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# JEE

## (Main)

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

# 2024

### COMPUTER BASED TEST (CBT)

### Memory Based Questions & Solutions

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Date: 27 January, 2024 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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PART : MATHEMATICS

1. The number of common terms of the progression 4, 9, 14 .....up to 25 terms and 3, 6, 9, ....  
Up to 27 terms is

Up to 37 terms, is

- (1) 8 (2) 9 (3) 7 (4) 10

Ans. (3)

Sol. 4, 9, 14 ..... and 3, 6, 9, .....

$$T_{25} = 124 \quad T_{37} = 37 \times 3 = 111$$

Common diff : 5      common diff = 3

Clearly first common term = 9

Common diff = L.C.M (5, 3) = 15

$\therefore T_n$  (of common terms of two given A.P)

$$= 9 + (n-1) \times 15 \\ = 15n - 6$$

$$\therefore 15n - 6 \leq 111$$

$$15n \leq 117$$

$$n \leq 7.8$$

$\therefore$  Number of common terms = 7

2. If  $\int_0^1 \frac{1}{\sqrt{3+x} + \sqrt{1+x}} dx = a + b\sqrt{2} + c\sqrt{3}$ . Then  $(a - 3b - 4c)$  is equal to.

- (1) 7 (2) 9 (3) 8 (4) 10

Ans. (2)

Sol. 
$$\int_0^1 \frac{1}{\sqrt{3+x} + \sqrt{1+x}} dx = \frac{1}{2} \left( \frac{2}{3} (3+x)^{\frac{3}{2}} - \frac{2}{3} (1+x)^{\frac{3}{2}} \right)_0^1$$
$$= \frac{1}{3} \left[ \left( 4^{\frac{3}{2}} - 2^{\frac{3}{2}} \right) - \left( 3^{\frac{3}{2}} - 1^{\frac{3}{2}} \right) \right]$$
$$= \frac{1}{3} (2^3 - 2\sqrt{2} - 3\sqrt{3} + 1) = \frac{1}{3} (9 - 2\sqrt{2} - 3\sqrt{3}) = 3 - \frac{2}{3}\sqrt{2} - \sqrt{3}$$

$$a = 3, b = -\frac{2}{3}, c = -1$$

$$a - 3b - 4c = 3 - 3 \left( -\frac{2}{3} \right) - 4(-1) = 9$$

3. If  $8 = 3 + \frac{3+p}{4} + \frac{3+2p}{4^2} + \dots \infty$ , then  $p$  is equal to.

- (1) 9 (2)  $\frac{5}{4}$  (3) 3 (4) 1

Ans. (1)

Sol.  $8 = 3 + \frac{3+p}{4} + \frac{3+2p}{4^2} + \dots$  (1)

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$$2 = \frac{3}{4} + \frac{3+p}{4^2} + \dots \quad (2)$$

(1) - (2)

$$6 = 3 + \frac{p}{4} + \frac{p}{4^2} + \dots$$

$$3 = \frac{p}{4} + \frac{p}{4^2} + \dots$$

$$\frac{p}{4} = 3 \Rightarrow p = 9$$

4. Chord length of ellipse  $\frac{x^2}{25} + \frac{y^2}{16} = 1$  with mid point  $\left(1, \frac{2}{5}\right)$  is equal to \_\_\_\_\_.

(1)  $\frac{\sqrt{1681}}{5}$

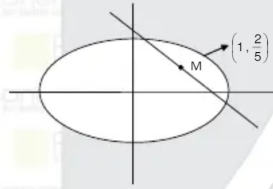
(2)  $\frac{\sqrt{1691}}{5}$

(3)  $\frac{\sqrt{691}}{5}$

(4)  $\frac{\sqrt{961}}{5}$

Ans. (2)

Sol.



