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JEE
(Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 25 January, 2023 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300






SUBJECT: MATHEMATICS

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PART : MATHEMATICS

61. The integral $16 \int_1^2 \frac{dx}{x^3(x^2+2)^2}$ is equal to

- (1) $\frac{11}{6} - \log_e 4$ (2) $\frac{11}{12} + \log_e 4$ (3) $\frac{11}{6} + \log_e 4$ (4) $\frac{11}{12} - \log_e 4$

Ans. (1)

Sol.

$$\int_1^2 \frac{dx}{x^3 x^4 \left(1 + \frac{2}{x^2}\right)^2}$$

Let $1 + \frac{2}{x^2} = t \Rightarrow \frac{-4}{x^3} dx = dt$

$$I = \frac{-1}{4} \int_3^{\frac{3}{2}} \frac{(t-1)^2}{t^2} dt = -\frac{1}{16} \int_3^{\frac{3}{2}} \frac{(t^2 - 2t + 1)}{t^2} dt$$

$$= \frac{-1}{16} \int_3^{\frac{3}{2}} \left(1 - \frac{2}{t} + \frac{1}{t^2}\right) dt$$

$$= \frac{-1}{16} \left(t - 2 \ln|t| - \frac{1}{t} \right)_3^{\frac{3}{2}}$$

$$= \frac{-1}{16} \left(\frac{3}{2} - 2 \ln \frac{3}{2} - \frac{2}{3} \right) - \left(3 - 2 \ln 2 - \frac{1}{3} \right)$$

$$= \frac{-1}{16} \left(2 \left(\ln 2 - \ln \frac{3}{2} \right) - \frac{3}{2} - \frac{1}{3} \right)$$

$$= \frac{-1}{16} \left(2 \ln 3 - \frac{11}{6} \right) = \frac{-1}{16} \left(\ln 4 - \frac{11}{6} \right) = \frac{11 - 6 \ln 4}{16 \times 6}$$

$$\frac{11 - 6 \ln 4}{96}$$

62. $\sum_{k=0}^6 {}^{51-k}C_3$ is equal to

- (1) ${}^{51}C_3 - {}^{45}C_3$ (2) ${}^{52}C_4 - {}^{45}C_4$ (3) ${}^{52}C_3 - {}^{45}C_3$ (4) ${}^{51}C_4 - {}^{45}C_4$

Ans. (2)

Sol.

$${}^{51}C_3 + {}^{50}C_3 + \dots + {}^{45}C_3$$

$$\Rightarrow {}^{45}C_4 + {}^{45}C_3 + {}^{46}C_3 + \dots + {}^{51}C_3 - {}^{45}C_4$$

$$\Rightarrow {}^{46}C_4 + {}^{46}C_3 + \dots$$

$$= {}^{51}C_4 + {}^{51}C_3 - {}^{45}C_4 = {}^{52}C_4 - {}^{45}C_4$$

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63. Let A, B, C be 3×3 matrices such that A is symmetric and B and C are skew-symmetric.

Consider the statements

(S₁) $A^{13} B^{26} - B^{26} A^{13}$ is symmetric

(S₂) $A^{26} C^{13} - C^{13} A^{26}$ is symmetric

Then,

(1) Only S₁ is true

(2) Both S₁ and S₂ are false

(3) Both S₁ and S₂ are true

(4) Only S₂ is true

Ans. (4)

Sol. S₁ : $(A^{13} B^{26} - B^{26} A^{13})^T = (A^{13} B^{26})^T - (B^{26} A^{13})^T$

$$\Rightarrow (B^{26})^T (A^{13})^T - (A^{13})^T (B^{26})^T$$

$$\Rightarrow (B^T)^{26} (A^T)^{13} - (A^T)^{13} (B^T)^{26}$$

$$\Rightarrow (-B)^{26} A^{13} - A^{13} (-B)^{26}$$

$$\Rightarrow -(A^{13} B^{26} - B^{26} A^{13}) \text{ so skew symmetric}$$

$$S_2 : (A^{26} C^{13} - C^{13} A^{26})^T$$

$$= (C^T)^{13} (A^T)^{26} - (A^T)^{26} (C^T)^{13}$$

$$= -C^{13} A^{26} + A^{26} C^{13}$$

So, symmetric matrix

Hence S₂ is true and S₁ is false

64. The number of functions $f : \{1, 2, 3, 4\} \rightarrow \{a \in \mathbb{Z} \mid |a| \leq 8\}$ satisfying $f(n) + \frac{1}{n} f(n+1) = 1, \forall n \in \{1, 2, 3\}$ is

