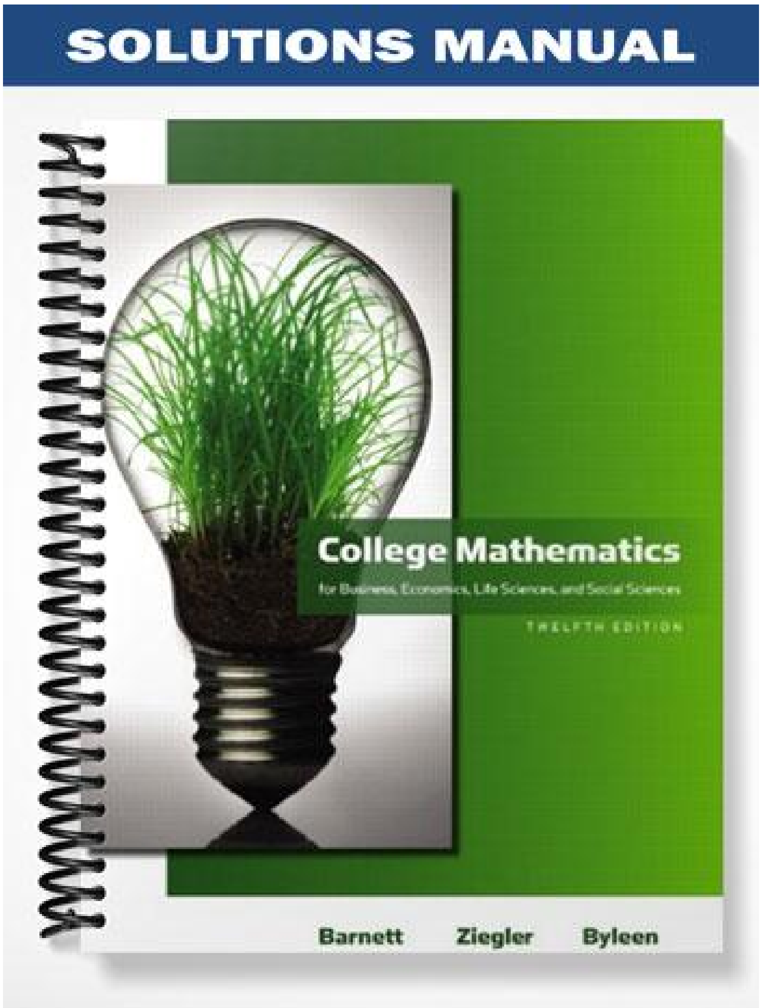
SOLUTIONS MANUAL
College Mathematics
for Business, Economics, Life Sciences, and Social Sciences
TWELFTH EDITION
Barnett
Ziegler
Byleen

ONLINE INSTRUCTOR'S SOLUTIONS MANUAL

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COLLEGE MATHEMATICS
FOR BUSINESS, ECONOMICS, LIFE SCIENCES AND SOCIAL SCIENCES
TWELFTH EDITION

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Publishing as Prentice Hall, 75 Arlington Street, Boston, MA 02116.

ISBN-13: 978-0-321-64598-2
ISBN-10: 0-321-64598-7

Prentice Hall
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www.pearsonhighered.com

1 LINEAR EQUATIONS AND GRAPHS

EXERCISE 1-1

2.
$$\begin{aligned} 3y - 4 &= 6y - 19 \\ 3y &= 6y - 15 \\ 3y - 6y &= -15 \\ -3y &= -15 \\ y &= 5 \end{aligned}$$

4. $5x + 2 > 1$

$5x > -1$

$x > -\frac{1}{5}$

6. $-4x \le 8$

$\frac{-4x}{-4} \ge \frac{8}{-4}$ (Dividing by a negative number)

$x \ge -2$

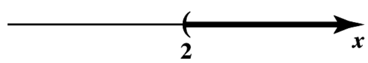
8. $-2x + 8 < 4$

$-2x + 8 - 8 < 4 - 8$

$-2x < -4$

$\frac{-2x}{-2} > \frac{-4}{-2}$ (Dividing by a negative number)

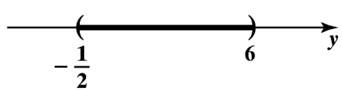
$x > 2$ or $(2, \infty)$



10. $-4 < 2y - 3 < 9$

$-1 < 2y < 12$

$-\frac{1}{2} < y < 6$ or $(-1/2, 6)$.



12. $\frac{m}{3} - 4 = \frac{2}{3}$

Multiply both sides of the equation by 3 to obtain:

$m - 12 = 2$

$m = 14$

14. $\frac{x}{-4} < \frac{5}{6}$

Multiply both sides by (-4) which will result in changing the direction of the inequality as well.

$x > \frac{-20}{6}$ and simplified we have $x > -\frac{10}{3}$.

16.
$$\begin{aligned} -3y + 9 + y &= 13 - 8y \\ -2y + 9 &= 13 - 8y \\ 6y &= 4 \\ y &= \frac{4}{6} = \frac{2}{3} \end{aligned}$$

18.
$$\begin{aligned} -3(4 - x) &= 5 - (x + 1) \\ -12 + 3x &= 5 - x - 1 \\ -12 + 3x &= 4 - x \\ 12 - 12 + 3x &= 12 + 4 - x \\ 3x &= 16 - x \\ 4x &= 16 \\ x &= 4 \end{aligned}$$

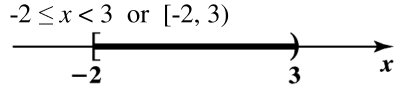
20.
$$x - 2 \geq 2(x - 5)$$
$$x - 2 \geq 2x - 10$$
$$x - 2 + 2 \geq 2x - 10 + 2$$
$$x \geq 2x - 8$$
$$x \leq 8$$