$$T = S_1 \Rightarrow \frac{x}{25} + \frac{y \cdot 2}{16} = \frac{1}{25} + \frac{4}{16 \times 25}$$

$$\frac{x}{25} + \frac{y}{8 \times 5} = \frac{5}{100}$$

$$4x + \frac{5}{2}y = 5 \Rightarrow 8x + 5y - 10 = 0$$

$$\frac{x^2}{25} + \frac{y^2}{16} = 1 \Rightarrow (4x)^2 + (5y)^2 = 400$$

$$\Rightarrow (4x)^2 + (8x - 10)^2 = 400$$

$$\Rightarrow 4x^2 + (4x - 5)^2 = 100 \Rightarrow 20x^2 - 40x - 75 = 0$$

$$\Rightarrow 4x^2 - 8x - 15 = 0$$

$$l = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} = \sqrt{(x_2 - x_1)^2 + \left\{ \frac{10 - 8x_2}{5} - \frac{(10 - 8x_1)}{5} \right\}^2}$$

$$= \sqrt{(x_2 - x_1)^2 + \frac{64}{25}(x_2 - x_1)^2} = \sqrt{\frac{89}{4}(x_2 - x_1)^2}$$

$$= \sqrt{\frac{89}{4}} \sqrt{(x_1 - x_2)^2 - 4x_1x_2} = \sqrt{\frac{89}{5}} \sqrt{4 + 4 \times \frac{15}{4}} = \frac{\sqrt{89} \times \sqrt{19}}{5}$$

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5. If  $\sum_{i=1}^{10} x_i = 50$ , and  $\sum_{i < j} x_i x_j = 1100$ , then standard deviation of  $x_1, x_2, \dots, x_{10}$  is

(1) 5

(2) 2

(3)  $\sqrt{2}$

(4)  $\sqrt{5}$

Ans. (4)

Sol.  $\therefore \left( \sum_{i=1}^{10} x_i \right)^2 = \sum_{i=1}^{10} x_i^2 + 2 \left( \sum_{i < j} x_i x_j \right)$

$$\Rightarrow (50)^2 = \sum_{i=1}^{10} x_i^2 + 2(1100)$$

$$\Rightarrow \sum_{i=1}^{10} x_i^2 = 2500 - 2200 = 300$$

$$\therefore \sigma^2 = \frac{\sum x_i^2}{10} - \left( \frac{\sum x_i}{10} \right)^2$$

$$\Rightarrow \sigma^2 = \frac{300}{10} - \left( \frac{50}{10} \right)^2 = 30 - 25$$

$$\therefore \text{standard deviation} = \sqrt{5}$$

6. If the shortest distance of the parabola  $y^2 = 4x$  from the centre of the circle  $x^2 + y^2 - 4x - 16y + 64 = 0$  is 'd', then find  $d^2$

(1) 10

(2) 20

(C) 30

(4) 15

Ans. (2)

Sol.  $y^2 = 4x$  ;  $x^2 + y^2 - 4x - 16y + 64 = 0$   
circle (2,8) radius = 2

$\therefore$  shortest distance will lie along common normal

∴ normal at p(t) to parabola is  
 ∴  $y + tx = 2t + t^2$ , now it will pass through (2, 8)  
 $\Rightarrow 8 + 2t = 2t + t^2$   
 $t = 2 \therefore p(t) \equiv p(t^2, 2t) \equiv P(4, 4)$   
 $\therefore d = \sqrt{4+16} = \sqrt{20}$   
 $\therefore d^2 = 20$

7. If  $f(x) = x^3 + x^2 f'(1) + x f''(2) + f'''(3)$ . Then find  $f'(10)$ .

Ans. (202)

Sol.  $f(x) = x^3 + ax^2 + bx + c$

$$f'(x) = 3x^2 + 2xf'(1) + f''(2)$$

$$f''(x) = 6x + 2f'(1)$$

$$f'''(x) = 6$$

$$f'''(3) = 6$$

$$f'''(2) = 12 + 2f'(1)$$

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

adding

$$0 = 15 + 3f'(1) \Rightarrow f'(1) = -5$$

$$f''(2) = 12 - 10 = 2$$

$$x = 10$$

$$f'(10) = 300 + 20(-5) + 2 = 300 - 100 + 2 = 202$$

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8. If  ${}^{n-1}C_r = (k^2 - 8) {}^n C_{r+1}$ , then an interval in which k lies is

