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RAJASTHAN BOARD OF SECONDARY EDUCATION

2023

CLASS XII

Questions & Solutions

Date: 31 March 2023 | TIME : (08:30 a.m. to 11:45 a.m)

Duration: 3 hr 15 min.| Max. Marks: 80

SUBJECT: MATHEMATICS

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SS-15-Mathematics

Roll No. | | | | | | | |

SENIOR SECONDARY EXAMINATION, 2023
MATHEMATICS

Time allowed : 3 hr, 15 Min. **Maximum Marks : 80**

GENERAL INSTRUCTIONS TO THE EXAMINEES:

1. Candidate 'must write first his / her Roll No. on the question paper compulsorily.
2. All the questions are compulsory.
3. Write the answer to each question in the given answer-book only.
4. For questions having more than one part, the answers to those parts are to be written together in continuity.
5. If there is any error / difference / contradiction in Hindi & English version of the question paper, the question of Hindi version should be treated valid.
6. Write down the serial number of the question before attempting it.
7. Question No. 17 to 23 having internal choice.
8. Solve Question number 23 on graph paper.

SECTION – A

(1) **Multiple Choice Questions:**

(i) If $f : R \to R, f(x) = \sin x$ and $g : R \to R$, $g(x) = X^2$ then $(f \circ g)(x)$ is equal to **[1]**

(1) $\sin x^2$ (2) $\sin x$ (3) $\sin^2 x^2$ (4) $\sin^2 x$

Sol. $fog(x) = f[g(x)]$
$= f[x^2] = \sin x^2$

(ii) If the order of a matrix is m x n, then the number of elements in it are, - **[1]**

(1) m (2) n (3) mn (4) m–n

Sol. (3)

(iii) If $y = x \cdot \log_e x$, then the value of $\frac{d^2y}{dx^2}$ will be **[1]**

(1) $\frac{1}{1+x}$ (2) $\frac{1}{x}$ (3) $\log_e(1+x)$ (4) $1+\log_e x$

Sol. $y = x \log x$

$\frac{dy}{dx} = x \times \frac{1}{x} + \log x \times 1$

$\frac{d^2y}{dx^2} = \frac{1}{x}$

(iv) The anti-derivative of $\left(\sqrt{x} + \frac{1}{\sqrt{x}}\right)$ with respect to x **[1]**

(1) $\frac{1}{3}x^{\frac{1}{3}} + 2x^{\frac{1}{2}} + C$ (2) $\frac{2}{3}x^{\frac{2}{3}} + \frac{1}{2}x^2 + C$

(3) $\frac{2}{3}x^{\frac{3}{2}} + 2x^{\frac{1}{2}} + C$ (4) $\frac{3}{2}x^{\frac{3}{2}} + \frac{1}{2}x^{\frac{1}{2}} + C$

Sol. $\int \left(\sqrt{x} + \frac{1}{\sqrt{x}}\right) dx$

$= \frac{x^{3/2}}{3/2} + \frac{x^{1/2}}{1/2} + C$

$= \frac{2}{3}x^{3/2} + 2x^{1/2} + C$

(v) The value of $\int \cos^2 x\,dx$ is **[1]**

(1) $\frac{x}{2}+\frac{1}{4}\sin 2x+C$ (2) $x^2+\frac{1}{4}\sin 2x+C$

(3) $\frac{x}{4}+\frac{1}{2}\sin x+C$ (4) $\frac{x^2}{4}+\frac{1}{2}\sin^2 x+C$

Sol. $\int \cos^2 x\,dx$

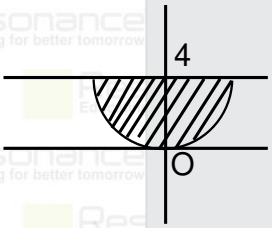
$= \int \frac{1+\cos 2x}{2}dx$

$= \frac{1}{2}x+\frac{1}{4}\sin 2x+C$

(vi) The area of the region bounded by the curve $y = x^2$ and the line $y = 4$ is **[1]**

(1) $\frac{33}{2}$ (2) $\frac{8}{3}$ (3) $\frac{32}{3}$ (4) $\frac{4}{3}$

Sol.



$2\int_0^4 x\,dy$

$= 2\int_0^4 \sqrt{y}\,dy$

$= 2\times \frac{2}{3}\left[(4)^{3/2}-0\right]$

$= \frac{4}{3}\times 8$

$\Rightarrow \frac{32}{3}$

(vii) The value of $\hat{i}.(\hat{j}\times\hat{k})+\hat{j}.(\hat{i}\times\hat{k})+\hat{k}.(\hat{i}\times\hat{j})$ is - **[1]**

(1) 0 (2) –1 (3) 1 (4) 3

Sol. $\hat{i}.(\hat{j}\times\hat{k})+\hat{j}.(\hat{i}\times\hat{k})+\hat{k}.(\hat{i}\times\hat{j})$

$\Rightarrow \hat{i}.\hat{i}+\hat{j}.-\hat{j}+\hat{k}.\hat{k}$

$\Rightarrow 1$

(viii) If the magnitude of two vectors $\vec{a}$ and $\vec{b}$ are $\sqrt{3}$ and 2 respectively and $\vec{a}.\vec{b} = \sqrt{6}$, then the angle between $\vec{a}$ and $\vec{b}$ is **[1]**

(1) $\frac{\pi}{2}$ (2) $\frac{\pi}{3}$ (3) $\frac{\pi}{6}$ (4) $\frac{\pi}{4}$

Sol. $|\vec{a}| = \sqrt{3}$; $|\vec{b}| = 2$

$= \vec{a}.\vec{b} = \sqrt{6}$

$=|\vec{a}||\vec{b}|\cos\theta = \sqrt{6}$

$= \cos\theta = \frac{\sqrt{6}}{\sqrt{3}\times 2} \Rightarrow \frac{1}{\sqrt{2}}$

$\theta = \frac{\pi}{4}$

(ix) The equation of the plane with intercepts of 2, 3 and 4 on the x, y and z-axes respectively is – **[1]**

(1) 4x + 6y + 3z = 12 (2) 6x + 4y + 3z = 12

(3) 3x + 4y + 6z = 12 (4) 5x + 4y + 3z = 12

Sol. $\frac{x}{2}+\frac{y}{3}+\frac{z}{4}=1$

$\Rightarrow 6x + 4y + 3z = 12$

(x) If $P(A) = \frac{7}{13}$, $P(B) = \frac{9}{13}$ and $P(A \cap B) = \frac{4}{13}$, then the value of $P(A/B)$ is – **[1]**

