Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 7- Linear Programming

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Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 7- Linear Programming

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Maharashtra Board Solutions Class 12-Arts & Science Maths (Part 1): Chapter 7- Linear Programming

Maharashtra Board 12th Maths Chapter 7, Class 12 Maths Chapter 7 solutions

Ex 7.1

Question 1.

Solve graphically :

(i) $x \geq 0$

Solution:

Consider the line whose equation is $x = 0$. This represents the Y-axis.

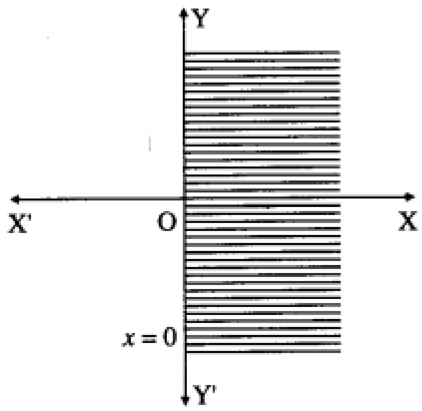
To find the solution set, we have to check any point other than origin.

Let us check the point (1, 1)

When $x = 1$, $x \geq 0$

$\therefore$ (1, 1) lies in the required region

Therefore, the solution set is the Y-axis and the right side of the Y-axis which is shaded in the graph.



ii) $x \leq 0$

Solution:

Consider the line whose equation is $x = 0$.

This represents the Y-axis.

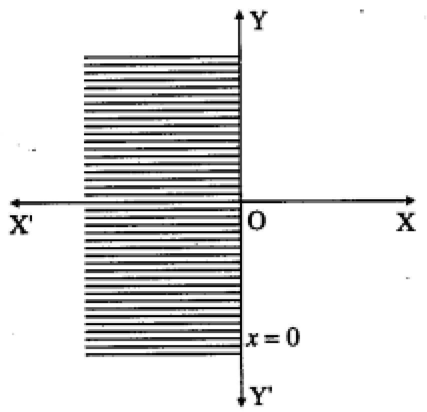
To find the solution set, we have to check any point other than origin.

Let us check the point (1, 1).

When $x = 1$, $x \nleq 0$

∴ (1, 1) does not lie in the required region.

Therefore, the solution set is the Y-axis and the left side of the Y-axis which is shaded in the graph.



(iii) y ≥ 0

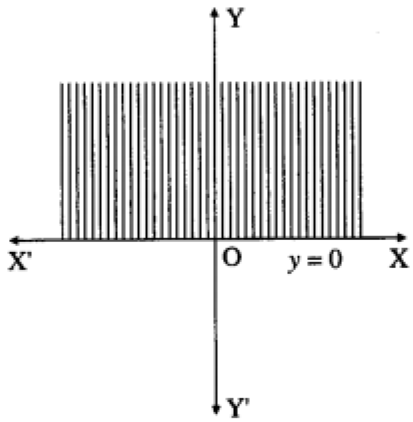
Solution:

Consider the line whose equation is y = 0. This represents the X-axis. To find the solution set, we have to check any point other than origin. Let us check the point (1, 1).

When y = 1, y ≥ 0

∴ (1, 1) lies in the required region.

Therefore, the solution set is the X-axis and above the X-axis which is shaded in the graph.



(iv) $y \leq 0$

Solution:

(iv) Consider the line whose equation is $y = 0$. This represents the X-axis.

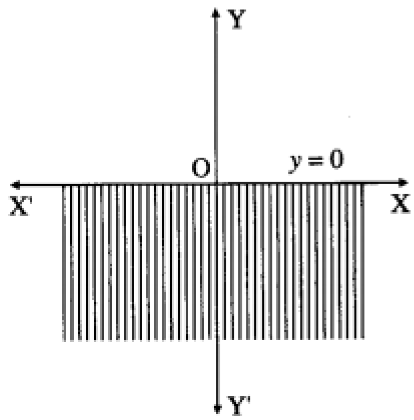
To find the solution set, we have to check any point other than origin.

Let us check the point (1, 1).

When $y = 1$, $y \nleqslant 0$.

∴ (1, 1) does not lie in the required region.

Therefore, the solution set is the X-axis and below the X-axis which is shaded in the graph.



Question 2.

Solve graphically :

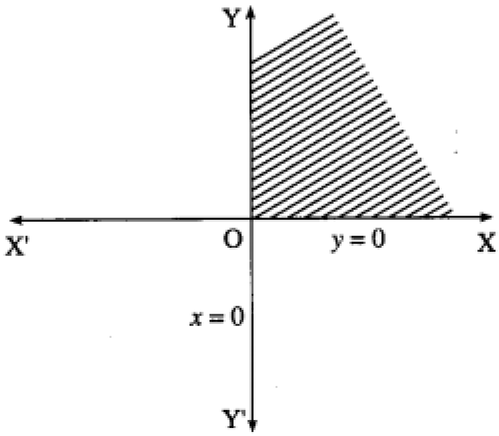
(i) $x \geq 0$ and $y \geq 0$

Solution:

Consider the lines whose equations are $x = 0$, $y = 0$.

These represents the equations of Y-axis and X-axis respectively, which divide the plane into four parts.

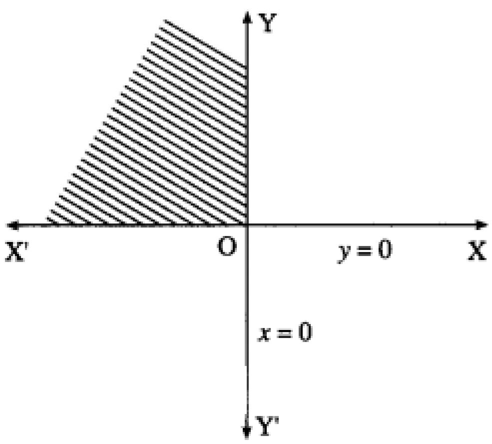
(i) Since $x \geq 0$, $y \geq 0$, the solution set is in the first quadrant which is shaded in the graph.



(ii) x ≤ 0 and y ≥ 0

Solution:

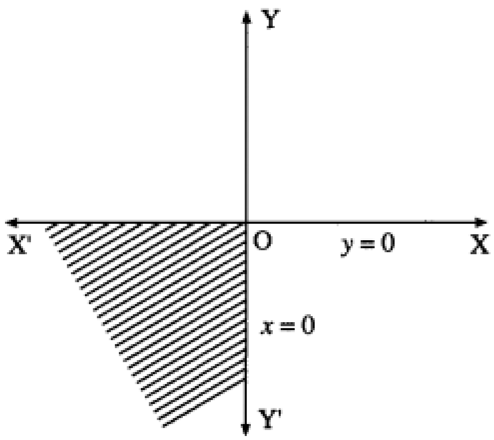
Since x ≤ 0, y ≥ 0, the solution set is in the second quadrant which is shaded in the graph.



(iii) x ≤ 0 and y ≤ 0

Solution:

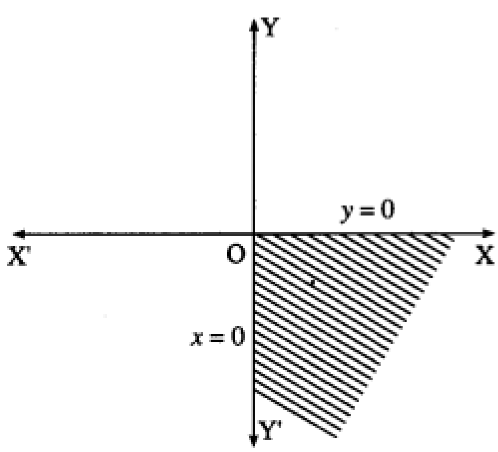
Since x ≤ 0, y ≤ 0, the solution set is in the third quadrant which is shaded in the graph.



(iv) x ≥ 0 and y ≤ 0

Solution:

Since x ≥ 0, y ≤ 0, the solution set is in the fourth ! quadrant which is shaded in the graph.



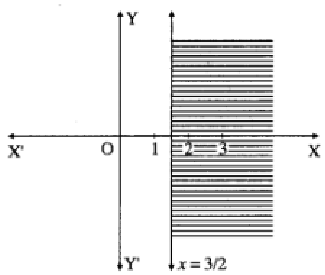
Question 3.

Solve graphically :

(i) $2x - 3 \geq 0$

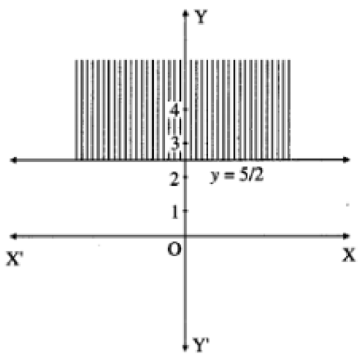
Solution:

Consider the line whose equation is $2x - 3 = 0$,
i.e. $x = \frac{3}{2}$
This represents a line parallel to Y-axis passing through the point $(\frac{3}{2}, 0)$
Draw the line $x = \frac{3}{2}$.
To find the solution set, we have to check the position of the origin (0, 0).
When $x = 0$, $2x - 3 = 2 \times 0 - 3 = -3 \ngeq 0$
∴ the coordinates of the origin does not satisfy the given inequality.
∴ the solution set consists of the line $x = \frac{3}{2}$ and the non-origin side of the line which is shaded in the graph.



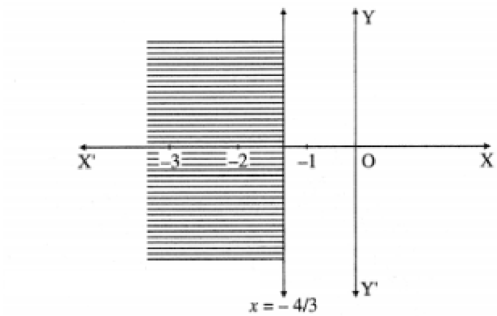
(ii) $2y - 5 \geq 0$
Solution:
Consider the line whose equation is $2y - 5 = 0$, i.e. $y = \frac{5}{2}$

This represents a line parallel to X-axis passing through the point (0, $\frac{5}{2}$).
Draw the line y = $\frac{5}{2}$.
To find the solution set, we have to check the position of the origin (0, 0).
When y = 0, 2y – 5 = 2 × 0 – 5 = -5 $\not\geq$ 0
$\therefore$ the coordinates of the origin does not satisfy the given inequality.
$\therefore$ the solution set consists of the line y = $\frac{5}{2}$ and the non-origin side of the line which is shaded in the graph.



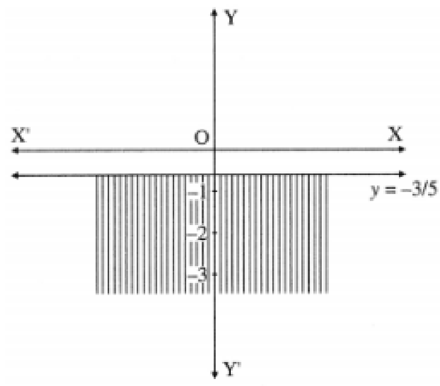
(iii) 3x + 4 ≤ 0
Solution:
(iii) Consider the line whose equation is 3x + 4 = 0,
i.e. x = $-\frac{4}{3}$

This represents a line parallel to Y-axis passing through the point $(-\frac{4}{3}, 0)$.
Draw the line $x = -\frac{4}{3}$.
To find the solution set, we have to check the position of the origin (0, 0).
When x = 0, $3x + 4 = 3 \times 0 + 4 = 4 \not\leq 0$
∴ the coordinates of the origin does not satisfy the given inequality.
∴ the solution set consists of the line $x = -\frac{4}{3}$ and the non-origin side of the line which is shaded in the graph.



(iv) $5y + 3 \leq 0$
Solution:
(iv) Consider the line whose equation is $5y + 3 = 0$,
i.e. $y = \frac{-3}{5}$

This represents a line parallel to X-axis passing through the point (0, $\frac{-3}{5}$)
Draw the line y = $\frac{-3}{5}$.
To find the solution set, we have to check the position of the origin (0, 0).
When y = 0, $5y + 3 = 5 \times 0 + 3 = 3 \not\leq 0$
$\therefore$ the coordinates of the origin does not satisfy the given inequality.
$\therefore$ the solution set consists of the line y = $\frac{-3}{5}$ and the non-origin side of the line which is shaded in the graph.



Question 4.
Solve graphically :
(i) $x + 2y \leq 6$
Solution:
Consider the line whose equation is $x + 2y = 6$.
To find the points of intersection of this line with the coordinate axes.