- (1)  $(2\sqrt{2}, 3]$  (2)  $(-2\sqrt{2}, 2\sqrt{2})$  (3)  $(3, \infty)$  (4)  $(-\infty, -3)$

Ans. (1)

Sol.  ${}^{n-1}C_r = (k^2 - 8) \frac{n}{r+1} {}^{n-1}C_r$

$$k^2 - 8 = \frac{r+1}{n}$$

$$0 < k^2 - 8 \leq 1$$

$$8 < k^2 \leq 9$$

$$2\sqrt{2} < k \leq 3 \text{ or } -3 \leq k < -2\sqrt{2}$$

9. Let  $\vec{a} = \hat{i} + 2\hat{j} + k\hat{k}$ ,  $\vec{b} = 3(\hat{i} - \hat{j} + \hat{k})$  and a vector  $\vec{c}$  is defined such that  $\vec{a} \times \vec{c} = \vec{b}$  and  $\vec{a} \cdot \vec{c} = 3$ , then

$$\vec{a} \cdot ((\vec{c} \times \vec{b}) - \vec{b} - \vec{c}) \text{ is}$$

- (1) 24 (2) 25 (3) 52 (4) 42

Ans. (1)

Sol.  $(\vec{a} \times \vec{c}) \cdot \vec{b} = \vec{b} \cdot \vec{b}$

$$[\vec{a} \vec{c} \vec{b}] = 9(1 + 1 + 1) = 27$$

$$\vec{a} \cdot \vec{b} = 3(1 - 2 + 1) = 0$$

$$\vec{a} \cdot \vec{c} = 3$$

$$\vec{a} \cdot ((\vec{c} \times \vec{b}) - \vec{b} - \vec{c}) = [\vec{a} \vec{c} \vec{b}] - \vec{a} \cdot \vec{b} - \vec{a} \cdot \vec{c}$$

$$= 27 - 0 - 3 = 24$$

10. Let  $a \in \mathbb{R}$  such that equation  $\cos 2x + \sin x = 2a - 7$  has a solution. If range of a is  $[p, q]$  and

$$r = \tan 9^\circ + \tan 81^\circ - \frac{1}{\cot 63^\circ} - \tan 27^\circ, \text{ then } pqr \text{ is } \underline{\hspace{2cm}}.$$

Ans. (48)

Sol.  $1 - 2 \sin^2 x + \sin x = 2a - 7$

$$2t^2 - at + 2a - 8 = 0$$

$$\Rightarrow (t - 2)(2t + 4 - a) = 0$$

$$\Rightarrow a = 2 \sin x + 4$$

$$a \in [2, 6] \Rightarrow p = 2, q = 6$$



$$\tan \theta + \cot \theta = 2 \operatorname{cosec} 2\theta$$

$$r = 2 \operatorname{cosec} 18^\circ - 2 \operatorname{cosec} 54^\circ = 2 \left[ \frac{4}{\sqrt{5}-1} - \frac{4}{\sqrt{5}+1} \right]$$

$$= 8 \times \frac{2}{5-1} = 4$$

$$\text{So } pqr = 2 \times 6 \times 4 = 48$$

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11.  $a = \lim_{x \rightarrow 0} \frac{\sqrt{1+\sqrt{1+x^4}} - \sqrt{2}}{x^4}$

$$b = \lim_{x \rightarrow 0} \frac{\sin^2(x)}{\sqrt{2} - \sqrt{1+\cos x}}$$

Then  $ab^3 =$

(1) 16

(2) 32

(3) 48

(4) 8

Ans. (2)

