CHAPTER 28

LINEAR PROGRAMMING

CONCEPT TYPE QUESTIONS

Directions : This section contains multiple choice questions. Each question has four choices (a), (b), (c) and (d), out of which only one is correct.

1. L.P.P is a process of finding
(a) Maximum value of objective function
(b) Minimum value of objective function
(c) Optimum value of objective function
(d) None of these

2. L.P.P. has constraints of
(a) one variables
(b) two variables
(c) one or two variables
(d) two or more variables

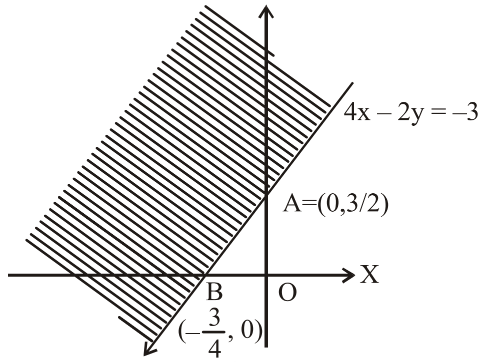
3. Corner points of feasible region of inequalities gives
(a) optional solution of L.P.P.
(b) objective function
(c) constraints.
(d) linear assumption

4. The optimal value of the objective function is attained at the points
(a) Given by intersection of inequations with axes only
(b) Given by intersection of inequations with x- axis only
(c) Given by corner points of the feasible region
(d) None of these.

5. Which of the following statement is correct?
(a) Every L.P.P. admits an optimal solution
(b) A L.P.P. admits a unique optimal solution
(c) If a L.P.P. admits two optimal solutions, it has an infinite number of optimal solutions
(d) The set of all feasible solutions of a L.P.P. is not a convex set.

6. If a point (h, k) satisfies an inequation $ax + by \geq 4$, then the half plane represented by the inequation is
(a) The half plane containing the point (h, k) but excluding the points on $ax + by = 4$
(b) The half plane containing the point (h, k) and the points on $ax + by = 4$
(c) Whole xy-plane
(d) None of these

7. Shaded region is represented by

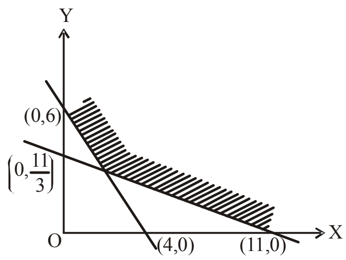


(a) $4x - 2y \leq 3$ (b) $4x - 2y \leq -3$
(c) $4x - 2y \geq 3$ (d) $4x - 2y \geq -3$

8. The maximum value of $z = 5x + 2y$, subject to the constraints $x + y \leq 7$, $x + 2y \leq 10$, $x, y \geq 0$ is
(a) 10 (b) 26
(c) 35 (d) 70

9. The maximum value of $P = x + 3y$ such that $2x + y \leq 20$, $x + 2y \leq 20$, $x \geq 0, y \geq 0$ is
(a) 10 (b) 60
(c) 30 (d) None of these

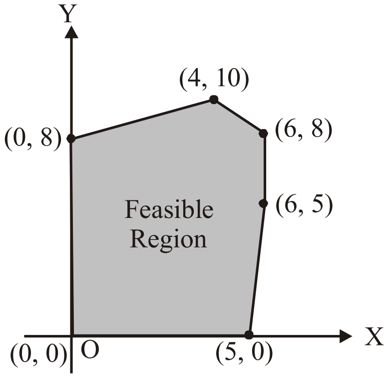
10. For the following feasible region, the linear constraints are



(a) $x \geq 0,\ y \geq 0,\ 3x + 2y \geq 12,\ x + 3y \geq 11$
(b) $x \geq 0,\ y \geq 0,\ 3x + 2y \leq 12,\ x + 3y \geq 11$
(c) $x \geq 0,\ y \geq 0,\ 3x + 2y \leq 12,\ x + 3y \leq 11$
(d) None of these

11. Objective function of a L.P.P. is
(a) a constant
(b) a function to be optimised
(c) a relation between the variables
(d) None of these

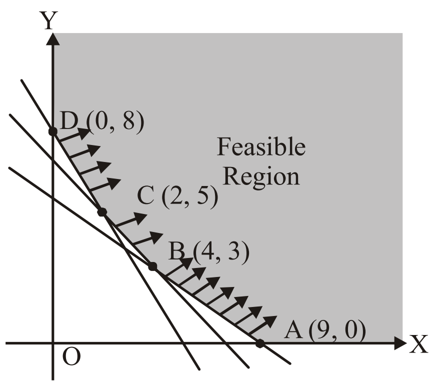
12. The feasible region for an LPP is shown shaded in the figure. Let $Z = 3x - 4y$ be the objective function. Minimum of Z occurs at



(a) (0, 0) (b) (0, 8)
(c) (5, 0) (d) (4, 10)

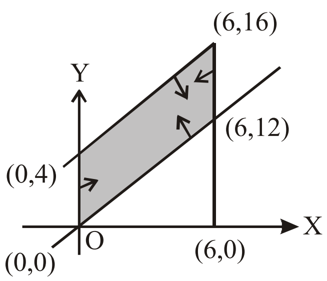
13. Region represented by $x \geq 0, y \geq 0$ is
(a) first quadrant (b) second quadrant
(c) third quadrant (d) fourth quadrant

14. Feasible region for an LPP is shown shaded in the following figure. Minimum of $Z = 4x + 3y$ occurs at the point.



(a) (0, 8) (b) (2, 5)
(c) (4, 3) (d) (9, 0)

15. The feasible region for LPP is shown shaded in the figure. Let $f = 3x - 4y$ be the objective function, then maximum value of f is



(a) 12 (b) 8 (c) 0 (d) –18

16. Maximize $Z = 3x + 5y$, subject to $x + 4y \leq 24$, $3x + y \leq 21$, $x + y, \leq 9$, $x \geq 0$, $y \geq 0$, is
(a) 20 at (1, 0) (b) 30 at (0, 6)
(c) 37 at (4, 5) (d) 33 at (6, 3)

17. $Z = 6x + 21y$, subject to $x + 2y \geq 3$, $x + 4y \geq 4$, $3x + y \geq 3$, $x \geq 0, y \geq 0$. The minimum value of Z occurs at
(a) (4, 0) (b) (28, 8)
(c) $\left(2, \frac{1}{2}\right)$ (d) (0, 3)

18. Maximize $Z = 4x + 6y$, subject to $3x + 2y \leq 12$, $x + y \geq 4$, $x, y \geq 0$, is
(a) 16 at (4,0) (b) 24 at (0, 4)
(c) 24 at (6, 0) (d) 36 at (0, 6)

19. Shamli wants to invest ₹50,000 in saving certificates and PPE. She wants to invest atleast ₹15,000 in saving certificates and at least ₹20,000 in PPF. The rate of interest on saving certificates is 8% p.a. and that on PPF is 9% p.a. Formulation of the above problem as LPP to determine maximum yearly income, is

(a) Maximize $Z = 0.08x + 0.09y$
Subject to, $x + y \leq 50{,}000$, $x \geq 15000$, $y \geq 20{,}000$

(b) Maximize $Z = 0.08x + 0.09y$
Subject to, $x + y \leq 50{,}000$, $x \geq 15000$, $y \leq 20{,}000$

(c) Maximize $Z = 0.08x + 0.09y$
Subject to, $x + y \leq 50{,}000$, $x \leq 15000$, $y \geq 20{,}000$

(d) Maximize $Z = 0.08x + 0.09y$
Subject to, $x + y \leq 50{,}000$, $x \leq 15000$, $y \leq 20{,}000$

20. A furniture manufacturer produces tables and bookshelves made up of wood and steel. The weekly requirement of wood and steel is given as below.

