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JEE (MAIN) 2024

MEMORY BASED QUESTIONS & SOLUTIONS

SHIFT-2

DATE & DAY: 30th January 2024 & Tuesday

PAPER-1

Duration: 3 Hrs.
Time: 03:00 PM - 06:00 PM

SUBJECT: MATHEMATICS

REGISTERED & CORPORATE OFFICE (CIN: U80302RJ2007PLC024029):
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PART : MATHEMATICS

1. Let S_K denotes sum of first k terms of sequence 3, 7, 11, 15, ... Value of n, if

$$40 < \frac{6}{n(n+1)} \sum_{k=1}^{n} S_k < 42 \text{ , is } \_\_\_\_\_$$

Ans. **(9)**

Sol. $S_K = 3 + 7 + 11 + \ldots\ldots$ up to k terms

$= \frac{k}{2}[6+(k-1)4] = k(2k+1)$

$\sum_{k=1}^{n}(2k^2+k) = \frac{2n(n+1)(2n+1)}{6} + \frac{n(n+1)}{2}$

$40 < 2(2n+1) + 3 < 42$

$35 < 4n < 37$

$8.75 < n < 9.25$

$n = 9$

2. Let $f(x) = \frac{x}{\left(1+x^4\right)^{\frac{1}{4}}}$ & $g(x) = f(f(f(f(x))))$ then $\int_0^{\sqrt{2\sqrt{5}}} x^2 g(x)dx$ is

(1) $\frac{13}{6}$ (2) $\frac{6}{13}$ (3) $\frac{2}{5}$ (4) $\frac{7}{2}$

Ans. **(1)**

Sol. $\frac{\frac{x}{\left(1+x^4\right)^{\frac{1}{4}}}}{\left(1+\frac{x^4}{1+x^4}\right)^{\frac{1}{4}}} = \frac{x}{\left(1+2x^4\right)^{\frac{1}{4}}}$

So $f(f(f(f(x)))) = \frac{x}{\left(1+4x^4\right)^{\frac{1}{4}}} = g(x)$

$\int_0^{\sqrt{2\sqrt{5}}} x^2 g(x)dx = \int_0^{\sqrt{2\sqrt{5}}} \frac{x^3}{\left(1+4x^4\right)^{\frac{1}{4}}}dx$

$\int_1^3 \frac{\frac{1}{4}t^3dt}{t} = \frac{1}{4}\int_1^3 t^2dt = \frac{1}{12}(27-1) = \frac{26}{12} = \frac{13}{6}$

$1+4x^4 = t^4$

$16x^3dx = 4t^3dt$

$x^3dx = \frac{1}{4}t^3dt$

3. $\bar{a}.\bar{b} = 3\sqrt{2}$ & $|\bar{b}|^2 = 6$ such that $\bar{a} = \hat{i} + \alpha\hat{j} + \beta\hat{k}$. If angle between $\bar{a}$ & $\bar{b}$ is $\frac{\pi}{4}$ then value of $(\alpha^2+\beta^2)|\bar{a}\times\bar{b}|^2$ is _____.

Ans. **(90)**

Sol. $\bar{a}.\bar{b} = 3\sqrt{2}$

$|\bar{a}||\bar{b}|\cos\frac{\pi}{4} = 3\sqrt{2}$

$|\bar{a}|\sqrt{6}.\frac{1}{\sqrt{2}} = 3\sqrt{2}$

$|\bar{a}| = \sqrt{6} = \sqrt{1+\alpha^2+\beta^2}$

$\alpha^2 + \beta^2 = 5$

$|\bar{a}\times\bar{b}|^2 = |\bar{a}|^2|\bar{b}|^2\sin^2\frac{\pi}{4} = 6\times6\times\frac{1}{2} = 18$

So $(\alpha^2+\beta^2)|\bar{a}\times\bar{b}|^2 = 5 \times 18 = 90$

4. $R = \begin{bmatrix} x & 0 & 0 \\ 0 & y & 0 \\ 0 & 0 & z \end{bmatrix}$, $x\sin\theta = y\sin\left(0+\frac{2\pi}{3}\right) = z\sin\left(0+\frac{4\pi}{3}\right) \neq 0$

Statement – 1 : Trace (R) = 0

Statement – 2 : Trace (adj(adj (R)) = 0

(1) Statement –1 is true and statement – 2 is false (2) Statement –1 is false and statement – 2 is false

