Chapter 2--An Introduction to Linear Programming

1. The maximization or minimization of a quantity is the
A. goal of management science.
B. decision for decision analysis.
C. constraint of operations research.
D. objective of linear programming.

2. Decision variables
A. tell how much or how many of something to produce, invest, purchase, hire, etc.
B. represent the values of the constraints.
C. measure the objective function.
D. must exist for each constraint.

3. Which of the following is a valid objective function for a linear programming problem?
A. Max 5xy
B. Min 4x + 3y + (2/3)z
C. Max $5x^2 + 6y^2$
D. Min $(x_1 + x_2)/x_3$

4. Which of the following statements is NOT true?
A. A feasible solution satisfies all constraints.
B. An optimal solution satisfies all constraints.
C. An infeasible solution violates all constraints.
D. A feasible solution point does not have to lie on the boundary of the feasible region.

5. A solution that satisfies all the constraints of a linear programming problem except the nonnegativity constraints is called
A. optimal.
B. feasible.
C. infeasible.
D. semi-feasible.

6. Slack
A. is the difference between the left and right sides of a constraint.
B. is the amount by which the left side of a £ constraint is smaller than the right side.
C. is the amount by which the left side of a ³ constraint is larger than the right side.
D. exists for each variable in a linear programming problem.

7. To find the optimal solution to a linear programming problem using the graphical method
A. find the feasible point that is the farthest away from the origin.
B. find the feasible point that is at the highest location.
C. find the feasible point that is closest to the origin.
D. None of the alternatives is correct.

8. Which of the following special cases does not require reformulation of the problem in order to obtain a solution?
A. alternate optimality
B. infeasibility
C. unboundedness
D. each case requires a reformulation.

9. The improvement in the value of the objective function per unit increase in a right-hand side is the
A. sensitivity value.
B. dual price.
C. constraint coefficient.
D. slack value.

10. As long as the slope of the objective function stays between the slopes of the binding constraints
A. the value of the objective function won't change.
B. there will be alternative optimal solutions.
C. the values of the dual variables won't change.
D. there will be no slack in the solution.

11. Infeasibility means that the number of solutions to the linear programming models that satisfies all constraints is
A. at least 1.
B. 0.
C. an infinite number.
D. at least 2.

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12. A constraint that does not affect the feasible region is a
A. non-negativity constraint.
B. redundant constraint.
C. standard constraint.
D. slack constraint.

13. Whenever all the constraints in a linear program are expressed as equalities, the linear program is said to be written in
A. standard form.
B. bounded form.
C. feasible form.
D. alternative form.

14. All of the following statements about a redundant constraint are correct EXCEPT
A. A redundant constraint does not affect the optimal solution.
B. A redundant constraint does not affect the feasible region.
C. Recognizing a redundant constraint is easy with the graphical solution method.
D. At the optimal solution, a redundant constraint will have zero slack.

15. All linear programming problems have all of the following properties EXCEPT
A. a linear objective function that is to be maximized or minimized.
B. a set of linear constraints.
C. alternative optimal solutions.
D. variables that are all restricted to nonnegative values.

16. Increasing the right-hand side of a nonbinding constraint will not cause a change in the optimal solution.
True False

17. In a linear programming problem, the objective function and the constraints must be linear functions of the decision variables.
True False

18. In a feasible problem, an equal-to constraint cannot be nonbinding.
True False

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19. Only binding constraints form the shape (boundaries) of the feasible region.
True False

20. The constraint $5x_1 - 2x_2$ £ 0 passes through the point (20, 50).
True False

21. A redundant constraint is a binding constraint.
True False

22. Because surplus variables represent the amount by which the solution exceeds a minimum target, they are given positive coefficients in the objective function.
True False

23. Alternative optimal solutions occur when there is no feasible solution to the problem.
True False

24. A range of optimality is applicable only if the other coefficient remains at its original value.
True False

25. Because the dual price represents the improvement in the value of the optimal solution per unit increase in right-hand-side, a dual price cannot be negative.
True False

26. Decision variables limit the degree to which the objective in a linear programming problem is satisfied.
True False

27. No matter what value it has, each objective function line is parallel to every other objective function line in a problem.
True False

28. The point (3, 2) is feasible for the constraint $2x_1 + 6x_2$ £ 30.
True False

29. The constraint $2x_1 - x_2 = 0$ passes through the point (200,100).
True False

30. The standard form of a linear programming problem will have the same solution as the original problem.
True False

31. An optimal solution to a linear programming problem can be found at an extreme point of the feasible region for the problem.
True False

32. An unbounded feasible region might not result in an unbounded solution for a minimization or maximization problem.
True False

33. An infeasible problem is one in which the objective function can be increased to infinity.
True False

34. A linear programming problem can be both unbounded and infeasible.
True False

35. It is possible to have exactly two optimal solutions to a linear programming problem.
True False

36. Explain the difference between profit and contribution in an objective function. Why is it important for the decision maker to know which of these the objective function coefficients represent?

37. Explain how to graph the line $x_1 - 2x_2$ ³ 0.

38. Create a linear programming problem with two decision variables and three constraints that will include both a slack and a surplus variable in standard form. Write your problem in standard form.

39. Explain what to look for in problems that are infeasible or unbounded.

40. Use a graph to illustrate why a change in an objective function coefficient does not necessarily lead to a change in the optimal values of the decision variables, but a change in the right-hand sides of a binding constraint does lead to new values.