Material / Product ↓	Wood	Steel
Table (x)	8	2
Book shelf (y)	11	3

The weekly variability of wood and steel is 450 and 100 units respectively. Profit on a table ₹1000 and that on a bookshelf is ₹1200. To determine the number of tables and bookshelves to be produced every week in order to maximize the total profit, formulation of the problem as L.P.P. is

(a) Maximize $Z = 1000x + 1200y$
Subject to
$8x + 11y \geq 450$, $2x + 3y \leq 100$, $x \geq 0$, $y \geq 0$

(b) Maximize $Z = 1000x + 1200y$
Subject to
$8x + 11y \leq 450$, $2x + 3y \leq 100$, $x \geq 0$, $y \geq 0$

(c) Maximize $Z = 1000x + 1200y$
Subject to
$8x + 11y \leq 450$, $2x + 3y \geq 100$, $x \geq 0$, $y \geq 0$

(d) Maximize $Z = 1000x + 1200y$
Subject to
$8x + 11y \geq 450$, $2x + 3y \geq 100$, $x \geq 0$, $y \geq 0$

21. Corner points of the feasible region for an LPP are (0, 2) (3, 0) (6, 0), (6, 8) and (0, 5). Let $F = 4x + 6y$ be the objective function.
The minimum value of F occurs at
(a) (0, 2) only
(b) (3, 0) only
(c) the mid-point of the line segment joining the points (0, 2) and (3, 0) only
(d) any point on the line segment joining the points (0, 2) and (3, 0)

22. The point at which the maximum value of $(3x + 2y)$ subject to the constraints $x + y \le 2,\ x \ge 0, y \ge 0$ is obtained, is
(a) (0, 0) (b) (1.5, 1.5) (c) (2, 0) (d) (0, 2)

23. For the constraint of a linear optimizing function $z = x_1 + x_2$, given by $x_1 + x_2 \le 1, 3x_1 + x_2 \ge 3$ and $x_1, x_2 \ge 0$,
(a) There are two feasible regions
(b) There are infinite feasible regions
(c) There is no feasible region
(d) None of these.

24. Which of the following is not a vertex of the positive region bounded by the inequalities $2x + 3y \le 6$, $5x + 3y \le 15$ and $x, y \ge 0$?
(a) (0, 2) (b) (0, 0) (c) (3, 0) (d) None

25. The area of the feasible region for the following constraints $3y + x \ge 3, x \ge 0, y \ge 0$ will be
(a) Bounded (b) Unbounded
(c) Convex (d) Concave

26. The maximum value of $z = 4x + 2y$ subject to constraints $2x + 3y \le 18,\ x + y \ge 10$ and $x, y \ge 0$, is
(a) 36 (b) 40 (c) 20 (d) None

27. The maximum value of $P = x + 3y$ such that $2x + y \le 20$, $x + 2y \le 20, x \ge 0, y \ge 0$ is
(a) 10 (b) 60 (c) 30 (d) None

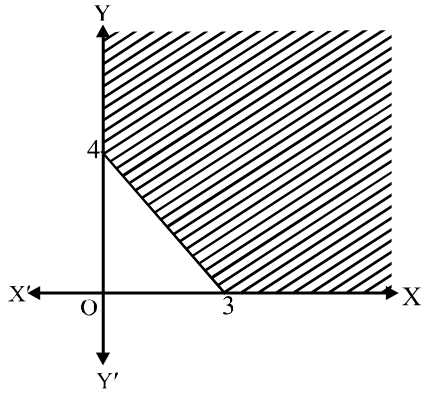
28. The maximum value of $z = 6x + 8y$ subject to constraints $2x + y \le 30, x + 2y \le 24$ and $x \ge 0, y \ge 0$ is
(a) 90 (b) 120 (c) 96 (d) 240

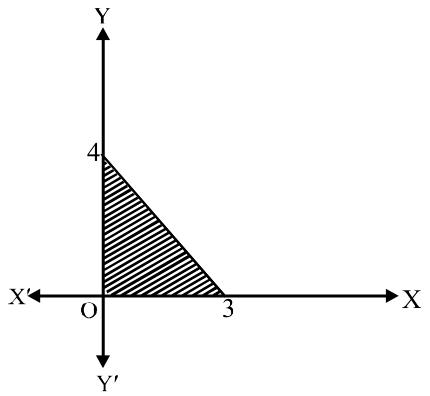
29. A wholesale merchant wants to start the business of cereal with ` 24000. Wheat is ` 400 per quintal and rice is ` 600 per quintal. He has capacity to store 200 quintal cereal. He earns the profit ` 25 per quintal on wheat and ` 40 per quintal on rice. If he store x quintal rice and y quintal wheat, then for maximum profit, the objective function is
(a) $25x + 40y$ (b) $40x + 25y$
(c) $400x + 600y$ (d) $\frac{400}{40}x + \frac{600}{25}y$

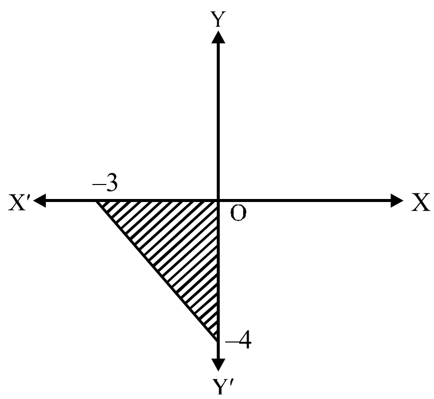
30. The value of objective function is maximum under linear constraints, is
(a) At the centre of feasible region
(b) At (0, 0)
(c) At any vertex of feasible region
(d) The vertex which is at maximum distance from (0, 0)

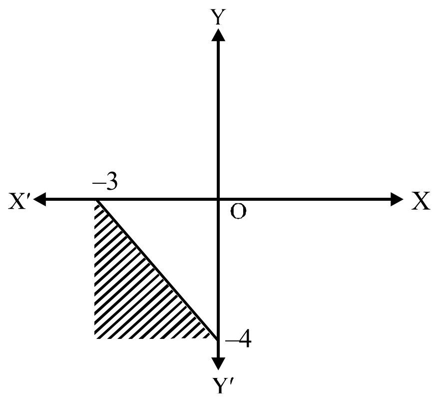
31. The feasible solution of a L.P.P. belongs to
(a) Only first quadrant (b) First and third quadrant
(c) Second quadrant (d) Any quadrant

32. Graph of the constraints $\frac{x}{3} + \frac{y}{4} \le 1, x \ge 0, y \ge 0$ is

(a)


(b)


(c)


(d)


33. The lines $5x + 4y \geq 20$, $x \leq 6$, $y \leq 4$ form
(a) A square (b) A rhombus
(c) A triangle (d) A quadrilateral

34. The graph of inequations $x \leq y$ and $y \leq x + 3$ is located in
(a) II quadrant (b) I, II quadrants
(c) I, II, III quadrants (d) II, III, IV quadrants

35. A linear programming of linear functions deals with
(a) Minimizing (b) Optimizing
(c) Maximizing (d) None of these

INTEGER TYPE QUESTIONS

Directions : This section contains integer type questions. The answer to each of the question is a single digit integer, ranging from 0 to 9. Choose the correct option.

