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JEE
(Main)

2021

COMPUTER BASED TEST (CBT)

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Date: 27 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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**RESULT: JEE (Advanced),
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HIGHEST No. of Classroom Selections

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5 AIRs in TOP-50 in JEE (Adv.) 2020 from Classroom



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Total Selections in JEE (Advanced) 2020	Eligible for JEE (Advanced) Through JEE (Main) 2020	NEET 2020
4505	14755	2646
Classroom: 3441 Distance: 1064	Classroom: 11047 Distance: 3708	Classroom: 1833 Distance: 813

ADMISSION OPEN for Session 2021-22

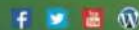
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1. If $\vec{a} = \hat{i} + \hat{j} + \hat{k}$, $\vec{b} = 2\hat{i} + \hat{j} - \hat{k}$ and $\vec{c} = 4\hat{i} + 3\hat{j} + \hat{k}$ then the value of $((\vec{a} + \vec{b}) \times (\vec{a} - (\vec{a} - \vec{b}) \times \vec{b})) \times \vec{c}$ is :

- (1) $(30\hat{i} - 34\hat{j} + 36\hat{k})$ (2) $(30\hat{i} + 34\hat{j} + 36\hat{k})$
 (3) $(30\hat{i} + 34\hat{j} - 36\hat{k})$ (4) None of these

Ans. (1)

Sol. $\vec{a} + \vec{b} = 3\hat{i} + 2\hat{j} = \vec{r}_1$

$$\vec{r}_2 = \vec{a} - (\vec{a} - \vec{b}) \times \vec{b} = \vec{r}_2 = (\hat{i} + \hat{j} + \hat{k}) - (\hat{i} + 2\hat{k}) \times (2\hat{i} + \hat{j} - \hat{k})$$

$$(\hat{i} + \hat{j} + \hat{k}) - (-\hat{k} - \hat{j} + 4\hat{j} - 2\hat{i}) = (3\hat{i} - 2\hat{j} + 2\hat{k})$$

$$= (\vec{r}_1 \cdot \vec{c}) \vec{r}_2 - (\vec{r}_2 \cdot \vec{c}) \vec{r}_1$$

$$= 18(3\hat{i} - 2\hat{j} + 2\hat{k}) - 8(3\hat{i} + 2\hat{j})$$

$$= (30\hat{i} - 34\hat{j} + 36\hat{k}) \quad \text{Ans.}$$

2. Which of the following is logically equivalent to $(p \vee q) \wedge (\sim p \rightarrow q)$ is :

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$$(1) (p \vee q)$$

$$(2) (p \wedge q)$$

$$(3) \sim p \vee q$$

$$(4) p \wedge \sim q$$

Ans. (1)

Sol. We know $p \rightarrow q = \sim p \vee q$

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$$\Rightarrow (p \vee q) \wedge (\sim p \vee q) = p \vee q \quad \text{Ans.}$$

3. If $S_1 = \{z : |z - 3 - 2i|^2 = 8\}$ and $S_2 = \{z : |z - \bar{z}| = 8\}$ and $S_3 = \{z : \operatorname{re}(z) \geq 5\}$ then $S_1 \cap S_2 \cap S_3$ has

(1) Infinite many element

(2) Only one element

(3) No any element

(4) Two element

Ans. (2)

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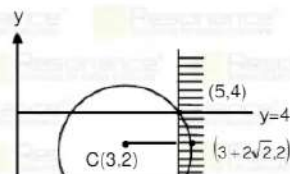
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Sol. Let $z = x + iy$



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$$S_2 \Rightarrow |2y| = 8 \Rightarrow |y| = 4$$

$$y = \pm 4$$

$$S_3 \Rightarrow x \geq 5$$

$$S_1 \Rightarrow |z - 3 - 2i|^2 = 8 \Rightarrow (x-3)^2 + (y-2)^2 = 8$$

Is a circle with centre (3,2) and radius = $2\sqrt{2}$

$\therefore$ Circle passes through (5,4)

