



Sol.  $S = \frac{1^2}{0!} + \frac{2^2}{1!} + \frac{3^2}{2!} + \dots$

$$T_n = \frac{n^2}{(n-1)!}$$

$$= \frac{n^2 - 1}{(n-1)!} + \frac{1}{(n-1)!}$$

$$= \frac{(n-1)(n+1)}{(n-1)!} + \frac{1}{(n-1)!}$$

$$= \frac{n+1}{(n-2)!} + \frac{1}{(n-1)!}$$

$$= \frac{n-2+3}{(n-2)!} + \frac{1}{(n-1)!}$$

$$T_n = \frac{1}{(n-3)!} + \frac{3}{(n-2)!} + \frac{1}{(n-1)!}$$

$$\sum_{n=1}^{\infty} T_n = e + 3e + e = 5e$$

4. Let  $y = f(x)$  be the solution of the differential equation

$$\frac{dy}{dx} + 3y \tan^2 x + 3y = \sec^2 x \quad \text{such that} \quad f(0) = \frac{e^3}{3} + 1,$$

then  $f\left(\frac{\pi}{4}\right)$  is equal to

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

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

Answer (2)

Sol.  $\frac{dy}{dx} + 3y(1 + \tan^2 x) = \sec^2 x$

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

$$\text{I.F.} = e^{\int 3\sec^2 x dx} = e^{3\tan x}$$

$$\Rightarrow y(e^{3\tan x}) = \int e^{3\tan x} \cdot \sec^2 x dx + c$$

$$= \frac{e^{3\tan x}}{3} + c$$

$$f(0) = \frac{e^3}{3} + 1$$

$$y(e^0) = \frac{e^0}{3} + c = \frac{e^3}{3} + 1$$

$$\Rightarrow c = \frac{e^3}{3} + \frac{2}{3}$$

$$f\left(\frac{\pi}{4}\right) \Rightarrow y\left(\frac{\pi}{4}\right) e^1 = \frac{e^3}{3} + \frac{e^3}{3} + \frac{2}{3}$$

$$\Rightarrow y\left(\frac{\pi}{4}\right) = \frac{1}{e^3} \left[ \frac{2e^3 + 2}{3} \right]$$

$$= \frac{2}{3} \left[ 1 + \frac{1}{e^3} \right]$$

5. Area bounded by  $|x - y| \leq y \leq 4\sqrt{x}$  is equal to (in square units)

(1)  $\frac{2048}{3}$

(2)  $\frac{1024}{3}$

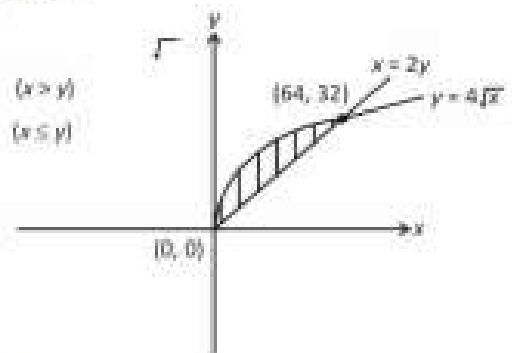
(3)  $\frac{512}{3}$

(4)  $\frac{128}{3}$

Answer (2)

Sol.  $|x - y| \leq y \leq 4\sqrt{x}$

$$\begin{cases} x = 2y \\ x - y = y \quad (x > y) \\ x - y = -y \quad (x \leq y) \\ x = 0 \end{cases}$$



$$\text{Area} = \int_0^{64} \left( 4\sqrt{x} - \frac{x}{2} \right) dx$$

$$= \left[ \frac{4x^{3/2}}{3/2} - \frac{x^2}{4} \right]_0^{64} = \frac{8}{3}(8)^3 - \frac{64^2}{4} = \frac{1024}{3}$$