36. The number of corner points of the L.P.P.
Max $Z = 20x + 3y$ subject to the constraints
$x + y \leq 5$, $2x + 3y \leq 12$, $x \geq 0$, $y \geq 0$ are
(a) 4 (b) 3 (c) 2 (d) 1

37. Consider the objective function $Z = 40x + 50y$. The minimum number of constraints that are required to maximize Z are
(a) 4 (b) 2 (c) 3 (d) 1

38. The no. of convex polygon formed bounding the feasible region of the L.P.P. Max. $Z = 30x + 60y$ subject to the constraints $5x + 2y \leq 10$, $x + y \leq 4$, $x \geq 0$, $y \geq 0$ are
(a) 2 (b) 3 (c) 4 (d) 1

ASSERTION - REASON TYPE QUESTIONS

Directions: Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
(a) Assertion is correct, Reason is correct; Reason is a correct explanation for assertion.
(b) Assertion is correct, Reason is correct; Reason is not a correct explanation for Assertion
(c) Assertion is correct, Reason is incorrect
(d) Assertion is incorrect, Reason is correct.

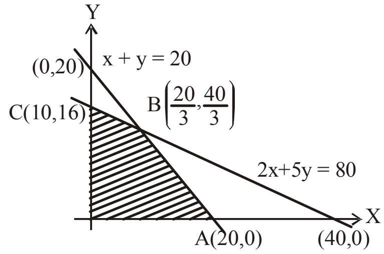
39. **Assertion :** The region represented by the set $\{(x, y) : 4 \leq x^2 + y^2 \leq 9\}$ is a convex set.
Reason : The set $\{(x, y) : 4 \leq x^2 + y^2 \leq 9\}$ represents the region between two concentric circles of radii 2 and 3.

40. **Assertion :** If a L.P.P. admits two optimal solutions then it has infinitely many optimal solutions.
Reason : If the value of the objective function of a LPP is same at two corners then it is same at every point on the line joining two corner points.

CRITICALTHINKING TYPE QUESTIONS

Directions : This section contains multiple choice questions. Each question has four choices (a), (b), (c) and (d), out of which only one is correct.

41. Shaded region in the following figure is represented by



(a) $2x + 5y \geq 80$, $x + y \leq 20$, $x \geq 0$, $y \leq 0$
(b) $2x + 5y \geq 80$, $x + y \geq 20$, $x \geq 0$, $y \geq 0$
(c) $2x + 5y \leq 80$, $x + y \leq 20$, $x \geq 0$, $y \geq 0$
(d) $2x + 5y \leq 80$, $x + y \leq 20$, $x \leq 0$, $y \leq 0$

42. The maximum value of $z = 2x + 5y$ subject to the constraints $2x + 5y \leq 10$, $x + 2y \geq 1$, $x - y \leq 4$, $x \geq y \geq 0$, occurs at
(a) exactly one point
(b) exactly two points
(c) infinitely many points
(d) None of these

43. Consider Max. $z = -2x - 3y$ subject to
$\frac{x}{2} + \frac{y}{3} \leq 1$, $\frac{x}{3} + \frac{y}{2} \leq 1$, $x, y \geq 0$
The max value of z is :
(a) 0 (b) 4 (c) 9 (d) 6

44. The solution region satisfied by the inequalities
$x + y \leq 5$, $x \leq 4$, $y \leq 4$,
$x \geq 0, y \geq 0, 5x + y \geq 5, x + 6y \geq 6$,
is bounded by
(a) 4 straight lines (b) 5 straight lines
(c) 6 straight lines (d) unbounded

45. Corner points of the feasible region determined by the system of linear constraints are (0, 3), (1, 1) and (3, 0). Let $Z = px + qy$, where $p, q > 0$. Condition on p and q so that the minimum of Z occurs at (3, 0) and (1, 1) is
(a) $p = 2q$ (b) $p = \frac{q}{2}$
(c) $p = 3q$ (d) $p = q$

46. The corner points of the feasible region determined by the system of linear constraints are (0, 10), (5, 5) (15, 15), (0, 20). Let $Z = px + qy$, where $p, q > 0$. Condition on p and q so that the maximum of Z occurs at both the points (15, 15) and (0, 20) is
(a) $p = q$ (b) $p = 2q$ (c) $q = 2p$ (d) $q = 3p$

47. Corner points of the feasible region for an LPP are (0, 2), (3, 0), (6, 0), (6, 8) and (0, 5). Let $F = 4x + 6y$ be the objective function.
The minimum value of F occurs at
(a) (0, 2) only
(b) (3, 0) only
(c) the mid point of the line segment joining the points (0, 2) and (3, 0).
(d) any point on the line segment joining the points (0, 2) and (3, 0).

48. The region represented by the inequalities $x \geq 6$, $y \geq 2$, $2x + y \leq 10$, $x \geq 0$, $y \geq 0$ is
(a) unbounded (b) a polygon
(c) exterior of a triangle (d) None of these

49. $Z = 7x + y$, subject to $5x + y \geq 5$, $x + y \geq 3$, $x \geq 0$, $y \geq 0$. The minimum value of Z occurs at
(a) $(3, 0)$ (b) $\left(\frac{1}{2}, \frac{5}{2}\right)$
(c) $(7, 0)$ (d) $(0, 5)$

50. A brick manufacture has two depots A and B, with stocks of 30000 and 20000 bricks respectively. He receive orders from three builders P, Q and R for 15000, 20,000 and 15000 bricks respectively. The cost (in `) of transporting 1000 bricks to the builders from the depots as given in the table.

To / From	Transportation cost per 1000 bricks (in `)		
	P	Q	R
A	40	20	20
B	20	60	40

The manufacturer wishes to find how to fulfill the order so that transportation cost is minimum. Formulation of the L.P.P., is given as
(a) Minimize $Z = 40x - 20y$
Subject to, $x + y \geq 15$, $x + y \leq 30$, $x \geq 15$, $y \leq 20$, $x \geq 0$, $y \geq 0$
(b) Minimize $Z = 40x - 20y$
Subject to, $x + y \geq 15$, $x + y \leq 30$, $x \leq 15$, $y \geq 20$, $x \geq 0$, $y \geq 0$
(c) Minimize $Z = 40x - 20y$
Subject to, $x + y \geq 15$, $x + y \leq 30$, $x \leq 15$, $y \leq 20$, $x \geq 0$, $y \geq 0$
(d) Minimize $Z = 40x - 20y$
Subject to, $x + y \geq 15$, $x + y \leq 30$, $x \geq 15$, $y \geq 20$, $x \geq 0$, $y \geq 0$

