

Class XII Session 2025-26
Subject - Mathematics
Sample Question Paper - 2

Time Allowed: 3 hours

Maximum Marks: 80

General Instructions:

1. This Question paper contains 38 questions. All questions are compulsory.
2. This Question paper is divided into five Sections - A, B, C, D and E.
3. In Section A, Questions no. 1 to 18 are multiple choice questions (MCQs) and Questions no. 19 and 20 are Assertion-Reason based questions of 1 mark each.
4. In Section B, Questions no. 21 to 25 are Very Short Answer (VSA)-type questions, carrying 2 marks each.
5. In Section C, Questions no. 26 to 31 are Short Answer (SA)-type questions, carrying 3 marks each.
6. In Section D, Questions no. 32 to 35 are Long Answer (LA)-type questions, carrying 5 marks each.
7. In Section E, Questions no. 36 to 38 are Case study-based questions, carrying 4 marks each.
8. There is no overall choice. However, an internal choice has been provided in 2 questions in Section B, 3 questions in Section C, 2 questions in Section D and one subpart each in 2 questions of Section E.
9. Use of calculators is not allowed.

Section A

1. If $|A| = 2$, where A is a 2×2 matrix, then $|4A^{-1}|$ equals:
a) 2
b) 4
c) 8
d) $\frac{1}{32}$
2. Let A be a 3×3 matrix such that $|\text{adj } A| = 64$. Then $|A|$ is equal to:
a) 8 only
b) 64
c) 8 or -8
d) -8 only
3. Let A be the area of a triangle having vertices (x_1, y_1) , (x_2, y_2) and (x_3, y_3) . Which of the following is correct?
a) $\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}^2 = A^2$
b) $\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \pm 2A$
c) $\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \pm \frac{A}{2}$
d) $\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \pm A$
4. If $\begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 6 \\ 3 \\ 2 \end{bmatrix}$, then the value of $(2x + y - z)$ is:
a) 2
b) 5

- c) 1 d) 3
5. The equation of a line passing through point (2, -1, 0) and parallel to the line $\frac{x}{1} = \frac{y-1}{2} = \frac{2-z}{2}$ is: [1]
- a) $\frac{x-2}{1} = \frac{y-1}{2} = \frac{z}{2}$ b) $\frac{x-2}{1} = \frac{y+1}{2} = \frac{z}{-2}$
- c) $\frac{x+2}{1} = \frac{y-1}{2} = \frac{z}{-2}$ d) $\frac{x+2}{1} = \frac{y-1}{2} = \frac{z}{2}$
6. The solution of the DE $\cos x(1 + \cos y)dx - \sin y(1 + \sin x)dy = 0$ is [1]
- a) $1 + \sin x \cos y = C$ b) $2\sin x \cos y - \cos x = C$
- c) $\sin x \cos y + \cos x = C$ d) $(1 + \sin x)(1 + \cos y) = C$
7. A linear programming problem deals with the optimization of a/an: [1]
- a) linear function b) logarithmic function
- c) quadratic function d) exponential function
8. The value of p for which the vectors $2\hat{i} + p\hat{j} + \hat{k}$ and $-4\hat{i} - 6\hat{j} + 26\hat{k}$ are perpendicular to each other, is: [1]
- a) 3 b) -3
- c) $-\frac{17}{3}$ d) $\frac{17}{3}$
9. $\int x^2 e^{x^3} dx$ equals [1]
- a) $\frac{1}{2}e^{x^2} + C$ b) $\frac{1}{2}e^{x^3} + C$
- c) $\frac{1}{3}e^{x^3} + C$ d) $\frac{1}{3}e^{x^2} + C$
10. Find the value of x and y are respectively, if $\begin{bmatrix} x & y \\ 3y & x \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$. [1]
- a) 3, 2 b) 4, 3
- c) 2, 1 d) 1, 1
11. Corner points of the feasible region for an LPP are (0, 2), (3, 0), (6, 0), (6, 8) and (0, 5). Let $F = 4x + 6y$ be the objective function. Maximum of F – Minimum of F = [1]
- a) 18 b) 60
- c) 42 d) 48
12. For any two vectors $\vec{a}$ and $\vec{b}$ which of the following statements is always true? [1]
- a) $\vec{a} \cdot \vec{b} < |\vec{a}||\vec{b}|$ b) $\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}|$
- c) $\vec{a} \cdot \vec{b} \leq |\vec{a}||\vec{b}|$ d) $\vec{a} \cdot \vec{b} \geq |\vec{a}||\vec{b}|$
13. An ordered pair (α, β) for which the system of linear equations [1]
- $(1 + \alpha)x + \beta y + z = 2$
- $\alpha x + (1 + \beta)y + z = 3$
- $\alpha x + \beta y + 2z = 2$
- has a unique solution is
- a) (2, 4) b) (-4, 2)
- c) (-3, 1) d) (1, -3)
14. If for two events A and B, $P(A - B) = \frac{1}{5}$ and $P(A) = \frac{3}{5}$, then $P\left(\frac{B}{A}\right)$ is equal to [1]

a) $\frac{2}{5}$

b) $\frac{1}{2}$

c) $\frac{3}{5}$

d) $\frac{2}{3}$

15. Integrating factor of the differential equation $\frac{dy}{dx} + y \tan x - \sec x = 0$ is: [1]

a) $e^{\sec x}$

b) $e^{\cos x}$

c) $\sec x$

d) $\cos x$

16. If $|\vec{a}| = 4$ and $-3 \leq \lambda \leq 2$, then $|\lambda \vec{a}|$ lies in [1]

a) $[0, 12]$

b) $[8, 12]$

c) $[2, 3]$

d) $[-12, 8]$

17. For what value of k may the function $f(x) = \begin{cases} k(3x^2 - 5x), & x \leq 0 \\ \cos x, & x > 0 \end{cases}$ become continuous? [1]

a) 1

b) $-\frac{1}{2}$

c) 0

d) No value

18. Direction cosines of a line perpendicular to both x-axis and z-axis are: [1]

a) 0, 0, 1

b) 1, 1, 1

c) 1, 0, 1

d) 0, 1, 0

19. **Assertion (A):** If the circumference of the circle is changing at the rate of 10 cm/s, then the area of the circle changes at the rate 30 cm²/s, if radius is 3 cm. [1]

Reason (R): If A and r are the area and radius of the circle, respectively, then rate of change of area of the circle is given by $\frac{dA}{dt} = 2\pi r \frac{dr}{dt}$.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

20. **Assertion (A):** If R is the relation defined in set $\{1, 2, 3, 4, 5, 6\}$ as $R = \{(a, b) : b = a + 1\}$, then R is reflexive. [1]

Reason (R): The relation R in the set $\{1, 2, 3\}$ given by $R = \{(1, 2), (2, 1)\}$ is symmetric.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

Section B

21. Find the value of $\tan^{-1}\left(-\frac{1}{\sqrt{3}}\right) + \cot^{-1}\left(\frac{1}{\sqrt{3}}\right) + \tan^{-1}\left[\sin\left(\frac{-\pi}{2}\right)\right]$. [2]

OR

Find the principal value of $\operatorname{cosec}^{-1}(-1)$.

22. The total cost $C(x)$ associated with provision of free mid-day meals to x students of a school in primary classes [2]

is given by $C(x) = 0.005x^3 - 0.02x^2 + 30x + 50$.

If the marginal cost is given by rate of change $\frac{dC}{dx}$ of total cost, then write the marginal cost of food for 300 students. What value is shown here?

23. Find the value(s) of 'a' for which $f(x) = x^3 - ax$ is an increasing function on R . [2]

OR

The length x of a rectangle is decreasing at the rate of 5 cm/min and the width y increasing at the rate of 4 cm/min, find the rate of change its area when $x = 5$ cm and $y = 8$ cm.

