

## MATHEMATICS

### SECTION - A

**Multiple Choice Questions:** This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

**Choose the correct answer :**

1. The remainder when  $64^{64}$  is divided by 7 is equal to  
 (1) 1 (2) 2  
 (3) 3 (4) 4

**Answer (1)**

**Sol.**  $64^{64} \Rightarrow (63+1)^{64} = 63\lambda + 1$

$$64^{64} \Rightarrow (63+1)^{64}$$

$$63\lambda + 1$$

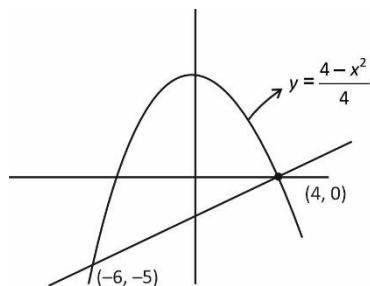
Required remainder when divided 7 is 1.

2. Area bounded by the curves  $y = 4 - \frac{x^2}{4}$  and  $y = \frac{x-4}{2}$  (in square units) is

- (1)  $\frac{125}{3}$  (2)  $\frac{20}{3}$   
 (3)  $\frac{80}{3}$  (4)  $\frac{120}{3}$

**Answer (1)**

**Sol.**  $y = \frac{4-x^2}{4}$  and  $y = \frac{x-4}{2}$



$$\text{Area} = \int_{-6}^4 \left( \left( 4 - \frac{x^2}{4} \right) - \left( \frac{x-4}{2} \right) \right) dx$$

$$= \int_{-6}^4 \left( -\frac{x^2}{4} - \frac{x+6}{2} \right) dx$$

$$= \left( -\frac{x^3}{12} - \frac{x^2}{4} + 6x \right)_{-6}^4$$

$$\Rightarrow \frac{125}{3} \text{ square unit}$$

3. If  $x_1, x_2, x_3, x_4$  are in GP, then we subtract 2, 4, 7, 8 from  $x_1, x_2, x_3, x_4$  respectively, then the resultant numbers are in AP, then the value of  $\frac{1}{24} (x_1 \cdot x_2 \cdot x_3 \cdot x_4)$  is

- (1)  $\frac{2^4}{3^8}$   
 (2)  $\frac{2^3}{3^9}$   
 (3)  $\frac{2}{3^9}$   
 (4)  $\frac{2}{3^8}$

**Answer (2)**

**Sol.**  $x_1, x_2, x_3, x_4 \rightarrow \text{GP}$   
 $\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$   
 $a \quad ar \quad ar^2 \quad ar^3$

$$a-2, ar-4, ar^2-7, ar^3-8 \rightarrow \text{AP}$$

$$\begin{cases} 2(ar-4) = a+ar^2-9 & \dots(1) \\ 2(ar^2-7) = ar+ar^3-12 & \dots(2) \end{cases} \begin{cases} r = -2 \\ a = \frac{1}{9} \end{cases}$$

$$\frac{1}{24} (x_1 x_2 x_3 x_4) = \frac{1}{24} a^4 r^{1+2+3} = \frac{1}{24} \times a^4 \times r^6$$

$$= \frac{1}{24} \times \left( \frac{1}{9} \right)^4 \times (-2)^6$$

$$= \frac{2^3}{3^9}$$

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4. If  $f(x) = \left\lfloor \frac{x^2}{2} \right\rfloor - [\sqrt{x}] \forall x \in [0, 4]$ , where  $[.]$  denotes the greatest integer function, then number of points of discontinuity of  $f(x)$  is
- (1) 12 (2) 8  
(3) 6 (4) 4

**Answer (2)**

**Sol.**  $y = \left\lfloor \frac{x^2}{2} \right\rfloor - [\sqrt{x}]$ , critical points when  $\left\lfloor \frac{x^2}{2} \right\rfloor$  and  $[\sqrt{x}]$

becomes integer.

$$\{0, 1, \sqrt{2}, \sqrt{4}, \sqrt{6}, \sqrt{8}, \sqrt{10}, \sqrt{12}, \sqrt{14}, 4\}$$

Continues at  $0^+$ , continuous at  $4^-$ .

$$\left\lfloor \frac{x^2}{2} \right\rfloor = [\sqrt{x}], \text{ which occurs at } x = \sqrt{2}$$

$\Rightarrow$  Not continuous

The function is discontinuous at 8 points.