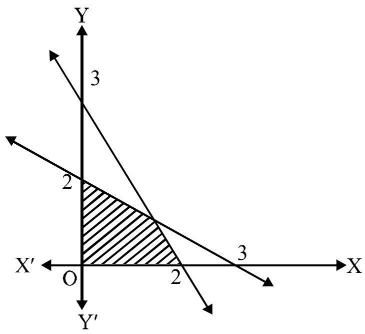
51. The solution set of the following system of inequations:
$x + 2y \leq 3$, $3x + 4y \geq 12$, $x \geq 0$, $y \geq 1$, is
(a) bounded region (b) unbounded region
(c) only one point (d) empty set

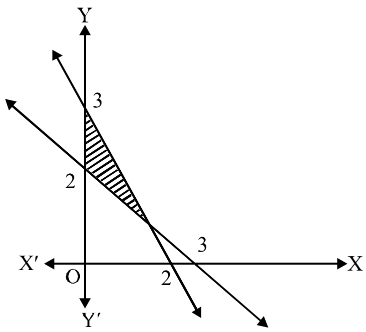
52. A company manufactures two types of products A and B. The storage capacity of its godown is 100 units. Total investment amount is ` 30,000. The cost price of A and B are ` 400 and ` 900 respectively. Suppose all the products have sold and per unit profit is ` 100 and ` 120 through A and B respectively. If x units of A and y units of B be produced, then two linear constraints and iso-profit line are respectively
(a) $x + y = 100$; $4x + 9y = 300$, $100x + 120y = c$
(b) $x + y \leq 100$; $4x + 9y \leq 300$, $x + 2y = c$
(c) $x + y \leq 100$; $4x + 9y \leq 300, 100x + 120y = c$
(d) $x + y \leq 100$; $9x + 4y \leq 300$, $x + 2y = c$

53. Which of the following cannot be considered as the objective function of a linear programming problem?
(a) Maximize $z = 3x + 2y$
(b) Minimize $z = 6x + 7y + 9z$
(c) Maximize $z = 2x$
(d) Minimize $z = x^2 + 2xy + y^2$

54. Inequation $y - x \leq 0$ represents
(a) The half plane that contains the positive X-axis
(b) Closed half plane above the line $y = x$, which contains positive Y-axis
(c) Half plane that contains the negative X-axis
(d) None of these

55. Graph of the inequalities $x \geq 0$, $y \geq 0$, $2x + 3y \geq 6$, $3x + 2y \geq 6$ is

(a)


(b)


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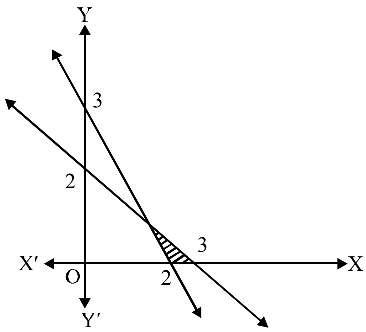

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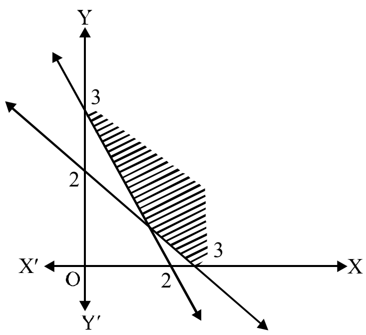


56. A printing company prints two types of magazines A and B. The company earns ` 10 and ` 15 on each magazine A and B respectively. These are processed on three machines I, II & III and total time in hours available per week on each machine is as follows:

Magzine →	A(x)	B(y)	Time available
↓ Machine			
I	2	3	36
II	5	2	50
III	2	6	60

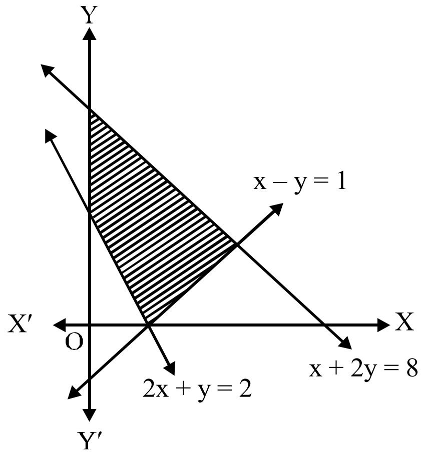
The number of constraints is

(a) 3 (b) 4
(c) 5 (d) 6

57. Children have been invited to a birthday party. It is necessary to give them return gifts. For the purpose, it was decided that they would be given pens and pencils in a bag. It was also decided that the number of items in a bag would be atleast 5. If the cost of a pen is ` 10 and cost of a pencil is ` 5, minimize the cost of a bag containing pens and pencils. Formulation of LPP for this problem is

(a) Minimize $C = 5x + 10y$ subject to $x + y \leq 10, x \geq 0, y \geq 0$
(b) Minimize $C = 5x + 10y$ subject to $x + y \geq 10, x \geq 0, y \geq 0$
(c) Minimize $C = 5x + 10y$ subject to $x + y \geq 5, x \geq 0, y \geq 0$
(d) Minimize $C = 5x + 10y$ subject to $x + y \leq 5, x \geq 0, y \geq 0$

58. The linear inequations for which the shaded area in the following figure is the solution set, are

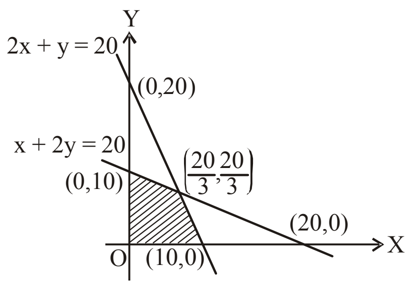


(a) $x + y \leq 1, 2x + y \geq 2, x - 2y \geq 8, x \leq 0, y \geq 0$
(b) $x - y \geq 1, 2x + y \geq 2, x + 2y \geq 8, x \geq 0, y \geq 0$
(c) $x - y \leq 1, 2x + y \geq 2, x + 2y \leq 8, x \geq 0, y \geq 0$
(d) $x + y \geq 1, 2x + y \leq 2, x + 2y \geq 8, x \geq 0, y \geq 0$

HINTS AND SOLUTIONS

CONCEPT TYPE QUESTIONS

1. (c) 2. (d) 3. (a) 4. (c)
5. (c) 6. (b) 7. (d)
8. (c) Change the inequalities into equations and draw the graph of lines, thus we get the required feasible region. The region bounded by the vertices A(0, 5), B(4, 3), C (7, 0).
The objective function is maximum at C(7,0) and Max $z = 5 \times 7 + 2 \times 0 = 35$.
9. (c) Obviously, $P = x + 3y$ will be maximum at (0, 10).
$\therefore P = 0 + 3 \times 10 = 30$.



