MATHEMATICS

JEE–MAIN EXAMINATION – JUNE, 2022

24 June S - 01 Paper Solution

SECTION-A

1. Let $A = \{z \in C : 1 \le |z-(1+i)| \le 2\}$ and $B = \{z \in A : |z-(1-i)| = 1\}$. Then, B :

(A) is an empty set

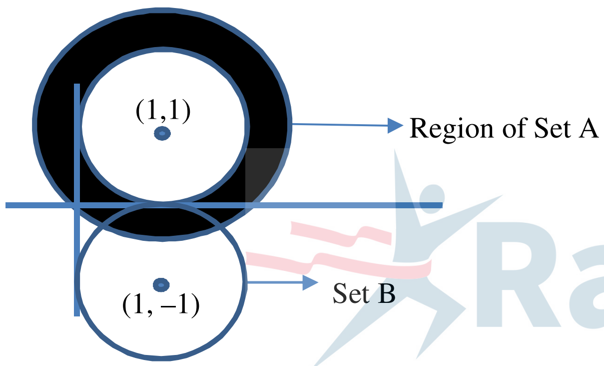
(B) contains exactly two elements

(C) contains exactly three elements

(D) is an infinite set

Ans. (D)

Sol. $A = \{z \in C : 1 \le |z-(1+i)| \le 2\}$



$B = \{z \in A : |z-(1-i)| = 1\}$.

$A \cap B$ has infinite set.

2. The remainder when 3^{2022} is divided by 5 is

(A) 1 (B) 2

(C) 3 (D) 4

Ans. (D)

Sol. $3^{2022} = 9^{1011} = (10-1)^{1011} = 10\,m - 1 = 10\,m - 5 + 4$

$= 5\,(2m-1) + 4$ (m is integer)

Remainder = 4

3. The surface area of a balloon of spherical shape being inflated, increases at a constant rate. If initially, the radius of balloon is 3 units and after 5 seconds,, it becomes 7 units, then its radius after 9 seconds is :

(A) 9 (B) 10

(C) 11 (D) 12

Ans. (A)

Sol. Let r be the radius of spherical balloon

S = Surface area

$S = 4\pi r^2$

$\frac{dS}{dt} = 8\pi r \times \frac{dr}{dt} = k$ (constant)

$4\pi r^2 = kt + C$ (C is constant of integration)

For $t = 0$, $r = 3 \Rightarrow 36\pi = C$

For $t = 5$, $r = 7 \Rightarrow K = 32\pi$

$4\pi r^2 = 32\pi t + 36\pi$

$r^2 = 8t + 9$

for $t = 9$

$r^2 = 81$

$r = 9$

4. Bag A contains 2 white, 1 black and 3 red balls and bag B contains 3 black, 2 red and n white balls. One bag is chosen at random and 2 balls drawn from it at random, are found to be 1 red and 1 black. If the probability that both balls come from Bag A is $\frac{6}{11}$, then n is equal to ______ .

(A) 13 (B) 6

(C) 4 (D) 3

Ans. (C)

Sol. E_1 = denotes selection for 1st bag

E_2 = denotes selection for 2nd bag

$P(E_1) = \frac{1}{2}$, $P(E_2) = \frac{1}{2}$

A = selected balls are 1 red & 1 black

$P\left(\frac{A}{E_1}\right) = \frac{{}^3C_1 \times {}^1C_1}{{}^6C_2} = \frac{1}{5}$

$P\left(\frac{A}{E_1}\right) = \frac{{}^3C_1 \times {}^2C_1}{(n+5)_{C_2}} = \frac{12}{(n+5)(n+4)}$

$$P\left(\frac{E_1}{A}\right) = \frac{P(E_1)\times P\left(\frac{A}{E_1}\right)}{P(E_1)\times P\left(\frac{A}{E_1}\right) + P(E_2)\times P\left(\frac{A}{E_2}\right)}$$

$$= \frac{\frac{1}{10}}{\frac{1}{10}+\frac{6}{(n+5)(n+4)}} = \frac{6}{11}$$

$\Rightarrow n = 4$

5. Let $x^2 + y^2 + Ax + By + C = 0$ be a circle passing through (0, 6) and touching the parabola $y = x^2$ at (2, 4). Then A + C is equal to______ .