24. Evaluate $\int \frac{x^3+x}{x^4-9} dx$ [2]
25. Find the absolute maximum and minimum values of the function f given by $f(x) = \cos^2 x + \sin x$, $x \in [0, \pi]$ [2]

Section C

26. By using the properties of definite integrals, evaluate the integral $\int_0^{\frac{\pi}{4}} \log(1 + \tan x) dx$ [3]
27. A bag contains 5 red and 3 black balls and another bag contains 2 red and 6 black balls. Two balls are drawn at random (without replacement) from one of the bags and both are found to be red. Find the probability that balls are drawn from the first bag. [3]
28. Evaluate $\int \frac{\sin(x-a)}{\sin(x+a)} dx$. [3]

OR

Evaluate the integral: $\int (2x + 5) \sqrt{10 - 4x - 3x^2} dx$

29. Solve the initial value problem: $\tan x \frac{dy}{dx} = 2x \tan x + x^2 - y$; $\tan x \neq 0$ given that $y = 0$ when $x = \frac{\pi}{2}$ [3]

OR

Find the particular solution of the differential equation $x \cos\left(\frac{y}{x}\right) \frac{dy}{dx} = y \cos\left(\frac{y}{x}\right) + x$, given that when $x = 1$, $y = \frac{\pi}{4}$

30. Solved the linear programming problem graphically: [3]

Maximize $Z = 60x + 15y$

Subject to constraints

$$x + y \leq 50$$

$$3x + y \leq 90$$

$$x, y \geq 0$$

OR

Solve the following LPP by graphical method:

Minimize $Z = 20x + 10y$

Subject to

$$x + 2y \leq 40$$

$$3x + y \geq 30$$

$$4x + 3y \geq 60$$

$$\text{and } x, y \geq 0$$

31. Differentiate $\tan^{-1}\left(\frac{\sqrt{1-x^2}}{x}\right)$ w.r.t $\cos^{-1}\left(2x\sqrt{1-x^2}\right)$, when $x \neq 0$. [3]

Section D

32. Using integration, find the area of the triangle formed by positive X-axis and tangent and normal to the circle $x^2 + y^2 = 4$ at $(1, \sqrt{3})$. [5]
33. Let $A = \{1, 2, 3\}$ and $R = \{(a, b) : a, b \in A \text{ and } |a^2 - b^2| \leq 5\}$. Write R as set of ordered pairs. Mention whether R is [5]
- reflexive
 - symmetric
 - transitive

Give reason in each case.

OR

Show that the function $f: R_0 \rightarrow R_0$, defined as $f(x) = \frac{1}{x}$, is one-one onto, where R_0 is the set non-zero real numbers.

Is the result true, if the domain R_0 is replaced by N with co-domain being same as R_0 ?

34. Solve the system of equations

[5]

$$\frac{2}{x} + \frac{3}{y} + \frac{10}{z} = 4$$

$$\frac{4}{x} - \frac{6}{y} + \frac{5}{z} = 1$$

$$\frac{6}{x} + \frac{9}{y} - \frac{20}{z} = 2$$

35. Find the image of the point $(0, 2, 3)$ in the line $\frac{x+3}{5} = \frac{y-1}{2} = \frac{z+4}{3}$

[5]

OR

By computing the shortest distance determine whether the pairs of lines intersect or not:

$$\vec{r} = (\hat{i} - \hat{j}) + \lambda(2\hat{i} + \hat{k}) \text{ and } \vec{r} = (2\hat{i} - \hat{j}) + \mu(\hat{i} + \hat{j} - \hat{k})$$

Section E

36. Read the following text carefully and answer the questions that follow:

[4]

A shopkeeper sells three types of flower seeds A_1, A_2, A_3 . They are sold in the form of a mixture, where the proportions of these seeds are $4 : 4 : 2$ respectively. The germination rates of the three types of seeds are 45%, 60% and 35% respectively.



Based on the above information:

- Calculate the probability that a randomly chosen seed will germinate. (1)
- Calculate the probability that the seed is of type A_2 , given that a randomly chosen seed germinates. (1)
- A die is throw and a card is selected at random from a deck of 52 playing cards. Then find the probability of getting an even number on the die and a spade card. (2)

OR

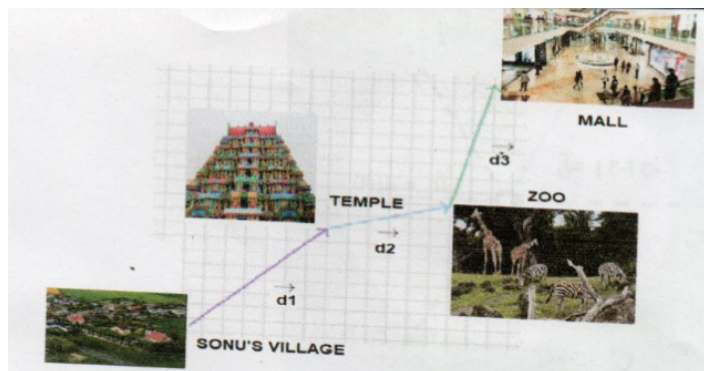
If A and B are any two events such that $P(A) + P(B) - P(A \text{ and } B) = P(A)$, then find $P(A|B)$. (2)

37. Read the following text carefully and answer the questions that follow:

[4]

Sonu left from his village on weekend. First, he travelled d_1 displacement up to a temple. After this, he left for the zoo and travelled d_2 displacement. After this he left for shopping in a mall - Total driving time of Deepal from village to Mall was 1.5 hr.

If $d_1 = (6, 8)$ $d_2 = (3, 4)$ and $d_3 = (7, 12)$ km



- What is the total displacement from village to Mall? (1)

ii. What is the speed of Sonu from Village to Mall? (1)

iii. What is the Displacement from Village to Zoo? (2)

OR

What is the displacement from temple to Mall? (2)

38. **Read the following text carefully and answer the questions that follow:**

[4]

Mrs. Maya is the owner of a high-rise residential society having 50 apartments. When he set rent at ₹10000/month, all apartments are rented. If he increases rent by ₹250/ month, one fewer apartment is rented. The maintenance cost for each occupied unit is ₹500/month.



i. If P is the rent price per apartment and N is the number of rented apartments, then find the profit. (1)

ii. If x represents the number of apartments which are not rented, then express profit as a function of x . (1)

iii. Find the number of apartments which are not rented so that profit is maximum. (2)

OR

Verify that profit is maximum at critical value of x by second derivative test. (2)

Solution

Section A

1.

(c) 8

Explanation:

8

2.

(c) 8 or -8

Explanation:

8 or -8

Explanation

We know that $|\text{Adj } A| = |A|^{n-1}$, n is the order of the matrix.

$$\therefore 64 = |A|^{3-1}$$

$$|A|^2 = 64$$

$$|A| = \pm 8$$

3.

$$(b) \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \pm 2A$$

Explanation:

$$\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = \pm 2A$$

Explanation:

$$A = \frac{1}{2} [x_1 (y_2 - y_3) - x_2 (y_1 - y_3) + x_3 (y_1 - y_2)]$$

$$2A = [x_1 (y_2 - y_3) - x_2 (y_1 - y_3) + x_3 (y_1 - y_2)]$$

4.

(b) 5

Explanation:

5

Explanation

$$\begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 6 \\ 3 \\ 2 \end{bmatrix}$$

$$\begin{bmatrix} x + y + z \\ y + z \\ z \end{bmatrix} = \begin{bmatrix} 6 \\ 3 \\ 2 \end{bmatrix}$$

$$\Rightarrow x + y + z = 6 \text{ -----(i)}$$

$$y + z = 3 \text{ -----(ii)}$$

$$z = 2 \text{ -----(iii)}$$

from (ii) and (iii)

$$y + 2 = 3$$

$$y = 1$$

$$x + y + z = 6$$

$$x + 3 = 6$$

$$x = 3$$

$$(2x + y - z)$$

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

$$= 6 + 1 - 2$$

$$= 7 - 2$$

$$= 5$$

5.

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

Explanation:

$$\frac{x-2}{1} = \frac{y+1}{2} = \frac{z}{-2}$$

6.

$$(d) (1 + \sin x)(1 + \cos y) = C$$

Explanation:

$$\text{Given } \cos x (1 + \cos y) dx - \sin y (1 + \sin x) dy = 0$$

$$\text{Let } 1 + \cos y = t \text{ and } 1 + \sin x = u$$

On differentiating both equations, we obtain

$$-\sin y dy = dt \text{ and } \cos x dx = du$$

Put this in the first equation

$$t du + u dt = 0$$

$$-\frac{du}{u} = \frac{dt}{t}$$

$$-\log u = \log t + C$$

$$\log u + \log t = C$$

$$\log ut = C$$

$$ut = C$$

$$(1 + \sin x)(1 + \cos y) = C$$

7. (a) linear function

Explanation:

linear function

8. (a) 3

Explanation:

3

9.

$$(c) \frac{1}{3}e^{x^3} + C$$

Explanation:

$$\text{Let } I = \int x^2 e^{x^3} dx$$

$$\text{Also, let } x^3 = t, \Rightarrow 3x^2 dx = dt$$

Thus,

$$\Rightarrow I = \frac{1}{3} \int e^t dt$$

$$= \frac{1}{3} (e^t) + C$$

$$= \frac{1}{3} (e^{x^3}) + C$$

10.

