

$$\Rightarrow \frac{x^2 - y^2}{x^2 + y^2} = \tan^{-1} a \quad \text{-----(1)} \quad \frac{1}{2}$$

Differentiating (1) w.r.t. x, we get

$$\frac{(x^2 + y^2) \left(2x - 2y \frac{dy}{dx} \right) - (x^2 - y^2) \left(2x + 2y \frac{dy}{dx} \right)}{(x^2 + y^2)^2} = 0$$

$$\text{or, } 2x(x^2 + y^2) - 2y(x^2 + y^2) \frac{dy}{dx} - 2x(x^2 - y^2) - 2y(x^2 - y^2) \frac{dy}{dx} = 0 \quad 2$$

$$\text{or, } \frac{dy}{dx} [-2x^2y - \cancel{2y^3} - 2x^2y + \cancel{2y^3}] = -2x^3 - 2xy^2 + 2x^3 - 2xy^2 \quad 1$$

$$\Rightarrow \frac{dy}{dx} [-4x^2y] = -4xy^2$$

$$\Rightarrow \frac{dy}{dx} = \frac{-4xy^2}{-4x^2y} = \frac{y}{x} \quad \frac{1}{2}$$

15. We know that e^x , $\sin x$ and $\cos x$ functions are continuous and differentiable everywhere. Product, sum and difference of two continuous functions is again a continuous function, so

f is also continuous in $\left[\frac{\pi}{4}, \frac{5\pi}{4} \right]$ 1

$$\text{Now, } f\left(\frac{\pi}{4}\right) = e^{\frac{\pi}{4}} \left(\sin \frac{\pi}{4} - \cos \frac{\pi}{4} \right) = 0$$

$$f\left(\frac{5\pi}{4}\right) = e^{\frac{5\pi}{4}} \left(\sin \frac{5\pi}{4} - \cos \frac{5\pi}{4} \right) = 0$$

$$\Rightarrow f\left(\frac{\pi}{4}\right) = f\left(\frac{5\pi}{4}\right) \quad 1$$

\therefore Rolle's theorem is applicable

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

$$\therefore f'(x) = 0 \text{ gives } 2e^x \sin x = 0$$

$$\text{or } \sin x = 0 \Rightarrow x = 0, \pi \quad 1$$

$$\text{Now } \pi \in \left(\frac{\pi}{4}, \frac{5\pi}{4} \right)$$

\therefore The theorem is verified with $x = \pi$ 1

16. Let $x = 25$, $x + \Delta x = 25.2$ so $\Delta x = 0.2$

Let $y = \sqrt{x} \Rightarrow \frac{dy}{dx} = \frac{1}{2\sqrt{x}} = \frac{1}{2\sqrt{25}} = \frac{1}{10}$ at $x = 25$

$dy = \frac{dy}{dx} \cdot \Delta x$

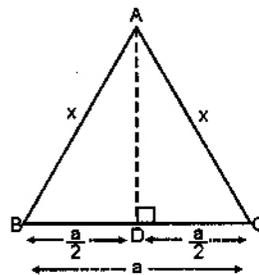
or $\Delta y = \frac{dy}{dx} \cdot \Delta x = \frac{1}{10} \times 0.2 = 0.02$

$\therefore \sqrt{25.2} = y + \Delta y = 5 + 0.02 = 5.02$

OR

Let A be the area of ΔABC in which $AB = AC = x$ and $BC = a$

$\therefore A = \frac{1}{2} BC \times AD$
 $= \frac{1}{2} a \sqrt{x^2 - \frac{a^2}{4}} = \frac{a}{4} \sqrt{4x^2 - a^2}$



$\frac{dA}{dt} = \frac{a}{4} \cdot \frac{1}{2\sqrt{4x^2 - a^2}} \cdot 8x \cdot \frac{dx}{dt}$

$= \frac{ax \times 9}{\sqrt{4x^2 - a^2}}$

$\therefore \left(\frac{dA}{dt}\right)_{at x=a} = \frac{9a \cdot a}{\sqrt{3a^2}} = 3\sqrt{3} \text{ cm}^2/\text{second}$

17. $I = \int_{-1}^{\frac{1}{2}} |x \cos(\pi x)| dx$

Three cases arise :

Case I: $-1 < x < \frac{-1}{2}$

$\Rightarrow -\pi < \pi x < -\frac{\pi}{2}$

$\Rightarrow \cos \pi x < 0 \Rightarrow x \cos \pi x > 0$

Case II : $-\frac{1}{2} < x < 0$

$$-\frac{\pi}{2} < \pi x < 0$$

$$\Rightarrow \cos(\pi x) > 0$$

$$\Rightarrow x \cos(\pi x) < 0$$

1/2

case III : $0 < x < \frac{1}{2}$

$$\Rightarrow 0 < \pi x < \frac{\pi}{2}$$

$$\Rightarrow \cos \pi x > 0$$

$$\Rightarrow x \cos \pi x > 0$$

1/2

$$\therefore I = \int_{-1}^{-1/2} x \cos \pi x \, dx + \int_{-1/2}^0 -x \cos \pi x \, dx + \int_0^{1/2} x \cos \pi x \, dx$$

1

$$= \left[\frac{x \sin \pi x}{\pi} + \frac{\cos \pi x}{\pi^2} \right]_{-1}^{-1/2} - \left[\frac{x \sin \pi x}{\pi} + \frac{\cos \pi x}{\pi^2} \right]_{-1/2}^0 + \left[\frac{x \sin \pi x}{\pi} + \frac{\cos \pi x}{\pi^2} \right]_0^{1/2}$$

1

$$= \left[\left(\frac{1}{2\pi} + 0 \right) - \left(0 - \frac{1}{\pi^2} \right) \right] - \left[- \left(\frac{1}{2\pi} + 0 \right) + \left(0 + \frac{1}{\pi^2} \right) \right] + \left[- \left(0 + \frac{1}{\pi^2} \right) + \left(\frac{1}{2\pi} + 0 \right) \right]$$

$$\frac{1}{2\pi} + \frac{1}{\pi^2} + \frac{1}{2\pi} - \frac{1}{\pi^2} + \frac{1}{2\pi} - \frac{1}{\pi^2}$$

$$= \frac{3}{2\pi} - \frac{1}{\pi^2}$$

1/2

18. $y e^{\frac{x}{y}} dx = \left(x e^{\frac{x}{y}} + y \right) dy$

$$\Rightarrow \frac{dx}{dy} = \frac{x e^{\frac{x}{y}} + y}{y \cdot e^{\frac{x}{y}}}$$

1/2

Let $x = vy \Rightarrow \frac{dx}{dy} = v + y \cdot \frac{dv}{dy}$

1/2

$$\therefore v + y \frac{dv}{dy} = \frac{vy \cdot e^v + y}{y \cdot e^v} \quad 1$$

$$\Rightarrow y \frac{dv}{dy} = \frac{vye^v + y}{y \cdot e^v} - v = \frac{\cancel{vye^v} + y - \cancel{vye^v}}{y \cdot e^v} = \frac{1}{e^v} \quad \frac{1}{2}$$

$$\Rightarrow e^v dv = \frac{dy}{y} \quad 1$$

Integrating we get $e^v = \log y + \log c = \log cy$ 1

Substituting $v = \frac{x}{y}$, we get $\frac{1}{2}$

$$e^{\frac{x}{y}} = \log cy$$

19. $(1+y+x^2y)dx + (x+x^3)dy = 0$

$$\Rightarrow x(1+x^2)dy = -[1+y(1+x^2)]dx$$

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

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

$$\therefore \text{I.F.} = \int e^{\frac{1}{x} dx} = e^{\log x} = x \quad 1$$

\therefore The solution is

$$y \cdot x = -\int \frac{1}{x(1+x^2)} \cdot x dx = -\int \frac{dx}{1+x^2} \quad 1$$

$$= \tan^{-1} x + c$$

when $x=1, y=0$

$$\therefore 0 = -\tan^{-1}(1) + c \quad \Rightarrow c = \frac{\pi}{4} \quad \frac{1}{2}$$

$$\therefore xy = -\tan^{-1} x + \frac{\pi}{4} \quad \frac{1}{2}$$

20. $\vec{a}, \vec{b} = 0$ and $\vec{a} \cdot \vec{c} = 0$ $\frac{1}{2}$
 $\Rightarrow \vec{a} \perp \vec{b}$ and $\vec{a} \perp \vec{c}$

