BACHELOR OF COMPUTER APPLICATIONS (BCA_NEW)

Course Code: BCS-012

Course Title: BASIC MATHEMATICS

Assignment Number: BCA (I)/012/Assignment/2024-25

***Last Dates for Submission*: 31stOctober, 2024 (For July Session)**

: 30thApril, 2025 (For January Session)

Maximum Marks: 100

Weightage : 25%

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BCS-012 - Basic Mathematics

Q-1: For what value of 'K' the points $(-K+1, 2K)$, $(K, 2-2K)$ and $(-4-K, 6-2K)$ are collinear.

Ans: The given points are collinear if

$$\begin{vmatrix} -K+1 & 2K & 1 \\ K & 2-2K & 1 \\ -4-K & 6-2K & 1 \end{vmatrix} = 0$$

$$\Rightarrow \begin{vmatrix} K & 2-2K & 1 \\ -2K+1 & 4K-2 & 0 \\ -4-2K & 4 & 0 \end{vmatrix} = 0 \quad \begin{bmatrix} R_2 \Rightarrow R_2 - R1 \\ R3 \Rightarrow R_3 - R_1 \end{bmatrix}$$

$\Rightarrow 4(-2K+1) - (-4-2K)(4K-2) = 0$

$\Rightarrow (1-2K)(4-8-4K) = 0$

$\Rightarrow (1-2K)(-4-4K) = 0$

$\Rightarrow (1-2K)(K+1) = 0$

$\Rightarrow \boxed{K = \frac{1}{2} \text{ or } K = -1}$

$\rightarrow$ -1 and $\frac{1}{2}$ are the value of 'K' at which points are collinear.

Q-2 Solve the following system of equations by using matrix Inverse method:

$$3x + 4y + 7z = 14$$
$$2x - y + 3z = 4$$
$$2x + 2y - 3z = 0$$

Ans: These equations can be written in a matrix as:

$$\begin{bmatrix} 3 & 4 & 7 \\ 2 & -1 & 3 \\ 2 & 2 & -3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 14 \\ 4 \\ 0 \end{bmatrix}$$

OR

$$AX = B$$

$$A = \begin{bmatrix} 3 & 4 & 7 \\ 2 & -1 & 3 \\ 2 & 2 & -3 \end{bmatrix}, \quad X = \begin{bmatrix} x \\ y \\ z \end{bmatrix} \quad \text{and} \quad B = \begin{bmatrix} 14 \\ 4 \\ 0 \end{bmatrix}$$

$$|A| = 3\begin{vmatrix} -1 & 3 \\ 2 & -3 \end{vmatrix} - 4\begin{vmatrix} 2 & 3 \\ 2 & -3 \end{vmatrix} + 7\begin{vmatrix} 2 & -1 \\ 2 & 2 \end{vmatrix}$$

$$= 3(3-6) - 4(-6-6) + 7(4+2)$$

$$= 3(-3) - 4(-12) + 7(6)$$

$$= -9 + 48 + 42$$

$$\boxed{|A| = 81}$$

So for the Unique ... solution we used

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

$$A^{-1} = \frac{\text{adj}(A)}{|A|}$$

Cofactors of A are:

$$C_{11} = (-1)^{1+1} \cdot \quad 3-6 = -3 = -3$$

$$C_{21} = (-1)^{2+1} \cdot \quad -12-14 = -(-26) = 26$$

$$C_{31} = (-1)^{3+1} \cdot \quad 12+7 = 19 = 19$$

$$C_{12} = (-1)^{1+2} \cdot \quad -6-6 = -(-12) = 12$$

$$C_{22} = (-1)^{2+2} \cdot \quad -9-14 = +(-23) = 23$$

$$C_{32} = (-1)^{3+2} \cdot \quad 9-14 = -(-5) = 5$$

$$C_{13} = (-1)^{1+3} \cdot \quad 4+2 = 6 = 6$$

$$C_{23} = (-1)^{2+3} \cdot \quad 6-8 = -(-2) = 2$$

$$C_{33} = (-1)^{3+3} \cdot \quad -3-8 = -11 = -11$$

$$\text{adj}\,A = \begin{bmatrix} -3 & 12 & 6 \\ 26 & -23 & 2 \\ 19 & 5 & -11 \end{bmatrix}^T = \begin{bmatrix} -3 & 26 & 19 \\ 12 & -23 & 5 \\ 6 & 2 & -11 \end{bmatrix}$$

