



JEE (MAIN) 2024

MEMORY BASED QUESTIONS & SOLUTIONS

SHIFT-2

DATE & DAY: 31st January 2024 & Wednesday

PAPER-1

Duration: 3 Hrs.

Time: 03:00 PM - 06:00 PM

SUBJECT: MATHEMATICS

ADMISSIONS OPEN FOR CLASS 12+

ACADEMIC SESSION 2024-25



TARGET: JEE (ADV.) 2024

For Class XII Passed Student

VISHESH COURSE

MODE: OFFLINE/ONLINE



CLASS STARTS
08th APRIL, 2024



TARGET: JEE (MAIN) 2024

For Class XII Passed Student

ABHYAAS COURSE

MODE: OFFLINE/ONLINE



CLASS STARTS
08th APRIL, 2024

SCHOLARSHIP ON THE BASIS OF JEE (MAIN) 2024 %ILE/AIR

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PART : MATHEMATICS

1. The number of solutions of the equation $e^{\sin x} - 2e^{-\sin x} = 2$ is
 (1) 1 (2) 0 (3) infinite (4) 2

Ans. (2)
 Sol. Let $e^{\sin x} = t$

$$\Rightarrow t - \frac{2}{t} = 2 \Rightarrow t^2 - 2t - 2 = 0$$

$$(t - 1)^2 = 3$$

$$t - 1 = \pm \sqrt{3}$$

$$t = 1 \pm \sqrt{3} \text{ but } t > 0$$

$$\text{so, } e^{\sin x} = 1 + \sqrt{3}$$

$$\text{Now, } -1 \leq \sin x \leq 1$$

$$e^{-1} \leq e^{\sin x} \leq e$$

$$e \approx 2.72 \text{ but } 1 + \sqrt{3} \approx 2.73$$

$$\Rightarrow \text{No. of solutions} = 0$$

2. If $a = \sin^{-1}(\sin 5)$ and $b = \cos^{-1}(\cos 5)$ then value of $a^2 + b^2$ is
 (1) $(2\pi - 5)^2$ (2) $(3\pi - 7)^2$ (3) $2(2\pi - 5)^2$ (4) $2(3\pi - 7)^2$

Ans. (3)
Sol. $a = \sin^{-1}(\sin 5)$, $b = \cos^{-1}(\cos 5)$
 $a = 5 - 2\pi$, $b = 2\pi - 5$
 $a^2 + b^2 = (5 - 2\pi)^2 + (2\pi - 5)^2$
 $= 2(2\pi - 5)^2$

3. If 2nd, 8th, 44th term of a non-constant arithmetic progression is same as 1st, 2nd & 3rd term of Geometric progression respectively and first term of arithmetic progression is 1, then sum of first 20 terms of that arithmetic progression is

Ans. (970)
Sol. Let common difference = d
 $t_2 = 1 + d$, $t_8 = 1 + 7d$, $t_{44} = 1 + 43d$
 but these are in G.P.
 $\Rightarrow (1 + 7d)^2 = (1 + d)(1 + 43d)$
 $\Rightarrow 6d^2 - 30d = 0 \Rightarrow d = 5 (\because d \neq 0)$
 Now, sum of first 20 terms of an AP = $\frac{20}{2} (2a + (20 - 1)d) = 10(2 + 95) = 970$

4. If $f : \mathbb{R} \rightarrow (0, \infty)$ is an increasing function such that $\lim_{x \rightarrow \infty} \frac{f(7x)}{f(x)} = 1$, then the value of $\lim_{x \rightarrow \infty} \left[\frac{f(5x)}{f(x)} - 1 \right]$ (where $[\cdot]$ denote the greatest integer function) is
 (1) 1 (2) 0 (3) 2 (4) 3

Ans. (2)
Sol. $f(x) \leq f(5x) \leq f(7x)$, $\forall x > 0$
 $1 \leq \frac{f(5x)}{f(x)} \leq \frac{f(7x)}{f(x)}$
 As $x \rightarrow \infty$ $\frac{f(5x)}{f(x)} \rightarrow 1$
 $\lim_{x \rightarrow \infty} \left[\frac{f(5x)}{f(x)} - 1 \right] = 0$