(A) 16 (B) 88/5

(C) 72 (D) –8

Ans. (A)

Sol. $x^2+y^2+Ax+By+C=0$ is passing through (0,6)

$\Rightarrow 6B + C = -36$

The tangent of the parabola $y = x^2$ at (2, 4) is

$4x - y - 4 = 0$ ----(1)

The tangent of circle $x^2+y^2+Ax+By+C=0$ at (2, 4) is

$(4 + A)x + (8 + B)y + 2A + 4B + 2C = 0$ -----(2)

From Equation (1) and (2)

$$\frac{4+A}{4} = \frac{8+B}{-1} = \frac{2A+4B+2C}{-4}$$

$A + 4B = -36$ ---(3)

$3A + 4B + 2C = -4$ ---(4)

From equation (3) and (4)
A+ C = 16

6. The number of values of α for which the system of equations :
$x + y + z = \alpha$
$\alpha x + 2\alpha y + 3z = -1$
$x + 3\alpha y + 5z = 4$

is inconsistent, is

(A) 0 (B) 1

(C) 2 (D) 3

Ans. (B)

Sol. $x+y+z=\alpha$

$\alpha x+2\alpha y+3z=-1$

$x+3\alpha y+5z=4$

Has inconsistent solution

$$D = \begin{vmatrix} 1 & 1 & 1 \\ \alpha & 2\alpha & 3 \\ 1 & 3\alpha & 5 \end{vmatrix} = 0$$

$\Rightarrow (\alpha-1)^2 = 0$

$\alpha = 1$

For $\alpha = 1$

$$D_1 = \begin{vmatrix} 1 & 1 & 1 \\ -1 & 2 & 3 \\ 4 & 3 & 5 \end{vmatrix}$$

$= (10 - 9) - (-5-12) + (-3-8)$

$= 1+17-11 \neq 0$

For $\alpha = 1$ the system of equation has Inconsistent solution

7. If the sum of the squares of the reciprocals of the roots α and β of the equation $3x^2 + \lambda x - 1 = 0$ is 15, then $6(\alpha^3 + \beta^3)^2$ is equal to :

(A) 18 (B) 24

(C) 36 (D) 96

Ans. (B)

Sol. **Here** α, β roots of equation $3x^2+\lambda x-1=0$

$\alpha+\beta = \frac{-\lambda}{3}$, $\alpha\beta = \frac{-1}{3}$

$$\frac{1}{\alpha^2}+\frac{1}{\beta^2} = \frac{(\alpha+\beta)^2-2\alpha\beta}{\alpha^2\beta^2} = 15$$

$\lambda^2 = 9$

Now $6(\alpha^3+\beta^3)^2 = 6\left((\alpha+\beta)\left((\alpha+\beta)^2-3\alpha\beta\right)\right)^2$

$$= 6\left(\frac{\lambda^2}{9}\right)\left\{\frac{\lambda^2}{9}+1\right\}^2 = 24$$

8. The set of all values of k for which $(\tan^{-1}x)^3 + (\cot^{-1}x)^3 = k\pi^3, x \in R$, is the interval :

(A) $\left[\frac{1}{32}, \frac{7}{8}\right)$ (B) $\left(\frac{1}{24}, \frac{13}{16}\right)$

(C) $\left[\frac{1}{48}, \frac{13}{16}\right]$ (D) $\left[\frac{1}{32}, \frac{9}{8}\right)$

Ans. (A)

Sol. **Let S =** $(\tan^{-1}x)^3 + (\cot^{-1}x)^3$

$= \left(\tan^{-1}x + \cot^{-1}x\right) - 3\tan^{-1}x.\cot^{-1}x\left(\tan^{-1}x + \cot^{-1}x\right)$

$= \frac{\pi^3}{8} - \frac{3\pi}{2}\tan^{-1}x\left(\frac{\pi}{2} - \tan^{-1}x\right)$

$= \frac{3\pi}{2}\left(\tan^{-1}x - \frac{\pi}{4}\right)^2 + \frac{\pi^3}{32}$

$\Rightarrow \frac{\pi^3}{32} \le S < \frac{7}{8}\pi^3$

$= \frac{\pi^3}{32} \le K\pi^3 < \frac{7}{8}\pi^3$

$\frac{1}{32} \le K < \frac{7}{8}$

9. Let $S = \{\sqrt{n} : 1 \le n \le 50$ and n is odd$\}$

Let $a \in S$ and $A = \begin{bmatrix} 1 & 0 & a \\ -1 & 1 & 0 \\ -a & 0 & 1 \end{bmatrix}$