Now, $X = A^{-1}B = \frac{1}{81}\begin{bmatrix} -3 & 26 & 19 \\ 12 & -23 & 5 \\ 6 & 2 & -11 \end{bmatrix}\begin{bmatrix} 14 \\ 4 \\ 0 \end{bmatrix}$

$$X = \frac{1}{81}\begin{bmatrix} -3(14)+26(4)+19(0) \\ 12(14)-(23)(4)+5(0) \\ 6(14)+2(4)+(-11)(0) \end{bmatrix}$$

$$X = \frac{1}{81}\begin{bmatrix} 62 \\ 76 \\ 92 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 62/81 \\ 76/81 \\ 92/81 \end{bmatrix}$$

So, $x = \frac{62}{81}$, $y = \frac{76}{81}$, and $z = \frac{92}{81}$ are the solution

Q-3 Use principle of mathematical Induction to prove that

$$\frac{1}{1\times 2} + \frac{1}{2\times 3} + \cdots\cdots + \frac{1}{n(n+1)} = \frac{n}{n+1}$$

Sol:-

Let

$$P(n) = \frac{1}{1\times 2} + \frac{1}{2\times 3} + \cdots + \frac{1}{n(n+1)} = \frac{n}{n+1}$$

For $n=1$, LHS $= \frac{1}{1\times 2} = \frac{1}{2}$; RHS $= \frac{1}{1+1} = \frac{1}{2}$

$\therefore$ LHS = RHS

$\therefore$ $P(1)$ is True

Let us assume P(K) is true for some $K \in N$

i.e, $\frac{1}{1\times2} + \frac{1}{2\times3} + \dots + \frac{1}{K(K+1)} = \frac{K}{K+1}$

Adding $(K+1)^{th}$ term $= \frac{1}{(K+1)(K+2)}$ on both sides,

we get,

$$\frac{1}{1\times2} + \frac{1}{2\times3} + \dots + \frac{1}{K(K+1)} + \frac{1}{(K+1)(K+2)}$$

$$= \frac{K}{K+1} + \frac{1}{(K+1)(K+2)}$$

$$= \frac{K(K+2)+1}{(K+1)\ (K+2)} \Rightarrow \frac{K^2+2K+1}{(K+1)\ (K+2)}$$

$$= \frac{(K+1)^{\cancel{2}}}{\cancel{(K+1)}(K+2)} = \frac{K+1}{K+2} \Rightarrow \frac{K+1}{(K+1)+1}$$

Which is $P(K+1)$

Thus, $P(K) \Rightarrow P(K+1)$

Hence, by mathematical induction P(n) is true for all $n \in N$.

Q-4: How many terms of G.P $\sqrt{3}, 3, 3\sqrt{3}, \dots$ Add upto $39+13$

Sol: $a = \sqrt{3}$, $r = \frac{3}{\sqrt{3}} = \sqrt{3}$

$$S_n = \frac{a(r^n-1)}{r-1}$$

$$= 39+13 = \frac{\sqrt{3}(\sqrt{3}^n-1)}{\sqrt{3}-1}$$

$$52 = \frac{\sqrt{3}(\sqrt{3}^n-1)}{\sqrt{3}-1}$$

$$53(\sqrt{3}-1) = \sqrt{3}(\sqrt{3}^n - 1)$$
$$53\sqrt{3} - 53 = \sqrt{3}(\sqrt{3}^n - 1)$$
$$53\sqrt{3} - 53 = \sqrt{3}(\sqrt{3}^n - 1)$$
$$53\sqrt{3} - 53 = \sqrt{3}^{n+1} - \sqrt{3}$$
$$53\sqrt{3} - 53 + \sqrt{3} = \sqrt{3}^{n+1}$$
$$53\sqrt{3} - 53 = \sqrt{3}^{n+1}$$

Now, $53\sqrt{3} - 53 \approx (\sqrt{3})^6$

Let's put $(\sqrt{3})^6$ in our eq

$$(\sqrt{3})^6 = \sqrt{3}^{n+1}$$

Comparing the power

$$6 = n+1$$
$$\boxed{n = 5}$$

So, 5 terms needed.