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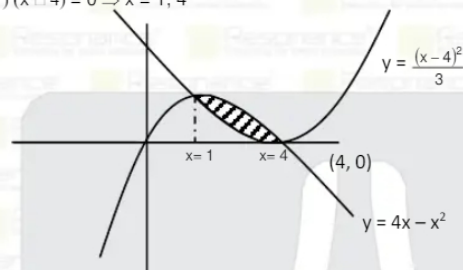
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5. The area bounded by the curves $3y = (x - 4)^2$ and $y = 4x - x^2$ is
 (1) 10 (2) 6 (3) 14 (4) 27

Ans. (2)
Sol. Solving $3y = (x - 4)^2$ and $y = 4x - x^2$
 $12x - 3x^2 = x^2 - 8x + 16$
 $\Rightarrow 4x^2 - 20x + 16 = 0$
 $(x - 1)(x - 4) = 0 \Rightarrow x = 1, 4$



$$\begin{aligned} \text{Area} &= \int_1^4 \left((4x - x^2) - \frac{(x-4)^2}{3} \right) dx \\ &= \left(2x^2 - \frac{x^3}{3} - \frac{(x-4)^3}{9} \right) \Big|_1^4 \\ &= 2(16 - 1) - \frac{1}{3}(3)(21) - \frac{1}{9}(0 + 27) \\ &= 30 - 21 - 3 = 6 \end{aligned}$$

6. The number of ways in which 21 identical apples to be distributed into 3 children in such a way that each children get at least 2 apples is

- (1) 133 (2) 134 (3) 135 (4) 136

Ans. (4)

Sol. Let 1st student get x
 2nd student get y
 3rd student get z
 $\Rightarrow x + y + z = 21, \quad x, y, z \geq 2$
 Let $x = 2 + t_1, \quad y = 2 + t_2, \quad z = 2 + t_3$
 $\Rightarrow t_1 + t_2 + t_3 = 15, \quad t_1, t_2, t_3 \geq 0$
 number of ways = ${}^{17}C_2 = \frac{17 \times 16}{2} = 17 \times 8 = 136$

7. If $z_1 + z_2 = 5$ & $z_1^3 + z_2^3 = 20 + 15i$ then $|z_1^4 + z_2^4|$ is equal to

Ans. (75)

Sol. $z_1^3 + z_2^3 = (z_1 + z_2)(z_1^2 + z_2^2 - 3z_1z_2) \Rightarrow 20 + 15i = 5(25 - 3z_1z_2) \Rightarrow z_1z_2 = 7 - i$
 Now $z_1^2 + z_2^2 + 2z_1z_2 = 25 \Rightarrow z_1^2 + z_2^2 = 25 - 2(7 - i) \Rightarrow z_1^2 + z_2^2 = 11 + 2i$
 Now $z_1^4 + z_2^4 + 2(7 - i)^2 = 121 - 4 + 44i \Rightarrow z_1^4 + z_2^4 = 21 + 72i$
 So $|z_1^4 + z_2^4| = \sqrt{441 + (72)^2} = \sqrt{5625} = 75$

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8. If A is a matrix of order 3×3 and $\det A = 2$ and $n = \det (\text{adj}(\text{adj}(\dots(\text{adj}A)))$, the remainder when n is divided by 9, is

- (1) 2 (2) 4 (3) 6 (4) 7

Ans. (4)

Sol. $|\text{adj}A| = |A|^2$
 $|\text{adj}(\text{adj}(\dots(\text{adj}A))) = |A|^{2^{2^{2^{\dots}}}} = 2^{2^{2^{2^{\dots}}}}$ (1)
 $\therefore 2^{2^{2^k}} = 4^{1012} = (3+1)^{1012} = 3k+1$, where k is odd
 $\Rightarrow |\text{adj}(\text{adj}(\dots(\text{adj}A))) = 2^{3k+1} = 2 \cdot 8^k$
 $= 2(9-1)^k = 9m-2$
 $\Rightarrow = 9P+7$
 Remainder = 7

