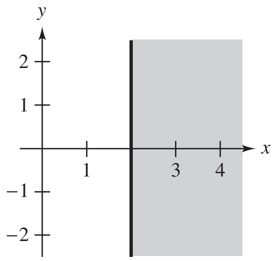
Chapter 9

Section 9.1 *(page 447)*

1. f **3.** a **5.** b

7.



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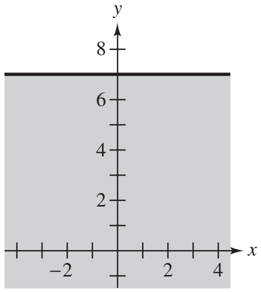

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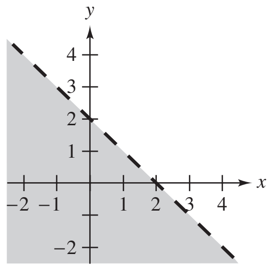

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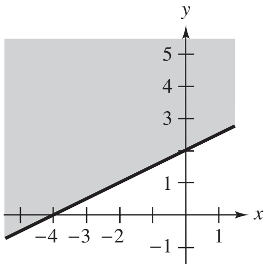

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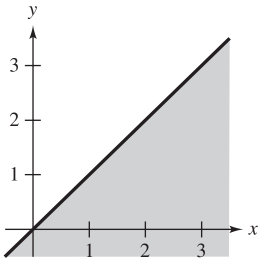

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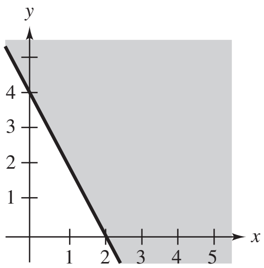

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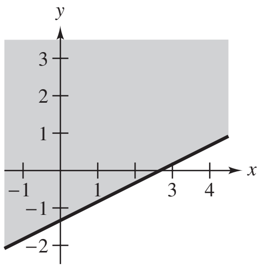

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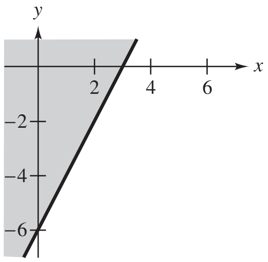

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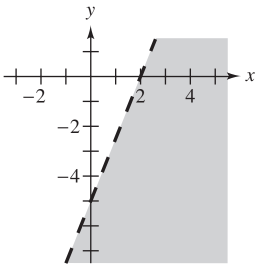

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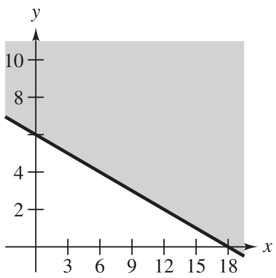

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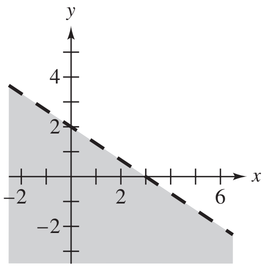
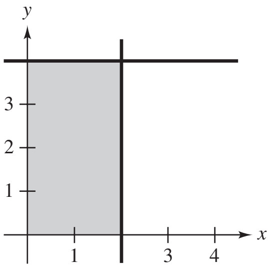


29. (a) No (b) No (c) Yes (d) Yes

31. (a) No (b) Yes (c) Yes (d) Yes

33.



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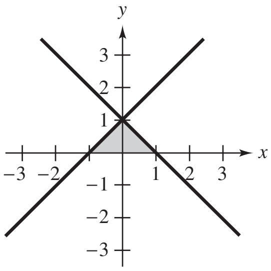

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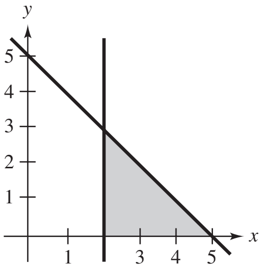

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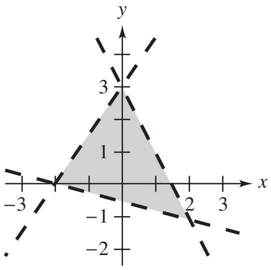

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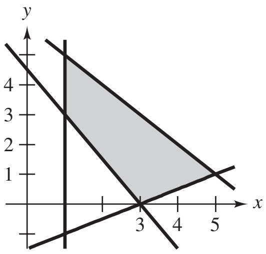

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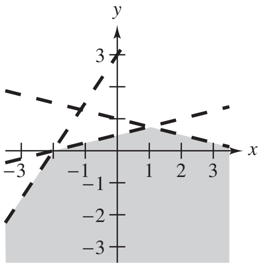

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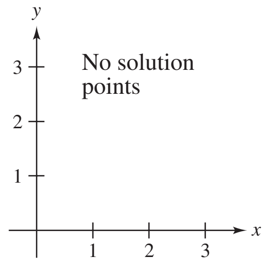
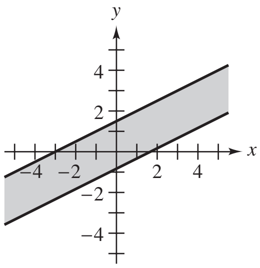


47.