Q-5: If $y = ae^{mx} + be^{-mx}$, prove that $\frac{d^2y}{dx^2} = m^2 y$

Sol:- Let

$y = ae^{mx} + be^{-mx}$ ——— eq (1)

Differentiate with respect to x,

$$\frac{dy}{dx} = ame^{mx} - bme^{-mx} \qquad \left[\because \frac{d}{dx}e^x = e^x\right]$$

Differentiate again with respect to x.

$$\frac{d^2y}{dx^2} = am^2e^{mx} + bm^2e^{-mx}$$

$$\Rightarrow \frac{d^2y}{dx^2} = m^2(ae^{mx} + be^{-mx})$$

$$\Rightarrow \frac{d^2y}{dx^2} = m^2y \qquad [\text{from } 1]$$

Hence prooved.

Q-6 : Integrate function $f(x) = \dfrac{x}{[(x+1)(2x-1)]}$ w.r.t x.

Sol

We will ~~t~~ use partial fraction decomposition

$$= \frac{x}{(x+1)(2x-1)} = \frac{A}{x+1} + \frac{B}{2x-1} \quad \text{—— eq (1)}$$

Taking RHS and by adding both ~~com~~ fractions, we get

$$\frac{A}{x+1} + \frac{B}{2x-1} = \frac{A(2x-1) + B(x+1)}{(x+1)(2x-1)}$$

from eq (1)

$$\frac{x}{\cancel{(x+1)(2x-1)}} = \frac{A(2x-1) + B(x+1)}{\cancel{(x+1)(2x-1)}}$$

$$\Rightarrow \quad x = A(2x-1) + B(x+1)$$

$$\Rightarrow \quad x = (2A)x - A + Bx + B$$

$$\Rightarrow \quad x = (2A+B)x + (-A+B)$$

Now, match the coefficients of same terms

For the x coefficient

$$1 = 2A + B \quad \text{—— eq (2)}$$

For the constant term :

$$0 = -A + B \quad \text{—— eq (3)}$$

From eq(3)

$$B = A$$

Substitute $B = A$ into the eq(2) ;

$$1 = 2A + A \Rightarrow 1 = 3A = A = \frac{1}{3}$$

Since $B = A$: $\quad B = \dfrac{1}{3}$

Now put the value of A and B in the eq (1)

$$\frac{x}{(x+1)(2x-1)} = \frac{1/3}{x+1} + \frac{1/3}{2x-1}$$

Taking RHS

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

To integrate:

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

$$= \frac{1}{3}\left[\ln|x+1| + (1/u)dx + c\right]$$ [by substitution method]

$u = 2x-1$, $du = 2dx$ Hence $\boxed{dx = \frac{du}{2}}$

so,

$$\int \frac{1}{2x-1}\,dx = \int \frac{1}{u} \cdot \frac{du}{2} = \frac{1}{2}\ln|u| = \frac{1}{2}\ln|2x-1| + c$$

$$\Rightarrow \frac{1}{3}\left(\ln|x+1| + \frac{1}{2}\ln|2-1|\right) + c$$

$$\Rightarrow \boxed{\frac{1}{3}\ln|x+1| + \frac{1}{6}\ln|2-1| + c}$$

Q-7: If $1, w, w^2$ are cube roots of unity show that $(1+w)^2 - (1+w)^3 + w^2 = 0$.