Sol.  $a = \lim_{x \rightarrow 0} \frac{\sqrt{1+\sqrt{1+x^4}} - \sqrt{2}}{x^4}$

$$= \lim_{x \rightarrow 0} \frac{1 + \sqrt{1+x^4} - 2}{x^4 (\sqrt{1+\sqrt{1+x^4}} + \sqrt{2})}$$

$$= \frac{1}{2\sqrt{2}} \lim_{x \rightarrow 0} \frac{\sqrt{1+x^4} - 1}{x^4}$$

$$= \frac{1}{2\sqrt{2}} \lim_{x \rightarrow 0} \frac{(1+x^4) - 1}{x^4 (\sqrt{1+x^4} + 1)} = \frac{1}{2\sqrt{2}} \cdot \frac{1}{2} = \frac{1}{4\sqrt{2}}$$

$$b = \lim_{x \rightarrow 0} \frac{(1 - \cos^2 x) \sqrt{2 + \sqrt{1 + \cos x}}}{2 - (1 + \cos x)}$$

$$= \lim_{x \rightarrow 0} (1 + \cos x) \sqrt{2 + \sqrt{1 + \cos x}}$$

$$= (2)(2\sqrt{2}) = 4\sqrt{2}$$

$$\text{So } ab^3 = \frac{1}{4\sqrt{2}} \times 64(2\sqrt{2}) = 32$$

12. If the sum of coefficients in expansion of  $(1 - 3x + 10x^2)^n$  is A and that of in  $(1 + x^2)^n$  is B, then  $(n \in \mathbb{N})$

(1)  $A = B^3$

(2)  $B = A^3$

(3)  $A = 3B$

(4)  $B = 3A$

Ans. (1)

Sol. Taking  $n = 1$

$$1 - 3 + 10 = A, \quad 1 + 1 = B$$

$$A = 8, B = 2, A = B^3$$

Alternate

$$\text{Put } x = 1 \quad (1 - 3 + 10)^n = A, (1 + 1)^n = B$$

$$8^n = A, 2^n = B$$

$$(2^n)^3 = A \Rightarrow A = B^3$$

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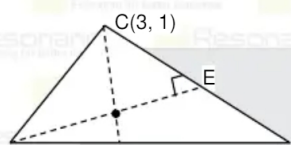
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13. The vertices of a triangle are (1, 2), (2, 3), (3, 1) and its orthocentre is (a, b) if  $I_1 = \int_a^b x \sin(4x - x^2) dx$

$$I_2 = \int_a^b \sin(4x - x^2) dx, \text{ then find } \frac{36 I_1}{I_2}$$

Ans. (72)

Sol.



A (1, 2)      D      B(2, 3)

$$m_{AB} = 1$$

$$m_{BC} = -2$$

$$m_{CD} = -1$$

$$m_{AE} = \frac{1}{2}$$

Equation of CD is

Equation of AE is

$$y - 1 = -1(x - 3)$$

$$y - 2 = \frac{1}{2}(x - 1)$$

$$x + y = 4 \quad \text{--- (1)}$$

$$2y - 4 = x - 1$$

$$x - 2y = -3 \quad \text{--- (2)}$$

Now co-ordinates of orthocentre is  $H\left(\frac{5}{3}, \frac{7}{3}\right)$

$$I_1 = \int_{\frac{5}{3}}^{\frac{7}{3}} x \sin(4x - x^2) dx = \int_{\frac{5}{3}}^{\frac{7}{3}} x \sin(x(4-x)) dx$$

$$I_1 = \int_{\frac{5}{3}}^{\frac{7}{3}} (4-x) \sin((4-x)x) dx$$

$$\text{Now } 2I_1 = \int_{\frac{5}{3}}^{\frac{7}{3}} 4 \sin(4x - x^2) dx$$

$$2I_1 = 4I_2$$

$$I_1 = 2I_2$$

$$\frac{I_1}{I_2} = 2$$

$$\frac{36I_1}{I_2} = 72$$

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14. Let  $S = \{1, 2, 3, \dots, 10\}$ ,  $M$  is the set of all subsets of  $S$ ,  $R: M \rightarrow M$  be a relation such that