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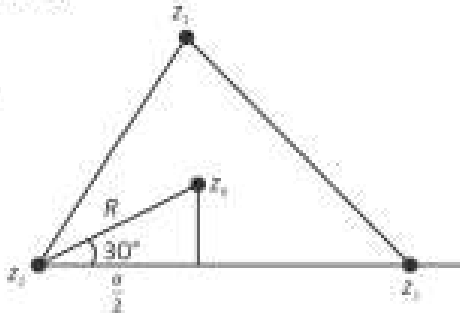
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6. Let  $A(z_1)$ ,  $B(z_2)$  and  $C(z_3)$  are the vertices of an equilateral triangle. If  $z_0$  is the centroid of triangle  $ABC$  and  $|z_1 - z_2| = 1$  then the value of  $\sum_{i=1}^3 |z_i - z_0|^2$  is equal to

- (1) 1                                      (2) 2  
 (3) 3                                      (4) 9

Answer (1)

Sol.



$$\Rightarrow \cos 30^\circ = \frac{\frac{\sqrt{3}}{2}}{R} = \frac{\frac{a}{2}}{R} \Rightarrow R = \frac{a}{\sqrt{3}}$$

$$\Rightarrow |z_1 - z_0| = |z_2 - z_0| = |z_3 - z_0| = \frac{a}{\sqrt{3}}$$

$$\Rightarrow \sum_{i=1}^3 |z_i - z_0|^2 = 3 \cdot \left(\frac{a}{\sqrt{3}}\right)^2 = \frac{3a^2}{3}$$

$$= a^2 = |z_1 - z_2|^2 = 1$$

7. If  $f(x) = ||x+2| - 2|x||$ , then the sum of number of points of local maxima and local minima is

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

Answer (2)

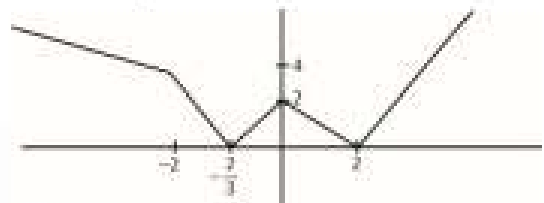
$$\text{Sol. } f(x) = \begin{cases} |-x-2+2x| & x \leq -2 \\ |x+2+2x| & -2 \leq x \leq 0 \\ |x+2-2x| & x \geq 0 \end{cases}$$

$$f(x) = \begin{cases} |-x-2+2x| & x \leq -2 \\ |x+2+2x| & -2 \leq x \leq 0 \\ |x+2-2x| & x \geq 0 \end{cases}$$

$$f(x) = \begin{cases} |x-2| & x \leq -2 \\ |3x+2| & -2 < x \leq 0 \\ |2-x| & x > 0 \end{cases}$$

$$f(x) = \begin{cases} 2-x & x \leq -2 \\ -3x-2 & -2 < x \leq -\frac{2}{3} \\ 3x+2 & -\frac{2}{3} < x \leq 0 \end{cases}$$

$$f(x) = \begin{cases} 2-x & x \leq -2 \\ -3x-2 & -2 < x \leq -\frac{2}{3} \\ 3x+2 & -\frac{2}{3} < x \leq 0 \\ 2-x & 0 < x < 2 \\ x-2 & x \geq 2 \end{cases}$$



No. of maxima = 1

No. of minima = 2

8. If  $x(x-2)(12-k) = 2$  has both roots same. Then the distance of  $\left(k, \frac{k}{2}\right)$  from the line  $3x+4y+5=0$  is

- (1) 24                                      (2) 14  
 (3) 15                                      (4) 20

Answer (3)

$$\text{Sol. } x^2 - 2x - \frac{2}{12-k} = 0$$

$$D = 0$$

$$4 - 4 \cdot \left(-\frac{2}{12-k}\right) = 0$$

$$\Rightarrow 1 + \frac{2}{12-k} = 0$$

$$\Rightarrow k = 14$$

$$\therefore \left(k, \frac{k}{2}\right) = (14, 7)$$

$$d = \frac{|3 \times 14 + 4 \times 7 + 5|}{5}$$

$$= 15$$

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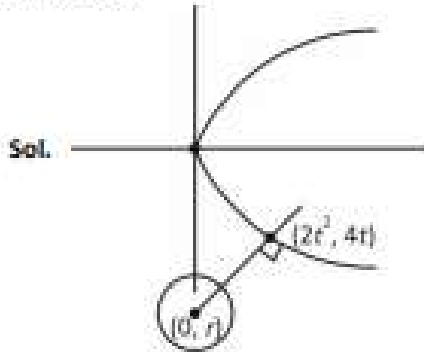
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9. The shortest distance between the parabola  $y^2 = 8x$  and the circle  $x^2 + y^2 + 12y + 35 = 0$  is