9. A biased coin in which probability of getting head is twice to that of tail. If coin is tossed 3 times then the probability of getting two tails and one head is

- (1) 1/9 (2) 2/9 (3) 2/27 (4) 1/27

Ans. (2)

Sol. $P(H) = p \quad P(T) = q \quad \Rightarrow p = 2q \quad \text{and}$
 $p + q = 1 \Rightarrow q = 1/3 \quad \Rightarrow p = 2/3$
 $P(2T, 1H) = {}^3C_2 q^2 p$
 $= {}^3C_2 \cdot \frac{1}{9} \cdot \frac{2}{3} = \frac{2}{9}$

10. The value of $\frac{120}{\pi^3} \int_0^{\pi/2} \frac{x^2 \sin x \cos x}{\sin^4 x + \cos^4 x} dx$ is

Ans. (15)

Sol. Let $I = \int_0^{\pi/2} \frac{x^2 \sin x \cos x}{\sin^4 x + \cos^4 x} dx$ (1)
 $I = \int_0^{\pi/2} \frac{(\pi-x)^2 \sin x \cos x}{\sin^4 x + \cos^4 x} dx$, by king property(2)
 adding equation (1) and (2)
 $2I = \int_0^{\pi/2} \frac{\pi(2x-\pi) \sin x \cos x}{\sin^4 x + \cos^4 x} dx$
 $I = \pi \int_0^{\pi/2} \frac{(2x-\pi) \sin x \cos x}{\sin^4 x + \cos^4 x} dx$ (3)
 $I = \pi \int_0^{\pi/2} \frac{-2x \sin x \cos x}{\sin^4 x + \cos^4 x} dx$ (4)

adding equation (3) and (4)

$$2I = -\pi^2 \int_0^{\pi/2} \frac{\sin x \cos x}{\sin^4 x + \cos^4 x} dx$$

$$I = -\frac{\pi^2}{2 \times 2} \int_0^{\pi/2} \frac{2 \sin x \cos x dx}{\sin^4 x + \cos^4 x}$$

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$$I = -\frac{\pi^2}{4} \int_0^{\pi/2} \frac{2 \tan x \sec^2 x}{\tan^4 x + 1} dx$$

$$I = -\frac{\pi^2}{2 \times 2} \tan^{-1}(\tan^2 x) \Big|_0^{\pi/2}$$

$$I = -\frac{\pi^3}{8}$$

$$\text{Now } \frac{120}{\pi^3} \int_0^{\pi/2} \frac{x^2 \sin x \cos x}{\sin^4 x + \cos^4 x} dx$$

$$= \frac{120}{\pi^3} \times \left(\frac{\pi^3}{8} \right) = 15$$

11. If the mean and variance of 6 observations a, b, 68, 44, 48, 60 are 55 and 194 respectively and a > b then a + 3b is

(1) 190 (2) 180 (3) 200 (4) 210

Ans. (2)

$$\text{Sol. Mean} = \frac{a+b+68+44+48+60}{6} = 55 \Rightarrow a+b = 110 \quad \dots\dots (1)$$

$$\text{Variance} = \frac{\sum (x_i - \bar{x})^2}{n} = \frac{(55-a)^2 + (55-b)^2 + (13)^2 + (11)^2 + 7^2 + 5^2}{6} = 194$$

$$\Rightarrow a^2 + b^2 - 110(a+b) = -5250 \Rightarrow a^2 + b^2 = 6850. \quad \dots\dots (2)$$

after solving equation (1) and (2), we get a = 75 & b = 35 $\Rightarrow a + 3b = 75 + 105 = 180$

12. If $\lim_{x \rightarrow 0} \frac{ax^2 e^x - b \log_e(1+x) + cx e^{-x}}{x^2 \sin x} = 1$ then the value of $16(a^2 + b^2 + c^2)$ is