49. $y \le 4 - x$
$x \ge 0$
$y \ge 0$

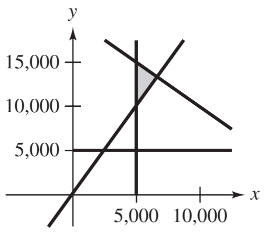
51. $y < 2x + 1$
$x \ge 0$
$y \ge 0$
$x \le 4$

53. $2 \le x \le 5$
$1 \le y \le 7$

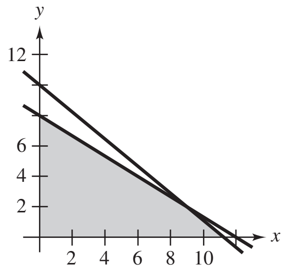
55. $10x - 7y \ge -46$
$3x + 5y \le 43$
$10x - 7y \le 25$
$3x + 5y \ge -28$

57. $y \le \frac{3}{2}x$
$y \le -x + 5$
$y \ge 0$

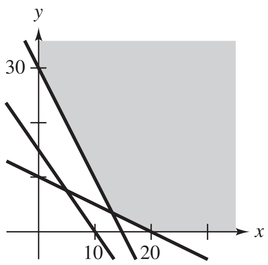
59. x = amount in one account
y = amount in other account
$x + y \le 20{,}000$
$x \ge 5000$
$y \ge 5000$
$2x \le y$



61. $x + \frac{3}{2}y \le 12$
$\frac{4}{3}x + \frac{3}{2}y \le 15$
$x \ge 0$
$y \ge 0$

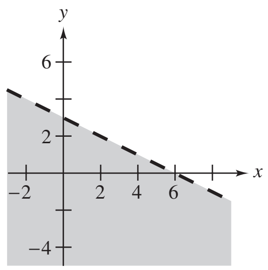


63. x = # of ounces of food X
y = # of ounces of food Y
$20x + 10y \ge 300$
$15x + 10y \ge 150$
$10x + 20y \ge 200$
$x \ge 0$
$y \ge 0$



65. The solution points lie above the boundary line. Explanations will vary.

67.

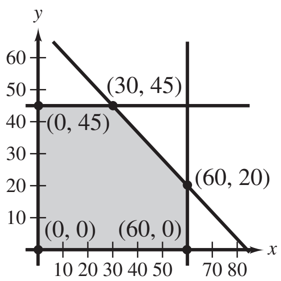


(a) The graph includes the boundary.
(b) The graph is shaded above the boundary.

Section 9.2 *(page 454)*

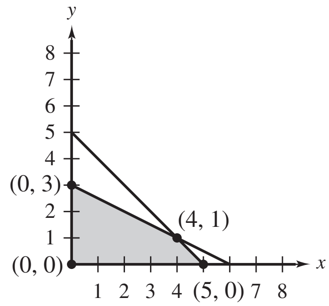
1. (a) Minimum is 0 at (0, 0). Minimum is 41 at (3, 4).
(b) Minimum is 0 at (0, 0). Maximum is 20 at (4, 0).

3.



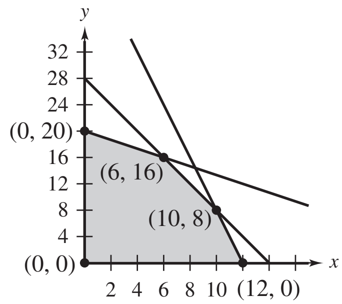
(a) Minimum is 0 at (0, 0). Maximum is 740 at (60, 20).
(b) Minimum is 0 at (0, 0). Maximum is 2100 at any point on the line segment between (30, 45) and (60, 20).

5.



(a) Minimum is 0 at (0, 0). Maximum is 21 at (4, 1).
(b) Minimum is −3 at (0, 3). Maximum is 10 at (5, 0).
(c) Minimum is −25 at (5, 0). Maximum is 3 at (0, 3).

7.