41. Explain the concepts of proportionality, additivity, and divisibility.

42. Explain the steps necessary to put a linear program in standard form.

43. Explain the steps of the graphical solution procedure for a minimization problem.

44. Solve the following system of simultaneous equations.

$6X + 2Y = 50$
$2X + 4Y = 20$

45. Solve the following system of simultaneous equations.

$6X + 4Y = 40$
$2X + 3Y = 20$

46. Consider the following linear programming problem

Max	8X + 7Y
s.t.	15X + 5Y £ 75
	10X + 6Y £ 60
	X + Y £ 8
	X, Y ³ 0

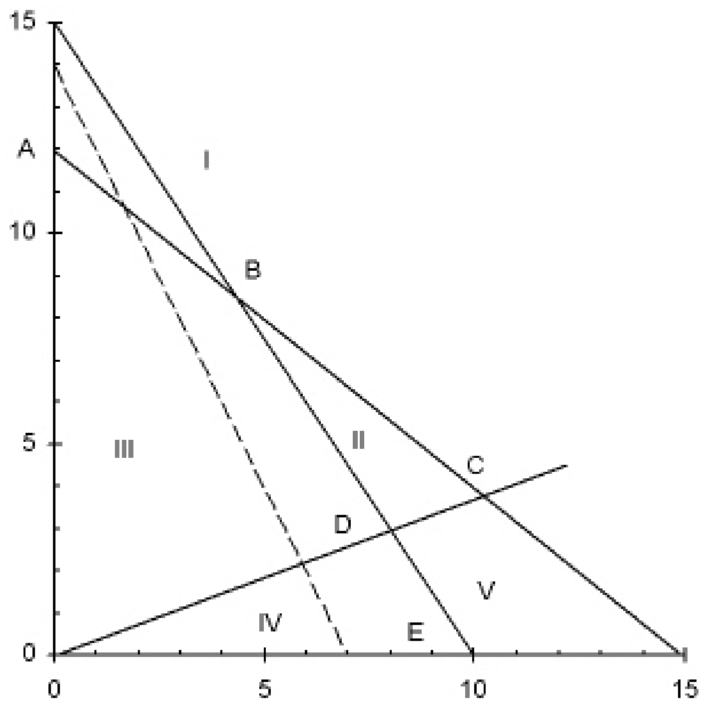
a. Use a graph to show each constraint and the feasible region.
b. Identify the optimal solution point on your graph. What are the values of X and Y at the optimal solution?
c. What is the optimal value of the objective function?

47. For the following linear programming problem, determine the optimal solution by the graphical solution method

Max -X + 2Y

s.t. 6X - 2Y £ 3
-2X + 3Y £ 6
X + Y £ 3
X, Y ³ 0

48. Use this graph to answer the questions.



Max 20X + 10Y

s.t. 12X + 15Y £ 180
15X + 10Y £ 150
3X - 8Y £ 0
X , Y ³ 0

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a. Which area (I, II, III, IV, or V) forms the feasible region?
b. Which point (A, B, C, D, or E) is optimal?
c. Which constraints are binding?
d. Which slack variables are zero?

49. Find the complete optimal solution to this linear programming problem.

Min 5X + 6Y

s.t. 3X + Y ³ 15
X + 2Y ³ 12
3X + 2Y ³ 24
X , Y ³ 0

50. Find the complete optimal solution to this linear programming problem.

Max 5X + 3Y

s.t. 2X + 3Y £ 30
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51. Find the complete optimal solution to this linear programming problem.

Max 2X + 3Y

s.t. 4X + 9Y £ 72
10X + 11Y £ 110
17X + 9Y £ 153
X , Y ³ 0

52. Find the complete optimal solution to this linear programming problem.

Min 3X + 3Y

s.t. 12X + 4Y ³ 48
10X + 5Y ³ 50
4X + 8Y ³ 32
X , Y ³ 0

53. For the following linear programming problem, determine the optimal solution by the graphical solution method. Are any of the constraints redundant? If yes, then identify the constraint that is redundant.

Max X + 2Y

s.t. X + Y £ 3
X - 2Y ³ 0
Y £ 1
X, Y ³ 0

54. Maxwell Manufacturing makes two models of felt tip marking pens. Requirements for each lot of pens are given below.

	Fliptop Model	Tiptop Model	Available
Plastic	3	4	36
Ink Assembly	5	4	40
Molding Time	5	2	30

The profit for either model is $1000 per lot.

a. What is the linear programming model for this problem?

b. Find the optimal solution.

c. Will there be excess capacity in any resource?

55. The Sanders Garden Shop mixes two types of grass seed into a blend. Each type of grass has been rated (per pound) according to its shade tolerance, ability to stand up to traffic, and drought resistance, as shown in the table. Type A seed costs $1 and Type B seed costs $2. If the blend needs to score at least 300 points for shade tolerance, 400 points for traffic resistance, and 750 points for drought resistance, how many pounds of each seed should be in the blend? Which targets will be exceeded? How much will the blend cost?

	Type A	Type B
Shade Tolerance	1	1
Traffic Resistance	2	1
Drought Resistance	2	5

56. Muir Manufacturing produces two popular grades of commercial carpeting among its many other products. In the coming production period, Muir needs to decide how many rolls of each grade should be produced in order to maximize profit. Each roll of Grade X carpet uses 50 units of synthetic fiber, requires 25 hours of production time, and needs 20 units of foam backing. Each roll of Grade Y carpet uses 40 units of synthetic fiber, requires 28 hours of production time, and needs 15 units of foam backing.

The profit per roll of Grade X carpet is $200 and the profit per roll of Grade Y carpet is $160. In the coming production period, Muir has 3000 units of synthetic fiber available for use. Workers have been scheduled to provide at least 1800 hours of production time (overtime is a possibility). The company has 1500 units of foam backing available for use.

Develop and solve a linear programming model for this problem.

57. Does the following linear programming problem exhibit infeasibility, unboundedness, or alternate optimal solutions? Explain.

Min 1X + 1Y

s.t. 5X + 3Y £ 30
3X + 4Y ³ 36
Y £ 7
X , Y ³ 0

58. Does the following linear programming problem exhibit infeasibility, unboundedness, or alternate optimal solutions? Explain.

Min 3X + 3Y

s.t. 1X + 2Y £ 16
1X + 1Y £ 10
5X + 3Y £ 45
X , Y ³ 0

59. A businessman is considering opening a small specialized trucking firm. To make the firm profitable, it is estimated that it must have a daily trucking capacity of at least 84,000 cu. ft. Two types of trucks are appropriate for the specialized operation. Their characteristics and costs are summarized in the table below. Note that truck 2 requires 3 drivers for long haul trips. There are 41 potential drivers available and there are facilities for at most 40 trucks. The businessman's objective is to minimize the total cost outlay for trucks.

		Capacity	Drivers
Truck	Cost	(Cu. Ft.)	Needed
Small	$18,000	2,400	1
Large	$45,000	6,000	3

Solve the problem graphically and note there are alternate optimal solutions. Which optimal solution:

a. uses only one type of truck?
b. utilizes the minimum total number of trucks?
c. uses the same number of small and large trucks?

60. Consider the following linear program:

MAX 60X + 43Y

s.t.
X + 3Y ³ 9
6X - 2Y = 12
X + 2Y £ 10
X, Y ³ 0

a. Write the problem in standard form.
b. What is the feasible region for the problem?
c. Show that regardless of the values of the actual objective function coefficients, the optimal solution will occur at one of two points. Solve for these points and then determine which one maximizes the current objective function.