Ans. (81)

$$\text{Sol. } \lim_{x \rightarrow 0} \frac{ax^2 \left(1+x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \right) - b \left(x - \frac{x^2}{2} + \frac{x^3}{3} - \dots \right) + cx \left(1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots \right)}{x^3 \left(\frac{\sin x}{x} \right)} = 1$$

$$\Rightarrow \lim_{x \rightarrow 0} \frac{(c-b)x + \left(\frac{b}{2} - c + a \right) x^2 + \left(a - \frac{b}{3} + \frac{c}{2} \right) x^3 \dots}{x^3} = 1$$

$$\Rightarrow c - b = 0, \quad \frac{b}{2} - c + a = 0$$

$$\text{and } a - \frac{b}{3} + \frac{c}{2} = 1$$

$$a = \frac{3}{4}, \quad b = c = \frac{3}{2}$$

$$a^2 + b^2 + c^2 = \left(\frac{9}{16} + \frac{9}{4} + \frac{9}{4} \right)$$

$$16(a^2 + b^2 + c^2) = 9 + 36 + 36 = 81$$

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13. A line of negative slope passing through the centre of circle $x^2 + y^2 - 16x - 4y = 0$ intersects +ve x and y-axis at A and B respectively then the minimum value of OA + OB (O is origin) is

Ans. (18)

Sol. Let slope of line is -m

$$\therefore \text{Equation of straight line } (y - 2) = -m(x - 8) \Rightarrow mx + y = 8m + 2$$

$$A = \left(8 + \frac{2}{m}, 0\right) \quad B = (0, 2 + 8m)$$

$$OA + OB = 10 + \frac{2}{m} + 8m \geq 18$$

$$(OA + OB)_{\min} = 18$$

14. If reflection of A(1, -10, 1) about the line $\frac{x-1}{2} = \frac{y-1}{3} = \frac{z-2}{5}$ is (α, β, γ) then the value of

$$|2\alpha + 3\beta + 5\gamma| \text{ is.}$$

Ans. (23)

Sol.

A (1, -10, 1)

B $(2\lambda+1, 3\lambda+1, 5\lambda+2)$

Let co-ordinate of foot is

$B(2\lambda + 1, 3\lambda + 1, 5\lambda + 2)$

Direction ratio of AB is $2\lambda, 3\lambda + 11, 5\lambda + 1$

AB is perpendicular to the given line so $2\lambda(2) + (3\lambda+11)3 + (5\lambda+1)5 = 0 \Rightarrow \lambda = -1$

So, foot is B(-1, -2, -3)

Now image of A (1, -10, 1) about the line $\frac{x-1}{2} = \frac{y-1}{3} = \frac{z-2}{5}$ is (α, β, γ)

$$\text{so, } \frac{\alpha+1}{2} = -1, \frac{\beta-10}{2} = -2, \frac{\gamma+1}{2} = -3 \Rightarrow \alpha = -3, \beta = 6, \gamma = -7$$

$$\Rightarrow |2\alpha + 3\beta + 5\gamma| = |-6 + 18 - 35| = 23$$

15. If ${}^6C_m + 2({}^6C_{m+1}) + {}^6C_{m+2} = {}^8C_3$ (where $m \neq 1$) & $\frac{{}^{n-1}P_3}{{}^n P_4} = \frac{1}{8}$, then value of ${}^{n+1}C_m + {}^n P_m$ is

Ans. (420)

Sol. ${}^6C_m + {}^6C_{m+1} + {}^6C_{m+2} = {}^8C_3$

$$\Rightarrow {}^7C_{m+1} + {}^7C_{m+2} = {}^8C_3$$

$$\Rightarrow {}^8C_{m+2} = {}^8C_3 = {}^8C_5$$

$$\Rightarrow m + 2 = 5 (\because m \neq 1)$$

$$\Rightarrow m = 3$$

$$\frac{{}^{(n-1)}P_3}{{}^n P_4} = \frac{1}{8} \Rightarrow \frac{1}{n} = \frac{1}{8} \Rightarrow n = 8$$

$$\text{Now } {}^{n+1}C_m + {}^n P_m = {}^9C_3 + {}^8P_3 = 84 + 336 = 420$$

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16. If $\frac{dT}{dt} = -k(T - 85)$ and $T = 160$ at $t = 0$ then the value of T at $t = 45$, is

$$(1) 85 + 75 e^{45k} \quad (2) 85 + 75 e^{-45k} \quad (3) 75 + 85 e^{45k} \quad (4) 75 + 85 e^{-45k}$$