$(A, B) \in R \Rightarrow A \cap B = \phi$  then relation  $R$  is

- (1) symmetric (2) Transitive (3) Reflexive (4) none

Ans. (1)

Sol.  $A \in M$

$$A \cap A = A \neq \phi$$

So  $R$  is not reflexive

If  $(A, B) \in R$

$$A \cap B = \phi \Rightarrow B \cap A = \phi$$

$$\Rightarrow (B, A) \in R$$

So  $R$  is symmetric

If  $(A, B)$  and  $(B, C) \in R \Rightarrow A \cap B = \phi$  and  $B \cap C = \phi$

$\Rightarrow A \cap C$  is not necessarily  $\phi$  set. Hence  $A \cap C$  not necessarily belongs to  $R$ .

So  $R$  is not a transitive relation

eg.  $A = \{1, 2\}$ ,  $B = \{3, 4\}$ ,  $C = \{2, 5\}$

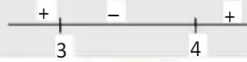
$$A \cap B = \phi, B \cap C = \phi \text{ but } A \cap C = \{2\} \neq \phi$$

15. If  $f(x) = \begin{cases} a(7x - x^2 - 12) & ; x < 3 \\ b & ; x = 3 \\ \sin(x-3) & ; x > 3 \end{cases}$  is continuous at  $x = 3$ , then number of ordered pairs  $(a, b)$  are

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

Ans. (1)

Sol.  $x^2 - 7x + 12 = (x - 3)(x - 4)$



$$\begin{cases} -\frac{a}{b} & ; x < 3 \\ b & ; x = 3 \\ \sin(x-3) & ; 3 < x < 4 \\ 2^{x-3} & ; x > 4 \end{cases}$$

$$-\frac{a}{b} = b = 2^1 \Rightarrow b = 2, -a = 4$$

$$(a, b) = (-4, 2)$$

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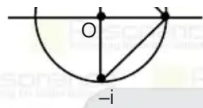
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16.  $S = \{z : |z + i| = |z - i| = |z - 1|\}$ , then  $n(S)$  is equal to

Ans. (1)

Sol.





17. If  $\alpha$  satisfies the equations  $1 + x + x^2 = 0$  and  $(1+\alpha)^7 = a + b\alpha + c\alpha^2$ , where  $a, b, c \in \mathbb{R}$  then  $5(3a - 2b - c)$  is \_\_\_\_\_

Ans. (5)

Sol.  $1 + x + x^2 = 0 \Rightarrow \alpha = \omega \text{ or } \omega^2$

Let  $\alpha = \omega$

so  $(1 + \omega)^7 = a + b\omega + c\omega^2 \quad \omega = \frac{-1 + \sqrt{3}i}{2}$

$-\omega^2 = a + b\omega + c\omega^2 \quad \omega^2 = \frac{-1 - \sqrt{3}i}{2}$

$a + b\omega + (c+1)\omega^2 = 0$

$\Rightarrow a + b\left(\frac{-1 + \sqrt{3}i}{2}\right) + (c+1)\left(\frac{-1 - \sqrt{3}i}{2}\right) = 0$

$\Rightarrow a - \frac{b+c+1}{2} = 0 \quad \& \quad \frac{\sqrt{3}}{2}b - \frac{\sqrt{3}}{2}(c+1) = 0$

$2a - b - c - 1 = 0$

$\Rightarrow b - c = 1$

$2a - b - b = 0$

$b = c + 1$

$a = b$

so  $5(3a - 2b - c) = 5(3b - 2b - c) = 5(b - c) = 5 \times 1 = 5$

18. If the points  $(2k, 3k)$ ,  $(1, 0)$ ,  $(0, 0)$  and  $(0, 1)$  lie on a circle then the value of  $k$  is

(1)  $\frac{5}{13}$

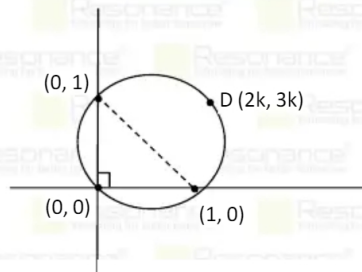
(2)  $\frac{10}{13}$

(3)  $\frac{13}{5}$

(4)  $\frac{13}{10}$

Ans. (1)

Sol.