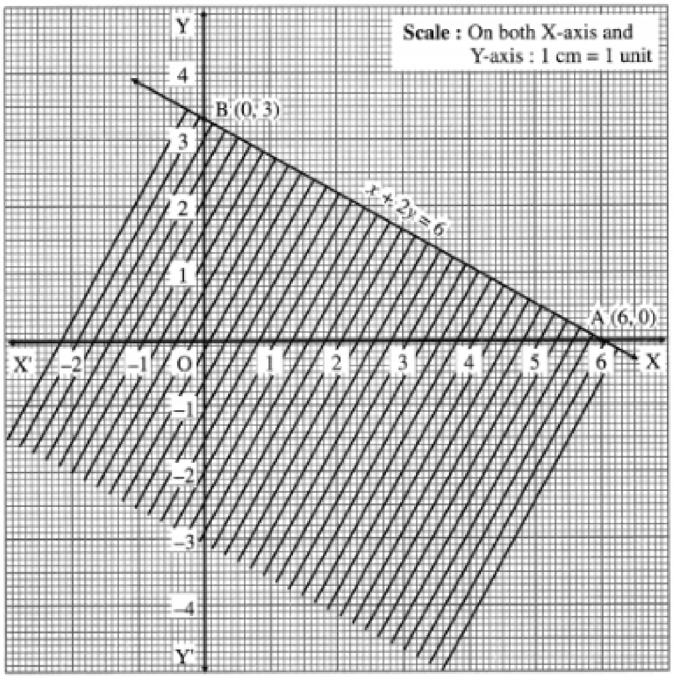
To find the points of intersection of this line with the coordinate axes.

Put y = 0, we get x = 6.

∴ A = (6, 0) is a point on the line.

Put x = 0, we get 2y = 6, i.e. y = 3

∴ B = (0, 3) is another point on the line.

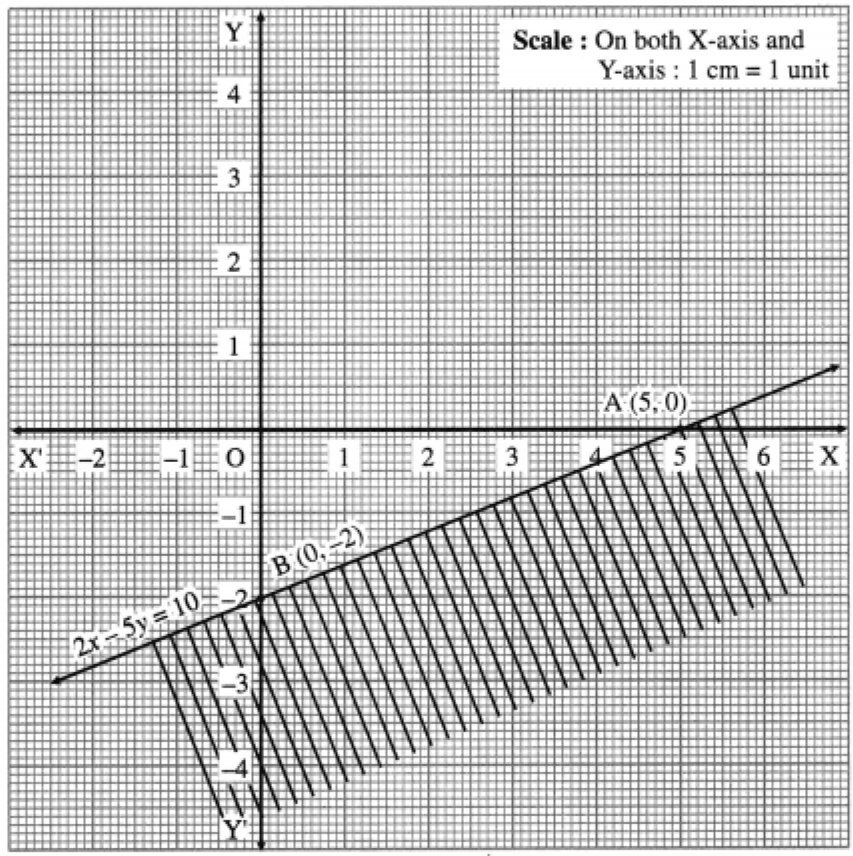


Draw the line AB joining these points. This line divide the line into two parts.

1. Origin side 2. Non-origin side

1. Origin side 2. Non-origin side
To find the solution set, we have to check the position of the origin (0, 0) with respect to the line.
When $x = 0$, $y = 0$, then $x + 2y = 0$ which is less than 6.
$\therefore x + 2y \leq 6$ in this case.
Hence, origin lies in the required region. Therefore, the given inequality is the origin side which is
shaded in the graph.
This is the solution set of $x + 2y \leq 6$.

(ii) $2x - 5y \geq 10$
Solution:
Consider the line whose equation is $2x - 5y = 10$.
To find the points of intersection of this line with the coordinate axes.
Put $y = 0$, we get $2x = 10$, i.e. $x = 5$.
$\therefore A = (5, 0)$ is a point on the line.
Put $x = 0$, we get $-5y = 10$, i.e. $y = -2$
$\therefore B = (0, -2)$ is another point on the line.



Draw the line AB joining these points. This line J divide the plane in two parts.

1. Origin side 2. Non-origin side

To find the solution set, we have to check the position of the origin (0, 0) with respect to the line. When x = 0, y = 0, then 2x – 5y = 0 which is neither greater nor equal to 10.

∴ $2x - 5y \ngeq 10$ in this case.

Hence (0, 0) will not lie in the required region.

Therefore, the given inequality is the non-origin side, which is shaded in the graph.

This is the solution set of $2x - 5y \geq 10$.

(iii) $3x + 2y \geq 0$

Solution:

Consider the line whose equation is $3x + 2y = 0$.

The constant term is zero, therefore this line is passing through the origin.

$\therefore$ one point on the line is $O \equiv (0, 0)$.

To find the another point, we can give any value of x and get the corresponding value of y.

Put $x = 2$, we get $6 + 2y = 0$ i.e. $y = -3$

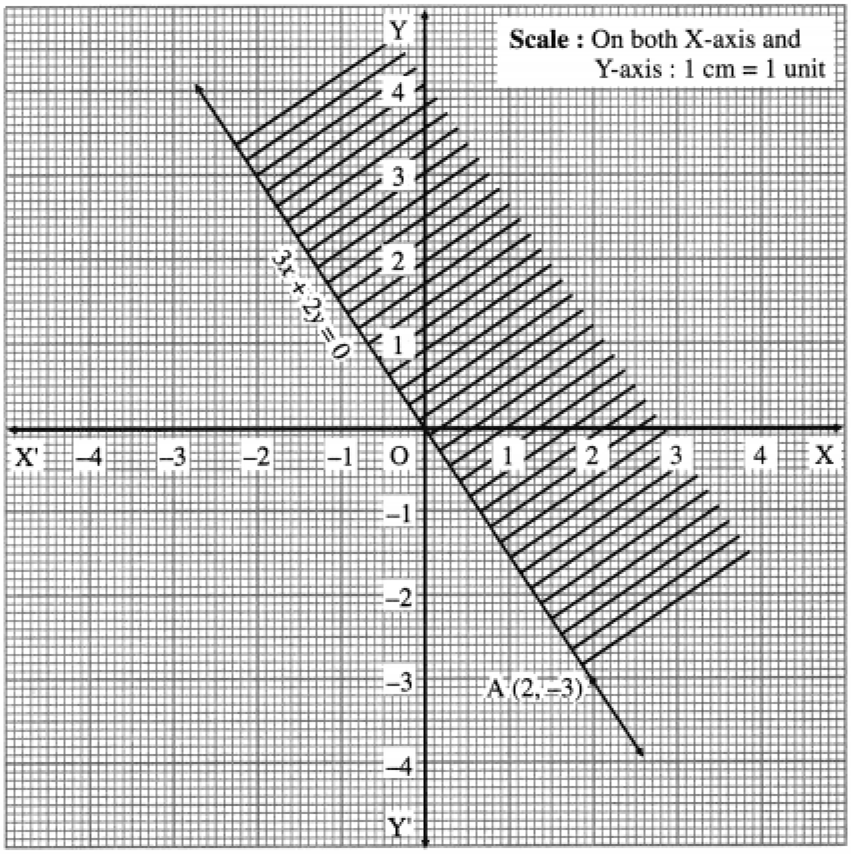
$\therefore$ $A = (2, -3)$ is another point on the line.

Draw the line OA.

To find the solution set, we cannot check $(0, 0)$ as it is already on the line.

We can check any other point which is not on the line.

Let us check the point $(1, 1)$



When x = 1, y = 1, then 3x + 2y = 3 + 2 = 5 which is greater than zero.

∴ 3x + 2y > 0 in this case.

Hence (1, 1) lies in the required region. Therefore, the required region is the upper side which is shaded in the graph.

This is the solution set of 3x + 2y ≥ 0.

(iv) 5x – 3y ≤ 0

Solution:

Consider the line whose equation is 5x – 3y = 0. The constant term is zero, therefore this line is passing through the origin.

∴ one point on the line is the origin O = (0, 0).

To find the other point, we can give any value of x and get the corresponding value of y.

Put x = 3, we get 15 – 3y = 0, i.e. y = 5

∴ A ≡ (3, 5) is another point on the line.

Draw the line OA.

To find the solution set, we cannot check o(0, 0), as it is already on the line. We can check any other point which is not on the line.

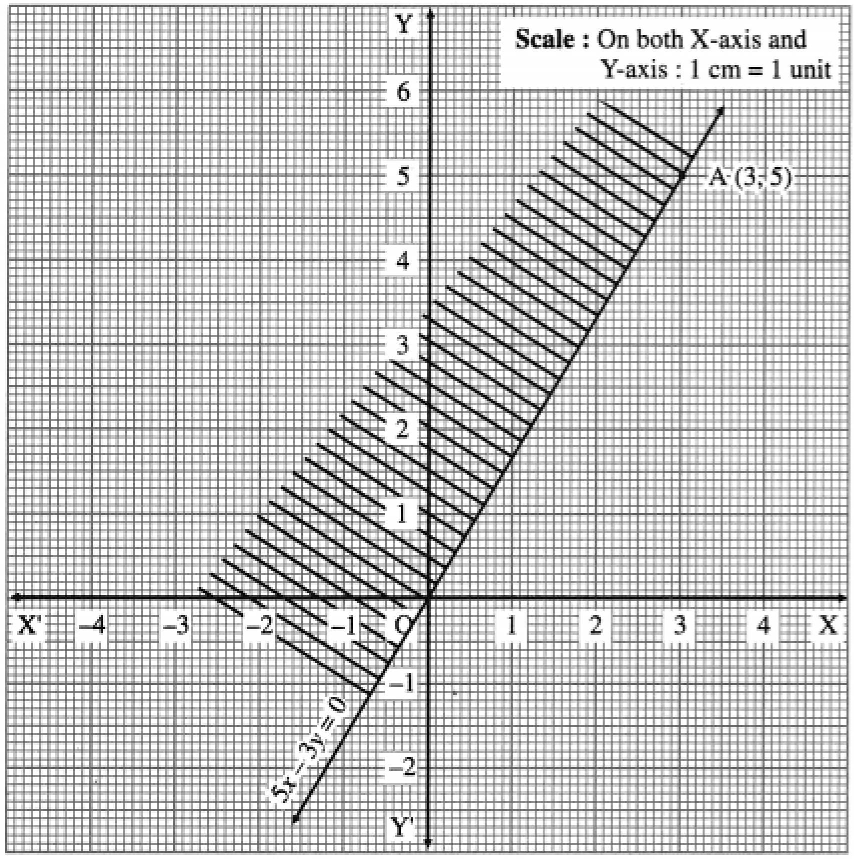
Let us check the point (1, -1).

When x = 1, y = -1 then 5x – 3y = 5 + 3 = 8

which is neither less nor equal to zero.

∴ $5x - 3y \nleq 0$ in this case.

Hence (1, -1) will not lie in the required region. Therefore, the required region is the upper side which is shaded in the graph.



This is the solution set of $5x - 3y \leq 0$.

Question 5.