Ans. (2)

Sol. $\int \frac{dt}{T - 85} = -\int k dt$

$$\ln|T - 85| = -kt + c$$

$$\text{at } t = 0, T = 160$$

$$\ln 75 = c$$

$$\therefore |T - 85| = \dots$$

$$\ln \left| \frac{T-85}{75} \right| = -kt$$

$$\frac{T-85}{75} = +e^{-kt} \quad (\text{--rejected because } T = 160 \text{ at } t = 0)$$

$$T = 85 + 75e^{-kt}$$

$$\text{at } t = 45, T = 85 + 75e^{-45k}$$

17. If $f(x) = e^{-|\ln x|}$; $x \in (0, \infty)$ is discontinuous at m points and non-differentiable at n points then the value of $m + n$ is

Ans. (1)

Sol. Since $|\ln x|$ is continuous in $(0, \infty)$
 $\Rightarrow f(x) = e^{-|\ln x|}$ is continuous in $(0, \infty)$
 \Rightarrow So number of points where $f(x)$ is discontinuous, $m = 0$

$$f(x) = \begin{cases} e^{\ln x} & ; 0 < x < 1 \\ e^{-\ln x} & ; x \geq 1 \end{cases}$$

$f(1^-) = 1, f(1^+) = -1 \Rightarrow$ So number of points where $f(x)$ is non-differentiable, $n = 1$
 $m + n = 0 + 1 = 1$

18. A is a square matrix of order 3 and v_1, v_2, v_3 are 3 column matrices such that

$$Av_1 = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}, Av_2 = \begin{bmatrix} -1 \\ 0 \\ 2 \end{bmatrix}, Av_3 = \begin{bmatrix} 0 \\ -1 \\ 2 \end{bmatrix} \text{ where } v_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}, v_2 = \begin{bmatrix} 2 \\ 0 \\ 3 \end{bmatrix}, v_3 = \begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix} \text{ then the value of } |A| \text{ is}$$

- (1) 9 (2) $\frac{9}{2}$ (3) $\frac{9}{4}$ (4) $\frac{9}{8}$

Ans. (3)

Sol. $A \begin{bmatrix} 1 & 2 & 1 \\ 1 & 0 & 1 \\ 1 & 3 & -1 \end{bmatrix} = \begin{bmatrix} 1 & -1 & 0 \\ 2 & 0 & -1 \\ 3 & 2 & 2 \end{bmatrix}$

$$|A| \begin{vmatrix} 1 & 2 & 1 \\ 1 & 0 & 1 \\ 1 & 3 & -1 \end{vmatrix} = \begin{vmatrix} 1 & -1 & 0 \\ 2 & 0 & -1 \\ 3 & 2 & 2 \end{vmatrix} \Rightarrow |A| = \frac{9}{4}$$

19. An ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ ($a > b$) whose eccentricity is $\frac{1}{\sqrt{2}}$ and passes through the focus of the parabola whose vertex is $(2,3)$ and directrix is $2x + y - 6 = 0$ then the length of the latus rectum of ellipse is

- (1) $\sqrt{656}$ (2) $\frac{\sqrt{656}}{5}$ (3) $\frac{\sqrt{656}}{10}$ (4) $\frac{\sqrt{656}}{2}$

Ans. (2)

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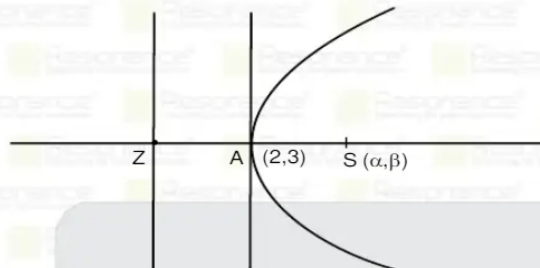
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Sol. Let foot of perpendicular from vertex of parabola on the directrix is point Z