(3) Statement –1 is false and statement – 2 is true (4) Statement –1 is true and statement – 2 is true

Ans. **(2)**

Sol. $y=\frac{x\sin\theta}{\sin\left(\theta+\frac{2\pi}{3}\right)}$, $z=\frac{x\sin\theta}{\sin\left(\theta+\frac{4\pi}{3}\right)}$

$$x+y+z=\frac{-3x}{4\sin\left(\theta+\frac{2\pi}{3}\right)\sin\left(\theta+\frac{4\pi}{3}\right)}\neq 0$$

$\Rightarrow$ Statement–1 is wrong

$$R=\begin{bmatrix}x&0&0\\0&y&0\\0&0&z\end{bmatrix},\ \text{adj } R=\begin{bmatrix}yz&0&0\\0&xz&0\\0&0&xy\end{bmatrix}$$

$$\text{adj(adj,R)}=\begin{bmatrix}x^2yz&0&0\\0&y^2xz&0\\0&0&z^2xy\end{bmatrix}\Rightarrow \text{Tr (adj (adj R) = } xyz(x+y+z)\neq 0$$

5. If $|\vec{a}\times\vec{b}|=2$, and $|\vec{a}|=1$, then $\left|(\vec{a}\times\vec{b})-\vec{a}\right|^2$ is

Ans. **(5)**

Sol. $|\vec{a}\times\vec{b}|=2$ and $|\vec{a}|=1=\left|(\vec{a}\times\vec{b})-\vec{a}\right|^2=|\vec{a}\times\vec{b}|^2+|\vec{a}|^2-2\vec{a}.(\vec{a}\times\vec{b})=(2)^2+1-0=5$

6. If 11^{th} term of G.P., whose 1^{st} term is 'a' and 3^{rd} term is 'b', is equal to p^{th} term of G.P. whose first term is 'a' and 5^{th} term is 'b', then value of p is

Ans. **(21)**

Sol. $(T_1=a,\ T_3=ar_1^2=b\Rightarrow r_1^2=b/a)$ and $(T_1=a,\ T_5=ar_2^4=b$

11^{th} term of first GP = p^{th} term of second G.P.

$a(r_1)^{10}=a(r_2)^{p-1}$

$$\left(\left(\frac{b}{a}\right)^{1/2}\right)^{10}=\left(\left(\frac{b}{a}\right)^{1/4}\right)^{p-1}\Rightarrow 5=\frac{p-1}{4}\Rightarrow p=21$$

7. Let $f(x)=\begin{cases}x^2+3x+a; & x\le 1\\ bx+2; & x>1\end{cases}$ is differentiable everywhere. The value of $\int_{-2}^{2}f(x)dx$ is

(1) $\frac{37}{2}$ (2) $\frac{36}{2}$ (3) $\frac{37}{4}$ (4) $\frac{36}{4}$

Ans. **(1)**

Sol. f(x) is continuous at x = 1

$f(1^-)=f(1)=f(1^{+1})$

$a+4=b+2\Rightarrow b=a+2$

f(x) is differential at x = 1

$f'(1^-)=f'(1^+)$

$5=b\Rightarrow a=3$

Now $\int_{-2}^{2}f(x)dx=\int_{-2}^{1}(x^2+3x+3)dx+\int_{1}^{2}(5x+2)dx$

$$=\left(\frac{x^3}{3}+\frac{3x^2}{2}+3x\right)_{-2}^{1}+\left(\frac{5x^2}{2}+2x\right)_{1}^{2}=\left(\frac{1}{3}(1+8)+\frac{3}{2}(1-4)+9\right)+\frac{5}{2}(4-1)+2$$

$$=3-\frac{9}{2}+9+\frac{15}{2}+2=14+\frac{9}{2}=\frac{37}{2}$$

8. Bag A contains 3 white & 7 red balls and bag B contains 2 white & 3 Red balls. If a ball is picked up randomly then what is the probability that the ball picked is white from bag A

(1) $\frac{3}{20}$ (2) $\frac{2}{20}$ (3) $\frac{3}{10}$ (4) $\frac{4}{20}$

Ans. **(1)**

Sol. Let A is event that bag A is selected

B is event that red bag B is selected

W is event that white ball is drawn

W is event that white ball is drawn

$P(A) = P(B) = \frac{1}{2}$

$P(A \cap W) = P(A)P\left(\frac{W}{a}\right)\left(\frac{W}{a}\right) = \frac{1}{2}\cdot\frac{3}{10} = \frac{3}{20}$