Sol =

$$(1+w)^2 = 1^2 + 2\cdot 1\cdot w + w^2 = 1 + 2w + w^2$$
$$(1+w)^3 = (1+w)(1+w^2) = (1+w)(1+2w+w^2)$$

$$= (1+w)(1+2w+w^2) = 1+2w+w^2 + w(1+2w+w^2)$$
$$= 1+2w+w^2 + w + 2w^2 + w^3$$

$= 1+3\omega+3\omega^2+\omega^3$

$\Rightarrow 1+3\omega+3\omega^2+1$ [Property of cube root $\omega^3=1$]

$= 3\omega^2+3\omega+2$

Substitute the expanded forms into the original eq

$(1+\omega)^2-(1+\omega)^3+\omega^2 = (1+2\omega+\omega^2)-(2+3\omega+3\omega^2)+\omega^2$

Taking RHS

$= (1+2\omega+\omega^2)-(2+3\omega+3\omega^2)+\omega^2$

$= 1+2\omega+\omega^2-2-3\omega-3\omega^2-\omega^2$

$= (1-2)+(2\omega-3\omega)+(\omega^2-3\omega^2-\omega^2)$

$= -1-\omega-\omega^2$

Use the property $1+\omega+\omega^2=0$

$-(1+\omega+\omega^2) = 0$

our RHS is 0 so the expression is

$$\boxed{(1+\omega)^2-(1+\omega)^3+\omega^2=0}$$

Q-8: If α, β are roots of equation $2x^2-3x-5=0$, then find a Quadratic equation whose roots are α^2, β^2.

Sol: α and β are two roots of the given quadratic equation $2x^2-3x-5=0$

$\Rightarrow 2x^2-3x-5=0$

$= 2x^2-5x+2x-5=0$

$= x(2x-5)+1(2x-5)=0$

$= (2x-5)(x+1)=0$

$= 2x-5=0$ and $x+1=0$

$\therefore x = \frac{5}{2}$ and $x = -1$

$\therefore \alpha = \frac{5}{2}$ and $\beta = -1$

$\alpha^2 = \left(\frac{5}{2}\right) = \frac{25}{4}$ and $\beta^2 = (-1)^2 = 1$

$\because$ New roots are $\frac{25}{4}$ and 1

New quadratic equation,

$$\left(x - \frac{25}{4}\right)(x-1) = 0$$

$$x^2 - x - \frac{25x}{4} + \frac{25}{4} = 0$$

$$4x^2 - 4x - 25x + 25$$

$$\Rightarrow \boxed{4x^2 - 29x + 25 = 0}$$

Q-9: Solve the inequality $\frac{3}{5}(x-2) \le \frac{5}{3}(2-x)$ and graph the solution set.

Sol:

$$\frac{3(x-2)}{5} \le \frac{5(2-x)}{3}$$

$$3 \times 3(x-2) \le 5 \times 5(2-x)$$

$$9(x-2) \le 25(2-x)$$

$$9x - 18 \le 50 - 25x$$

$$9x - 18 + 18 + 25x \le 50 - 25x + 18 + 25x$$

$$= 9x + 25x \le 50 + 18$$

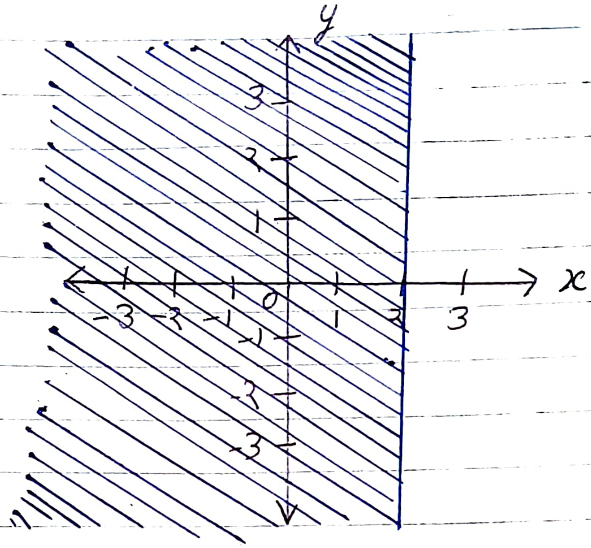
$$34x \le 68$$

$$x \le \frac{68}{34}$$

$$x \le 2$$

Hence, x is a real number which less than or equal to 2.
Hence, $x \in (-\infty, 2]$ is the solution.

Graph of the solution set.



Q-10: If positive number exceeds its positive square root by 12, then find the number.

Sol- Let the required number be x.

