

**FINAL JEE-MAIN EXAMINATION – APRIL, 2023**

**(Held On Tuesday 11<sup>th</sup> April, 2023)**

**TIME : 9 : 00 AM to 12 : 00 NOON**

**MATHEMATICS**

**TEST PAPER WITH SOLUTION**

**SECTION-A**

1. The value of the integral

$$\int_{-\log_e 2}^{\log_e 2} e^x (\log_e (e^x + \sqrt{1+e^{2x}})) dx \text{ is equal to}$$

(1)  $\log_e \left( \frac{2(2+\sqrt{5})}{\sqrt{1+\sqrt{5}}} \right) - \frac{\sqrt{5}}{2}$

(2)  $\log_e \left( \frac{\sqrt{2}(3-\sqrt{5})^2}{\sqrt{1+\sqrt{5}}} \right) + \frac{\sqrt{5}}{2}$

(3)  $\log_e \left( \frac{(2+\sqrt{5})^2}{\sqrt{1+\sqrt{5}}} \right) + \frac{\sqrt{5}}{2}$

(4)  $\log_e \left( \frac{\sqrt{2}(2+\sqrt{5})^2}{\sqrt{1+\sqrt{5}}} \right) - \frac{\sqrt{5}}{2}$

**Official Ans. by NTA (4)**

**Ans. (4)**

**Sol.**  $I = \int_{-\ln 2}^{\ln 2} e^x (\ln (e^x + \sqrt{1+e^{2x}})) dx$

Put  $e^x = t \Rightarrow e^x dx = dt$

$$I = \int_{1/2}^2 \ln(t + \sqrt{1+t^2}) dt$$

Applying integration by parts.

$$= \left[ t \ln(t + \sqrt{1+t^2}) \right]_{1/2}^2 - \int_{1/2}^2 \frac{t}{t + \sqrt{1+t^2}} \left( 1 + \frac{2t}{2\sqrt{1+t^2}} \right) dt$$

$$= 2 \ln(2 + \sqrt{5}) - \frac{1}{2} \ln \left( \frac{1 + \sqrt{5}}{2} \right) - \int_{1/2}^2 \frac{t}{\sqrt{1+t^2}} dt$$

$$= 2 \ln(2 + \sqrt{5}) - \frac{1}{2} \ln \left( \frac{1 + \sqrt{5}}{2} \right) - \frac{\sqrt{5}}{2}$$

$$= \ln \left( \frac{(2 + \sqrt{5})^2}{\left( \frac{\sqrt{5} + 1}{2} \right)^{\frac{1}{2}}} \right) - \frac{\sqrt{5}}{2}$$

2. If equation of the plane that contains the point  $(-2, 3, 5)$  and is perpendicular to each of the planes

$$2x + 4y + 5z = 8 \text{ and } 3x - 2y + 3z = 5 \text{ is}$$

$$\alpha x + \beta y + \gamma z + 97 = 0 \text{ then } \alpha + \beta + \gamma =$$

(1) 18

(2) 17

(3) 16

(4) 15

**Official Ans. by NTA (4)**

**Ans. (4)**

**Sol.** The equation of plane through  $(-2, 3, 5)$  is

$$a(x+2) + b(y-3) + c(z-5) = 0$$

it is perpendicular to  $2x+4y+5z=8$  &  $3x-2y+3z=5$

$$\therefore 2a + 4b + 5c = 0$$

$$3a - 2b + 3c = 0$$

$$\therefore \frac{a}{\begin{vmatrix} 4 & 5 \\ -2 & 3 \end{vmatrix}} = \frac{-b}{\begin{vmatrix} 2 & 5 \\ 3 & 3 \end{vmatrix}} = \frac{c}{\begin{vmatrix} 2 & 4 \\ 3 & -2 \end{vmatrix}}$$

$$\Rightarrow \frac{a}{22} = \frac{b}{9} = \frac{c}{-16}$$

$\therefore$  Equation of Plane is

$$22(x+2) + 9(y-3) - 16(z-5) = 0$$

$$\Rightarrow 22x + 9y - 16z + 97 = 0$$

Comparing with  $\alpha x + \beta y + \gamma z + 97 = 0$

We get  $\alpha + \beta + \gamma = 22 + 9 - 16 = 15$

3. Let R be a rectangle given by the lines  $x = 0, x = 2, y = 0$  and  $y = 5$ . Let  $A(\alpha, 0)$  and  $B(0, \beta), \alpha \in [0, 2]$  and  $\beta \in [0, 5]$ , be such that the line segment AB divides the area of the rectangle R in the ratio 4:1. Then, the mid-point of AB lies on a

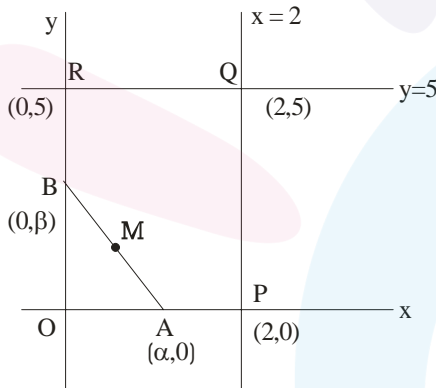
- (1) parabola
- (2) hyperbola
- (3) straight line
- (4) circle

**Official Ans. by NTA (2)**

**Ans. (2)**

Sol. 
$$\frac{\text{ar}(\text{OPQR})}{\text{or}(\text{OAB})} = \frac{4}{1}$$

Let M be the mid-point of AB.



$$M(h, k) = \left( \frac{\alpha}{2}, \frac{\beta}{2} \right)$$

$$\Rightarrow \frac{10 - \frac{1}{2}\alpha\beta}{\frac{1}{2}\alpha\beta} = 4$$

$$\Rightarrow \frac{5}{2}\alpha\beta = 10 \Rightarrow \alpha\beta = 4$$

$$\Rightarrow (2h)(2k) = 4$$

$\therefore$  Locus of M is  $xy = 1$

Which is a hyperbola.

4. Let sets A and B have 5 elements each. Let the mean of the elements in sets A and B be 5 and 8 respectively and the variance of the elements in sets A and B be 12 and 20 respectively. A new set C of 10 elements is formed by subtracting 3 from each element of A and adding 2 to each element of B. Then the sum of the mean and variance of the elements of C is \_\_\_\_\_.