10. (a)
11. (b) Objective function is a linear function (of the variable involved) whose maximum or minimum value is to be found.
12. (b) Construct the following table of the values of the objective function :

Corner Point	(0, 0)	(5, 0)	(6, 5)	(6, 8)	(4, 10)	(0, 8)
Value of $Z = 3x - 4y$	0	**15**	–2	–14	–28	**–32**

(Maximum) (Minimum)

13. (a) Solution set of the given inequalities is $\{(x, y) : x \geq 0\} \cap \{(x, y) : y \geq 0\} = \{(x, y) : x \geq 0, y \geq 0\}$, i.e., the set of all these points whose both coordinates are non-negative. All these points lie in the first quadrants (including points on +ve X-axis, +ve Y-axis and the origin).
14. (b) Construct the following table of functional values :

Corner Point	(0, 8)	(2, 5)	(4, 3)	(9, 0)
Value of $Z = 4x + 3y$	24	**23**	25	36

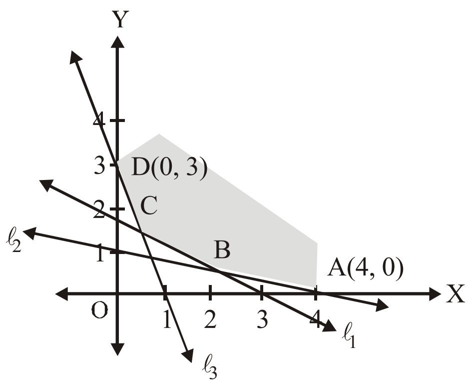
(Minimum)

15. (c) Construct the following table of values of objective function f.

Corner Point	(0,0)	(6,12)	(6,16)	(0,4)
Value of $f = 3x - 4y$	**0**	–30	**–46**	–16

Maximum Minimum

16. (c) We have, maximize $Z = 3x + 5y$
Subject to constraints :
$x + 4y \leq 24, 3x + y \leq 21, x + y \leq 9, x \geq 0, y \geq 0$
Let $\ell_1 : x + 4y = 24$
$\ell_2 : 3x + y = 21$
$\ell_3 : x + y = 9$
$\ell_4 : x = 0$ and $\ell_5 : y = 0$
On solving these equations we will get points as O(0, 0), A(7, 0), B(6, 3), C(4, 5), D(0, 6)
Now maximize $Z = 3x + 5y$
Z at O(0, 0) = 3(0) + 5(0) = 0
Z at A(7, 0) = 3(7) + 5(0) = 21
Z at B(6, 3) = 3(6) + 5(3) = 33
Z at C(4, 5) = 3(4) + 5(5) = 37
Z at D(0, 6) = 3(0) + 5(6) = 30
Thus, Z is maximized at C(4, 5) and its maximum value is 37.
17. (c) We have, minimize $Z = 6x + 21y$
Subject to $x + 2y \geq 3, x + 4y \geq 4, 3x + y \geq 3, x \geq 0, y \geq 0$
Let $\ell_1 : x + 2y = 3$: $\ell_2 = x + 4y = 4$, $\ell_3 : 3x + y = 3$
Shaded portion is the feasible region, where A (4, 0), $B\left(2, \frac{1}{2}\right)$, C(0.6, 1.2), D (0, 3).



For B: Solving ℓ_1 and ℓ_2, we get B(2, 1/2)
For C: Solving ℓ_1 and ℓ_3, we get C(0.6, 1.2)
Now, minimize $Z = 6x + 21y$
Z at A(4, 0) = 6(4) + 21(0) = 24

Z at B $\left(2, \frac{1}{2}\right) = 6(2) + 21\left(\frac{1}{2}\right) = 22.5$

Z at C (0.6, 1.2) = 6(0.6) + 21(1.2) = 3.6 + 25.2 = 28.8

Z at D (0, 3) = 6(0) + 21(3) = 63

Thus, Z is minimized at $B\left(2, \frac{1}{2}\right)$ and its minimum value is 22.5.

18. (d) We have, minimized Z = 4x + 6y

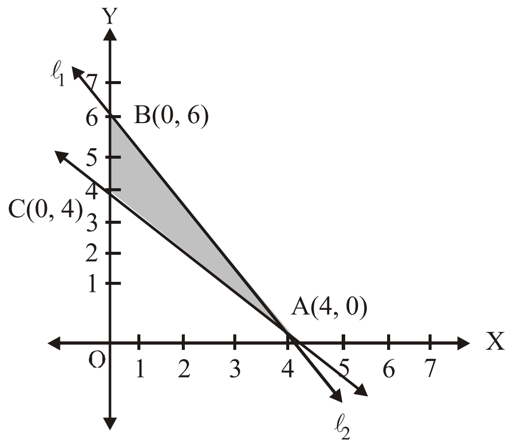
Subject to $3x + 2y \le 12$, $x + y \ge 4$, $x, y \ge 0$

Let $\ell_1 : 3x + 2y = 12$

$\ell_2 : x + y = 4$

$\ell_3 : x = 0$ and $\ell_4 : y = 0$

Shaded portion ABC is the feasible region, where A(4, 0), C(0, 4), B(0, 6).



Now maximize Z = 4x + 6y

Z at A(4, 0) = 4(4) + 6(0) = 16

Z at B (0, 6) = 4(0) + 6(6) = 36

Z at C (0, 4) = 4(0) + 6(4) = 24

Thus, Z is maximized at B(0, 6) and its maximum value is 36.

19. (a) Let Shamali invest ` x in saving certificate and ` y in PPF.

$\therefore x + y \le 50000$, $x \ge 15000$ and $y \ge 20000$

Total income $= \frac{8}{100}x + \frac{9}{100}y$

$\therefore$ Given problem can be formulated as

Maximize Z = 0.08x + 0.09y

Subject to, $x + y \le 50000$, $x \ge 15000$, $y \ge 20000$.

20. (b) Given x and y units of tables and bookshelves are produced

Profit on one table is ` 1000

$\therefore$ Profit on x table is ` 1000x

Profit on one bookshelf is ` 1200

$\therefore$ Profit on y bookshelves is ` 1200y

$\therefore$ Profit Z = 1000x + 1200y

Material \ Product	Table (x)	Bookshelf (y)	Availability
Wood	8	11	450
Steel	2	3	100

$\therefore$ Constraints are $8x + 11y \le 450$, $2x + 3y \le 100$, $x \ge 0$, $y \ge 0$

$\therefore$ Given problem can be formulated as

Maximize Z = 1000x + 1200 y

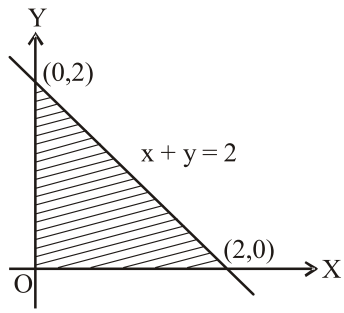
Subject to, $8x + 11y \le 450$, $2x + 3y \le 100$, $x \ge 0$, $y \ge 0$

21. (d) Construct the following table of objective function

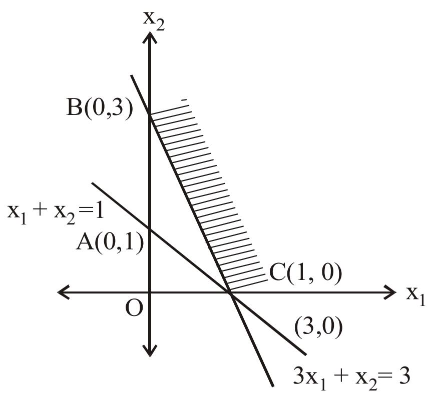
Corner Point	Value of F = 4x + 6y	
(0, 2)	$4 \times 0 + 6 \times 2 = 12$	} ← minimum
(3, 0)	$4 \times 3 + 6 \times 0 = 12$	
(6, 0)	$4 \times 6 + 6 \times 0 = 24$	
(6, 8)	$4 \times 6 + 6 \times 8 = 72$	← maximum
(0, 5)	$4 \times 0 + 6 \times 5 = 30$	

Since the minimum value (F) = 12 occurs at two distinct corner points, it occurs at every points of the segment joining these two points.