(d) 1, 1**Explanation:**

$$\text{Given, } \begin{bmatrix} x & y \\ 3y & x \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

On multiplying the matrices of left side, we get

$$\begin{bmatrix} x \cdot 1 + 2 \cdot y \\ 3y \cdot 1 + 2 \cdot x \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} x + 2y \\ 3y + 2x \end{bmatrix} = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$$

Now, equating the corresponding elements, we get

$$x + 2y = 3 \dots (i)$$

$$\text{and } 3y + 2x = 5 \dots (ii)$$

On solving Eqs. (i) and (ii), we get

$$x = 1 \text{ and } y = 1$$

11.

(b) 60**Explanation:**Here the objective function is given by : $F = 4x + 6y$.

Corner points	$Z = 4x + 6y$
(0, 2)	12(Min.)
(3, 0)	12.(Min.)
(6, 0)	24
(6, 8)	72
(0, 5)	30

Maximum of F – Minimum of $F = 72 - 12 = 30$.

12.

(c) $\vec{a} \cdot \vec{b} \leq |\vec{a}| |\vec{b}|$ **Explanation:**

The correct answer is $\vec{a} \cdot \vec{b} \leq |\vec{a}| |\vec{b}|$. This follows from the Cauchy-Schwarz inequality, which states that the dot product of two vectors is less than or equal to the product of their magnitudes. Equality holds only when the vectors are parallel.

13. **(a)** (2, 4)**Explanation:**

(2, 4)

14.

(d) $\frac{2}{3}$ **Explanation:**

$$\frac{2}{3}$$

15.

(c) $\sec x$ **Explanation:**

$$\text{Given that } \frac{dy}{dx} + y \tan x - \sec x = 0$$

$$\text{Here, } P = \tan x, Q = \sec x$$

$$\text{IF} = e^{\int P dx} = e^{\int \tan x dx}$$

$$= e^{\log \sec x}$$

$$= \sec x$$

16. (a) $[0, 12]$

Explanation:

$$|\lambda \vec{a}| = |\lambda| |\vec{a}|$$

$$= |\lambda| \times 4$$

$$= 4|\lambda| \geq 0$$

When

$$\lambda = -3 \Rightarrow 41 - 31 = 12$$

$$\lambda = 0 \Rightarrow 4 \times 0 = 0.$$

$$1 \rightarrow \vec{a} \text{ lie b/w.}$$

$$|\lambda| \vec{a} \Rightarrow [-0, 12]$$

$$[0, 12]$$

17.

(d) No value

Explanation:

No value

18.

(d) 0, 1, 0

Explanation:

0, 1, 0

19. (a) Both A and R are true and R is the correct explanation of A.

Explanation:

Circumference of circle with radius r is given by $C = 2\pi r$

Differentiating w.r.t. 't', we get

$$\frac{dC}{dt} = 2\pi \frac{dr}{dt}$$

$$\text{Given, } \frac{dC}{dt} = 10 \text{ cm/s}$$

$$\therefore 10 = 2\pi \frac{dr}{dt}$$

$$\Rightarrow \frac{dr}{dt} = \frac{5}{\pi} \text{ cm/s}$$

Now, Area of circle, $A = \pi r^2$

$$\therefore \frac{dA}{dt} = 2\pi r \frac{dr}{dt}$$

Substituting $r = 3 \text{ cm}$ and $\frac{dr}{dt} = \frac{5}{\pi} \text{ cm/s}$, we get

$$\frac{dA}{dt} = 2\pi \times 3 \times \frac{5}{\pi}$$

$$\therefore \frac{dA}{dt} = 30 \text{ cm}^2/\text{s}$$

20.

(d) A is false but R is true.

Explanation:

Assertion: Let $A = \{1, 2, 3, 4, 5, 6\}$

A relation R is defined on set A is

$$R = \{(a, b) : b = a + 1\}$$

$$\therefore R = \{(1, 2), (2, 3), (3, 4), (4, 5), (5, 6)\}$$

Now, $6 \in A$ but $(6, 6) \notin R$

$\therefore$ R is not reflexive.

Reason: Given set $A = \{1, 2, 3\}$

A relation R on A is defined as

$$R = \{(1, 2), (2, 1)\}$$

$$\therefore (1, 2) \in R \text{ and } (2, 1) \in R.$$

So, R is symmetric.

Section B

$$\begin{aligned}
 21. \text{ We have, } & \tan^{-1}\left(-\frac{1}{\sqrt{3}}\right) + \cot^{-1}\left(\frac{1}{\sqrt{3}}\right) + \tan^{-1}\left[\sin\left(\frac{-\pi}{2}\right)\right] \\
 &= \tan^{-1}\left(\tan\frac{5\pi}{6}\right) + \cot^{-1}\left(\cot\frac{\pi}{3}\right) + \tan^{-1}(-1) \\
 &= \tan^{-1}\left[\tan\left(\pi - \frac{\pi}{6}\right)\right] + \cot^{-1}\left[\cot\left(\frac{\pi}{3}\right)\right] + \tan^{-1}\left[\tan\left(\pi - \frac{\pi}{4}\right)\right] \\
 &= \tan^{-1}\left(-\tan\frac{\pi}{6}\right) + \cot^{-1}\left(\cot\frac{\pi}{3}\right) + \tan^{-1}\left(-\tan\frac{\pi}{4}\right) \left[\begin{array}{l} \because \tan^{-1}(\tan x) = x, x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right) \\ \cot^{-1}(\cot x) = x, x \in (0, \pi) \\ \text{and } \tan^{-1}(-x) = -\tan^{-1}x \end{array} \right] \\
 &= -\frac{\pi}{6} + \frac{\pi}{3} - \frac{\pi}{4} = \frac{-2\pi + 4\pi - 3\pi}{12} \\
 &= \frac{-5\pi + 4\pi}{12} = \frac{-\pi}{12}
 \end{aligned}$$

OR

We know that the range of principal value of $\operatorname{cosec}^{-1}$ is $\left[-\frac{\pi}{2}, \frac{\pi}{2}\right] - [0]$

Let $\operatorname{cosec}^{-1}(-1) = \theta$. Then we have, $\operatorname{cosec} \theta = -1$

$$\operatorname{cosec} \theta = -1 = -\operatorname{cosec} \frac{\pi}{2} = \operatorname{cosec} \left(\frac{-\pi}{2}\right)$$

$$\therefore \theta = \frac{-\pi}{2} \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] - [0]$$

Hence, the principal value of $\operatorname{cosec}^{-1}(-1)$ is equal to $\frac{-\pi}{2}$

$$22. \text{ Given, } C(x) = 0.005x^3 - 0.02x^2 + 30x + 50$$

On differentiating both sides w.r.t. x , we get

$$\frac{dC}{dx} = 0.005(3x^2) - 0.02(2x) + 30$$

$$= 0.015x^2 - 0.04x + 30$$

On putting $x = 300$, we get

$$\frac{dC}{dx} = 0.015(300)^2 - 0.04(300) + 30$$

$$= 1350 - 12 + 30 = 1368$$

Therefore, the marginal cost of food for 300 students is Rs 1368.

By providing free mid-day meals to the students of primary classes, care and concern is shown towards their health and nutritional status.

23. Given:

$$f(x) = x^3 - ax$$

$$f'(x) = 3x^2 - a$$

Given that $f(x)$ is an increasing function

$$\therefore f'(x) > 0 \text{ for all } x \in \mathbb{R}$$

$$\Rightarrow 3x^2 - a > 0 \text{ for all } x \in \mathbb{R}$$

$$\Rightarrow a < 3x^2 \text{ for all } x \in \mathbb{R}$$

But the least value of $3x^2 = 0$ for $x = 0$

$$\therefore a \leq 0$$

OR

Let A denote the area of rectangle at instant t .

$$\therefore A = xy \text{ (area of rectangle)}$$

$$\Rightarrow \left. \begin{array}{l} \frac{dx}{dt} = -5 \text{ cm/min} \\ \frac{dy}{dt} = 4 \text{ cm/min} \end{array} \right\} \text{ (given),}$$

$$\frac{dA}{dt} = x \frac{dy}{dt} + y \frac{dx}{dt}$$

$$\Rightarrow \left(\frac{dA}{dt}\right)_{x=5, y=8} = 5 \times 4 + 8 \times (-5) \text{ cm}^2/\text{min}$$

$$\Rightarrow \frac{dA}{dt} = (20 - 40) \text{ cm}^2/\text{min}$$

$$\Rightarrow \frac{dA}{dt} = -20 \text{ cm}^2/\text{min}$$

Here, (-) ve sign shows that area is decreasing at the rate of $20 \text{ cm}^2/\text{min}$.