$\Rightarrow$ There is exactly one point (5,4) in $S_1 \cap S_2 \cap S_3$

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Ans. 16.00

Sol. Put $x = 3 \Rightarrow f(3) = 0$

$$e^{-x} [t^3 + t^2 + 4(F(t))^x] = F(x)$$

$$e^{-x} (x^3 + x^2 + 4F(x)) - (27 + 9 + 4F(3)) = F(x)$$

$$\Rightarrow F(x) = e^{-x} (x^3 + x^2 - 36 + 4F(x))$$

$$\Rightarrow e^x F(x) = x^3 + x^2 - 36 + 4F(x)$$

$$F(x) = \frac{x^3 + x^2 - 36}{(e^x - 4)}$$

$$F'(x) = \frac{(3x^2 + 2x)(e^x - 4) - (e^x)(x^3 + x^2 - 36)}{(e^x - 4)^2}$$

$$F'(4) = \frac{56(e^4 - 4) - e^4(44)}{(e^4 - 4)^2}$$

$$F'(4) = \frac{12e^4 - 224}{(e^4 - 4)^2}$$

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5. The coefficient of x^7 and x^{-7} in the expansion of $\left(x^2 + \frac{1}{bx}\right)^{11}$ and $\left(x + \frac{1}{bx^2}\right)^{11}$ respectively are equal then

the value of b is :

- (1) 1 (2) -1 (3) 0 (4) 2

Ans. (1)

Sol. $\left(x^2 + \frac{1}{bx}\right)^{11}$

$$T_{r+1} = {}^{11}C_r (x^2)^{11-r} \left(\frac{1}{bx}\right)^r = {}^{11}C_r (x)^{22-3r} \left(\frac{1}{b}\right)^r$$

$$\text{for } x^4 \Rightarrow 22 - 3r = 7 \Rightarrow r = 5$$

$$\therefore \text{coefficient of } x^7 = {}^{11}C_5 \left(\frac{1}{b}\right)^5$$

$$\text{similarly } \left(x + \frac{1}{bx^2}\right)^{11}$$

$$\text{For } x^{-7} \Rightarrow 11 - 3r = -7 \Rightarrow r = 6$$

$$\therefore \text{coefficient } x^{-7} = {}^{11}C_6 \left(\frac{1}{b}\right)^6$$

$${}^{11}C_5 \left(\frac{1}{b}\right)^5 = {}^{11}C_6 \left(\frac{1}{b}\right)^6 \Rightarrow b = 1$$

6. Evaluate $\lim_{x \rightarrow 2} \frac{x^2 f(2) - 4f(x)}{x - 2}$, if $f(2) = 4$ & $f'(2) = 1$

Ans. (12)

$$\text{Sol. } \lim_{x \rightarrow 2} \frac{x^2 f(2) - 4f(x)}{x - 2} = \lim_{x \rightarrow 2} \frac{2xf(2) - 4f'(x)}{1} = 2 \cdot (2) \cdot f(2) - 4f'(2) = 16 - 4 = 12$$

7. If $\sin \theta + \cos \theta = \frac{1}{2}$, then the value of $16(\sin 2\theta + \cos 4\theta + \sin 6\theta)$ is :

$$\text{Sol. } (\sin \theta + \cos \theta)^2 = \frac{1}{4}$$

$$1 + \sin 2\theta = \frac{1}{4}$$

$$\sin 2\theta = \frac{-3}{4}$$

$$16(\sin 2\theta + \cos 4\theta + \sin 6\theta) = 16(\sin 2\theta + 1 - 2\sin^2 2\theta + 3\sin 2\theta - 4\sin^3 2\theta)$$

$$= 16(4\sin 2\theta + 1 - 2\sin^2 2\theta - 4\sin^3 2\theta) = -23$$

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8. If mean and variance of eight observation 10, 13, 6, 7, a, 12, b, 12 are 9 and $\frac{37}{4}$ respectively, then the value of $(a-b)^2$ is
- (1) 25 (2) 36 (3) 16 (4) 49

Ans. (3)

Sol. $9 = \frac{10+13+6+7+a+12+b+12}{8}$

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$$\begin{aligned}\sum x_i^2 &= 100+169+36+49+a^2+144+b^2+144 \\ &= a^2+b^2+642 \\ \sigma^2 &= \frac{\sum x_i^2}{8} - (\bar{x})^2 = \frac{37}{4} \\ \frac{a^2+b^2+642}{8} - 81 &= \frac{37}{4} \\ \Rightarrow a^2+b^2 &= 80 \Rightarrow a^2+(12-a)^2 = 80 \Rightarrow a^2-12a+32 = 0 \\ \Rightarrow a &= 4 \quad \text{or} \quad a = 8 \\ b &= 8 \quad \text{or} \quad b = 4 \\ \Rightarrow (a-b)^2 &= 16 \text{ Ans.}\end{aligned}$$