(1) 2

(2) 1

(3) 4

(4) 3

Ans. (1)

Sol. $nf(n) + f(n+1) = n$

$$f(1) + f(2) = 1$$

$$2f(2) + f(3) = 2$$

$$3f(3) + f(4) = 3$$

$$2 \cdot (1 - f(1)) + f(3) = 2$$

$$f(3) = 2f(1)$$

$$3 \cdot 2f(1) + f(4) = 3$$

$$f(4) = 3 - 6f(1)$$

$$-8 \leq f(4) \leq 8$$

$$-8 \leq 3 - 6f(1) \leq 8$$

$$-11 \leq -6f(1) \leq 5$$

$$-\frac{5}{6} \leq f(1) \leq \frac{11}{6}$$

$$f(1) = 0, 1$$

$$\text{C-I: } f(1) = 0, \Rightarrow f(2) = 1$$

$$f(3) = 0, f(4) = 3$$

$$\text{C-II: } f(1) = 1, \Rightarrow f(2) = 0$$

$$\Rightarrow f(3) = 2, f(4) = -3$$

so '2' such fⁿs.

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65. If the four points, whose position vectors are $3\hat{i} - 4\hat{j} + 2\hat{k}$, $\hat{i} + 2\hat{j} - \hat{k}$, $-2\hat{i} - \hat{j} + 3\hat{k}$ and $5\hat{i} - 2\alpha\hat{j} + 4\hat{k}$ are coplanar, then α is equal to

- (1) $\frac{107}{17}$ (2) $\frac{73}{17}$ (3) $-\frac{73}{17}$ (4) $-\frac{107}{17}$

Ans. (2)

Sol.
$$\begin{vmatrix} 3-5 & -4+2\alpha & 2-4 \\ 3-1 & -4-2 & 2+1 \\ 3+2 & -4+1 & 2-3 \end{vmatrix} = \begin{vmatrix} -2 & 2\alpha-4 & -2 \\ 2 & -6 & 3 \\ 5 & -3 & -1 \end{vmatrix} = 0$$

$$\begin{vmatrix} 0 & 2\alpha-4 & -2 \\ -1 & -6 & 3 \\ 6 & -3 & -1 \end{vmatrix} = 0 \Rightarrow -(2\alpha-4)(1-18)-2(3+36)=0$$

$$(\alpha-2)(-17)+39=0$$

$$\alpha-2 = \frac{39}{17} \Rightarrow \alpha = 2 + \frac{39}{17} = \frac{34+39}{17}$$

$$\alpha = \frac{73}{17}$$

66. Let $f(x) = 2x^n + \lambda$, $\lambda \in \mathbb{R}$, $n \in \mathbb{N}$ and $f(4) = 133$, $f(5) = 255$. Then the sum of all the positive integer divisors of $(f(3) - f(2))$ is

- (1) 59 (2) 60 (3) 61 (4) 58

Ans. (2)

Sol. $f(4) = 2(4^n) + \lambda = 133$ $f(5) = 2(5^n) + \lambda = 255$

$$f(5) - f(4) = 2(5^n - 4^n) = 122$$

$$\Rightarrow 5^n - (4^n) = 61$$

$$\Rightarrow n = 3$$

$$\Rightarrow \lambda = 5$$

$$\Rightarrow f(3) - f(2) = 2(3^3 - 2^3) = 2(27 - 8)$$

$$= 2(19) = 38 = 2^1 \cdot 19^1$$

$$\text{Hence sum of all positive integer divisors of } 38 \text{ is } = (2^0 + 2^1)(19^0 + 19^1) = 60$$

67. Let Δ , $\nabla \in \{\wedge, \vee\}$ be such that $(p \rightarrow q) \Delta (p \nabla q)$ is a tautology. Then

- (1) $\Delta = \wedge, \nabla = \wedge$ (2) $\Delta = \vee, \nabla = \vee$ (3) $\Delta = \vee, \nabla = \wedge$ (4) $\Delta = \wedge, \nabla = \vee$

Ans. (2)

Sol. If $\Delta = \nabla = \vee$

$$\Rightarrow (p \rightarrow q) \vee (p \vee q)$$

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

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



$$\Rightarrow (t \vee q) \vee q = t \vee q = t$$

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68. The equations of two sides of a variable triangle are $x = 0$ and $y = 3$, and its third side is a tangent to the parabola $y^2 = 6x$. The locus of its circumcentre is:

(1) $4y^2 - 18y + 3x + 18 = 0$

(2) $4y^2 - 18y - 3x + 18 = 0$

(3) $4y^2 + 18y + 3x + 18 = 0$

(4) $4y^2 - 18y - 3x - 18 = 0$

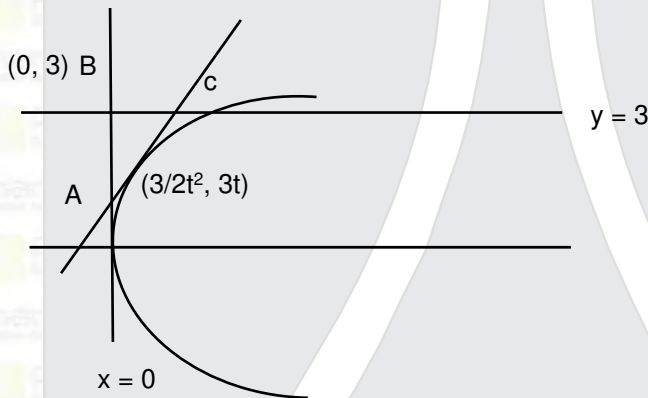
Ans. (1)

Sol. $AC \rightarrow T = 0 \Rightarrow yt = x + \frac{3}{2}t^2$

$A \rightarrow \left(0, \frac{3}{2}t\right)$ $C \rightarrow \left(3t - \frac{3}{2}t^2, 3\right)$

Circum-centre of ΔABC is mid point of AC so $2h = 3t - \frac{3}{2}t^2$, $2k = \frac{3}{2}t + 3$

eliminating $t \Rightarrow 4y^2 - 18y + 3x + 18 = 0$



69. Let T and C respectively be the transverse and conjugate axes of the hyperbola $16x^2 - y^2 + 64x + 4y + 44 = 0$. Then the area of the region above the parabola $x^2 = y + 4$, below the transverse axis T and on the right of the conjugate axis C is:

(1) $4\sqrt{6} + \frac{44}{3}$

(2) $4\sqrt{6} - \frac{28}{3}$

(3) $4\sqrt{6} + \frac{28}{3}$

(4) $4\sqrt{6} - \frac{44}{3}$

Ans. (3)

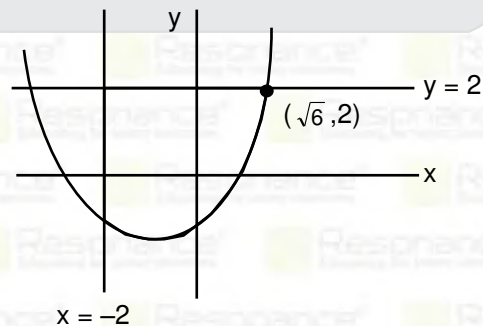
Sol. $16(x^2 + 4x) - (y^2 - 4y) + 44 = 0$

$16(x + 2)^2 - 64 - (y - 2)^2 + 4 + 44 = 0$

$16(x + 2)^2 - (y - 2)^2 = 16$

$\int_{-2}^{\sqrt{6}} (2 - (x^2 - 4)) dx = \int_{-2}^{\sqrt{6}} (6 - x^2) dx$

$6(\sqrt{16} + 2) - \frac{1}{3}(6\sqrt{6} + 8) = 4\sqrt{6} + \frac{28}{3}$



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70. The number of numbers, strictly between 5000 and 10000 can be formed using the digits 1,3,5,7,9 without repetition, is

- (1) 72 (2) 120 (3) 6 (4) 12

Ans. (1)

Sol. Digit in thousand place must be 5, 7 or 9.

= 3 ways

Now Total numbers between 5000 to 10000

are = $3 \times 4 \times 3 \times 2 = 72$

71. The shortest distance between the lines $x + 1 = 2y = -12z$ and $x = y + 2 = 6z - 6$ is

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

Ans. (3) $\frac{x+1}{12} = \frac{y}{6} = \frac{z}{-1}$ & $\frac{x}{6} = \frac{y+2}{6} = \frac{z-1}{1}$

$$\vec{n} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 12 & 6 & -1 \\ 6 & 6 & 1 \end{vmatrix} = i\hat{i}(12) - j\hat{j}(12+6) + k\hat{k}(12 \times 6 - 6 \times 6)$$

$$= 2\hat{i} - 3\hat{j} + 6\hat{k}$$

$$S.D = \left| (\hat{i} - 2\hat{j} + \hat{k}) \cdot \frac{(2\hat{i} - 3\hat{j} + 6\hat{k})}{\sqrt{4+9+36}} \right| = \frac{2+6+6}{7} = 2$$

72. Let z be a complex number such that $\left| \frac{z-2i}{z+i} \right| = 2$, $z \neq -i$. Then z lies on the circle of radius 2 and centre