(1) $\frac{4}{9}$ (2) $\frac{7}{9}$ (3) $\frac{5}{9}$ (4) $\frac{5}{13}$

Sol. $P(A/B) = \frac{P(A \cap B)}{P(B)}$

$= \frac{4/13}{9/13} = \frac{4}{9}$

(xi) If a pair of dice is thrown, then the probability of getting an even prime number on each die is - **[1]**

(1) 0 (2) $\frac{1}{3}$ (3) $\frac{1}{12}$ (4) $\frac{1}{36}$

Sol. (D) $\frac{1}{36}$

(xii) If a coin is tossed three times, where E: head on third toss; F: heads on first two tosses, then the value of P(E/F) is - **[1]**

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

Sol. S = {HHH, HHT, HTH, HTT,THH,THT,TTH,TTT}

E = {HHH, HTH, THH, TTH}

$F = \{HHH, HHT\} = P(F) = \frac{2}{8} = \frac{1}{4}$

$P(E/F) = \frac{P(E \cap F)}{P(F)}$ $P(E \cap F) = \{1\} = \frac{1}{8}$

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

2. Fill in the blanks:

(i) If $x\begin{bmatrix}2\\3\end{bmatrix} + y\begin{bmatrix}-1\\1\end{bmatrix} = \begin{bmatrix}10\\5\end{bmatrix}$, then (x +y) = _____. **[1]**

Sol. $\begin{bmatrix}2x\\3x\end{bmatrix} + \begin{bmatrix}-y\\y\end{bmatrix} = \begin{bmatrix}10\\5\end{bmatrix}$

$2x - y = 10$

$3x + y = 5$

$5x = 15$

$x = 3$; $y = -4$

$\therefore x + y = 3 - 4 = -1$

(ii) The derivative of $\cos\left(\sqrt{x}\right)$ with respect to x is _____. **[1]**

Sol. $\frac{d}{dx}\cos\sqrt{x} = -\sin\sqrt{x} \times \frac{1}{2\sqrt{x}}$

(iii) The slope of the tangent line at x = 4 to the curvey $y = 3x^4 - 4x$ will be _____. **[1]**

Sol. $y = 3x^4 - 4x$

slope $\frac{dy}{dx} = 12x^3 - 4$

slope at point x = 4

$\left(\frac{dy}{dx}\right)x = 4$

$= 12 \times (4)^3 - 4$

$= 12 \times 64 - 4$

$= 768 - 4$

$\Rightarrow 764$

(iv) The value of $\int x^2\left(1 - \frac{1}{x^2}\right)dx$ will be _____. **[1]**

Sol. $\int x^2(1 - \frac{1}{x^2})dx$

$\int \left(x^2 - 1\right)dx$

$\int x^2dx - \int 1\,dx \Rightarrow \frac{x^3}{3} - x + C$

(v) If the coordinates of the points A, B, C and D are then (1,2,3), (4, 5, 7), (-4, 3, -6) and (2, 9, 2) respectively, the acute angle between the lines AB and CD will be_____. **[1]**

Sol. direction ratio of
AB line $\Rightarrow$ (3, 3, 4)
direction ratio of CD line
$\Rightarrow$ (6, 6, 8)

$\because \frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2} = \frac{1}{2} \quad \therefore$ AB || CD

(vi) If a pair of two unbiased dice is thrown once, then the probability that the sum of the numbers on both the dice is 5 will be_____. **[1]**

Sol. n (s) = 36
Sum of number on both dice = 5
{14, 23, 32, 41}

$\Rightarrow \frac{1}{9}$

3. Very short answer type questions:

(i) Find the principal value of $\sin^{-1}\left(-\frac{1}{2}\right)$. **[1]**

Sol. **(i)** $\sin^{-1}\left(\frac{-1}{2}\right) = \theta$

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

$\Rightarrow -\sin\left(\frac{1}{2}\right)$

$\Rightarrow \frac{-\pi}{6} \in \left[\frac{-\pi}{2}, \frac{\pi}{2}\right]$

(ii) Find the values of x and y from the following equation: **[1]**

$$2\begin{bmatrix} x & 5 \\ 7 & y-3 \end{bmatrix} + \begin{bmatrix} 3 & -4 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 7 & 6 \\ 15 & 14 \end{bmatrix}$$

Sol. $$2\begin{bmatrix} x & 5 \\ 7 & y-3 \end{bmatrix} + \begin{bmatrix} 3 & -4 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 7 & 6 \\ 15 & 14 \end{bmatrix}$$

$$\begin{bmatrix} 2x & 10 \\ 14 & 2y-6 \end{bmatrix} + \begin{bmatrix} 3 & -4 \\ 1 & 2 \end{bmatrix} = \begin{bmatrix} 7 & 6 \\ 15 & 14 \end{bmatrix}$$

$\Rightarrow 2x + 3 = 7 \Rightarrow 2x = 4 \Rightarrow x = 2$
$2y - 4 = 14 \Rightarrow 2y = 18 \Rightarrow y = 9$
$x = 2$ and $y = 9$

(iii) Evaluate $\begin{vmatrix} 102 & 18 & 36 \\ 1 & 3 & 4 \\ 17 & 3 & 6 \end{vmatrix}$ **[1]**

Sol. $\begin{vmatrix} 102 & 18 & 36 \\ 1 & 3 & 4 \\ 17 & 3 & 6 \end{vmatrix}$

$\begin{vmatrix} 6\times17 & 6\times3 & 6\times6 \\ 1 & 3 & 4 \\ 17 & 3 & 6 \end{vmatrix} \Rightarrow 6 \begin{vmatrix} 17 & 3 & 6 \\ 1 & 3 & 4 \\ 17 & 3 & 6 \end{vmatrix}$

$= 0$

(iv) Examine the continuity of the function $f(x) = 2x^2 - 1$ at $x = 3$ **[1]**

Sol. $f(x) = 2x^2 - 1$ at $x = 3$

$\lim\limits_{x+3} (2x^2 - 1) = f(3)$

L.H.L.

$\lim\limits_{h\to0} f(3 - h)$

$\lim\limits_{h\to0} 2[3-h]^2 - 1 = 17$

R.H.L.

