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JEE (MAIN) 2024

MEMORY BASED QUESTIONS & SOLUTIONS

SHIFT-2

DATE & DAY: 29th January 2024 & Monday

PAPER-1

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

SUBJECT: MATHEMATICS

PART : MATHEMATICS

1. If $\sin\frac{y}{x} = \ell n|x| + \frac{\alpha}{2}$ is a solution of differential equation $x\cos\frac{y}{x}\frac{dy}{dx} = y\cos\frac{y}{x} + x$ where $y(1) = \frac{\pi}{3}$ then $\alpha^2 =$

Ans. (3)

Sol. Given differential equation is $x\cos\frac{y}{x}\frac{dy}{dx} - y\cos\frac{y}{x} = x$

$\Rightarrow \cos\frac{y}{x}\left(x\frac{dy}{dx}-y\right)=x$

$\Rightarrow \cos\frac{y}{x}\left(\frac{x\frac{dy}{dx}-y.1}{x^2}\right)=\frac{1}{x}$

Let $\frac{y}{x}=t$

$\cos t\frac{dt}{dx}=\frac{1}{x}$

$\cos t dt=\frac{1}{x}dx$

on integration

$\sin t = \ell n\,|x| + c$

$y(1) = \frac{\pi}{3} \Rightarrow \sin\frac{\pi}{3}=0+c$

$\Rightarrow c=\frac{\sqrt{3}}{2}$

$\therefore$ solution is $\sin\frac{y}{x}=\ell n\,|\,x\,|+\frac{\sqrt{3}}{2}$

$\therefore \frac{\alpha}{2}=\frac{\sqrt{3}}{2} \Rightarrow \alpha^2=3$

2. **Find** remainder when $\left((64)^{32}\right)^{32}$ divided by 9.

Ans. **(1)**

Sol. $\left((64)^{32}\right)^{32}=\left(8^{64}\right)^{32}$

$= 8^{2048}$

$= (9-1)^{2048}$

$= 9^{2048} - {}^{2048}C_1 9^{2047} + {}^{2048}C_2.9^{2046} \ldots\ldots\; {}^{2046}C_{2045}.9 + {}^{2046}C_{2046}$

$= 9K + 1$

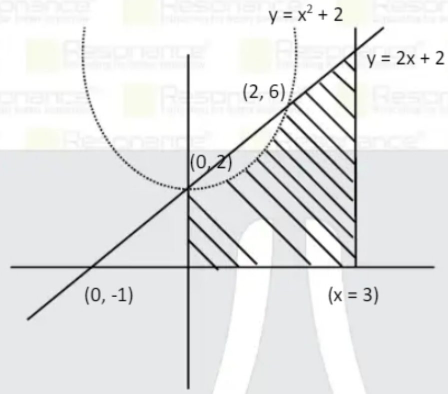
Remainder $= 1$

3. Area bounded by $0 \le x \le 3$, $0 \le y \le$ minimum $(2x + 2, x^2 + 2)$ is A then 12A is

(1) 164 (2) 170 (3) 180 (4) 184

Ans. **(1)**

Sol.



$A = \int_0^2 (x^2+2)dx + \int_2^3 (2x+2)dx$

$A = \left(\frac{x^3}{3}+2x\right)_0^2 + \left(x^2+2x\right)_2^3$

$A = \frac{41}{3} \Rightarrow 12A = 164$

4. Let $\cos(2\sin^{-1}x) = \frac{1}{9}$, $x > 0$ holds true for $x = \frac{m}{n}$, where m and n are co-prime further α and β are root of quadratic equation $mx^2 - n\,x - m + n = 0$, $(\alpha > \beta)$ then point (α, β) lies on the line

(1) $5x - 8y = 9$ (2) $5x + y = 9$ (3) $8x + 5y = 9$ (4) $8x - 5y = 3$

Ans. **(3)**

Sol. $\sin^{-1}x = \theta \in I^{st}$ quadrant

$\cos 2\theta = \frac{1}{9} \Rightarrow 1 - 2\sin^2\theta = \frac{1}{9} \Rightarrow \sin^2\theta = \frac{4}{9}$