22. $\frac{y}{4} - \frac{y}{3} = \frac{1}{2}$

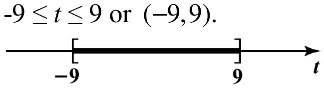
Multiply both sides by 12:
$$3y - 4y = 6$$
$$-y = 6$$
$$y = -6$$

24.
$$\frac{u}{2} - \frac{2}{3} < \frac{u}{3} + 2$$
$$\frac{u}{2} - \frac{u}{3} < 2 + \frac{2}{3}$$
$$\frac{u}{6} < \frac{8}{3}$$
$$u < 16$$

26.
$$-4 \leq 5x + 6 < 21$$
$$-6 - 4 \leq 5x < 21 - 6$$
$$-10 \leq 5x < 15$$
$$-2 \leq x < 3 \text{ or } [-2, 3)$$



28.
$$-1 \leq \frac{2}{3}t + 5 \leq 11$$
$$-5 - 1 \leq \frac{2}{3}t \leq 11 - 5$$
$$-6 \leq \frac{2}{3}t \leq 6$$
$$-18 \leq 2t \leq 18$$
$$-9 \leq t \leq 9 \text{ or } (-9, 9).$$



30.
$$y = -\frac{2}{3}x + 8$$
$$y - 8 = -\frac{2}{3}x + 8 - 8$$
$$-\frac{2}{3}x = y - 8$$
$$-2x = 3y - 24$$
$$x = \frac{3y - 24}{-2} = -\frac{3}{2}y + 12$$

32.
$$y = mx + b$$
$$y - b = mx + b - b$$
$$mx = y - b$$
$$m = \frac{y - b}{x}$$

34.
$$C = \frac{5}{9}(F - 32)$$
$$\frac{9}{5}C = F - 32$$
$$32 + \frac{9}{5}C = F$$
$$F = \frac{9}{5}C + 32$$

36.
$$-10 \leq 8 - 3u \leq -6$$
$$-18 \leq -3u \leq -14$$
$$18 \geq 3u \geq 14$$
$$6 \geq u \geq \frac{14}{3}$$
$$\frac{14}{3} \leq u \leq 6 \text{ or } (14/3, 6)$$

38. (A) Two must be negative and one positive or all three must be positive.

(B) Two must be positive and one negative or all three must be negative.

(C) Two must be negative and one positive or all three must be positive.

(D) $a \neq 0$ and b and c must have opposite signs.

40. If a and b are negative and $\frac{b}{a} > 1$, then multiplying both sides by the negative number a we obtain $b < a$ and hence $a - b > 0$.

42. False. Consider the two closed intervals [1, 2] and [2, 3]. Their intersection is {2} which is not an interval.

44. False. Consider the two closed intervals [-1, 0] and [1, 2]. Their union is $[-1, 0] \cup [1, 2]$ which is not an interval.

46. True. Let $A = [a, b]$, $B = [c, d]$, where $a \le c \le b$, so that $A \cap B \ne \varnothing$. Then $A \cap B = [c, b]$ if $b \le d$ and $A \cap B = [c, d]$ if $d \le b$. In either case, the intersection is a closed interval.

48. Let x = number of quarters in the meter. Then
$100 - x$ = number of dimes in the meter.

Now, $0.25x + 0.10(100 - x) = 14.50$ or

$$0.25x + 10 - 0.10x = 14.50$$
$$0.15x = 4.50$$
$$x = \frac{4.50}{0.15} = 30$$

Thus, there will be 30 quarters and 70 dimes.

50. Let x be the amount invested in "Fund A" and $(500{,}000 – x)$ the amount invested in "Fund B". Then $0.052x + 0.077(500{,}000 – x) = 30{,}000$.
Solving for x:

$$(0.077)(500{,}000) – 30{,}000 = (0.077 – 0.052)x$$
$$8{,}500 = 0.025x$$
$$x = \frac{8{,}500}{0.025} = \$340{,}000$$

So, \$340,000 should be invested in Fund A and \$160,000 in Fund B.

52. Let x be the price of the house in 1960. Then

$$\frac{29.6}{195.3} = \frac{x}{200{,}000} \text{ (refer to Table 2, Example 10)}$$
$$x = 200{,}000 \cdot \frac{29.6}{195.3} \approx \$30{,}312$$

To the nearest dollar, the house would be valued \$30,312 in 1960.

54. (A) It is $60 – 0.15(60) = \$51$

(B) Let x be the retail price. Then

$$136 = x – 0.15x = 0.85x$$

So, $x = \frac{136}{0.85} = \$160$.

56. Let x be the number of times you must clean the living room carpet to make buying cheaper than renting. Then

$(20 + 2(16))x = 300 + 3(9)x$

Solving for x

$52x = 300 + 27x$

$25x = 300$

$x = \frac{300}{25} = 12$

58. Let x be the amount of the second employee's sales during the month. Then

(A) $3,000 + 0.05x = 4,000$

or $x = \frac{4,000 - 3,000}{0.05} = \$20,000$

(B) In view of Problem 57 we have:

$2,000 + 0.08(x - 7,000) = 3,000 + 0.05x$

Solving for x:

$2,000 - (0.08)7,000 - 3,000 = 0.05x - 0.08x$

$-1,560 = -0.03x$

$x = \frac{1,560}{0.03} = \$52,000$

(C) An employee who chooses (A) will earn more than he or she would with the other option until $52,000 in sales is achieved, after which the other option would earn more.

60. Let x = number of books produced. Then

Costs: $C = 2.10x + 92,000$

Revenue: $R = 15x$

To find the break-even point, set $R = C$:

$15x = 2.10x + 92,000$

$12.9x = 92,000$

$x = \frac{92,000}{12.9} \approx 7,132$

Thus, 7,132 books will have to be sold for the publisher to break even.