Solve graphically :

(i) $2x + y \geq 2$ and $x - y \leq 1$

Solution:

First we draw the lines AB and AC whose equations are $2x + y = 2$ and $x - y = 1$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$2x+y=2$	A (1, 0)	B (0, 2)	$\geqslant$	non-origin side of line AB
AC	$x-y=1$	A (1, 0)	C (0, −1)	$\leqslant$	origin side of line AC

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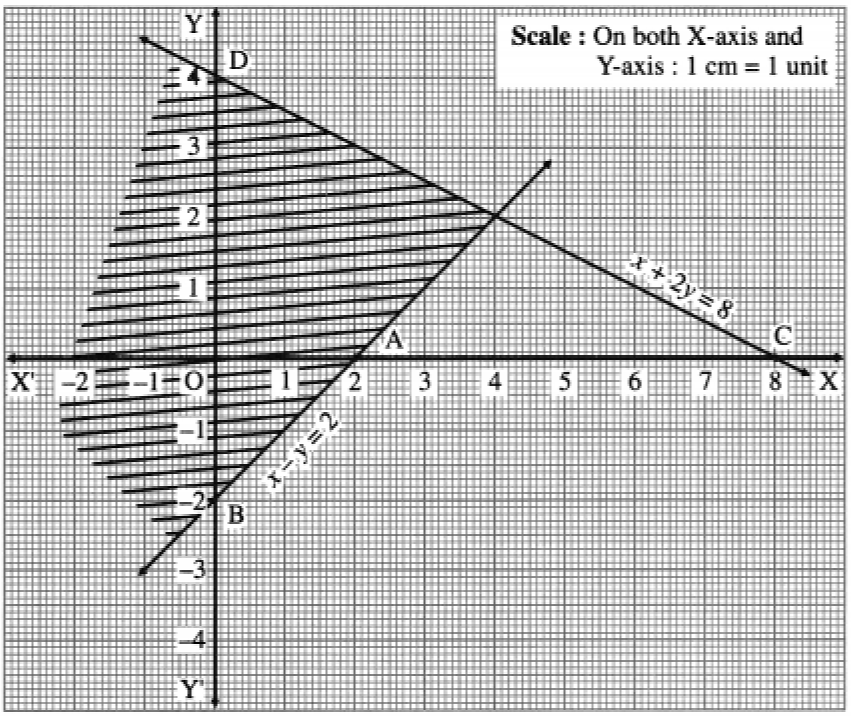
The solution set of the given system of inequalities is shaded in the graph.

(ii) $x - y \leq 2$ and $x + 2y \leq 8$

Solution:

First we draw the lines AB and CD whose equations are $x - y = 2$ and $x + 2y = 8$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x-y=2$	A (2, 0)	B (0, −2)	$\leqslant$	origin side of line AB
CD	$x+2y=8$	C (8, 0)	D (0, 4)	$\leqslant$	origin side of line CD



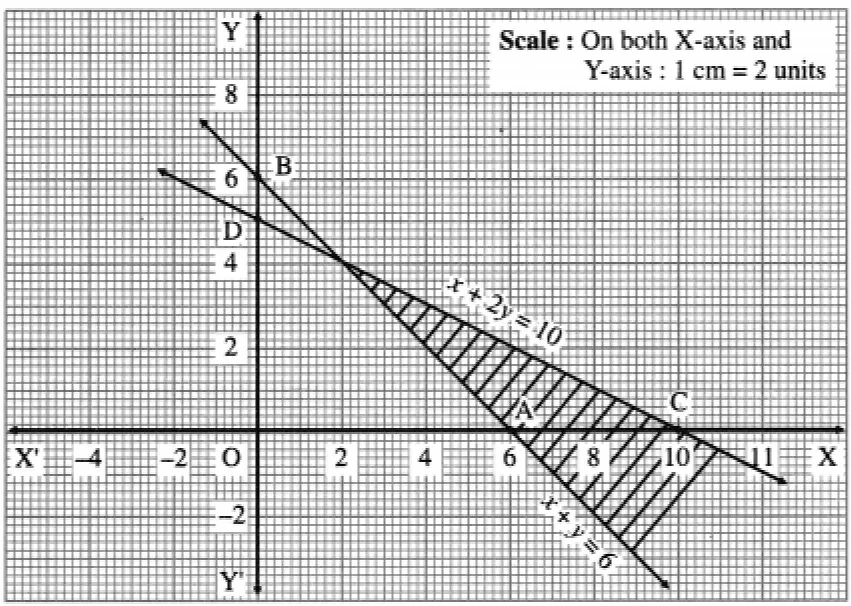
The solution set of the given system of inequalities is shaded in the graph.

(iii) x + y ≥ 6 and x + 2y ≤ 10

Solution:

First we draw the lines AB and CD whose equations are x + y = 6 and x + 2y = 10 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x+y=6$	A (6, 0)	B (0, 6)	$\geqslant$	non-origin side of line AB
CD	$x+2y=10$	C (10, 0)	D (0, 5)	$\leqslant$	origin side of line CD



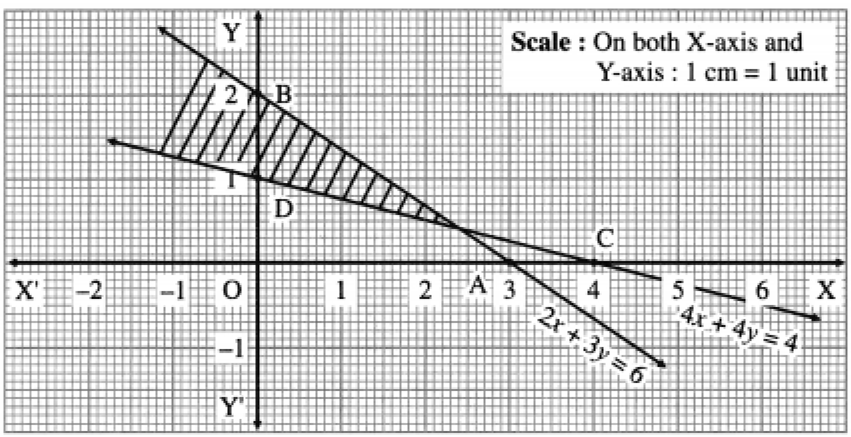
The solution set of the given system of inequalities is shaded in the graph.

(iv) 2x + 3y ≤ 6 and x + 4y ≥ 4

Solution:

First we draw the lines AB and CD whose equations are 2x + 3y = 6 and x + 4y = 4 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$2x+3y=6$	A (3, 0)	B (0, 2)	$\leqslant$	origin side of line AB
CD	$x+4y=4$	C (4, 0)	D (0, 1)	$\geqslant$	non-origin side of line CD



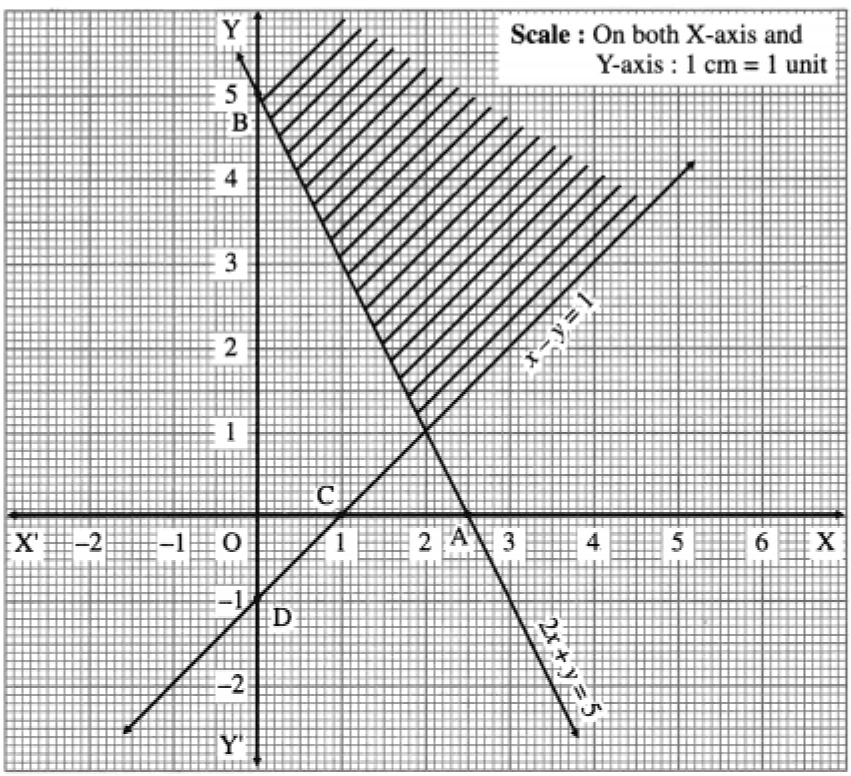
The solution set of the given system of inequalities is shaded in the graph.

(v) 2x + y ≥ 5 and x – y ≤ 1

Solution:

First we draw the lines AB and CD whose equations are 2x + y = 5 and x – y = 1 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$2x+y=5$	A (2.5, 0)	B (0, 5)	$\geqslant$	non-origin side of line AB
CD	$x-y=1$	C (1, 0)	D (0, −1)	$\leqslant$	origin side of line CD



The solution set of the given system of inequations is shaded in the graph.

Ex 7.2

I) Find the feasible solution of the following inequations graphically.

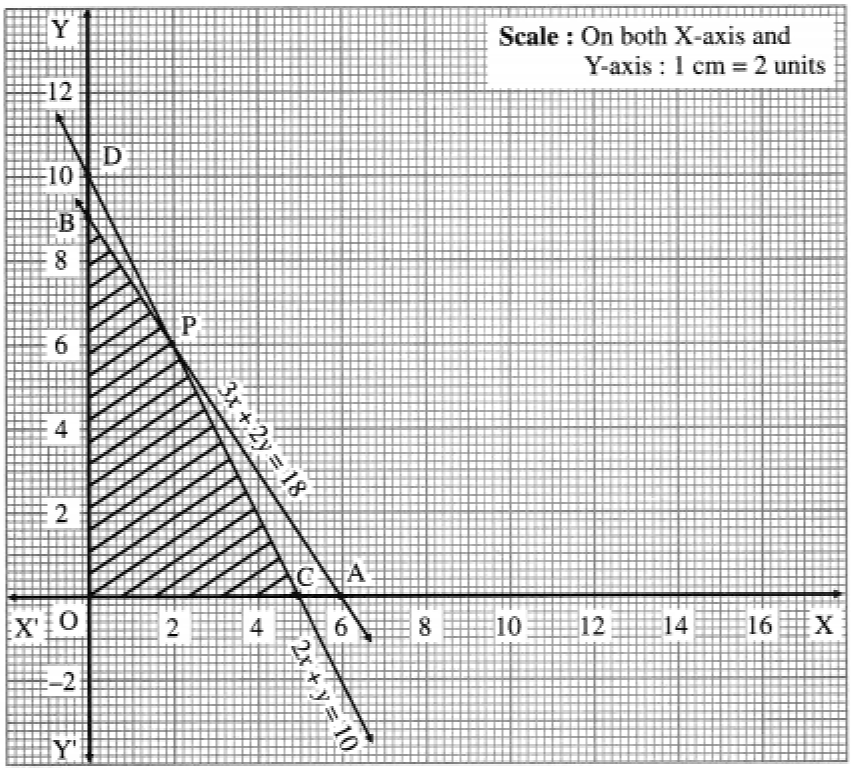
Question 1.

$3x + 2y \leq 18, 2x + y \leq 10, x \geq 0, y \geq 0$

Solution:

First we draw the lines AB and CD whose equations are $3x + 2y = 18$ and $2x + y = 10$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$3x+2y=18$	A (6, 0)	B (0, 9)	$\leqslant$	origin side of line AB
CD	$2x+y=10$	C (5, 0)	D (0, 10)	$\leqslant$	origin side of line CD



The feasible solution is OCPBO which is shaded in the graph.

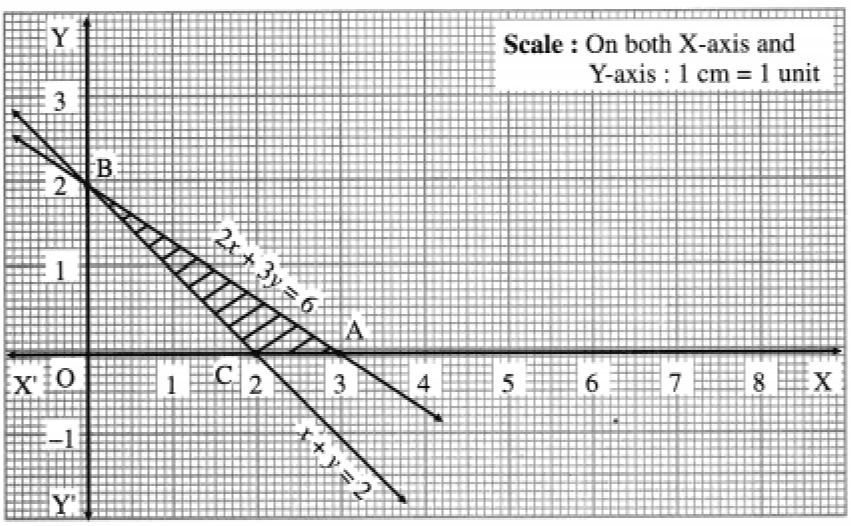
Question 2.

$2x + 3y \leq 6$, $x + y \geq 2$, $x \geq 0$, $y \geq 0$

Solution:

First we draw the lines AB and CB whose equations are $2x + 3y = 6$ and $x + y = 2$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$2x + 3y = 6$	A (3, 0)	B (0, 2)	$\leqslant$	origin side of line AB
CB	$x + y = 2$	C (2, 0)	B (0, 2)	$\geqslant$	non-origin side of line CB



The feasible solution is ΔABC which is shaded in the graph.