5. Solve:  $\int_0^{\pi} \frac{(x+3)\sin x}{1+3\cos^2 x} dx$

- (1)  $\frac{\pi(\pi+6)}{3\sqrt{3}}$  (2)  $\frac{\pi(\pi+6)}{2\sqrt{3}}$   
(3)  $\frac{\pi^2}{2\sqrt{3}}$  (4)  $\frac{\pi^2}{4\sqrt{3}}$

**Answer (1)**

**Sol.**  $I = \int_0^{\pi} \frac{(x+3)\sin x}{1+3\cos^2 x} dx$

$$= \int_0^{\pi/2} \left( \frac{(x+3)\sin x}{1+3\cos^2 x} + \frac{(\pi-x+3)\sin(\pi-x)}{1+3\cos^2(\pi-x)} \right) dx$$

$$= \int_0^{\pi/2} \frac{(\pi+6)\sin x}{1+3\cos^2 x} dx$$

$$= (\pi+6) \int_0^{\pi/2} \frac{\sin x}{1+3\cos^2 x} dx$$

Let  $\cos x = t \Rightarrow \sin x dx = -dt$

$$= (\pi+6) \int_1^0 \frac{-dt}{1+3t^2} dx$$

$$= \frac{\pi+6}{3} \int_0^1 \frac{dt}{\left(\frac{1}{\sqrt{3}}\right)^2 + t^2} dx$$

$$= \frac{\pi+6}{3} \cdot \sqrt{3} \left[ \tan^{-1} \sqrt{3}t \right]_0^1 = \frac{\pi+6}{\sqrt{3}} \cdot \frac{\pi}{3} = \frac{\pi(\pi+6)}{3\sqrt{3}}$$

6. If  $\alpha$  and  $\beta$  are negative real roots of the quadratic equation  $x^2 - (p+2)x + (2p+9) = 0$  and  $p \in (\alpha, \beta)$ . Then the value of  $\beta^2 - 2\alpha$  is

- (1) 11  
(2) 13  
(3) 7  
(4) 5

**Answer (2)****Sol.**  $\alpha\beta > 0$ 

$$\Rightarrow 2p+9 > 0$$

$$\Rightarrow p > -\frac{9}{2}$$

$$\text{and } \alpha + \beta < 0$$

$$p+2 < 0$$

$$\Rightarrow p < -2$$

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

$$\beta^2 - 2\alpha = 4 - 2\left(-\frac{9}{2}\right)$$

$$= 4 + 9$$

$$= 13$$

7. Let the straight line  $AB : x + y - 2 = 0$ ,  $AC : 3y - x = 2$  intersects  $x$ -axis at  $B$  and  $C$  respectively. If  $P$  is the orthocentre of the triangle  $ABC$ , then area of the triangle  $CPB$  is

- (1) 10 sq. units  
(2) 8 sq. units  
(3) 6 sq. units  
(4) 7 sq. units

**Answer (3)**

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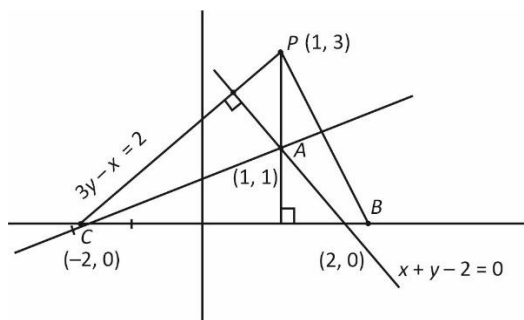
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Sol.