61. Solve the following linear program graphically.

MAX 5X + 7Y

s.t.
X £ 6
2X + 3Y £ 19
X + Y £ 8
X, Y ³ 0

62. Given the following linear program:

MIN 150X + 210Y

s.t.
3.8X + 1.2Y ³ 22.8
Y ³ 6
Y £ 15
45X + 30Y = 630
X, Y ³ 0

Solve the problem graphically. How many extreme points exist for this problem?

63. Solve the following linear program by the graphical method.

MAX 4X + 5Y

s.t.

X + 3Y £ 22
-X + Y £ 4
Y £ 6
2X - 5Y £ 0
X, Y ³ 0

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C. constraint of operations research.
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C. find the feasible point that is closest to the origin.
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FALSE

17. In a linear programming problem, the objective function and the constraints must be linear functions of the decision variables.
TRUE

18. In a feasible problem, an equal-to constraint cannot be nonbinding.
TRUE

19. Only binding constraints form the shape (boundaries) of the feasible region.
FALSE

20. The constraint $5x_1 - 2x_2$ £ 0 passes through the point (20, 50).
TRUE

21. A redundant constraint is a binding constraint.
FALSE

22. Because surplus variables represent the amount by which the solution exceeds a minimum target, they are given positive coefficients in the objective function.
FALSE

23. Alternative optimal solutions occur when there is no feasible solution to the problem.
FALSE

24. A range of optimality is applicable only if the other coefficient remains at its original value.
TRUE

25. Because the dual price represents the improvement in the value of the optimal solution per unit increase in right-hand-side, a dual price cannot be negative.
FALSE

26. Decision variables limit the degree to which the objective in a linear programming problem is satisfied.
FALSE

27. No matter what value it has, each objective function line is parallel to every other objective function line in a problem.
TRUE

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28. The point (3, 2) is feasible for the constraint $2x_1 + 6x_2$ £ 30.
TRUE

29. The constraint $2x_1 - x_2 = 0$ passes through the point (200,100).
FALSE

30. The standard form of a linear programming problem will have the same solution as the original problem.
TRUE

31. An optimal solution to a linear programming problem can be found at an extreme point of the feasible region for the problem.
TRUE

32. An unbounded feasible region might not result in an unbounded solution for a minimization or maximization problem.
TRUE

33. An infeasible problem is one in which the objective function can be increased to infinity.
FALSE

34. A linear programming problem can be both unbounded and infeasible.
FALSE

35. It is possible to have exactly two optimal solutions to a linear programming problem.
FALSE

36. Explain the difference between profit and contribution in an objective function. Why is it important for the decision maker to know which of these the objective function coefficients represent?

Answer not provided.

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37. Explain how to graph the line $x_1 - 2x_2$ ³ 0.

Answer not provided.

38. Create a linear programming problem with two decision variables and three constraints that will include both a slack and a surplus variable in standard form. Write your problem in standard form.

Answer not provided.

39. Explain what to look for in problems that are infeasible or unbounded.

Answer not provided.

40. Use a graph to illustrate why a change in an objective function coefficient does not necessarily lead to a change in the optimal values of the decision variables, but a change in the right-hand sides of a binding constraint does lead to new values.

Answer not provided.

41. Explain the concepts of proportionality, additivity, and divisibility.

Answer not provided.

42. Explain the steps necessary to put a linear program in standard form.

Answer not provided.

43. Explain the steps of the graphical solution procedure for a minimization problem.

Answer not provided.

44. Solve the following system of simultaneous equations.

6X + 2Y = 50
2X + 4Y = 20

X = 8, Y =1

45. Solve the following system of simultaneous equations.

6X + 4Y = 40
2X + 3Y = 20

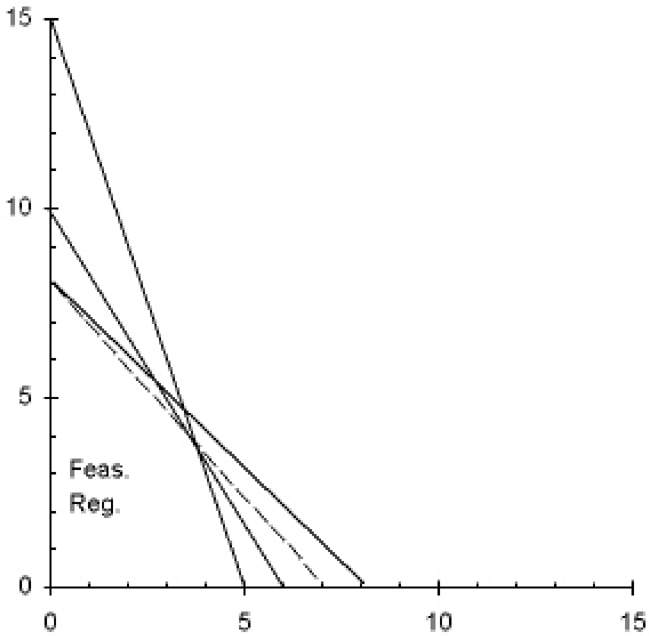
X = 4, Y = 4

46. Consider the following linear programming problem

Max	8X + 7Y
s.t.	15X + 5Y £ 75
	10X + 6Y £ 60
	X + Y £ 8
	X, Y ³ 0

a. Use a graph to show each constraint and the feasible region.
b. Identify the optimal solution point on your graph. What are the values of X and Y at the optimal solution?
c. What is the optimal value of the objective function?

a.