24. We have

$$I = \int \frac{x^3 + x}{x^4 - 9} dx = \int \frac{x^3}{x^4 - 9} dx + \int \frac{x}{x^4 - 9} dx = I_1 + I_2$$

$$\text{Now } I_1 = \int \frac{x^3}{x^4-9}$$

Put $t = x^4 - 9$ so that $4x^3 dx = dt$. Therefore

$$I_1 = \frac{1}{4} \int \frac{dt}{t} = \frac{1}{4} \log |t| + C_1 = \frac{1}{4} \log |x^4 - 9| + C_1$$

$$\text{Again, } I_2 = \int \frac{x dx}{x^4-9}$$

Put $x^2 = u$ so that $2x dx = du$. Then

$$I_2 = \frac{1}{2} \int \frac{du}{u^2-(3)^2} = \frac{1}{2 \times 6} \log \left| \frac{u-3}{u+3} \right| + C_2$$

$$= \frac{1}{12} \log \left| \frac{x^2-3}{x^2+3} \right| + C_2$$

Thus $I = I_1 + I_2$

$$= \frac{1}{4} \log |x^4 - 9| + \frac{1}{12} \log \left| \frac{x^2-3}{x^2+3} \right| + C$$

25. It is given that $f(x) = \cos^2 x + \sin x$, $x \in [0, \pi]$

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

$$= -2 \sin x \cos x + \cos x$$

Now, if $f'(x) = 0$

$$\Rightarrow 2 \sin x \cos x = \cos x$$

$$\Rightarrow \cos x (2 \sin x - 1) = 0$$

$$\Rightarrow \sin x = \frac{1}{2} \text{ or } \cos x = 0$$

$$\Rightarrow x = \frac{\pi}{6}, \frac{5\pi}{6} \text{ or } \frac{\pi}{2} \text{ as } x \in [0, \pi]$$

Next, evaluating the value of f at critical points $x = \frac{\pi}{2}$ and $x = \frac{\pi}{6}$ and at the end points of the interval $[0, \pi]$, (i.e. at $x = 0$ and $x = \pi$), we get,

$$f\left(\frac{\pi}{6}\right) = \cos^2 \frac{\pi}{6} + \sin \frac{\pi}{6} = \left(\frac{\sqrt{3}}{2}\right)^2 + \frac{1}{2} = \frac{5}{4}$$

$$f\left(\frac{5\pi}{6}\right) = \cos^2\left(\frac{5\pi}{6}\right) + \sin\left(\frac{5\pi}{6}\right) = \cos^2\left(\pi - \frac{\pi}{6}\right) + \sin\left(\pi - \frac{\pi}{6}\right) = \cos^2 \frac{\pi}{6} - \sin \frac{\pi}{6} = \frac{5}{4}$$

$$f(0) = \cos^2 0 + \sin 0 = 1 + 0 = 1$$

$$f(\pi) = \cos^2 \pi + \sin \pi = (-1)^2 + 0 = 1$$

$$f\left(\frac{\pi}{2}\right) = \cos^2 \frac{\pi}{2} + \sin \frac{\pi}{2} = 0 + 1 = 1$$

Therefore, the absolute maximum value of f is $\frac{5}{4}$ occurring at $x = \frac{\pi}{6}$ and the absolute minimum value of f is 1 occurring at $x = 1, \frac{\pi}{2}$ and π .

Section C

26. Given $\int_0^{\frac{\pi}{4}} \log(1 + \tan x) dx$

$$\text{Let } I = \int_0^{\frac{\pi}{4}} \log(1 + \tan x) dx \dots (i)$$

$$\text{as, } \left\{ \int_0^a f(x) dx = \int_0^a f(a-x) dx \right\}$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log \left[1 + \tan \left(\frac{\pi}{4} - x \right) \right] dx$$

$$\text{as } \left\{ \tan(A-B) = \frac{\tan(A) - \tan(B)}{1 + \tan(A) \tan(B)} \right\}$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log \left[1 + \frac{\tan\left(\frac{\pi}{4}\right) - \tan(x)}{1 + \tan\left(\frac{\pi}{4}\right) \tan(x)} \right] dx$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log \left[1 + \frac{1 - \tan(x)}{1 + \tan(x)} \right] dx$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log \left[\frac{2}{1 + \tan(x)} \right] dx$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log[2] dx - \int_0^{\frac{\pi}{4}} \log[1 + \tan(x)] dx$$

$$\Rightarrow I = \int_0^{\frac{\pi}{4}} \log[2] dx - I \text{ (from (i))}$$

$$\Rightarrow 2I = [x \log 2]_0^{\frac{\pi}{4}}$$

$$\Rightarrow 2I = \frac{\pi}{4} \log 2 - 0$$

$$\Rightarrow I = \frac{\pi}{8} \log 2$$

27. E_1 : ball drawn from first bag

E_2 : ball drawn from second bag

A : both drawn balls are red

$$\begin{aligned}
P(E_1) P(E_2) &= \frac{1}{2} \\
P(A|E_1) &= \frac{5}{8} \times \frac{4}{7} = \frac{20}{56} \\
P(A|E_2) &= \frac{2}{8} \times \frac{1}{7} = \frac{2}{56} \\
P(E_1 | A) &= \frac{\frac{1}{2} \cdot \frac{20}{56}}{\frac{1}{2} \cdot \frac{20}{56} + \frac{1}{2} \cdot \frac{2}{56}} \\
&= \frac{\frac{20}{112}}{\frac{22}{112}} = \frac{10}{11}
\end{aligned}$$

28. According to the question, $I = \int \frac{\sin(x-a)}{\sin(x+a)} dx$

$$\begin{aligned}
\text{Put } x + a &= t \Rightarrow dx = dt \\
\therefore I &= \int \frac{\sin(t-a)}{\sin t} dt = \int \frac{\sin(t-2a)}{\sin t} dt \\
&= \int \frac{\sin t \cos 2a - \cos t \sin 2a}{\sin t} dt \\
&[\because \sin(A-B) = \sin A \cos B - \cos A \sin B] \\
&= \int \cos 2a dt - \int \sin 2a \cdot \cot t dt \\
&= \cos 2a[t] - \sin 2a[\log|\sin t|] + C_1 \\
&= (x+a)\cos 2a - \sin 2a \log|\sin(x+a)| + C_1 \\
&[\text{put } t = x+a] \\
&= x\cos 2a - \sin 2a \log|\sin(x+a)| + C_1
\end{aligned}$$

OR

$$\text{Given, } I = \int (2x+5)\sqrt{10-4x-3x^2} dx$$

$$\text{Let, } 2x+5 = A \frac{d}{dx}(10-4x-3x^2) + B,$$

where A and B are constants.