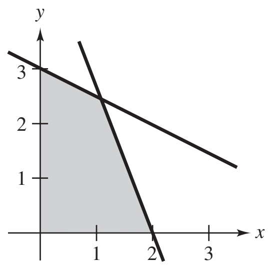
(a) Minimum is 0 at (0, 0). Maximum is 12 at (12, 0).
(b) Minimum is 0 at (0, 0). Maximum is 20 at (0, 20).
(c) Minimum is 0 at (0, 0). Maximum is 22 at (6, 16).

9. Minimum is 0 at (0, 0). Maximum is 12 at (3, 6).

11. Minimum is 0 at (0, 0). Maximum is 10 at (0, 10).

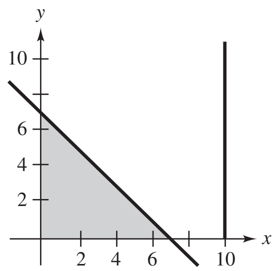
13. Minimum is 0 at (0, 0). Maximum is 50 at (0, 10).

15.



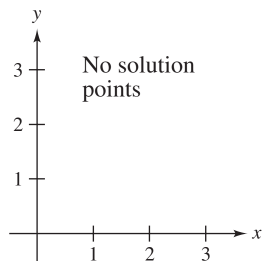
z is maximum at any point on the line segment between points (2, 0) and $\left(\frac{20}{19}, \frac{45}{19}\right)$.

17.



The constraint $x \le 10$ is extraneous.

19.



The feasible set is empty, no maximum.

21. 100 units of \$80 model
100 units of \$100 model
Maximum profit: \$5500

23. 3 bags of brand X
6 bags of brand Y
Minimum cost: \$240

25. 12 audits, 0 tax returns

27. (a) $t \geq 6$ (b) $2.4 \leq t \leq 6$ (c) $t \leq 2.4$
(d) Not possible

29. Answers will vary. Sample answer: $z = x + 5y$

31. Answers will vary. Sample answer: $z = 4x + y$

Section 9.3 *(page 468)*

1. Objective function should be maximized, not minimized.

3. All constraints must be $\leq$.

5.

x_1	x_2	s_1	s_2	b	Basic Variables
2	1	1	0	8	s_1
1	1	0	1	5	s_2
−1	−2	0	0	0	

7.

x_1	x_2	x_3	s_1	s_2	b	Basic Variables
1	2	0	1	0	12	s_1
1	0	1	0	1	8	s_2
−2	−3	−4	0	0	0	

9. (8, 0, 112, 0, 4) **11.** Maximum is 8 at (8, 0).

13. Maximum is 17 at (3, 4). **15.** Maximum is 740 at (60, 20).

17. Maximum is 43 at (7, 3).

19. Maximum is 210 at (0, 21, 21).

21. Maximum is 25 at (23, 0, 2) or $\left(\frac{43}{3}, 0, \frac{32}{3}\right)$.

23. Maximum is 24 at (0, 12, 0, 0).

25. Maximum is 2640 at (105, 150, 70).

27. 8 audits, 8 tax returns

29. $\frac{5000}{3}$ liters of the the first drink
$\frac{2500}{3}$ liters of the second drink
Maximum profit: about $1416.67

31. 322 of model A
764 of model B
484 of model C
Maximum profit: $79,310

33. 50 acres of crop X
0 acres of crop Y and crop Z
Maximum profit: $3000

35. $t \geq 5/2$

37. After one iteration, the simplex tableau is as follows.

x_1	x_2	s_1	s_2	b	Basic Variables
$-\frac{1}{2}$	0	1	$\frac{3}{2}$	7	s_1
$-\frac{1}{2}$	1	0	$\frac{1}{2}$	2	x_2
−2	0	0	1	4	

39. After one iteration, $x_1 = 2$, $x_2 = 0$, and $z = 5$. Bringing x_2 into the basis after another iteration, $x_1 = \frac{20}{19}$, $x_2 = \frac{45}{19}$, and z still equals 5.

41. Maximum is about 480.8 at (0, 5.16, 53.20, 31.37).

43. Maximum is about 346.88 at (14.78, 0, 60.51, 0).

45. False. The entering variable corresponds to the most negative entry.

Section 9.4 *(page 478)*

1. (Maximize)
Objective function:
$z = 6y_1 + 6y_2$
Constraints:
$2y_1 + y_2 \leq 2$
$y_1 + 2y_2 \leq 2$
$y_1, y_2 \geq 0$

3. (Maximize)
Objective function:
$z = 5y_1 + 8y_2 + 6y_3$
Constraints:
$y_1 + 2y_2 + 2y_3 \leq 9$
$2y_1 + 2y_2 + y_3 \leq 6$
$y_1, y_2, y_3 \geq 0$

5. (Maximize)
Objective function: $z = 7y_1 + 4y_2$
Constraints:
$y_1 + y_2 \leq 14$
$y_1 + 2y_2 \leq 20$
$2y_1 + y_2 \leq 24$
$y_1, y_2 \geq 0$

7. (a) Minimum is 6 at (1, 1).
(b) (Maximize)
Objective function:
$z = 3y_1 + 5y_2$
Constraints:
$y_1 + 3y_2 \leq 3$
$2y_1 + 2y_2 \leq 3$
$y_1, y_2 \geq 0$
(c) Maximum is 6 at $\left(\frac{3}{4}, \frac{3}{4}\right)$.