9. If matrix $A = \begin{bmatrix} 2 & 4 \\ -1 & 1 \end{bmatrix}$ and $A^{-1} = \alpha I + \beta A$, $\alpha, \beta \in \mathbb{R}$. Then the value of $(\alpha - 6\beta)$ is equal to :

Ans. (1)

Sol. Equation of $|A - \lambda I| = 0$

$$\begin{aligned}\begin{vmatrix} 2-\lambda & 4 \\ -1 & 1-\lambda \end{vmatrix} &= 0 \\ \Rightarrow (2-\lambda)(1-\lambda) + 4 &= 0 \Rightarrow \lambda^2 - 3\lambda + 2 + 4 = 0 \Rightarrow \lambda^2 - 3\lambda + 6 = 0 \\ A^2 - 3A + 6I &= 0 \\ \text{Multiply both side by } A^{-1} & \\ A - 3I + 6A^{-1} &= 0 \\ A^{-1} &= \frac{-A}{6} + \frac{I}{2} \quad \dots\dots\dots(1) \\ A^{-1} &= \alpha I + \beta A \quad \dots\dots\dots(2) \\ \text{Comparing equation (1) and (2)} & \\ \alpha &= \frac{1}{2}, \beta = -\frac{1}{6}\end{aligned}$$

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10. If α and β are the roots of the equation $x^2 - 20^{1/4}x + 5^{1/2} = 0$, then the value of $\alpha^8 + \beta^8$ is equal to :

(1) 25 (2) 50 (3) 75 (4) 100

Ans. (2)

Sol. $x^2 - 20^{1/4}x + 5^{1/2} = 0$

$$(x^2 + \sqrt{5})^2 = \sqrt{20} x^2$$

$$x^4 + 5 + 2\sqrt{5}x^2 = 2\sqrt{5}x^2$$

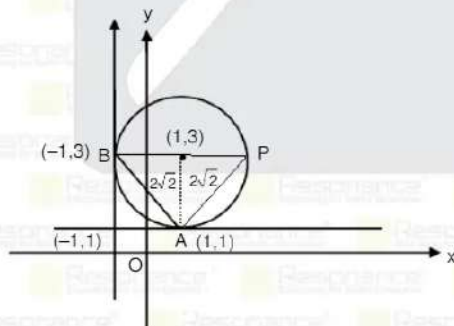
$$\alpha^8 = 25, \beta^8 = 25$$

$$= 3(3^{n-1} - n \cdot 3^{n-2} + \dots + (-1)^{n-1} n) + (-1)^{n-2}$$

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Q

Alternate :



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13. If $\log_3 2$, $\log_3(2^x - 5)$, $\log_3(2^x - \frac{7}{2})$ are in A.P, then the value of x is

- (1) 4 (2) 2 (3) 3 (4) 5

Ans. (3)

Sol. $2\log_3(2^x - 5) = \log_3 2 + \log_3(2^x - \frac{7}{2})$

$$\Rightarrow \log_3(2^x - 5)^2 = \log_3(2(2^x - \frac{7}{2}))$$

$$\Rightarrow (2^x)^2 - 10(2^x) + 25 = 2(2^x) - 7$$

$$\Rightarrow (2^x)^2 - 12(2^x) + 32 = 0$$

$$\Rightarrow 2^x = 4 \text{ or } 8$$

$$\Rightarrow x = 2 \text{ or } 3$$

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$$\Rightarrow x = 3$$

14. If $\sec y \frac{dy}{dx} = \sin(x+y) + \sin(x-y)$; $y(0) = 0$ then the value of $5y'(\frac{\pi}{2})$ is

- (1) 3 (2) 4 (3) 2 (4) 1

Ans. (3)

Sol. $\sec y \frac{dy}{dx} = 2\sin(x) \cos(y)$ (1)

$$\int \sec^2 y \, dy = \int 2\sin x \, dx$$

$$\tan y = -2\cos x + c$$

$$\text{When } x = 0, y = 0 \Rightarrow c = 2$$

$$\tan y = -2\cos x + 2 \quad \dots\dots\dots(2)$$

$$\therefore \sec^2 y \frac{dy}{dx} = 2\sin x$$

$$(1 + \tan^2 y) \frac{dy}{dx} = 2\sin x \quad \dots\dots\dots(3)$$

By equation (2) & (3)

$$\frac{dy}{dx} = \frac{2\sin x}{1 + (2 - 2\cos x)^2}$$

$$f'(\frac{\pi}{2}) = \frac{2}{1 + (2)^2} = \frac{2}{5} \Rightarrow 5f'(\frac{\pi}{2}) = 2$$