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

Ans. (4)

Sol. $\left| \frac{x+iy-2i}{x+iy+i} \right| = 2 \Rightarrow \frac{x^2 + (y-2)^2}{x^2 + (y+1)^2} = 4$

$$\Rightarrow x^2 + y^2 - 4y + 4 = 4x^2 + 4y^2 + 8y + 4$$

$$\Rightarrow 3x^2 + 3y^2 + 12y = 0$$

$$x^2 + y^2 + 4y = 0$$


$$\text{Centre} = (0, -2)$$

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73. If the function $f(x) = \begin{cases} (1+|\cos x|)^{\frac{\lambda}{|\cos x|}}, & 0 < x < \frac{\pi}{2} \\ \mu, & x = \frac{\pi}{2} \\ \frac{\cot 6x}{e^{\cot 4x}}, & \frac{\pi}{2} < x < \pi \end{cases}$

is continuous at $x = \frac{\pi}{2}$, then $9\lambda + 6\log_e \mu + \mu^6 - e^{6\lambda}$ is equal to

- (1) $2e^4+8$ (2) 11 (3) 8 (4) 10

Ans. (4)

Reso (Bonus) Since Function must be

$$f(x) = \begin{cases} (1+|\cos x|)^{\frac{\lambda}{|\cos x|}}, & 0 < x < \frac{\pi}{2} \\ \mu, & x = \frac{\pi}{2} \\ \frac{\cot 6x}{e^{\cot 4x}}, & \frac{\pi}{2} < x < \pi \end{cases}$$

Sol. $f\left(\frac{\pi}{2}^+\right) = \lim_{x \rightarrow \frac{\pi}{2}^+} \frac{\cot 6x}{e^{\cot 4x}} = \lim_{x \rightarrow \frac{\pi}{2}^+} \frac{\sin 4x \cdot \cos 6x}{\sin 6x \cdot \cos 4x}$

$$= \lim_{x \rightarrow \frac{\pi}{2}^+} \frac{4 \cos 4x}{6 \cos 6x} = \frac{2}{3}$$

LHL $f\left(\frac{\pi}{2}^-\right) = \lim_{x \rightarrow \frac{\pi}{2}^-} (1+|\cos x|)^{\frac{\lambda}{|\cos x|}} = e^\lambda \Rightarrow \lambda = \frac{2}{3}, \mu = e^{\frac{2}{3}}$

So, $9\lambda + 6 \ln \mu + \mu^6 - e^{6\lambda}$

$$= 9\left(\frac{2}{3}\right) + 6\left(\frac{2}{3}\right) + e^4 - e^4 = 6 + 4 = 10$$

74. Let $A = \begin{bmatrix} 1 & 3 \\ \sqrt{10} & \sqrt{10} \\ -3 & 1 \\ \sqrt{10} & \sqrt{10} \end{bmatrix}$ and $B = \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix}$, where $i = \sqrt{-1}$.

If $M = A^T B A$, then the inverse of the matrix $A M^{2023} A^T$ is

- (1) $\begin{bmatrix} 1 & -2023 \\ 0 & 1 \end{bmatrix}$ (2) $\begin{bmatrix} 1 & 0 \\ 2023 & 1 \end{bmatrix}$ (3) $\begin{bmatrix} 1 & 2023 \\ 0 & 1 \end{bmatrix}$ (4) $\begin{bmatrix} 1 & 0 \\ 2023 & 1 \end{bmatrix}$

Ans. (3)

Sol. $A A^T = \begin{bmatrix} 1 & 3 \\ \sqrt{10} & \sqrt{10} \\ -3 & 1 \\ \sqrt{10} & \sqrt{10} \end{bmatrix} \begin{bmatrix} 1 & -3 \\ \sqrt{10} & \sqrt{10} \\ 3 & 1 \\ \sqrt{10} & \sqrt{10} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

$M^2 = (A^T B A) (A^T B A)$

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$$= A^T B (A A^T) B A$$

$$= A^T B I B A = A^T B^2 A$$

$$\text{Similarly } M^{2023} = A^T B^{2023} A$$

$$\therefore B^2 = \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -2i \\ 0 & 1 \end{bmatrix}$$

$$B^3 = \begin{bmatrix} 1 & -2i \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -i \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -3i \\ 0 & 1 \end{bmatrix} \Rightarrow B^{2023} = \begin{bmatrix} 1 & -2023i \\ 0 & 1 \end{bmatrix}$$

$$\therefore M^{2023} = A^T B^{2023} A$$

$$A^T M^{2023} A^T = A (A^T B^{2023} A) A^T$$

$$= B^{2023} = \begin{bmatrix} 1 & -2023i \\ 0 & 1 \end{bmatrix}$$

$$\text{hence } (B^{2023})^{-1} = \begin{bmatrix} 1 & 2023i \\ 0 & 1 \end{bmatrix}$$

75. The foot of perpendicular of the point $(2, 0, 5)$ on the line $\frac{x+1}{2} = \frac{y-1}{5} = \frac{z+1}{-1}$ is (α, β, γ) . Then which of the following is NOT correct ?