- (1) 32
- (2) 38
- (3) 40
- (4) 36

**Official Ans. by NTA (2)**

**Ans. (2)**

Sol.  $A = \{a_1, a_2, a_3, a_4, a_5\}$

$$B = \{b_1, b_2, b_3, b_4, b_5\}$$

Given,  $\sum_{i=1}^5 a_i = 25, \sum_{i=1}^5 b_i = 40$

$$\frac{\sum_{i=1}^5 a_i^2}{5} - \left( \frac{\sum_{i=1}^5 a_i}{5} \right)^2 = 12, \quad \frac{\sum_{i=1}^5 b_i^2}{5} - \left( \frac{\sum_{i=1}^5 b_i}{5} \right)^2 = 20$$

$$\Rightarrow \sum_{i=1}^5 a_i^2 = 185, \quad \sum_{i=1}^5 b_i^2 = 420$$

Now,  $C = \{C_1, C_2, \dots, C_{10}\}$

s.f.  $C_i = a_i - 3$  or  $b_i + 2$   
First five elements      Last five elements

$$\therefore \text{Mean of } C, \bar{C} = \frac{(\sum a_i - 15) + (\sum b_i + 10)}{10}$$

$$\bar{C} = \frac{10 + 50}{10} = 6$$

$$\therefore \sigma^2 = \frac{\sum_{i=1}^{10} C_i^2}{10} - (\bar{C})^2$$

$$= \frac{\sum (a_i - 3)^2 + \sum (b_i + 2)^2}{10} - (6)^2$$

$$= \frac{\sum a_i^2 + \sum b_i^2 - 6\sum a_i + 4\sum b_i + 65}{10} - 36$$

$$= \frac{185 + 420 - 150 + 160 + 65}{10} - 36$$

$$= 32$$

$$\therefore \text{Mean} + \text{Variance} = \bar{C} + \sigma^2 = 6 + 32 = 38$$

5. Let  $f(x) = [x^2 - x] + |-x + [x]|$ , where  $x \in \mathbb{R}$  and  $[t]$  denotes the greatest integer less than or equal to  $t$ . Then,  $f$  is
- (1) continuous at  $x = 0$ , but not continuous at  $x = 1$
  - (2) continuous at  $x = 0$  and  $x = 1$
  - (3) not continuous at  $x = 0$  and  $x = 1$
  - (4) continuous at  $x = 1$ , but not continuous at  $x = 0$

**Official Ans. by NTA (4)**

**Ans. (4)**

**Sol.** Here  $f(x) = [x(x-1)] + \{x\}$

$f(0^+) = -1 + 0 = -1$	$f(1^+) = 0 + 0 = 0$
$f(0) = 0$	$f(1) = 0$
	$f(1^-) = -1 + 1 = 0$

$\therefore f(x)$  is continuous at  $x = 1$ , discontinuous at  $x = 0$

6. The number of triplets  $(x, y, z)$ , where  $x, y, z$  are distinct non negative integers satisfying  $x + y + z = 15$ , is
- (1) 80
  - (2) 114
  - (3) 92
  - (4) 136

**Official Ans. by NTA (2)**

**Ans. (2)**

**Sol.**  $x + y + z = 15$

$$\text{Total no. of solution} = {}^{15+3-1}C_{3-1} = 136 \quad \dots(1)$$

Let  $x = y \neq z$

$$2x + z = 15 \Rightarrow z = 15 - 2x$$

$$\Rightarrow x \in \{0, 1, 2, \dots, 7\} - \{5\}$$

$\therefore$  7 solutions

$\therefore$  there are 21 solutions in which exactly

Two of  $x_1, y_1, z$  are equal  $\dots(2)$

There is one solution in which  $x=y=z$   $\dots(3)$

$$\text{Required answer} = 136 - 21 - 1 = 114$$

7. For any vector  $\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$ , with  $10|a_i| < 1, i=1, 2, 3$ , consider the following statements:

(A) :  $\max\{|a_1|, |a_2|, |a_3|\} \leq |\vec{a}|$

(B) :  $|\vec{a}| \leq 3 \max\{|a_1|, |a_2|, |a_3|\}$

- (1) Only (B) is true
- (2) Only (A) is true
- (3) Neither (A) nor (B) is true
- (4) Both (A) and (B) are true

**Official Ans. by NTA (4)**

**Ans. (4)**

**Sol.** Without loss of generality

$$\text{Let } |a_1| \leq |a_2| \leq |a_3|$$

$$|\vec{a}|^2 = |a_1|^2 + |a_2|^2 + |a_3|^2 \geq (a_3)^2$$

$$\Rightarrow |\vec{a}| \geq |a_3| = \max\{|a_1|, |a_2|, |a_3|\}$$

A is true

$$|\vec{a}|^2 = |a_1|^2 + |a_2|^2 + |a_3|^2 \leq |a_3|^2 + |a_3|^2 + |a_3|^2$$

$$\Rightarrow |\vec{a}|^2 \leq 3|a_3|^2$$

$$\Rightarrow |\vec{a}| \leq \sqrt{3}|a_3| = \sqrt{3} \max\{|a_1|, |a_2|, |a_3|\}$$

$$\leq 3 \max\{|a_1|, |a_2|, |a_3|\}$$

(2) is true

8. Let  $w_1$  be the point obtained by the rotation of  $z_1 = 5 + 4i$  about the origin through a right angle in the anticlockwise direction, and  $w_2$  be the point obtained by the rotation of  $z_2 = 3 + 5i$  about the origin through a right angle in the clockwise direction. Then the principal argument of  $w_1 - w_2$  is equal to

(1)  $-\pi + \tan^{-1} \frac{33}{5}$

(2)  $-\pi - \tan^{-1} \frac{33}{5}$

(3)  $-\pi + \tan^{-1} \frac{8}{9}$

(4)  $\pi - \tan^{-1} \frac{8}{9}$

**Official Ans. by NTA (4)**

**Ans. (4)**

Sol.  $W_1 = z_1 i = (5 + 4i)i = -4 + 5i \dots(i)$

$W_2 = z_2 (-i) = (3 + 5i)(-i) = 5 - 3i \dots(2)$

$W_1 - W_2 = -9 + 8i$

Principal argument =  $\pi - \tan^{-1}\left(\frac{8}{9}\right)$

9. An organization awarded 48 medals in event 'A', 25 in event 'B' and 18 in event 'C'. If these medals went to total 60 men and only five men got medals in all the three events, then, how many received medals in exactly two of three events?