If $\sum_{a \in S} \det(\text{adj}A) = 100\lambda$, then λ is equal to

(A) 218 (B) 221

(C) 663 (D) 1717

Ans. (B)

Sol. $S = \{\sqrt{n} : 1 \le n \le 50$ and n is odd$\}$

$= \left\{\sqrt{1}, \sqrt{3}, \sqrt{5}..........\sqrt{49}\right\}$, 25 terms

$|A| = 1 + a^2$

$\sum_{a \in S} \det(\text{adj}A) = \sum_{a \in S} |A|^2 = \sum(1 + a^2)^2$

$= 22100 = 100\lambda$

$\lambda = 221$

10. $f(x) = 4\log_e(x - 1) - 2x^2 + 4x + 5$, $x > 1$, which one of the following is NOT correct ?

(A) f is increasing in (1, 2) and decreasing in (2, ∞)

(B) f(x)= –1 has exactly two solutions

(C) f'(e) –f'' (2) < 0

(D) f(x) = 0 has a root in the interval (e, e +1)

Ans. (C)

Sol. $f(x) = 4\log_e(x - 1) - 2x^2 + 4x + 5$, $x > 1$

$f'(x) = \frac{4}{x-1} - 4(x-1)$

For $1 < x < 2 \Rightarrow f'(x) > 0$

For $x > 2 \Rightarrow f'(x) < 0$ (option 1 is correct)

$f(x) = -1$ has two solution (option 2 is correct)

$f(e) > 0$

$f(e+1) < 0$

$f(e).f(e+1) < 0$ (option 4 is correct)

$f'(e) - f''(2) = \frac{4}{e-1} - 4(e-1) + 8 > 0$

(option C is incorrect)

11. the tangent at the point (x_1, y_1) on the curve $y = x^3 + 3x^2 + 5$ passes through the origin, then (x_1, y_1) does NOT lie on the curve :

(A) $x^2 + \frac{y^2}{81} = 2$ (B) $\frac{y^2}{9} - x^2 = 8$

(C) $y = 4x^2 + 5$ (D) $\frac{x}{3} - y^2 = 2$

Ans. (D)

Sol. **The tangent at (x_1, y_1) to the curve**

$y = x^3 + 3x^2 + 5$

$y - y_1 = \left(3x_1^2 + 6x_1\right)\left(x - x_1\right)$ passing through origin

$-y_1 = \left(3x_1^3 + 6x_1\right)\left(-x_1\right)$

$y_1 = \left(3x_1^3 + 6x_1^2\right)$ --------(1)

And (x_1, y_1) lies on the curve

$y = x^3 + 3x^2 + 5$

$y_1 = x_1^3 + 3x_1^2 + 5$ ----(2)

From equation (1) and (2)

$2y_1 = 3x_1^2 + \frac{15}{2}$

Hence the equation of curve $y = \frac{3}{2}x^2 + \frac{15}{2}$

This curve does not intersect $\frac{x}{3} - y^2 = 2$

12. The sum of absolute maximum and absolute minimum values of the function $f(x) = |2x^2 + 3x - 2| + \sin x \cos x$ in the interval [0, 1] is :

(A) $3 + \frac{\sin(1)\cos^2(1/2)}{2}$ (B) $3 + \frac{1}{2}(1 + 2\cos(1))\sin(1)$

(C) $5 + \frac{1}{2}(\sin(1) + \sin(2))$ (D) $2 + \sin\left(\frac{1}{2}\right)\cos\left(\frac{1}{2}\right)$

Ans. (B)

Sol. $f(x) = |2x^2 + 3x - 2| + \sin x \cos$ x

$f(x) = |(2x - 1)(x + 2)| + \sin x \cos x$

$$f'(x) = \begin{cases} 4x + 3 + \frac{\cos 2x}{4}, & \frac{1}{2} < x < 1 \\ -(4x+3) + \frac{\cos 2x}{4}, & 0 \le x < \frac{1}{2} \end{cases}$$