- (1)  $(2\sqrt{2} - 1)$  units      (2)  $(\sqrt{2} - 1)$  units  
 (3)  $(2\sqrt{2} + 1)$  units      (4)  $(\sqrt{2} + 1)$  units

Answer (1)



The common normal passes through centre and on which shortest distance will lie.

$$y^2 = 8x \Rightarrow 2y \frac{dy}{dx} = 8 \Rightarrow \frac{dy}{dx} = \frac{4}{y}$$

$$\Rightarrow \text{Slope of normal: } \frac{-y}{4} = \frac{-4t}{4} = -t$$

$$\Rightarrow -t = \frac{4t + 6}{2t^2 - 0} \Rightarrow 2t^3 + 4t + 6 = 0$$

$$\Rightarrow (t + 1)(2t^2 - 2t + 6) = 0$$

$$\Rightarrow t = -1 \text{ is only point}$$

$$\Rightarrow \text{distance} = \text{distance between } (0, -6) \text{ to } (2, -4) - \text{radius of circle} = 2\sqrt{2} - 1$$

10. Let  $f(x) = \log_7(1 - \log_7(x^2 - 9x + 8))$ . If the domain of  $f(x)$  is  $(\alpha, \beta) \cup (\gamma, \delta)$ . Then  $\alpha + \beta + \gamma + \delta$  equals to

- (1) 18      (2) 27  
 (3) 21      (4) 9

Answer (1)

Sol.  $1 - \log_7(x^2 - 9x + 8) > 0$

$$\Rightarrow \log_7(x^2 - 9x + 8) < 1$$

$$\Rightarrow x^2 - 9x + 8 < 7$$

$$\Rightarrow x^2 - 9x + 1 < 0$$

$$\Rightarrow x = \frac{9 \pm \sqrt{81 - 4}}{2}$$

$$\Rightarrow x = \frac{9 \pm \sqrt{77}}{2}$$

$$x^2 - 9x + 8 > 0$$

$$\Rightarrow x^2 - 8x - x - 8 > 0$$

$$\Rightarrow x(x - 8) - 1(x - 8) > 0$$

$$\Rightarrow (x - 1)(x - 8) > 0$$



$$\therefore x \in \left( \frac{9 - \sqrt{77}}{2}, 1 \right) \cup \left( 8, \frac{9 + \sqrt{77}}{2} \right)$$

$$\therefore \alpha + \beta + \gamma + \delta = \frac{9 - \sqrt{77}}{2} + 1 + 8 + \frac{9 + \sqrt{77}}{2}$$

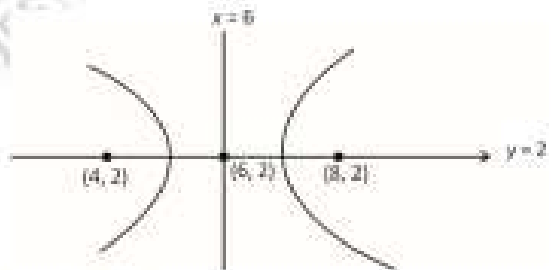
$$\therefore \boxed{\alpha + \beta + \gamma + \delta = 18}$$

11. If the coordinates of foci of a hyperbola  $3x^2 - y^2 - \alpha x + \beta y + \gamma = 0$  are  $(4, 2)$  and  $(8, 2)$ . Then  $(\alpha + \beta + \gamma)$  is equal to

- (1) 81      (2) 137  
 (3) 121      (4) 141

Answer (4)

Sol.