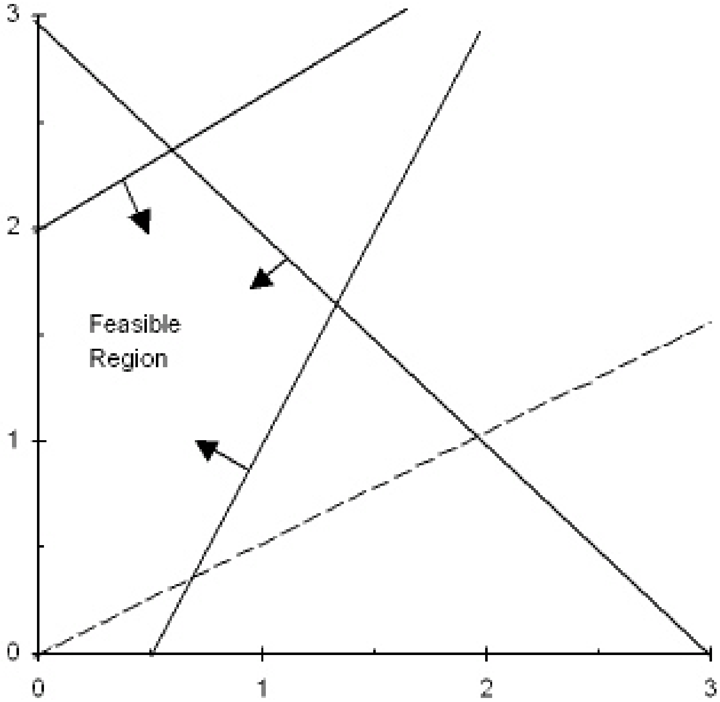
b. The optimal solution occurs at the intersection of constraints 2 and 3. The point is X = 3, Y = 5.
c. The value of the objective function is 59.

47. For the following linear programming problem, determine the optimal solution by the graphical solution method

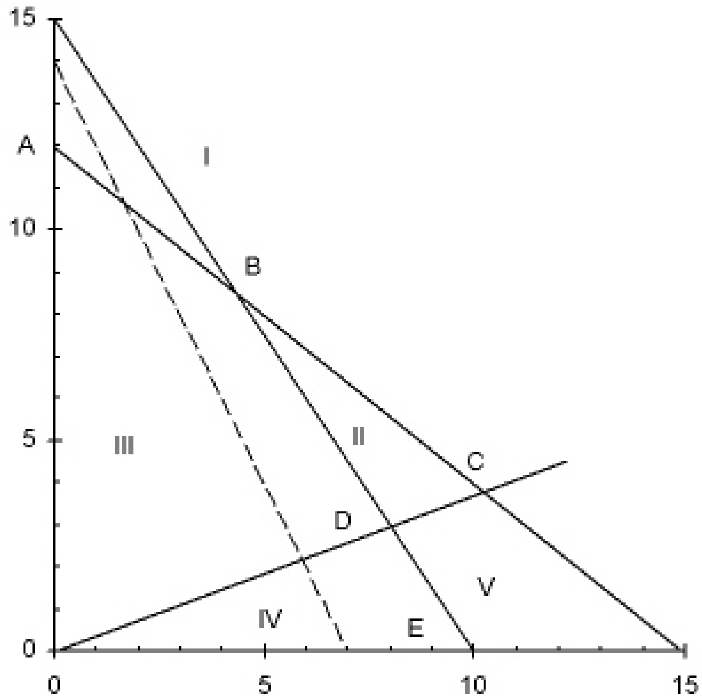
Max -X + 2Y

s.t. 6X - 2Y £ 3
-2X + 3Y £ 6
X + Y £ 3
X, Y ³ 0

X = 0.6 and Y = 2.4



48. Use this graph to answer the questions.



Max 20X + 10Y

s.t. 12X + 15Y £ 180
15X + 10Y £ 150
3X - 8Y £ 0
X , Y ³ 0

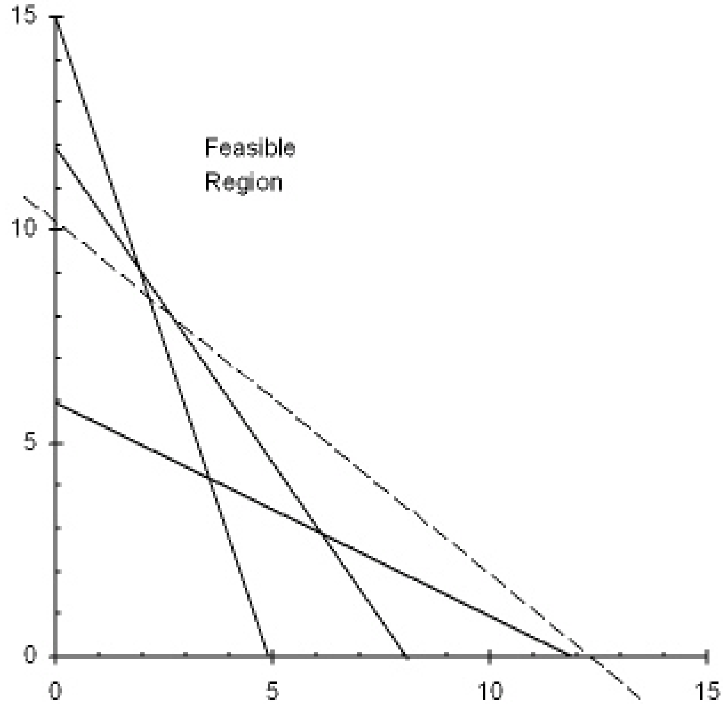
a. Which area (I, II, III, IV, or V) forms the feasible region?
b. Which point (A, B, C, D, or E) is optimal?
c. Which constraints are binding?
d. Which slack variables are zero?

a. Area III is the feasible region
b. Point D is optimal
c. Constraints 2 and 3 are binding
d. S_2 and S_3 are equal to 0

49. Find the complete optimal solution to this linear programming problem.

Min 5X + 6Y

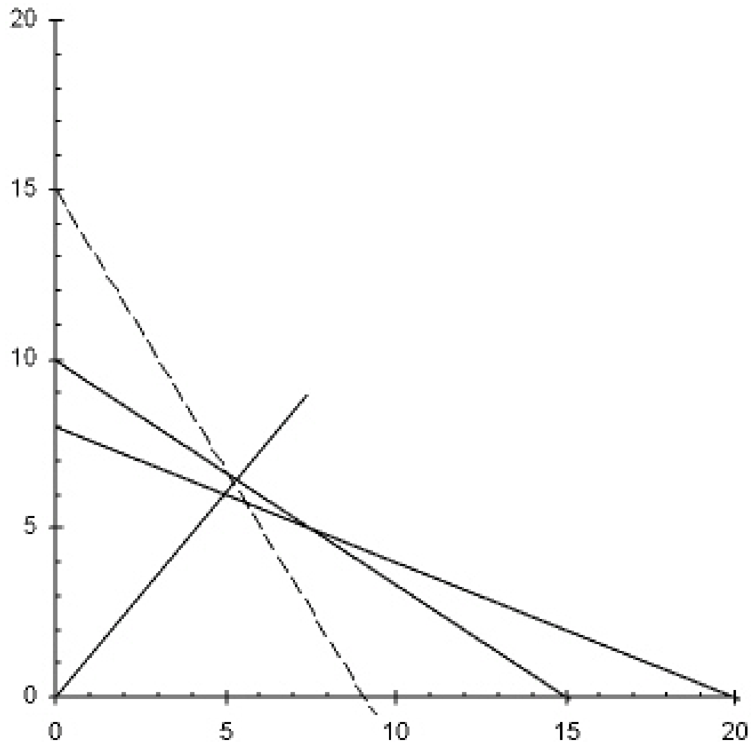
s.t. 3X + Y ³ 15
X + 2Y ³ 12
3X + 2Y ³ 24
X , Y ³ 0