- (1) 10
- (2) 9
- (3) 21
- (4) 15

Official Ans. by NTA (3)

Ans. (3)

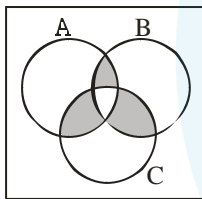
Sol.  $|A| = 48$

$|B| = 25$

$|C| = 18$

$|A \cup B \cup C| = 60$  [Total]

$|A \cap B \cap C| = 5$



$|A \cup B \cup C| = \sum |A| - \sum |A \cap B| + |A \cap B \cap C|$

$\Rightarrow \sum |A \cap B| = 48 + 25 + 18 + 5 - 60$

$= 36$

No. of men who received exactly 2 medals

$= \sum |A \cap B| - 3|A \cap B \cap C|$

$= 36 - 15$

$= 21$

10. Let  $S = \{M = [a_{ij}], a_{ij} \in \{0,1,2\}, 1 \leq i, j \leq 2\}$  be a sample space and  $A = \{M \in S : M \text{ is invertible}\}$  be an event. Then  $P(A)$  is equal to

(1)  $\frac{50}{81}$

(2)  $\frac{47}{81}$

(3)  $\frac{49}{81}$

(4)  $\frac{16}{27}$

Official Ans. by NTA (1)

Ans. (1)

Sol.  $M = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ , where  $a, b, c, d, \in \{0,1,2\}$

$n(s) = 3^4 = 81$

we first bound  $p(\bar{A})$

$|m| = 0 \Rightarrow ad = bc$

$ad = bc = 0 \Rightarrow$  no. of  $(a,b,c,d) = (3^2 - 2^2)^2 = 25$

$ad = bc = 1 \Rightarrow$  no. of  $(a,b,c,d) = 1^2 = 1$

$ad = bc = 2 \Rightarrow$  no. of  $(a,b,c,d) = 2^2 = 4$

$ad = bc = 4 \Rightarrow$  no. of  $(a,b,c,d) = 1^2 = 1$

$\therefore P(\bar{A}) = \frac{31}{81} \Rightarrow P(A) = \frac{50}{81}$

11. Consider ellipses  $E_k : kx^2 + ky^2 = 1, k = 1, 2, \dots,$

20. Let  $C_k$  be the circle which touches the four chords joining the end points (one on minor axis and another on major axis) of the ellipse  $E_k$ . If  $r_k$  is

the radius of the circle  $C_k$ , then the value of  $\sum_{k=1}^{20} \frac{1}{r_k^2}$

is

(1) 3080

(2) 3210

(3) 3320

(4) 2870

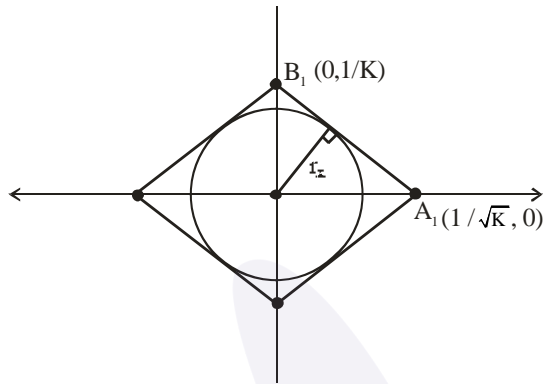
Official Ans. by NTA (1)

Ans. (1)

**Sol.**  $Kx^2 + K^2y^2 = 1$

$$\frac{x^2}{1/K} + \frac{y^2}{1/K^2} = 1$$

Now



Equation of

$$A_1B_1; \frac{x}{1/\sqrt{K}} + \frac{y}{1/K} = 1 \Rightarrow \sqrt{K}x + Ky = 1$$

$r_k = \perp r$  distance of  $(0,0)$  from line  $A_1B_1$

$$r_k = \left| \frac{(0+0-1)}{\sqrt{K+K^2}} \right| = \frac{1}{\sqrt{K+K^2}}$$

$$\frac{1}{r_k^2} = K + K^2 \Rightarrow \sum_{k=1}^{20} \frac{1}{r_k^2} = \sum_{k=1}^{20} (K + K^2)$$

$$= \sum_{K=1}^{20} K + \sum_{K=1}^{20} K^2$$

$$= \frac{20 \times 21}{2} + \frac{20 \cdot 21 \cdot 41}{6}$$

$$= 210 + 10 \times 7 \times 41$$

$$= 210 + 2870$$

$$= 3080$$

**12.** The number of integral solutions  $x$  of

$$\log_{x+\frac{7}{2}} \left( \frac{x-7}{2x-3} \right)^2 \geq 0$$

(1) 6 (2) 8

(3) 5 (4) 7

**Official Ans. by NTA (1)**

**Ans. (1)**

**Sol.**  $\log_{x+\frac{7}{2}} \left( \frac{x-7}{2x-3} \right)^2 \geq 0$

Feasible region :  $x + \frac{7}{2} > 0 \Rightarrow x > -\frac{7}{2}$

And  $x + \frac{7}{2} \neq 1 \Rightarrow x \neq -\frac{5}{2}$

And  $\frac{x-7}{2x-3} \neq 0$  and  $2x-3 \neq 0$

$\Downarrow$

$$x \neq 7$$

$\Downarrow$

$$x \neq \frac{3}{2}$$

Taking intersection :  $x \in \left( \frac{-7}{2}, \infty \right) - \left\{ -\frac{5}{2}, \frac{3}{2}, 7 \right\}$