For $0 \le x < \frac{1}{2} \Rightarrow f'(x) < 0$

For $\frac{1}{2} < x \le 1 \Rightarrow f'(x) > 0$

f (x) local minima at $x = \frac{1}{2}$ and

local maxima at x = 1

$f\left(\frac{1}{2}\right) + f(1) = 3 + \frac{1}{2}(1 + 2\cos 1)\sin 1$

13. If $\{a_i\}_{i=1}^{n}$ where n is an even integer, is an arithmetic progression with common difference 1, and $\sum_{i=1}^{n} a_i = 192$, $\sum_{i=1}^{n/2} a_{2i} = 120$, then n is equal to:

(A) 48 (B) 96

(C) 92 (D) 104

Ans. (B)

Sol. $\sum_{i=1}^{n} a_i = \frac{n}{2}\{2a_1 + (n+1)\} = 192$

$\Rightarrow 2a_1 + (n-1) = \frac{384}{n}$ ----(1)

$\sum_{i=1}^{n/2} a_{2i} = \frac{n}{4}\left[2a_1 + 2 + \left(\frac{n}{2} - 1\right)2\right] = 120$

$2a_1 + n = \frac{480}{n}$ ----(2)

From equation (2) and (1)

$1 = \frac{480}{n} - \frac{384}{n}$

n = 480 – 384 = 96

14. If x = x(y) is the solution of the differential equation $y\frac{dx}{dy} = 2x + y^3(y+1)e^y, x(1) = 0$; then x(e) is equal to :

(A) $e^3(e^e - 1)$ (B) $e^e(e^3 - 1)$

(C) $e^2(e^e + 1)$ (D) $e^e(e^2 - 1)$

Ans. (A)

Sol. $y\frac{dx}{dy} = 2x + y^3(y+1)e^y, x(1) = 0$

$\frac{dx}{dy} - \frac{2}{y}x = y^2(y+1)e^y$

I.f = $e^{\int \frac{-2}{y}dy} = \frac{1}{y^2}$

$x.\frac{1}{y^2} = \int (y+1)e^y dy$

$\frac{x}{y^2} = (y+1)e^y - e^y + c = y.e^y + c$

$x = y^3e^y + cy^2$

For x = 0, y = 1 $\Rightarrow$ c = –e

$x = y^3e^y - e.y^2$

$x(e) = e^3(e^e - 1)$

15. Let $\lambda x-2y=\mu$ be a tangent to the hyperbola $a^2x^2-y^2=b^2$. Then $\left(\frac{\lambda}{a}\right)^2-\left(\frac{\mu}{b}\right)^2$ is equal to:

(A) –2 (B) –4

(C) 2 (D) 4

Ans. (D)

Sol. $\lambda x-2y=\mu$ is a tangent to the curve

$a^2x^2-y^2=b^2$ then

$$a^2x^2-\left(\frac{\lambda x-\mu}{2}\right)^2=b^2$$

$$\left(4a^2-\lambda^2\right)x^2+2\lambda\mu x-\mu^2-4b^2=0$$

Disc. = 0

$$4\lambda^2\mu^2+4\left(4a^2-\lambda^2\right)\left(\mu^2+4b^2\right)=0$$

$$4\lambda^2b^2-4a^2\mu^2=16a^2b^2$$

$$\frac{\lambda^2}{a^2}-\frac{\mu^2}{b^2}=4$$

16. Let $\hat{a},\hat{b}$ be unit vectors. If $\vec{c}$ be a vector such that the angle between $\hat{a}$ and $\vec{c}$ is $\frac{\pi}{12}$, and $\hat{b}=\vec{c}+2(\vec{c}\times\hat{a})$, then $|6\vec{c}|^2$ is equal to

(A) $6(3-\sqrt{3})$ (B) $3+\sqrt{3}$

(C) $6(3+\sqrt{3})$ (D) $6(\sqrt{3}+1)$

Ans. (C)

Sol. $|\hat{b}|^2=|\vec{c}+2(\vec{c}\times\hat{a})|^2$

$$|\hat{b}|^2=|c|^2+4|\vec{c}\times\hat{a}|^2+4\vec{c}.(\vec{c}\times\hat{a})$$

$$1=|c|^2+4|c|^2\sin^2\frac{\pi}{12}+0$$

$$1=|c|^2+4|c|^2\left(\frac{\sqrt{3}-1}{2\sqrt{2}}\right)^2$$

$$|c|^2=\frac{1}{3-\sqrt{3}}=\frac{3+\sqrt{3}}{6}$$

So $6^2|c|^2=6(3+\sqrt{3})$

17. If a random variable X follows the Binomial distribution B (33, p) such that 3P(X = 0) = P(X = 1), then the value of $\frac{P(X=15)}{P(X=18)}-\frac{P(X=16)}{P(X=17)}$ is equal to

