\text{DEF} = 456$$

$$\text{ABC} = 123$$

As given in the question,

$$\text{GHI} = 1578 = 789 \times 2$$

$$\text{DEF} = 912 = 456 \times 2$$

$$\text{ABC} = 123 \times 2 = 246$$

Hence, option D is correct answer

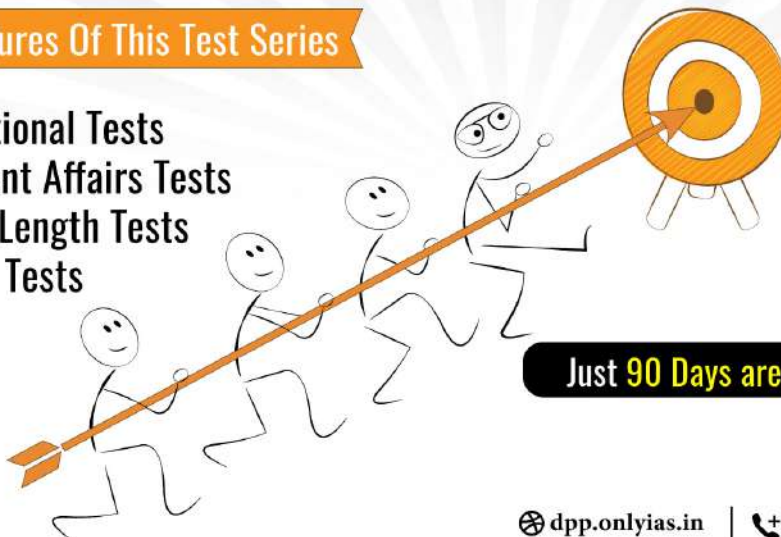
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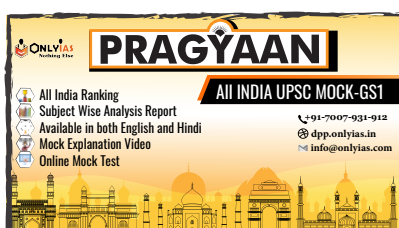
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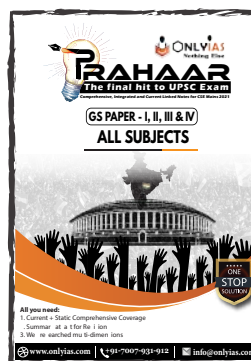
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