$\lim\limits_{h\to0} f(3 + h)$

$\lim\limits_{h\to0} 2[3+h]^2 - 1$

$\Rightarrow 17$

at point $x = 3$ $f(3) = 2 \times 9 - 1$

$= 17$

$\therefore$ L.H.L. = R.H.L = $f(3) = 17$

(v) The total revenue in Rupees received from the sale of x units of a product is given by $R(x) = 13x^2 + 26x + 15$. Find the marginal revenue, when $x = 7$ **[1]**

Sol. $R(x) = 13x^2 + 26x + 15$

$\frac{d}{dx} R(x) = 26x + 26$

$\therefore$ marginal revenue at $x = 7$

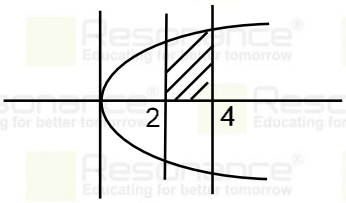
$= 26 \times 7 + 26$

$= 182 + 26$

$\Rightarrow 208$

(vi) Find the area of the region bounded by $y^2 = 9x$; $x = 2$, $x = 4$ and the x-axis in the first quadrant. **[1]**

Sol. $y^2 = 9x$; $x = 2$; $x = 4$



$x = 2 \quad x = 4$

$$\text{Area} = \int_2^4 y\,dx$$

$$\Rightarrow 3\left[\frac{x^{3/2}}{\frac{3}{2}}\right]_2^4$$

$$\Rightarrow 3\frac{2}{3}\left[(4)^{3/2} - (2)^{3/2}\right]$$

$$\Rightarrow 2\left[8 - 2\sqrt{2}\right]$$

$\Rightarrow 16 - 4\sqrt{2}$ sq. units Ans.

(vii) Find the position vector of a point R which internally divides the line joining two points P and Q whose position vectors are $\left(\hat{i} + 2\hat{j} - \hat{k}\right)$ and $\left(-\hat{i} + \hat{j} + \hat{k}\right)$ respectively in the ratio 2 : 1. **[1]**

Sol. Position vector of point R is

$$\Rightarrow \frac{\left(-\hat{i} + \hat{j} + k\right) \times 1 + \left(\hat{i} + 2\hat{j} - \hat{k}\right) \times 2}{1 + 2}$$

$$\Rightarrow \frac{-\hat{i} + \hat{j} + \hat{k} + 2\hat{i} + 4\hat{j} - 2\hat{k}}{3}$$

$$\Rightarrow \frac{\hat{i} + 5\hat{j} - \hat{k}}{3} \text{ Ans.}$$

(viii) Find the angle between the vectors $\left(\hat{i} - 2\hat{j} + 3\hat{k}\right)$ and $\left(3\hat{i} - 2\hat{j} + \hat{k}\right)$. **[1]**

Sol. $\cos\theta = \dfrac{\left(\hat{i} - 2\hat{j} + 3\hat{k}\right)\left(3\hat{i} - 2\hat{j} + \hat{k}\right)}{\sqrt{1+4+9}\sqrt{9+4+1}}$

$$\cos\theta \Rightarrow \frac{10}{14}$$

$$\theta = \cos^{-1}\left(\frac{5}{7}\right) \text{ Ans.}$$

(ix) Show that the line through the points (1, –1,2) and (3,4, – 2) is perpendicular to the line through the points (0, 3, 2) and (3, 5, 6). **[1]**

Sol. direction Ratio of
lines : (2,5, – 4)
and (3, 2, 4)
$\therefore$ if $2 \times 3 + 5 \times 2 + (-4) \times 4$
$\Rightarrow 6 + 10 - 16$
$= 0$
$\therefore$ lines are perpendicular

(x) The cartesian equation of a line is $\frac{x-5}{3} = \frac{y+4}{7} = \frac{z-6}{2}$. Write its vector form. **[1]**

Sol. $\frac{x-5}{3} = \frac{y+4}{7} = \frac{z-6}{2}$
vector forms $\Rightarrow$
$\bar{r} = \bar{a} + \lambda \bar{b}$
$\bar{r} = \left(5\hat{i} - 4\hat{j} + 6\hat{k}\right) + \lambda\left(3\hat{i} + 7\hat{j} + 2\hat{k}\right)$

(xi) Find the intercepts cut off by the plane 2x +y – z = 5 on co-ordinate axes. **[1]**

Sol. $2x + y - z = 5$
$\frac{2x}{5} + \frac{y}{5} - \frac{z}{5} = 1$
$\frac{x}{(5/2)} + \frac{y}{5} - \frac{Z}{5} = 1$

(xii) An unbiased die is thrown twice. Let the event A be 'odd number on the first throw' and B the event 'odd number on the second throw'. Check the independence of the events A and B. **[1]**

Sol. dice is thrown twice
n (s) = 36
$P(A) = \frac{18}{36} = \frac{1}{2}$ and $P(B) = \frac{1}{2}$
$P(A \cap B)$ = P(odd no. on both twice)
$\frac{9}{36} = \frac{1}{4}$
$\therefore P(A \cap B) = P(A) \times P(B)$
$\therefore$ A & B are independent event

SECTION – B

Short answer type questions:

4. If f (x) $\frac{(4x+3)}{(6x-4)}, x \neq \frac{2}{3}$, show that $(f \circ f)(x) = x$ for all $x \neq \frac{2}{3}$. **[2]**

Sol. $f(x) = \frac{4x+3}{6x-4}$

LHS fof(x) = $f\left[f(x)\right]$

$= f\left[\frac{4x+3}{6x-4}\right]$

$\Rightarrow \frac{16x+12+18x-12}{24x+18-24x+16}$

$\Rightarrow \frac{34x}{34} = x$

$\therefore$ LHS = RHS = x

5. If $A = \begin{bmatrix} \sin\alpha & \cos\alpha \\ -\cos\alpha & \sin\alpha \end{bmatrix}$, then verify that $A'A = I$. **[2]**

Sol. $A = \begin{bmatrix} \sin x & \cos x \\ -\cos x & \sin x \end{bmatrix}$

$A'A = I$

$\Rightarrow A' = \begin{bmatrix} \sin x & -\cos x \\ \cos x & \sin x \end{bmatrix}$

LHS $\therefore \begin{bmatrix} \sin x & \cos x \\ -\cos x & \sin x \end{bmatrix}\begin{bmatrix} \sin x & -\cos x \\ \cos x & \sin x \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

= I = RHS

6. Prove that $\begin{vmatrix} -a^2 & ab & ac \\ ba & -b^2 & bc \\ ca & cb & -c^2 \end{vmatrix} = 4a^2b^2c^2$ **[2]**

Sol. Using the property of determinant and without expanding , prove that:

$= abc \begin{vmatrix} -a & b & c \\ a & -b & c \\ a & b & -c \end{vmatrix}$ [Taking out factors a,b,c from R_1, R_2, R_3]

$= a^2b^2c^2 \begin{vmatrix} -1 & 1 & 1 \\ 1 & -1 & 1 \\ 1 & 1 & -1 \end{vmatrix}$ [Taking out factors a,b,c from C_1, C_2, C_3]

$= a^2b^2c^2 \begin{vmatrix} -1 & 1 & 1 \\ 0 & 0 & 2 \\ 0 & 2 & 0 \end{vmatrix}$ [$R_2 \to R_2 + R_1$ and $R_3 \to R_3 + R_1$]