Equation of circle is

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$(x-1)(x-0) + (y-0)(y-1) = 0$

In satisfy D(2k, 3k)

$(2k-1)(2k) + (3k)(3k-1) = 0$

$4k^2 - 2k + 9k^2 - 3k = 0$

$13k^2 - 5k = 0$

$\Rightarrow k = 0, \frac{5}{13}$

When  $k = 0$  Point D(0, 0)

So value of  $k = \frac{5}{13}$ .

19. If  $f(x) - f(y) = \ell n\left(\frac{x}{y}\right) + x - y$ , then find  $\sum_{k=1}^{20} f'\left(\frac{1}{k^2}\right)$

Ans. (2890)

Sol.  $f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} = \lim_{h \rightarrow 0} \left[ \ell n \frac{x+h}{x} + h - x + x \right] = \lim_{h \rightarrow 0} \left[ \ell n \left(1 + \frac{h}{x}\right) + h \right] = \frac{1}{x} + 1$

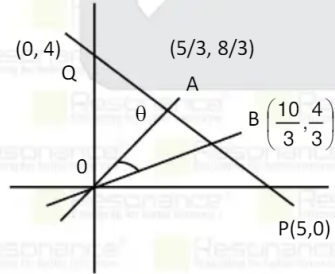
$$\sum_{k=1}^{20} f\left(\frac{1}{k^2}\right) = \sum_{k=1}^{20} (k^2 + 1) = \sum_{k=1}^{20} k^2 + \sum_{k=1}^{20} 1$$

$$= \frac{20 \times 21 \times 41}{6} + 20 = 2870 + 20 = 2890$$

20. Let  $L_1$  and  $L_2$  be two lines passing through the origin and trisect the portion of the line  $4x + 5y = 20$  which is intercepted between the co-ordinate axes, then the tangent of angle between the lines  $L_1$  and  $L_2$  is equal to

- (1)  $\frac{8}{5}$                       (2)  $\frac{41}{15}$                       (3)  $\frac{15}{41}$                       (4)  $\frac{30}{41}$

Ans. (4)  
Sol.



$$A\left(\frac{5}{3}, \frac{8}{3}\right), B\left(\frac{10}{3}, \frac{4}{3}\right)$$

$$m_{OA} = m_2 = \frac{8}{5}$$

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$$m_{OB} = m_1 = \frac{2}{5}$$

$$\tan\theta = \left| \frac{m_2 - m_1}{1 + m_1 m_2} \right| = \left| \frac{\frac{8}{5} - \frac{2}{5}}{1 + \frac{8}{5} \times \frac{2}{5}} \right|$$

$$= \frac{\frac{6}{5}}{1 + \frac{16}{25}} = \frac{6 \times 5}{25 + 16} = \frac{30}{41}$$

21. If one root of equation  $x^2 - px + 5 = 0$  is 4 and equation  $x^2 - px + q = 0$  has equal roots, then value of q is

- (1)  $\frac{441}{16}$                       (2)  $\frac{21}{64}$                       (3)  $\frac{441}{64}$                       (4)  $\frac{21}{16}$

Ans. (3)

Sol.  $16 - 4p + 5 = 0$

$$\Rightarrow p = \frac{21}{4}$$

$$x^2 - \frac{21}{4}x + q = 0$$

$$4x^2 - 21x + 4q = 0$$

Equation has equal roots, so

$$D = 0$$

$$441 - 64q = 0$$

$$q = \frac{441}{64}$$

22. Shortest distance between the lines



$$\frac{x-1}{2} = \frac{y+1}{4} = \frac{z-1}{3} \text{ and } \frac{2x-1}{5} = \frac{y-2}{3} = \frac{z}{6} \text{ is equal to}$$