(1) $\frac{\gamma}{\alpha} = \frac{5}{8}$

(2) $\frac{\beta}{\gamma} = -5$

(3) $\frac{\alpha\beta}{\gamma} = \frac{4}{15}$

(4) $\frac{\alpha}{\beta} = -8$

Ans. (2)

Sol. $\vec{PF} \cdot \vec{a} = 0 \Rightarrow (\alpha-2)2 + \beta.5 + (\gamma-5)(-1) = 0$

$$2\alpha + 5\beta - \gamma + 1 = 0$$

$$2(2t-1) + 5(5t+1) - (-t+1) + 1 = 0$$

$$30t = -5 \Rightarrow t = -\frac{1}{6}$$

$$\frac{\alpha+1}{2} = \frac{\beta-1}{5} = \frac{\gamma+1}{-1} = t$$

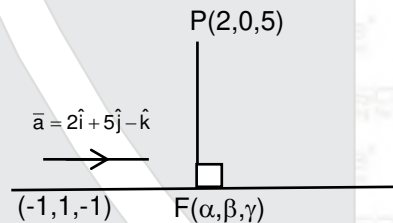
$$\alpha = -1 - \frac{1}{3} = -\frac{4}{3}$$

$$\beta = 1 - \frac{5}{6} = \frac{1}{6}$$

$$\gamma = -1 + \frac{1}{6} = -\frac{5}{6}$$

$$\frac{\beta}{\gamma} = -\frac{1}{5}, \frac{\gamma}{\alpha} = \frac{5}{6} \times \frac{3}{4} = \frac{5}{8}$$

$$\frac{\alpha\beta}{\gamma} = -\frac{4}{3} \times -\frac{1}{5} = \frac{4}{15}, \frac{\alpha}{\beta} = -\frac{4}{3} \times 6 = -8$$



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76. Let $f: \mathbb{R} \rightarrow \mathbb{R}$ be a function defined by $f(x) = \log_{\sqrt{m}} \left\{ \sqrt{2}(\sin x - \cos x) + m - 2 \right\}$, for some m , such that the range of f is $[0, 2]$. Then the value of m is _____.
- (1) 3 (2) 5 (3) 4 (4) 2

Ans. (2)

Sol. $\log_{\sqrt{5}} \left(\sqrt{2}(\sin x - \cos x) + m - 2 \right) \in [0, 2] \in [\log_{\sqrt{5}} 1, \log_{\sqrt{5}} 5]$

$$\Rightarrow \sqrt{2}(\sin x - \cos x) + m - 2 \in [1, m] \quad \dots\dots(i)$$

Range of $(\sin x - \cos x)$ is $[-\sqrt{2}, \sqrt{2}]$

So, from (i)

$$[-4 + m, m] \rightarrow [1, m] \Rightarrow -4 + m = 1 \Rightarrow m = 5$$

77. Let the function $f(x) = 2x^3 + (2p - 7)x^2 + 3(2p - 9)x - 6$ have a maxima for some value of $x < 0$ and a minima for some value of $x > 0$. Then, the set of all values of p is

- (1) $\left(\frac{9}{2}, \infty\right)$ (2) $\left(0, \frac{9}{2}\right)$ (3) $\left(-\frac{9}{2}, \frac{9}{2}\right)$ (4) $\left(-\infty, \frac{9}{2}\right)$

Ans. (4)

Sol. $f'(x) = 6x^2 + 2(2p - 7)x + 3(2p - 9)$

$$f'(0) < 0$$

$$3(2p - 9) < 0$$

$$2p - 9 < 0$$

$$p - \frac{9}{2} < 0 \Rightarrow p \in \left(-\infty, \frac{9}{2}\right)$$

78. Let $\vec{a} = -\hat{i} - \hat{j} + \hat{k}$, $\vec{a} \cdot \vec{b} = 1$ and $\vec{a} \times \vec{b} = \hat{i} - \hat{j}$. Then $\vec{a} - 6\vec{b}$ is equal to