9. f(x) is double differentiable function. Tangent at (1, f(1)) and (3,(f(3)) cuts positive x-axis at an angle $\frac{\pi}{6}$ and $\frac{\pi}{4}$ then value of $\int_1^3 \left((f'(x))^2+1\right)f''(x)dx$ is:

(1) $\frac{4}{3}-\frac{10}{9\sqrt{3}}$ (2) $\frac{3}{4}-\frac{10}{9\sqrt{3}}$ (3) $\frac{4}{3}-\frac{10}{\sqrt{3}}$ (4) $\frac{4}{3}-\frac{1}{9\sqrt{3}}$

Ans. **(1)**

Sol. $f'(1) = \tan\frac{\pi}{6} = \frac{1}{\sqrt{3}}, f'(3) = 1$

$I = \int_1^3 \left((f'(x))^2+1\right)f''(x)dx$

Let $f'(x) = t$

$f''(x)\,dx = dt$

$I = \int_{\frac{1}{\sqrt{3}}}^{1}\left(t^2+1\right)dt = \left(\frac{t^3}{3}+t\right)_{\frac{1}{\sqrt{3}}}^{1} = \frac{4}{3}-\frac{10}{9\sqrt{3}}$

10. Area bounded by $(y-2)^2 = x-1$, $x - 2y + 4 = 0$ and positive coordinate axes, is

Ans. **(5)**

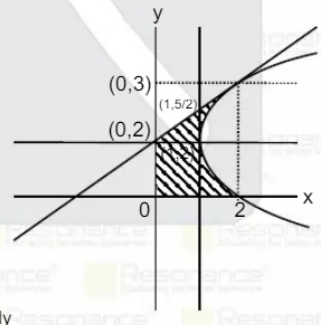
Sol. Solving $y-2 = \frac{x}{2}$ and $(y-2)^2 = x-1$

$x^2 = 4x - 4$

$(x-2)^2 = 0$

$x = 2$

$y = 3$



Area $= \int_0^3 (x_P - x_L)dy$

$= \int_0^3 \left((y-2)^2+1-2y+4\right)dy = \int_0^3 \left(y^2-6y+9\right)dy = \int_0^3 (y-3)^2 dy$

$\left(\frac{(y-3)^3}{3}\right)_0^3 = 0+\frac{27}{3} = 9$

required area $= 9 - \frac{1}{2}\times 4\times 2 = 5$

11. Let $f(x) = ae^{2x} + be^x + cx$, where $f(0) = -1$, $f'(\log_e 2) = 21$ and $\int_0^{\log_e 4} (f(x) - cx)dx = \frac{39}{2}$ then the value of $|a + b + c|$ is _____.

Ans. **(8)**

Sol. $f(0) = a + b = -1$ _____(1)

$f'(x) = 2ae^{2x} + be^x + c$

$f'(\log_e 2) = 8a + 2b + c = 21$ _____(2)

$$\int_0^{\log_e 4} (f(x) - cx)dx = \int_0^{\log_e 4} (ae^{2x} + be^x)dx$$

$$= \frac{a}{2}(16 - 1) + b(4 - 1)$$

$$= \frac{15a}{2} + 3b = \frac{39}{2} \quad \text{_____(3)}$$

$$\Rightarrow \frac{9a}{2} + 3(a + b) = \frac{39}{2} \Rightarrow \frac{9a}{2} = \frac{45}{2} \Rightarrow a = 5$$

From (2) $b = -6$ also $c = -7$

$|a + b + c| = |5 - 6 - 7| = 8$

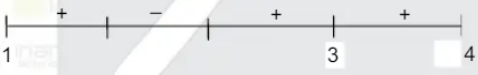
12. If $f(x) = (x - 2)^2 (x - 3)^3$ for $x \in [1, 4]$. If M and m denote maximum and minimum values respectively then M–m is

Ans. **(12)**

Sol. $f'(x) = 2(x - 2)(x - 3)^3 + 3(x - 2)^2 (x - 3)^2$

$= (x - 2)(x - 3)^2 (2x - 6 + 3x - 6)$

$= (5x - 12)(x - 2)(x - 3)^2$



Min max min max

Local max at $x = 2$ and $x = 4$

Local min at $x = \frac{12}{5}$ and $x = 1$

$f(1) = 1 \times (-8) = -8$

$$\begin{bmatrix} f(2) = 0 \\ f\left(\frac{12}{5}\right) = \frac{-12}{125} \\ f(4) = 4 \times 1 = 4 \end{bmatrix}$$

$M = 4$

$m = -8$

$M - m = 4 - (-8) = 12$

13. A question paper has three sections A,B, C having 8, 6, 4 questions respectively. If the student has to answer 15 questions attempting atleast four from each section. Find the number of ways the paper can be answered by student.