$\therefore \vec{a}$ is \perp to the plane of \vec{b} and \vec{c}

$\Rightarrow \vec{a}$ is parallel to $\vec{b} \times \vec{c}$

Let $\vec{a} = k(\vec{b} \times \vec{c})$, where k is a scalar

$$\therefore |\vec{a}| = |k| |\vec{b} \times \vec{c}|$$

$$= |k| |\vec{b}| |\vec{c}| \sin \frac{\pi}{6}$$

$$\therefore 1 = |k| \frac{1}{2} \Rightarrow |k| = 2$$

$$\therefore k = \pm 2$$

$$\therefore \vec{a} = \pm 2(\vec{b} \times \vec{c})$$

21. Equation of plane passing through $(0, -1, -1)$ is

$$a(x-0) + b(y+1) + c(z+1) = 0 \quad \text{---(i)}$$

(i) passes through $(4, 5, 1)$ and $(3, 9, 4)$

$$\Rightarrow 4a+6b+2c = 0 \quad \text{or} \quad 2a+3b+c=0 \quad \text{---(ii)}$$

$$\text{and } 3a + 10b + 5c = 0 \quad \text{---(iii)}$$

from (ii) and (iii), we get

$$\frac{a}{15-10} = \frac{-b}{10-3} = \frac{c}{20-9} \Rightarrow \frac{a}{5} = \frac{-b}{7} = \frac{c}{11} = k \text{ (say)}$$

$$\therefore a = 5k, b = -7k, c = 11k \quad \text{---(iv)}$$

Putting these values of a, b, c in (i), we get

$$5kx - 7k(y+1) + 11k(z+1) = 0$$

$$\text{or } 5x - 7y + 11z + 4 = 0 \quad \text{---(v)}$$

Putting the point $(-4, 4, 4)$ in (v), we get

$$-20 - 28 + 44 + 4 = 0 \text{ which is satisfied}$$

\therefore The given points are co-planar and equation

$$\text{of plane is } 5x - 7y + 11z + 4 = 0$$

22. According to the given question

$$P(H) = \frac{3}{4}, P(T) = \frac{1}{4}$$

Let X be the random variate, which can take values $0, 1, 2, 3$

$$P(X=0) = P(\text{No Tails}) = P(\text{HHH}) = \frac{3}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64} \quad \frac{1}{2}$$

$$P(X=1) = P(1 \text{ Tail}) = P(\text{HHT}) + P(\text{HTH}) + P(\text{THH})$$

$$= \frac{3}{4} \times \frac{3}{4} \times \frac{1}{4} + \frac{3}{4} \times \frac{1}{4} \times \frac{3}{4} + \frac{1}{4} \times \frac{3}{4} \times \frac{3}{4} = \frac{27}{64} \quad 1$$

$$P(X=2) = P(2 \text{ tails}) = P(\text{HTT}) + P(\text{THT}) + P(\text{TTH})$$

$$\frac{3}{4} \times \frac{1}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{3}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} \times \frac{3}{4} = \frac{9}{64} \quad 1$$

$$P(X=3) = P(3 \text{ tails}) = P(\text{TTT})$$

$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64} \quad \frac{1}{2}$$

Reqd. Probability Distribution is

X	0	1	2	3
P(X)	27/64	27/64	9/64	1/64

OR

For a fair coin, $p(H) = \frac{1}{2}$ and $p(T) = \frac{1}{2}$ where H and T denote Head and Tail respectively. 1/2

Let the coin be tossed n times

$$\therefore \text{Required probability} = 1 - p(\text{all Tails})$$

$$= 1 - \frac{1}{2^n} \quad \text{---(i)} \quad 1\frac{1}{2}$$

It has to be >80%

$$\text{Total probability} = 1 \quad 1$$

$$\therefore \text{(i) has to be } > \frac{4}{5}$$

$$\therefore 1 - \frac{1}{2^n} > \frac{4}{5} \Rightarrow n = 3$$

\therefore The fair coin has to be tossed 3 times for the desired situation. 1

SECTION C

23.

$$\Delta = \begin{vmatrix} (b+c)^2 & ab & ca \\ ab & (a+c)^2 & bc \\ ac & bc & (a+b)^2 \end{vmatrix}$$

Operating $R_1 \rightarrow a R_1, R_2 \rightarrow b R_2, R_3 \rightarrow c R_3$, to get

$$\Delta = \frac{1}{abc} \begin{vmatrix} a(b+c)^2 & a^2b & a^2c \\ ab^2 & b(a+c)^2 & b^2c \\ ac^2 & b^2c & c(a+b)^2 \end{vmatrix} = \frac{abc}{abc} \begin{vmatrix} (b+c)^2 & a^2 & a^2 \\ b^2 & (a+c)^2 & b^2 \\ c^2 & c^2 & (a+b)^2 \end{vmatrix} \quad 1+\frac{1}{2}$$

Operating $c_2 \rightarrow c_2 - c_1, c_3 \rightarrow c_3 - c_1$, to get

$$\Delta = \begin{vmatrix} (b+c)^2 & a^2-(b+c)^2 & a^2-(b+c)^2 \\ b^2 & (a+c)^2-b^2 & 0 \\ c^2 & 0 & (a+b)^2-c^2 \end{vmatrix} = (a+b+c)^2 \begin{vmatrix} (b+c)^2 & a-b-c & a-b-c \\ b^2 & a+b-c & 0 \\ c^2 & 0 & a+b-c \end{vmatrix} \quad 1+\frac{1}{2}$$

Operating $R_1 \rightarrow R_1 - (R_2 + R_3)$ to get

$$\Delta = (a+b+c)^2 \begin{vmatrix} 2bc & -2c & -2b \\ b^2 & a+c-b & 0 \\ c^2 & 0 & a+b-c \end{vmatrix} \begin{matrix} c_2 \rightarrow c_2 + \frac{1}{b}c_1, \\ c_3 \rightarrow c_3 + \frac{1}{c}c_1 \end{matrix}$$

$$= (a+b+c)^2 \begin{vmatrix} 2bc & 0 & 0 \\ b^2 & a+c & \frac{b^2}{c} \\ c^2 & \frac{c^2}{b} & a+b \end{vmatrix} \quad 1+1$$

$$(a+b+c)^2 [2bc(a^2+ac+ab+bc-bc)] = (a+b+c)^2 (2bc) a(a+b+c)$$

$$= (a+b+c)^3 \cdot 2abc \quad 1$$

24. Let the radius of circle be r and side of square be x

$$\therefore 2\pi r + 4x = k \quad \text{---(A)} \quad 1$$

Let A be the sum of the areas of circle and square

$$\therefore A = \pi r^2 + x^2$$

$$= \pi \left[\frac{k-4x}{2\pi} \right]^2 + x^2 \quad \text{[using (A)]} \quad 1$$

$$= \pi \left[\frac{k^2 + 16x^2 - 8kx}{4\pi^2} \right] + x^2$$

$$= \frac{k^2 + 16x^2 - 8kx}{4\pi} + x^2 \quad \frac{1}{2}$$

$$\therefore \frac{dA}{dx} = \frac{1}{4\pi} [0 + 32x - 8k] + 2x$$

$$= \frac{1}{4\pi} [32x - 8k + 8\pi x] \quad \frac{1}{2}$$

For optimisation $\frac{dA}{dx} = 0 \Rightarrow (32 + 8\pi x) = 8k$

$$\Rightarrow x = \frac{k}{4 + \pi} \quad \text{---(i)} \quad 1$$

$$\therefore \frac{d^2A}{dx^2} = \frac{1}{4\pi} [32 + 8\pi] > 0 \Rightarrow \text{Minima} \quad \frac{1}{2}$$