The complete optimal solution is X = 6, Y = 3, Z = 48, S_1 = 6, S_2 = 0, S_3 = 0

50. Find the complete optimal solution to this linear programming problem.

Max	5X + 3Y
s.t.	2X + 3Y £ 30
	2X + 5Y £ 40
	6X - 5Y £ 0
	X , Y ³ 0

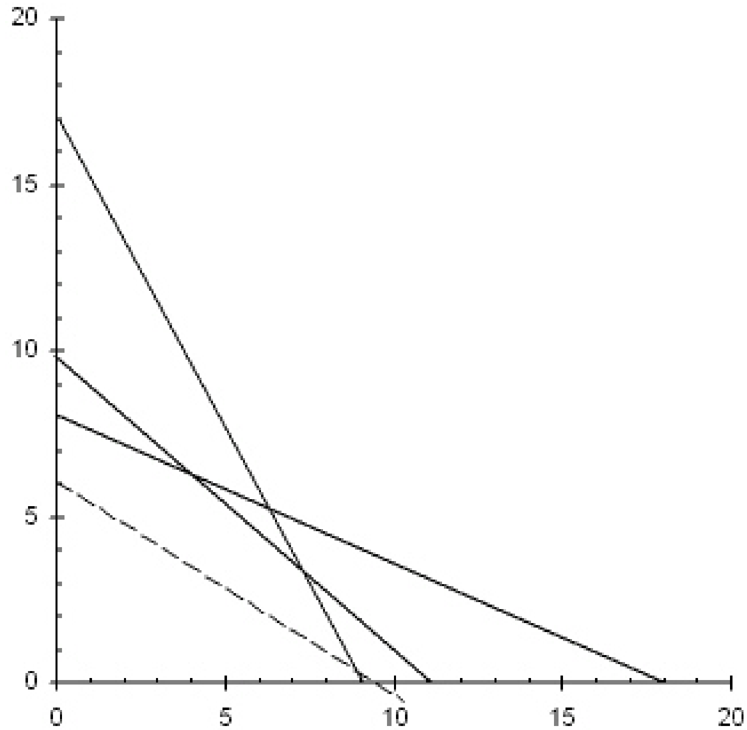


The complete optimal solution is X = 15, Y = 0, Z = 75, S_1 = 0, S_2 = 10, S_3 = 90

51. Find the complete optimal solution to this linear programming problem.

Max 2X + 3Y

s.t.
4X + 9Y £ 72
10X + 11Y £ 110
17X + 9Y £ 153
X , Y ³ 0



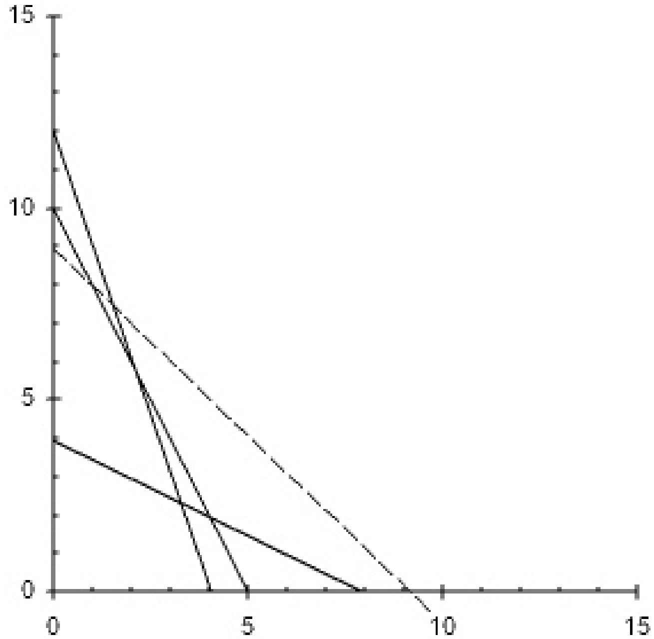
The complete optimal solution is X = 4.304, Y = 6.087, Z = 26.87, S_1 = 0, S_2 = 0, S_3 = 25.043

52. Find the complete optimal solution to this linear programming problem.

Min 3X + 3Y

s.t. 12X + 4Y ≥ 48
10X + 5Y ≥ 50
4X + 8Y ≥ 32
X , Y ≥ 0

Full file at https://testbankgo.info/p/



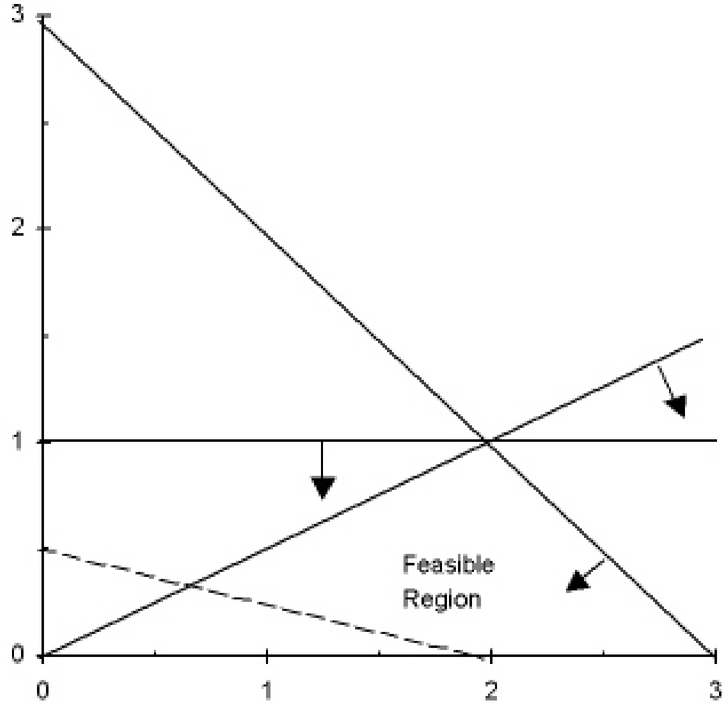
The complete optimal solution is X = 4, Y = 2, Z = 18, S_1 = 8, S_2 = 0, S_3 = 0

53. For the following linear programming problem, determine the optimal solution by the graphical solution method. Are any of the constraints redundant? If yes, then identify the constraint that is redundant.