(1)  $\frac{17}{\sqrt{1045}}$       (2)  $\frac{34}{\sqrt{1045}}$       (3)  $\frac{21}{\sqrt{964}}$       (4)  $\frac{17}{\sqrt{964}}$

Ans. (2)

Sol.  $SD = \frac{|\vec{a}_2 - \vec{a}_1 \cdot \vec{b}_1 \cdot \vec{b}_2|}{|\vec{b}_1 \times \vec{b}_2|}$

$$\Rightarrow \text{S.D.} = \frac{\begin{vmatrix} 1 & -1 & 2+1 & 0 & -1 \\ 2 & 5 & 3 & 6 & \\ 2 & 2 & 4 & 3 & \end{vmatrix}}{\begin{matrix} i & j & k \\ 5 & 3 & 6 \\ 2 & 2 & 4 \end{matrix}}$$

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$$\Rightarrow \text{S.D.} = \frac{-\frac{1}{2}(9-24) - 3\left(\frac{15}{2} - 12\right) - 1(10-6)}{\hat{i}(9-24) - \hat{j}\left(\frac{15}{2} - 12\right) + \hat{k}(10-6)}$$

$$\Rightarrow \text{S.D.} = \frac{\frac{15}{2} + \frac{27}{2} - 4}{\sqrt{225 + \frac{81}{4} + 16}} = \frac{21-4}{\sqrt{241 + \frac{81}{4}}} = \frac{34}{\sqrt{964 + 81}} = \frac{34}{\sqrt{1045}}$$

23.  $A = \begin{bmatrix} 2 & 0 & 1 \\ 1 & 0 & 0 \\ 3 & 2 & 0 \end{bmatrix}$ ;  $B = [B_1 \ B_{11} \ B_{111}]$ , where  $B_1, B_{11}, B_{111}$  are column vectors such that

$$AB_1 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, AB_{11} = \begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix}, AB_{111} = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$$

If  $\alpha =$  sum of the diagonal elements of  $B$ ,

$\beta = \text{Det}(B)$ , then value of  $8|\alpha^3 + \beta^3| =$

Ans. (9)

Sol. Let  $B_1 = \begin{bmatrix} p \\ q \\ r \end{bmatrix}$

$$AB_1 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

$$\Rightarrow AB_1 = \begin{bmatrix} 2 & 0 & 1 \\ 1 & 0 & 0 \\ 3 & 2 & 0 \end{bmatrix} \begin{bmatrix} p \\ q \\ r \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \begin{matrix} 2p + r = 1 \\ r = 1 \end{matrix}$$

$$\begin{matrix} p = 0 \\ 3p + 2q = 0 \Rightarrow q = 0 \end{matrix}$$

$$B_1 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$\dots \dots \begin{bmatrix} x \end{bmatrix}$$

$$\text{Let } B_{11} = \begin{bmatrix} y \\ z \end{bmatrix}$$

$$AB_{11} = \begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix}$$

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$$\Rightarrow \begin{bmatrix} 2 & 0 & 1 \\ 1 & 0 & 0 \\ 3 & 2 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ 1 \end{bmatrix} \Rightarrow 2x + z = 2 \Rightarrow z = 2$$

$$x = 0$$

$$3x + 2y = 1 \Rightarrow y = \frac{1}{2}$$

$$B_{11} = \begin{bmatrix} 0 \\ 1/2 \\ 2 \end{bmatrix}$$

$$\text{Let } B_{111} = \begin{bmatrix} \lambda \\ \mu \\ \phi \end{bmatrix}$$

$$AB_{111} = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 2 & 0 & 1 \\ 1 & 0 & 0 \\ 3 & 2 & 0 \end{bmatrix} \begin{bmatrix} \lambda \\ \mu \\ \phi \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix} \Rightarrow 2\lambda + \phi = 3 \Rightarrow \phi = -1$$