$\Rightarrow x^2 = \frac{4}{9} \Rightarrow x = \frac{2}{3} = \frac{m}{n}$

So $mx^2 - nx - m + n = 0$

$\Rightarrow 2x^2 - 3x + 1 = 0$

roots are $1, \frac{1}{2}$

$\alpha = 1, \beta = \frac{1}{2}$

So $(\alpha, \beta) = \left(1, \frac{1}{2}\right)$ lies or $5x + 8y = 9$

5. $\int_{\pi/6}^{\pi/3} \sqrt{1 - \sin 2\theta}\, d\theta = \alpha + \beta\sqrt{2} + \gamma\sqrt{3}$ then $3\alpha + 4\beta - \gamma =$

(1) 6 (2) 8 (3) 9 (4) 12

Ans. **(1)**

Sol. $I = \int_{\pi/6}^{\pi/3} \sqrt{1 - \sin 2\theta}\, d\theta$

$= \int_{\pi/6}^{\pi/3} |\sin\theta - \cos\theta|\, d\theta$

$= \int_{\pi/6}^{\pi/4} (\cos\theta - \sin\theta) d\theta + \int_{\pi/4}^{\pi/3} (\sin\theta - \cos\theta) d\theta$

$= [\sin\theta + \cos\theta]_{\pi/6}^{\pi/4} + [-\cos\theta - \sin\theta]_{\pi/4}^{\pi/3}$

$= \frac{2}{\sqrt{2}} - \frac{1}{2} - \frac{\sqrt{3}}{2} - \left(\frac{1}{2} + \frac{\sqrt{3}}{2} - \frac{2}{\sqrt{2}}\right)$

$= \frac{2}{\sqrt{2}} - \frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{2} - \frac{\sqrt{3}}{2} + \frac{2}{\sqrt{2}}$

$= -1 + \frac{4}{\sqrt{2}} - \sqrt{3}$

$= -1 + 2\sqrt{2} - \sqrt{3}$

$\alpha = -1, \beta = 2, \gamma = -1$

$\therefore 3\alpha + 4\beta - \gamma = -3 + 8 + 1 = 6$

6. 8 identical book are to be place in 4 identical shelf. Find the number of different ways can be done.

Ans. **(165)**

Sol. $x_1 + x_2 + x_3 + x_4 = 8$ $x_i \geq 0 \ \forall\ I \in \{1, 2, 3\}$

${}^{8+4-1}C_8 = {}^{11}C_3 = \frac{11.10.9}{6} = 165$

7. Find the probability that number selected from 1 to 50 such that number is divisible by at least by 4,6 or 7

(1) $\frac{21}{50}$ (2) $\frac{1}{2}$ (3) $\frac{19}{50}$ (4) $\frac{23}{50}$

Ans. **(1)**

Sol. Number disable by 4, 6 or 7 (from 1 to 5)

$= \{4, 8, 12, \ldots\ldots., 48\} \cup \{6, 18, 30, 42\} \cup \{7, 14, 21, 35, 49\}$

Favourable no's = 21 no's

Probability = $\frac{21}{50}$

8. If $a_1, a_2 \ldots.$ are in G.P. such that $a_1 = \frac{1}{8}$, $a_1 \neq a_2$ and every term is equal to arithmetic mean of it's two successive terms then find $S_{20} - S_{18}$.

(1) -2^{15} (2) -2^{18} (3) -2^{20} (4) -2^{21}

Ans. **(1)**

Sol. $T_n = \frac{T_{n+1} + T_{n+2}}{2}$

$\Rightarrow 2ar^{n-1} = ar^n + ar^{n+1}$

$\Rightarrow r^2 + r = 2 \Rightarrow r = 1$ ro -2

$\Rightarrow r \neq 1 \because (a_1 \neq a_2) \Rightarrow r = -2$

Now

$S_{20} - S_{18} = T_{19} + T_{20}$

$= ar^{18} + ar^{19}$

$= ar^{18}(1 + r)$

$\frac{1}{8}(-2)^{18}(-1) = -2^{15}$

9. Distance of (2, 4) from the line $2x + y + 2 = 0$ measured parallel to the $\sqrt{3}x + y + 2 = 0$ is

(1) $20\left(2-\sqrt{3}\right)$ (2) $20\left(2+\sqrt{3}\right)$ (3) $20\left(3-\sqrt{2}\right)$ (4) $20\left(3+\sqrt{2}\right)$