Now  $\log_a b \geq 0$  if  $a > 1$  and  $b \geq 1$

Or

$$a \in (0,1) \text{ and } b \in (0,1)$$

C-I;  $x + \frac{7}{2} > 1$  and  $\left( \frac{x-7}{2x-3} \right)^2 \geq 1$

$$x > -\frac{5}{2} \quad (2x-3)^2 - (x-7)^2 \leq 0$$

$$(2x-3+x-7)(2x-3-x+7) \leq 0$$

$$(3x-10)(x+4) \leq 0$$

$$x \in \left[ -4, \frac{10}{3} \right]$$

Intersection :  $x \in \left( \frac{-5}{2}, \frac{10}{3} \right]$

C-II  $x + \frac{7}{2} \in (0,1)$  and  $\left( \frac{x-7}{2x-3} \right)^2 \in (0,1)$

$$0 < x + \frac{7}{2} < 1 \quad \left( \frac{x-7}{2x-3} \right)^2 < 1$$

$$-\frac{7}{2} < x < -\frac{5}{2} \quad (x-7)^2 < (2x-3)^2$$

$$x \in (-\infty, -4) \cup \left( \frac{10}{3}, \infty \right)$$

No common values of  $x$ .

Hence intersection with feasible region

We get  $x \in \left( \frac{-5}{2}, \frac{10}{3} \right] - \left\{ \frac{3}{2} \right\}$

Integral value of  $x$  are  $\{-2, -1, 0, 1, 2, 3\}$

No. of integral values = 6

13. Area of the region  $\{(x, y) : x^2 + (y - 2)^2 \leq 4, x^2 \geq 2y\}$  is

- (1)  $2\pi - \frac{16}{3}$                       (2)  $\pi - \frac{8}{3}$   
 (3)  $\pi + \frac{8}{3}$                         (4)  $2\pi + \frac{16}{3}$

**Official Ans. by NTA (1)**

**Ans. (1)**

**Sol.**  $x^2 + (y - 2)^2 \leq 2^2$  and  $x^2 \geq 2y$

Solving circle and parabola simultaneously :

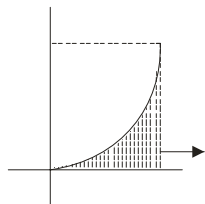
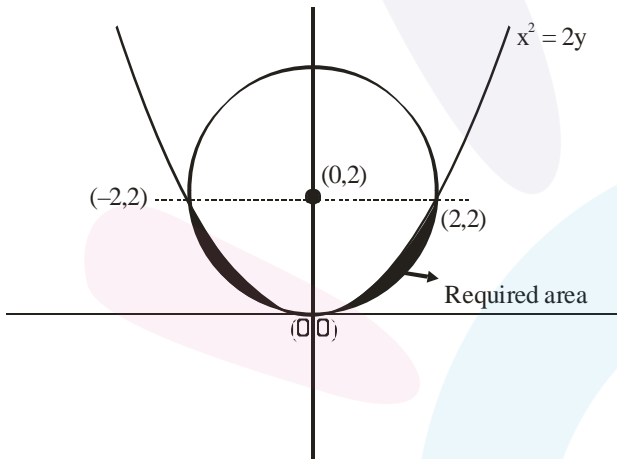
$$2y + y^2 - 4y + 4 = 4$$

$$y^2 - 2y = 0$$

$$y = 0, 2$$

$$\text{Put } y = 2 \text{ in } x^2 = 2y \rightarrow x = \pm 2$$

$$\Rightarrow (2, 2) \text{ and } (-2, 2)$$



$$= 2 \times 2 - \frac{1}{4} \cdot \pi \cdot 2^2 = 4 - \pi$$

$$\text{Required area} = 2 \left[ \int_0^2 \frac{x^2}{2} dx - (4 - \pi) \right]$$

$$= 2 \left[ \frac{x^3}{6} \Big|_0^2 - 4 + \pi \right]$$

$$= 2 \left[ \frac{4}{3} + \pi - 4 \right]$$

$$= 2 \left[ \pi - \frac{8}{3} \right]$$

$$= 2\pi - \frac{16}{3}$$

14. Let  $f : [2, 4] \rightarrow \mathbb{R}$  be a differentiable function such that  $(x \log_e x) f'(x) + (\log_e x) f(x) + f(x) \geq 1$ ,

$$x \in [2, 4] \text{ with } f(2) = \frac{1}{2} \text{ and } f(4) = \frac{1}{4}.$$

Consider the following two statements:

(A) :  $f(x) \leq 1$ , for all  $x \in [2, 4]$

(B) :  $f(x) \geq \frac{1}{8}$ , for all  $x \in [2, 4]$

Then,

- (1) Only statement (B) is true  
 (2) Neither statement (A) nor statement (B) is true  
 (3) Both the statement (A) and (B) are true  
 (4) Only statement (A) is true

**Official Ans. by NTA (3)**

**Ans. (Bonus)**

**Sol.**  $x \ln x f'(x) + \ln x f(x) + f(x) \geq 1, x \in [2, 4]$

$$\text{And } f(2) = \frac{1}{2}, f(4) = \frac{1}{4}$$

$$\text{Now } x \ln x \frac{dy}{dx} + (\ln + 1)y \geq 1$$

$$\frac{d}{dx} (y \cdot x \ln x) \geq 1$$

$$\frac{d}{dx} (f(x) \cdot x \ln x) \geq 1$$

$$\Rightarrow \frac{d}{dx} (x \ln x f(x) - x) \geq 0, x \in [2, 4]$$

$\Rightarrow$  The function  $g(x) = x \ln x f(x) - x$  is increasing in  $[2, 4]$

$$\text{And } g(2) = 2 \ln 2 f(2) - 2 = \ln 2 - 2$$

$$g(4) = 4 \ln 4 f(4) - 4 = \ln 4 - 4$$

$$= 2(\ln 2 - 2)$$

$$\text{Now } g(2) \leq g(x) \leq g(4)$$

$$\ln 2 - 2 \leq x \ln x f(x) - x \leq 2(\ln 2 - 2)$$

$$\frac{\ln 2 - 2}{x \ln x} + \frac{1}{\ln x} \leq f(x) \leq \frac{2(\ln 2 - 2)}{x \ln x} + \frac{1}{\ln x}$$

Now for  $x \in [2, 4]$

$$\frac{2(\ln 2 - 2)}{x \ln x} + \frac{1}{\ln x} < \frac{2(\ln 2 - 2)}{2 \ln 2} + \frac{1}{\ln 2} = 1 - \frac{1}{\ln 2} < 1$$

$$\Rightarrow f(x) \leq 1 \text{ for } x \in [2, 4]$$

Also for  $x \in [2, 4]$  :

$$\frac{\ln 2 - 2}{x \ln x} + \frac{1}{\ln x} \geq \frac{\ln 2 - 2}{4 \ln 4} + \frac{1}{\ln 4} = \frac{1}{8} + \frac{1}{2 \ln 2} > \frac{1}{8}$$

$$\Rightarrow f(x) \geq \frac{1}{8} \text{ for } x \in [2, 4]$$

Hence both A and B are true.