62. Let x = number of books produced.

Costs: $C(x) = 92,000 + 2.70x$

Revenue: $R(x) = 15x$

(A) The obvious strategy is to raise the price of the book.

(B) To find the break-even point, set $R(x) = C(x)$:

$15x = 92,000 + 2.70x$

$12.30x = 92,000$

$x = 7,480$

The company must sell more than 7,480 books to make a profit.

(C) From Problem 60, the production level at the break-even point is: 7,132 books. At this production level, the costs are

$C(7,132) = 92,000 + 2.70(7,132) = \$111,256.40$

If p is the new price of the book, then we need

$7{,}132p = 111{,}256.40$

and $p \approx \$15.60$

The company should sell the book for at least \$15.60.

64. $-49 \le F \le 14$

$-49 \le \frac{9}{5}C + 32 \le 14$

$-32 - 49 \le \frac{9}{5}C \le 14 - 32$

$-81 \le \frac{9}{5}C \le -18$

$(-81)\cdot 5 \le 9C \le (-18)\cdot 5$

$\frac{(-81)\cdot 5}{9} \le C \le \frac{(-18)\cdot 5}{9}$

$-45 \le C \le -10$

66. Note that $\text{IQ} = \frac{\text{MA}}{\text{CA}} \times 100$ (see problem 65). Thus

$80 < \text{IQ} < 140$

$80 < \frac{\text{MA}}{12} \times 100 < 140$

or $\frac{(80)(12)}{100} < \text{MA} < \frac{(140)(12)}{100}$

or $9.6 < \text{MA} < 16.8$

68. Note that $C = \frac{B}{L} \times 100$ (see problem 67). Thus

$\frac{15}{17.4} \times 100 < C < \frac{20}{17.4} \times 100$

or $86.2 < C < 114.9$

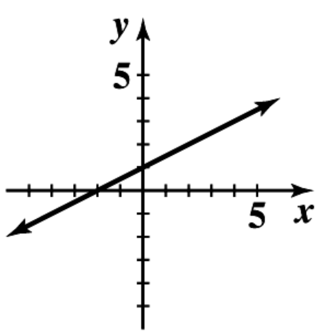
EXERCISE 1-2

2. (A)

4. (B); slope is not defined for a vertical line

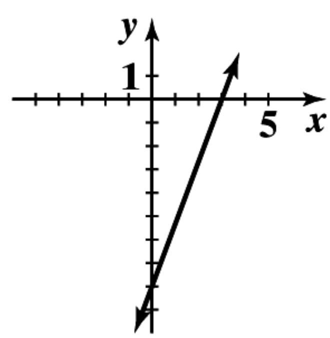
6. $y = \frac{x}{2} + 1$

x	y
0	1
2	2
4	3



8. $8x - 3y = 24$

x	y
0	−8
3	0
6	8



10. Slope: $m = 3$

y intercept: $b = 2$

12. Slope: $m = -\frac{10}{3}$

y intercept: $b = 4$

14. Slope: $m = \frac{1}{5}$, y intercept: $b = -\frac{1}{2}$

16. $m = 1$, $b = 5$ so $y = x + 5$.

18. $m = \frac{6}{7}$, y intercept: $b = -\frac{9}{2}$ so $y = \frac{6}{7}x - \frac{9}{2}$

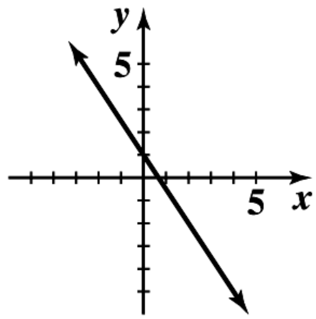
20. x intercept: 1; y intercept: 3; $y = -3x + 3$

22. x intercept: 2, y intercept: -1; $y = \frac{1}{2}x - 1$

24. $y = -\frac{3}{2}x + 1$

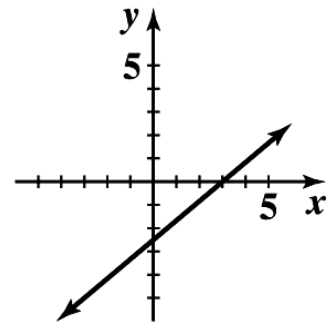
$m = -\frac{3}{2}$, $b = 1$

x	y
0	1
2	–2
–2	4

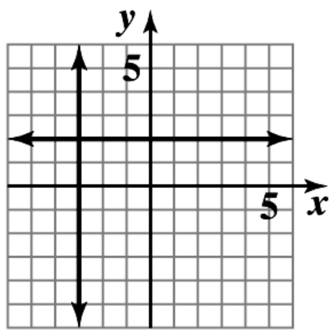


26. $5x - 6y = 15$

x	y
0	–2.5
3	0
–3	–5



28.



30. $5x - y = -2$

$-y = -5x - 2$

Multiply both sides by (-1);

$y = 5x + 2$

$m = 5$

32. $2x - 3y = 18$

$-3y = -2x + 18$

Divide both sides by (-3);

$y = \frac{2}{3}x - 6$

$m = \frac{2}{3}$

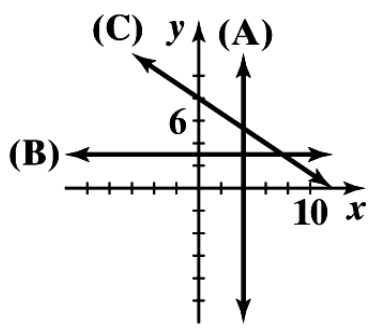
34. $-x + 8y = 4$

$8y = x + 4$

$y = \frac{1}{8}x + \frac{1}{2}$

Slope = $\frac{1}{8}$

36.