$$X = 1 \text{ and } x - y + 2 = 0$$

$$\Rightarrow \text{Area of } \triangle PCB = 6 \text{ sq. units}$$

8. If  $\vec{a}$  and  $\vec{b}$  are unit vectors such that angle between  $\vec{a}$  and  $\vec{b}$  is  $\sin^{-1}\left(\frac{\sqrt{65}}{9}\right)$  and  $\vec{c} = 3\vec{a} + 4\vec{b} + 9(\vec{a} \times \vec{b})$ . Then, the value of  $\vec{c} \cdot \vec{a} - 3\vec{c} \cdot \vec{b}$  is

- (1)  $\frac{101}{3}$  (2)  $\frac{-101}{9}$   
(3)  $\frac{101}{9}$  (4)  $\frac{-101}{3}$

Answer (2)

Sol.  $\vec{c} = 3\vec{a} + 4\vec{b} + 9(\vec{a} \times \vec{b})$

angle between  $\vec{a}$  and  $\vec{b}$  is  $\sin^{-1}\left(\frac{\sqrt{65}}{9}\right)$

$$\Rightarrow \sin \theta = \frac{\sqrt{65}}{9}$$

$$\Rightarrow \cos \theta = \frac{4}{9}$$

Also,  $\vec{c} \cdot \vec{a} = 3|\vec{a}| + 4\vec{a} \cdot \vec{b}$

$$= 3 + 4 \times \frac{4}{9}$$

$$= 3 + \frac{16}{9}$$

$$= \frac{43}{9}$$

$$\vec{c} \cdot \vec{b} = 3\vec{a} \cdot \vec{b} + 4|\vec{b}|^2$$

$$= 3 \times \frac{4}{9} + 4 = \frac{16}{3}$$

$$\vec{c} \cdot \vec{a} - 3\vec{c} \cdot \vec{b} = \frac{43}{9} - 3\left(\frac{16}{3}\right)$$

$$= \frac{-101}{9}$$

9. Consider two statements:

**Statement 1:**  $\left(\frac{z+i}{z-i}\right)$  is purely real and  $|z| = 1$ , then there are exactly 2 complex numbers  $z$ .

**Statement 2:**  $\left(\frac{z+1}{z-1}\right)$  is purely imaginary, then there are infinite such complex numbers  $z$ .

Then

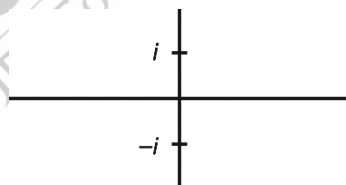
- (1) Statement 1 is true  
(2) Statement 2 is true  
(3) Both statement 1 and statement 2 are true  
(4) Both statement 1 and statement 2 are false

Answer (3)

Sol. Statement 1:  $\left(\frac{-i-z}{i-z}\right)$

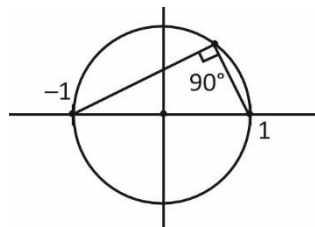
Using rotation

$\arg\left(\frac{-i-z}{i-z}\right)$  is 0 or  $\pi$



$$\Rightarrow z \text{ lies on the same line as } \pm i.$$

Statement 2:  $\left(\frac{-1-z}{1-z}\right)$  is imaginary



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- $\Rightarrow$  (z) lies on the circle  
 $\Rightarrow$  again infinite such complex numbers.  
 $z = \cos\theta + i\sin\theta$ , satisfies.