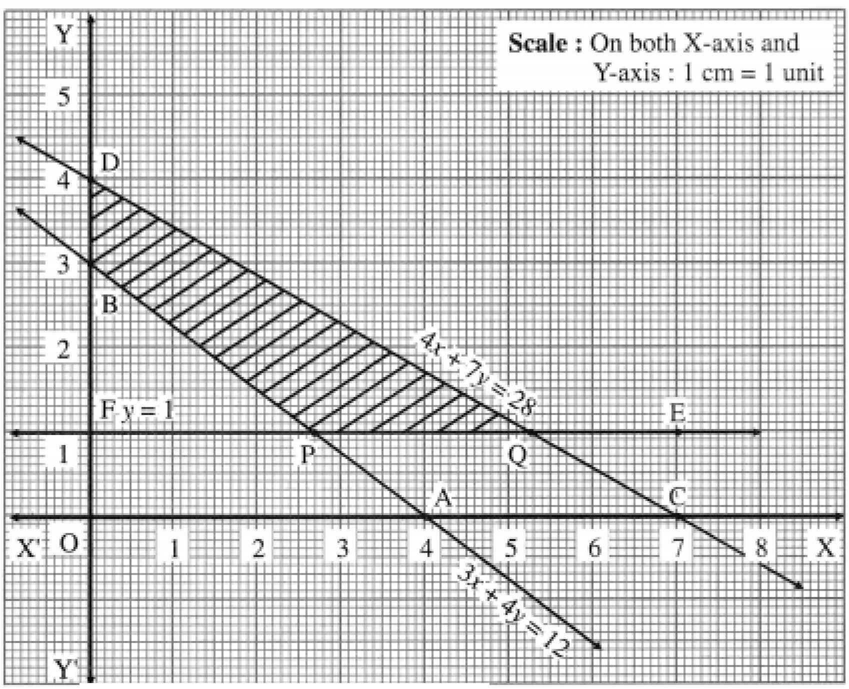
Question 3.

$3x + 4y \geq 12$, $4x + 7y \leq 28$, $y \geq 1$, $x \geq 0$

Solution:

First we draw the lines AB, CD and EF whose equations are $3x + 4y = 12$, $4x + 7y = 28$ and $y = 1$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$3x + 4y = 12$	A (4, 0)	B (0, 3)	$\geqslant$	non-origin side of line AB
CD	$4x + 7y = 28$	C (7, 0)	D (0, 4)	$\leqslant$	origin side of line CD
EF	$y = 1$	—	F (0, 1)	$\geqslant$	non-origin side of line EF



The feasible solution is PQDBP. which is shaded in the graph.

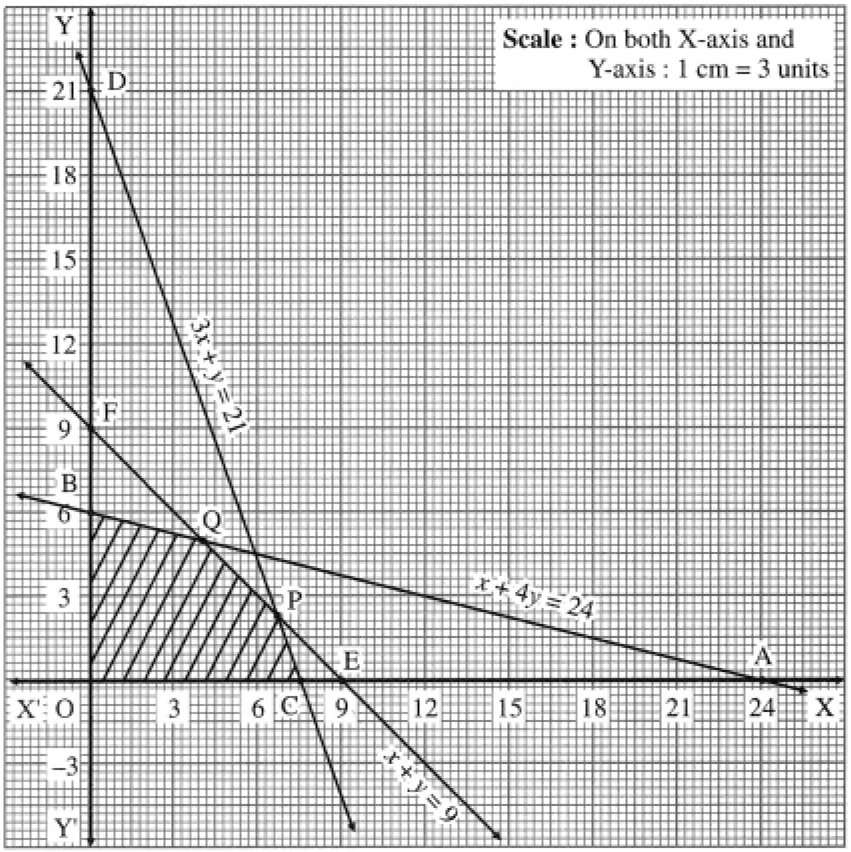
Question 4.

x + 4y ≤ 24, 3x + y ≤ 21, x + y ≤ 9, x ≥ 0, y ≥ 0.

Solution:

First we draw the lines AB, CD and EF whose equations are x + 4y = 24, 3x + y = 21 and x + y = 9 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x + 4y = 24$	A (24, 0)	B (0, 6)	$\leqslant$	origin side of line AB
CD	$3x + y = 21$	C (7, 0)	D (0, 21)	$\leqslant$	origin side of line CD
EF	$x + y = 9$	E (9, 0)	F (0, 9)	$\leqslant$	origin side of line EF



The feasible solution is OCPQBO. which is shaded in the graph.

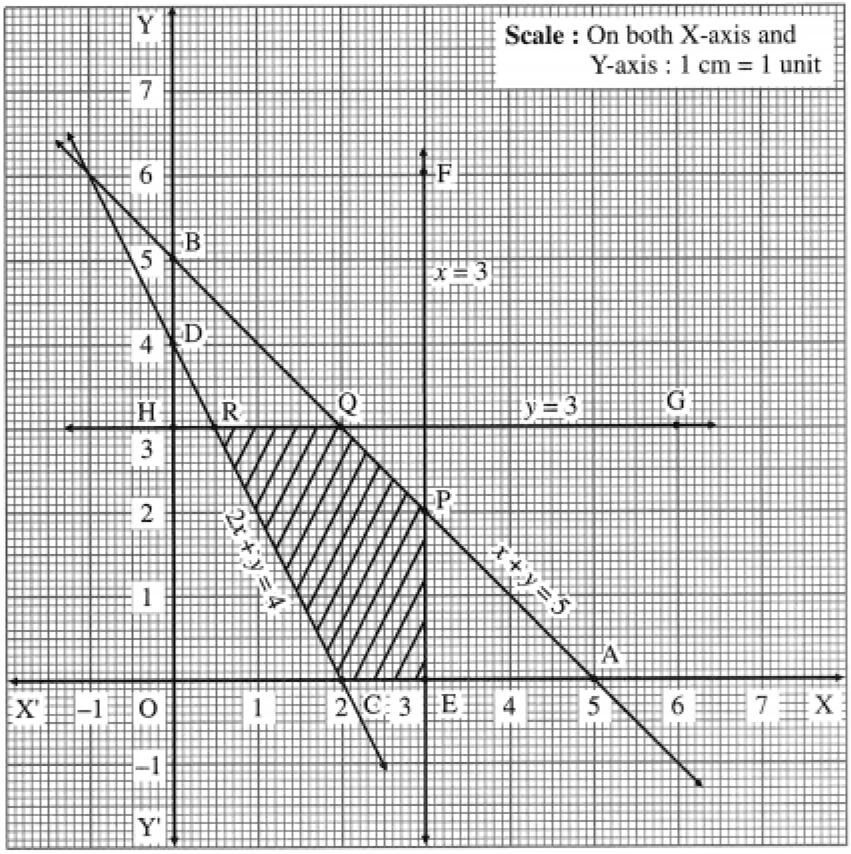
Question 5.

0 ≤ x ≤ 3, 0 ≤ y ≤ 3, x + y ≤ 5, 2x + y ≥ 4

Solution:

First we draw the lines AB, CD, EF and GH whose equations are x + y = 5, 2x + y = 4, x = 3 and y = 3 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x+y=5$	A (5, 0)	B (0, 5)	$\leqslant$	origin side of line AB
CD	$2x+y=4$	C (2, 0)	D (0, 4)	$\geqslant$	non-origin side of line CD
EF	$x=3$	E (3, 0)	—	$\leqslant$	origin side of line EF
GH	$y=3$	—	H (0, 3)	$\leqslant$	origin side of line GH



The feasible solution is CEPQRC. which is shaded in the graph.

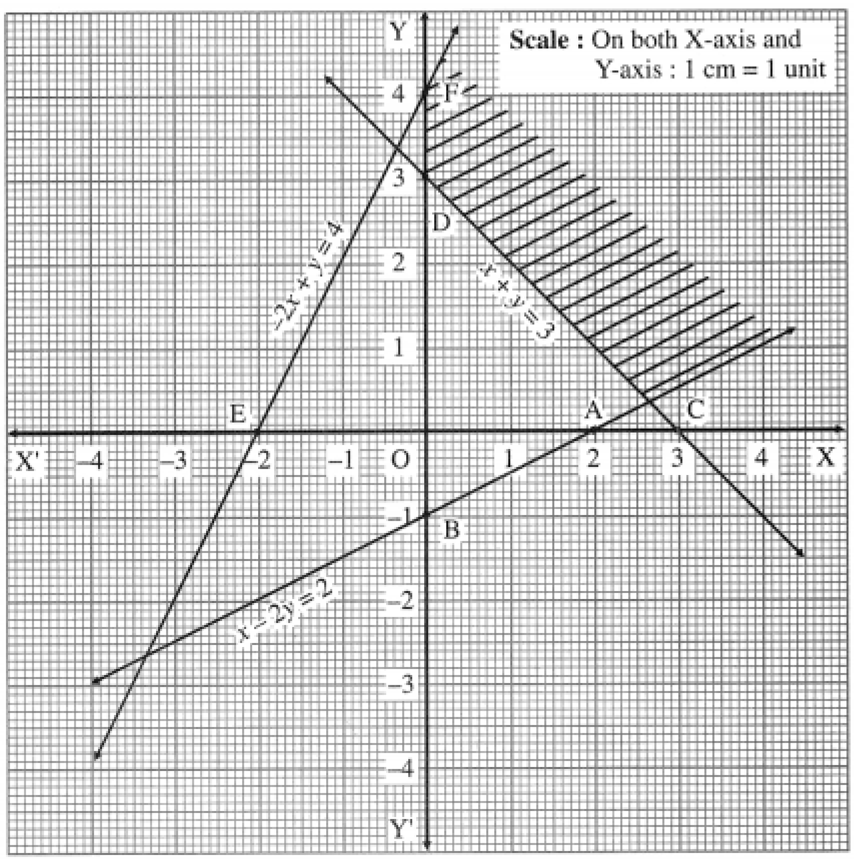
Question 6.

x – 2y ≤ 2, x + y ≥ 3, -2x + y ≤ 4, x ≥ 0, y ≥ 0

Solution:

First we draw the lines AB, CD and EF whose equations are x – 2y = 2, x + y = 3 and -2x + y = 4 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x-2y=2$	A (2, 0)	B (0, −1)	$\leqslant$	origin side of line AB
CD	$x+y=3$	C (3, 0)	D (0, 3)	$\geqslant$	non-origin side of line CD
EF	$-2x+y=4$	E (−2, 0)	F (0, 4)	$\leqslant$	origin side of line EF



The feasible solution is shaded in the graph.

Question 7.

A company produces two types of articles A and B which requires silver and gold. Each unit of A requires 3 gm of silver and 1 gm of gold, while each unit of B requires 2 gm of silver and 2 gm of gold. The company has 6 gm of silver and 4 gm of gold. Construct the inequations and find the feasible solution graphically.

Solution:

Let the company produces x units of article A and y units of article B.