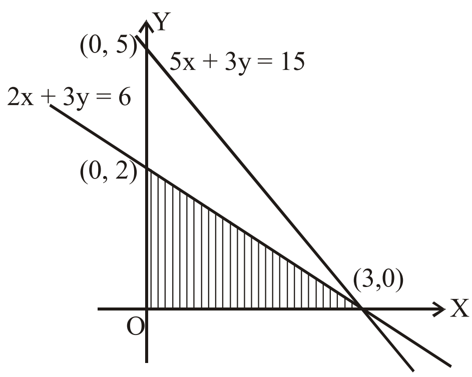
22. (c) Hence maximum z is at (2, 0).



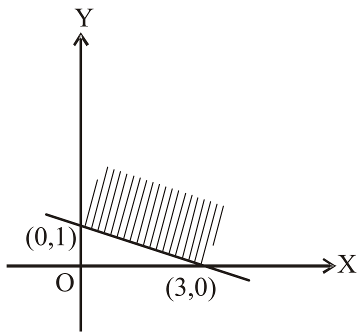
23. (c) Clearly from graph there is no feasible region.



24. (d) Here (0, 2), (0, 0) and (3, 0) all are vertices of feasible region. Hence option (d) is correct.

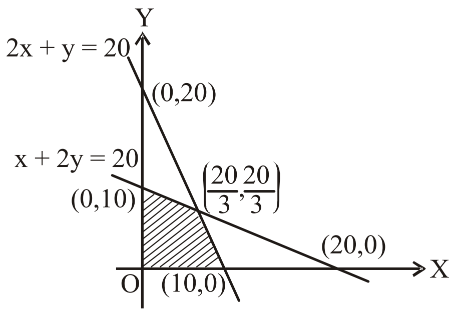


25. **(b)**

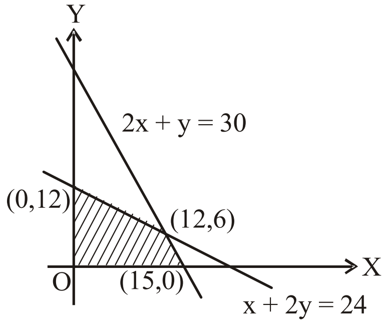


26. **(d)** After drawing the graph, we get the points on the region are (9,0), (0,6), (10, 0), (0, 10) and (12, –2) But there is no feasible point as no point satisfy all the inequations simultaneously.

27. **(c)** Obviously, $P = x + 3y$ will be maximum at (0, 10).
$\therefore P = 0 + 3 \times 10 = 30$.



28. **(b)** Here, $2x + y \le 30$, $x + 2y \le 24$, $x, y \ge 0$
The shaded region represents the feasible region, hence
$z = 6x + 8y$. Obviously it is maximum at (12, 6).
Hence $z = 12 \times 6 + 8 \times 6 = 120$



29. **(b)** For maximum profit, $z = 40x + 25y$.

30. **(c)** **31.** **(d)**

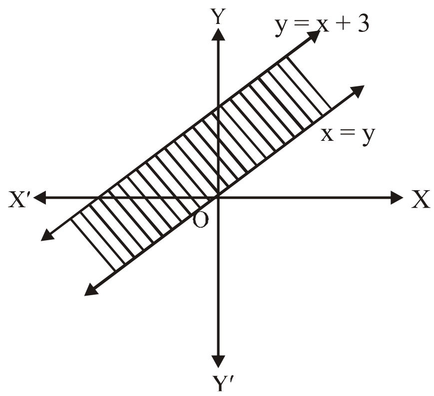
32. **(b)** Take a test point O (0,0).

Equation of the constraint is $\frac{x}{3} + \frac{y}{4} \le 1$

$\Rightarrow 4x + 3y \le 12$
Since $4(0) + 3(0) \le 12$, the feasible region lies below the line $4x + 3y = 12$
Since $x \ge 0$, $y \ge 0$
the feasible region lies in the first quadrant.

33. **(d)** Common region is quadrilateral.

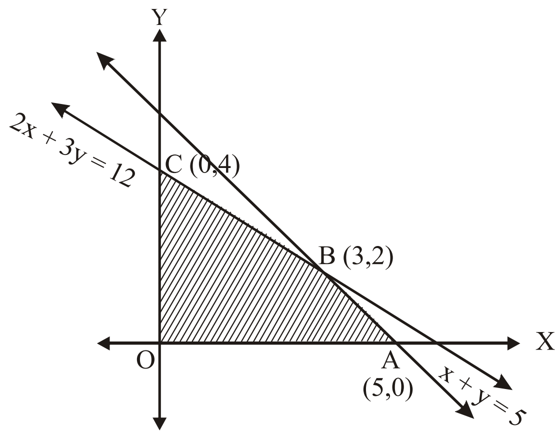
34. **(c)** The shaded area is the required area given in graph as below.



35. **(b)**

INTEGER TYPE QUESTIONS

36. **(a)** As is obvious from the figure.

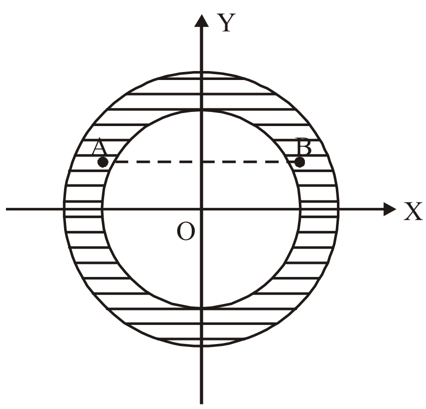


37. **(c)** Two constraints are $x \ge 0$, $y \ge 0$ and the third one will be of the type $ax + by \le c$.

38. **(d)**

ASSERTION - REASON TYPE QUESTIONS

39. **(d)** From the figure it is clear that the region is not a convex set.

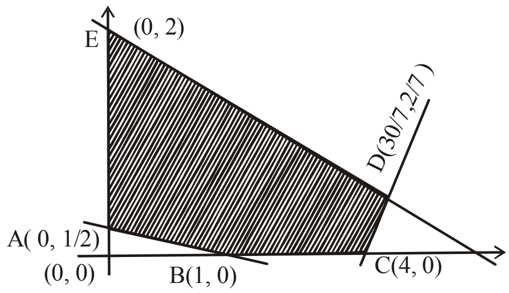


40. **(a)** It is a standard result.

CRITICALTHINKING TYPE QUESTIONS

41. (c) In given all equations, the origin is present in shaded area, answer (c) satisfy this condition.

42. (c) We find that the feasible region is on the same side of the line $2x + 5y = 10$ as the origin, on the same side of the line $x - y = 4$ as the origin and on the opposite side of the line $x + 2y = 1$ from the origin. Moreover, the lines meet the coordinate axes at (5, 0), (0, 2); (1, 0), (0, 1/2) and (4, 0). The lines $x - y = 4$ and $2x + 5y = 10$ intersect at $\left(\frac{30}{7}, \frac{2}{7}\right)$.