10. The value of the limit

$$\lim_{x \rightarrow 0^+} \frac{(\tan^{-1} 5x^{1/3})^2 \cdot \log_e(1+3x^2) \cdot (e^{5x^{4/3}} - 1)}{(\sin^{-1}(3\sqrt{x}))^8} \text{ is}$$

- (1)  $\frac{5^3}{3^7}$                       (2)  $\frac{5^3}{3^6}$   
 (3)  $\frac{5^2}{3^7}$                       (4)  $\frac{5^2}{3^6}$

**Answer (1)**

**Sol.**  $\lim_{x \rightarrow 0^+} \left( \frac{\tan^{-1} 5x^{1/3}}{5x^{1/3}} \right)^2 \cdot (25x^{2/3}) \cdot \frac{\log(1+3x^2)}{(3x^2)} \cdot (3x^2) \cdot \frac{(e^{5x^{4/3}} - 1)}{(5 \cdot x^{4/3})}$

$$(5x^{4/3}) \left( \frac{(3\sqrt{x})}{\sin^{-1}(3\sqrt{x})} \right)^8 \frac{1}{(3\sqrt{x})^8}$$

$$\lim_{x \rightarrow 0^+} (1)(25x^{2/3})(1) \cdot (3x^2) \cdot (1) \cdot 5x^{4/3} \cdot \frac{1}{3^8 \cdot x^4}$$

$$\lim_{x \rightarrow 0^+} \left( \frac{25.3 \times 5}{3^8} \right) = \frac{5^3}{3^7}$$

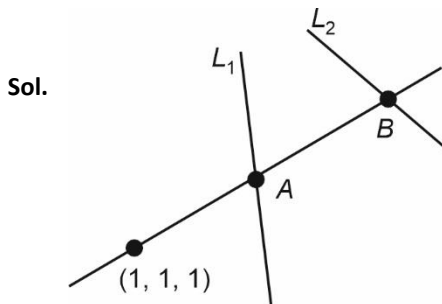
11. Line  $L$  passes through (1, 1, 1) and Line  $L$  intersects  $L_1$  and  $L_2$  where

$$L_1: \frac{x-1}{2} = \frac{y+1}{3} = \frac{z}{4} \text{ and } L_2: \frac{x-1}{1} = \frac{y+3}{4} = \frac{z}{1}, \text{ then } L$$

passes through

- (1) (0, 0, 0)                      (2) (1, 2, 3)  
 (3) (-1, 3, 4)                      (4) (9, 15, 18)

**Answer (4)**



$$L: \frac{x-1}{a} = \frac{y-1}{b} = \frac{z-1}{c}$$

As  $L$  passes through (1, 1, 1)

$$L_1: \frac{x-1}{2} = \frac{y+1}{3} = \frac{z}{4} = \lambda \text{ (say)}$$

Any point on  $L_1$  be  $A(2\lambda + 1, 3\lambda - 1, 4\lambda)$

$$L_2: \frac{x-1}{1} = \frac{y-3}{4} = \frac{z}{1} = \mu \text{ (say)}$$

Any point on  $L_2$  be  $B(\mu + 1, 4\mu + 3, \mu)$

Dr of  $L$  be  $\langle 2\lambda, 3\lambda - 2, 4\lambda - 1 \rangle$  or  $\langle \mu, 4\mu + 2, \mu - 1 \rangle$

Now,

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

$$\Rightarrow \lambda = -4$$

$$\mu = \frac{-8}{9}$$

$$\Rightarrow \text{Dr of } L: \text{be } \langle -8, -14, -17 \rangle$$

$$\therefore L: \frac{X-1}{8} = \frac{Y-1}{14} = \frac{Z-1}{17}$$

12. If  $x(x^2 + e^x)dy + (e^x(x-2)y - x^3)dx = 0$ . Such that  $f(1) = 1$ . Then which of the following is correct.

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

**Answer (3)**

**Sol.**  $x(x^2 + e^x)dy + (e^x(x-2)y - x^3)dx = 0$

$$\frac{dy}{dx} + \frac{e^x(x-2)}{x(x^2 + e^x)}y = \frac{x^3}{x(x^2 + e^x)}$$

$$\text{If } = e^{\int \frac{e^x(x-2)}{x(x^2 + e^x)} dx}$$

$$= e^{\int \frac{e^x + 2x^2 - 2e^x - 2x^2}{x(x^2 + e^x)} dx}$$

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$$= e^{\int \frac{e^x + 2x}{e^x + x^2} dx - \int \frac{2}{x} dx}$$