$$\Rightarrow 2x+5 = A(-4-6x) + B \dots(i)$$

$$\Rightarrow 2x+5 = -6Ax + (B-4A)$$

Comparing the coefficient of x and constant term we get ,

$$\Rightarrow -6A = 2 \Rightarrow A = \frac{-1}{3}$$

$$B - 4A = 5$$

$$= 5 + 4\left(\frac{-1}{3}\right) = \frac{11}{3}$$

$$\therefore A = \frac{-1}{3} \text{ and } B = \frac{11}{3}$$

$$\text{Thus, } (2x+5) = \frac{-1}{3}(-4-6x) + \frac{11}{3} [\text{From Eq. (i)}]$$

$$\text{Now, } I = \frac{-1}{3} \int (-4-6x)\sqrt{10-4x-3x^2} dx + \frac{11}{3} \int \sqrt{10-4x-3x^2} dx$$

$$\text{let } I = \frac{-1}{3} I_1 + \frac{11}{3} I_2 \dots(ii)$$

$$\text{Consider } I_1 = \int (-4-6x)\sqrt{10-4x-3x^2} dx$$

$$\text{Put, } 10-4x-3x^2 = t$$

$$\Rightarrow (-4-6x)dx = dt$$

$$\therefore I_1 = \int \sqrt{t} dt = \frac{2}{3} t^{3/2} + C_1$$

$$= \frac{2}{3} (10-4x-3x^2)^{3/2} + C_1 \dots(iii)$$

$$\text{consider } I_2 = \int \sqrt{10-4x-3x^2} dx$$

$$= \sqrt{3} \int \sqrt{-\left(x^2 + \frac{4}{3}x - \frac{10}{3}\right)} dx$$

$$= \sqrt{3} \int \sqrt{-\left(x^2 + 2 \cdot \frac{2}{3}x + \left(\frac{2}{3}\right)^2 - \left(\frac{2}{3}\right)^2 - \frac{10}{3}\right)} dx$$

$$= \sqrt{3} \int \sqrt{\frac{34}{9} - \left(x + \frac{2}{3}\right)^2} dx$$

$$= \sqrt{3} \int \sqrt{\left(\frac{\sqrt{34}}{3}\right)^2 - \left(x + \frac{2}{3}\right)^2} dx$$

$$= \frac{\sqrt{3}}{2} \left[\left(x + \frac{2}{3}\right) \sqrt{\left(\frac{\sqrt{34}}{3}\right)^2 - \left(x + \frac{2}{3}\right)^2} + \frac{34}{9} \sin^{-1} \left(\frac{\left(x + \frac{2}{3}\right)}{\left(\frac{\sqrt{34}}{3}\right)} \right) + C_2 \right]$$

$$[\because \int \sqrt{a^2 - x^2} dx = \frac{x}{2} \sqrt{a^2 - x^2} + \frac{a^2}{2} \sin^{-1} \left(\frac{x}{a} \right) + C]$$

$$= \frac{\sqrt{3}}{2} \left[\left(x + \frac{2}{3}\right) \sqrt{\frac{34}{9} - \left(x + \frac{2}{3}\right)^2} + \frac{34}{9} \sin^{-1} \left(\frac{3x+2}{\sqrt{34}} \right) + C_2 \right] \dots(iv)$$

From Equations. (ii), (iii) and (iv), we get

$$I = \frac{-2}{9} (10 - 4x - 3x^2)^{\frac{3}{2}} + \frac{11\sqrt{3}}{6} \left[\left(x + \frac{2}{3} \right) \sqrt{\frac{34}{9} - \left(x + \frac{2}{3} \right)^2} + \frac{34}{9} \sin^{-1} \left(\frac{3x+2}{\sqrt{34}} \right) \right] + C \text{ [where, } C = \frac{-C_1}{3} + \frac{11}{3} C_2 \text{]}$$

29. The given differential equation is,

$$\tan x \frac{dy}{dx} = 2x \tan x + x^2 - y$$

$$\Rightarrow \frac{dy}{dx} + \frac{1}{\tan x} y = \frac{2x \tan x + x^2}{\tan x}$$

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

This is a linear differential equation of the form $\frac{dy}{dx} + Py = Q$

$$\text{I.F.} = e^{\int P dx} = e^{\int \cot x dx} = e^{\log \sin x} = \sin x$$

The solution of the given differential equation is given by

$$y \times (\text{I.F.}) = \int Q \times (\text{I.F.}) dx + C$$

$$y \times \sin x = \int (2x + x^2 + \cot x) \sin x dx + C$$

$$y \sin x = \int 2x \sin x dx + \int x^2 \cos x dx + C$$

$$y \sin x = \int 2x \sin x dx + [x^2 \int \cos x dx - \int \left(\frac{d}{dx} x^2 \times \int \cos x dx \right) + C]$$

$$y \sin x = \int 2x \sin x dx + x^2 \sin x - \int 2x \sin x dx + C$$

$$y \sin x = x^2 \sin x + C$$

$$y = x^2 + \operatorname{cosec} x \times C \dots (i)$$

It is given that, $y = 0$ when $x = \frac{\pi}{2}$

$$\therefore 0 = \left(\frac{\pi}{2} \right)^2 + \operatorname{cosec} \frac{\pi}{2} \times C$$

$$C = -\frac{\pi^2}{4}$$

Putting $C = -\frac{\pi^2}{4}$ in (i), we get

$$y = x^2 - \frac{\pi^2}{4} \operatorname{cosec} x$$

Hence, $y = x^2 - \frac{\pi^2}{4} \operatorname{cosec} x$ is the required solution.

OR

The given differential equation is,

$$x \cos \left(\frac{y}{x} \right) \frac{dy}{dx} = y \cos \left(\frac{y}{x} \right) + x$$

$$\Rightarrow \frac{dy}{dx} = \frac{y \cos \left(\frac{y}{x} \right) + x}{x \cos \left(\frac{y}{x} \right)}$$

This is a homogeneous differential equation

Put $y = vx$ and $\frac{dy}{dx} = v + x \frac{dv}{dx}$, we get

$$v + x \frac{dv}{dx} = \frac{vx \cos v + x}{x \cos v}$$

$$\Rightarrow v + x \frac{dv}{dx} = \frac{v \cos v + 1}{\cos v}$$

$$\Rightarrow x \frac{dv}{dx} = \frac{v \cos v + 1 - v \cos v}{\cos v}$$

$$\Rightarrow x \frac{dv}{dx} = \frac{1}{\cos v}$$

$$\Rightarrow \cos v dv = \frac{1}{x} dx$$

Integrating both sides, we get

$$\int \cos v dv = \int \frac{1}{x} dx$$

$$\Rightarrow \sin v = \log |x| + C$$

Put $v = \frac{y}{x}$, we get

$$\sin \frac{y}{x} = \log |x| + C \dots (i)$$

At $x = 1$, $y = \frac{\pi}{4}$... (given)

Putting $C = \frac{1}{\sqrt{2}}$ in (i), we get

$$\sin \frac{y}{x} = \log |x| + \frac{1}{\sqrt{2}}$$

Hence, $\sin \frac{y}{x} = \log x + \frac{1}{\sqrt{2}}$ is the required solution.

30. We have to maximize $Z = 60x + 15y$ First, we will convert the given inequations into equations, we obtain the following equations:

$$x + y = 50, 3x + y = 90, x = 0 \text{ and } y = 0$$

Region represented by $x + y \leq 50$:

The line $x + y = 50$ meets the coordinate axes at $A(50, 0)$ and $B(0, 50)$ respectively. By joining these points we obtain the line $3x + 5y = 15$. Clearly $(0, 0)$ satisfies the inequality $x + y \leq 50$. Therefore, the region containing the origin represents the solution set of the inequality $x + y \leq 50$.

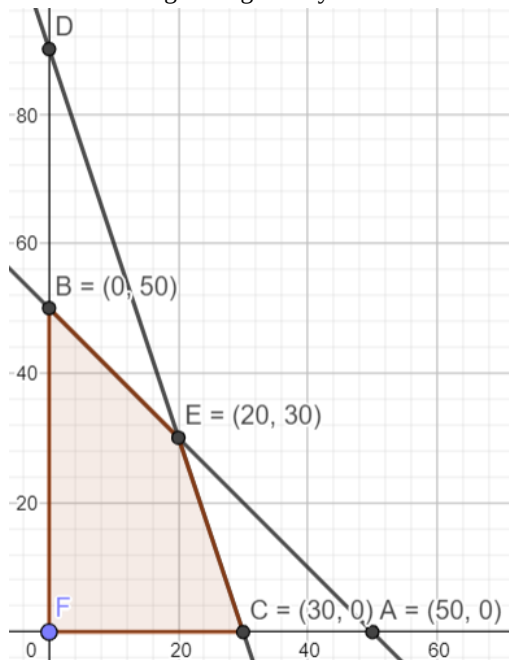
Region represented by $3x + y \leq 90$:

The line $3x + y = 90$ meets the coordinate axes at $C(30, 0)$ and $D(0, 90)$ respectively. By joining these points we obtain the line $3x + y = 90$. Clearly $(0, 0)$ satisfies the inequality $3x + y \leq 90$. Therefore, the region containing the origin represents the solution set of the inequality $3x + y \leq 90$.

Region represented by $x \geq 0$ and $y \geq 0$:

since, every point in the first quadrant satisfies these inequalities. Therefore, the first quadrant is the region represented by the inequalities $x \geq 0$, and $y \geq 0$.

The feasible region is given by



The corner points of the feasible region are $O(0, 0)$, $C(30, 0)$, $E(20, 30)$ and $B(0, 50)$.