(1) 342 (2) 344 (3) 374 (4) 340

Ans. **(2)**

Sol.

8	**6**	**4**
A	B	C
7	4	$4 \rightarrow {}^8C_7 \times {}^6C_4 \times {}^4C_4$
6	5	$4 \rightarrow {}^8C_6 \times {}^6C_5 \times {}^4C_4$

5 6 4 $\rightarrow {}^8C_5 \times {}^6C_6 \times {}^4C_4$

An adding all cases we get

$({}^8C_7 \times {}^6C_4 \times {}^4C_4) + ({}^8C_6 \times {}^6C_5 \times {}^4C_4) + ({}^8C_5 \times {}^6C_6 \times {}^4C_4)$

$= \left(8 \times \frac{6 \times 5}{2} \times 1\right) + \left(\frac{8 \times 7}{2} \times 6 \times 1\right) + \left(\frac{8 \times 7 \times 6}{3 \times 2}\right)$

= 120 + 168 + 56 = 344

14. Consider the system of equations

$x + y + z = 5$

$x + 2y + \lambda^2 z = 9$

$x + 3y + \lambda z = \mu$

(1) system has unique solution for $\lambda = 1, \mu \neq 13$

(2) system has infinite solution for $\lambda = 1, \mu = 13$

(3) system is inconsistent for $\lambda = 1, \mu \in R$

(4) system has infinite solution for $\lambda = 1, \mu \neq 13$

Ans. **(2)**

Sol. $x + y + z = 5$ .....(1)

$x + 2y + \lambda^2 z = 9$ .....(2)

$x + 3y + \lambda z = \mu$ .....(3)

from (1) + (3) – 2(2)

$z(\lambda + 1 - 2\lambda^2) = (\mu - 13)$

for infinite solution $\lambda = -1/2, 1$ and $\mu = 13$

15. Let $\alpha, \beta \in \left(0, \frac{\pi}{2}\right)$, $3\sin(\alpha + \beta) = 2\sin(\alpha - \beta)$ and $\tan\alpha = k \tan\beta$ then the value of k is

(1) – 5 (2) 5 (3) 3 (4) – 3

Ans. **(1)**

Sol. $3\sin(\alpha+\beta) = 2\sin(\alpha-\beta)$

$$\frac{\sin(\alpha+\beta)}{\sin(\alpha-\beta)} = \frac{2}{3}$$

$$\frac{\sin(\alpha+\beta)+\sin(\alpha-\beta)}{\sin(\alpha+\beta)-\sin(\alpha-\beta)} = \frac{5}{-1}$$

$$\frac{2\sin\alpha\cos\beta}{2\cos\alpha\sin\beta} = \frac{5}{-1}$$

$$\frac{\tan\alpha}{\tan\beta} = -5$$

$k = -5$

16. $L_1 \equiv \hat{i} - \hat{j} + 2\hat{k} + \lambda(\hat{i} - \hat{j} + 2\hat{k}) \quad \lambda \in R$

$L_2 \equiv \hat{j} - \hat{k} + \mu(3\hat{i} + \hat{j} + p\hat{k})$

$L_3 \equiv s(l\hat{i} + m\hat{j} + n\hat{k})$

L_1 is perpendicular to L_2

L_3 is perpendicular to L_1 & L_2

then (ℓ, m, n) can be

(1) (–1, 7, 4) (2) (4, –1, 7) (3) (7, 4, –1) (4) (7, –1, 4)

Ans. **(1)**

Sol. Since L_1 is perpendicular to L_2

$\Rightarrow (\hat{i} - \hat{j} + 2\hat{k}).(3\hat{i} + \hat{j} + p\hat{k}) = 0$

$3 - 1 + 2p = 0 \Rightarrow p = -1$

$L_3 \perp L_1$ & L_2

$\Rightarrow L_3$ is parallel to $(\hat{i} - \hat{j} + 2\hat{k}) \times (3\hat{i} + \hat{j} + p\hat{k})$

$$(\hat{i} - \hat{j} + 2\hat{k}) \times (3\hat{i} + \hat{j} + p\hat{k}) = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 2 \\ 3 & 1 & -1 \end{vmatrix} = -\hat{i} + 7\hat{j} + 4\hat{k}$$