$$= e^{\ln|e^x + x^2| - 2\ln x} = \frac{e^x + x^2}{x^2}$$

$$\therefore y \left( \frac{e^x + x^2}{x^2} \right) = \int \frac{x^3}{x(x^2 + e^x)} \times \frac{(e^x + x^2)}{x^2} dx$$

$$y \left( \frac{e^x + x^2}{x^2} \right) = x + c$$

$$\therefore y(1) = 1$$

$$\Rightarrow \left( \frac{e+1}{1} \right) = 1 + c$$

$$\Rightarrow c = e$$

$$\therefore y = \frac{(x+e)x^2}{e^x + x^2}$$

13. Consider a squad of 15 players consisting of 7 batsman, 6 bowler, 1 captain and 1 vice captain. A team of 10 players to be selected such that team has at least 4 batsman and 4 bowler and out of captain and vice captain atleast 1 must be present in the team. Then number of ways to select such team is
- (1) 1475                      (2) 1575  
(3) 1075                      (4) 1500

**Answer (2)**

**Sol.**

| Batsman | Bowler | Captain | Vice | Number of ways                           |
|---------|--------|---------|------|--|
| 4       | 4      | 1       | 1    | ${}^7C_4 \cdot {}^6C_4 \cdot 1 \times 1$ |
| 4       | 5      | 1       | 0    | ${}^7C_4 \cdot {}^6C_4 \cdot {}^1C_1$    |
| 4       | 5      | 0       | 1    | ${}^7C_4 \cdot {}^6C_5 \cdot {}^1C_1$    |
| 5       | 4      | 1       | 0    | ${}^7C_5 \cdot {}^6C_4 \cdot {}^1C_1$    |
| 5       | 4      | 0       | 1    | ${}^7C_5 \cdot {}^6C_4 \cdot {}^1C_1$    |

$$\Rightarrow {}^7C_4 \cdot {}^6C_4 [1] + {}^7C_4 [2] + {}^7C_5 \cdot {}^6C_4 [2]$$

$$= 35 \cdot 15 + 35 \times 12 + 21 \cdot 15 \times 2$$

$$= 525 + 420 + 630 = 1575$$

14.  
15.  
16.  
17.  
18.  
19.  
20.

## SECTION - B

**Numerical Value Type Questions:** This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Let A be a set defined as  $A = \{2, 3, 6, 9\}$ . Find the number of singular matrices of order  $2 \times 2$  such that elements are from the set A.

**Answer (36)**

$$\text{Sol. } \begin{vmatrix} a & d \\ b & c \end{vmatrix} = ab - bc = 0 \Rightarrow ad = bc$$

Case I: exactly 1 number is used

$$\Rightarrow \text{All singular} \Rightarrow {}^4C_1$$

Case II: exactly 2 number is used

$${}^4C_2 \cdot 2 \times 2$$

Case III: exactly 3 number is used

None will be singular

Case IV: exactly 4 number is used

$$ab = cd \Rightarrow 2 \times 9 = 3 \times 6$$

$$\begin{bmatrix} 9 & \square \\ \square & 2 \end{bmatrix} {}^4C_1 \times 2! \Rightarrow 8 \text{ matrices}$$

$$\Rightarrow 4 + 6 \times 4 + 0 + 8 = 36 \text{ matrices}$$

22.  
23.  
24.  
25.



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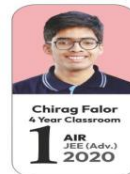
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