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15. A circle with centre (2, 3) passes through the origin. A diameter PQ is such that it is perpendicular to the line joining the centre of circle and origin. The coordinates of points P and Q are :
 (1) (-1, 5) & (5, 1) (2) (-2, 5) & (-5, 1) (3) (3, 6) & (5, 1) (4) (-1, 1) & (5, -1)

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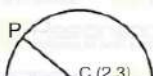
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Ans. (1)

Sol. $(x-2)^2 + (y-3)^2 = 13$



(0,0) C(2,3) Q

$$y = \frac{3}{2}x$$

line perpendicular to the above line and passing through (2,3) is $3y + 2x = 13$

Coordinates of P, Q $\Rightarrow (2 \pm \sqrt{13} \cos \theta, 3 \pm \sqrt{13} \sin \theta)$

$$\Rightarrow \left(2 \pm \sqrt{13} \left(\frac{-3}{\sqrt{13}} \right), 3 \pm \sqrt{13} \left(\frac{2}{\sqrt{13}} \right) \right)$$

$$\Rightarrow (-1, 5) \text{ \& \& } (5, 1)$$

16. Evaluate $\lim_{n \rightarrow \infty} \frac{1}{n} \sum_{j=1}^n \frac{(2j-1)+8n}{((2j-1)+4n)}$

Ans. (1)

$$\text{Sol. } \lim_{n \rightarrow \infty} \frac{1}{n} \sum_{j=1}^n \left(\frac{2 \frac{j}{n} - \frac{1}{n} + 8}{2 \frac{j}{n} - \frac{1}{n} + 4} \right) \frac{1}{n}$$

$$= \int_0^1 \frac{2x+8}{2x+4} dx$$

$$= \int_0^1 dx + \int_0^1 \frac{4}{2x+4} dx$$

$$= 1 + 4 \cdot \frac{1}{2} [\ln(2x+4)]_0^1$$

$$= 1 + 2[\ln 6 - \ln 4]$$

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

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$$x \in (8, 10)$$

$$\therefore a = 8 \text{ and } b = 10$$

$$\therefore I = \int_a^b \frac{\sin^3 x \, dx}{\sin^3 x + \sin^3(a+b-x)} = \int_b^a \frac{\sin^3 x \, dx}{\sin^3 x + \sin^3(a+b-x)}$$

Using the property

$$\int_a^b f(x) \, dx = \int_a^b f(a+b-x) \, dx, \text{ we get}$$

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$$\therefore I = 1 \text{ Ans.}$$

20. Find area bounded by $y = \max\{0, \ln x\}$ and $y < 2^x$ where $\frac{1}{2} < x < 1$:

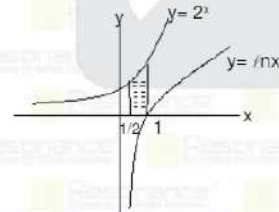
$$(1) \frac{2+\sqrt{2}}{\ln 2}$$

$$(2) \frac{2-\sqrt{2}}{\ln 2}$$

$$(3) \frac{1-\sqrt{2}}{\ln 2}$$

$$(4) \frac{1+\sqrt{2}}{\ln 2}$$

Ans. (2)
Sol.



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$$\frac{1}{2} \quad \left(\ln 2 \right) \frac{1}{2} \quad \ln 2$$

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$$21. \text{ If } f(x) = \frac{\sin^2 x}{2 + \sin^2 x} - \frac{2 + \cos^2 x}{\cos^2 x} \cos 2x, \quad x \in (0, \pi]. \text{ Then the maximum value of } f(x) \text{ is ?}$$

Ans. 06.00

$$\text{Sol. } R_1 \rightarrow R_1 - R_2$$

$$R_2 \rightarrow R_2 - R_3$$

$$\begin{array}{ccc} -2 & -2 & 0 \\ = & 2 & 0 & -1 \end{array}$$

$$\sin^2 x \quad \cos^2 x \quad 1 + \cos 2x$$

$$= -2(\cos^2 x) + 2(2 + 2\cos 2x + \sin^2 x)$$

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$$= -2(\cos^2 x - \sin^2 x) + 4 \cos 2x + 4$$

$$= 4 + 2\cos 2x = 2(2 + \cos 2x), \text{ maximum value of } f(x) = 6$$

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