Putting the value of x in (A) to get

$$2\pi r + 4 \cdot \frac{k}{4 + \pi} = k$$

$$\Rightarrow 2\pi r = k - \frac{4k}{4 + \pi} = \frac{\pi k}{4 + \pi} \quad 1$$

$$2r = \frac{k}{4 + \pi} \quad \text{---(ii)} \quad \frac{1}{2}$$

From (i) and (ii), $x = 2r$ 1/2

OR

Let P(x,y) be the position of the Helicopter and the position of soldier at A(3, 2)

$$\therefore AP = \sqrt{(x-3)^2 + (y-2)^2} = \sqrt{(x-3)^2 + (x^2)^2} \quad \left[\because y = x^2 + 2 \text{ is the } \right. \\ \left. = n \text{ of curve} \right] \quad 2$$

Let $AP^2 = z = (x-3)^2 + x^4$

$$\Rightarrow \frac{dz}{dx} = 2(x-3) + 4x^3$$

1

For optimisation $\frac{dz}{dx} = 0 \Rightarrow 2x^3 + x - 3 = 0$

or $(x-1)(2x^2 + 2x + 3) = 0 \Rightarrow x=1$ [other factor gives no real values]

1

$$\frac{d^2z}{dx^2} = 6x^2 + 1 > 0 \Rightarrow \text{Minima}$$

when $x=1, y=x^2+2=3$

\therefore The required point is (1, 3)

1

And distance $AP = \sqrt{(1-3)^2 + (3-2)^2} = \sqrt{5}$

1

25. $\int \frac{1}{\sin x (5-4\cos x)} dx = \int \frac{\sin x}{\sin^2 x (5-4\cos x)} dx$

 $\frac{1}{2}$

$$= \int \frac{\sin x}{(1-\cos^2 x)(5-4\cos x)} dx$$

$$= -\int \frac{dt}{(1-t^2)(5-4t)}, \text{ where } \cos x = t, dt = -\sin x dx$$

$$= -\int \frac{dt}{(1-t)(1+t)(5-4t)}$$

1

Let $\frac{1}{(1-t)(1+t)(5-4t)} = \frac{A}{1-t} + \frac{B}{1+t} + \frac{C}{5-4t}$

 $\frac{1}{2}$

$$\Rightarrow 1 = A(1+t)(5-4t) + B(1-t)(5-4t) + c(1-t^2) \quad \text{---(i)}$$

Putting $t = 1$ in (i) to get $A = \frac{1}{2}$

Putting $t = -1$ in (i) to get $B = \frac{1}{18}$

Putting $t = \frac{5}{4}$ in (i) to get $C = -\frac{16}{9}$

 $1\frac{1}{2}$

$$\therefore I = -\left[\frac{1}{2} \int \frac{dt}{1-t} + \frac{1}{18} \int \frac{dt}{1+t} - \frac{16}{9} \int \frac{dt}{5-4t} \right]$$

$$-\left[-\frac{1}{2} \log |1-t| + \frac{1}{18} \log |1+t| - \frac{16}{9x^4} \log |5-4t|\right] + c \quad 1\frac{1}{2}$$

$$= \frac{1}{2} \log |1-\cos x| - \frac{1}{18} \log |1+\cos x| - \frac{4}{9} \log |5-4\cos x| + c \quad 1$$

OR

$$I = \int \sqrt{\frac{1-\sqrt{x}}{1+\sqrt{x}}} dx = \int \frac{\sqrt{1-\sqrt{x}} \cdot \sqrt{1-\sqrt{x}}}{\sqrt{1+\sqrt{x}} \sqrt{1-\sqrt{x}}} dx = \int \frac{1-\sqrt{x}}{\sqrt{1-x}} dx \quad 1\frac{1}{2}$$

$$= \int \frac{dx}{\sqrt{1-x}} - \int \frac{\sqrt{x}}{\sqrt{1-x}} dx = I_1 - I_2 \quad \frac{1}{2}$$

$$I_1 = \int (1-x)^{-\frac{1}{2}} dx = -2(1-x)^{\frac{1}{2}} + c_1 \text{ or } -2\sqrt{1-x} + c_1 \quad 1$$

$$I_2 = \int \frac{\sqrt{x}}{\sqrt{1-x}} dx : \text{Let } x = \sin^2 \theta, dx = 2\sin \theta \cos \theta d\theta \quad \frac{1}{2}$$

$$= \int \frac{\sin \theta \cdot 2\sin \theta \cos \theta d\theta}{\cos \theta} = 2 \int \sin^2 \theta d\theta \quad 1$$

$$= \int (1-\cos 2\theta) d\theta = \theta - \frac{\sin 2\theta}{2} = \theta - \sin \theta \cos \theta + c_2 \quad 1$$

$$= \sin^{-1} \sqrt{x} - \sqrt{x} \sqrt{1-x} + c_2$$

$$\therefore I = -2\sqrt{1-x} - \sin^{-1} \sqrt{x} + \sqrt{x} \sqrt{1-x} + C$$

$$= \sqrt{1-x} [\sqrt{x} - 2] - \sin^{-1} \sqrt{x} + C \quad \frac{1}{2}$$

26. Equations of curves are

$$x^2 + y^2 = 5 \text{ and } y = \begin{cases} 1-x, & x < 1 \\ x-1, & x > 1 \end{cases}$$

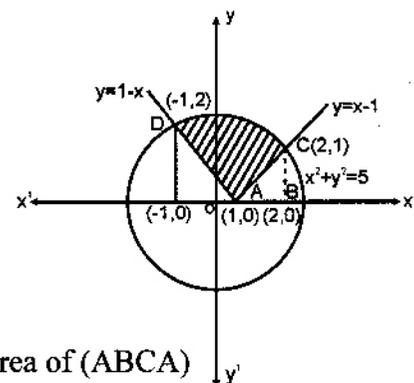
correct figure

--1

Points of intersection are C(2, 1)

D(-1, 2)

Required Area = Area of (EABCDE) - Area of (ADEA) - Area of (ABCA)



$$= \int_{-1}^2 \sqrt{5-x^2} dx - \int_{-1}^1 (1-x) dx - \int_{-1}^2 (x-1) dx$$

$$= \left[\frac{x}{2} \sqrt{5-x^2} + \frac{5}{2} \sin^{-1} \frac{x}{\sqrt{5}} \right]_{-1}^2 - \left[x - \frac{x^2}{2} \right]_{-1}^1 - \left[\frac{x^2}{2} - x \right]_{-1}^2$$

$$= \left[\left\{ 1 + \frac{5}{2} \sin^{-1} \frac{2}{\sqrt{5}} \right\} - \left\{ -\frac{1}{2} \times 2 + \frac{5}{2} \sin^{-1} \left(\frac{-1}{\sqrt{5}} \right) \right\} \right] - \left[\left(1 - \frac{1}{2} \right) - \left(-1 - \frac{1}{2} \right) \right] - \left[(2-2) - \left(\frac{1}{2} - 1 \right) \right]$$