The values of the objective function at the vertices of the pentagon are:

(i) $Z = 0 + \frac{5}{2} = \frac{5}{2}$ (ii) $Z = 2 + 0 = 2$

(iii) $Z = 8 + 0 = 8$ (iv) $Z = \frac{60}{7} + \frac{10}{7} = 10$

(v) $Z = 0 + 10 = 10$

The maximum value 10 occurs at the points $D\left(\frac{30}{7}, \frac{2}{7}\right)$ and E(0, 2). Since D and E are adjacent vertices, the objective function has the same maximum value 10 at all the points on the line DE.

43. (a) Given problem is max $z = -2x - 3y$

Subject to $\frac{x}{2} + \frac{y}{3} \leq 1$, $\frac{x}{3} + \frac{y}{2} \leq 1$, x, y ≥ 0

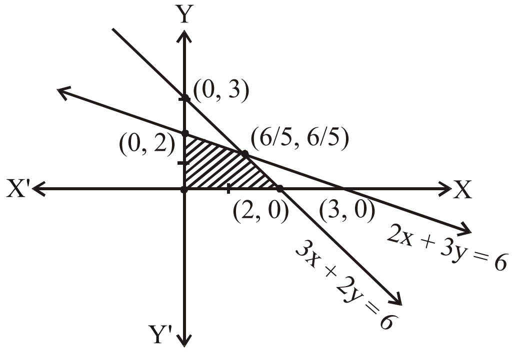
First convert these inequations into equations we get

$3x + 2y = 6$ ...(i)

$2x + 3y = 6$ ...(ii)

on solving these two equation, we get point of intersection is $\left(\frac{6}{5}, \frac{6}{5}\right)$.

Now, we draw the graph of these lines.



Shaded portion shows the feasible region.

Now, the corner points are

$(0, 2), (2,0), \left(\frac{6}{5}, \frac{6}{5}\right), (0, 0)$.

At (0, 2),

value of $z = -2(0) - 3(2) = -6$

At (2, 0),

value of $z = -2(2) - 3(0) = -4$

At $\left(\frac{6}{5}, \frac{6}{5}\right)$, Value of $z = -2\left(\frac{6}{5}\right) - 3\left(\frac{6}{5}\right)$

$= \frac{-30}{5} = -6$

At (0, 0), value of $z = -2(0) - 3(0) = 0$

$\therefore$ The max value of z is 0.

44. (b) We find that the solution set satisfies $x \geq 0$, $y \geq 0$, $x \leq 4$, $y \leq 4$ so that the solution region lies within the square enclosed by the lines x= 0, y = 0, x = 4, y = 4. Moreover, the solution region is bounded by the lines

$x + y = 5,$ …(i)

$5x + y = 5$ …(ii)

$x + 6y = 6$ …(iii)

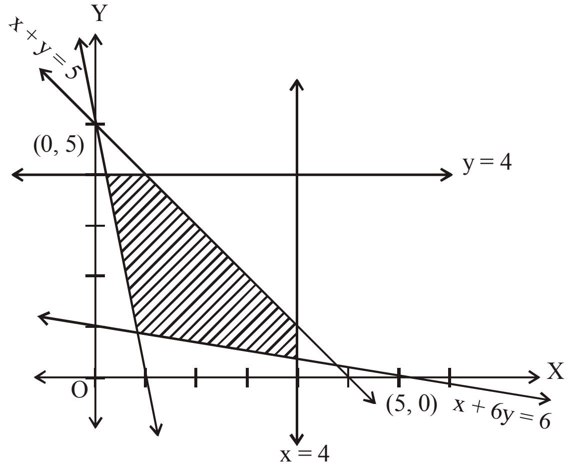
Line (i) meets the coordinate axes in (5, 0) and (0, 5) and the lines x = 4 and y = 4 in (4, 1) and (1, 4), and $0 < 5$ is true.

Hence (0, 0) belongs to the half plane $x + y \leq 5$.

But (0, 0) does not belong to the half planes $5x + y \geq 5$ and $x + 6y \geq 6$. The line $5x + y = 5$, meets the coordinate axes in (1, 0) and (0, 5), and meets the line x = 4 in (4, 1), where as it meets the line y = 4 in (1/5, 4).

Similarly $x + 6y = 6$ meets x = 4 in (4, 1/3) and y = 4 in (–18, 4).

The solution is marked as the shaded region.



45. **(b)** We must have value of Z at (3, 0) = value of Z at (1, 1) and this value must be less than the value (0, 3)

$\Rightarrow 3\,p + 0\,q = 1\,p + 1\,q$ and $3\,p < 3\,q$

$\Rightarrow 3\,p = p + q$ and $p < q$

$\Rightarrow\ p = \frac{1}{2}q.$

46. **(d)** We must have the value of Z at (0, 20) equal to the value of Z at (15, 15) and this common value must be greater than the values at (0, 10) and (5, 5), i.e.,

$15\,p + 15\,q = 20\,q > 10\,q$ and $20\,q > 5\,p + 5\,q$

$\Rightarrow q = 3\,p.$

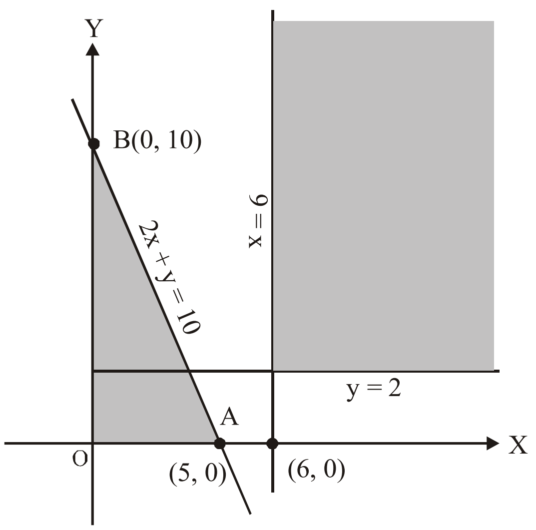
47. **(d)** Construct the following table of functional values :

Corner Point	(0, 2)	(3, 0)	(6, 0)	(6, 8)	(0, 5)
Value of F = 4 x + 6 y	**12**	**12**	24	**72**	30

↑minimum ↑ maximum

Since the minimum value (F) = 12 occurs at two distinct corner points, it occurs at every point of the segment joining these two points.

48. **(d)** The graph of the inequalities $2x + y \le 10, x \ge 0, y \ge 0$ is the region bounded by ΔAOB. This region has no point common with the region $\{(x, y) : x \ge 6, y \ge 2\}$ as is clear from the figure . Hence, the region of the given inequalities is the empty set.