- (1) $3(\hat{i} - \hat{j} - \hat{k})$ (2) $3(\hat{i} - \hat{j} + \hat{k})$ (3) $3(\hat{i} + \hat{j} - \hat{k})$ (4) $3(\hat{i} + \hat{j} + \hat{k})$

Ans. (4)

Sol. $\vec{a} \times \vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -1 & -1 & 1 \\ x & y & z \end{vmatrix}$

$$= (-z - y)\hat{i} - j(-z - x) + k(-y + x) = i - j$$

$$-z - y = 1, z + x = -1, x = y$$

also $(\vec{a} \cdot \vec{b}) = 1$

$$-x - y + z = 1$$

$$-2x + z = 1$$

$$x + z = -1$$

$$-3x = 2$$

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

$$y = -\frac{2}{3}, z = -1 + \frac{2}{3}$$

$$= -\frac{1}{3}$$

$$\text{now } \vec{a} - 6\vec{b} = (-\hat{i} - \hat{j} + \hat{k}) - 6\left(\frac{-2\hat{i}}{3} - \frac{2\hat{j}}{3} - \frac{\hat{k}}{3}\right)$$

$$= 3\hat{i} + 3\hat{j} + 3\hat{k}$$

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79. Let $y = y(t)$ be a solution of the differential equation $\frac{dy}{dt} + \alpha y = \gamma e^{-\beta t}$

where, $\alpha > 0$, $\beta > 0$ and $\gamma > 0$. Then $\lim_{t \rightarrow \infty} y(t)$

- (1) is -1 (2) is 0 (3) is 1 (4) does not exist

Ans. (2)

Sol. I.F. = $e^{\int \alpha dt} = e^{\alpha t}$

Solution $y \cdot e^{\alpha t} = \int e^{\alpha t} \cdot \gamma \cdot e^{-\beta t} dt + c$

$$\Rightarrow y e^{\alpha t} = \gamma \int e^{(\alpha-\beta)t} dt + c$$

$$\Rightarrow y(t) \cdot e^{\alpha t} = \gamma \frac{e^{(\alpha-\beta)t}}{(\alpha-\beta)} + c$$

$$\Rightarrow y(t) = \gamma \frac{e^{-\beta t}}{(\alpha-\beta)} + c e^{-\alpha t}$$

$$\lim_{t \rightarrow \infty} y(t) = \lim_{t \rightarrow \infty} \left(\frac{\gamma \cdot e^{-\beta t}}{(\alpha-\beta)} - c \cdot e^{-\alpha t} \right)$$

$$= 0 - 0 = 0$$

80. Let N be the sum of the numbers appeared when two fair dice are rolled and let the probability that

$N - 2$, $\sqrt{3N}$, $N + 2$ are in geometric progression be $\frac{k}{48}$. Then the value of k is.

- (1) 16 (2) 2 (3) 8 (4) 4

Ans. (4)

Sol. $n-2, \sqrt{3n}, n+2 \rightarrow$ G.P.

$$(\sqrt{3n})^2 = (n-2)(n+2)$$

$$\Rightarrow 3n = n^2 - 4$$

$$\Rightarrow n^2 - 3n - 4 = 0$$

$$\Rightarrow (n-4)(n+1) = 0$$

$$\Rightarrow n = 4, n = -1$$

$$\Rightarrow n = 4$$

$$P(S = 4) = \frac{3}{36} = \frac{1}{12} = \frac{4}{48}$$

$$\Rightarrow k = 4$$

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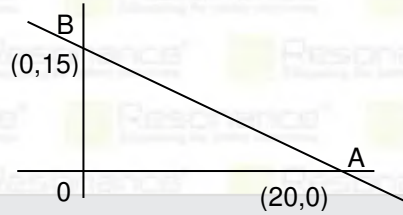
81. A triangle is formed by X-axis, Y-axis and the line $3x + 4y = 60$. Then the number of points $P(a, b)$ which lie strictly inside the triangle, where a is an integer and b is a multiple of a , is _____.

Ans. 31

Sol. $y = \frac{60 - 3x}{4}$

- (1, 1), (1, 2),(1, 14) → 14
- (2, 2), (2, 4),(2, 12) → 6
- (3, 3), (3, 6),(3, 12) → 4
- (4, 4), (4, 8), → 2
- (5, 5), (5, 10), → 2
- (6, 6), (7, 7), (8, 8) → 3

Total number of points lying inside the triangle = 31



82. If $\int_{\frac{1}{3}}^3 |\log_e x| dx = \frac{m}{n} \log_e \left(\frac{n^2}{e} \right)$, where m and n are co-prime natural numbers, then $m^2 + n^2 - 5$ is equal to _____.