The given data can be tabulated as:

	Article A (x)	Article B (y)	Availability
Gold	1	2	4
Silver	3	2	6

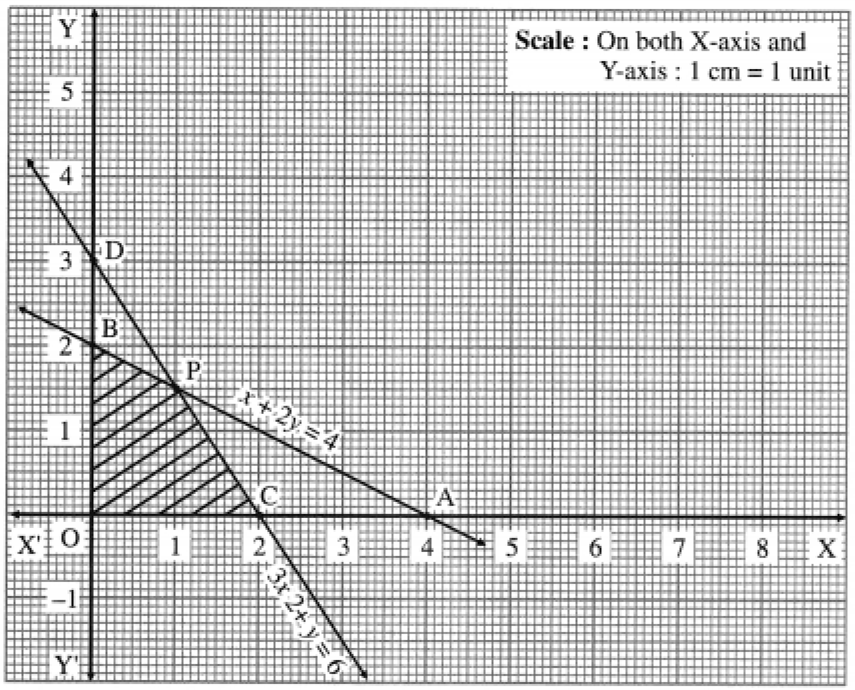
Inequations are :

$x + 2y \leq 4$ and $3x + 2y \leq 6$

x and y are number of items, $x \geq 0$, $y \geq 0$

First we draw the lines AB and CD whose equations are $x + 2y = 4$ and $3x + 2y = 6$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x + 2y = 4$	A (4, 0)	B (0, 2)	$\leqslant$	origin side of line AB
CD	$3x + 2y = 6$	C (2, 0)	D (0, 3)	$\leqslant$	origin side of line CD



The feasible solution is OCPBO. which is shaded in the graph.

Question 8.

A furniture dealer deals in tables and chairs. He has Rs.1,50,000 to invest and a space to store at most 60 pieces. A table costs him Rs.1500 and a chair Rs.750. Construct the inequations and find the feasible solution.

Question is modified

A furniture dealer deals in tables and chairs. He has ₹ 15,000 to invest and a space to store at most 60 pieces. A table costs him ₹ 150 and a chair ₹ 750. Construct the inequations and find the feasible solution.

Solution:

Let x be the number of tables and y be the number of chairs. Then $x \geq 0$, $y \geq 0$.

The dealer has a space to store at most 60 pieces.

$\therefore x + y \leq 60$

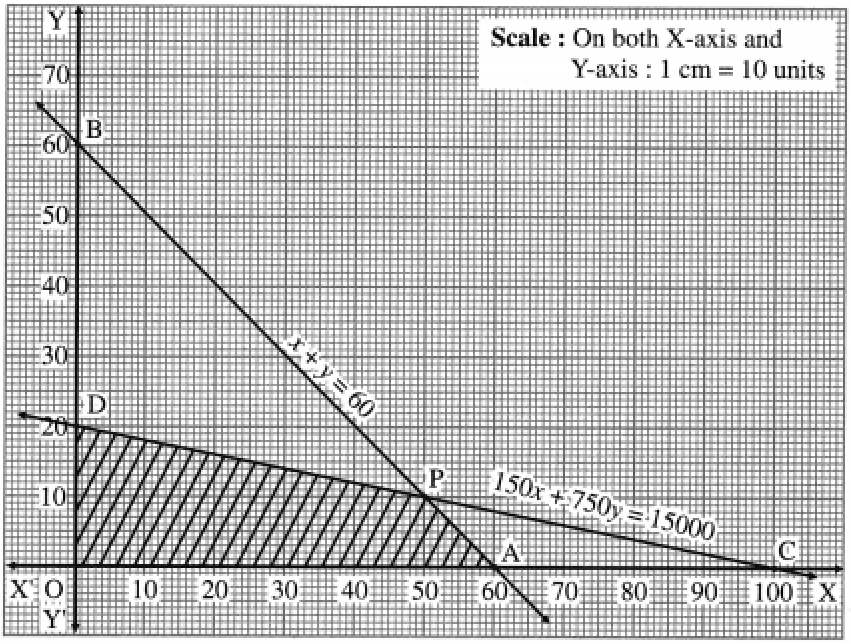
Since, the cost of each table is ₹ 150 and that of each chair is ₹ 750, the total cost of x tables and y chairs is $150x + 750y$. Since the dealer has ₹ 15,000 to invest, $150x + 750y \leq 15{,}000$

Hence the system of inequations are

$x + y \leq 60$, $150x + 750y \leq 15000$, $x \geq 0$, $y \geq 0$.

First we draw the lines AB and CD whose equations are $x + y = 60$ and $150x + 750y = 15{,}000$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x + 2y = 4$	A (4, 0)	B (0, 2)	$\leqslant$	origin side of line AB
CD	$3x + 2y = 6$	C (2, 0)	D (0, 3)	$\leqslant$	origin side of line CD



The feasible solution is OAPDO. which is shaded in the graph.

Ex 7.3

Question 1.

A manufacturing firm produces two types of gadgets A and B, which are first processed in the foundry and then sent to machine shop for finishing. The number of man hours of labour required in each shop for production of A and B per unit and the number of man hours available for the firm are as follows :

Gadgets	Foundry	Machine Shop
A	10	5
B	6	4
Time available (hour)	60	35

Profit on the sale of A is ₹ 30 and B is ₹ 20 per units. Formulate the L.P.P. to have maximum profit.

Solution:

Let the number of gadgets A produced by the firm be x and the number of gadgets B produced by the firm be y.

The profit on the sale of A is ₹ 30 per unit and on the sale of B is ₹ 20 per unit.

∴ total profit is $z = 30x + 20y$.

This is a linear function which is to be maximized. Hence it is the objective function.

The constraints are as per the following table :

	Gadgets A (x)	Gadgets B (y)	Total available Time (in hour)
Foundry	10	6	60
Machine shop	5	4	35

From the table total man hours of labour required for x units of gadget A and y units of gadget B in foundry is $(10x + 6y)$ hours and total man hours of labour required in machine shop is $(5x + 4y)$ hours.

Since, maximum time avilable in foundry and machine shops are 60 hours and 35 hours respectively.

Therefore, the constraints are $10x + 6y \leq 60$, $5x + 4y \leq 35$. Since, x and y cannot be negative, we have $x \geq 0$, $y \geq 0$. Hence, the given LPP can be formulated as :

Maximize $z = 30x + 20y$, subject to $10x + 6y \leq 60$, $5x + 4y \leq 35$, $x \geq 0$, $y \geq 0$.

Question 2.

In a cattle breading firm, it is prescribed that the food ration for one animal must contain 14, 22 and 1 units of nutrients A, B and C respectively. Two different kinds of fodder are available. Each unit of these two contains the following amounts of these three nutrients :

Fodder / Nutrient	Fodder 1	Fodder 2
Nutrients A	2	1
Nutrients B	2	3
Nutrients C	1	1

The cost of fodder 1 is ₹3 per unit and that of fodder ₹ 2, Formulate the L.P.P. to minimize the cost.

Solution:

Let x units of fodder 1 and y units of fodder 2 be prescribed.

The cost of fodder 1 is ₹ 3 per unit and cost of fodder 2 is ₹ 2 per unit.

∴ total cost is $z = 3x + 2y$

This is the linear function which is to be minimized. Hence it is the objective function. The constraints are as per the following table :

Fodder → / Nutrient ↓	Fodder 1	Fodder 2	Minimum requirements
Nutrients A	2	1	14
Nutrients B	2	3	22
Nutrients C	1	1	1

From table fodder contains $(2x + y)$ units of nutrients A, $(2x + 3y)$ units of nutrients B and $(x + y)$ units of nutrients C. The minimum requirements of these nutrients are 14 units, 22 units and 1 unit respectively.

Therefore, the constraints are

$2x + y \geq 14, 2x + 3y \geq 22, x + y \geq 1$

Since, number of units (i.e. x and y) cannot be negative, we have, $x \geq 0, y \geq 0$.

Hence, the given LPP can be formulated as

Minimize $z = 3x + 2y$, subject to

$2x + y \geq 14, 2x + 3y \geq 22, x + y \geq 1, x \geq 0, y \geq 0$.

Question 3.

A company manufactures two types of chemicals A and B. Each chemical requires two types of raw material P and Q. The table below shows number of units of P and Q required to manufacture one unit of A and one unit of B and the total availability of P and Q.

Raw Material \ Chemical	A	B	Availability
P	3	2	120
Q	2	5	160

The company gets profits of ₹350 and ₹400 by selling one unit of A and one unit of B respectively. (Assume that the entire production of A and B can be sold). How many units of the chemicals A and B should be manufactured so that the company get maximum profit? Formulate the problem as L.P.P. to maximize the profit.

Solution:

Let the company manufactures x units of chemical A and y units of chemical B. Then the total profit f to the company is p = ₹ (350x + 400y).

This is a linear function which is to be maximized.

Hence, it is the objective function.

The constraints are as per the following table:

Raw Material ↓ \ Chemical →	A (x)	B (y)	Availability
P	3	2	120
Q	2	5	160

The raw material P required for x units of chemical A and y units of chemical B is 3x + 2y. Since, the maximum availability of P is 120, we have the first constraint as 3x + 2y ≤ 120.

Similarly, considering the raw material Q, we have : $2x + 5y \le 160$.

Since, x and y cannot be negative, we have, $x \ge 0, y \ge 0$.

Hence, the given LPP can be formulated as :

Maximize $p = 350x + 400y$, subject to

$3x + 2y \le 120$, $2x + 5y \le 160$, $x \ge 0$, $y \ge 0$.

Question 4.

A printing company prints two types of magazines A and B. The company earns ₹ 10 and ₹ 15 on magazines A and B per copy. These are processed on three machines I, II, III. Magazine A requires 2 hours on Machine I, 5 hours on Machine II and 2 hours on Machine III. Magazine B requires 3 hours on Machine I, 2 hours on Machine II and 6 hours on Machine III. Machines I, II, III are available for 36, 50, 60 hours per week respectively. Formulate the L.P.P. to determine weekly production of A and B, so that the total profit is maximum.

Solution:

Let the company prints x magazine of type A and y magazine of type B.

Profit on sale of magazine A is ₹ 10 per copy and magazine B is ₹ 15 per copy.

Therefore, the total earning z of the company is

$z = ₹\ (10x + 15y)$.

This is a linear function which is to be maximized.

Hence, it is the objective function.

The constraints are as per the following table:

Machine type ↓ / Magazine type →	Time required per unit		Available time per week (in hours)
	Magazine A (x)	Magazine B (y)	
Machine I	2	3	36
Machine II	5	2	50
Machine III	2	6	60

From the table, the total time required for Machine I is $(2x + 3y)$ hours, for Machine II is $(5x + 2y)$ hours and for Machine III is $(2x + 6y)$ hours. The machines I, II, III are available for 36,50 and 60 hours per week. Therefore, the constraints are $2x + 3y \le 36$, $5x + 2y \le 50$, $2x + 6y \le 60$.

Since x and y cannot be negative. We have, $x \ge 0, y \ge 0$. Hence, the given LPP can be formulated as :

Maximize $z = 10x + 15y$, subject to

$2x + 3y \le 36, 5x + 2y \le 50, 2x + 6y \le 60, x \ge 0, y \ge 0$.

Question 5.

A manufacture produces bulbs and tubes. Each of these must be processed through two machines M_1 and M_2. A package of bulbs require 1 hour of work on Machine M_1 and 3 hours of work on M_2. A package of tubes require 2 hours on Machine M_1 and 4 hours on Machine M_2. He earns a profit of ₹ 13.5 per package of bulbs and ₹ 55 per package of tubes. Formulate the LLP to maximize the profit, if he operates the machine M_1, for atmost 10 hours a day and machine M_2 for atmost 12 hours a day.

Solution:

Let the number of packages of bulbs produced by manufacturer be x and packages of tubes be y. The manufacturer earns a profit of ₹ 13.5 per package of bulbs and ₹ 55 per package of tubes.

Therefore, his total profit is p = ₹ (13.5x + 55y)

This is a linear function which is to be maximized.

Hence, it is the objective function.

The constraints are as per the following table :

	Bulbs (x)	Tubes (y)	Available Time
Machine M_1	1	2	10
Machine M_2	3	4	12

From the table, the total time required for Machine M_1 is (x + 2y) hours and for Machine M_2 is (3x + 4y) hours.

Given Machine M_1 and M_2 are available for atmost 10 hours and 12 hours a day respectively.