9. (a) Minimum is 13 at (1, 1).
(b) (Maximize)
Objective function:
$z = 3y_1 + 5y_2$
Constraints:
$y_1 + 3y_2 \leq 5$
$2y_1 + 2y_2 \leq 8$
$y_1, y_2 \geq 0$
(c) Maximum is 13 at $\left(\frac{7}{2}, \frac{1}{2}\right)$.

11. (a) Minimum is 8 at $\left(\frac{4}{3}, \frac{5}{3}\right)$.
(b) (Maximize)
Objective function: $z = 3y_1 + 2y_2$
Constraints:
$y_1 - y_2 \leq 1$
$y_1 + 2y_2 \leq 4$
$y_1, y_2 \geq 0$
(c) Maximum is 8 at (2, 1).

13. (a) Minimum is 9 at $\left(\frac{1}{2}, 2\right)$.
(b) (Maximum)
Objective function: $z = 4y_1 + 2y_2$
Constraints:
$4y_1 \leq 6$
$y_1 + y_2 \leq 3$
$y_1, y_2 \geq 0$
(c) Maximum is 9 at $\left(\frac{3}{2}, \frac{3}{2}\right)$.

15. Minimum is $\frac{9}{5}$ at $\left(1, \frac{9}{5}\right)$. **17.** Minimum is 8 at (0, 8).

19. Minimum is 5 at (5, 0). **21.** Minimum is 18 at $\left(\frac{1}{5}, 2, \frac{7}{5}\right)$.

23. Minimum is 64 at $\left(\frac{4}{3}, 4, 16\right)$.

25. 22.5 days for plant 1
10.5 days for plant 2
4.75 days for plant 3
Minimum operating cost: $2,152,500

27. Answers will vary.

29. 1 liter of drink A
1 liter of drink B
Minimum cost: $5

31. 3 liters of drink A
0 liters of drink B
Minimum cost: $3

33. Minimum is 87.14 at (21.43, 2.86, 25.71, 0).

Section 9.5 *(page 488)*

1.

x_1	x_2	s_1	s_2	b	Basic Variables
2	1	−1	0	4	s_1
1	1	0	1	8	s_2
−10	−4	0	0	0	

3.

x_1	x_2	s_1	s_2	b	Basic Variables
2	1	1	0	4	s_1
1	3	0	−1	2	s_2
1	1	0	0	0	

5.

x_1	x_2	x_3	s_1	s_2	s_3	b	Basic Variables
4	1	0	−1	0	0	10	s_1
1	1	3	0	1	0	30	s_2
2	1	4	0	0	−1	16	s_3
−1	0	−1	0	0	0	0	

7.

x_1	x_2	x_3	s_1	s_2	b	Basic Variables
5	4	5	−1	0	12	s_1
1	6	0	0	1	5	s_2
4	2	1	0	0	0	

9. Maximum is 12 at (0, 6).
11. Minimum is 16 at any point on the line segment between (0, 8) and (2, 7).
13. Maximum is 25 at (5, 20, 0).
15. Maximum is 12 at (0, 6). The solution is the same.
17. Maximum is 16 at (2, 7). The value of w is the same, but the point (x_1, x_2) is different. (Note: Any point on the line segment between (0, 6) and (2, 7) is an optimal solution.)
19. Maximum is 25 at (5, 20, 0). The solution is the same.
21. Maximum is 40 at (0, 8).
23. Maximum is 108 at (0, 36).
25. Minimum is 15 at (5, 10).
27. Maximum is 30 at (5, 20, 0).
29. Minimum is -20 at $\left(11, \frac{1}{2}, 0\right)$. (Note: Any point on the line segment between $\left(11, \frac{1}{2}, 0\right)$ and (10, 0, 0) is an optimal solution.)
31. Maximum is 9 at (4, 1).
33. Maximum is 4 at (1, 4).
35. Maximum is 6 at (0, 3).
37. Maximum is 24 at (1, 4).
39. Maximum is 0 at (2, 0).
41. Maximum is 9 at (4, 5).
43. Maximum is 3 at (0, 3).
45. Maximum is -4 at (2, 0).
47. 300 tires from S_1 to C_1
600 tires from S_1 to C_2
200 tires from S_2 to C_1
Minimum cost $1100
49. 600 tires from S_1 to C_2
500 tires from S_2 to C_1
Minimum cost: $1100
51. (a)