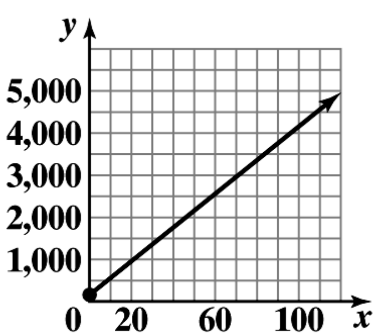


(A) $x = 4$

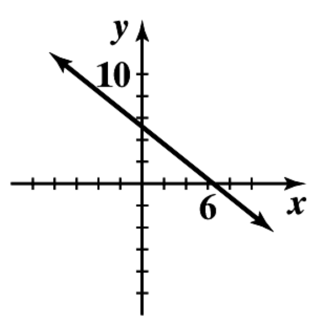
(B) $y = 3$

(C) $y = -\frac{2}{3}x + 8$

38.



40. (A)

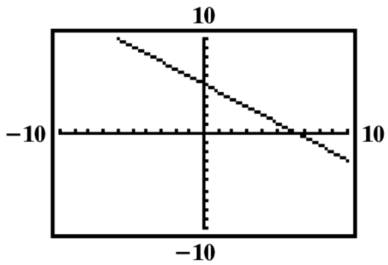


(B) Set $f(x) = 0$,

$-0.8x + 5.2 = 0$, $x = 6.5$.

Set $x = 0$, $y = 5.2$.

(C)



(D) x intercept: 6.5;
y intercept: 5.2

(E) $x > 6.5$

42. The equation of the vertical line is $x = -5$ and the equation of the horizontal line is $y = 6$.

44. The equation of the vertical line is $x = 2.6$ and the equation of the horizontal line is $y = 3.8$.

46. $y - 1 = -6[x - (-4)]$
$y - 1 = -6x - 24$
$y = -6x - 23$

48. $y - 2 = \frac{4}{3}[x - (-6)]$
$y - 2 = \frac{4}{3}x + 8$
$y = \frac{4}{3}x + 10$

50. $y - (-2.7) = 0(x - 3.1)$
$y + 2.7 = 0$ or $y = -2.7$

52. (A) $m = \frac{5-2}{3-1} = \frac{3}{2}$

(B) Using $y - y_1 = m(x - x_1)$, where $m = \frac{3}{2}$ and $(x_1, y_1) = (1, 2)$ or (3, 5), we get:

$y - 2 = \frac{3}{2}(x - 1)$ or $y - 5 = \frac{3}{2}(x - 3)$

Those two equations are equivalent. After simplifying either one of these, we obtain: $-3x + 2y = 1$.

(C) Slope-intercept form: $y = \frac{3}{2}x + \frac{1}{2}$

54. (A) $m = \frac{7-3}{-3-2} = -\frac{4}{5}$

(B) Using $y - y_1 = m(x - x_1)$, where $m = -\frac{4}{5}$ and $(x_1, y_1) = (-3,7)$, we obtain:

$y - 7 = -\frac{4}{5}(x + 3)$ or $4x + 5y = 23$.

(C) Slope-intercept form: $y = -\frac{4}{5}x + \frac{23}{5}$

56. (A) $m = \frac{4-4}{0-1} = \frac{0}{-1} = 0$

(B) The line through (1, 4) and (0, 4) is horizontal; $y = 4$.

(C) Slope-intercept form is the same: $y = 4$.

58. (A) $m = \frac{-3-0}{2-2} = \frac{-3}{0}$ which is not defined.

(B) The line through (2, 0) and (2, -3) is vertical; $x = 2$.

(C) No slope-intercept form

60. The graphs are parallel lines with slope -0.5.

62. Let C be the total weekly cost of producing x picnic tables. Then

$C = 1{,}200 + 45x$

For $C = \$4{,}800$, we have

$1{,}200 + 45x = 4{,}800$

Solving for x we obtain

$$x = \frac{4{,}800 - 1{,}200}{45} = 80$$

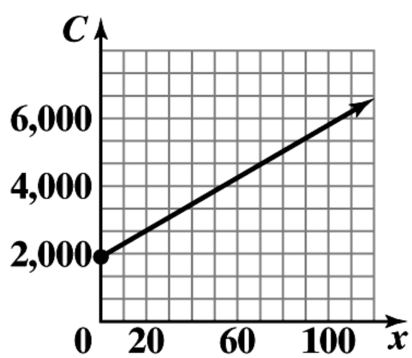
64. Let y be daily cost of producing x tennis rackets. Then we have two points for (x, y):
(50, 3,855) and (60, 4,245).

(A) Since x and y are linearly related, then the two points (50, 3,855) and (60, 4,245) will lie on the line expressing the linear relationship between x and y. Therefore

$$y - 3{,}855 = \frac{(4{,}245 - 3{,}855)}{(60-50)}(x - 50)$$

or $y = 39x + 1{,}905$

(B)



(C) The y intercept, \$1,905, is the fixed cost and the slope, \$39, is the cost per racket.

66. Let R and C be retail price and cost respectively. Then two points for (C, R) are (20, 33) and (60, 93).

(A) If C and R are linearly related, then the line expressing their relationship passes through the points (20, 33) and (60, 93). Therefore,

$$R - 33 = \frac{(93-33)}{(60-20)}(C - 20)$$

or $R = 1.5C + 3$

(B) For R = \$240 we have

$240 = 1.5C + 3$

or $C = \frac{240-3}{1.5} = \$158$

68. We observe that for (t, V) two points are given: (0, 224,000) and (16, 115,200)

(A) A linear model will be a line passing through the two points (0, 224,0000) and (16, 115,200). The equation of this line is:

$$V - 115{,}200 = \frac{(224{,}000 - 115{,}200)}{(0-16)}(t - 16) \text{ or } V = -6{,}800t + 224{,}000$$