So, $x = \sqrt{x} + 12$ [Given: Number is greater than its positive square root]

$= x - 12 = \sqrt{x}$

Squaring on both sides, we get

$(x-12) = x$

$x^2 + 12^2 - 2x(12) = x$

$= x^2 - 25x + 144 = 0$

$x(x-16) - 9(x-16) = 0$

$(x-16)(x-9) = 0$

$\therefore x = 16, x = 9$

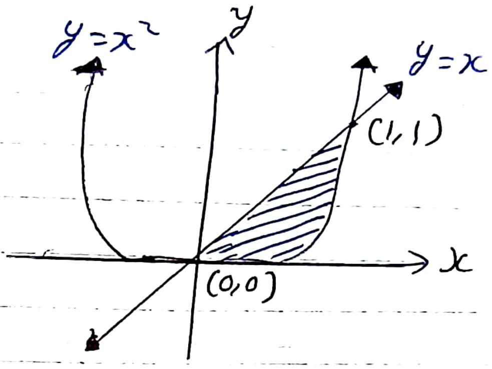
As $9 < 12$, it was given that the number will be greater than 12.

So, $x = 16$, is the required number.

Q-11: Find the area bounded by the curves $x^2 = y$ and $y = x$

Sol

By solving equation $y = x^2$ and $y = x$



$\therefore x^2 = x$

$\therefore x^2 - x = 0$

$x(x-1) = 0$

$\therefore x = 0$ or $x = 1$

Points of intersection of both curves are (0, 0) and (1, 1)

Required area A

$$= \left| \int_a^b [f_1(x) - f_2(x) dx] \right| = \int_0^1 x - x^2 dx$$

$$= \left[\frac{x^2}{2} - \frac{x^3}{3}\right]_0^1 = \frac{1}{2} - \frac{1}{3} = \frac{1}{6}$$

$$\boxed{A = |I| = \frac{1}{6} \text{ sq Unit.}}$$

Q-12: find the inverse of the matrix $A = \begin{bmatrix} 1 & 6 & 4 \\ 2 & 4 & -1 \\ -1 & 2 & 5 \end{bmatrix}$, if it exists.

Sol- Let's first find the determinant to check if inverse exists or not.

$$|A| = \begin{vmatrix} 1 & 6 & 4 \\ 2 & 4 & -1 \\ -1 & 2 & 5 \end{vmatrix}$$

$$|A| = 1\begin{vmatrix} 4 & -1 \\ 2 & 5 \end{vmatrix} - 6\begin{vmatrix} 2 & -1 \\ -1 & 5 \end{vmatrix} + 4\begin{vmatrix} 2 & 4 \\ -1 & 2 \end{vmatrix}$$

$1(20+20) - 6(10-1) + 4(4+4)$

$= 22 - 54 + 32$

$54 - 54$

$|A| = 0$

So,

Determinant is zero, therefore inverse matrix doesn't exist.

Q-13: If m times the m^{th} term of an A.P is n times its n^{th} term, show that $(m+n)^{th}$ term of the A.P. is zero.

Sol: Given,

n^{th} term of AP $= t_n = a + (n-1)d$

m^{th} term of AP $= t_m = a + (m-1)d$

$\Rightarrow mt_m = nt_n$

$m[a + (m-1)d] = n[a + (n-1)d]$

$m[a + (m-1)d] - n[a + (n-1)d] = 0$

$a(m-n) + d[(m+n)(m-n) - (m-n)] = 0$

$(m-n)[a + d((m+n) - 1)] = 0$

$a + [(m+n) - 1]d = 0$

But $t_{m+n} = a + [(m+n) - 1]d$

$\boxed{\therefore t_{m+n} = 0}$

Q-14: Show that

i) $\lim_{x \to 0} \frac{|x|}{x}$ does not exist

Sol

$LHL = \lim_{h \to 0} \frac{|0-h|}{0-h} = \lim_{h \to 0} \frac{h}{-h} = -1$

RHL

$$\lim_{h\to 0} \frac{|0+h|}{0+h} = \lim_{h\to 0} \frac{h}{h} = 1.$$

$LHL \neq RHL$

$\therefore$ Limit does not exist at $x=0$.