Max X + 2Y

s.t. X + Y £ 3
X - 2Y ³ 0
Y £ 1
X, Y ³ 0

X = 2, and Y = 1 Yes, there is a redundant constraint; Y £ 1



54. Maxwell Manufacturing makes two models of felt tip marking pens. Requirements for each lot of pens are given below.

	Fliptop Model	Tiptop Model	Available
Plastic	3	4	36
Ink Assembly	5	4	40
Molding Time	5	2	30

The profit for either model is $1000 per lot.

a. What is the linear programming model for this problem?

b. Find the optimal solution.

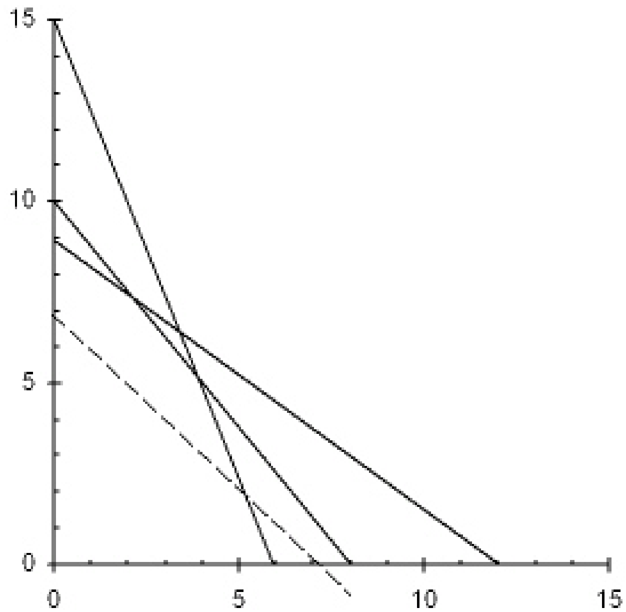
c. Will there be excess capacity in any resource?

a. Let F = the number of lots of Fliptop pens to produce
Let T = the number of lots of Tiptop pens to produce

Max 1000F + 1000T

s.t. 3F + 4T £ 36
5F + 4T £ 40
5F + 2T £ 30
F , T ³ 0

b.



The complete optimal solution is F = 2, T = 7.5, Z = 9500, S_1 = 0, S_2 = 0, S_3 = 5

c. There is an excess of 5 units of molding time available.

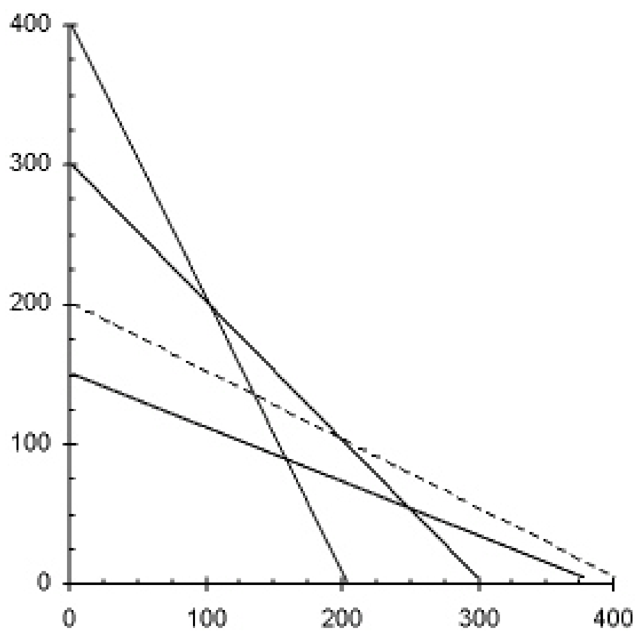
55. The Sanders Garden Shop mixes two types of grass seed into a blend. Each type of grass has been rated (per pound) according to its shade tolerance, ability to stand up to traffic, and drought resistance, as shown in the table. Type A seed costs $1 and Type B seed costs $2. If the blend needs to score at least 300 points for shade tolerance, 400 points for traffic resistance, and 750 points for drought resistance, how many pounds of each seed should be in the blend? Which targets will be exceeded? How much will the blend cost?

	Type A	Type B
Shade Tolerance	1	1
Traffic Resistance	2	1
Drought Resistance	2	5

Let A = the pounds of Type A seed in the blend
Let B = the pounds of Type B seed in the blend

Min $1A + 2B$

s.t.
$1A + 1B \geq 300$
$2A + 1B \geq 400$
$2A + 5B \geq 750$
$A, B \geq 0$



The optimal solution is at A = 250, B = 50. Constraint 2 has a surplus value of 150. The cost is 350.

56. Muir Manufacturing produces two popular grades of commercial carpeting among its many other products. In the coming production period, Muir needs to decide how many rolls of each grade should be produced in order to maximize profit. Each roll of Grade X carpet uses 50 units of synthetic fiber, requires 25 hours of production time, and needs 20 units of foam backing. Each roll of Grade Y carpet uses 40 units of synthetic fiber, requires 28 hours of production time, and needs 15 units of foam backing.

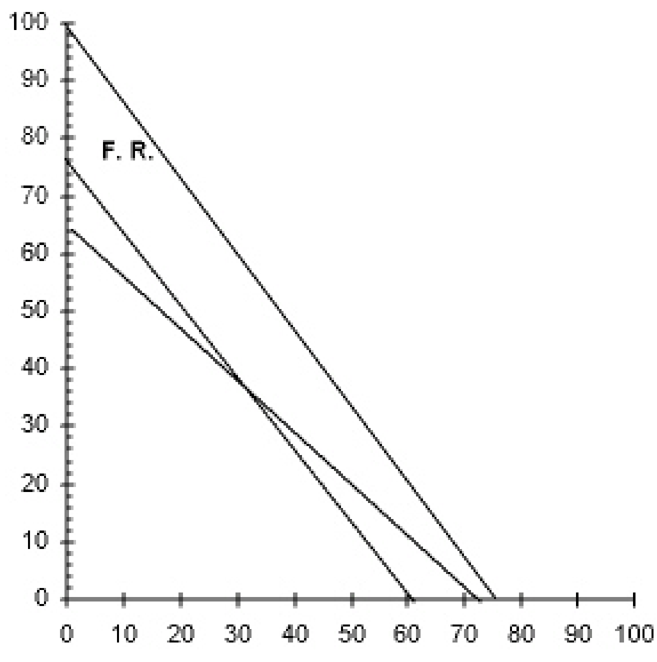
The profit per roll of Grade X carpet is $200 and the profit per roll of Grade Y carpet is $160. In the coming production period, Muir has 3000 units of synthetic fiber available for use. Workers have been scheduled to provide at least 1800 hours of production time (overtime is a possibility). The company has 1500 units of foam backing available for use.