LMVT on  $(yx (\ln x))$  not satisfied.

Hence no such function exists.

Therefore it should be bonus.

15. Let  $y = y(x)$  be a solution curve of the differential equation,  $(1 - x^2 y^2) dx = y dx + x dy$ .

If the line  $x = 1$  intersects the curve  $y = y(x)$  at  $y = 2$  and the line  $x = 2$  intersects the curve  $y = y(x)$  at  $y = \alpha$ , then a value of  $\alpha$  is

- (1)  $\frac{3e^2}{2(3e^2 - 1)}$
- (2)  $\frac{3e^2}{2(3e^2 + 1)}$
- (3)  $\frac{1 - 3e^2}{2(3e^2 + 1)}$
- (4)  $\frac{1 + 3e^2}{2(3e^2 - 1)}$

**Official Ans. by NTA (4)**

**Ans. (4)**

**Sol.**  $(1 - x^2 y^2) dx = y dx + x dy, y(1) = 2$

$$y(2) = \alpha = ?$$

$$dx = \frac{d(xy)}{1 - (xy)^2}$$

$$\int dx = \int \frac{d(xy)}{1 - (xy)^2}$$

$$x = \frac{1}{2} \ln \left| \frac{1 + xy}{1 - xy} \right| + C$$

Put  $x = 1$  and  $y = 2$  :

$$1 = \frac{1}{2} \ln \left| \frac{1 + 2}{1 - 2} \right| + C$$

$$C = 1 - \frac{1}{2} \ln 3$$

Now put  $x = 2$  :

$$2 = \frac{1}{2} \ln \left| \frac{1 + 2\alpha}{1 - 2\alpha} \right| + 1 - \frac{1}{2} \ln 3$$

$$1 + \frac{1}{2} \ln 3 = \frac{1}{2} \ln \left| \frac{1 + 2\alpha}{1 - 2\alpha} \right|$$

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

$$\left| \frac{1 + 2\alpha}{1 - 2\alpha} \right| = 3e^2$$

$$\frac{1 + 2\alpha}{1 - 2\alpha} = 3e^2, -3e^2$$

$$\frac{1 + 2\alpha}{1 - 2\alpha} = 3e^2 \Rightarrow \alpha = \frac{3e^2 - 1}{2(3e^2 + 1)}$$

$$\text{And } \frac{1 + 2\alpha}{1 - 2\alpha} = -3e^2 \Rightarrow \alpha = \frac{3e^2 + 1}{2(3e^2 - 1)}$$

16. Let A be a  $2 \times 2$  matrix with real entries such that  $A' = \alpha A + I$ , where  $\alpha \in \mathbb{R} - \{-1, 1\}$ . If  $\det(A^2 - A) = 4$ , then the sum of all possible values of  $\alpha$  is equal to

- (1) 0
- (2)  $\frac{3}{2}$
- (3)  $\frac{5}{2}$
- (4) 2

**Official Ans. by NTA (3)**

**Ans. (3)**

Sol.  $A^T = \alpha A + I$   
 $A = \alpha A^T + I$   
 $A = \alpha(\alpha A + I) + I$   
 $A = \alpha^2 A + (\alpha + 1)I$   
 $A(1 - \alpha^2) = (\alpha + 1)I$

$$A = \frac{I}{1 - \alpha} \quad \dots(1)$$

$$|A| = \frac{1}{(1 - \alpha)^2} \quad \dots(2)$$

$$|A^2 - A| = |A||A - I| \quad \dots(3)$$

$$A - I = \frac{I}{1 - \alpha} - I = \frac{\alpha}{1 - \alpha} I$$

$$|A - I| = \left(\frac{\alpha}{1 - \alpha}\right)^2 \quad \dots(4)$$

Now  $|A^2 - A| = 4$

$$|A||A - I| = 4$$

$$\Rightarrow \frac{1}{(1 - \alpha)^2} \frac{\alpha^2}{(1 - \alpha)^2} = 4$$

$$\Rightarrow \frac{\alpha}{(1 - \alpha)^2} = \pm 2$$

$$\Rightarrow 2(1 - \alpha)^2 = \pm \alpha$$

$(C_1) 2(1 - \alpha)^2 = \alpha$ $2\alpha^2 - 5\alpha + 2 = 0 <_{\alpha_1}^{\alpha_2}$ $\alpha_1 + \alpha_2 = \frac{5}{2}$	$(C_2) 2(1 - \alpha)^2 = -\alpha$ $2\alpha^2 - 3\alpha + 2 = 0$ $\alpha \notin \mathbb{R}$
--	--

Sum of value of  $\alpha = \frac{5}{2}$

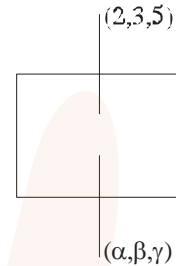
17. Let  $(\alpha, \beta, \gamma)$  be the image of the point  $P(2, 3, 5)$  in the plane  $2x + y - 3z = 6$ . Then  $\alpha + \beta + \gamma$  is equal to
- (1) 10
  - (2) 5
  - (3) 12
  - (4) 9

Official Ans. by NTA (1)

Ans. (1)

Sol.  $\frac{\alpha - 2}{2} = \frac{\beta - 3}{1} = \frac{\gamma - 5}{-3} = -2 \left( \frac{2 \times 2 + 3 - 3 \times 5 - 6}{2^2 + 1^2 + 1 - 3^2} \right) = 2$