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

$= -a^2b^2c^2 (0 - 4)$

$= 4a^2b^2c^2$

7. Show the points A (a, b + c), B (b, c + a) and C (c, a + b) are collinear. **[2]**

Sol. Show the points A (a, b +c), B (b, c + a), C (c, a + b) are collinear

Solution :

The area of the triangle with vertices A (a, b +c), B (b, c + a), C (c, a + b) is given by the absolute value of the relation.

$$\Delta = \frac{1}{2}\begin{vmatrix} a & b+c & 1 \\ b & c+a & 1 \\ c & a+b & 1 \end{vmatrix}$$

$$= \frac{1}{2}\begin{vmatrix} a & b+c & 1 \\ b-c & a-b & 0 \\ c-a & a-c & 0 \end{vmatrix} \qquad [R_2 \to R_2 - R_1 \text{ and } R_3 \to R_3 - R_1]$$

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

$$= \frac{1}{2}(a-b)(c-a)\begin{vmatrix} a & b+c & 1 \\ -1 & 1 & 0 \\ 0 & 0 & 0 \end{vmatrix} \qquad [R_3 \to R_3 + R_2]$$

$= 0$

Thus, the area of the triangle formed by points is zero

Hence, the points are collinear.

8. Prove that the function f given by $f(x) = \begin{cases} x^2+3 & \text{if } x \neq 0 \\ 1, & \text{if } x = 0 \end{cases}$ is not continuous at x = 0. **[2]**

Sol. $f(x) \begin{cases} x^2+3 & ; \ x \neq 0 \\ 1 & ; \ x = 0 \end{cases}$

LHL (x < 0)

$$\Rightarrow \lim_{h \to 0} f(0-h)$$

$$\Rightarrow \lim_{h \to 0} (0-h)^2 + 3 \Rightarrow 3$$

RHL (x > 0)

$$\Rightarrow \lim_{h \to 0} (0+h)^2 + 3 = 3$$

at point x = 0 $\quad f(0) = 1$

$\because$ LHL = RHL $\neq f(0)$

$\therefore f(x)$ is not continious at x = 0

9. Find the intervals in which the function f given by $f(x) = X^2 - 4x + 6$ is **[2]**

(i) Increasing

(ii) Decreasing

Sol. $f(x) = x^2 - 4x + 6$

$f'(x) = 2x - 4$

(i) for Increasing $f'(x) > 0$

$2x - 4 > 0$

$x > 2$; $x \in (2, \infty) \uparrow$

(iii) for Decreasing $f'(x) < 0$

$x < 2$; $x \in (-\infty, 2) \downarrow$

10. Find the approximate change in the volume of a cube of side x meters caused by increasing the side by 2%. **[2]**

Sol. Volume of cube = x^3

Approximate volume $= \Delta v = \frac{dv}{dx} \times \Delta x$

$\Delta v = 3x^2 \times \Delta x$

$\therefore \Delta v = 3x^2 \times 0.02x$

$\Delta v = 0.06x^3$ Ans.

11. Evaluate $\int \frac{\sec^2 x}{\sqrt{\tan^2 x + 4}} dx$. **[2]**

Sol. We have $I = \int \frac{\sec^2 x}{\sqrt{\tan^2 x + 4}} dx$

substitute $u = \frac{\tan(x)}{2} = \frac{du}{dx} = \frac{\sec^2(x)}{2} = dx = \frac{2}{\sec^2(x)} du$

$\Rightarrow I = \int \frac{2}{\sqrt{4u^2 + 4}}$

$\Rightarrow I = \int \frac{1}{u^2 + 1}$

$\Rightarrow I = \ln\left|u + \sqrt{u^2 + 1}\right| + c \left[\because \int \frac{du}{\sqrt{u^2 + 1}} = \ln\left|u + \sqrt{u^2 + 1} + c\right|\right]$

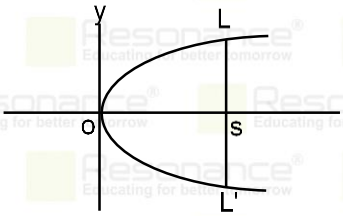
$\Rightarrow I = \ln\left|\frac{\tan x}{2} + \sqrt{\left(\frac{\tan x}{2}\right)^2 + 1}\right| + c$

$\Rightarrow I = \ln\left|\frac{\tan x}{2} + \frac{\sqrt{\tan^2 + 4}}{2}\right| + c$

12. Find the area of the region bounded by the parabola $y^2 = 4ax$ and its latus rectum. **[2]**

Sol. The equation of parabola is

$y^2 = 4ax$



Let 0 be the vertex

s be the focus

L.L' be the Latus Rectum of Parabola

The equation of Latus Rectum is $X = a$ also we know that parabola is symmetric about x axis

Required Area = 2 (Area of OSL)

$$= 2\int_0^a y\,dx$$

$$= 2\int_0^a 2\sqrt{a}\sqrt{x}\,dx`$$

$$= 4\sqrt{a}\int_0^a x^{1/2}\,dx$$

$$= 4\sqrt{a}\left[\frac{x^{3/2}}{\frac{3}{2}}\right]_0^a$$

$$= 4\sqrt{a}\frac{2}{3}\left[x^{3/2}\right]_0^a$$

$$= \frac{8\sqrt{a}}{3}\left[a^{3/2} - 0\right]$$

$$= \frac{8\sqrt{a}}{3}a^{3/2} = \frac{8}{3}a^2 \text{ sq. units}$$

13. Form the differential equation of the family of circles touching the y-axis at origin. **[2]**

Sol. Circles touching y – axis at origin will have centres on x axis. Le t (a,0) be the centre of a circle Then radius of the circle should be a unit, since circle Should touch y axis at origin.

Eq of circle with central at (a , 0) and radius a .

$(x-a)^2 + (y-0)^2 = a^2$

$x^2 + y^2 - 2ax = o$ …….. (1)

This above Eq. represents the family of circles touching y - axis at origin. to find the differential Eq, of system of circles touching y-axis at origin,

Eliminate the arbitrag constant "a" from Eq.

Differentiating Eq. (1) w.r.to x.