$$\lambda = 2$$

$$3\lambda + 2\mu = 1 \Rightarrow \mu = -\frac{5}{2}$$

$$B_{111} = \begin{bmatrix} 2 \\ -5/2 \\ -1 \end{bmatrix} \Rightarrow B = \begin{bmatrix} 0 & 0 & 2 \\ 0 & 1/2 & -5/2 \\ 1 & 2 & -1 \end{bmatrix}$$

$$\alpha = 0 + 1/2 - 1 = -1/2$$

$$\beta = \begin{vmatrix} 0 & 0 & 2 \\ 0 & 1/2 & -5/2 \\ 1 & 2 & -1 \end{vmatrix} = 2 \left( -\frac{1}{2} \right) = -1$$

$$|\alpha^3 + \beta^3| = \left| -\frac{1}{8} - 1 \right| = \frac{9}{8} \Rightarrow 8|\alpha^3 + \beta^3| = 9$$

24. If  $f : N - \{1\} \rightarrow N - \{1\}$  is given by  $f(n) =$  largest prime factor of  $n$ , then  $f$  is  
 (1) one-one and onto (2) one-one and into  
 (3) Many one and onto (4) Many one and into

Ans. (4)

Sol. Largest prime factors of two different natural numbers can be same so it is many-one.

example  $f(6) = 3, f(12) = 3$

As range of  $f(x)$  is set of prime numbers so range of  $f(x)$  is proper subset of co-domain so  $f$  is into.

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25. Matrix  $f(x) = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Statement 1:  $f(-x)$  is inverse of  $f(x)$

Statement 2:  $f(x)f(y) = f(x+y)$

(1) Statement- 1 is true & Statement -2 is true      (2) Statement- 1 is true & Statement -2 is false

(3) Statement- 1 is false & Statement -2 is true      (4) Statement- 1 is false & Statement -2 is false

Ans. (1)

Sol.  $f(x) = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix}$

$$f(x)f(y) = \begin{bmatrix} \cos x & -\sin x & 0 \\ \sin x & \cos x & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos y & -\sin y & 0 \\ \sin y & \cos y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos(x+y) & -\sin(x+y) & 0 \\ \sin(x+y) & \cos(x+y) & 0 \\ 0 & 0 & 1 \end{bmatrix} = f(x+y)$$

So statement 2 is true

$f(x) \cdot f(-x) = I$  so,  $f(-x)$  is inverse of  $f(x)$ .

so statement 1 is true

26. If  $\frac{dx}{dt} + ax = 0$ ,  $x(0) = 2$ ,

$\frac{dy}{dt} + by = 0$ ,  $y(0) = 1$ , and

$3(x(1)) = 2(y(1))$  and  $x(t) = y(t)$  then  $t$  is equal to

(1)  $\log_3 2$

(2)  $\log_2 3$

(3)  $2 \log_3 2$

(4)  $3 \log_2 3$

Ans. (1)

Sol.  $\int \frac{1}{x} dx = -\int a dt \Rightarrow \ln|x| = -at + C$

$\Rightarrow x = \pm e^C \cdot e^{-at} \quad x = \lambda \cdot e^{-at}$

$x(0) = 2 \Rightarrow \lambda = 2$  so  $x = 2e^{-at}$  (1)

$\frac{dy}{dt} = -by \Rightarrow \int \frac{1}{y} dy = \int -b dt$

$\Rightarrow \ln|y| = -bt + c \Rightarrow y = \pm e^c \cdot e^{-bt}$

$\Rightarrow y = \mu \cdot e^{-bt}$

$y(0) = 1 \Rightarrow 1 = \mu \Rightarrow y = e^{-bt}$  (2)

Now  $3(x(1)) = 2(y(1)) \Rightarrow 3 \cdot 2 \cdot e^{-a} = 2 \cdot e^{-b}$

$\Rightarrow e^{a-b} = 3$

Now again  $x(t) = y(t)$

$\Rightarrow 2 e^{-at} = e^{-bt} \Rightarrow e^{(a-b)t} = 2$

$\Rightarrow 3^t = 2 \Rightarrow t = \log_3 2$

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