(B) For $t = 10$

$V = -6{,}800(10) + 224{,}000 = \$156{,}000$

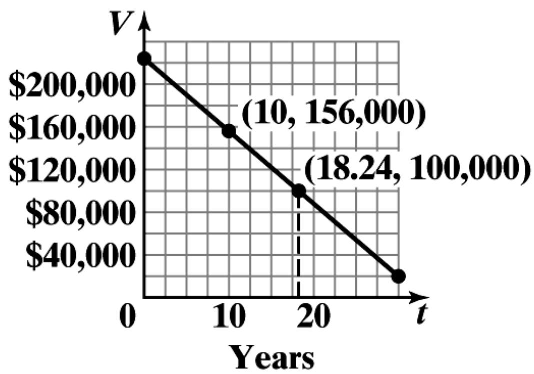
(C) For V = \$100,000

$100{,}000 = -6{,}800t + 224{,}000$

or $t = \frac{(224{,}000 - 100{,}000)}{6{,}800} \approx 18.24$

So, during the 19th year, the depreciated value falls below \$100,000.

(D)



70. We have two representations for (x, T) namely: (29.9, 212) and (28.4, 191).

(A) The line of the form $T = mx + b$ has slope:

$m = \frac{(212-191)}{(29.9-28.4)} = 14$

Using, say (29.9, 212˚) will give the value for b:

$212 = 14(29.9) + b$ or $b = -206.6$

Thus, $T = 14x - 206.6$.

(B) For $x = 31$, we have

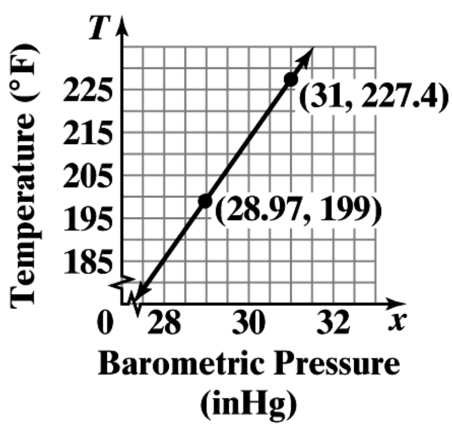
$T = 14(31) - 206.6 = 227.4$˚F

(C) For T = 199˚F, we have

$199 = 14x - 206.6$

or $x = \frac{199+206.6}{14} \approx 28.97$ inHg

(D)



72. Let T be the true airspeed at the altitude A (thousands of feet), then we have two representations of (A, T): (0, 200) and (10, 360).

(A) A linear relationship between A and T has slope

$m = \frac{(360-200)}{(100-0)} = 16$. Now using the point (0, 200) we obtain the equation of the line:

$T - 200 = 16(A\text{-}0)$

or $T = 16A + 200$

(B) For $A = 6.5$ (6,500 feet)

$T = 16(6.5) + 200 = 304$ mph

74. For (t, I) we have two representations:

(0, 30,000) and (16, 48,000).

(A) The linear equation will be:

$$I - 30{,}000 = \frac{(48{,}000-30{,}000)}{(16-0)}(t-0)$$

or $I = 1125t + 30{,}000$

(B) For $t = 40$, we have $I = 1125(40) + 30{,}000 = \$75{,}000$.

76. We have two representations of (t, m): (1, 25.2) and (6, 23.9).

(A) The equation of the line relating m to t is:

$$m - 25.2 = \frac{(23.9-25.2)}{(6-1)}(t-1)$$

or $m = -0.26t + 25.46$

(B) For $m = 20\%$, we have

$$20 = -0.26t + 25.2 \text{ or } t = \frac{25.46-20}{0.26} = 21$$

So, the year will be 2021

78. (A) For (x, p) we have two representations: (9,800, 1.94) and (9,400, 1.82).

The slope is

$$m = \frac{(1.94-1.82)}{(9{,}800-9{,}400)} = 0.0003$$

Using one of the points, say (9,800, 1.94), we find b:

$1.94 = (0.0003)(9{,}800) + b$

or $b = -1$

So, the desired equation is: $p = 0.0003x - 1$.

(B) Here the two representations of (x, p) are: (9,300, 1.94) and (9,500, 1.82). The slope is

$$m = \frac{(1.94-1.82)}{(9{,}300-9{,}500)} = -0.0006$$

Using one of the points, say (9,300, 1.94) we find b:

$1.94 = -0.0006(9{,}300) + b$

or $b = 7.52$

So, the desired equation is: $p = -0.0006x + 7.52$.

(C) To find the equilibrium point, we need to solve

$0.0003x - 1 = -0.0006x + 7.52$ for x. Observe that

$0.0009x = 8.52$ or

$$x = \frac{8.52}{0.0009} = 9{,}467$$

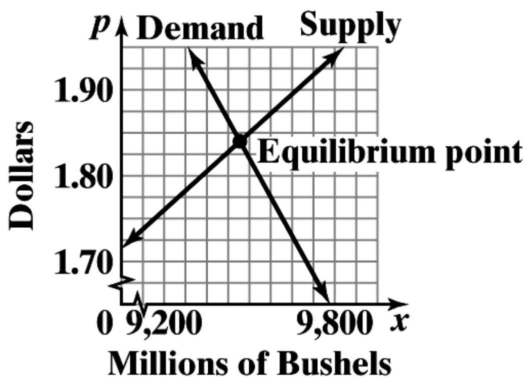
Substituting $x = 9{,}467$ in either of equations in (A) or (B)

we obtain

$p = .0003(9{,}467) - 1 \approx 1.84$

So, the desired point is (9,467, 1.84).

(D)



80. We have two representations of (w, d): (3, 18) and (5, 10).

(A) The line through these two points has a slope $\frac{(18-10)}{(3-5)} = -4$.

So, the equation of the line is

$d - 10 = -4(w - 5)$

or $d = -4w + 30$

(B) For $w = 0$, $d = 30$ in.