49. **(d)** We have, maximize $Z = 7x + y$,

Subject to :

$5x + y \ge 5, x + y \ge 3, x, y \ge 0.$

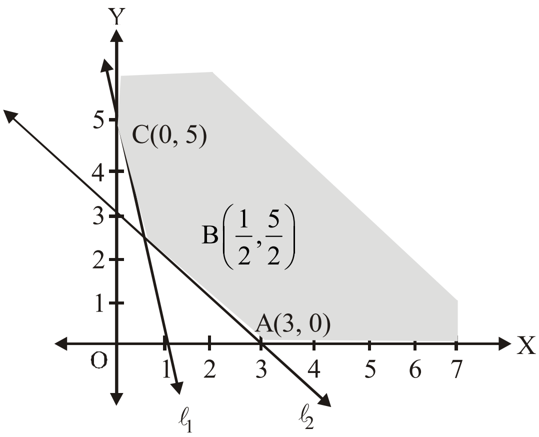
Let $\ell_1 : 5x + y = 5$

$\ell_2 : x + y = 3$

$\ell_3 : x = 0$ and $\ell_4 :\ y = 0$

Shaded portion is the feasible region,

Where A(3, 0), $B\left(\frac{1}{2}, \frac{5}{2}\right)$, C(0, 5)



For B : Solving ℓ_1 and ℓ_2, we get $B\left(\frac{1}{2}, \frac{5}{2}\right)$

Now maximize $Z = 7x + y$

Z at A(3, 0) = 7(3) + 0 = 21

Z at $B\left(\frac{1}{2}, \frac{5}{2}\right) = 7\left(\frac{1}{2}\right) + \frac{5}{2} = 6$

Z at C(0, 5) = 7(0) + 5 = 5

Thus Z, is minimized at C(0, 5) and its minimum value is 5

50. **(c)** The given information can be expressed as given in the diagram:

In order to simply, we assume that 1 unit = 1000 bricks

Suppose that depot A supplies x units to P and y units to Q, so that depot A supplies (30 – x – y) bricks to builder R.

Now, as P requires a total of 15000 bricks, it requires (15 – x) units from depot B.

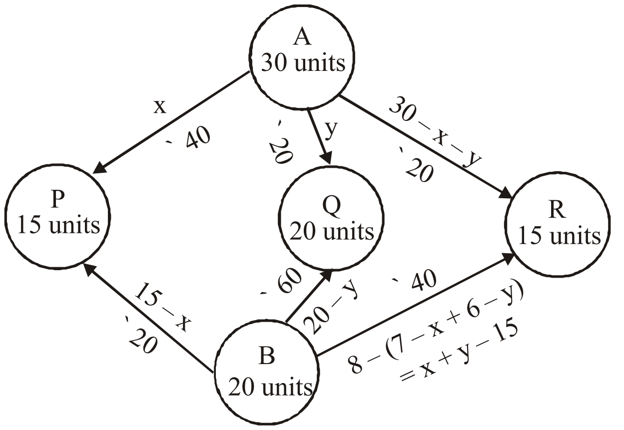
Similarly, Q requires (20 – y) units from B and R requires 15 – (30 – x – y) = x + y – 15 units from B.

Using the transportation cost given in table, total transportation cost.

$Z = 40x + 20y + 20(30 - x - y) + 20(15 - x) + 60(20 - y) + 40(x + y - 15)$

$= 40x - 20y + 1500$

Obviously the constraints are that all quantities of bricks supplied from A and B to P, Q, R are non-negative.



$\therefore\ x \geq 0, y \geq 0, 30 - x - y \geq 0, 15 - x \geq 0, 20 - y \geq 0,$
$x + y - 15 \geq 0.$

Since, 1500 is a constant, hence instead of minimizing $Z = 40x - 20y + 1500$, we can minimize $Z = 40x - 20y$.

Hence, mathematical formulation of the given LPP is

Minimize $Z = 40x - 20y$,

subject to the constraints:

$x + y \geq 15,$

$x + y \leq 30,$

$x \leq 15, y \leq 20,$

$x \geq 0, y \geq 0$

51. (d) The solution region is bounded by the straight lines

$x + 2y = 3$ …(i)

$3x + 4y = 12$ …(ii)

$x = 0$ …(iii)

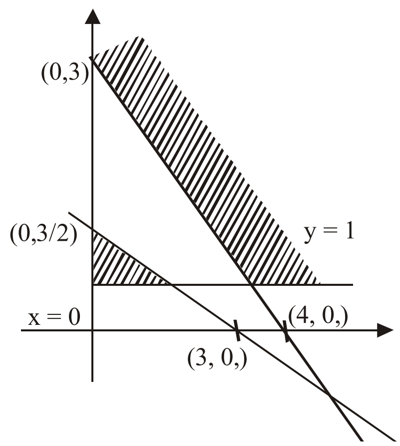
$y = 1$ …(iv)

The straight lines (i) and (ii) meet the x-axis in (3, 0) and (4,0) and for (0, 0), $x + 2y \leq 3 \Rightarrow 0 \leq 3$ which is true.

Hence (0, 0) lies in the half plane $x + 2y \leq 3$. Also the lines (1) and (2) meet the y-axis in (0, 3/2) and (0, 3) and for (0,0) $3x + 4y \geq 12 \Rightarrow 0 \geq 12$ which is not true. Hence (0, 0) doesn't belong to the half plane $3x + 4y \geq 0$.

Also $x \geq 0$, $y \geq 1 \Rightarrow$ the solution set belongs to the first quadrant. Moreover all the boundary lines are part of the solution.

From the shaded region, We find that there is no solution of the given system. Hence the solution set is an empty set.

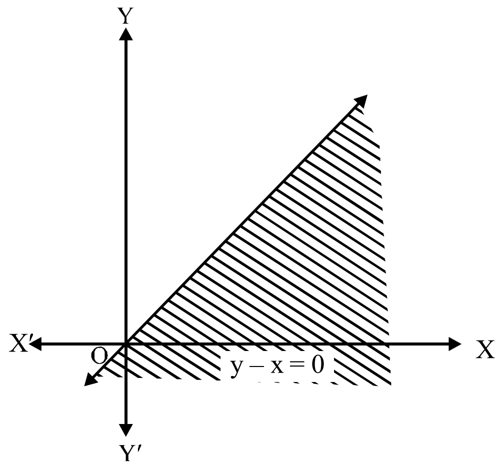


52. **(c)** $x + y \leq 100;\ 400x + 900y \leq 30000$ or

$4x + 9y \leq 300$ and $100x + 120y = c.$

53. **(d)** d is the only option which is not linear.

54. **(a)**



55. **(c)** Take a test point O(0, 0)

Since, $2(0) + 3(0) \leq 6$, the feasible region lies below the line $2x + 3y = 6$

Since, $3(0) + 2(0) \geq 6$ is incorrect, the feasible region lies above the line $3x + 2y = 6$

$\therefore$ the feasible region lies in the common region between the lines $2x + 3y = 6$ and $3x + 2y = 6$

Since $x \geq 0$, $y \geq 0$, the feasible region lies in the first quadrant.

56. **(c)** Constraints are $2x + 3y \leq 36; 5x + 2y \leq 50; 2x + 6y \leq 60,$ $x \leq 0, y \leq 0$

$\therefore$ The number of constraints are 5.

57. **(a)** Let the no. of pencils in a bag be x

Let the no. of pens in a bag be y. There should be at least 5 items in a bag

$\therefore$ we have $x + y \geq 5$

cost of pencils in a bag = \`5x

cost of pens in bag \`10y

$\therefore$ Total cost of a bag = $5x + 10y$,

The total cost has to minimized

$\therefore$ Objective function is minimize $C = 5x + 10y$ subject to $x + y \geq 5, x \geq 0, y \geq 0$

58. **(c)** Let $L_1 : x + 2y = 8;$

$L_2\ 2x + y = 2;$

$L_3 : x - y = 1$

Since the shaded area is below the line L_1, we have $x + 2y \leq 8$. Since the shaded area is above the line L_2, we have $2x + y \geq 2$. Since the common region is to the left of the line L_3, we have $x - y \leq 1$