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

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

27. Lines $\frac{x-x_1}{l_1} = \frac{y-y_1}{m_1} = \frac{z-z_1}{n_1}$ and $\frac{x-x_2}{l_2} = \frac{y-y_2}{m_2} = \frac{z-z_2}{n_2}$ are

coplanar if $\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$

In this case $\begin{vmatrix} -2 & -1 & 0 \\ -3 & 1 & 5 \\ -1 & 2 & 5 \end{vmatrix} = -2(5-10) + 1(-15+5) + 0 = 10-10 = 0$

\therefore Lines are coplanar

Equation of plane containing this is

$$\begin{vmatrix} x+3 & y-1 & z-5 \\ -3 & 1 & 5 \\ -1 & 2 & 5 \end{vmatrix} = 0$$

$$\Rightarrow 5x - 10y + 5z = 0$$

$$\text{or } x - 2y + z = 0$$

28. Let events E_1, E_2, E_3, E_4 and A be defined as follows

E_1 : Missing card is a diamond

E_2 : Missing card is a spade

E_3 : Missing card is a club

E_4 : Missing card is a heart

A : Drawing two diamond cards

$$P(E_1) = P(E_2) = P(E_3) = P(E_4) = \frac{1}{4}$$

$$P\left(\frac{A}{E_1}\right) = \frac{12}{51} \times \frac{11}{50}$$

$$P\left(\frac{A}{E_2}\right) = P\left(\frac{A}{E_3}\right) = P\left(\frac{A}{E_4}\right) = \frac{13}{51} \times \frac{12}{50}$$

$$P\left(\frac{E_4}{A}\right) = \sum_{i=1}^4 \frac{P(E_i) \cdot P\left(\frac{A}{E_i}\right)}{P(E_i) \cdot P\left(\frac{A}{E_i}\right)}$$

$$\frac{\frac{1}{4} \cdot \frac{13}{51} \times \frac{12}{50}}{\frac{1}{4} \left[\frac{12 \times 11 + 13 \times 12 + 13 \times 12 + 13 \times 12}{51 \cdot 50} \right]}$$

$$= \frac{13 \times \cancel{12}}{3 \times 13 \times \cancel{12} + \cancel{12} \times 11} = \frac{13}{39+11} = \frac{13}{50}$$

29. Let x and y be the units taken of Food A and Food B respectively then LPP is,

Minimise $z = 4x + 3y$

Subject to constraints

$200x + 100y \geq 4000$ or $2x + y \geq 40$

$x + 2y \geq 50$

$40x + 40y \geq 1400$ or $x + y \geq 35$

$x \geq 0, y \geq 0$

Correct Graph

The corners of feasible region are

$A(50,0)$, $B(20,15)$, $C(5,30)$, $D(0,40)$

1

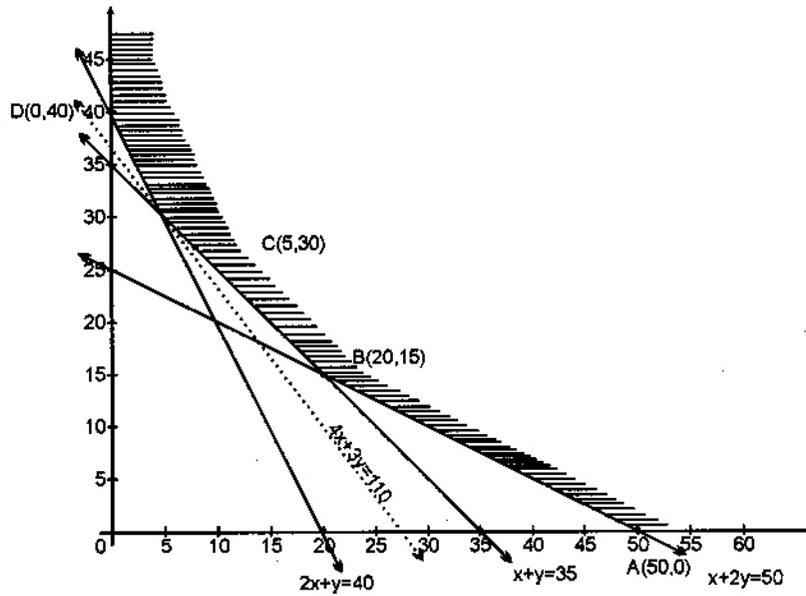
$Z_A = 200$, $Z_B = 125$, $Z_C = 110$, $Z_D = 120$

$\therefore Z$ is minimum at C

\therefore 5 units of Food A and 30 units of Food B

will give the minimum cost (which is Rs 110)

1



CBSE SAMPLE PAPER - III
CLASS XII MATHEMATICS
BLUE PRINT

S. No.	Topics	VSA	SA	LA	Total
1. (a)	Relations and Functions	-	4(1)	-	
(b)	Inverse Trigonometric Functions	2(2)	4(1)	-	10(4)
2. (a)	Matrices	1(1)	-	6(1)	
(b)	Determinants	2(2)	4(1)	-	13(5)
3. (a)	Continuity and differentiability	1(1)	12(3)	-	
(b)	Applications of derivatives	-	-	6(1)	
(c)	Integration	-	12(3)	-	
(d)	Application of integrals			6(1)	
(e)	Differential Equations	1(1)	-	6(1)	44(11)
4. (a)	Vectors	2(2)	4(1)	-	
(b)	3-dimensional Geometry	1(1)	4(1)	6(1)	17(6)
5.	Linear - Programming	-	-	6(1)	6(1)
6.	Probability	-	4(1)	6(1)	10(2)
	Total	10(10)	48(12)	42(7)	100(29)

SAMPLE PAPER - III

MATHEMATICS

CLASS - XII

Time : 3 Hours

Max. Marks : 100

General Instructions

1. All questions are compulsory.
2. The question paper consist of 29 questions divided into three sections A, B and C. Section A comprises of 10 questions of one mark each, section B comprises of 12 questions of four marks each and section C comprises of 07 questions of six marks each.
3. All questions in Section A are to be answered in one word, one sentence or as per the exact requirement of the question.
4. There is no overall choice. However, internal choice has been provided in 04 questions of four marks each and 02 questions of six marks each. You have to attempt only one of the alternatives in all such questions.
5. Use of calculators in not permitted. You may ask for logarithmic tables, if required.

SECTION A

1. Write the principal value of $\cos^{-1}\left(-\frac{\sqrt{3}}{2}\right)$.
2. Write the range of the principal branch of $\sec^{-1}(x)$ defined on the domain $R-(-1, 1)$.
3. Find x if $\begin{vmatrix} 3 & 4 \\ -5 & 2 \end{vmatrix} = \begin{vmatrix} 2x & 4 \\ -5 & 3 \end{vmatrix}$.
4. If A is a square matrix of order 3 such that $|\text{adj } A| = 64$. Find $|A|$
5. If A is a square matrix satisfying $A^2=1$, then what is the inverse of A ?
6. If $f(x) = \sin x^\circ$, find $\frac{dy}{dx}$
7. What is the degree of the following differential equation?

$$y \frac{d^2y}{dx^2} + \left(\frac{dy}{dx}\right)^3 = x \left(\frac{d^3y}{dx^3}\right)^2$$

8. If \vec{a} and \vec{b} represent the two adjacent sides of a parallelogram, then write the area of parallelogram in terms of \vec{a} and \vec{b} .
9. Find the angle between two vectors \vec{a} and \vec{b} if $|\vec{a}|=3$, $|\vec{b}|=4$ and $|\vec{a} \times \vec{b}|=6$
10. Find the direction cosines of a line, passing through origin and lying in the first octant, making equal angles with the three coordinate axes.