Ans. **(2)**

Sol. Slope of line $\sqrt{3}x + y + 2 = 0$ is $-\sqrt{3} = \tan\theta$

$\cos\theta = -\frac{1}{2}$, $\sin\theta = \frac{\sqrt{3}}{2}$

line through (2, 4) whose slope is $-\sqrt{3}$ is

$$\frac{x-2}{-\frac{1}{2}} = \frac{y-4}{\frac{\sqrt{3}}{2}} = r$$

$x = 2 - \frac{r}{2}$, $y = 4 + \frac{\sqrt{3}}{2}r$

line is $2x + y + 2 = 0$

$4 - r + 4 + \frac{\sqrt{3}}{2}r + 2 = 0$

$\left(1-\frac{\sqrt{3}}{2}\right)r = 10 \Rightarrow r = \frac{20}{2-\sqrt{3}} = 20\left(2+\sqrt{3}\right)$

10. If α and β are roots of the equation $x^2 - \sqrt{6}x + 3 = 0$ and where $\text{Im}(\beta) < 0$ if $\frac{\alpha^{99}}{\beta} + \beta^{98} = 3(a+ib)$ then find a + b + n

Ans. **(47)**

Sol. $x^2 - \sqrt{6}x + 3 = 0$

$$x = \frac{\sqrt{6} \pm \sqrt{-6}}{2} < \begin{matrix} \frac{\sqrt{6}(1+i)}{2} = \alpha \\ \frac{\sqrt{6}(1-i)}{2} = \beta \end{matrix}$$

$\therefore \alpha^2 = 3i$, $\beta^2 = -3i$

$\frac{\alpha^{99}}{\beta}+\beta^{98}=\frac{\alpha^{99}+\beta^{99}}{\beta}=\frac{\alpha.(\alpha^2)^{49}+\beta(\beta^2)^{49}}{\beta}$

$=\frac{\alpha.(3i)^{49}+\beta(-3i)^{49}}{\beta}=\frac{3^{49}(\alpha i-\beta i)}{\beta}$

$=\frac{3^{49}(-\sqrt{6})2}{\sqrt{6}(1-i)}=\frac{-3^{49}(1+i)2}{2}$

$=-3^{49}(1+i)=3^{49}(-1-i)$

n = 49 , a = – 1 b = –1

11. If mean of 5 terms = $\frac{24}{5}$ & variance of terms = $\frac{194}{25}$ & mean of 4 terms = $\frac{7}{2}$, then find variance of 4 terms ?

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

Ans. **(3)**

Sol. $\frac{x_1+x_2+x_3+x_4+x_5}{5}=\frac{24}{5} \Rightarrow x_1+x_2+x_3+x_4+x_5=24$

& $\frac{x_1+x_2+x_3+x_4}{4}=\frac{7}{2} \Rightarrow x_1+x_2+x_3+x_4=14$

$\therefore x_5 = 10$

also $\frac{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2}{5}-\frac{576}{25}=\frac{194}{25}$

$\Rightarrow x_1^2+x_2^2+x_3^2+x_4^2=54$

$\therefore$ Var. = $\frac{\sum_{i=1}^{4}x_i^2}{4}-\left(\frac{\sum x_i}{4}\right)^2$

$=\frac{54}{4}-\frac{49}{4}=\frac{5}{4}$

12. If r = |z|, θ =arg(z) and z = 2 – 2itan$\left(\frac{5\pi}{8}\right)$ then find (r, θ)

(1) $\left(2\sec\frac{5\pi}{8},\frac{3\pi}{8}\right)$ (2) $\left(2\sec\frac{3\pi}{8},\frac{3\pi}{8}\right)$ (3) $\left(2\tan\frac{3\pi}{8},\frac{5\pi}{8}\right)$ (4) $\left(2\tan\frac{3\pi}{8},\frac{3\pi}{8}\right)$