The values of Z at these corner points are as follows given by

Corner point $Z = 60x + 15y$

$O(0, 0) : 60 \times 0 + 15 \times 0 = 0$

$C(30, 0) : 60 \times 30 + 15 \times 0 = 1800$

$E(20, 30) : 60 \times 20 + 15 \times 30 = 1650$

$B(0, 50) : 60 \times 0 + 15 \times 50 = 750$

Therefore, the maximum value of Z is 1800 at the point $(30, 0)$. Hence, $x = 30$ and $y = 0$ is the optimal solution of the given LPP.

Thus, the optimal value of Z is 1800. This is the required solution.

OR

Converting the given inequalities into equations, we obtain the following equations:

$x + 2y = 40$, $3x + y = 30$, $4x + 3y = 60$, $x = 0$ and $y = 0$

Region represented by $x + 2y \leq 40$:

The line $x + 2y = 40$ meets the coordinate axes at $A_1(40, 0)$ and $B_1(0, 20)$ respectively. Join these points to obtain the line $x + 2y = 40$.

Clearly, $(0, 0)$ satisfies the inequality $x + 2y \leq 40$. So, the region in xy -plane that contains the origin represents the solution set of the given inequality.

Region represented by $3x + y \geq 30$:

The line $3x + y = 30$ meets x and y axes at $A_2(10, 0)$ and $B_2(0, 30)$ respectively. Join these points to obtain this line.

We find that the point $O(0, 0)$ does not satisfy the inequality $3x + y \geq 30$.

So, that region in xy -plane which does not contain the origin is the solution set of this inequality.

Region represented by $4x + 3y \geq 60$:

The line $4x + 3y = 60$ meets x and y axes at $A_3(15, 0)$ and $B_1(0, 20)$ respectively.

Join these points to obtain the line $4x + 3y = 60$. We observe that the point $O(0, 0)$ does not satisfy the inequality $4x + 3y \geq 60$.

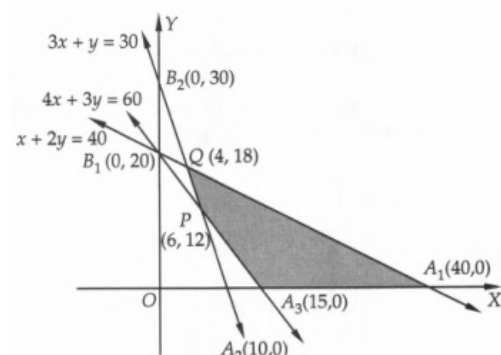
So, the region not containing the origin in xy -plane represents the solution set of the given inequality.

Region represented by $x \geq 0, y \geq 0$:

Clearly, the region represented by the non-negativity restrictions $x \geq 0$ and $y \geq 0$ is the first quadrant in xy -plane.

The shaded region A_3A_1QP in a figure represents the common region of the regions represented by the above inequations.

This region represents the feasible region of the given LPP.



The coordinates of the corner points of the shaded feasible region are $A_3(15, 0)$, $A_1(40, 0)$, $Q(4, 18)$ and $P(6, 12)$. These points have been obtained by solving the equations of the corresponding intersecting lines, simultaneously.

The values of the objective function at these points are given in the following table:

Point (x, y)	Value of the objective function $Z = 20x + 10y$
$A_3(15, 0)$	$Z = 20 \times 15 + 10 \times 0 = 300$
$A_1(40, 0)$	$Z = 20 \times 40 + 10 \times 0 = 800$
$Q(4, 18)$	$Z = 20 \times 4 + 10 \times 18 = 260$
$P(6, 12)$	$Z = 20 \times 6 + 10 \times 12 = 240$

Out of these values of Z , the minimum value is 240 which is attained at point $P(6, 12)$. Hence, $x = 6, y = 12$ is the optimal solution of the given LPP and the optimal value of Z is 240.

31. Let $u = \tan^{-1} \left[\frac{\sqrt{1-x^2}}{x} \right]$

Put $x = \cos \theta \Rightarrow \theta = \cos^{-1} x$

Then, $u = \tan^{-1} \left[\frac{\sqrt{1-\cos^2 \theta}}{\cos \theta} \right]$

$= \tan^{-1} \left[\frac{\sqrt{\sin^2 \theta}}{\cos \theta} \right] \left[\because \cos^2 \theta + \sin^2 \theta = 1 \Rightarrow \sin^2 \theta = 1 - \cos^2 \theta \right]$

$= \tan^{-1} \left[\frac{\sin \theta}{\cos \theta} \right]$

$= \tan^{-1} [\tan \theta] = \theta$

$\Rightarrow u = \cos^{-1} x$

On differentiating both sides w.r.t x , we get

$$\frac{du}{dx} = -\frac{1}{\sqrt{1-x^2}}$$

Again, let $v = \cos^{-1} (2x\sqrt{1-x^2})$

Put $x = \cos \theta \Rightarrow \theta = \cos^{-1} x$

Then, $v = \cos^{-1} [2 \cos \theta \sqrt{1-\cos^2 \theta}]$

$= \cos^{-1} [2 \cos \theta \sin \theta] \left[\because \sin \theta = \sqrt{1-\cos^2 \theta} \right]$
 $\Rightarrow \sin^2 \theta = 1 - \cos^2 \theta$

$= \cos^{-1} [\sin 2\theta]$

$= \cos^{-1} \left[\cos \left(\frac{\pi}{2} - 2\theta \right) \right] = \frac{\pi}{2} - 2\theta$

$\Rightarrow v = \frac{\pi}{2} - 2 \cos^{-1} x \left[\because \theta = \cos^{-1} x \right]$

On differentiating both sides w.r.t x , we get

$$\frac{dv}{dx} = \frac{2}{\sqrt{1-x^2}}$$

Now, $\frac{du}{dv} = \frac{du}{dx} \times \frac{dx}{dv} = -\frac{1}{\sqrt{1-x^2}} \times \frac{\sqrt{1-x^2}}{2}$

$= -\frac{1}{2}$

32. According to the question ,

Given equation of circle is $x^2 + y^2 = 4$ (i)

On differentiating Eq. (i) w.r.t. x , we get

$$2x + 2y \frac{dy}{dx} = 0$$

$$\Rightarrow x + y \frac{dy}{dx} = 0$$

$$\Rightarrow \frac{dy}{dx} = -\frac{x}{y}$$

$$\Rightarrow \left(\frac{dy}{dx} \right)_{(1, \sqrt{3})} = -\frac{1}{\sqrt{3}}$$

$$\therefore m = -\frac{1}{\sqrt{3}} \text{ ('m' is slope of tangent)}$$

Now, equation of tangent at point $(1, \sqrt{3})$ is

$$(y - \sqrt{3}) = -\frac{1}{\sqrt{3}}(x - 1)$$

$$\Rightarrow \sqrt{3}y - 3 = -x + 1$$

$$\Rightarrow x + \sqrt{3}y = 4 \text{(ii)}$$

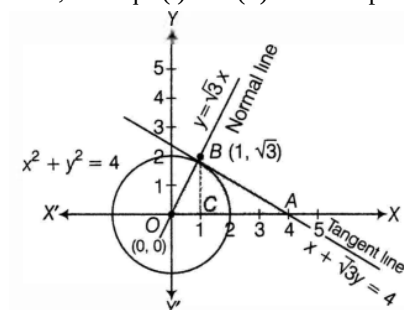
equation of normal passing through point $(1, \sqrt{3})$ and

$$\text{slope of normal} = \frac{-1}{m_{(\text{tangent})}} = \sqrt{3}$$

$$(y - \sqrt{3}) = \sqrt{3}(x - 1)$$

$$(y - \sqrt{3}) = \sqrt{3}x - \sqrt{3} \text{(iii)}$$

Now, the Eqs. (i) and (ii) can be represented in the graph as shown below:



On putting $y = 0$ in Eq. (i), we get

$$x + 0 = 4$$

$$\Rightarrow x = 4$$

$\therefore$ the tangent line $x + \sqrt{3}y = 4$ cuts the X-axis at $A(4,0)$.