SECTION B

11. Show that the relation R in the set $A = \{x; x \in Z, 0 \leq x \leq 12\}$ given by $R = \{(a, b) : |a-b| \text{ is divisible by } 4\}$ is an equivalence relation. Find the set of all elements related to 1.
12. Solve for x : $2 \tan^{-1}(\sin x) = \tan^{-1}(2 \sec x)$, $0 < x < \frac{\pi}{2}$

OR

$$\text{Show that : } \tan^{-1} \frac{1}{2} \left[\sin^{-1} \frac{2x}{1+x^2} + \cos^{-1} \frac{1-y^2}{1+y^2} \right] = \frac{x+y}{1-xy}, \quad |x| < 1, y > 0, xy < 1$$

13. If none of a , b and c is zero, using properties of determinants.

prove that :
$$\begin{vmatrix} -bc & b^2+bc & c^2+bc \\ a^2+ac & -ac & c^2+ac \\ a^2+ab & b^2+ab & -ab \end{vmatrix} = (bc+ca+ab)^3$$

14. If $\sqrt{1-x^2} + \sqrt{1-y^2} = a(x-y)$, prove that $\frac{dy}{dx} = \sqrt{\frac{1-y^2}{1-x^2}}$

15. If $y = (x + \sqrt{x^2-1})^m$, then show that $(x^2+1) \frac{d^2y}{dx^2} + x \frac{dy}{dx} - m^2y = 0$

16. Find all the points of discontinuity of the function $f(x) = (x^2)$ on $[1, 2)$, where $[.]$ denotes the greatest integer function.

OR

Differentiate $\sin^{-1} (2x\sqrt{1-x^2})$ w.r.t. $\cos^{-1} \left(\frac{1-x^2}{1+x^2} \right)$

17. Evaluate : $\int \frac{1}{\cos(x-a) \cos(x-b)} dx$

OR

Evaluate : $\int x(\log x)^2 \cdot dx$

18. Evaluate : $\int \frac{x}{x^3-1} dx$

19. Using properties of definite integrals, evaluate.

$$\int_0^{\pi} \frac{x dx}{4 - \cos^2 x}$$

20. The dot products of a vector with the vectors $\hat{i}-3\hat{k}$, $\hat{i}-2\hat{k}$ and $\hat{i}+\hat{j}+4\hat{k}$ are 0, 5 and 8 respectively. Find the vector.

21. Find the equation of plane passing through the point $(1, 2, 1)$ and perpendicular to the line joining the points $(1, 4, 2)$ and $(2, 3, 5)$. Also, find the perpendicular distance of the plane from the origin.

OR

Find the equation of the perpendicular drawn from the point $P(2, 4, -1)$ to the line

$$\frac{x+5}{1} = \frac{y+3}{4} = \frac{z-6}{-9}$$

22. A biased die is twice as likely to show an even number as an odd number. The die is rolled three times. If occurrence of an even number is considered a success, then write the probability distribution of number of successes. Also find the mean number of successes.

SECTION C

23. Using matrices, solve the following system of equations :

$$\frac{1}{x} - \frac{1}{y} + \frac{1}{z} = 4; \quad \frac{2}{x} + \frac{1}{y} - \frac{3}{z} = 0; \quad \frac{1}{x} + \frac{1}{y} + \frac{1}{z} = 2x \neq 0, y \neq 0, z \neq 0$$

24. Show that the volume of the greatest cylinder which can be inscribed in a cone of height h and semivertical angle α , is $\frac{4}{27} \pi h^3 \tan^2 \alpha$

OR

Show that the normal at any point θ to the curve $x = a \cos \theta + a \theta \sin \theta$ and $y = a \sin \theta - a \theta \cos \theta$ is at a constant distance from the origin.

25. Find the area of the region: $\{(x,y) : 0 \leq y \leq x^2, 0 \leq y \leq x+2; 0 \leq x \leq 3\}$

26. Find the particular solution of the differential equation

$$(x dy - y dx) y \cdot \sin\left(\frac{y}{x}\right) = (y dx + x dy) x \cos\frac{y}{x}, \text{ given that } y = \pi \text{ when } x = 3.$$

27. Find the equation of the plane passing through the point $(1, 1, 1)$ and containing the line

$$\vec{r} = (-3\hat{i} + \hat{j} + 5\hat{k}) + \lambda(3\hat{i} - \hat{j} + 5\hat{k}). \text{ Also, show that the plane contains the line}$$

$$\vec{r} = (-\hat{i} + 2\hat{j} + 5\hat{k}) + \lambda(\hat{i} - 2\hat{j} - 5\hat{k})$$

28. A company sells two different products A and B. The two products are produced in a common production process which has a total capacity of 500 man hours. It takes 5 hours to produce a unit of A and 3 hours to produce a unit of B. The demand in the market shows that the maximum number of units of A that can be sold is 70 and that of B is 125. Profit on each unit of A is Rs. 20 and on B is Rs. 15. How many units of A and B should be produced to maximise the profit. Form an L.P.P. and solve it graphically.

29. Two bags A and B contain 4 white and 3 black balls and 2 white and 2 black balls respectively. From bag A, two balls are drawn at random and then transferred to bag B. A ball is then drawn from bag B and is found to be a black ball. What is the probability that the transferred balls were 1 white and 1 black?

OR

In an examination, 10 questions of true - false type are asked. A student tosses a fair coin to determine his answer to each question. If the coin falls heads, he answers 'true' and if it falls tails, he answers

'false'. Show that the probability that he answers at most 7 questions correctly is $\frac{121}{128}$.

MARKING SCHEME
MATHEMATICS CLASS - XII
SAMPLE PAPER III

SECTION A

1. $\frac{5\pi}{6}$

2. $\left[0, \frac{\pi}{2}\right) \cup \left(\frac{\pi}{2}, \pi\right]$

3. $x=1$

4. $|A'| = \pm 8$

5. $A^{-1} = A$

6. $\frac{\pi}{180} \cos x^\circ$

7. 2

8. $|\vec{a} \times \vec{b}|$

9. $\frac{\pi}{6}$

10. $\left\langle \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right\rangle$

(1 mark for correct answer for Qs. 1 to 10)

SECTION B

11. (i) $\forall a \in A, |a-a|=0$ is divisible by 4. $\therefore R$ is reflexive --(i) 1/2

(ii) $a, b \in A, (a, b) \in R \Rightarrow |a-b|$ is divisible by 4.

$\Rightarrow |b-a|$ is divisible by 4 $\therefore R$ is symmetric --(ii) 1/2

(iii) $a, b, c \in A, (a, b) \in R$ and $(b, c) \in R$

$\Rightarrow |a-b|$ is divisible by 4 and $|b-c|$ is divisible by 4

$\therefore (a-b)$ and $(b-c)$ are divisible by 4 and so

$(a-b) + (b-c) = (a-c)$ is divisible by 4. Hence 1

$|a-c|$ is divisible by 4 $\Rightarrow (a, c) \in R$. Hence R is transitive

Hence R is an equivalence relation from (i), (ii) and (iii).