Develop and solve a linear programming model for this problem.

Let X = the number of rolls of Grade X carpet to make
Let Y = the number of rolls of Grade Y carpet to make

Max 200X + 160Y

s.t.
50X + 40Y £ 3000
25X + 28Y ³ 1800
20X + 15Y £ 1500
X , Y ³ 0



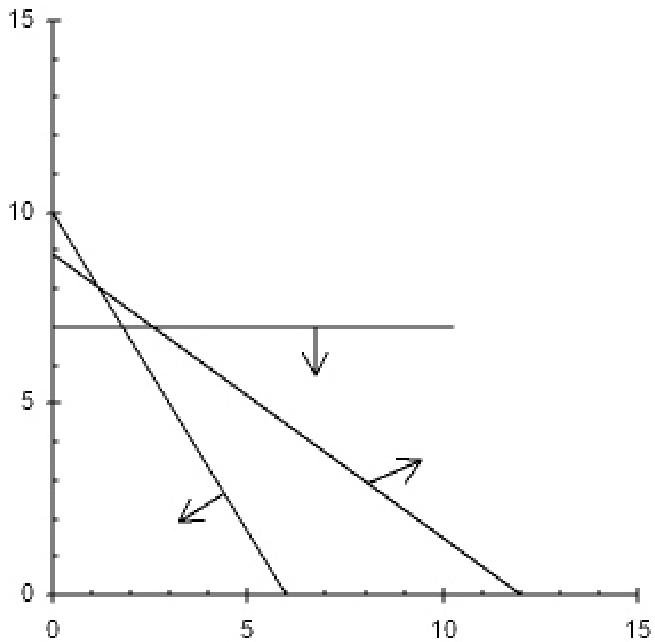
The complete optimal solution is X = 30, Y = 37.5, Z = 12000, S_1 = 0, S_2 = 0, S_3 = 337.5

57. Does the following linear programming problem exhibit infeasibility, unboundedness, or alternate optimal solutions? Explain.

Min 1X + 1Y

s.t.
5X + 3Y £ 30
3X + 4Y ³ 36
Y £ 7
X , Y ³ 0

The problem is infeasible.

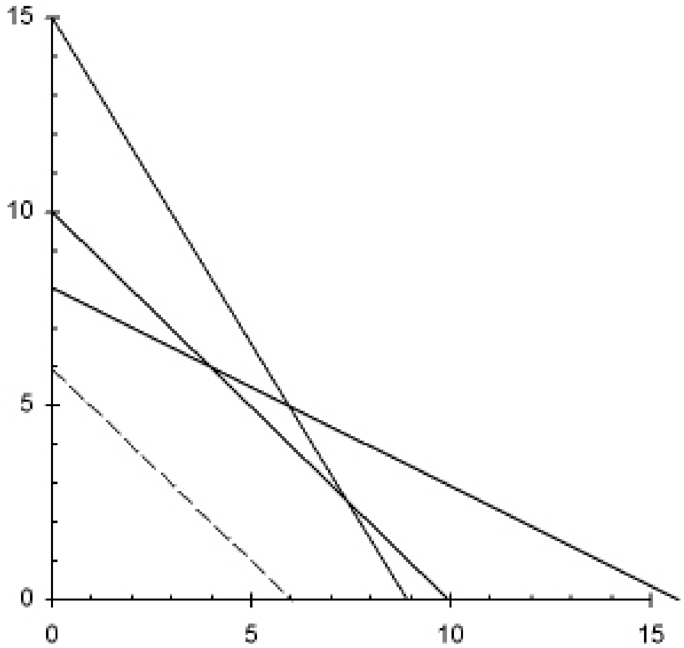


58. Does the following linear programming problem exhibit infeasibility, unboundedness, or alternate optimal solutions? Explain.

Min 3X + 3Y

s.t.
1X + 2Y £ 16
1X + 1Y £ 10
5X + 3Y £ 45
X , Y ³ 0

The problem has alternate optimal solutions.



59. A businessman is considering opening a small specialized trucking firm. To make the firm profitable, it is estimated that it must have a daily trucking capacity of at least 84,000 cu. ft. Two types of trucks are appropriate for the specialized operation. Their characteristics and costs are summarized in the table below. Note that truck 2 requires 3 drivers for long haul trips. There are 41 potential drivers available and there are facilities for at most 40 trucks. The businessman's objective is to minimize the total cost outlay for trucks.

		Capacity	Drivers
Truck	Cost	(Cu. Ft.)	Needed
Small	$18,000	2,400	1
Large	$45,000	6,000	3

Solve the problem graphically and note there are alternate optimal solutions. Which optimal solution:

a. uses only one type of truck?
b. utilizes the minimum total number of trucks?
c. uses the same number of small and large trucks?

a. 35 small, 0 large
b. 5 small, 12 large
c. 10 small, 10 large

60. Consider the following linear program:

MAX 60X + 43Y

s.t.
X + 3Y ³ 9
6X - 2Y = 12
X + 2Y £ 10
X, Y ³ 0

a. Write the problem in standard form.
b. What is the feasible region for the problem?
c. Show that regardless of the values of the actual objective function coefficients, the optimal solution will occur at one of two points. Solve for these points and then determine which one maximizes the current objective function.

a. MAX 60X + 43Y

S.T.
X + 3Y - S_1 = 9
6X - 2Y = 12
X + 2Y + S_3 = 10
X, Y, S_1, S_3 ³ 0

b. Line segment of 6X - 2Y = 12 between (22/7,24/7) and (27/10,21/10).