$\frac{\alpha - 2}{2} = 2$	$\beta - 3 = 2$	$\gamma - 5 = -6$
$\alpha = 6$	$\beta = 5$	$\gamma = -1$



$$\alpha + \beta + \gamma = 10$$

18. Let  $\vec{a}$  be a non-zero vector parallel to the line of intersection of the two planes described by  $\hat{i} + \hat{j}, \hat{i} + \hat{k}$  and  $\hat{i} - \hat{j}, \hat{j} - \hat{k}$ . If  $\theta$  is the angle between the vector  $\vec{a}$  and the vector  $\vec{b} = 2\hat{i} - 2\hat{j} + \hat{k}$  and  $\vec{a} \cdot \vec{b} = 6$  then the ordered pair  $(\theta, |\vec{a} \times \vec{b}|)$  is equal to

- (1)  $\left(\frac{\pi}{4}, 3\sqrt{6}\right)$
- (2)  $\left(\frac{\pi}{3}, 3\sqrt{6}\right)$
- (3)  $\left(\frac{\pi}{3}, 6\right)$
- (4)  $\left(\frac{\pi}{4}, 6\right)$

Official Ans. by NTA (4)

Ans. (4)

- Sol.  $\vec{n}_1$  and  $\vec{n}_2$  are normal vector to the plane  $\hat{i} + \hat{j}, \hat{i} + \hat{k}$  and  $\hat{i} - \hat{j}, \hat{j} - \hat{k}$  respectively

$$\vec{n}_1 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{vmatrix} = \hat{i} - \hat{j} - \hat{k}$$

$$\vec{n}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{vmatrix} = \hat{i} + \hat{j} + \hat{k}$$

$$\vec{a} = \lambda |\vec{n}_2 \times \vec{n}_1|$$



$$= \lambda \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & -1 \\ 1 & 1 & 1 \end{vmatrix} = \lambda(-2\hat{j} + 2\hat{k})$$

$$\vec{a} \cdot \vec{b} = \lambda|0+4+2| = 6$$

$$\Rightarrow \lambda = 1$$

$$\vec{a} = -2\hat{j} + 2\hat{k}$$

$$\cos \theta = \frac{\vec{a} \cdot \vec{b}}{|\vec{a}||\vec{b}|}$$

$$\cos \theta = \frac{6}{2\sqrt{2} \times 3} = \frac{1}{\sqrt{2}}$$

$$\theta = \frac{\pi}{4}$$

Now  $|\vec{a} \cdot \vec{b}|^2 + |\vec{a} \times \vec{b}|^2 = |\vec{a}|^2 |\vec{b}|^2$

$$36 + |\vec{a} \times \vec{b}|^2 = 8 \times 9 = 72$$

$$|\vec{a} \times \vec{b}|^2 = 36$$

$$|\vec{a} \times \vec{b}| = 6$$

19. The number of elements in the set  $S = \{\theta \in [0, 2\pi] : 3\cos^4 \theta - 5\cos^2 \theta - 2\sin^2 \theta + 2 = 0\}$  is

- (1) 10 (2) 8  
(3) 9 (4) 12

Official Ans. by NTA (3)

Ans. (3)

Sol.  $3\cos^4 \theta - 5\cos^2 \theta - 2\sin^2 \theta + 2 = 0$   
 $\Rightarrow 3\cos^4 \theta - 3\cos^2 \theta - 2\cos^2 \theta - 2\sin^2 \theta + 2 = 0$   
 $\Rightarrow 3\cos^4 \theta - 3\cos^2 \theta + 2\sin^2 \theta - 2\sin^2 \theta = 0$   
 $\Rightarrow 3\cos^2 \theta (\cos^2 \theta - 1) + 2\sin^2 \theta (\sin^2 \theta - 1) = 0$   
 $\Rightarrow -3\cos^2 \theta \sin^2 \theta + 2\sin^2 \theta (1 + \sin^2 \theta) \cos^2 \theta - 1$   
 $\Rightarrow \sin^2 \theta \cos^2 \theta (2 + 2\sin^2 \theta - 3) = 0$   
 $\Rightarrow \sin^2 \theta \cos^2 \theta (2\sin^2 \theta - 1) = 0$

(C1)  $\sin^2 \theta = 0 \rightarrow 3$  solution ;  $\theta = \{0, \pi, 2\pi\}$

(C2)  $\cos^2 \theta = 0 \rightarrow 2$  solution ;  $\theta = \left\{ \frac{\pi}{2}, \frac{3\pi}{2} \right\}$

(C3)  $\sin^2 \theta = \frac{1}{2} \rightarrow 4$  solution ;  $\theta = \left\{ \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4} \right\}$

No. of solution = 9

20. Let  $x_1, x_2, \dots, x_{100}$  be in an arithmetic progression, with  $x_1 = 2$  and their mean equal to 200. If  $y_i = i(x_i - i), 1 \leq i \leq 100$ , then the mean of  $y_1, y_2, \dots, y_{100}$  is .

- (1) 10101.50  
(2) 10051.50  
(3) 10049.50  
(4) 10100

Official Ans. by NTA (3)

Ans. (3)

Sol. Mean = 200

$$\Rightarrow \frac{100}{2}(2 \times 2 + 99d) = 200$$

$$\Rightarrow 4 + 99d = 400$$

$$\Rightarrow d = 4$$

$$y_i = i(x_i - i)$$

$$= i(2 + (i-1)4 - i) = 3i^2 - 2i$$

$$\text{Mean} = \frac{\sum y_i}{100}$$

$$= \frac{1}{100} \sum_{i=1}^{100} 3i^2 - 2i$$

$$= \frac{1}{100} \left\{ \frac{3 \times 100 \times 101 \times 201}{6} - \frac{2 \times 100 \times 101}{2} \right\}$$

$$= 101 \left\{ \frac{201}{2} - 1 \right\} = 101 \times 99.5$$

$$= 10049.50$$

SECTION-B

21. The mean of the coefficients of  $x, x^2, \dots, x^7$  in the binomial expansion of  $(2+x)^9$  is \_\_\_\_\_.

Official Ans. by NTA (2736)

Ans. (2736)

Sol. Coefficient of  $x = {}^9C_1 \cdot 2^8$

Of  $x^2 = {}^9C_2 \cdot 2^7$

Of  $x^7 = {}^9C_7 \cdot 2^2$

$$\text{Mean} = \frac{{}^9C_1 \cdot 2^8 + {}^9C_2 \cdot 2^7 + \dots + {}^9C_7 \cdot 2^2}{7}$$

$$= \frac{(1+2)^9 - {}^9C_0 \cdot 2^9 - {}^9C_8 \cdot 2^1 - {}^9C_9}{7}$$

$$= \frac{3^9 - 2^9 - 18 - 1}{7}$$

$$= \frac{19152}{7} = 2736$$

22. Let  $S = 109 + \frac{108}{5} + \frac{107}{5^2} + \dots + \frac{2}{5^{107}} + \frac{1}{5^{108}}$ .

Then the value of  $(16S - (25)^{-54})$  is equal to \_\_\_\_\_.