(A) 1320 (B) 1088

(C) $\frac{120}{1331}$ (D) $\frac{1088}{1089}$

Ans. (A)

Sol. n = 33, let probability of success is p and q = 1 – p

$$3p(x=0)=p(x=1)$$

$$3.{}^{33}C_0(q)^{33}={}^{33}C_1pq^{32}$$

$$p=\frac{1}{12},\ q=\frac{11}{12},\ \frac{q}{p}=11$$

$$\frac{p(x=15)}{p(x=18)}-\frac{p(x=16)}{p(x=17)}$$

$$\frac{{}^{33}C_{15}p^{15}q^{18}}{{}^{33}C_{18}p^{18}q^{15}}-\frac{{}^{33}C_{16}p^{16}q^{17}}{{}^{33}C_{17}p^{17}q^{16}}=\left(\frac{q}{p}\right)^3-\left(\frac{q}{p}\right)$$

$$=(11)^3-11$$

= 1320

18. The domain of the function

$$f(x)=\frac{\cos^{-1}\left(\frac{x^2-5x+6}{x^2-9}\right)}{\log_e(x^2-3x+2)}$$ is

(A) $(-\infty,1)\cup(2,\infty)$

(B) $(2,\infty)$

(C) $\left[-\frac{1}{2},1\right)\cup(2,\infty)$

(D) $\left[-\frac{1}{2},1\right)\cup(2,\infty)-\left\{\frac{3+\sqrt{5}}{2},\frac{3-\sqrt{5}}{2}\right\}$

Ans. (D)

Sol. $-1\le\frac{x^2-5x+6}{x^2-9}\le1$

$$\frac{x^2-5x+6}{x^2-9}-1\le0$$

$$\frac{1}{x+3} \geq 0$$

$x \in (-3, \infty)$ **......(1)**

$$\frac{x^2-5x+6}{x^2-9}+1 \geq 0$$

$$\frac{2x+1}{x+3} \geq 0$$

$x \in (-\infty, -3) \cup \left[-\frac{1}{2}, \infty\right)$**......(2)**

after taking intersection

$$x \in \left[-\frac{1}{2}, \infty\right)$$

$$x^2-3x+2>0$$

$$x \in (-\infty, 1) \cup (2, \infty)$$

$$x^2-3x+2 \neq 1$$

$$x \neq \frac{3 \pm \sqrt{5}}{2}$$

after taking intersection of each solution

$$\left[-\frac{1}{2}, 1\right) \cup (2, \infty) - \left\{\frac{3+\sqrt{5}}{2}, \frac{3-\sqrt{5}}{2}\right\}$$

19. Let

$S = \left\{\theta \in [-\pi, \pi] - \left\{\pm\frac{\pi}{2}\right\} : \sin\theta\tan\theta + \tan\theta = \sin 2\theta\right\}$.

If $T = \sum_{\theta \in S} \cos 2\theta$, then $T + n(S)$ is equal

(A) $7+\sqrt{3}$ (B) 9

(C) $8+\sqrt{3}$ (D) 10

Ans. (B)

Sol. $\sin\theta\tan\theta + \tan\theta = \sin 2\theta$

$$\tan\theta(\sin\theta+1) = \frac{2\tan\theta}{1+\tan^2\theta}$$

$\tan\theta = 0 \Rightarrow \theta = -\pi, 0, \pi$

$(\sin\theta+1) = 2.\cos^2\theta = 2(1+\sin\theta)(1-\sin\theta)$

$\sin\theta = -1$ which is not possible

$\sin\theta = \frac{1}{2} \qquad \theta = \frac{\pi}{6}, \frac{5\pi}{6}$

n(s) = 5

$$T = \cos 0 + \cos 2\pi + \cos 2\pi + \cos\frac{\pi}{3} + \cos\frac{5\pi}{3}$$

T = 4

T + n(s) = 9

20. The number of choices of $\Delta \in \{\wedge, \vee, \Rightarrow, \Leftrightarrow\}$, such that $(p\Delta q) \Rightarrow ((p\Delta \sim q) \vee ((\sim p)\Delta q))$ is a tautology, is

(A) 1 (B) 2

(C) 3 (D) 4

Ans. (B)

Sol. For tautology $((p\Delta \sim q) \vee ((\sim p)\Delta q))$ must be true.