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

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

but the value of 2a in Eq…….. (1)

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

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

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

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

14. For given vectors $\vec{a} = 2\hat{i} - \hat{j} + 2\hat{k}$ and $\vec{b} = -\hat{i} + \hat{j} - \hat{k}$, find the unit vector in the direction of the vector $\vec{a} + \vec{b}$. **[2]**

Sol. $\vec{a} = 2i - j + 2\hat{k}$ $\vec{b} = -i - j + k$

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

$\vec{a} + \vec{b} = \hat{i} + \hat{k}$

Let. $(\vec{a} + \vec{b}) = \vec{p}$

$\hat{P} = \frac{\vec{p}}{|\vec{p}|}$

$|\vec{P}| = |\vec{a} + \vec{b}| = \sqrt{1^2 + 1^2} = \sqrt{2}$

$|\vec{p}| = \sqrt{2}$

$\hat{P} = \frac{\hat{i} + \hat{k}}{\sqrt{2}}$

$\hat{P} = \frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{k}$

15. Find the angle between the planes whose vector equations are $\vec{r}.(2\hat{i}+2\hat{j}-3\hat{k})=5$ and $\vec{r}.(3\hat{i}-3\hat{j}+5\hat{k})=3$ **[2]**

Sol. $\vec{r}.(2\hat{i}+2j-3\hat{k})=5$

$\vec{r}.(3\hat{i}-3j+5k)=3$

angle betⁿ two planes $\cos\theta=\left|\frac{\vec{n}_1.\vec{n}_2}{\|\vec{n}_1\|\|\vec{n}_2\|}\right|$

$\cos\theta=\left|\frac{6-6-15}{\sqrt{17}\times\sqrt{43}}\right|$

$\cos\theta=\frac{15}{\sqrt{17}\sqrt{43}} \Rightarrow \theta=\cos^{-1}\left(\frac{15}{\sqrt{17}\sqrt{43}}\right)$

Ans. $\theta=\cos^{-1}\frac{15}{\sqrt{731}}$

16. If a fair coin is tossed 10 times, find the probability of exactly six heads. **[2]**

Sol. A fair coin is tossed 10 times

Let x : denote the number of heads appearing .

The repeated tosses of a coin are Bernoulli trials .

So, $P(X=x) = {}^nC_x\, p^x\, q^{n-x}$, x = 0, 1,2.....x

probability of exactly six heads = p (x = 6)

$$= {}^{10}C_6\ p^6\, q^{10-6}$$

$$= {}^{10}C_6\left(\frac{1}{2}\right)^6\left(\frac{1}{2}\right)^4\left[\because p=\frac{1}{2}\right]$$

$$= \frac{10!}{6!\times4!}\left(\frac{1}{2}\right)^{10}$$

$$= \frac{10\times9\times8\times7}{4\times3\times2}\times\left(\frac{1}{2}\right)^{10}$$

$$= \frac{105}{512}$$

SECTION – C

17. If $\sin\left(\sin^{-1}\frac{1}{5}+\cos^{-1}x\right)=1$, then find the value of x. **[3]**

OR

Show that $\sin^{-1}\frac{3}{5}-\sin^{-1}\frac{8}{17}=\cos^{-1}\frac{84}{85}$. **[3]**

Sol. $\sin\left(\sin^{-1}\frac{1}{5}+\cos^{-1}x\right)=1$

$\sin^{-1}\frac{1}{5}\pm\cos^{-1}x=\sin^{-1}(1)$

$\sin^{-1}\frac{1}{5}+\cos^{-1}=\frac{\pi}{2}$ $\quad\therefore \sin^{-1}x+\cos^{-1}x=\frac{\pi}{2}$

$\sin^{-1}\frac{1}{5}=\frac{\pi}{2}-\cos^{-1}x$

$\sin^{-1}\frac{1}{5}=\sin^{-1}x$ $\quad\therefore \sin^{-1}x+\cos^{-1}x=\frac{\pi}{2}$

compare on both side $\quad \sin^{-1}x=\frac{\pi}{2}-\cos^{-1}x$

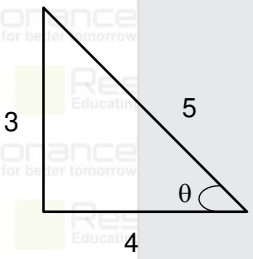
$\frac{1}{5}=x$

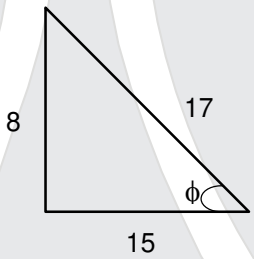
OR

17. $\text{Sin}^{-1}\frac{3}{5}-\text{Sin}^{-1}\frac{8}{17}=\text{Cos}^{-1}\frac{84}{85}$

$\text{Sin}^{-1}\frac{3}{4}=\theta$ $\qquad \text{Sin}^{-1}\frac{8}{17}=\phi$

$\frac{3}{5}=\text{Sin}\theta$ $\qquad \frac{8}{17}=\text{Sin}\phi$





$\tan\theta=\frac{3}{4}$ $\qquad \tan\phi=\frac{8}{15}$

$\theta=\tan^{-1}\frac{3}{4}$ $\qquad \phi=\tan^{-1}\frac{8}{15}$

L.H.S $\quad \tan^{-1}\frac{3}{4}-\tan^{-1}\frac{8}{15}$

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

$\tan^{-1}\frac{3}{4}-\tan^{-1}\frac{8}{15}$

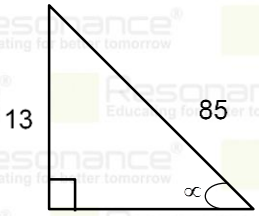
$\tan^{-1}\left(\frac{\frac{3}{4}-\frac{8}{15}}{1+\frac{3}{4}\times\frac{8}{15}}\right)$

$\tan^{-1}\left(\frac{45-32}{60}\right)$

$\tan^{-1}\left(\frac{13}{84}\right)$ $\quad\ldots\ldots$ (1)

Now $\quad$ RHS $\quad \cos^{-1}\frac{84}{85}=\propto$

$\cos \propto = \frac{84}{85}$



$\tan \propto = \frac{13}{84}$

$\propto = \tan^{-1} \frac{13}{84} = \cos^{-1} \frac{84}{85}$ .....(2)

LHS = RHS

18. Differentiate $(\log x)^{\cos x}$ with respect to x. **[3]**

Sol. Let $y = (\log x)^{\cos x}$ .....(i)

taking log on both sides, we get

log y = cos x log (log x)

Differentiating both sides, we get

$$\frac{d}{dx}(\log y) = \frac{d}{dx}[\cos x \log(\log x)]$$

$$\frac{1}{y}\frac{dy}{dx} = \cos x \frac{d}{dx}(\log(\log x)) + \log(\log x)\frac{d}{dx}(\cos x) \quad \left[\because \frac{d}{dx}(u.v) = u\frac{dv}{dx} + v\frac{du}{dx}\right]$$

$$\Rightarrow \frac{1}{y}\frac{dy}{dx} = (\cos x) \times \frac{1}{\log x}\frac{d}{dx}(\log x) + \log(\log x)(-\sin x)$$

$$\Rightarrow \frac{dy}{dx} = y\left[\frac{\cos x}{\log x} \times \frac{1}{x} - \sin x \log(\log x)\right]$$

$$\Rightarrow \frac{dy}{dx} = (\log x)^{\cos x}\left[\frac{\cos x}{x \log x} - \sin x \log(\log x)\right] \text{ [using (i)]}$$