(C) For $d = 0$,

$-4w + 30 = 0$

or $w = \frac{30}{4} = 7.5$ lbs.

82. (A) This line has the following equation:

$$y - 35 = \frac{(17-35)}{(40-0)}(x - 0)$$

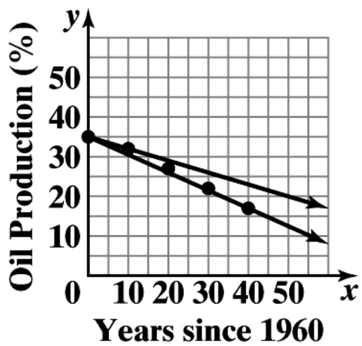
or $y = -0.45x + 35$

(B) This line has the following equation:

$$y - 35 = \frac{(32-35)}{(10-0)}(x - 0)$$

or $y = -0.3x + 35$

(C)



(D) $y = -0.45x + 35$:
$y = -0.45(60) + 35 = 8\%$

$y = -0.3x + 35$:
$y = -0.3(60) + 35 = 17\%$

(E) As can be seen from the graph, the line from (A) is better.

EXERCISE 1-3

2. (A) $w = 52 + 1.9h$

(B) The rate of change of weight with respect to height is 1.9 inches per kilogram.

(C) 5'8" is 8 inches over 5 feet and the model predicts the weight to be
$w = 52 + 1.9(8) = 67.2$ kg.

(D) For $w = 70$, we have
$70 = 52 + 1.9h$
or $h = \dfrac{70-52}{1.9} \approx 9.5$
So, the height of this man is predicted to be 5'9.5".

4. We have two representations of (d, P): (0, 14.7) and (34, 29.4).

(A) A line relating P to d passes through the above two points. Its equation is:
$$P - 14.7 = \frac{(29.4-14.7)}{(34-0)}(d-0)$$
or $P \approx 0.432d + 14.7$

(B) The rate of change of pressure with respect to depth is approximately 0.432 lbs/in^2 per foot.

(C) For $d = 50$,
$P = 0.432(50) + 14.7 \approx 36.3$ lbs/in^2

(D) For $P = 4$ atmospheres, we have $P = 4(14.7) = 58.8$ lbs/in^2 and hence
$58.8 = 0.432d + 14.7$
or $d = \dfrac{58.8-14.7}{0.432} \approx 102$ ft.

6. We have two representations of (t, a): (0, 2,880) and (180, 0).

(A) The linear model relating altitude a to the time in air t has the following equation:

$$a - 2{,}880 = \frac{(0 - 2{,}880)}{(180 - 0)}(t - 0)$$

or $a = -16t + 2{,}880$

(B) The rate of descent for an ATPS system parachute is 16 ft/sec.

(C) It is 16 ft/sec.

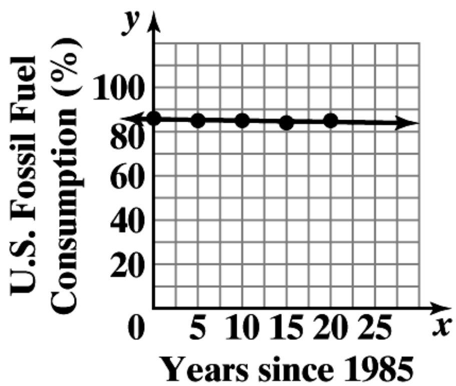
8. We have two representations of (t, s): (0, 1,403) and (20, 1,481).
So, the line passing through these points has the following equation:

$$s - 1{,}403 = \frac{(1{,}481 - 1{,}403)}{(20 - 0)}(t - 0)$$

or $s = 3.9t + 1{,}449$

The slope of this line (model) is the rate of change of the speed of sound with respect to temperature; 3.9 m/s per ˚C.

10. (A)



(B) The percent rate of change of fossil fuel consumption is -0.06% per year.

(C) For $x = 35$ (2020 is 35 years from 1985), we have

$$y = -0.06(35) + 85.6 \approx 83.5,$$

i.e. 83.5% of total production.

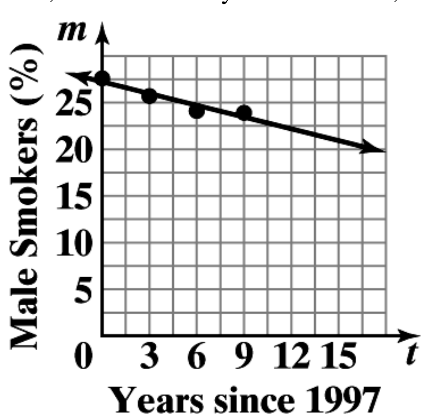
(D) For $y = 80$, we have:

$$80 = -0.06x + 85.6$$

or $x = \dfrac{80 - 85.6}{-0.06} = 93.3$

So, it would be 93 years after 1985, which will be 2078.

12.



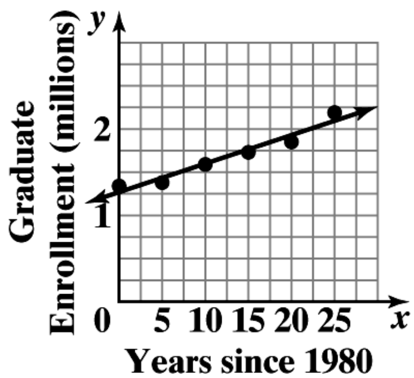
(B) For $m = 15$, we have

$$15 = -0.42t + 27.23$$

or $t = \dfrac{15 - 27.23}{-0.42} \approx 29.12$

So, during 2026 the percentage of male smokers will fall below 15%.