Ans. **(2)**

Sol. $z = 2 - 2i\tan\frac{5\pi}{8}$

$= 2 + 2i\tan\left(\pi-\frac{5\pi}{8}\right)$

$= 2 + 2i\tan\frac{3\pi}{8}$

$= 2\sec\frac{3\pi}{8}\left(\cos\frac{3\pi}{8}+i\sin\frac{3\pi}{8}\right)$

$\therefore r = 2\sec\frac{3\pi}{8}, \theta=\frac{3\pi}{8}$

13. If A = {1,2,3,4,} then minimum number of ordered pair added to make it equivalence relation on set A containing (1,3) and (1,2) is

(1) 8 (2) 9 (3) 12 (4) 16

Ans. **(1)**

Sol. Minimum ordered pairs are (1,1) (2,2), (3,3), (4,4), (3,1), (2,1), (2,3), (3,2)

" 8 ordered pairs"

14. If ℓna, ℓnb, ℓnc are in A.P. and ℓna – ℓn2b, ℓn2b – ℓn3c, ℓn3c – ℓna are in A.P. then a : b : c is

(1) 1 2 : 3 (2) 7 : 7 : 4 (3) 9 : 6 : 4 (4) 4 : 6 : 9

Ans. **(3)**

Sol. ℓna, ℓnb, ℓnc are in A.P. ⇒ a , b, c are in G.P.

$\ell na - \ell n2b$, $\ell n\, 2b - \ell n\, 3c$ and $\ell n\, 3c - \ell na$ are in A.P.

$\Rightarrow \frac{a}{2b}, \frac{2b}{3c}, \frac{3c}{a}$ are also in G.P.

Let a = a, b = ar, c = ar^2

So, $\frac{1}{2r}, \frac{2}{3r}$, $3r^2$ are in G.P.

$\Rightarrow \frac{4}{9r^2} = \frac{3}{2}r \Rightarrow r^3 = \frac{8}{27} \Rightarrow r = \frac{2}{3}$

$a : b : c = 1 : \frac{2}{3} : \frac{4}{9} \Rightarrow 9 : 6 : 4$

15. $y = \log_e\left(\frac{1+x^2}{1-x^2}\right)$ then find $225(y'' - y')$ at $x = \frac{1}{2}$

Ans. (736)

Sol. $y = \ell n\,(1+x^2) - \ell n\,(1-x^2)$

$\frac{dy}{dx} = \frac{2x}{1+x^2} + \frac{2x}{1-x^2}$

$= \frac{2x(1-x^2+1+x^2)}{1-x^4} = \frac{4x}{1-x^4}$

$\frac{d^2y}{dx^2} = 4.\frac{(1-x^4)1 - x.(-4x^3)}{(1-x^4)^2}$

$= 4.\frac{1-x^4+4x^4}{(1-x^4)^2} = \frac{4(1+3x^4)}{(1-x^4)^2}$

$\therefore \frac{dy}{dx} - \frac{d^2y}{dx^2} = \frac{4x}{1-x^4} - \frac{4(1+3x^4)}{(1-x^4)^2}$

Put $x = \frac{1}{2}$

$\left(\frac{dy}{dx} - \frac{d^2y}{dx^2}\right)_{at\, x=\frac{1}{2}} = \frac{2}{1-\frac{1}{16}} - \frac{4\left(1+\frac{3}{16}\right)}{\left(1-\frac{1}{16}\right)^2}$

$= \frac{32}{15} - \frac{4.19.16}{225} = \frac{480-1216}{225} = \frac{-736}{225}$

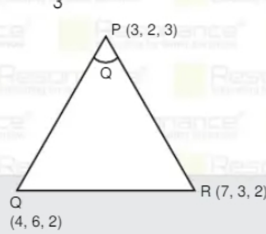
$\Rightarrow 225\,(y'' - y')$ at $x = \frac{1}{2} = 736$

16. If p (3, 2, 3) , Q (4, 6, 2), R (7, 3, 2) are the vertices of Δ PQR, then find ∠QPR = .

(1) $\cos^{-1}\frac{1}{18}$ (2) $\frac{\pi}{6}$ (3) $\frac{\pi}{3}$ (4) $\cos^{-1}\frac{7}{18}$