So, coordinate of Z is

$$\frac{x-2}{2} = \frac{y-3}{1} = \frac{-(4+3)-6}{4+1} \Rightarrow z = \left(\frac{8}{5}, \frac{14}{5} \right)$$

$$\Rightarrow \text{focus } S = \left(\frac{12}{5}, \frac{16}{5} \right)$$

$$\text{Now eccentricity equal to } \frac{1}{\sqrt{2}} \Rightarrow b^2 = \frac{a^2}{2}$$

$$\therefore \frac{144}{25a^2} + \frac{256}{25 \times \frac{a^2}{2}} = 1$$

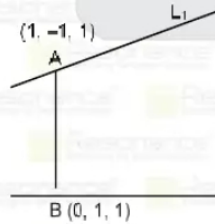
$$a^2 = \frac{656}{25}, b^2 = \frac{328}{25}$$

$$\text{Now length of latus rectum} = \frac{2b^2}{a} = \frac{\sqrt{656}}{5}$$

20. The shortest distance between the line $L_1 = (\hat{i} - \hat{j} + \hat{k}) + \lambda(2\hat{i} - 14\hat{j} + 5\hat{k})$ and $L_2 = (\hat{j} + \hat{k}) + \mu(-2\hat{i} - 4\hat{j} + 7\hat{k})$ then L_1 and L_2 is

- (1) $\frac{5}{\sqrt{221}}$ (2) $\frac{10}{\sqrt{221}}$ (3) $\frac{2}{\sqrt{221}}$ (4) $\frac{5}{11}$

Ans. (1)
Sol.



Let $\vec{p} = 2\hat{i} - 14\hat{j} + 5\hat{k}$
and $\vec{q} = -2\hat{i} - 4\hat{j} + 7\hat{k}$

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$$\vec{p} \times \vec{q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -14 & 5 \\ -2 & -4 & 7 \end{vmatrix}$$

$$= \hat{i}(-98 + 20) - \hat{j}(14 + 10) + \hat{k}(-8 - 28)$$

$$= -78\hat{i} - 24\hat{j} - 36\hat{k}$$

$$\vec{AB} = -\hat{i} + 2\hat{j}$$

$$\text{S.D.} = \frac{|\vec{AB} \cdot (\vec{p} \times \vec{q})|}{|\vec{p} \times \vec{q}|} = \frac{|78 - 48|}{\sqrt{(78)^2 + (24)^2 + (36)^2}} = \frac{30}{\sqrt{7956}}$$

$$= \frac{30}{6\sqrt{221}} = \frac{5}{\sqrt{221}}$$

21. If $F : (-\infty, -1] \rightarrow (a, b]$ is defined as $f(x) = e^{x^3 - 3x + 1}$ such that F is both one-one and onto then the distance from a point $P(2a + 4, b + 2)$ to curve $x + ye^{-3} - 4 = 0$ is

- (1) $\sqrt{e^3 + 2}$ (2) $\frac{e^3 + 2}{\sqrt{e^3 + 1}}$ (3) $\frac{e^3 + 2}{\sqrt{e^6 + 1}}$ (4) e

Ans. (3)

Sol. $f(x) = e^{(x^3 - 3x + 1)} \cdot 3(x - 1)(x + 1)$

$$a = \lim_{x \rightarrow -2} e^{x^3 - 3x + 1} = 0$$

$$b = f(-1) = e^{-1 + 3 + 1} = e^3$$

$$P(2a + 4, b + 2) = (4, 2 + e^3)$$

$$\text{Distance} = \frac{|4 + (2 + e^3)e^{-3} - 4|}{\sqrt{1 + e^{-6}}} = \frac{e^3 + 2}{\sqrt{1 + e^6}}$$

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PERCENTILE BOOSTER COURSE

COURSE COMMENCEMENT: 5th FEBRUARY 2024

TARGET **JEE (Main) 2024**
April Attempt

MODE:
OFFLINE/
ONLINE

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TARGET: JEE (MAIN) 2024

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