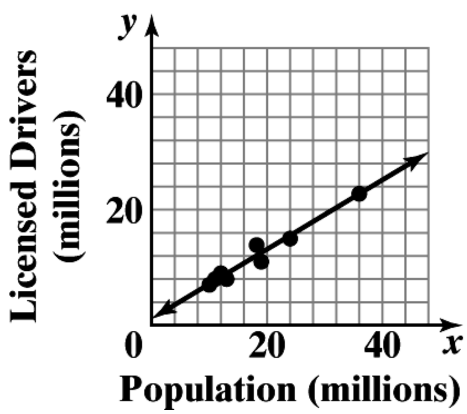
14.



(B) For 2016, $x = 36$ and $y = 0.033(36) + 1.27 \approx 2.5$, so there will be about 2,500,000 graduate students enrolled in 2016.

(C) Graduate student enrollment is increasing at a rate of 0.033 million (or 33,000) students per year.

16.



(B) For $x = 5$, we have

$$y = 0.60(5) + 1.15 = 4.15$$

So the model estimates 4,150,000 licensed drivers in Minnesota in 2006.

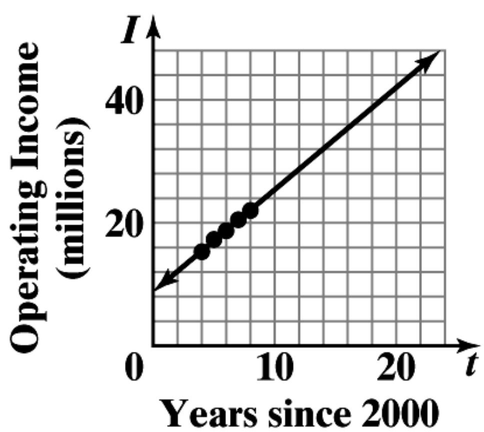
(C) For $y = 4$, we have

$$4 = 0.60x + 1.15$$

or $x = \dfrac{4 - 1.15}{0.60} \approx 4.75$

So, the model estimates the population of Wisconsin in 2006 to be 4,750,000.

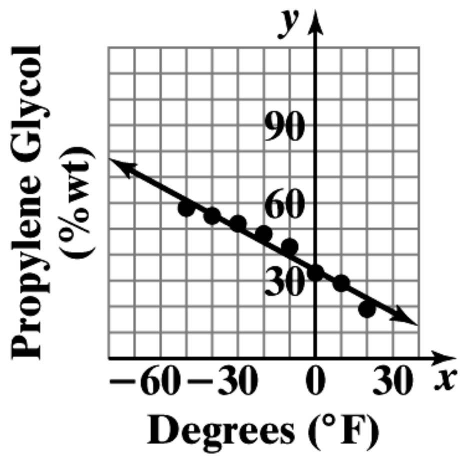
18.



(B) For 2018, $t = 18$ and from the model $I = 1.66(18) + 8.80 \approx 38.68$.

So, the predicted operating income will be about \$38.68 billion.

20.



(B) For $P = 30$, we have:
$30 = -0.54T + 34$
or $T = \dfrac{34-30}{0.54} \approx 7^\circ\text{F}$

(C) For $T = 15$, we have:
$P = -0.54(15) + 34 = 25.9$,
i.e., the estimated percentage of propylene glycol is 25.9%.

22. (A) The rate of change of height with respect to Dbh is 1.66 ft/in.

(B) One inch increase in Dbh produces a height increase of approximately 1.66 ft.

(C) For $x = 12$, we have:
$y = 1.66(12) - 5.14 \approx 15$ ft.

(D) For $y = 25$, we have:
$25 = 1.66x - 5.14$
or $x = \dfrac{25+5.14}{1.66} \approx 18$ in.

24. (A) Annual revenue is increasing at a rate of \$4.89 billion per year.

(B) For 2020, $x = 20$ and $y = 4.89(20) + 38.99 \approx 136.79$.
So, the predicted annual revenue is \$136.79 billion.

26. (A) Annual expenditure per consumer unit on residential telephone service is decreasing at a rate of \$30.70 per year. Annual expenditure per consumer unit on cellular service is increasing at a rate of \$64.00 per year.

(B) For 2015, $x = 15$. For residential service we have:
$y = -30.7(15) + 713 = \$252.50$

For cellular service we have,
$y = 64.0(15) + 142 = \$1,102$

(C) For 2025, the models predict annual expenditure per consumer unit to be -\$54.50 on residential service and \$1,742 on cellular service. The residential model clearly gives an unreasonable prediction for 2025. The cellular model prediction seems overly high.

28. Men: $y = -0.2710x + 121.7933$
Women: $y = -0.1918x + 131.5458$

The graphs of these lines indicate that the women will not catch up with the men. To see this algebraically, if we set the equations equal to each other an solve, then we obtain x = -123.1, so the lines intersect at a point outside of the domain of our functions. Also, the mens' slope is steeper so their times, already lower, are decreasing more rapidly.

30. Supply: $y = 1.53x + 2.85$;
Demand: $y = -2.21x + 10.66$

To find equilibrium price we solve the following equation for x and then use that to find y:

$$1.53x + 2.85 = -2.21x + 10.66$$

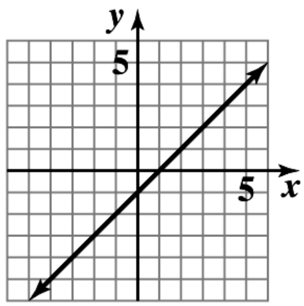
or $$x = \frac{(10.66 - 2.85)}{(1.53 + 2.21)} \approx 2.09,$$

and $y = 1.53(2.09) + 2.85 \approx \$6.05$.