Ans. (3)

Sol. A



D.R of PR = " 1, 4, –1"

D.R of PR = " 4, 1, –1"

$\cos\theta = \left|\frac{1\times4+4\times1+-1\times-1}{\sqrt{1+16+1}\sqrt{16+1+1}}\right|$

$\Rightarrow \cos\theta = \frac{1}{2} \Rightarrow \theta = \frac{\pi}{3}$

17. (α,β) lies on the $y^2 = 4x$ and (α, β) also lies on chord with mid point $\left(1,\frac{5}{4}\right)$ of another parabola $x^2 = 8y$, then value $|(8-\beta)(\alpha-28)$ is

(1) 192 (2) 92 (3) 64 (4) 128

Ans. (A)

Sol. Let $(\alpha, \beta) = (t^2, 2t)$

Now equation chord with mid point. $\left(1,\frac{5}{4}\right)$ to the parabola $x^2 = 8y$

$\Rightarrow x - 4\left(y+\frac{5}{4}\right) = 1 - 10$

$\Rightarrow x - xy + 4 = 0$

$(t^2, 2t)$ satisfy $x - 4y + 4 = 0$

$t^2 - 8t + 4 = 0$

$|(8-\beta)(\alpha-28)| = |(8-2t)(t^2-28)|$
$= |(8-2t)(8t-4-28)| = 2(4-t)\,8(t-4) = 16\,|t^2-8t+16|$
$16 \times 12 = 192$

18. In which interval the function $f(x) = \frac{x}{x^2-6x-16}$ is increasing

(1) ϕ (2) $\left[1,\frac{3}{7}\right) \cup \left(\frac{5}{4},\infty\right)$ (3) $\left(\frac{5}{4},\infty\right)$ (4) $\left[\frac{3}{4},\frac{5}{4}\right]$

Ans. (1)

Sol. $f(x) = \frac{x}{x^2-6x-16}$

$= f'(x) = \frac{(x^2-6x-16).1 - x.(2x-6)}{(x^2-6x-16)^2}$

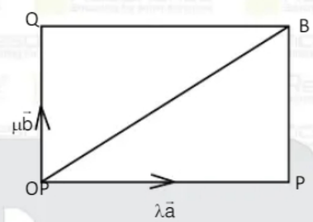
$= \frac{x^2-6x-16-2x^2+6x}{(x^2-6x-16)^2}$

$= \frac{-x^2-16}{(x^2-6x-16)^2} < 0 \forall x \in Df$

$\therefore$ f(x) is decreasing

19. If $\overrightarrow{OA} = \vec{a}$ $\overrightarrow{OC} = \vec{b}$ and area of ΔOAC is S and a parallelogram with sides parallel to $\overrightarrow{OA}$ and $\overrightarrow{OC}$ and diagonal $\overrightarrow{OB} = 12\vec{a} + 4\vec{b}$, has area equal to B, then $\frac{B}{S}$ is equal to______.

Ans. (96)



Sol. area of $\Delta = \frac{1}{2}|\vec{a} \times \vec{b}| = S$ (1)

$\therefore \overrightarrow{OB} = \lambda\vec{a} + \mu\vec{b} = 12\vec{a} + 4\vec{b}$

$\therefore$ area of ||gm = $\left|\overrightarrow{OP} \times \overrightarrow{OQ}\right|$

$= \left|12\vec{a} \times 4\vec{b}\right|$

$B = 48\left|\vec{a} \times \vec{b}\right|$

$\therefore \frac{B}{S} = \frac{48\left|\vec{a}\times\vec{b}\right|}{\frac{1}{2}\left|\vec{a}\times\vec{b}\right|} = 96$

20. Unit vector $\hat{u} = x\hat{i} + y\hat{j} + z\hat{k}$ makes angles $\frac{\pi}{2}, \frac{\pi}{3}, \frac{2\pi}{3}$ with $\left(\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{k}\right)$, $\left(\frac{1}{\sqrt{2}}\hat{j} + \frac{1}{\sqrt{2}}\hat{k}\right)$ and $\left(\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right)$ respectively and $\vec{v} = \frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j} + \frac{1}{\sqrt{2}}\hat{k}$. Find $|\vec{u} - \vec{v}|$