½

Set of all elements of A, related to 1 is {1, 5, 9}

½

12. Given equation can be written as

$$\tan^{-1}\left(\frac{2 \sin x}{1-\sin^2 x}\right) = \tan^{-1}\left(\frac{2}{\cos x}\right), 0 < x < \frac{\pi}{2}$$

1½

$$\Rightarrow \frac{2 \sin x}{\cos^2 x} = \frac{2}{\cos x} \Rightarrow \tan x = 1$$

1½

$$\Rightarrow x = \frac{\pi}{4}$$

1

OR

$$\text{LHS} = \tan \frac{1}{2}(2 \tan^{-1} x + 2 \tan^{-1} y)$$

1½

$$= \tan(\tan^{-1} x + \tan^{-1} y) = \tan \tan^{-1}\left(\frac{x+y}{1-xy}\right)$$

1½

$$= \frac{x+y}{1-xy}$$

1

13. Given determinant can be written as

$$\Delta = \frac{1}{abc} \begin{vmatrix} -abc & ab(b+c) & ac(b+c) \\ ab(a+c) & -abc & bc(a+c) \\ ac(a+b) & bc(b+a) & -abc \end{vmatrix}$$

1

$$\Delta = \frac{abc}{abc} \begin{vmatrix} -bc & ab+ac & ab+ac \\ ab+bc & -ac & ab+bc \\ ac+bc & bc+ac & -ab \end{vmatrix} \begin{matrix} R_1 \rightarrow R_1 + R_2 + R_3 \\ = (ab+bc+ac) \end{matrix} \begin{vmatrix} 1 & 1 & 1 \\ ab+bc & -ac & ab+bc \\ ac+bc & bc+ac & -ab \end{vmatrix}$$

1

$$\begin{matrix} C_2 \rightarrow C_2 - C_1 \\ C_3 \rightarrow C_3 - C_1 \end{matrix} \Delta = (ab+bc+ac) \begin{vmatrix} 1 & 0 & 0 \\ ab+bc & -(ab+bc+ac) & ab+bc \\ ac+bc & 0 & -(ab+bc+ac) \end{vmatrix}$$

1

$$= (ab+bc+ac)^3$$

1

14. Putting $x = \cos \alpha$ and $y = \cos \beta$ to get

$$\sin \alpha + \sin \beta = a(\cos \alpha - \cos \beta) \Rightarrow \frac{2 \sin \frac{\alpha+\beta}{2} \cos \left(\frac{\alpha-\beta}{2} \right)}{-2 \sin \frac{\alpha+\beta}{2} \sin \frac{\alpha-\beta}{2}} = a \quad 1$$

$$\Rightarrow \cot \left(\frac{\alpha-\beta}{2} \right) = -a, \Rightarrow \alpha-\beta = 2 \cot^{-1}(-a) \text{ or } \cos^{-1}x - \cos^{-1}y = 2 \cot^{-1}(-a) \quad 1$$

Differentiating to get $-\frac{1}{\sqrt{1-x^2}} + \frac{1}{\sqrt{1-y^2}} \frac{dy}{dx} = 0 \quad 1$

$$\Rightarrow \frac{dy}{dx} = \sqrt{\frac{1-y^2}{1-x^2}} \quad 1]$$

15. Getting

$$\frac{dy}{dx} = m \cdot (x + \sqrt{x^2+1})^{m-1} \left(1 + \frac{x}{\sqrt{x^2+1}} \right) = \frac{m(x + \sqrt{x^2+1})^m}{\sqrt{x^2+1}} = \frac{m}{\sqrt{x^2+1}} \cdot y \quad 1$$

$$\Rightarrow \sqrt{x^2+1} \cdot \frac{dy}{dx} = my \quad \text{--(i)} \quad \frac{1}{2}$$

$$\therefore \sqrt{x^2+1} \cdot \frac{d^2y}{dx^2} + \frac{x}{\sqrt{x^2+1}} \cdot \frac{dy}{dx} = m \cdot \frac{dy}{dx} \quad 1$$

$$\Rightarrow (x^2+1) \frac{d^2y}{dx^2} + x \cdot \frac{dy}{dx} = m \sqrt{x^2+1} \frac{dy}{dx} = m \cdot my = m^2y \quad \text{(using i)} \quad 1$$

$$\text{or } (x^2+1) \frac{d^2y}{dx^2} + x \frac{dy}{dx} - m^2y = 0 \quad \frac{1}{2}$$

16. $f(x) = [x^2], 1 \leq x < 2 \Rightarrow f(x) = \begin{cases} 1, & 1 \leq x < \sqrt{2} \\ 2, & \sqrt{2} \leq x < \sqrt{3} \\ 3, & \sqrt{3} \leq x < 2 \end{cases} \quad 1$

At $x = \sqrt{2}$, LHL = 1, RHL = 2 $\therefore x = \sqrt{2}$ is a discontinuity of $f(x)$ $1\frac{1}{2}$

At $x = \sqrt{3}$, LHL = 2, RHL = 3 $\therefore x = \sqrt{3}$ is also a discontinuity of $f(x)$ 1

i.e. $\sqrt{2}, \sqrt{3}$ are two discontinuities in $[1, 2)$ $\frac{1}{2}$

OR

$$\text{Let } y = \sin^{-1}(2x\sqrt{1-x^2}) \text{ and } z = \cos^{-1}\left(\frac{1-x^2}{1+x^2}\right) \quad \frac{1}{2}$$

Put $x = \sin\theta$ to get

$$y = \sin^{-1}(\sin 2\theta) = 2\theta = 2\sin^{-1}x \text{ and } z = 2\tan^{-1}x \quad 1+\frac{1}{2}$$

$$\frac{dy}{dx} = \frac{2}{\sqrt{1-x^2}} \text{ and } \frac{dz}{dx} = \frac{2}{1+x^2} \quad 1$$

$$\Rightarrow \frac{dy}{dz} = \frac{1+x^2}{\sqrt{1-x^2}} \quad 1$$

$$17. \quad I = \int \frac{1}{\cos(x-a)\cos(x-b)} dx = \frac{1}{\sin(b-a)} \int \frac{\sin[(x-a)-(x-b)]}{\cos(x-a)\cos(x-b)} dx \quad 1$$

$$= \frac{1}{\sin(b-a)} \int \left[\frac{\sin(x-a)\cos(x-b)}{\cos(x-a)\cos(x-b)} - \frac{\cos(x-a)\sin(x-b)}{\cos(x-a)\cos(x-b)} \right] dx \quad 1$$

$$= \frac{1}{\sin(b-a)} \int [\tan(x-a) - \tan(x-b)] dx \quad 1$$

$$= \frac{1}{\sin(b-a)} [\log|\sec(x-a)| - \log|\sec(x-b)|] + c \quad 1$$

OR

$$I = \int (\log x)^2 \cdot x dx = (\log x)^2 \cdot \frac{x^2}{2} - \int 2 \cdot \frac{\log x}{x} \cdot \frac{x^2}{2} dx \quad 1\frac{1}{2}$$

$$= \frac{x^2}{2} (\log x)^2 - \log x \cdot \frac{x^2}{2} + \int \frac{1}{x} \cdot \frac{x^2}{2} dx \quad 1\frac{1}{2}$$

$$= \frac{x^2}{2} (\log x)^2 - \frac{x^2}{2} \log x + \frac{x^2}{4} + c \text{ or } \frac{x^2}{2} \left[(\log x)^2 - \log x + \frac{1}{2} \right] + c \quad 1$$

$$18. \quad \frac{x}{x^2-1} = \frac{x}{(x-1)(x^2+x+1)} = \frac{A}{x-1} + \frac{Bx+C}{x^2+x+1} \Rightarrow x = A(x^2+x+1) + (Bx+C)(x-1) \quad \frac{1}{2}$$

$$\Rightarrow A+B=0, A-B+C=1 \text{ and } A-C=0 \Rightarrow A = \frac{1}{3}, B = -\frac{1}{3}, C = \frac{1}{3} \quad 1$$

$$\therefore I = \int \frac{x}{x^2-1} dx = \frac{1}{3} \int \frac{1}{x-1} dx - \frac{1}{3} \int \frac{x-1}{x^2+x+1} dx \quad 1$$

$$= \frac{1}{3} \log|x-1| - \frac{1}{6} \int \frac{2x+1}{x^2+x+1} dx + \frac{1}{2} \int \frac{1}{x^2+x+1} dx \quad 1$$

$$= \frac{1}{3} \log|x-1| - \frac{1}{6} \log|x^2+x+1| + \frac{1}{2} \int \frac{1}{\left(x+\frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2} dx$$