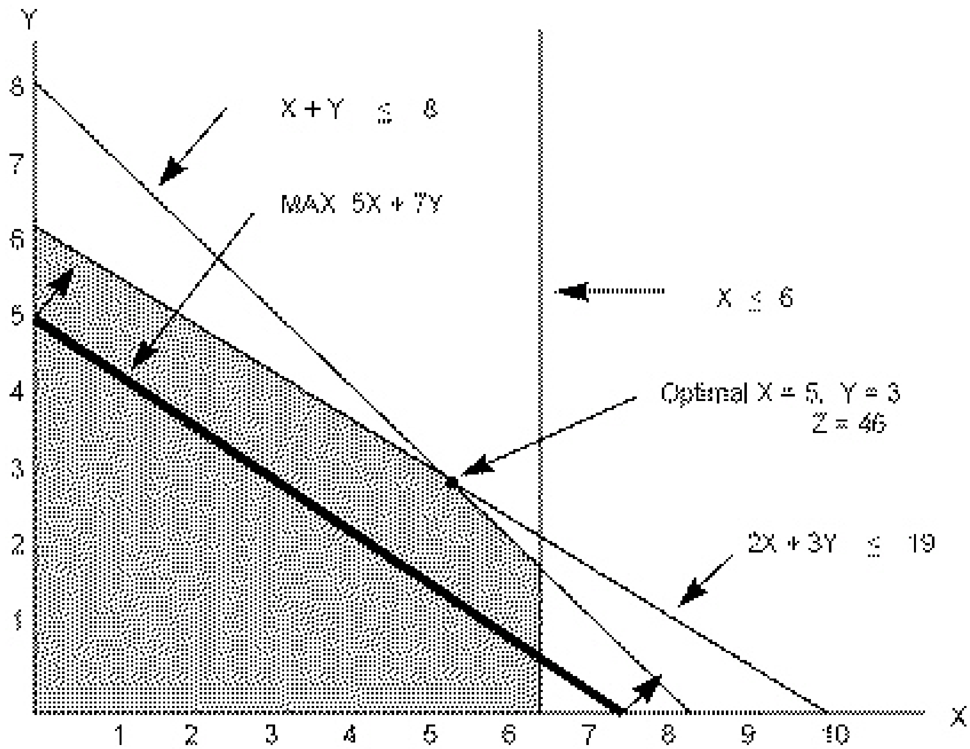
c. Extreme points: (22/7,24/7) and (27/10,21/10). First one is optimal, giving Z = 336.

61. Solve the following linear program graphically.

MAX 5X + 7Y

s.t.
X £ 6
2X + 3Y £ 19
X + Y £ 8
X, Y ³ 0

From the graph below we see that the optimal solution occurs at X = 5, Y = 3, and Z = 46.



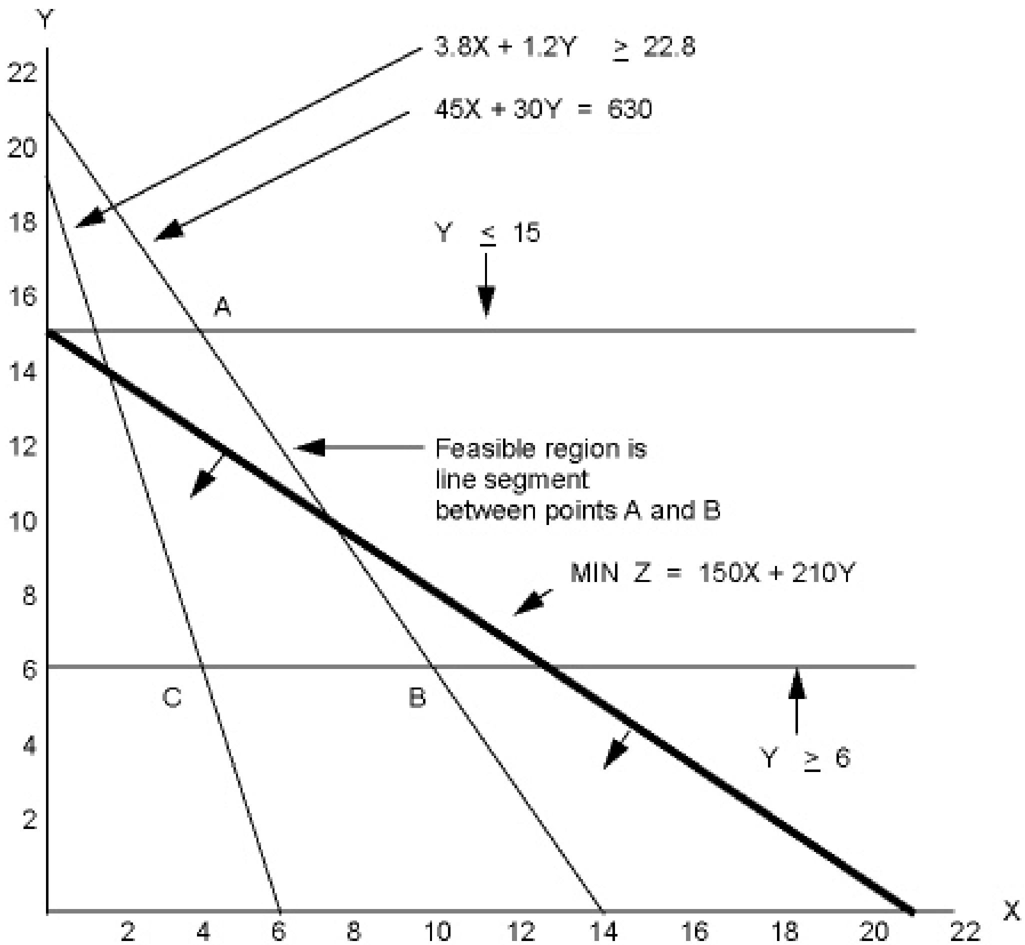
62. Given the following linear program:

MIN 150X + 210Y

s.t. 3.8X + 1.2Y ³ 22.8
Y ³ 6
Y £ 15
45X + 30Y = 630
X, Y ³ 0

Solve the problem graphically. How many extreme points exist for this problem?

Two extreme points exist (Points A and B below). The optimal solution is X = 10, Y = 6, and Z = 2760 (Point B).



63. Solve the following linear program by the graphical method.

MAX 4X + 5Y

s.t.
X + 3Y £ 22
-X + Y £ 4
Y £ 6
2X - 5Y £ 0
X, Y ³ 0

Two extreme points exist (Points A and B below). The optimal solution is X = 10, Y = 6, and Z = 2760 (Point B).