OR

If $y = 500e^{7x} + 600e^{-7x}$, show that $\frac{d^2y}{dx^2} = 49\ y$. **[3]**

Sol. We have $y = 500\, e^{7x} + 600\, e^{-7x}$ .....(i)

Differentiating w.r.t. 'x',

$$\frac{dy}{dx} = \frac{d}{dx}\left[500e^{7x} + 600e^{-7x}\right]$$

$$\frac{dy}{dx} = 500\left(7e^{7x}\right) + 600\left(7e^{-7x}\right)$$

$$\Rightarrow \frac{dy}{dx} = 3500e^{7x} - 4200e^{-7x}$$

Again differentiating w.r.t. 'x'

$$\frac{d^2y}{dx^2} = \frac{d}{dx}\left[3500e^{7x} - 4200e^{-7x}\right]$$

$$\frac{d^2y}{dx^2} = 3500\left(7e^{7x}\right) - 4200\left(-7e^{-7x}\right)$$

$$\frac{d^2y}{dx^2} = 49\left(500\,e^{7x} + 600\,e^{-7x}\right)$$

$$\frac{d^2y}{dx^2} = 49y \text{ [using...(i)]}$$

19. Evaluate $\int \frac{1}{\sqrt{(x-1)(x-2)}}dx$. **[3]**

Sol. We have $I = \int \frac{1}{\sqrt{(x-1)(x-2)}}dx$

Complete the square;

$$I = \int \frac{1}{\sqrt{\left(x-\frac{3}{2}\right)^2 - \frac{1}{4}}}dx$$

Substitute $u = 2x - 3 \rightarrow \frac{du}{dx} = 2 \rightarrow dx = \frac{1}{2}du$

$$I = \int \frac{1}{2\sqrt{\frac{u^2}{4} - \frac{1}{4}}}dx$$

$$I = \int \frac{1}{\sqrt{u^2-1}}dx$$

$$I = \ln\left|u + \sqrt{u^2-1}\right| + C \qquad \left[\because \int \frac{dx}{\sqrt{x^2-1}} = \ln\left|x + \sqrt{x^2-1}\right| + C\right]$$

undo substitution u = 2x–3;

$$I = \ln\left|(2x-3) + \sqrt{(2x-3)^2-1}\right| + C$$

$$I = \ln\left|(2x-3) + \sqrt{4x^2-12x+8}\right| + C$$

OR

Evaluate $\int \frac{x^2+1}{x^2-5x+6}dx$. **[3]**

Sol. We have $I = \int \frac{x^2+1}{x^2-5x+6}dx$

$$I = \int \frac{x^2-5x+6+5x-5}{x^2-5x+6}dx$$

$$I = \int\left(\frac{5x-5}{x^2-5x+6}+1\right)dx$$

$$I = \int \frac{x-1}{x^2-5x+6} + \int dx$$

Write (x-1) as $\frac{1}{2}(2x-5)+\frac{3}{2}$ and split :

$$I=5\left[\int\frac{2x-5}{2\left(x^2-5x+6\right)}dx+\int\frac{3}{2\left(x^2-5x+6\right)}dx\right]+\int dx$$

$$I=\frac{5}{2}\int\frac{2x-5}{x^2-5x+6}dx+\frac{15}{2}\int\frac{dx}{x^2-5x+6}+x$$

Now solving : $I_1=\int\frac{2x-5}{x^2-5x+6}dx$

Substitute $u=x^2-5x+6\rightarrow\frac{du}{dx}=2x-5\rightarrow dx=\frac{1}{2x-5}du$

$$\Rightarrow I_1=\int\frac{1}{u}dx\ =\ \ln|u|$$

Undo Substitution $u=\ x^2-5x+6$:

$$I_1=\ln\left|x^2-5x+6\right|$$

Now solving : $I_2=\int\frac{1}{x^2-5x+6}dx$

$$I_2=\int\frac{1}{(x-3)(x-2)}dx$$

$$I_2=\int\left(\frac{1}{x-3}-\frac{1}{x-2}\right)dx$$

$$I_2=\int\frac{dx}{x-3}-\int\frac{dx}{x-2}$$

$$I_2=\ln|x-3|-\ln|x-2|\qquad\left[\because\ln M-\ln N=\ln\left(\frac{M}{N}\right)\right]$$

Now :

$$I=\frac{5}{2}\ln\left|x^2-5x+6\right|+\frac{15}{2}\ln\left|\frac{x-3}{x-2}\right|+x+C$$

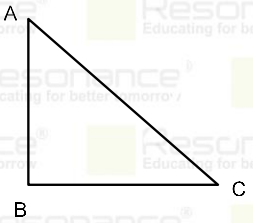
20. Show that the vectors $2\hat{i}-\hat{j}+\hat{k}$, $\hat{i}-3\hat{j}-5\hat{k}$ and $3\hat{i}-4\hat{j}-4\hat{k}$ form the vertices of a right angled triangle. **[3]**

Sol. Show that vector, $2\hat{i}-\hat{j}+\hat{k}$, $\hat{i}-3\hat{j}+5\hat{k}$ and $3\hat{i}-4\hat{j}+4\hat{k}$. form the vertices of a Right angled Triangle

Given A $\left(2\hat{i}-\hat{j}+\hat{k}\right)$

B $\left(\hat{i}-3\hat{j}+5\hat{k}\right)$

C $\left(3\hat{i}-4\hat{j}+4\hat{k}\right)$



We Know that two vectors are perpendicular to each other
If their scalar product is zero
then,

find $\overrightarrow{AB}, \overrightarrow{BC}, \overrightarrow{CA}$

$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$

$= \left(3\hat{i} - 4\hat{j} + 4\hat{k}\right) - \left(2\hat{i} - \hat{j} + \hat{k}\right)$

$\overrightarrow{AB} = -3\hat{i} - 2\hat{j} + 6\hat{k}$

$\overrightarrow{BC} = \overrightarrow{OC} - \overrightarrow{OB}$

$= \left(3\hat{i} - 4\hat{j} + 4\hat{k}\right) - \left(\hat{i} - 3\hat{j} + 5\hat{k}\right)$

$\overrightarrow{BC} = \left(2\hat{i} - \hat{j} + \hat{k}\right)$

$\overrightarrow{CA} = \overrightarrow{OA} - \overrightarrow{OC}$

$= \left(2\hat{i} - \hat{j} + \hat{k}\right) - \left(3\hat{i} - 4\hat{j} + 4\hat{k}\right) = -\hat{i} - 3\hat{j} + 5\hat{k}$

find $\overrightarrow{BC} \cdot \overrightarrow{CA}$

$= \left(2\hat{i} - \hat{j} + \hat{k}\right)\left(-\hat{i} - 3\hat{j} + 5\hat{k}\right)$