Ans. 20

Sol. $\int_{\frac{1}{3}}^1 -\ln x dx + \int_1^3 \ln x dx$
 $-(x \ln x - x)_{\frac{1}{3}}^1 + (x \ln x - x)_1^3$
 $-[(0-1) - (\frac{1}{3} \ln \frac{1}{3} - \frac{1}{3})] + [(3 \ln 3 - 3) - (0-1)]$
 $2 - \frac{1}{3} + 3 \ln 3 - \frac{1}{3} \ln 3 - 3$
 $-\frac{4}{3} + \frac{8}{3} \ln 3 = (2 \ln 3 - 1) \frac{4}{3}$
 $\frac{4}{3} (\ln 9 - \ln e) = \frac{4}{3} \ln \frac{9}{e}$
 $m = 4, n = 3$
 $m^2 + n^2 - 5 = 4^2 + 3^2 - 5 = 20$

83. Suppose Anil's mother wants to give 5 whole fruits to Anil from a basket of 7 red apples, 5 white apples and 8 oranges. If in the selected 5 fruits, at least 2 orange, at least one red apple and at least one white apple must be given, then the number of ways, Anil's mother can offer 5 fruits to Anil is _____.

Ans. (6860)

Sol.	7 Red Apple	5 white Apple	8 oranges	
	x	+	y	+
	z	=	5	
	≥ 1		≥ 1	≥ 2
C-I	2		1	2
C-II	1		2	2
C-III	1		1	3

${}^7C_2 \cdot {}^5C_1 \cdot {}^8C_2 + {}^7C_1 \cdot {}^5C_2 \cdot {}^8C_2 + {}^7C_1 \cdot {}^5C_1 \cdot {}^8C_3$
 $= 2940 + 1960 + 1960 = 6860$

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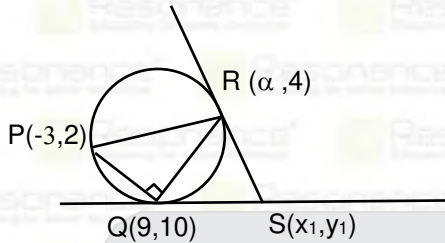
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84. Point P(-3, 2), Q (9, 10) and R (α, 4) lie on a circle C with PR as its diameter. The tangents to C at the points Q and R intersect at the point S. If S lies on the line 2x - ky = 1, then k is equal to _____ .

Ans. (3)



$$\frac{4-10}{\alpha-9} \times \frac{8}{12} = -1 \Rightarrow \alpha-9 = 6 \times \frac{2}{3} = 4 \Rightarrow \alpha = 13$$

$$(x+3)(x-13) + (y-2)(y-4) = 0 \Rightarrow x^2 + y^2 - 10x - 6y - 31 = 0$$

equation of line QR is

$$y-4 = \frac{-6}{4}(x-13)$$

$$\Rightarrow 2y-8 = -3x+39$$

$$3x+2y-47=0 \quad \dots\dots(i)$$

$$T=0 \Rightarrow xx_1 + yy_1 - 5(x+x_1) - 3(y+y_1) - 31 = 0$$

$$x(x_1-5) + y(y_1-3) - 5x_1 - 3y_1 - 31 = 0 \quad \dots\dots(ii)$$

(i) and (ii) are coincident

$$\frac{x_1-5}{3} = \frac{y_1-3}{2} = \frac{5x_1+3y_1+31}{47} = t$$

$$5(5+3t) + 3(3+2t) + 31 = 47t$$

$$\Rightarrow t = \frac{5}{2}$$

$$\Rightarrow S(x_1, y_1) = \left(\frac{25}{2}, 8\right)$$

$$2x - ky = 1 \Rightarrow k = \frac{2x-1}{y} = \frac{25-1}{8} = 3$$

85. If m and n respectively are the numbers of positive and negative values of θ in the interval $[-\pi, \pi]$ that satisfy the equation $\cos 2\theta \cos \frac{\theta}{2} = \cos 3\theta \cos \frac{9\theta}{2}$, then mn is equal to _____ .

Ans. (25)

Sol. $\cos \frac{5\theta}{2} + \cos \frac{3\theta}{2} = \cos \frac{15\theta}{2} + \cos \frac{3\theta}{2} \Rightarrow \frac{15\theta}{2} = 2n\pi \pm \frac{5\theta}{2} \begin{cases} 5\theta = 2n\pi \Rightarrow \theta = \frac{2n\pi}{5} \\ 10\theta = 2n\pi \Rightarrow \theta = \frac{n\pi}{5} \end{cases} \theta = \frac{n\pi}{5}$

$$-\pi \leq \frac{p\pi}{5} \leq \pi$$

$$-5 \leq p \leq 5$$

$$m = 5$$

$$n = 5$$

$$m n = 25$$

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86. The remainder when $(2023)^{2023}$ is divided by 35 is _____.