Therefore, the constraints are $x + 2y \le 10$, $3x + 4y \le 12$. Since, x and y cannot be negative, we have, $x \ge 0$, $y \ge 0$. Hence, the given LPP can be formulated as :

Maximize $p = 13.5x + 55y$, subject to $x + 2y \le 10$, $3x + 4y \le 12$, $x \ge 0$, $y \ge 0$.

Question 6.

A company manufactures two types of fertilizers F_1 and F_2. Each type of fertilizer requires two raw materials A and B. The number of units of A and B required to manufacture one unit of fertilizer F_1 and F_2 and availability of the raw materials A and B per day are given in the

table below :

Fertilizers / Raw Material	F1	F2	Availability
A	2	3	40
B	1	4	70

By selling one unit of F_1 and one unit of F_2, company gets a profit of ₹ 500 and ₹ 750

respectively. Formulate the problem as L.P.P. to maximize the profit.

Solution:

Let the company manufactures x units of fertilizers F_1 and y units of fertilizers F_1. Then the total profit to the company is

z = ₹(500x + 750y).

This is a linear function that is to be maximized. Hence, it is an objective function.

Fertilizers→ Raw Material ↓	F_1	F_2	Availability
A	2	3	40
B	1	4	70

The raw material A required for x units of Fertilizers F_1 and y units of Fertilizers F_2 is 2x + Since the maximum availability of A is 40, we have the first constraint as $2x + 3y \leq 40$.

Similarly, considering the raw material B, we have $x + 4y \leq 70$.

Since, x and y cannot be negative, we have, $x \geq 0, y \geq 0$.

Hence, the given LPP can be formulated as:

Maximize $z = 500x + 750y$, subject to

$2x + 3y \leq 40, x + 4y \leq 70, x \geq 0, y \geq 0$.

Question 7.

A doctor has prescribed two different units of foods A and B to form a weekly diet for a sick person. The minimum requirements of fats, carbohydrates and proteins are 18, 28, 14 units respectively. One unit of food A has 4 units of fats. 14 units of carbohydrates and 8 units of protein. One unit of food B has 6 units of fat, 12 units of carbohydrates and 8 units of protein. The price of food A is ₹ 4.5 per unit and that of food B is ₹ 3.5 per unit. Form the L.P.P. so that the sick person's diet meets the requirements at a minimum cost.

Solution:

Let the diet of sick person include x units of food A and y units of food B.

Then $x \geq 0, y \geq 0$.

The prices of food A and B are ₹ 4.5 and ₹ 3.5 per unit respectively.

Therefore, the total cost is z = ₹ $(4.5x + 3.5y)$

This is the linear function which is to be minimized.

Hence, it is objective function.

The constraints are as per the following table :

Ingredients ↓ \ Food Type →	Food A ₹ (x)	Food B ₹ (y)	Minimum requirements
Fats	4	6	18
Carbohydrates	14	12	28
Proteins	8	8	14

From the table, the sick person's diet will include $(4x + 6y)$ units of fats, $(14x + 12y)$ units of carbohydrates and $(8x + 8y)$ units of proteins. The minimum requirements of these ingredients are 18 units, 28 units and 14 units respectively.

Therefore, the constraints are

$4x + 6y \geq 18$, $14x + 12y \geq 28$, $8x + 8y \geq 14$.

Hence, the given LPP can be formulated as

Minimize $z = 4.5x + 3.5y$, subject to

$4x + 6y \geq 18$, $14x + 12y \geq 28$, $8x + 8y \geq 14$, $x \geq 0$, $y \geq 0$.

Question 8.

If John drives a car at a speed of 60 kms/hour he has to spend ₹ 5 per km on petrol. If he drives at a faster speed of 90 kms/hour, the cost of petrol increases to ₹ 8 per km. He has ₹ 600 to spend on petrol and wishes to travel the maximum distance within an hour. Formulate the above problem as L.P.P.

Solution:

Let John travel xl km at a speed of 60 km/ hour and x_1 km at a speed of 90 km/hour.

Therefore, time required to travel a distance of x_1 km is x160 hours and the time required to travel a distance of

x_2 km is x290 hours.

∴ total time required to travel is (x160+x290) hours.

Since he wishes to travel the maximum distance within an hour,

x160+x290 ≤ 1

He has to spend ₹ 5 per km on petrol at a speed of 60 km/hour and ₹ 8 per km at a speed of 90 km/hour.

∴ the total cost of travelling is ₹ $(5x_1 + 8x_2)$

Since he has ₹ 600 to spend on petrol,

$5x_1 + 8x_2 \leq 600$

Since distance is never negative, $x_1 \geq 0$, $x_2 \geq 0$.

Total distance travelled by John is z. = $(x_1 + x_2)$ km.

This is the linear function which is to be maximized.

Hence, it is objective function.

Hence, the given LPP can be formulated as :

Maximize $z = x_1 + x_2$, subject to

x160+x290 ≤ 1, $5x_1 + 8x_2 \leq 600$, $x_1 \geq 0$, $x_2 \geq 0$.

Question 9.

The company makes concrete bricks made up of cement and sand. The weight of a concrete brick has to be least 5 kg. Cement costs ₹ 20 per kg. and sand costs of ₹ 6 per kg. strength consideration dictate that a concrete brick should contain minimum 4 kg. of cement and not more than 2 kg. of sand. Form the L.P.P. for the cost to be minimum.

Solution:

Let the company use x_1 kg of cement and x_2 kg of sand to make concrete bricks.

Cement costs ₹ 20 per kg and sand costs ₹ 6 per kg.

∴ the total cost c = ₹ $(20x_1 + 6x_2)$

This is a linear function which is to be minimized.

Hence, it is the objective function.

Total weight of brick = $(x_1 + x_2)$ kg

Since the weight of concrete brick has to be at least 5 kg,

∴ $x_1 + x_2 \geq 5$.

Since concrete brick should contain minimum 4 kg of cement and not more than 2 kg of sand,

$x_1 \geq 4$ and $0 \leq x_2 \leq 2$

Hence, the given LPP can be formulated as :

Minimize $c = 20x_1 + 6x_2$, subject to

$x_1 + x_2 \geq 5$, $x_1 \geq 4$, $0 \leq x_2 \leq 2$.

Ex 7.4

Question 1.

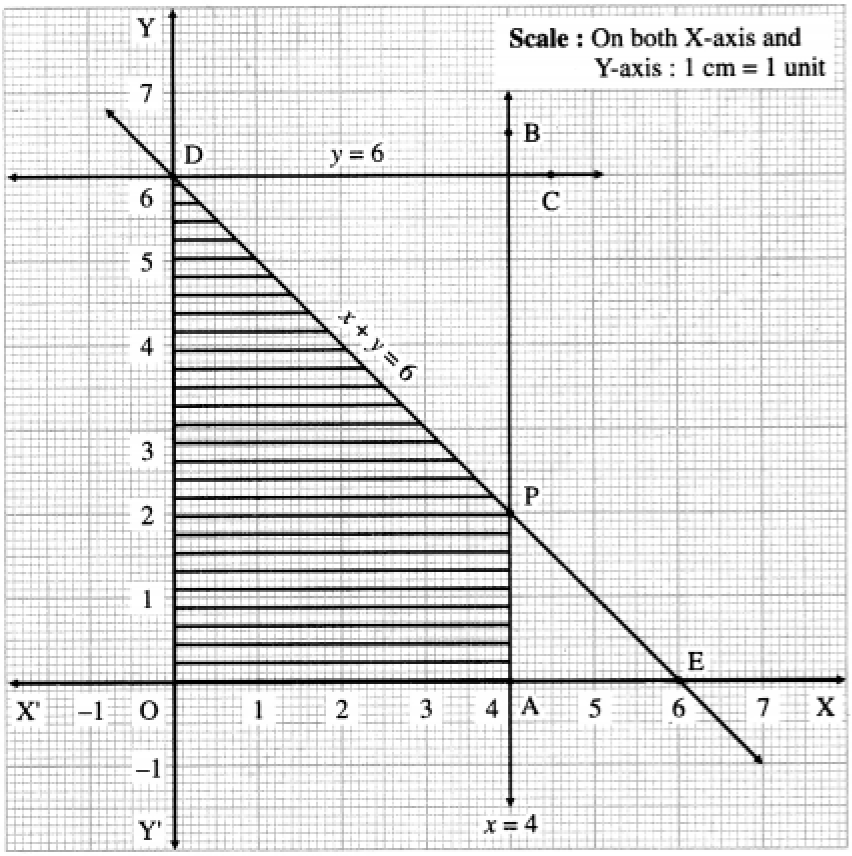
Maximize : $z = 11x + 8y$ subject to $x \leq 4$, $y \leq 6$,

$x + y \leq 6$, $x \geq 0$, $y \geq 0$.

Solution:

First we draw the lines AB, CD and ED whose equations are $x = 4$, $y = 6$ and $x + y = 6$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x=4$	A (4, 0)	—	$\leqslant$	origin side of the line AB
CD	$y=6$	—	D (0, 6)	$\leqslant$	origin side of the line CD
ED	$x+y=6$	E (6, 0)	D (0, 6)	$\leqslant$	origin side of the line ED



The feasible region is shaded portion OAPDO in the graph.

The vertices of the feasible region are O (0, 0), A (4, 0), P and D (0, 6)

P is point of intersection of lines x + y = 6 and x = 4.

Substituting x = 4 in x + y = 6, we get

4 + y = 6 ∴ y = 2 ∴ P is (4, 2).

∴ the corner points of feasible region are O (0, 0), A (4, 0), P(4, 2) and D(0 ,6).

The values of the objective function z = 11x + 8y at these vertices are

z (O) = 11(0) + 8(0) = 0 + 0 = 0

z(a) = 11(4) + 8(0) = 44 + 0 = 44

z (P) = 11(4) + 8(2) = 44 + 16 = 60

z (D) = 11(0) + 8(2) = 0 + 16 = 16

∴ z has maximum value 60, when x = 4 and y = 2.

Question 2.

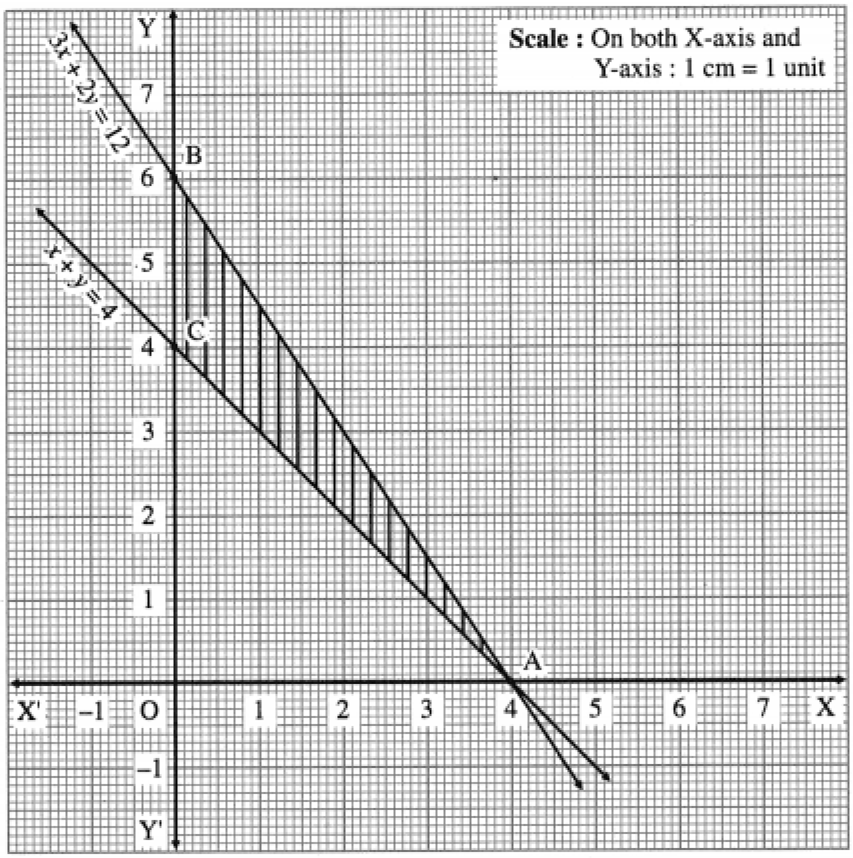
Maximize : z = 4x + 6y subject to $3x + 2y \leq 12$,

$x + y \geq 4$, $x, y \geq 0$.

Solution:

First we draw the lines AB and AC whose equations are 3x + 2y = 12 and x + y = 4 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$3x+2y=12$	A (4, 0)	B (0, 6)	$\leqslant$	origin side of line AB
AC	$x+y=4$	A (4, 0)	C (0, 4)	$\geqslant$	non-origin side of line AC



The feasible region is the ΔABC which is shaded in the graph.