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

Ans. (1)

Sol. $\vec{u} = x_i = + y_j + z_k$, $\vec{a}_1 = \frac{1}{\sqrt{2}}i + \frac{1}{\sqrt{2}}k$, $\vec{a}_2 = \frac{1}{\sqrt{2}}j + \frac{1}{\sqrt{2}}k$, $\vec{a}_3 = \frac{1}{\sqrt{2}}i + \frac{1}{\sqrt{2}}j$

$\because \vec{u} \perp \vec{a}_1 \therefore \vec{u}.\vec{a}_1 = 0 \Rightarrow \frac{x}{\sqrt{2}} + \frac{z}{\sqrt{2}} = 0 \Rightarrow x + z = 0$

$\vec{u} \wedge \vec{a}_2 = \frac{\pi}{3} \therefore \vec{u}.\vec{a}_2 = |\vec{u}||\vec{a}_2|\cos\frac{\pi}{3}$

$\frac{1}{\sqrt{2}}y + \frac{1}{\sqrt{2}}z = \frac{1}{2} \Rightarrow y + z = \frac{1}{\sqrt{2}}$

$\vec{x} \wedge \vec{a}_3 = \frac{2\pi}{3}$ $\frac{1}{\sqrt{2}}x + \frac{1}{\sqrt{2}}y = -\frac{1}{2} \Rightarrow x + y = -\frac{1}{\sqrt{2}}$

$\therefore x + y + z = 0$

$y = 0, x = \frac{-1}{\sqrt{2}}, z = \frac{1}{\sqrt{2}}$

$\vec{u} = \frac{\quad}{\sqrt{2}}\hat{i} + \frac{\quad}{\sqrt{2}}\hat{k}$

$\vec{u} - \vec{v} = \frac{-2}{\sqrt{2}}\hat{i} - \frac{1}{\sqrt{2}}\hat{j}$

$\therefore |\vec{u} - \vec{v}| = \sqrt{\frac{4}{2} + \frac{1}{2}} = \sqrt{\frac{5}{2}}$

21. Consider function $f(x) = 2x + 3x^{2/3}$

(1) Exactly 1 local minima & no local maxima
(2) Exactly 1 local minima & 1 local maxima
(3) No local minima & 1 local maxima
(4) No local maxima & 1 local minima

Ans. (2)

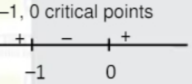
Sol. $f(x) = 2x + 3x^{2/3}$

$f'(x) = 2 + 3.\frac{2}{3}x^{\frac{2}{3}-1}$

$= 2 + 2x^{-\frac{1}{3}}$

$= \frac{2\left(1 + x^{\frac{1}{3}}\right)}{x^{\frac{1}{3}}} = 0$

x = –1, 0 critical points



Maxima at x = – 1
Minima at x = 0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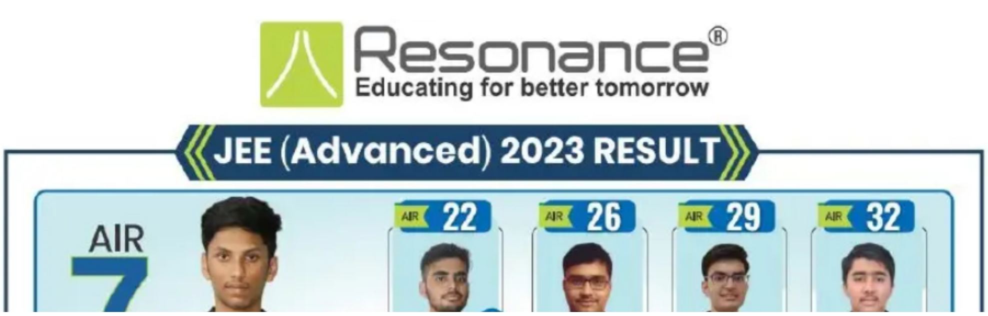
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