$\ell = -1$, m = 7, n = 4

17. If A = {1, 2,3,4} then find number of symmetric relation on A which is not reflexive is

Ans. **(960)**

Sol. If set A has n elements then number of symmetric relation = $2^{\frac{n^2+n}{2}} = 2^{10} (\because n = 4)$

number of reflexive and symmetric relation = $2^{\frac{n^2-n}{2}} = 2^6$ $(\because n = 4)$

number of relation which is symmetric but not reflexive = $2^{10} - 2^6 = 960$

18. Find number of common roots of the equations $Z^{1901} + Z^{100} + 1 = 0$ and $Z^3 + 2Z^2 + 2Z + 1 = 0$

(1) 2 (2) 3 (3) 4 (4) 6

Ans. **(1)**

Sol. $Z^3 + 2Z^2 + 2Z + 1 = 0$

$(Z+1)(Z^2 - Z + 1) + 2Z(Z+1) = 0$

$(Z+1)(Z^2 + Z + 1) = 0$

$\Rightarrow Z = -1, \quad Z = \omega, \ \omega^2$

$Z = -1$ does not satisfy $Z^{1901} + Z^{100} + 1 = 0$

If $Z = \omega \Rightarrow Z^{1901} + Z^{100} + 1 = \omega^{1901} + \omega^{100} + 1$

$= \omega^{1899} \cdot \omega^2 + \omega^{99} \times \omega + 1$

$= \omega^2 + \omega + 1 = 0$

If $Z = \omega^2 \Rightarrow \quad Z^{1901} + Z^{100} + 1 = \omega^{2(1901)}) + \omega^{100} + 1$

$= \omega + \omega^2 + 1 = 0$

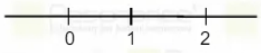
Number common roots = 2

19. Find number of real solutions of the equation $x(x^2 + |x| + 5|x-1| - 6|x-2|) = 0$

(1) 2 (2) 3 (3) 4 (4) 6

Ans. **(2)**

Sol.



Case-I : If $x \geq 2$

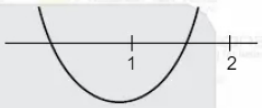
$x(x^2+x+ 5x-5-6x+12) = 0$

$x(x^2 + 7) = 0 \Rightarrow x = 0$ (Rejected)

Case –II : if $1 \leq x < 2$

$x(x^2+x+5x-5+6x-12) = 0$

$x(x^2+12x-17) = 0 \Rightarrow$ one solution in [1,2)



Case-III: If $0 \leq x < 1$

$x(x^2+x-5x+ 5+6x-12) = 0$

$x(x^2+2x- 7) = 0 \Rightarrow x = 0$ is only solution in [0,1)

Case –IV : If $x < 0$

$x(x^2- x - 5x + 5 + 6x - 12) = 0$

$x(x^2-7) = 0 \Rightarrow x = 0, \sqrt{7}, -\sqrt{7}$

$x = -\sqrt{7}$ is only the solution

So number of required solution is 3

20. $f\left(\frac{x}{y}\right) = \frac{f(x)}{f(y)}$ and $f'(1) = 2024$, then

(1) $x f'(x) - 2024 f(x) = 0$ (2) $2024 f'(x) = f(x)$

(3) $f'(x) - 2024 f(x) = 0$ (4) None of these

Ans. **(1)**

Sol. Put $x = y = 1$

$f(1) = 1$

Now put $x = 1 \Rightarrow f\left(\frac{1}{y}\right) = \frac{1}{f(y)}$

$f(y) = \pm y^n$

but $f(1) = 1 \Rightarrow f(y) = y^n$

$f'(y) = ny^{n-1} \Rightarrow f'(1) = n = 2024$

$f(x) = x^{2024}$

$f'(x) = 2024\, x^{2023}$

$xf'(x) = 2024\, f(x) \Rightarrow xf'(x) - 2024f(x) = 0$

21. $\sum_{r=0}^{n} \frac{{}^{n}C_r \cdot {}^{n}C_r}{r+1} = \alpha, \sum_{r=0}^{n} \frac{{}^{n}C_r \cdot {}^{n+1}C_r}{r+1} = \beta$. If $4\beta = 7\alpha$ then n is