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

19. $I = \int_0^{\pi} \frac{x dx}{4 - \cos^2 x} = \int_0^{\pi} \frac{(\pi-x) dx}{4 - \cos^2(\pi-x)} = \int_0^{\pi} \frac{(\pi-x) dx}{4 - \cos^2 x} \quad 1$

$$\therefore 2I = \pi \int_0^{\pi} \frac{1}{4 - \cos^2 x} dx = 2\pi \int_0^{\pi/2} \frac{\sec^2 x}{4 - \tan^2 x + 3} dx \quad 1$$

$$I = \frac{\pi}{4} \int_0^{\infty} \frac{dt}{t^2 + 3/4}, \quad \tan x = t \Rightarrow I = \frac{\pi}{4} \cdot \frac{2}{\sqrt{3}} \tan^{-1} \frac{2t}{\sqrt{3}} \tan^{-1} \frac{2t}{\sqrt{3}} \Big|_0^{\infty} \quad 1$$

$$I = \frac{\pi}{2\sqrt{3}} \cdot \frac{\pi}{2} = \frac{\pi^2}{4\sqrt{3}} \quad 1$$

20. Let the required vector be $\vec{a} = x\hat{i} + y\hat{j} + z\hat{k}$

$$\therefore \vec{a} \cdot (\hat{i} - 3\hat{k}) = 0 \Rightarrow x - 3z = 0 \quad \text{--(i)} \quad 1$$

$$\vec{a} \cdot (\hat{i} - 2\hat{k}) = 5 \Rightarrow x - 2z = 5 \quad \text{--(ii)} \quad \frac{1}{2}$$

$$\vec{a} \cdot (\hat{i} + \hat{j} + 4\hat{k}) = 8 \Rightarrow x + y + 4z = 8 \quad \text{--(iii)} \quad \frac{1}{2}$$

solving (i) and (ii) to get $x=15, z=5$ 1

Putting in (iii) to get $y = -27$ 1/2

$$\vec{a} = 15\hat{i} - 27\hat{j} + 5\hat{k} \quad \frac{1}{2}$$

21. Here $\vec{a} = \hat{i} + 2\hat{j} + \hat{k}$ and $\vec{n} = (2-1)\hat{i} + (3-4)\hat{j} + (5-2)\hat{k}$

$$= \hat{i} - \hat{j} + 3\hat{k} \quad 1$$

$$\therefore \text{equation of plane is } \vec{r} \cdot (\hat{i} - \hat{j} + 3\hat{k}) = (\hat{i} + 2\hat{j} + \hat{k}) \cdot (\hat{i} - \hat{j} + 3\hat{k}) = 2 \quad 1+1$$

$$\text{or } x - y + 3z - 2 = 0$$

$$\text{Distance from origin} = \frac{2}{\sqrt{1+1+9}} = \frac{2}{\sqrt{11}} \text{ or } \frac{2\sqrt{11}}{11} \text{ units}$$

1

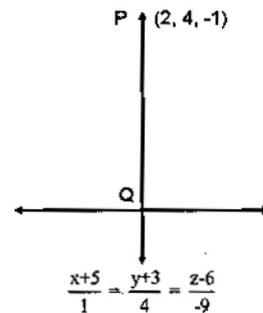
OR

Any point on the given line is, $(\lambda - 5, 4\lambda - 3, -9\lambda + 6)$ for some value of λ , this point is Q, such that PQ is \perp to the line

$$\Rightarrow (\lambda - 7)1 + (4\lambda - 7)4 + (-9\lambda + 7)(-9) = 0 \Rightarrow \lambda = 1$$

\therefore Q is $(-4, 1, -3)$ and equation of line PQ is

$$\frac{x-2}{6} = \frac{y-4}{3} = \frac{z+1}{2}$$



1

1½

1

22. Getting P(odd number) = $\frac{1}{3}$, P(even number) = $\frac{2}{3}$

½

Let X be the random variable "getting an even number"

$$\therefore X \quad 0 \quad 1 \quad 2 \quad 3$$

½

$$P(X) \quad \frac{1}{27} \quad \frac{6}{27} \quad \frac{12}{27} \quad \frac{8}{27}$$

1½

$$X \cdot P(X) \quad 0 \quad \frac{6}{27} \quad \frac{24}{27} \quad \frac{24}{27}$$

½

$$\text{Mean} = \sum XP(X) = \frac{54}{27} = 2$$

1

23. Given equation can be written as

$$\begin{pmatrix} 1 & -1 & 1 \\ 2 & 1 & -3 \\ 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} \frac{1}{x} \\ \frac{1}{y} \\ \frac{1}{z} \end{pmatrix} = \begin{pmatrix} 4 \\ 0 \\ 2 \end{pmatrix} \text{ or } A \cdot X = B$$

½

$$|A| = 1(4) + 1(5) + 1(1) = 10 \neq 0 \therefore X = A^{-1} \cdot B$$

1

cofactors are :

$$A_{11}=4, A_{12}=-5, A_{13}=1$$

$$A_{21}=2, A_{22}=0, A_{23}=-2$$

$$A_{31}=2, A_{32}=5, A_{33}=3$$

2

$$\therefore A^{-1} = \frac{1}{10} \begin{pmatrix} 4 & 2 & 2 \\ -5 & 0 & 5 \\ 1 & 2 & 3 \end{pmatrix}$$

1

$$\begin{pmatrix} 1/x \\ 1/y \\ 1/z \end{pmatrix} = \frac{1}{10} \begin{pmatrix} 4 & 2 & 2 \\ -5 & 0 & 5 \\ 1 & -2 & 3 \end{pmatrix} \begin{pmatrix} 4 \\ 0 \\ 2 \end{pmatrix} = \begin{pmatrix} 2 \\ -1 \\ 1 \end{pmatrix}$$

1

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

1/2

24. Let the radius of inscribed cylinder be x and its height be y

$$\therefore \text{Volume (v)} = \pi x^2 y$$

$$= \pi (h-y)^2 \tan^2 \alpha \cdot y$$

$$= \pi \tan^2 \alpha [h^2 y - 2hy^2 + y^3]$$

$$\frac{dv}{dy} = \pi \tan^2 \alpha [h^2 - 4hy + 3y^2]$$

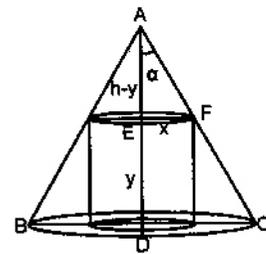
$$\frac{dv}{dy} = 0 \Rightarrow 3y^2 - 4hy + h^2 = 0 \text{ or } 3(y-h)(3y-h) = 0 \Rightarrow y=h, y=h/3$$

1/2

1

1

1 1/2



since $y=h$ is not possible $\therefore y=h/3$ is the only point

$$\frac{d^2v}{dy^2} = 6y - 4h = 6\left(\frac{h}{3}\right) - 4h = -2h < 0 \therefore y = \frac{h}{3} \text{ is a maxima}$$

1

$$= \frac{4}{27} \pi h^3 \tan^2 \alpha$$

OR

$$\frac{dx}{d\theta} = -a \sin \theta + a \sin \theta + a \theta \cos \theta = a \theta \cos \theta$$

1

$$\frac{dy}{d\theta} = a \cos \theta - a \cos \theta + a \theta \sin \theta = a \theta \sin \theta$$

1

$$\Rightarrow \frac{dy}{dx} = \tan\theta \therefore \text{slope of normal} = -\cot\theta \quad 1$$

\therefore Equation of normal is

$$y - a(\sin\theta - \theta \cos\theta) = -\frac{\cos\theta}{\sin\theta} [x - a(\cos\theta + \theta \sin\theta)] \quad 1$$