Ans. (7)

Sol. $-7^{2023} = -7 \times 7^{2022}$

$$= \frac{-7^{2022}}{5}$$

$$= \frac{-[50-1]^{011}}{5} = \frac{[5\lambda-1]}{5}$$

remainder = + 1

when divided by 5 now remainder is 7 when divided 35

87. 25% of the population are smokers. A smoker has 27 times more chances to develop lung cancer than a non smoker. A person is diagnosed with lung cancer and the probability that this person is a smoker is

$\frac{k}{10}$. Then the value of k is _____.

Ans. (9)

Sol. $P(S) = \frac{1}{4}, P(N) = \frac{3}{4}$

$$P\left(\frac{C}{S}\right) = 27 P\left(\frac{C}{N}\right); P\left(\frac{S}{C}\right) = \frac{P(S)P\left(\frac{C}{S}\right)}{P(S)P\left(\frac{C}{S}\right) + P(N)P\left(\frac{C}{N}\right)}$$

$$= \frac{\frac{1}{4} \times 27 \times P\left(\frac{C}{N}\right)}{\frac{1}{4} \times 27 \times P\left(\frac{C}{N}\right) + \frac{3}{4} \times P\left(\frac{C}{N}\right)} = \frac{27}{27+3} = \frac{27}{30} = \frac{9}{10} = \frac{k}{10} \Rightarrow k = 9$$

88. If the shortest distance between the line joining the points (1, 2, 3) and (2, 3, 4) and the line

$\frac{x-1}{2} = \frac{y+1}{-1} = \frac{z-2}{0}$ is α , then $28\alpha^2$ is equal to _____.

Ans. (18)

$$\frac{x-1}{1} = \frac{y-2}{1} = \frac{z-3}{1}$$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -1 & 0 \\ 1 & 1 & 1 \end{vmatrix} = \hat{i}(-1) - \hat{j} \cdot 2 + \hat{k} \cdot 3; \text{ S.D} = \left| \hat{i}(0) + 3\hat{j} + \hat{k} \right| \frac{\left| -\hat{i} - 2\hat{j} + 3\hat{k} \right|}{\sqrt{1+4+9}} = \alpha$$

$$\alpha = \left| \frac{-6+3}{\sqrt{14}} \right| \Rightarrow 14\alpha^2 = 9 \Rightarrow 28\alpha^2 = 18$$

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89. Let $\alpha \in \mathbb{R}$ and let α, β be the roots of the equation $x^2 + 60^{1/4}x + \alpha = 0$

If $\alpha^4 + \beta^4 = -30$, then the product of all possible values of α is _____.

Ans. (45)

Sol. Since, $\alpha^4 + \beta^4 = -30$

$$\Rightarrow [(\alpha + \beta)^2 - 2\alpha\beta]^2 - 2\alpha^2\beta^2 = -30$$

$$\Rightarrow [(-60^{1/4})^2 - 2a]^2 - 2a^2 = -30$$

$$\Rightarrow (\sqrt{60} - 2a)^2 = 2a^2 - 30$$

$$\Rightarrow 60 + 4a^2 - 4a\sqrt{60} = 2a^2 - 30$$

$$\Rightarrow 2a^2 - 4a(\sqrt{60}) + 90 = 0$$

$$\Rightarrow a^2 - 2a(\sqrt{60}) + 45 = 0$$

So, product of value of $a = 45$

90. For the two positive numbers a, b , if a, b and $\frac{1}{18}$ are in a geometric progression, while $\frac{1}{a}, 10$ and $\frac{1}{b}$ are in an arithmetic progression, then $16a + 12b$ is equal to _____.

Ans. (3)

Sol. $b^2 = \frac{a}{18}$

$$20 = \frac{1}{a} + \frac{1}{b}$$

$$20 = \frac{1}{18b^2} + \frac{1}{b}$$

$$360b^2 = 1 + 18b$$

$$360b^2 - 18b - 1 = 0$$

$$b = \frac{18 + 42}{360 \times 2} = \frac{1}{12}$$

$$\text{and } a = 18b^2 = \frac{18}{144} = \frac{1}{8}$$


$$\text{So, } 12b + 16a = 1 + 2 = 3$$

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