$\therefore$ Required area = Area of shaded region OAB

$$= \int_0^1 y_{(\text{equation of normal})} dx + \int_1^4 y_{(\text{equation of tangent})} dx$$

$$= \int_0^1 \sqrt{3}x dx + \int_1^4 \left(\frac{4-x}{\sqrt{3}} \right) dx$$

$$= \sqrt{3} \left[\frac{x^2}{2} \right]_0^1 + \frac{1}{\sqrt{3}} \left[4x - \frac{x^2}{2} \right]_1^4$$

$$= \frac{\sqrt{3}}{2} + \frac{1}{\sqrt{3}} \left[16 - \frac{16}{2} - 4 + \frac{1}{2} \right]$$

$$= \frac{\sqrt{3}}{2} + \frac{1}{\sqrt{3}} \left[12 - \frac{15}{2} \right]$$

$$= \frac{\sqrt{3}}{2} + \frac{1}{\sqrt{3}} \left[\frac{9}{2} \right]$$

$$= \frac{\sqrt{3}}{2} + \frac{3\sqrt{3}}{2}$$

$$= \frac{4\sqrt{3}}{2}$$

$$= 2\sqrt{3} \text{ sq units.}$$

33. Given that

Let $A = \{1, 2, 3\}$ and $R = \{(a, b) : a, b \in A \text{ and } |a^2 - b^2| \leq 5\}$

Put $a = 1, b = 1$ $|1^2 - 1^2| \leq 5$, $(1, 1)$ is an ordered pair.

Put $a = 1, b = 2$ $|1^2 - 2^2| \leq 5$, $(1, 2)$ is an ordered pair.

Put $a = 1, b = 3$ $|1^2 - 3^2| > 5$, $(1, 3)$ is not an ordered pair.

Put $a = 2, b = 1$ $|2^2 - 1^2| \leq 5$, $(2, 1)$ is an ordered pair.

Put $a = 2, b = 2$ $|2^2 - 2^2| \leq 5$, $(2, 2)$ is an ordered pair.

Put $a = 2, b = 3$ $|2^2 - 3^2| \leq 5$, $(2, 3)$ is an ordered pair.

Put $a = 3, b = 1$ $|3^2 - 1^2| > 5$, $(3, 1)$ is not an ordered pair.

Put $a = 3, b = 2$ $|3^2 - 2^2| \leq 5$, $(3, 2)$ is an ordered pair.

Put $a = 3, b = 3$ $|3^2 - 3^2| \leq 5$, $(3, 3)$ is an ordered pair.

$R = \{(1, 1), (1, 2), (2, 1), (2, 2), (2, 3), (3, 2), (3, 3)\}$

i. For $(a, a) \in R$

$|a^2 - a^2| = 0 \leq 5$. Thus, it is reflexive.

ii. Let $(a, b) \in R$

$(a, b) \in R, |a^2 - b^2| \leq 5$

$|b^2 - a^2| \leq 5$

$(b, a) \in R$

Hence, it is symmetric

iii. Put $a = 1, b = 2, c = 3$

$|1^2 - 2^2| \leq 5$

$|2^2 - 3^2| \leq 5$

But $|1^2 - 3^2| > 5$

Thus, it is not transitive

OR

We observe the following properties of f .

Injectivity: Let $x, y \in R_0$ such that $f(x) = f(y)$. Then,

$$f(x) = f(y) \Rightarrow \frac{1}{x} = \frac{1}{y} \Rightarrow x = y$$

So, $f: R_0 \rightarrow R_0$ is one-one.

Surjectivity: Let y be an arbitrary element of R_0 (co-domain) such that $f(x) = y$. Then,

$$f(x) = y \Rightarrow \frac{1}{x} = y \Rightarrow x = \frac{1}{y}$$

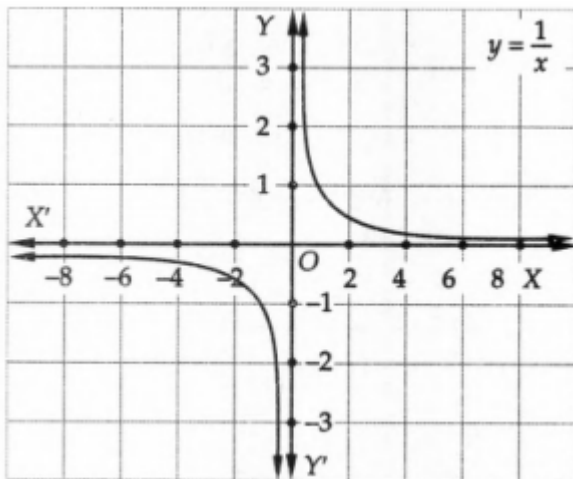
Clearly, $x = \frac{1}{y} \in R_0$ (domain) for all $y \in R_0$ (co-domain).

Thus, for each $y \in R_0$ (co-domain) there exists $x = \frac{1}{y} \in R_0$ (domain) such that $f(x) = \frac{1}{x} = y$

So, $f: R_0 \rightarrow R_0$ is onto.

Hence, $f: R_0 \rightarrow R_0$ is one-one onto.

This is also evident from the graph of $f(x)$ as shown in fig.



Let us now consider $f: N \rightarrow R_0$ given by $f(x) = \frac{1}{x}$

For any $x, y \in N$, we find that

$$f(x) = f(y) \Rightarrow \frac{1}{x} = \frac{1}{y} \Rightarrow x = y$$

So, $f: N \rightarrow R_0$ is one-one.

We find that $\frac{2}{3}, \frac{3}{5}$ etc. in co-domain R_0 do not have their pre-image in domain N . So, $f: N \rightarrow R_0$ is not onto.

Thus, $f: N \rightarrow R_0$ is one-one but not onto.

34. Let $\frac{1}{x} = u, \frac{1}{y} = v$ and $\frac{1}{z} = w$

$$2u + 3v + 10w = 4$$

$$4u - 6v + 5w = 1$$

$$6u + 9v - 20w = 2$$

$$A = \begin{bmatrix} 2 & 3 & 10 \\ 4 & -6 & 5 \\ 6 & 9 & -20 \end{bmatrix}, X = \begin{bmatrix} u \\ v \\ w \end{bmatrix} B = \begin{bmatrix} 4 \\ 1 \\ 2 \end{bmatrix}$$

$$\begin{aligned} \text{Now, } |A| &= \begin{vmatrix} 2 & 3 & 10 \\ 4 & -6 & 5 \\ 6 & 9 & -20 \end{vmatrix} \\ &= 2[120 - 45] - 3[-80 - 30] + 10[36 + 36] \\ &= 150 + 330 + 720 = 1200 \neq 0 \end{aligned}$$

$\Rightarrow A$ is non-singular and hence A^{-1} exists.

$$\text{Now, } A_{11} = 75, A_{12} = 110, A_{13} = 72$$

$$A_{21} = 150, A_{22} = -100, A_{23} = 0$$

$$A_{31} = 75, A_{32} = 30, A_{33} = -2$$

$$\therefore \text{adj}A = \begin{bmatrix} 75 & 150 & 75 \\ 110 & -100 & 30 \\ 72 & 0 & -24 \end{bmatrix}$$

$$A^{-1} = \frac{1}{|A|}(\text{adj}A) = \frac{1}{1200} \begin{bmatrix} 75 & 150 & 75 \\ 110 & -100 & 30 \\ 72 & 0 & -24 \end{bmatrix}$$

$$X = A^{-1}B$$

$$= \frac{1}{1200} \begin{bmatrix} 600 \\ 400 \\ 240 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{2} \\ \frac{1}{3} \\ \frac{1}{5} \end{bmatrix}$$

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \begin{bmatrix} \frac{1}{2} \\ \frac{1}{3} \\ \frac{1}{5} \end{bmatrix}$$

$$u = \frac{1}{2}, v = \frac{1}{3}, w = \frac{1}{5}$$

$$\frac{1}{x} = \frac{1}{2}, \frac{1}{y} = \frac{1}{3}, \frac{1}{z} = \frac{1}{5}$$

$$x = 2, y = 3, z = 5$$

35. We have,

$$\frac{x+3}{5} = \frac{y-1}{2} = \frac{z+4}{3} = \lambda$$

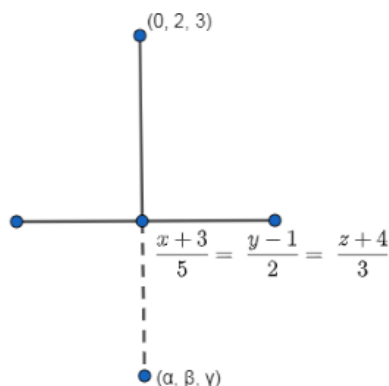
Therefore, the foot of the perpendicular is $(5\lambda - 3, 2\lambda + 1, 3\lambda - 4)$