Hyperbola:

$$\frac{(x - 6)^2}{a^2} - \frac{(y - 2)^2}{b^2} = 1$$

$$b^2x^2 - a^2y^2 - 12xb^2 + 4ya^2 + 4ya^2 + 36b^2 - 4a^2 - a^2b^2 = 0$$

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Comparing:  $\frac{b^2}{a^2} = 3 \Rightarrow e^2 = 1 + \frac{b^2}{a^2} = 4$

$\Rightarrow e = 2$

Similarly,  $2ae = 4 \Rightarrow a = 1 \Rightarrow b = \sqrt{3}$

$$\frac{(x-6)^2}{1} - \frac{(y-2)^2}{3} = 1$$

$$\Rightarrow 3x^2 - y^2 - 36x + 4y + 108 - 4 - 3 = 0$$

$$3x^2 - y^2 - 36x + 4y + 101 = 0$$

$\Rightarrow \alpha = 36$

$\beta = 4$

$\gamma = 101$

$\Rightarrow \alpha + \beta + \gamma = 141$

12. Let the probability distribution is defined for a random variable  $x$  as  $p(x) = k(1 - 3^{-x})$  for  $x = 0, 1, 2, 3$ . Then  $P(x \geq 2)$  is

(1)  $\frac{5}{17}$

(2)  $\frac{25}{34}$

(3)  $\frac{25}{68}$

(4)  $\frac{7}{25}$

Answer (2)

Sol.  $\Rightarrow \sum p(x) = 1$

$$\Rightarrow k[1 - 3^{-0} + 1 - 3^{-1} + 1 - 3^{-2} + 1 - 3^{-3}] = 0$$

$$k\left[4 - \left(1 + \frac{1}{3} + \frac{1}{3^2} + \frac{1}{3^3}\right)\right] = 1$$

$$\Rightarrow k = \frac{27}{68}$$

Now  $P(x \geq 2) = p(x=3) + P(x=2)$

$$= \frac{27}{68}\left(1 - \frac{1}{3^3}\right) + \frac{27}{68}\left(1 - \frac{1}{3^2}\right)$$

$$= \frac{26}{68} + \frac{3}{68}(8) = \frac{50}{68} = \frac{25}{34}$$

13. If the mean and variance of a data  $x_1 = 1, x_2 = 4, x_3 = a, x_4 = 7, x_5 = b$  are 5 and 10 respectively. If new data is  $r + x_i, r \in \{1, 2, 3, 4, 5\}$ , then the new variance is

(1) 17.6

(2) 16.9

(3) 20.4

(4) 21.4

Answer (3)

Sol.  $5 = \frac{1+4+a+7+b}{5} \Rightarrow a+b=13$

$$10 = \frac{1+16+a^2+49+b^2}{5} - (5)^2$$

$$a^2 + b^2 = 109$$

$$a = 3, b = 10$$

New digits:  $r + x_i, r \in \{1, 5\}$

$$1 + x_1, 2 + x_1, 3 + x_1, 4 + x_1, 5 + x_1$$

$$= 2, 6, 6, 11, 15$$

$$\text{Variance} = \frac{2^2 + 6^2 + 6^2 + 11^2 + 15^2}{5} - \left(\frac{2+6+6+11+15}{5}\right)^2$$

$$= 20.4$$

14. Let 9 points lie on the line  $y = 2x$  and 12 points on the  $y = \frac{x}{2}$  in the first quadrant. Find the number of triangles formed using these points and origin.

(1) 1134

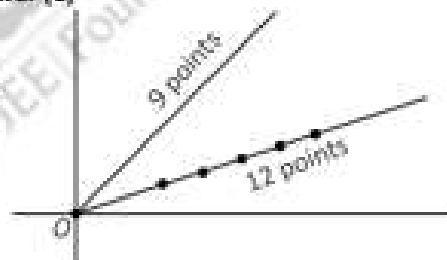
(2) 1096

(3) 1120

(4) 1026

Answer (1)

Sol.