The vertices of the feasible region (i.e. corner points) are A (4, 0), B (0, 6) and C (0, 4).

The values of the objective function z = 4x + 6y at these vertices are

z(a) = 4(4) + 6(0) = 16 + 0 = 16

z(B) = 4(0)+ 6(6) = 0 + 36 = 36

z(C) = 4(0) + 6(4) = 0 + 24 = 24

∴ has maximum value 36, when x = 0, y = 6.

Question 3.

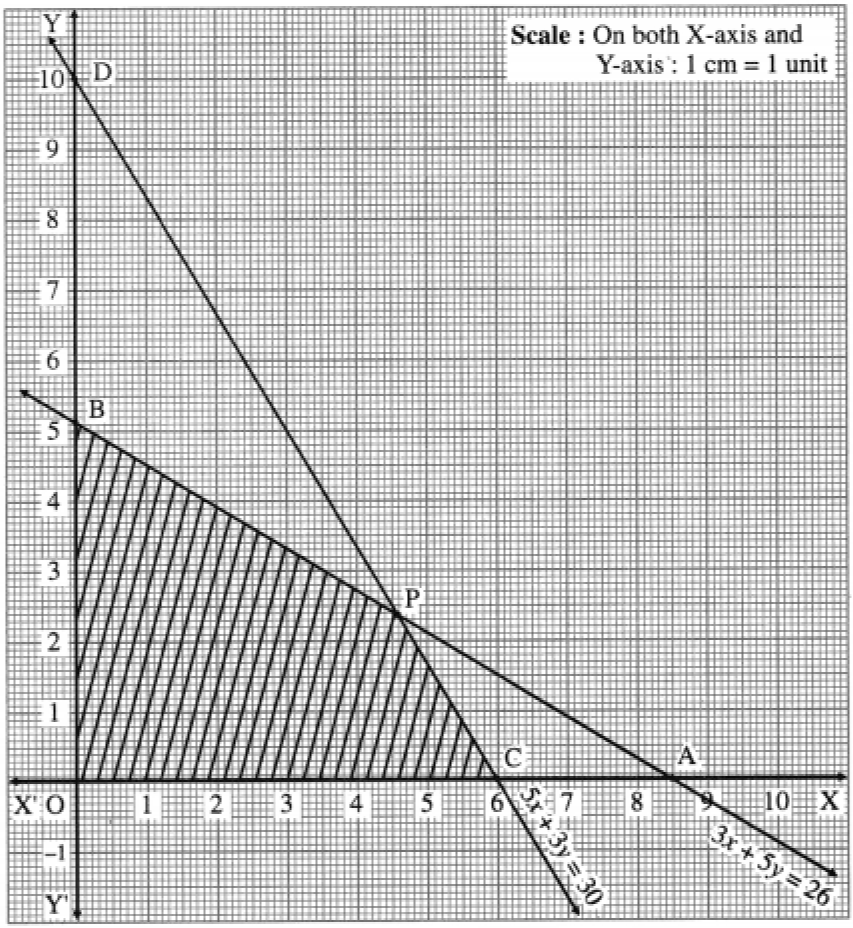
Maximize : $z = 7x + 11y$ subject to $3x + 5y \leq 26$

$5x + 3y \leq 30$, $x \geq 0$, $y \geq 0$.

Solution:

First we draw the lines AB and CD whose equations are $3x + 5y = 26$ and $5x + 3y = 30$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$3x + 5y = 26$	$A\left(\frac{26}{3}, 0\right)$	$B\left(0, \frac{26}{5}\right)$	$\leqslant$	origin side of line AB
CD	$5x + 3y = 30$	$C(6, 0)$	$D(0, 10)$	$\leqslant$	origin side of line CD



The feasible region is OCPBO which is shaded in the graph.

The vertices of the feasible region are O (0, 0), C (6, 0), p and B(0, 265)

The vertex P is the point of intersection of the lines

$3x + 5y = 26$ ... (1)

and $5x + 3y = 30$ ... (2)

Multiplying equation (1) by 3 and equation (2) by 5, we get

$9x + 15y = 78$

and $25x + 15y = 150$

On subtracting, we get

16x = 72 ∴ x = 7216=92 = 4.5

Substituting $x = 4.5$ in equation (2), we get

$5(4.5) + 3y = 30$

$22.5 + 3y = 30$

$\therefore 3y = 7.5 \therefore y = 2.5$

∴ P is (4.5, 2.5)

The values of the objective function $z = 7x + 11y$ at these corner points are

$z(O) = 7(0) + 11(0) = 0 + 0 = 0$

$z(C) = 7(6) + 11(0) = 42 + 0 = 42$

$z(P) = 7(4.5) + 11(2.5) = 31.5 + 27.5 = 59.0 = 59$

z(B) = 7(0) + 11(265)=2865 = 57.2

∴ z has maximum value 59, when $x = 4.5$ and $y = 2.5$.

Question 4.

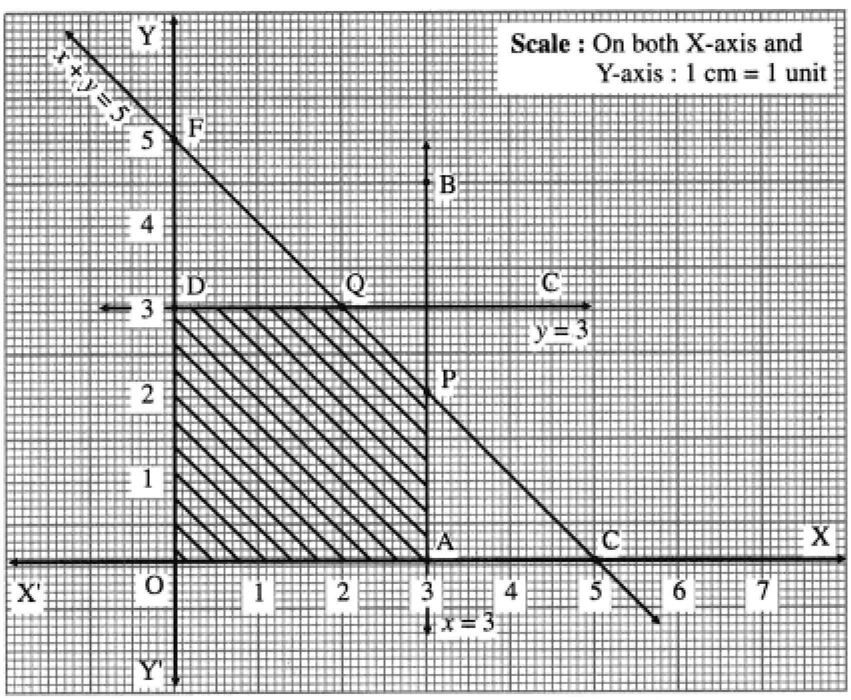
Maximize : $z = 10x + 25y$ subject to $0 \le x \le 3$,

$0 \le y \le 3$, $x + y \le 5$ also find maximum value of z.

Solution:

First we draw the lines AB, CD and EF whose equations are $x = 3$, $y = 3$ and $x + y = 5$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x=3$	A (3, 0)	—	$\leqslant$	origin side of line AB
CD	$y=3$	—	D (0, 3)	$\leqslant$	origin side of line CD
EF	$x+y=5$	E (5, 0)	F (0, 5)	$\leqslant$	origin side of line EF



The feasible region is OAPQDO which is shaded in the i graph.

The vertices of the feasible region are O (0, 0), A (3, 0), P, Q and D(0, 3).

t P is the point of intersection of the lines $x + y = 5$ and $x = 3$.

Substituting $x = 3$ in $x + y = 5$, we get

$3 + y = 5 \therefore y = 2$

$\therefore$ P is (3, 2)

Q is the point of intersection of the lines $x + y = 5$ and $y = 3$

Substituting $y = 3$ in $x + y = 5$, we get

$x + 3 = 5 \therefore x = 2$

$\therefore$ Q is (2, 3)

The values of the objective function $z = 10x + 25y$ at these vertices are

$z(O) = 10(0) + 25(0) = 0 + 0 = 0$

$z(a) = 10(3) + 25(0) = 30 + 0 = 30$

$z(P) = 10(3) + 25(2) = 30 + 50 = 80$

$z(Q) = 10(2) + 25(3) = 20 + 75 = 95$

$z(D) = 10(0)+ 25(3) = 0 + 75 = 75$

$\therefore$ z has maximum value 95, when $x = 2$ and $y = 3$.

Question 5.

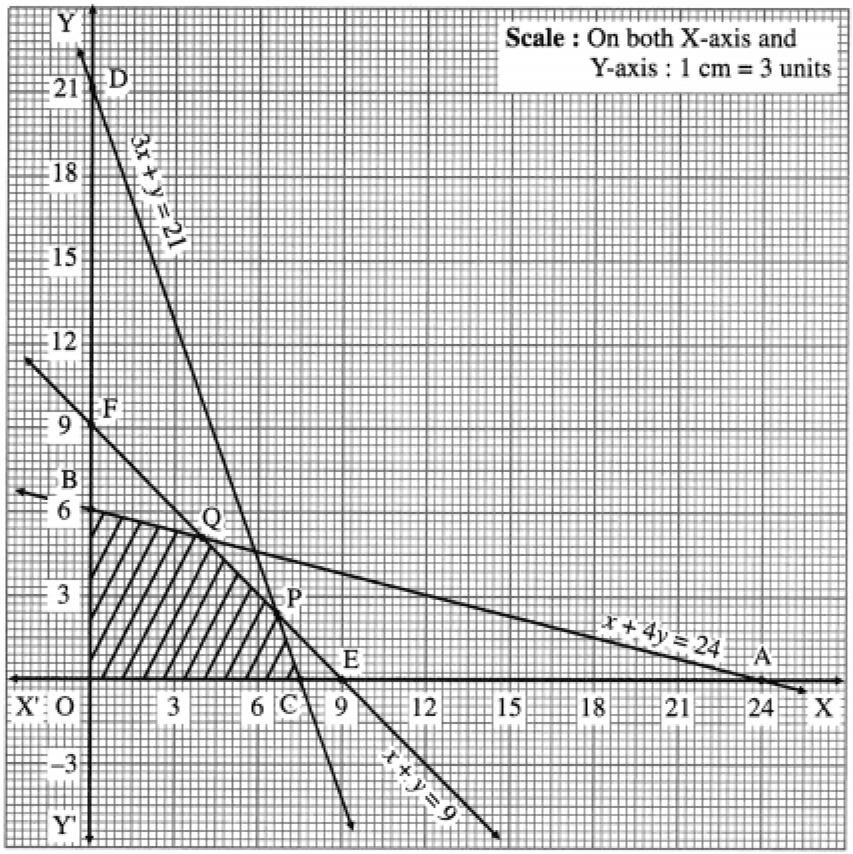
Maximize : $z = 3x + 5y$ subject to $x + 4y \le 24$, $3x + y \le 21$,

$x + y \le 9$, $x \ge 0$, $y \ge 0$ also find maximum value of z.

Solution:

First we draw the lines AB, CD and EF whose equations are x + 4y = 24, 3x + y = 21 and x + y = 9 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x+4y=24$	A (24, 0)	B (0, 6)	$\leqslant$	origin side of line AB
CD	$3x+y=21$	C (7, 0)	D (0, 21)	$\leqslant$	origin side of line CD
EF	$x+y=9$	E (9, 0)	F (0, 9)	$\leqslant$	origin side of line EF



The feasible region is OCPQBO which is shaded in the graph.

The vertices of the feasible region are O (0, 0), C (7, 0), P, Q and B (0, 6).

P is the point of intersection of the lines

3x + y = 21 … (1)

and x + y = 9 … (2)

On subtracting, we get 2x = 12 ∴ x = 6

Substituting x = 6 in equation (2), we get

6 + y = 9 ∴ y = 3

$\therefore$ P = (6, 3)

Q is the point of intersection of the lines

$x + 4y = 24$ ... (3)

and $x + y = 9$ ... (2)

On subtracting, we get

$3y = 15 \therefore y = 5$

Substituting y = 5 in equation (2), we get

$x + 5 = 9 \therefore x = 4$

$\therefore$ Q = (4, 5)

$\therefore$ the corner points of the feasible region are o(0,0), C(7, 0), P (6, 3), Q (4, 5) and B (0, 6).

The values of the objective function $2 = 3x + 5y$ at these corner points are

$z(O) = 3(0)+ 5(0) = 0 + 0 = 0$

$z(C) = 3(7) + 5(0) = 21 + 0 = 21$

$z(P) = 3(6) + 5(3) = 18 + 15 = 33$

$z(Q) = 3(4) + 5(5) = 12 + 25 = 37$

$z(B) = 3(0)+ 5(6) = 0 + 30 = 30$

$\therefore$ z has maximum value 37, when x = 4 and y = 5.

Question 6.