(ii) $f(x)=|x|$ is continuous at $x=0$

sol $f(x)=|x|$

to check the continuity of $f(x)$ at $x=a$,

$$\lim_{x\to 0^+} f(x) = \lim_{x\to 0^+} x = 0$$

and

$$\lim_{x\to 0^-} f(x) = \lim_{x\to 0}(-x) = 0 = f(0)$$

Now, $Rf(0) = Lf(0) = f(0)$

So the function $f(x)$ is continuous at $x=0$.

Q-15: Suriti wants to Invest at most 13000 in Saving Certificates and National Saving Bonds. She has to invest at least 3000 in Saving certificates and at least 4000 in National Saving Bonds. If Rate of Interest on Saving certificates is 8% per annum and ROI on National Saving bond is 10% annum. How much money should she invest to earn maximum yearly income? Find also the maximum yearly income.

Ans:

Let Suriti invests Rs x in Saving certificates and Rs y in National bonds.
Therefore,

$$x, y \geq 0$$

Suriti wants to invest at most Rs 12000 in Saving Certificates and National Saving bonds.

$$x+y \leq 12000$$

According to rules, she has to invest at least Rs 2000 in Saving Certificates and at least Rs 4000 in National Saving Bonds.

$$x \geq 2000$$
$$y \geq 4000$$

If the rate of interest on Saving certificate is 8% per annum and the rate of interest on National Saving Bond is 10% per annum.

Total earning from investment =

$$z = \frac{8x}{100} + \frac{10y}{100}$$ which is to be maximised.