Official Ans. by NTA (2175)

Ans. (2175)

Sol.  $S = 109 + \frac{108}{5} + \frac{107}{5^2} + \dots + \frac{1}{5^{108}}$

$$\frac{S}{5} = \frac{109}{5} + \frac{108}{5^2} + \dots + \frac{2}{5^{108}} + \frac{1}{5^{109}}$$

$$\frac{4S}{5} = 109 - \frac{1}{5} - \frac{1}{5^2} + \dots - \frac{1}{5^{108}} - \frac{1}{5^{109}}$$

$$= 109 - \left( \frac{1 \left( 1 - \frac{1}{5^{109}} \right)}{5 \left( 1 - \frac{1}{5} \right)} \right)$$

$$= 109 - \frac{1}{4} \left( 1 - \frac{1}{5^{109}} \right)$$

$$= 109 - \frac{1}{4} + \frac{1}{4} \times \frac{1}{5^{109}}$$

$$s = \frac{5}{4} \left( 109 - \frac{1}{4} + \frac{1}{4 \cdot 5^{109}} \right)$$

$$16S = 20 \times 109 - 5 + \frac{1}{5^{108}}$$

$$16S - (25)^{-54} = 2180 - 5 = 2175$$

23. For  $m, n > 0$ , let  $\alpha(m, n) = \int_0^2 t^m (1+3t)^n dt$ . If

$11\alpha(10, 6) + 18\alpha(11, 5) = p(14)^6$ , then  $p$  is equal to \_\_\_\_\_.

Official Ans. by NTA (32)

Ans. (32)

Sol.  $\alpha(m, n) = \int_0^2 t^m (1+3t)^n dt$

If  $11\alpha(10, 6) + 18\alpha(11, 5) = p(14)^6$  then P

$$= 11 \int_0^2 \frac{t^{10}}{\text{II}} \frac{(1+3t)^6}{\text{I}} + 10 \int_0^2 t^{11} (1+3t)^5 dt$$

$$= 11 \left[ (1+3t)^6 \cdot \frac{t^{11}}{11} - \int 6(1+3t)^5 \cdot 3 \frac{t^{11}}{11} \right]_0^2 + 18 \int_0^2 t^{11} (1+3t)^5 dt$$

$$= \left( t^{11} (1+3t)^6 \right)_0^2$$

$$= 2^{11} (7)^6$$

$$= 2^5 (14)^6$$

$$= 32 (14)^6$$

24. In an examination, 5 students have been allotted their seats as per their roll numbers. The number of ways, in which none of the students sits on the allotted seat, is \_\_\_\_\_.

Official Ans. by NTA (44)

Ans. (44)

Sol. Derangement of 5 students

$$D_5 = 5! \left( 1 - \frac{1}{1!} + \frac{1}{2!} - \frac{1}{3!} + \frac{1}{4!} - \frac{1}{5!} \right)$$

$$= 120 \left( \frac{1}{2} - \frac{1}{6} + \frac{1}{24} - \frac{1}{120} \right)$$

$$= 60 - 20 + 5 - 1$$

$$= 40 + 4$$

$$= 44$$

25. Let a line  $l$  pass through the origin and be perpendicular to the lines

$$l_1 : \vec{r} = (\hat{i} - 11\hat{j} - 7\hat{k}) + \lambda (\hat{i} + 2\hat{j} + 3\hat{k}), \lambda \in \mathbb{R}$$

and  $l_2 : \vec{r} = (-\hat{i} + \hat{k}) + \mu (2\hat{i} + 2\hat{j} + \hat{k}), \mu \in \mathbb{R}.$

If P is the point of intersection of  $l$  and  $l_1$ , and Q( $\alpha, \beta, \gamma$ ) is the foot of perpendicular from P on  $l_2$ , then  $9(\alpha + \beta + \gamma)$  is equal to \_\_\_\_\_ .

**Official Ans. by NTA (5)**

**Ans. (5)**

**Sol.** Let  $l = (0\hat{i} + 0\hat{j} + 0\hat{k}) + \gamma (\hat{a}\hat{i} + \hat{b}\hat{j} + \hat{c}\hat{k})$

$$= \gamma (\hat{a}\hat{i} + \hat{b}\hat{j} + \hat{c}\hat{k})$$

$$\hat{a}\hat{i} + \hat{b}\hat{j} + \hat{c}\hat{k} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & 3 \\ 2 & 2 & 1 \end{vmatrix}$$

$$= \hat{i}(2-6) - \hat{j}(1-6) + \hat{k}(2-4)$$

$$= -4\hat{i} - 5\hat{j} - 2\hat{k}$$

$$l = \gamma (-4\hat{i} + 5\hat{j} - 2\hat{k})$$

P is intersection of  $l$  and  $l_1$

$$-4\gamma = 1 + \lambda, 5\gamma = -11 + 2\lambda, -2\gamma = -7 + 3\lambda$$

By solving there equation  $\gamma = -1, P(4, -5, 2)$

Let Q( $-1 + 2\mu, 2\mu, 1 + \mu$ )

$$\overline{PQ} \cdot (2\hat{i} + 2\hat{j} + \hat{k}) = 0$$

$$-2 + 4\mu + 4\mu + 1 + \mu = 0$$

$$9\mu = 1$$

$$\mu = \frac{1}{9}$$

$$Q\left(\frac{-7}{9}, \frac{2}{9}, \frac{10}{9}\right)$$

$$9(\alpha + \beta + \gamma) = 9\left(\frac{-7}{9} + \frac{2}{9} + \frac{10}{9}\right) = 5$$