Total triangles : (two points of  $y = 2x, 1$  point of  $y = \frac{x}{2}$ ) +

(two points on  $y = \frac{x}{2}, 1$  point of  $y = 2x$ ) + (1 point on  $y =$

$2x, 1$  point of  $y = \frac{x}{2}$  and origin)

$$= {}^9C_2 \cdot {}^{12}C_1 + {}^9C_1 \cdot {}^{12}C_2 + {}^1C_1 \cdot {}^9C_1 \cdot {}^{12}C_1$$

$$= 1134$$

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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. If  $\lim_{x \rightarrow 0} \left( \frac{\tan x}{x} \right)^{\frac{1}{x^2}} = P$ ,

then  $96 \ln P$  is

**Answer (32)**

**Sol.**  $\lim_{x \rightarrow 0} \left( \frac{\tan x}{x} \right)^{\frac{1}{x^2}} = 1^{\infty}$  (form)

$$L = \lim_{x \rightarrow 0} \left( \frac{\tan x}{x} - 1 \right)^{\frac{1}{x^2}}$$

$$= \lim_{x \rightarrow 0} \left( \frac{\tan x - x}{x^3} \right)$$

$$= \lim_{x \rightarrow 0} \left( \frac{x + \frac{x^3}{3} + \frac{2}{15}x^5 + \dots - x}{x^3} \right)$$

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

$$\therefore = \lim_{x \rightarrow 0} \left( \frac{\tan x}{x} \right)^{\frac{1}{x^2}} = e^{1/3} = P$$

$$96 \ln P = \frac{96}{3} = 32$$

22. Let  $A = \{-3, -2, -1, 0, 1, 2, 3\}$ . A relation  $R$  is defined such that  $xRy$  iff  $y = \max\{x, 1\}$ .

Number of elements required to make it reflexive is  $l$ , number of elements required to make it symmetric is  $m$  and number of elements in the relation  $R$  is  $n$ . Then value of  $l + m + n$  is equal to

**Answer (15)**

**Sol.**  $R = \{(-3, 1), (-2, 1), (-1, 1), (0, 1), (1, 1), (2, 2), (3, 3)\}$

$$\therefore l = 4 \text{ i.e., } \{-3, -3\}, \{-2, -2\}, \{-1, -1\}, \{0, 0\}$$

$$m = 4 \text{ i.e., } \{1, -3\}, \{1, -2\}, \{1, -1\}, \{1, 0\}$$

$$n = 7$$

$$l + m + n = 15$$

23. If  $(1 + x + x^2)^{20} = 1 + a_1x + a_2x^2 + \dots$ , then  $(a_1 + a_3 + a_5 + \dots + a_{39}) - 11a_2$  equals to

**Answer (28919)**

**Sol.**  $(1 + x + x^2)^{20} = 1 + a_1x + a_2x^2 + \dots + a_{39}x^{39} \dots (i)$

$$x = 1$$

$$3^{20} = 1 + a_1 + a_2 + \dots + a_{39} \dots (ii)$$

$$x = -1$$

$$1 = 1 - a_1 + a_2 - \dots + a_{39} \dots (iii)$$

$$(ii) - (iii)$$

$$3^{20} - 1 = 2[a_1 + a_3 + \dots + a_{39}]$$

$$\Rightarrow a_1 + a_3 + a_5 + \dots + a_{39} = \frac{3^{20} - 1}{2}$$

Diff. (i) w.r.t.  $x$

$$10(1 + x + x^2)^{19}(1 + 2x) = a_1 + 2a_2x + \dots + 20a_{39}x^{38}$$

Again diff. w.r.t.  $x$  and substitute  $x = 0$

$$10[9(1 + x + x^2)^{18}(1 + 2x)^2 + (1 + x + x^2)^{18}(2)] = 2a_2 + \dots$$

$$10[9 + 2] = 2a_2$$

$$55 = a_2$$

Now

$$(a_1 + a_3 + \dots + a_{39}) - 11a_2 = \frac{3^{20} - 1}{2} - 55 \times 11$$

$$= 28919$$

24.

25.



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