The direction ratios of the perpendicular is

$$(5\lambda - 3 - 0) : (2\lambda + 1 - 2) : (3\lambda - 4 - 3)$$

$$\Rightarrow (5\lambda - 3) : (2\lambda - 1) : (3\lambda - 7)$$

Direction ratio of the line is $5 : 2 : 3$



From the direction ratio of the line and direction ratio of its perpendicular, we have

$$5(5\lambda - 3) + 2(2\lambda - 1) + 3(3\lambda - 7) = 0$$

$$\Rightarrow 25\lambda - 15 + 4\lambda - 2 + 9\lambda - 21 = 0$$

$$\Rightarrow 38\lambda = 38$$

$$\Rightarrow \lambda = 1$$

Therefore, the foot of the perpendicular is (2, 3, -1)

The foot of the perpendicular is the mid-point of the line joining (0, 2, 3) and (a, β, γ)

Therefore, we have

$$\frac{\alpha+0}{2} = 2 \Rightarrow \alpha = 4$$

$$\frac{\beta+2}{2} = 3 \Rightarrow \beta = 4$$

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

Thus, the image is (4, 4, -5)

OR

Equation of line in vector form

$$\text{Line I: } \vec{r} = (\hat{i} - \hat{j} + 0\hat{k}) + \lambda(2\hat{i} + 0\hat{j} + \hat{k})$$

$$\text{Line II: } \vec{r} = (2\hat{i} - \hat{j}) + \mu(\hat{i} + \hat{j} - \hat{k})$$

Here,

$$\vec{a}_1 = \hat{i} - \hat{j} + 0\hat{k}$$

$$\vec{a}_2 = 2\hat{i} - \hat{j}$$

$$\vec{b}_1 = 2\hat{i} + 0\hat{j} + \hat{k}$$

$$\vec{b}_2 = \hat{i} + \hat{j} - \hat{k}$$

We know that the shortest distance between lines is

$$d = \frac{|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)|}{|\vec{b}_1 \times \vec{b}_2|}$$

$$(\vec{a}_2 - \vec{a}_1) = (2\hat{i} - \hat{j}) - (\hat{i} - \hat{j} + 0\hat{k})$$

$$(\vec{a}_2 - \vec{a}_1) = \hat{i} + 0\hat{j} + 0\hat{k}$$

$$\vec{b}_1 \times \vec{b}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 0 & 1 \\ 1 & 1 & -1 \end{vmatrix}$$

$$\vec{b}_1 \times \vec{b}_2 = (0 - 1)\hat{i} - (-2 - 1)\hat{j} + (2 - 0)\hat{k}$$

$$\Rightarrow \vec{b}_1 \times \vec{b}_2 = -\hat{i} + 3\hat{j} + 2\hat{k}$$

$$|\vec{b}_1 \times \vec{b}_2| = \sqrt{(-1)^2 + 3^2 + 2^2}$$

$$\Rightarrow |\vec{b}_1 \times \vec{b}_2| = \sqrt{14}$$

$$|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)| = |(\hat{i} + 0\hat{j} + 0\hat{k}) \cdot (-\hat{i} + 3\hat{j} + 2\hat{k})|$$

$$\Rightarrow |(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)| = 1$$

Substituting these values in the expression,

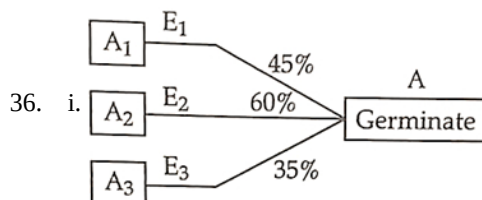
$$d = \frac{|(\vec{a}_2 - \vec{a}_1) \cdot (\vec{b}_1 \times \vec{b}_2)|}{|\vec{b}_1 \times \vec{b}_2|}$$

$$d = \frac{1}{\sqrt{14}}$$

$$d = \frac{1}{\sqrt{14}} \text{ units}$$

Shortest distance d between the lines is not 0. Hence the given lines are not intersecting.

Section E



$$\text{Here, } P(E_1) = \frac{4}{10}, P(E_2) = \frac{4}{10}, P(E_3) = \frac{2}{10}$$

$$P\left(\frac{A}{E_1}\right) = \frac{45}{100}, P\left(\frac{A}{E_2}\right) = \frac{60}{100}, P\left(\frac{A}{E_3}\right) = \frac{35}{100}$$

$$\therefore P(A) = P(E_1) \cdot P\left(\frac{A}{E_1}\right) + P(E_2) \cdot P\left(\frac{A}{E_2}\right) + P(E_3) \cdot P\left(\frac{A}{E_3}\right)$$

$$= \frac{4}{10} \times \frac{45}{100} + \frac{4}{10} \times \frac{60}{100} + \frac{2}{10} \times \frac{35}{100}$$

$$= \frac{180}{1000} + \frac{240}{1000} + \frac{70}{100}$$

$$= \frac{490}{1000} = 4.9$$

ii. Required probability = $P\left(\frac{E_2}{A}\right)$

$$= \frac{P(E_2) \cdot P\left(\frac{A}{E_2}\right)}{P(A)}$$

$$= \frac{\frac{4}{10} \times \frac{60}{100}}{\frac{490}{1000}}$$

$$= \frac{240}{490} = \frac{24}{49}$$

iii. Let,

E_1 = Event for getting an even number on die and

E_2 = Event that a spade card is selected

$$\therefore P(E_1) = \frac{3}{6}$$

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

$$\text{and } P(E_2) = \frac{13}{52} = \frac{1}{4}$$

$$\text{Then, } P(E_1 \cap E_2) = P(E_1) \cdot P(E_2)$$

$$= \frac{1}{2} \cdot \frac{1}{4} = \frac{1}{8}$$

OR

$$P(A) + P(B) - P(A \text{ and } B) = P(A)$$

$$\Rightarrow P(A) + P(B) - P(A \cap B) = P(A)$$

$$\Rightarrow P(B) - P(A \cap B) = 0$$

$$\Rightarrow P(A \cap B) = P(B)$$

$$\therefore P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$= \frac{P(B)}{P(B)}$$

$$= 1$$

37. i. Total displacement = $|\vec{d}_1| + |\vec{d}_2| + |\vec{d}_3|$

$$|\vec{d}_1| = \sqrt{6^2 + 8^2}$$

$$= \sqrt{36 + 64}$$

$$= \sqrt{100}$$

$$= 10 \text{ km}$$

$$|\vec{d}_2| = \sqrt{3^2 + 4^2}$$

$$= \sqrt{9 + 16}$$

$$= \sqrt{25}$$

$$= 5 \text{ km}$$

$$|\vec{d}_3| = \sqrt{7^2 + 12^2}$$

$$= \sqrt{49 + 144}$$

$$= 13.89$$

$$\text{Total displacement} = 10 + 5 + 13.89$$

$$= 28.89$$

$$\approx 29 \text{ km}$$

ii. Speed = $= \frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{28.89}{1.5}$$

$$= 19.26 \text{ km/hr}$$

iii. Displacement from village to zoo = $d_1 + d_2$

$$= 10 + 5$$

$$= 15 \text{ km}$$

OR

$$\text{Displacement from temple to mall} = d_2 + d_3$$

$$= 5 + 13.89$$

$$= 18.89$$

$$\approx 19 \text{ km}$$

38. i. If P is the rent price per apartment and N is the number of rented apartments, the profit is given by $NP - 500N = N(P - 500)$
[$\therefore$ ₹500/month is the maintenance charge for each occupied unit]

- ii. Let R be the rent price per apartment and N is the number of rented apartments.

Now, if x be the number of non-rented apartments, then $N(x) = 50 - x$ and $R(x) = 10000 + 250x$

Thus, profit = $P(x) = NR = (50 - x)(10000 + 250x - 500)$

$$= (50 - x)(9500 + 250x) = 250(50 - x)(38 + x)$$

- iii. We have, $P(x) = 250(50 - x)(38 + x)$

$$\text{Now, } P'(x) = 250[50 - x - (38 + x)] = 250[12 - 2x]$$

For maxima/minima, put $P'(x) = 0$

$$\Rightarrow 12 - 2x = 0 \Rightarrow x = 6$$

Number of apartments are 6.

OR

$$P'(x) = 250(12 - 2x)$$

$$P''(x) = -500 < 0$$

$\Rightarrow P(x)$ is maximum at $x = 6$