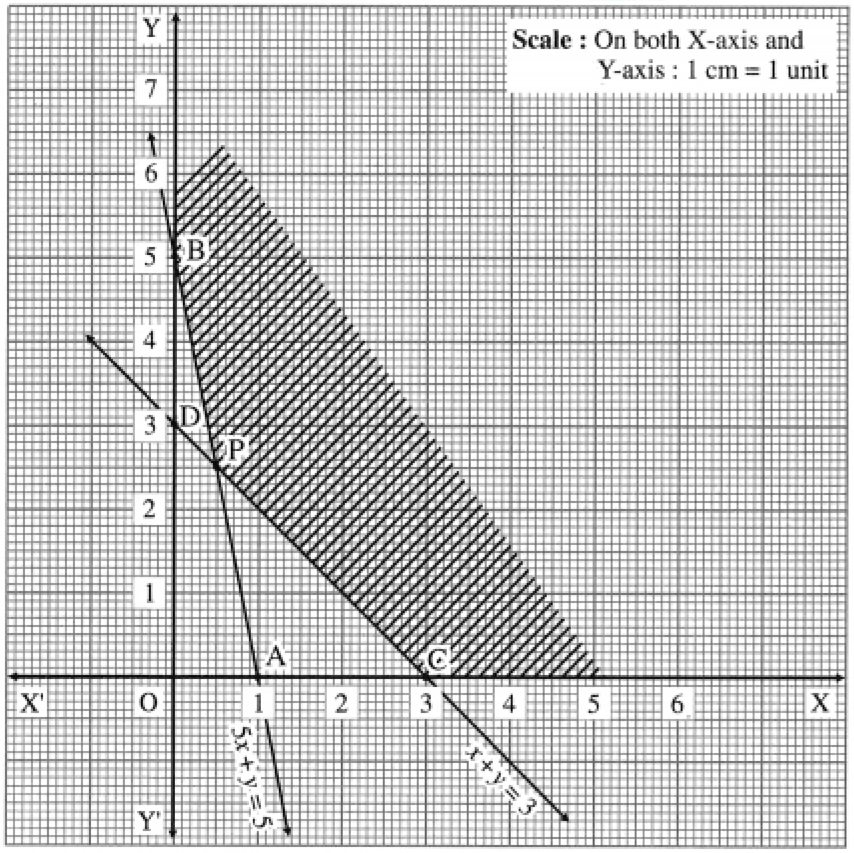
Minimize : $z = 7x + y$ subject to $5x + y \geq 5$, $x + y \geq 3$,

$x \ge 0, y \ge 0$.

Solution:

First we draw the lines AB and CD whose equations are $5x + y = 5$ and $x + y = 3$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$5x + y = 5$	A (1, 0)	B (0, 5)	$\geqslant$	non-origin side of line AB
CD	$x + y = 3$	C (3, 0)	D (0, 3)	$\geqslant$	non-origin side of line CD



The feasible region is XCPBY which is shaded in the graph.

The vertices of the feasible region are C (3, 0), P and B (0, 5).

P is the point of the intersection of the lines

$5x + y = 5$

and $x + y = 3$

On subtracting, we get

$4x = 2 \therefore x = 12$

Substituting $x = 12$ in $x + y = 3$, we get

12 + y = 3

∴ y = 52 ∴ P = (12,52)

The values of the objective function z = 7x + y at these vertices are

z(C) = 7(3) + 0 = 21

z(B) = 7(0) + 5 = 5

∴ z has minimum value 5, when x = 0 and y = 5.

Question 7.

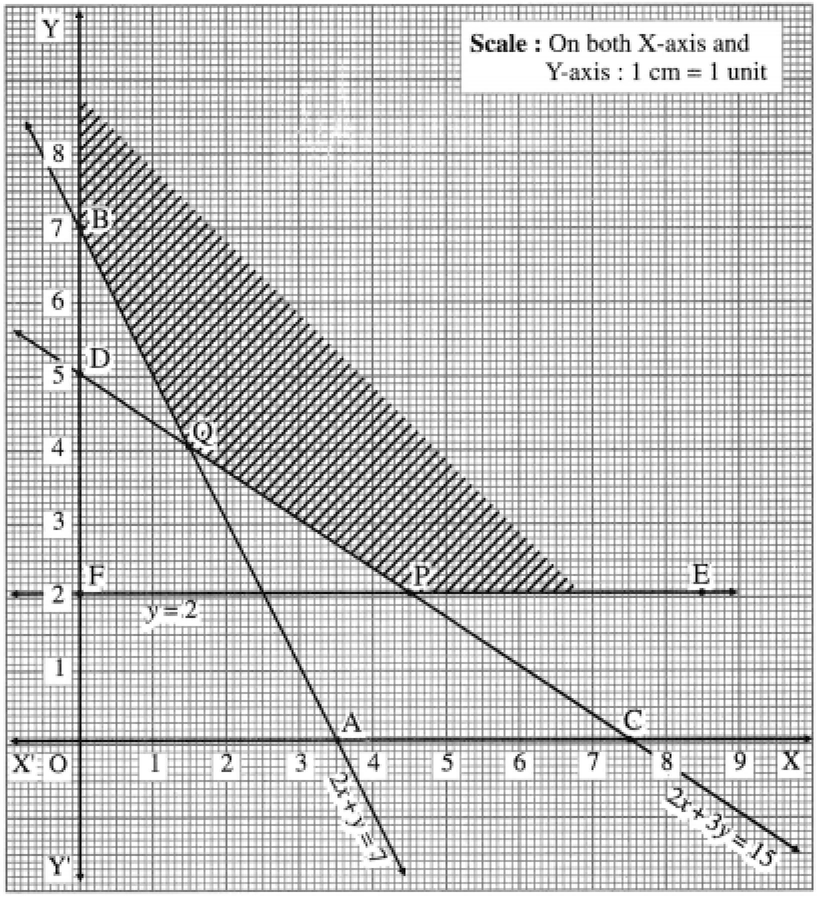
Minimize : z = 8x + 10y subject to 2x + y ≥ 7, 2x + 3y ≥ 15,

y ≥ 2, x ≥ 0, y ≥ 0.

Solution:

First we draw the lines AB, CD and EF whose equations are 2x + y = 7, 2x + 3y = 15 and y = 2 respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$2x+y=7$	A (3.5, 0)	B (0, 7)	$\geqslant$	non-origin side of line AB
CD	$2x+3y=15$	C (7.5, 0)	D (0, 5)	$\geqslant$	non-origin side of line CD
EF	$y=2$	—	F (0, 2)	$\geqslant$	non-origin side of line EF



The feasible region is EPQBY which is shaded in the graph. The vertices of the feasible region are P, Q and B(0,7). P is the point of intersection of the lines $2x + 3y = 15$ and $y = 2$.

Substituting y – 2 in $2x + 3y = 15$, we get $2x + 3(2) = 15$

$\therefore 2x = 9 \therefore x = 4.5 \therefore P = (4.5, 2)$

Q is the point of intersection of the lines

$2x + 3y = 15$ … (1)

and $2x + y = 7$ … (2)

On subtracting, we get

$2y = 8 \therefore y = 4$

$\therefore$ from (2), $2x + 4 = 7$

$\therefore 2x = 3 \therefore x = 1.5$

$\therefore Q = (1.5, 4)$

The values of the objective function $z = 8x + 10y$ at these vertices are

$z(P) = 8(4.5) + 10(2) = 36 + 20 = 56$

$z(Q) = 8(1.5) + 10(4) = 12 + 40 = 52$

$z(B) = 8(0) + 10(7) = 70$

$\therefore$ z has minimum value 52, when $x = 1.5$ and $y = 4$

Question 8.

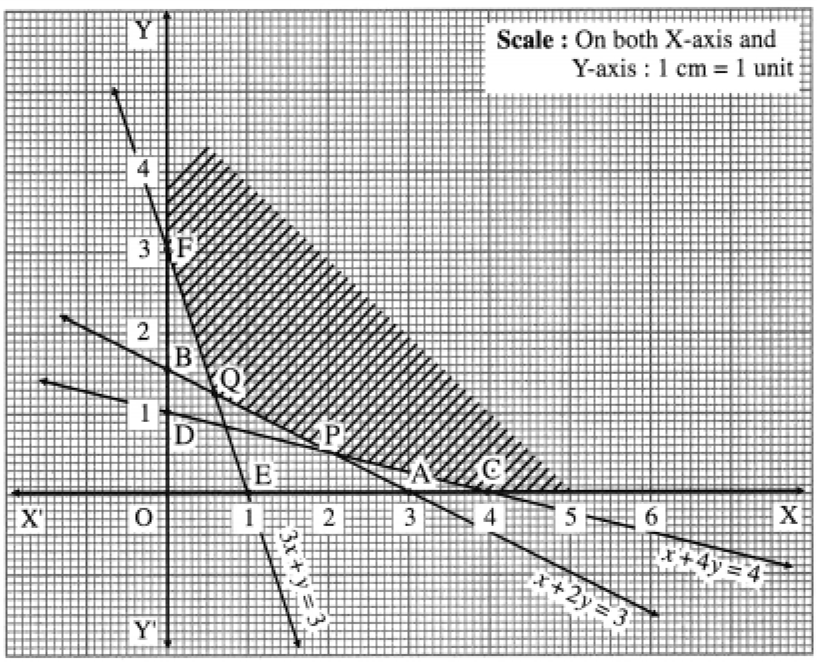
Minimize : $z = 6x + 21y$ subject to $x + 2y \geq 3$, $x + 4y \geq 4$,

$3x + y \geq 3$, $x \geq 0$, $y \geq 0$.

Solution:

First we draw the lines AB, CD and EF whose equations are $x + 2y = 3$, $x + 4y = 4$ and $3x + y = 3$ respectively.

Line	Equation	Points on the X-axis	Points on the Y-axis	Sign	Region
AB	$x+2y=3$	A (3, 0)	B $\left(0, \frac{3}{2}\right)$	$\geqslant$	non-origin side of line AB
CD	$x+4y=4$	C (4, 0)	D (0, 1)	$\geqslant$	non-origin side of line CD
EF	$3x+y=3$	E (1, 0)	F (0, 3)	$\geqslant$	non-origin side of line EF



The feasible region is XCPQFY which is shaded in the graph.

The vertices of the feasible region are C (4, 0), P, Q and F(0, 3).

P is the point of intersection of the lines x + 4y = 4 and x + 2y = 3

On subtracting, we get

$2y = 1 \therefore y = \frac{1}{2}$
Substituting $y = \frac{1}{2}$ in $x + 2y = 3$, we get
$x + 2\left(\frac{1}{2}\right) = 3$
$\therefore x = 2$
$\therefore P = (2, \frac{1}{2})$
Q is the point of intersection of the lines
$x + 2y = 3$ … (1)
and $3x + y = 3$ ….(2)
Multiplying equation (1) by 3, we get $3x + 6y = 9$
Subtracting equation (2) from this equation, we get
$5y = 6$
$\therefore y = \frac{6}{5}$
$\therefore$ from (1), $x + 2\left(\frac{6}{5}\right) = 3$
$\therefore x = 3 - \frac{12}{5} = \frac{3}{5}$
$Q \equiv \left(\frac{3}{5}, \frac{6}{5}\right)$
The values of the objective function $z = 6x + 21y$ at these vertices are
$z(C) = 6(4) + 21(0) = 24$
$z(P) = 6(2) + 21\left(\frac{1}{2}\right)$
$= 12 + 10.5 = 22.5$
$z(Q) = 6\left(\frac{3}{5}\right) + 21\left(\frac{6}{5}\right)$
$= \frac{18}{5} + \frac{126}{5} = \frac{144}{5} = 28.8$
$2\ (F) = 6(0) + 21(3) = 63$
$\therefore$ z has minimum value 22.5, when x = 2 and $y = \frac{1}{2}$.

Maharashtra Board Solutions Class 12 Arts & Science Maths (Part 1)

About About Maharashtra State Board (MSBSHSE)

The Maharashtra State Board of Secondary and Higher Secondary Education or MSBSHSE (Marathi: महाराष्ट्र राज्य माध्यमिक आणि उच्च माध्यमिक शिक्षण मंडळ), is an **autonomous and statutory body established in 1965**. The board was amended in the year 1977 under the provisions of the Maharashtra Act No. 41 of 1965.

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The Maharashtra government established the Maharashtra State Bureau of Textbook Production and Curriculum Research, also commonly referred to as Ebalbharati, in 1967 to take up the responsibility of providing quality textbooks to students from all classes studying under the Maharashtra State Board. MSBHSE prepares and updates the curriculum to provide holistic development for students. It is designed to tackle the difficulty in understanding the concepts with simple language with simple illustrations. Every year around 10 lakh students are enrolled in schools that are affiliated with the Maharashtra State Board.

FAQs

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