$= [2\times(-1)] - 3 + 5$

$= -2 - 3 + 5$

$= -5 + 5$

$\overrightarrow{BC} \cdot \overrightarrow{CA} = 0$

Therefor $\overrightarrow{BC}$ is Perpendicular to $\overrightarrow{CA}$

Hence ΔABC is a Right angled Triangle

OR

Find the area of a triangle having the points A (1, 1, 1), B(1, 2, 3) and C (2, 3, 1) as its vertices. **[3]**

Sol. Find the Area of a Triangle laving the Point. A(1,1,1) B (1,2,3) and C (2,3,1) as its vertices

Area of $\Delta ABC = \frac{1}{2}\left|\overrightarrow{AB} \times \overrightarrow{AC}\right|$

$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$

$= \left(\hat{i} + 2\hat{j} + 3\hat{k}\right) - \left(\hat{i} + \hat{j} + \hat{k}\right)$

$\overrightarrow{AB} = \left(0 + \hat{j} + 2\hat{k}\right)$

$\overrightarrow{AC} = \hat{i} + 2\hat{j}$

$$\overrightarrow{AB} \times \overrightarrow{AC} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 1 & 2 \\ 1 & 2 & 0 \end{vmatrix}$$

$= -4\hat{i} + 2\hat{j} - \hat{k}$

$\left|\overrightarrow{AB} \times \overrightarrow{AC}\right| = \sqrt{16 + 4 + 1} = \sqrt{21}$

Hence the area of ΔABC is $\frac{\sqrt{21}}{2}$ Square Unit

SECTION – D

21. Evaluate $\int_{-1}^{1} 5x^4\sqrt{x^5+1}\ dx$. **[4]**

Sol. $\int_{-1}^{1} 5x^4\ \sqrt{x^5+1}\,dx$

Put $x^5+1=t^2$

$5x^4 = 2t.\frac{dt}{dx}$.

$x = 1\ t = \sqrt{2}$

$x = -1\ t = 0$

$I = 2\int_{0}^{\sqrt{2}} t^2 dt$

$I = 2\left[\frac{t^3}{3}\right]_0^{\sqrt{2}}$

$I = 2\left[\frac{(\sqrt{2})^3}{2} - 0\right]$

$I = 2\left[\frac{2\sqrt{2}}{3}\right] \Rightarrow \frac{4\sqrt{2}}{3}$

OR

Evaluate $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sin^2 x\,dx$. **[4]**

Sol. $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \sin^2 x\,dx$

$f(x) = \text{Sin}^2x$

$f = (-x) = (\text{Sin}(-x))^2 = \text{Sin}^2x$ is even function

$\int_{-a}^{a} f(x)dx = 2\int_{0}^{a} f(x)dx$

$2\int_{0}^{\frac{\pi}{4}} \sin^2 x\,dx$

$2\int_{0}^{\frac{\pi}{4}} \frac{1-\text{Cos}2x}{2}dx = \int_{0}^{\frac{\pi}{4}} (1-\text{Cos}2x)dx$

$[x]_0^{\pi/4} - \left[\frac{\text{Sin}2x}{2}\right]_0^{\pi/4}$

$\left[\frac{\pi}{4}-0\right] - \frac{1}{2}\left[\sin 2\times\frac{\pi}{4} - \sin 0\right]$

$\frac{\pi}{4} - \frac{1}{2}[1-0] \Rightarrow \frac{\pi}{4} - \frac{1}{2}$

22. In a bank, principal increases continuously at the rate of 5% per year. An amount of Rs. 1,000 is deposited with this bank. How much will it worth after 10 years ($e^{0.5} = 1.648$). **[4]**

Sol. given $\frac{dp}{dt} = \left(\frac{5}{100}\right)p$

$20\frac{dp}{dt} = p$

$20\frac{dp}{p} = dt$

$20\ln p = t + c$

$p = c^{\left(\frac{t}{20}+k\right)}$

at t = 0 , p = 1000

$1000 = e^k$

at t = 10

$p = e^{\frac{1}{2}+k} = e^{0.5}.e^k$

given that $e^{0.5} = 1.648$

$p = 1.648 \times 1000 = 1648$

OR

Find the general solution of the differential equation $y\,dx - (x + 2y^2)\,dy = 0$. **[4]**

Sol. Given equation

$ydx - \left(x + 2y^2\right)dy = 0$

$ydx = \left(x + 2y^2\right)dy$

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

this is not the form $\frac{dy}{dx} + py = Q$

$\therefore$ We find $\frac{dx}{dy} = \frac{x + 2y^2}{y}$

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

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

differential equation is of the form.

$\frac{dx}{dy} + P_1x = Q_1$

Where $P_1 = -\frac{1}{y}$ and $Q_1 = 2y$

Now IF $= e^{\int -\frac{1}{y}dy}$

$= e^{\int -\frac{1}{y}dy}$

$= e^{-\log y}$

$= e^{\log\left(\frac{1}{y}\right)}$

$IF = \frac{1}{y}$

Solution Will be

$x \cdot (IF) = \int (Q \cdot IF)dy + C$

$x \cdot \frac{1}{y} = \int 2y \times \frac{1}{y} dy + C$

$\frac{x}{y} = \int 2dy + C$

$\frac{x}{y} = 2y + C$

$x = y(2y + C)$

$x = 2y^2 + cy$

23. Maximize Z = 5x + 3y subject to constraints $3x + 5y \le 15$, $5x + 2y \le 10$, $x \ge 0$, $y \ge 0$ by using graphical method. **[4]**