26. The number of integral terms in the expansion of

$$\left(3^{\frac{1}{2}} + 5^{\frac{1}{4}}\right)^{680}$$

is equal to

**Official Ans. by NTA (171)**

**Ans. (171)**

**Sol.** The number of integral term in the expression of

$$\left(3^{\frac{1}{2}} + 5^{\frac{1}{4}}\right)^{680}$$

is equal to

$$\text{General term} = {}^{680}C_r \left(3^{\frac{1}{2}}\right)^{680-r} \left(5^{\frac{1}{4}}\right)^r$$

$$= {}^{680}C_r 3^{\frac{680-r}{2}} 5^{\frac{r}{4}}$$

Value's of r, where  $\frac{r}{4}$  goes to integer

$$r = 0, 4, 8, 12, \dots, 680$$

All value of r are accepted for  $\frac{680-r}{2}$  as well so

No of integral terms = 171.

27. The number of ordered triplets of the truth values of p, q and r such that the truth value of the statement  $(p \vee q) \wedge (p \vee r) \Rightarrow (q \vee r)$  is True, is equal to \_\_\_\_\_ .

**Official Ans. by NTA (7)**

**Ans. (7)**

**Sol.**

p	q	r	Pvq	Pvr	(pvq) ^ (pvr)	qvr	(pvq) ^ (pvr) -> qvr
T	T	T	T	T	T	T	T
T	T	F	T	T	T	T	T
T	F	T	T	T	T	T	T
T	F	F	T	T	T	F	F
F	T	T	T	T	T	T	T
F	T	F	T	F	F	T	T
F	F	T	F	T	F	T	T
F	F	F	F	F	F	F	T

Hence total no of ordered triplets are 7

28. Let  $H_n = \frac{x^2}{1+n} - \frac{y^2}{3+n} = 1, n \in \mathbb{N}$ . Let  $k$  be the smallest even value of  $n$  such that the eccentricity of  $H_k$  is a rational number. If  $l$  is length of the latus return of  $H_k$ , then  $21l$  is equal to \_\_\_\_\_

Official Ans. by NTA (306)

Ans. (306)

Sol.  $H_n \Rightarrow \frac{x^2}{1+n} - \frac{y^2}{3+n} = 1$

$$e = \sqrt{1 + \frac{b^2}{a^2}} = \sqrt{1 + \frac{3+n}{1+n}} = \sqrt{\frac{2n+4}{n+1}}$$

$$e = \sqrt{\frac{2n+4}{n+1}}$$

$n = 48$  (smallest even value for which  $e \in \mathbb{Q}$ )

$$e = \frac{10}{7}$$

$$a^2 = n+1 \quad b^2 = n+3$$

$$= 49 \quad = 51$$

$$l = \text{length of LR} = \frac{2b^2}{a}$$

$$L = 2 \cdot \frac{51}{7}$$

$$l = \frac{102}{7}$$

$$21l = 306$$

29. If  $a$  and  $b$  are the roots of equation  $x^2 - 7x - 1 = 0$ , then the value of  $\frac{a^{21} + b^{21} + a^{17} + b^{17}}{a^{19} + b^{19}}$  is equal to \_\_\_\_\_

Official Ans. by NTA (51)

Ans. (51)

Sol.  $x^2 - 7x - 1 = 0 \quad <_b^a$

By newton's theorem

$$S_{n+2} - 7S_{n+1} - S_n = 0$$

$$S_{21} - 7S_{20} - S_{19} = 0$$

$$S_{20} - 7S_{19} - S_{18} = 0$$

$$S_{19} - 7S_{18} - S_{17} = 0$$

$$\frac{S_{21} + S_{17}}{S_{19}} = \frac{S_{21} + (S_{19} - 7S_{18})}{S_{19}}$$

$$= \frac{S_{21} + S_{19} - 7(S_{20} - 7S_{19})}{S_{19}}$$

$$= \frac{50S_{19} + (S_{21} - 7S_{20})}{S_{19}}$$

$$= 51 \cdot \frac{S_{19}}{S_{19}} = 51$$

30. Let  $A = \begin{bmatrix} 0 & 1 & 2 \\ a & 0 & 3 \\ 1 & c & 0 \end{bmatrix}$ , where  $a, c \in \mathbb{R}$ . If  $A^3 = A$

and the positive value of  $a$  belongs to the interval  $(n-1, n]$ , where  $n \in \mathbb{N}$ , then  $n$  is equal to \_\_\_\_\_

Official Ans. by NTA (2)

Ans. (2)

Sol.  $A = \begin{bmatrix} 0 & 1 & 2 \\ a & 0 & 3 \\ 1 & c & 0 \end{bmatrix}$

$$A^3 = A$$

$$A^2 = \begin{bmatrix} 0 & 1 & 2 \\ a & 0 & 3 \\ 1 & c & 0 \end{bmatrix} \begin{bmatrix} 0 & 1 & 2 \\ a & 0 & 3 \\ 1 & c & 0 \end{bmatrix}$$

$$A^2 = \begin{bmatrix} a+2 & 2c & 3 \\ 3 & a+3c & 2a \\ ac & 1 & 2+3c \end{bmatrix}$$

$$A^3 = \begin{bmatrix} a+2 & 2c & 3 \\ 3 & a+3c & 2a \\ ac & a & 2+3c \end{bmatrix} \begin{bmatrix} 0 & 1 & 2 \\ a & 0 & 3 \\ 1 & c & 0 \end{bmatrix}$$

$$A^3 = \begin{bmatrix} 2ac+3 & a+2+3c & 2a+4+6c \\ a(a+3c)+2a & 3+2ac & 6+3a+9c \\ a+2+3c & ac+c(2+3c) & 2ac+3 \end{bmatrix}$$

Given  $A^3 = A$

$$2ac+3=0 \dots(1) \text{ and } a+2+3c=1$$

$$a+1+3c=0$$

$$a+1-\frac{9}{2a}=0$$

$$2a^2+2a-9=0$$

$$f(1) < 0, f(2) > 0$$

$$a \in (1, 2]$$

$$n = 2$$