This is possible only when $\Delta = \vee \,\&\, \Rightarrow$

SECTION-B

1. The number of one-one function f : {a, b, c, d} → {0, 1, 2, … ..,10} such that 2f(a) – f(b) + 3f(c) + f(d) = 0 is _____ .

Ans. (31)

Sol. 2f(a) + 3f(c) = f(d) – f(b)

Using fundamental principle of counting

Number of one-one function is 31

2. In an examination, there are 5 multiple choice questions with 3 choices, out of which exactly one is correct There are 3 marks for each correct answer, -2 marks for each wrong answer and 0 mark if the question is not attempted. Then, the number of ways a student appearing in the examination gets 5 marks is_.

Ans. (4)

Sol. $x_1 + x_2 + x_3 + x_4 + x_5 = 5$

Only one possibilities 3, 3, 3, -2, -2

Number of ways is = $\frac{5!}{3!2!} \times 2 \times 2 = 40$

3. Let $A\left(\frac{3}{\sqrt{a}}, \sqrt{a}\right) a > 0$, be a fixed point in the xy-plane. The image of A in y-axis be B and the image of B in x-axis be C. If D(3 cos θ, a sin θ) is a point in the fourth quadrant such that the maximum area of ΔACD is 12 square units, then a is equal to _______ .

Ans. (8)

Sol. $A = \left(\frac{3}{\sqrt{a}}, \sqrt{a}\right)$

$B = \left(\frac{-3}{\sqrt{a}}, \sqrt{a}\right)$

$C = \left(-\frac{3}{\sqrt{a}}, -\sqrt{a}\right)$

Area of ACD

$$\frac{1}{2}\begin{vmatrix} \frac{3}{\sqrt{a}} & \sqrt{a} \\ -\frac{3}{\sqrt{a}} & -\sqrt{a} \\ 3\cos\theta & a\sin\theta \\ \frac{3}{\sqrt{a}} & \sqrt{a} \end{vmatrix}$$

$\frac{1}{2} 6\sqrt{a}(\cos\theta - \sin\theta)$

$3\sqrt{a}(\cos\theta - \sin\theta)$

max values of function is $3\sqrt{a}\sqrt{2}$

$3\sqrt{a}\sqrt{2} = 12$

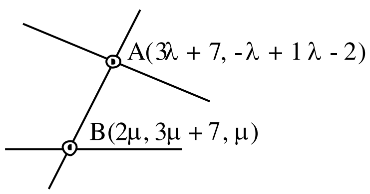
2a = 16

a = 8

4. Let a line having direction ratios 1, -4, 2 intersect the lines $\frac{x-7}{3} = \frac{y-1}{-1} = \frac{z+2}{1}$ and $\frac{x}{2} = \frac{y-7}{3} = \frac{z}{1}$ at the point A and B. Then $(AB)^2$ is equal to _____ .

Ans. (84)

Sol.



DR's of AB

$(3\lambda - 2\mu + 7, -\lambda - 3\mu - 6, \lambda - \mu - 2)$

$\frac{3\lambda - 2\mu + 7}{1} = \frac{-\lambda - 3\mu - 6}{-4} = \frac{\lambda - \mu - 2}{2}$

Taking first (2) $-12\lambda + 8\mu - 28 = -\lambda - 3\mu - 6$

$\lambda - \mu + 2 = 0$

Taking second & third

$-2\lambda - 6\mu - 12 = -4\lambda + 4\mu + 8$

$\lambda - 5\mu - 10 = 0$

After solving above two equation $\lambda = -5, \mu = -3$

A = (-8, 6, 7)

B = (-6, -2, -3)