Simplifying to get $x \cos\theta + y \sin\theta - a = 0$

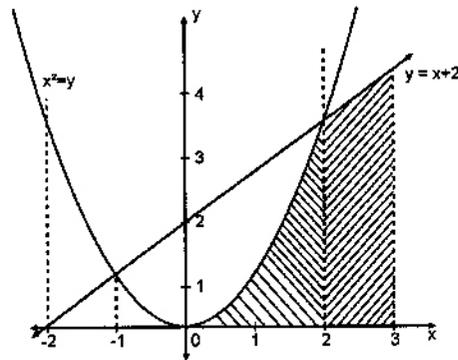
$$\text{Length of perpendicular from origin} = \frac{|a|}{\sqrt{\sin^2\theta + \cos^2\theta}} = |a| \quad (\text{constant}) \quad 1$$

25. For correct figure getting points of intersection as $x=-1, x=2$ 1/2

$$\text{Required area} = \int_0^2 x^2 dx + \int_2^3 (x+2) dx$$

$$\left[\frac{x^3}{3} \right]_0^2 + \left[\frac{(x+2)^2}{2} \right]_2^3$$

$$\frac{8}{3} + \frac{25}{2} - 8 = \frac{43}{6} \text{ sq.U}$$



2

1 1/2

1

26. Given differential equation can be written as

$$\left(xy \frac{dy}{dx} - y^2 \right) \sin\left(\frac{y}{x}\right) = \left(xy + x^2 \frac{dy}{dx} \right) \cos\left(\frac{y}{x}\right) \quad \text{--(i)} \quad 1/2$$

$$\text{Putting } \frac{y}{x} = v \text{ or } y = vx \text{ gives } \frac{dy}{dx} = v + x \frac{dv}{dx} \quad 1$$

$$\therefore \text{(i) becomes } v \sin v \left(v + x \frac{dv}{dx} \right) - v^2 \sin v = v \cos v + \left(v + x \frac{dv}{dx} \right) \cos v \quad 1$$

$$\Rightarrow (vx \sin v - x \cos v) \frac{dv}{dx} = 2v \cos v$$

$$\Rightarrow -\int \frac{v \sin v - \cos v}{v \cos v} dv = -\int \frac{2}{x} dx \Rightarrow \log|v \cos v| = -2 \log x + \log c \quad 1+1$$

$$\Rightarrow x^2 \cdot v \cdot \cos v = c \Rightarrow xy \cos \frac{y}{x} = c \quad 1/2$$

$$x=3, y=\pi \text{ gives } c = \frac{3\pi}{2} \quad 1/2$$

\Rightarrow solution is $2xy \cos y/x = 3\pi$

1/2

27. Let the given point be A (1, 1, 1) and the point on the line is P(-3, 1, 5)

$\therefore \overline{AP} = -4\hat{i} + 4\hat{k}$

1

\therefore The vector \perp to the plane is

$(-4\hat{i} + 4\hat{k}) \times (3\hat{i} - \hat{j} - 5\hat{k}) = 4\hat{i} - 8\hat{j} + 4\hat{k}$ or $\hat{i} - 2\hat{j} + \hat{k}$

1 1/2

\therefore Equation of plane is

$\vec{r} \cdot (\hat{i} - 2\hat{j} + \hat{k}) = (\hat{i} + \hat{j} + \hat{k}) \cdot (\hat{i} - 2\hat{j} + \hat{k}) = 0$ --(i)

1 1/2

or $x - 2y + z = 0$

Now, since $(\hat{i} - 2\hat{j} - 5\hat{k}) \cdot (\hat{i} - 2\hat{j} + \hat{k}) = 1 + 4 - 5 = 0$

\therefore The line $\vec{r} = (-\hat{i} + 2\hat{j} + 5\hat{k}) + \lambda(\hat{i} - 2\hat{j} - 5\hat{k})$ is parallel to the plane

1

Also, the point (-1, 2, 5) satisfies the equation of plane

as $(-1 - 4 + 5) = 0 \Rightarrow$ point lines on plane

1

hence the plane contains the line.

28. Let x be the number of units of A and y of B, which are produced

\therefore LPP is Maximise $z = 20x + 15y$

1

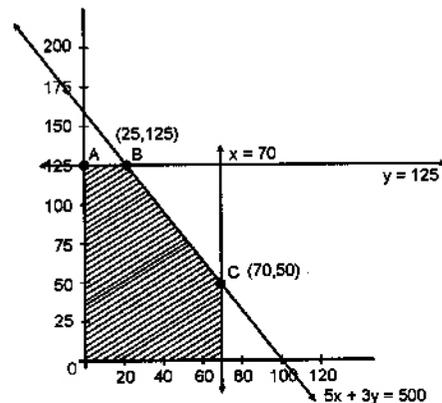
Subject to $5x + 3y \leq 500$

$x \leq 70$

$y \leq 125$

$x \geq 0, y \geq 0$

1 1/2



2

Getting vertices of feasible region as :

A(0, 125), B(25, 125), C(70, 50), D(70, 0)

1/2

Maximum Profit = Rs. 2375 at B

\therefore Number of Units of A = 25

1

Number of Units of B = 125

29. Let the events are defined as :

E_1 : 2 white balls are transferred from A to B

E_2 : 2 black balls are transferred

E_3 : 1 white and 1 black ball is transferred

1

A : 1 black ball is drawn from B

$$P(E_1) = \frac{4c_2}{7c_2} = \frac{4.3}{7.6} = \frac{2}{7}, P(E_2) = \frac{3c_2}{7c_2} = \frac{3.2}{7.6} = \frac{1}{7}, P(E_3) = \frac{4c_1 \cdot 3c_1}{7c_2} = \frac{4}{7} \quad 1\frac{1}{2}$$

$$P(A/E_1) = \frac{2}{6} = \frac{1}{3}, P(A/E_2) = \frac{4}{6} = \frac{2}{3}, P(A/E_3) = \frac{3}{6} = \frac{1}{2} \quad 1\frac{1}{2}$$

$$P(E_3/A) = \frac{P(E_3) \cdot P(A/E_3)}{P(E_1) P(A/E_1) + P(E_2) P(A/E_2) + P(E_3) P(A/E_3)} \quad \frac{1}{2}$$

$$= \frac{\frac{4}{7} \times \frac{1}{2}}{\frac{2}{7} \cdot \frac{1}{2} + \frac{1}{7} \cdot \frac{2}{3} + \frac{4}{7} \cdot \frac{1}{2}} \quad \frac{1}{2}$$

$$= \frac{3}{5} \quad 1$$

OR

$$P(\text{answer is true}) = \frac{1}{2}$$

$$P(\text{answer is false}) = \frac{1}{2} \quad 1$$

$$P(\text{at most 7 correct}) = 1 - \{P(8) + P(9) + P(10)\} \quad 2$$

(where P(8) etc means probability of 8 correct answers)

$$= 1 - \left\{ {}^{10}C_8 \left(\frac{1}{2}\right)^8 \cdot \left(\frac{1}{2}\right)^2 + {}^{10}C_9 \left(\frac{1}{2}\right)^9 \left(\frac{1}{2}\right) + {}^{10}C_{10} \left(\frac{1}{2}\right)^{10} \right\} \quad 1$$

$$= 1 - \left\{ {}^{10}C_2 + {}^{10}C_1 + {}^{10}C_0 \right\} \left(\frac{1}{2}\right)^{10} \quad 1$$

$$= 1 - \{45 + 10 + 1\} \frac{1}{1024}$$

$$= 1 - \frac{56}{1024} = 1 - \frac{7}{128} = \frac{121}{128} \quad 1$$