Sol. Maximize Z = 5x + 3y

Subject to

$3x + 5y \le 15$

$5x + 2y \le 10$

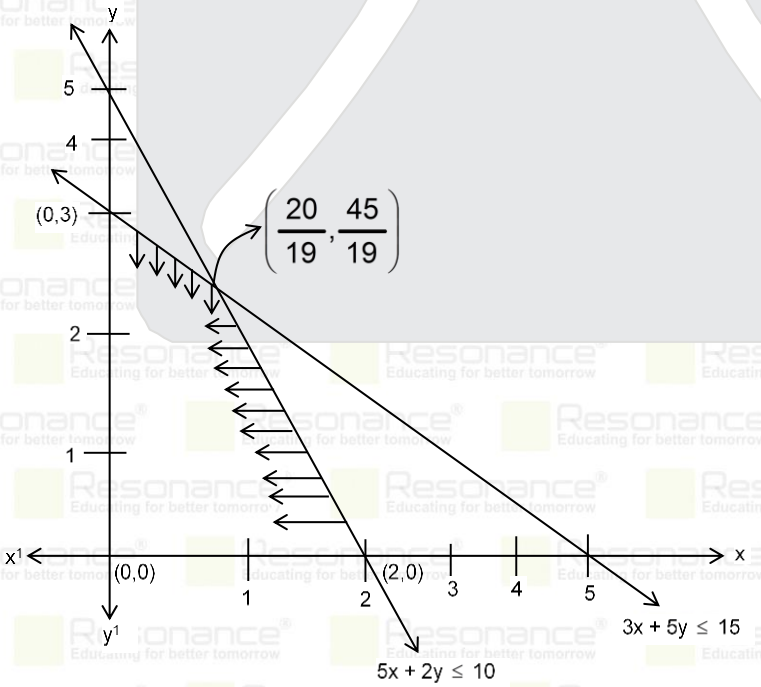
$x \le o, y \le 0$

$3x + 5y \le 15$

X	0	5
Y	3	0

$5x + 2y \le 10$

X	0	2
Y	5	0



Corner points	Value of Z

(0,3)	9
$\left(\frac{20}{19},\frac{45}{19}\right)$	$\frac{235}{19}=12.36$
(2,0)	10

Hence. $Z = \left(\frac{235}{19}\right)$ (12.36) is maximum at $\left(\frac{20}{19},\frac{45}{19}\right)$

OR

Minimize Z= 200x + 500y subject to constraints $x + 2y \geq 10$, $3x + 4y \leq 24$, $x \geq 0, y \geq 0$ by using graphical method **[4]**

Sol.

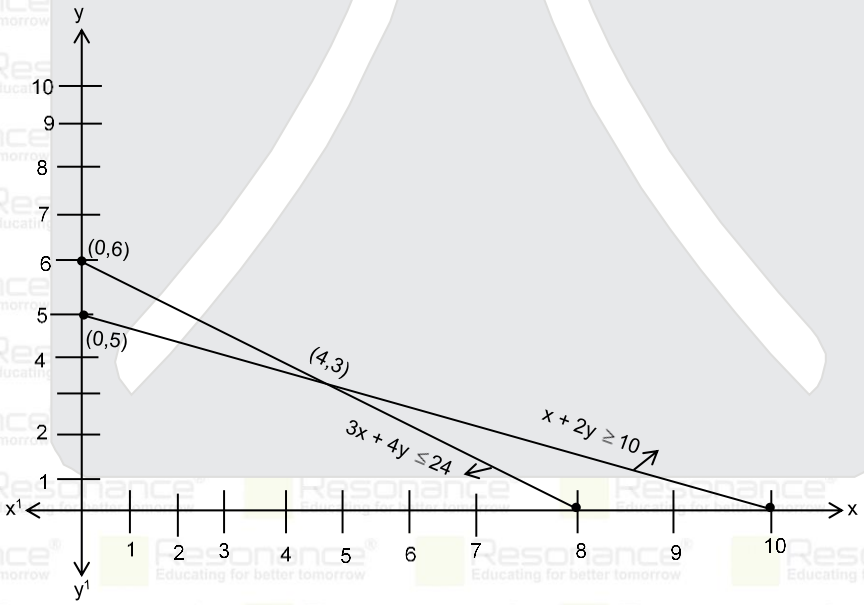
Minimize , Z = 200x + 500 y
Subject to , $x+2y \leq 10$
$3x + 4y \leq 24$
$x \leq 0 , y \leq 0$

$x + 2y \geq 10$

X	0	10
Y	5	0

$3x + 4y \leq 24$

X	0	8
Y	6	0



Corner Points	Value of Z
(0,6)	3000
(0,5)	2500
(4,3)	2300 …….. minimum.

Hence Z is minimum at (4,3) Ans.

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BOARD DIVISION (PSPD)

CUET (UG) 2023
Common University Entrance Test

About CUET (UG)

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- CUET, known as Common Universities Entrance Test (CUET), is a Computer Based All - India Test for admission to various Undergraduate Programmes in 44 Central Universities and other State Private + Deemed Universities of India.
- CUET (UG) is organized by National Testing Agency (NTA).
- Official Website: <www.samarth.cuet.ac.in> OR <www.cuet.nta.ac.in>

Points to Remember: CUET (UG) 2023

- Candidates can choose any Language/Domain Specific Subjects/General Test or a combination as per the requirements of the course in the specific University.
- The choice of Tests/Subjects depend on the course/s chosen by the candidate and the University/ies where admission is sought.
- A Candidate can take a maximum of **10 tests**.

S.No.	SECTION	NO. OF QUESTIONS	QUESTIONS TO ATTEMPT	DURATION
1.	SECTION-I (A+B)	50	40	45 Minutes
2.	SECTION-II	50/45	40/35	45 Minutes*
3.	SECTION-III	60	50	45 Minutes*

*Not yet announced by NTA.

- **Section IA – 13 Languages (As a medium and "Language")**
  Assamese | Bengali | English | Gujarati | Hindi | Kannada | Malayalam | Marathi | Odia | Punjabi | Tamil | Telugu | Urdu
- **Section IB – 20 Languages**
  Arabic | Bodo | Chinese | Dogri | French | German | Persian | Russian | Sindhi | Tibetan | Italian | Japanese | Kashmiri | Konkani | Maithili | Manipuri | Nepali | Santhali | Spanish | Sanskrit
- **Section II – 27 Domain-Specific Subjects**
  There are 27 Domains specific Subjects being offered under this Section. Candidate may choose a maximum of Six (06) Domains as desired by the applicable University/Universities.
- **Section III – General Test**
  General Knowledge, Current Affairs, General Mental Ability, Numerical Ability, Quantitative Reasoning (Simple application of basic mathematical concepts arithmetic/algebra geometry/mensuration/stat taught till Grade 8).

- Candidates, from any Stream (Arts / Commerce / Science), who are appearing in Class12th Examination in 2022-23 OR who have Passed the class 12th or equivalent examination, irrespective of their age can appear in the CUET (UG)–2023.
- Students of Science stream can explore some unique courses of B. Tech/ M. Tech / Bio-Tech courses through CUET exam at some renowned universities of India like DU / BHU etc.
- Candidates have to fulfil the age criteria if it is specified by a Particular University to which the candidate wishes to apply.

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* Availability of these subjects depends on number of students enrolled.

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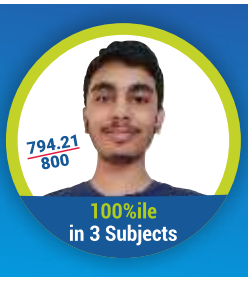

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