$(AB)^2$ = 4 + 64 + 16 = 84

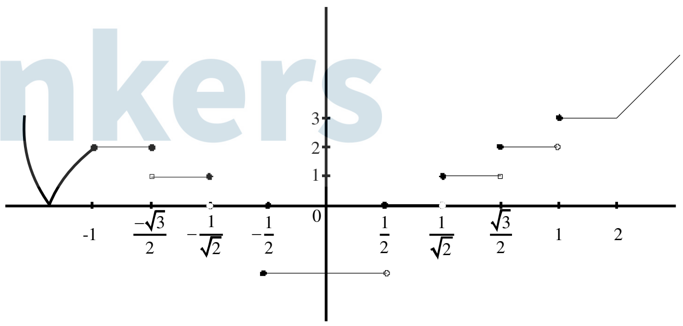
5. The number of points where the function

$$f(x) = \begin{cases} |2x^2 - 3x - 7| & \text{if} \quad x \le -1 \\ [4x^2 - 1] & \text{if} \quad -1 < x < 1 \\ |x+1| + |x-2| & \text{if} \quad x \ge 1 \end{cases}$$

[t] denotes the greatest integer $\le t$, is discontinuous is ______ .

Ans. (7)

Sol.



6. Let $f(\theta) = \sin\theta + \int_{-\pi/2}^{\pi/2} (\sin\theta + t\cos\theta) f(t)dt$. Then the value of $\left|\int_0^{\pi/2} f(\theta)d\theta\right|$ is _______ .

Ans. (1)

Sol. $f(\theta) = \sin\theta + \int_{-\pi/2}^{\pi/2} (\sin\theta + t\cos\theta)\, f(t)\, dt$

$f(\theta) = \sin\theta + \sin\theta \int_{-\pi/2}^{\pi/2} f(t)dt + \cos\theta \int_{-\pi/2}^{\pi/2} tf(t)dt$

Let $A = \int_{-\pi/2}^{\pi/2} f(t)dt, \; B = \int_{-\pi/2}^{\pi/2} tf(t)dt$

$$f(\theta)=\sin\theta+A\sin\theta+B\cos\theta$$

$$f(\theta)=(A+1)\sin\theta+B\cos\theta$$

$$A=\int_{-\pi/2}^{\pi/2}(A+1)\sin t+B\cos t\ dt$$

$$A=2B \qquad ......(1)$$

$$B=\int_{-\pi/2}^{\pi/2}t((A+1)\sin t+B\cos t)$$

$$B=\int_{-\pi/2}^{\pi/2}t(A+1)\sin t$$

$$B=(A+1)2\int_{0}^{\pi/2}t\sin t\ \ dt$$

$$B=(A+1)\ 2.1$$

$$2A+2-B=0\ .....(2)$$

After solving

$$B=-\frac{2}{3},A=-\frac{4}{3}$$

$$\left|\int_{0}^{\pi/2}f(\theta)d\theta\right|=\left|\int_{0}^{\pi/2}-\frac{1}{3}\sin\theta-\frac{2}{3}\cos\theta\right|$$

$$=1$$

7. Let $\underset{0\le x\le 2}{\text{Max}}\left\{\frac{9-x^2}{5-x}\right\}=\alpha$ and $\underset{0\le x\le 2}{\text{Min}}\left\{\frac{9-x^2}{5-x}\right\}=\beta$

If $\int_{\beta-\frac{8}{3}}^{2\alpha-1}\text{Max}\left\{\frac{9-x^2}{5-x},x\right\}dx=\alpha_1+\alpha_2\log_e\left(\frac{8}{15}\right)$ then $\alpha_1+\alpha_2$ is equal to ________

Ans. (34)

Sol. $y=\frac{9-x^2}{5-x}=5+x+\frac{16}{x-5}$

$$\frac{dy}{dx}=1-\frac{16}{(x-5)^2}$$

So critical point is x = 1 in [0, 2]

$$y(0)=\frac{9}{5},\ \ y(1)=2,\ \ y(2)=\frac{5}{3}$$

So $\alpha=2$ and $\beta=\frac{5}{3}$

$$I=\int_{-1}^{3}\max\left(\frac{9-x^2}{5-x},x\right)$$

$$I=\int_{-1}^{9/5}\frac{9-x^2}{5-x}dx+\int_{9/5}^{3}x\,dx$$

$$I=\int_{-1}^{9/5}5+x+\frac{16}{x-5}dx+\int_{9/5}^{3}x\,dx$$

After solving

$$I=14+\frac{28}{25}+16\ln\left(\frac{8}{15}\right)+\frac{72}{25}$$

$$\alpha_1=18 \text{ and } \alpha_2=16$$

8. If two tangents drawn from a point (α, β) lying on the ellipse $25x^2+4y^2=1$ to the parabola $y^2=4x$ are such that the slope of one tangent is four times the other, then the value of $(10\alpha+5)^2+(16\beta^2+50)^2$ equals __________