Ans. **(6)**

Sol. $\alpha = \frac{1}{n+1}\sum_{r=0}^{n} {}^{n+1}C_{r+1}\ {}^{n}C_r$

$\alpha = \frac{1}{n+1}\left({}^{2n+1}C_n\right)$

$\beta = \frac{1}{n+1}\sum_{r=0}^{n} {}^{n+1}C_{r+1}\ {}^{n+1}C_r$

$\beta = \frac{1}{n+1}\left({}^{2n+2}C_n\right)$

Now $4\beta = 7\alpha$

$\frac{4}{n+1}\left({}^{2n+2}C_n\right) = 7\left(\frac{{}^{2n+1}C_n}{n+1}\right)$

$\frac{4}{n+1}\ {}^{2n+2}C_{n+2} = \frac{7}{n+1}\ {}^{2n+1}C_{n+1}$

$4\left(\frac{2n+2}{n+2}\right) = 7$

$n = 6$

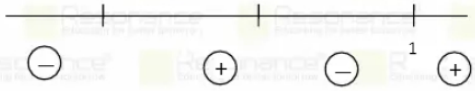
22. If the domain of $f(x) = \ell n\left(\frac{2x+3}{4x^2-x-3}\right) + \cos^{-1}\left(\frac{2x+1}{x+2}\right)$ is (α, β) find $5\alpha - 4\beta$.

(1) – 2 (2) 2 (3) 4 (4) – 4

Ans. **(1)**

Sol. For $\ell n\left(\frac{2x+3}{4x^2-x-3}\right)$ to be defined

$\frac{2x+3}{4x^2-x-3} > 0 \Rightarrow \frac{(2x+3)}{(4x+3)(x-1)} > 0$



$x \in \left(-\frac{3}{2}, -\frac{3}{4}\right) \cup (1, \alpha)$ .....(1)

for $\cos^{-1}\left(\frac{2x+1}{x+2}\right)$ to be defined

$$-1 \le \frac{2x+1}{x+2} \le 1 \Rightarrow \frac{3(x+1)}{x+2} \ge 0 \ \& \ \frac{x-1}{x+2} \le 0 \Rightarrow x \in [-1, 1] \quad \text{.....(2)}$$

(1) $\cap$ (2)

$$x \in \left[-1, -\frac{3}{4}\right]$$

$$\alpha = -1, \beta = -\frac{3}{4}$$

$$5\alpha = -5, \quad 4\beta = -3$$

$$5\alpha - 4\beta = -5 - (-3) = -2$$

COURSE

COURSE COMMENCEMENT: 5th FEBRUARY 2024

TARGET | JEE (Main) 2024
April Attempt

MODE: OFFLINE/ ONLINE

COURSE
Concept

Percentile Booster Course (PBC) is for those students who want to boost their percentile in JEE-Main 2024 through a systematic complete course revision & practice plan.

In this course, daily chapter wise tests, Full Syllabus Test, JEE Preparatory Test will be conducted and each test will be followed by proper offline/online discussion class.

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- Complete Course Coverage
- Chapter wise Test
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- Approx 2500 practice Que.
- Regular Test discussion classes for concept clearance

JEE (Main) 2024 April Attempt में
अधिकतम %ile प्राप्त करने के लिए आज ही Join करें।

SCAN TO APPLY

*T & C Apply

ADMISSIONS OPEN FOR CLASS 12+

ACADEMIC SESSION 2024-25

TARGET: JEE (ADV.) 2024
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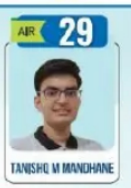
AIR 7

BIKKINA A. CHOWDARY

All India Ranks (AIR-CRL) in
Top 50 : 8 Top 100 : 15
All Students are from Our Offline/Online Classroom Programs


AIR 22 — DESHANK P. SINGH


AIR 26 — MAYANK SONI


AIR 29 — TANISHQ M MANDHANE


AIR 32 — KRITIN GUPTA


AIR 33 — NAMAN GOYAL


AIR 37 — S S SUMEDH


AIR 44 — KAUSHAL VIJAYVERGIYA

JEE (Main) 2023 RESULT

22 वर्षों से लगातार... श्रेष्ठ शिक्षण, श्रेष्ठ परिणाम...