Thus, the mathematical formulation of the given linear programming Problem is

$$\max Z = \frac{8x}{100} + \frac{10y}{100}$$

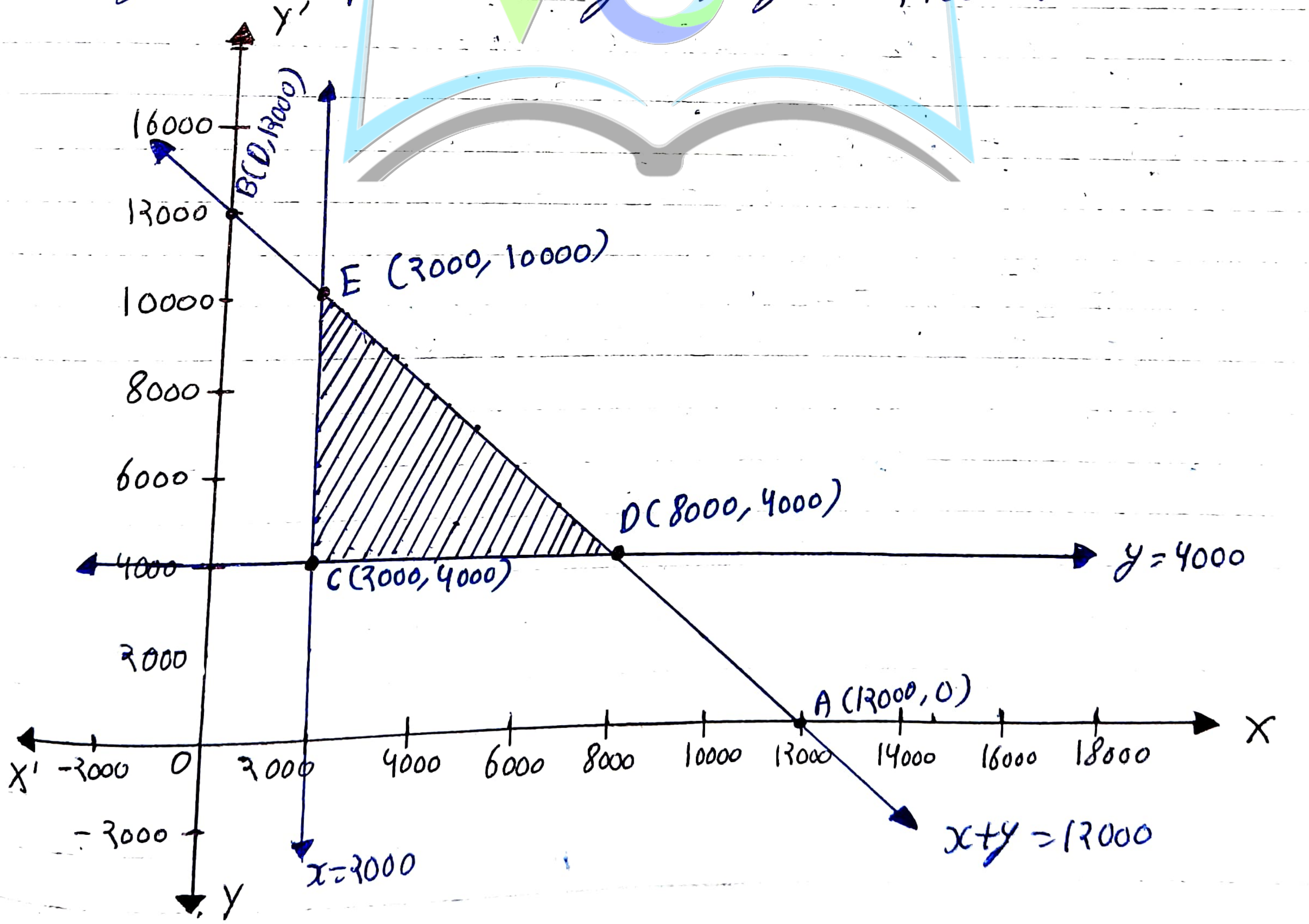
Subject to

$$x+y \le 12000$$
$$x \ge 2000$$
$$y \ge 4000$$

$$x, y \ge 0$$

First we will convert inequations in eqations
$x+y = 12000$, $x = 2000$, $y = 4000$, $x=0$, $y=0$

Region represented by $x+y \le 12000$:



The line $x+y = 13000$ meets the coordinate axes at $A(13000, 0)$ and $B(0, 13000)$ respectively. By joining these points we obatain the line $x+y = 13000$. Clearly $(0,0)$ satisfy the inequation $x+y \leq 13000$. So, the region which contains the origin represtents the solution set of the inequation $x+y \leq 13000$.

Region represented by $x \geq 3000$:
The line $x = 3000$ is the line that passes through $(3000, 0)$ and is parallel to y axis. The region to the right of the line $x = 3000$ will satisfy the inequation

Region represented by $y \geq 4000$:
The line $y = 4000$ is the line that passes through $(0, 4000)$ and is parallel to x axis. The region above the line $y = 4000$ will statisfy the inequation $y \geq 4000$.

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

Since, every point in the first quadrant satisfies these inequations. So, the first quadrant is the region represented by the inequations $x \geq 0$, $y \geq 0$.

The feasible region determined by the system of constraints is

The corner points are $E(3000, 10000)$, $D(8000, 4000)$, $C(3000, 4000)$

The values of Z at these points are as follows

Corner points	$Z = (8x/100) + (10y/100)$
E	1160
D	1040
C	560

The maximum value of z is 1160 which is attained at $E(2000, 10000)$.

Thus, the maximum earning is Rs 1160 obtained when Rs 2000 were invested in Saving's certificate and Rs 10000 were invested in National Saving Bond.

Q-16: A spherical ballon is being inflated at the rate of $900\ cm^3/sec$. How fast Radius of the balloon Increasing when the Radius is 15 cm.

Sol: Let r be the radius of the ballon and V be its volume at any time t.

$$\Rightarrow V = \frac{4}{3}\pi r^3$$

Differentiate both sides w.r.t t, we get,

$$\frac{dV}{dt} = \frac{4}{3}\pi \cdot 3r^2 \frac{dr}{dt}$$

$$\Rightarrow \frac{dV}{dt} = 4\pi r^2 \frac{dr}{dt}$$

It is given that $\frac{dV}{dt} = 900\ cm^2/sec$

$$\Rightarrow 900 = 4\pi r^2 \frac{dr}{dt}$$

$$= \frac{dr}{dt} = \frac{225}{\pi r^2}$$

When, $r = 15\ cm$

$$\Rightarrow \frac{dr}{dt} = \frac{225}{\pi \times (15)^2}$$

$$\Rightarrow \frac{dr}{dt} = \frac{1}{\pi} \text{ cm/s}$$

$\therefore$ Radius of the balloon is increasing at the rate of $\frac{1}{\pi}$ cm/s or 0.3183 cm/s when the radius is 15 cm.