Ans. (2929)

Sol. $\alpha=\frac{1}{5}\cos\theta,\ \beta=\frac{1}{2}\sin\theta$

Equation of tangent to $y^2=4x$

$$y=mx+\frac{1}{m}$$

It passes through (α,β)

$$\frac{1}{2}\sin\theta=m\frac{1}{5}\cos\theta+\frac{1}{m}$$

$$m^2\left(\frac{\cos\theta}{5}\right)-m\left(\frac{1}{2}\sin\theta\right)+1=0$$

It has two roots m_1 and m_2 where $m_1=4m_2$

$$m_1+m_2=\frac{\frac{1}{2}\sin\theta}{\frac{\cos\theta}{5}}$$

$$m_1m_2=\frac{5}{\cos\theta}$$

After eliminating m_1 and m_2

$$\cos\theta=\frac{-5\pm\sqrt{29}}{2}$$

$$\alpha=\frac{-5\pm\sqrt{29}}{10}\Rightarrow 10\alpha+5=\pm\sqrt{29}$$

$$\beta^2=\frac{1}{4}\sin^2\theta\Rightarrow 16\beta^2=-50\pm10\sqrt{29}$$

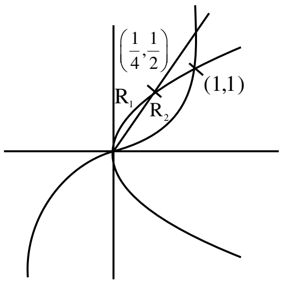
$$(10\alpha+5)^2+(16\beta^2+50)^2=2929$$

9. Let S be the region bounded by the curves $y = x^3$ and $y^2 = x$. The curve $y = 2|x|$ divides S into two regions of areas R_1 and R_2.

If $\max\{R_1, R_2\} = R_2$, then $\frac{R_2}{R_1}$ is equal to ____ .

Ans. (19)

Sol.



$$S = \int_0^1 \sqrt{x} - x^3$$

$$= \left[\frac{2x^{3/2}}{3} - \frac{x^4}{4}\right]_1^0$$

$$= \frac{5}{12}$$

$$R_1 = \int_0^{1/4} (\sqrt{x} - 2x)dx$$

$$= \left[\frac{2x^{3/2}}{3} - x^2\right]_0^{1/4} = \frac{1}{48}$$

$$\therefore\ R_2 = \frac{19}{48}$$

So, $\frac{R_2}{R_1} = 19$

10. If the shortest distance between the line

$\vec{r} = \left(-\hat{i} + 3\hat{k}\right) + \lambda\left(\hat{i} - a\hat{j}\right)$ and

$\vec{r} = \left(-\hat{j} + 2\hat{k}\right) + \mu\left(\hat{i} - \hat{j} + \hat{k}\right)$ is $\sqrt{\frac{2}{3}}$, then the integral value of a is equal to

Ans. (2)

Sol. $a_1 = (-1, 0, 3)$

$a_2 = (0, -1, 2)$

$b_1 = (1, -a, 0)$ dr's of line (1)

$b_2 = (1, -1, 1)$ dr's of line (2)

$\bar{a}_2 - \bar{a}_1 = (1, -1, -1)$

$$\bar{b}_1 \times \bar{b}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -a & 0 \\ 1 & -1 & 1 \end{vmatrix}$$

$\bar{b}_1 \times \bar{b}_2 = \hat{i}(-a) - \hat{j} + \hat{k}(a-1)$

$|\bar{b}_1 \times \bar{b}_2| = \sqrt{a^2 + 1 + (a-1)^2}$

$a_2 - a_1 . \bar{b}_1 \times \bar{b}_2 = 2 - 2a$

$$\frac{2(1-a)}{\sqrt{a^2 + 1 + (a-1)^2}} = \sqrt{\frac{2}{3}}$$

Squaring an both the side

After solving $a = 2, \frac{1}{2}$