	Outlet I	*Outlet II*
Plant A	a	$5000 - a$
Plant B	$3000 - a$	a

(b) Minimum cost: $40,000

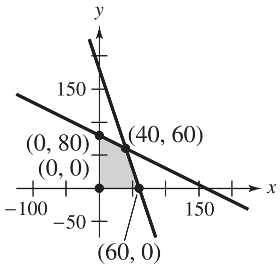
53. (a)

	Customer 1	*Customer 2*
Factory 1	0	200
Factory 2	200	100

(b) Minimum cost: $14,500
55. 9 television ads
4 newspaper ads
Maximum audience: 147,000,000
57. Feasible solution; s_1 and s_2 are positive.
59. Feasible solution; s_1 and s_2 are positive.
61. Not a feasible solution; s_3 is negative.
63. True. See paragraph before Example 2.

Review Exercises *(page 491)*

1.



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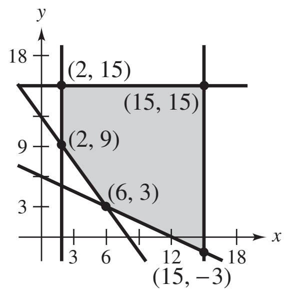
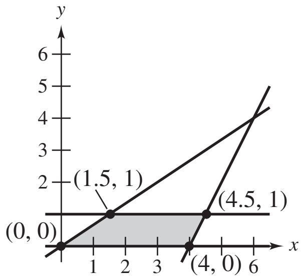


5.



7. Minimum is 0 at (0, 0).
Maximum is 47 at (5, 8).
9. Minimum is 0 at (0, 0).
Maximum is 20 at (5, 0).
11. Minimum is 0 at (0, 0).
Maximum is 2100 at $y = -\frac{5}{6}x + 70$ where $30 \le x \le 60$.
13. Minimum is 0 at (0, 0).
Maximum is 125 at (25, 0).
15. Minimum is 3 at (3, 0).
Maximum is 11 at (5, 2).
17. Minimum is -6 at (0, 6).
Maximum is $\frac{64}{3}$ at $\left(8, \frac{8}{3}\right)$.
19. Maximum is 26 at (12, 7).
21. Maximum is 20 at $\left(0, \frac{48}{5}, \frac{4}{5}\right)$. (Note: Any point on the line segment between $\left(0, \frac{48}{5}, \frac{4}{5}\right)$ and (0, 0, 20) is an optimal solution.)
23. Maximum is 232 at (100, 132).
25. Maximum is 3599 at (110, 537, 146).
27. (Maximize)
Objective function: $z = 30y_1 + 75y_2$
Constraints:
$y_1 + 3y_2 \le 7$
$y_1 + 6y_2 \le 3$
$2y_1 + 4y_2 \le 1$
$y_1, y_2 \ge 0$

29. Minimum is 75 at $(5, 2)$.

31. Minimum is 6006 at $\left(\frac{81}{2}, 138, 111\right)$.

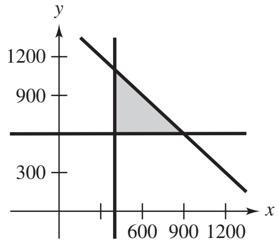
33. Minimum is $\frac{118}{3}$ at $\left(\frac{4}{3}, \frac{1}{3}, 0\right)$.

35. Maximum is 31 at $(1, 5)$.

37. Maximum is 67 at $(7, 27, 26)$.

39. Minimum is 90 at $(10, 0, 0)$.

41. $x + y \leq 1500$, $x \geq 400$, $y \geq 600$



43. (a) 2 vests, 5 purses (b) $500

45. $\frac{5}{3}$ liters of dietary drink I
$\frac{4}{3}$ liters of dietary drink II
Minimum cost: $19

47. 5 liters of dietary drink I
0 liters of dietary drink II
Minimum cost: $5

49. 3 bags of Brand X
6 bags of Brand Y
Minimum cost: $345

51. Minimum cost is $4800 when mines A, B, and C are operated for 7, 5, and 24 days, respectively. (*Note:* Any point in the triangular region bounded by $(7, 5, 24)$, $(12, 0, 24)$, and $(7, 0, 34)$, is an optimal solution.)