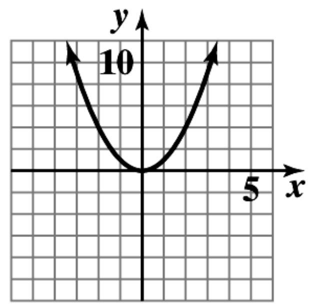
2 FUNCTIONS AND GRAPHS

EXERCISE 2-1

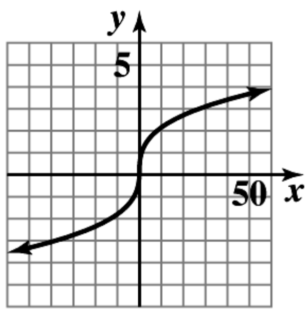
2.



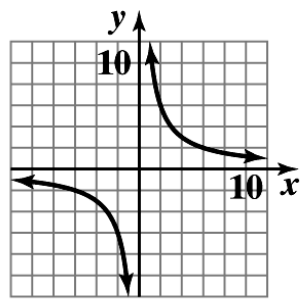
4.



6.



8.



10. The table specifies a function, since for each domain value there corresponds one and only one range value.

12. The table does not specify a function, since more than one range value corresponds to a given domain value.
(Range values 1, 2 correspond to domain value 9.)

14. This is a function.

16. The graph specifies a function; each vertical line in the plane intersects the graph in at most one point.

18. The graph does not specify a function. There are vertical lines which intersect the graph in more than one point. For example, the *y*-axis intersects the graph in two points.

20. The graph does not specify a function.

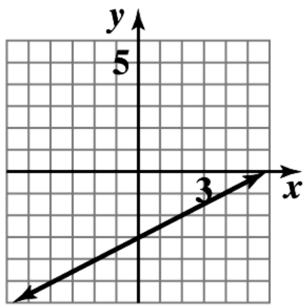
22. $y = 10 - 3x$ is linear.

24. $x^2 - y = 8$ is neither linear nor constant.

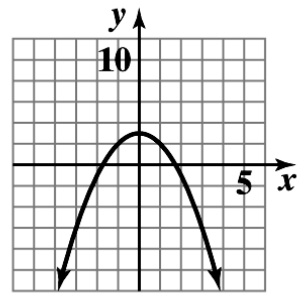
26. $y = \frac{2+x}{3} + \frac{2-x}{3} = \frac{2}{3} + \frac{x}{3} + \frac{2}{3} - \frac{x}{3}$
$= \frac{4}{3}$ which is constant.

28. $9x - 2y + 6 = 0$ is linear.

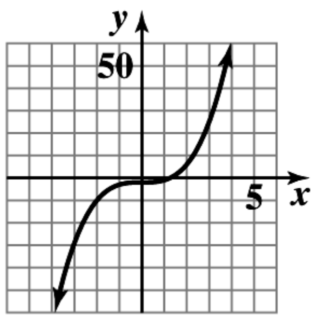
30.



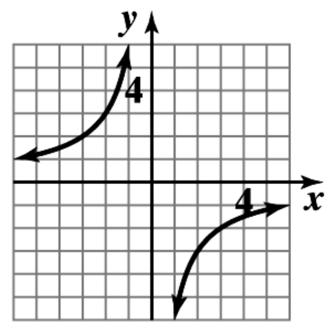
32.



34.



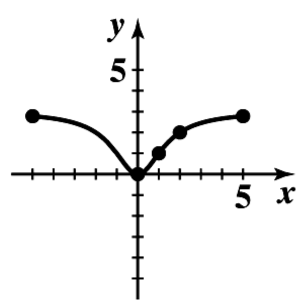
36.



38. $f(x) = \dfrac{3x^2}{x^2+2}$. Since the denominator is bigger than 1, we note that the values of f are between 0 and 3. Furthermore, the function f has the property that $f(-x) = f(x)$. So, adding points $x = 3$, $x = 4$, $x = 5$, we have:

x	-5	-4	-3	-2	-1	0	1	2	3	4	5
$F(x)$	2.78	2.67	2.45	2	1	0	1	2	2.45	2.67	2.78

The sketch is:



40. $y = f(4) = 0$

42. $y = f(-2) = 3$

44. $f(x) = 3$, $x < 0$ at $x = -4, -2$

46. $f(x) = 4$ at $x = 5$

48. $f(-6) = 2(-6) - 3 = -15$

50. $f(9) = 2(9) - 3 = 15$

52. $g(3+7) = g(10) = (10)^2 + 2(10) = 120$

54. $g(3) + g(7) = (3^2 + 2(3)) + (7^2 + 2(7)) = 78$

56. domain: all real numbers or $(-\infty, \infty)$

58. domain: all real numbers except 2

60. f is defined at the values of x where $5 + x > 0$, that is, all $x > -5$.

62. Given $x - y^2 = 1$. Solving for y, we have:

$y^2 = x - 1$

$y = \pm\sqrt{x-1}$

This equation does not specify a function, since each value of x, $x > 1$, determines two values of y. For example, corresponding to $x = 5$, we have $y = 2$ and $y = -2$; corresponding to $x = 10$, we have $y = 3$ and $y = -3$.

64. Given $x^2 + y = 10$. Solving for y, we have:

$y = 10 - x^2$

This equation specifies a function. The domain is all real numbers or $(-\infty, \infty)$.

66. Given $xy + y - x = 5$. Solving for y, we have:

$(x + 1)y = x + 5$ or $y = \dfrac{x+5}{x+1}$

This equation specifies a function. The domain is all real numbers except $x = -1$.

68. Given $x^2 - y^2 = 16$. Solving for y, we have:

$y^2 = x^2 - 16$ or $y = \pm\sqrt{x^2-16}$

Thus, the equation does not specify a function since, for $x = 5$, we have $y = \pm 3$, when $x = 6$, $y = \pm 2\sqrt{5}$, and so on.

70. $f(-3x) = (-3x)^2 - 1 = 9x^2 - 1$

72. $f(x+2) = (x+2)^2 - 1 = x^2 + 4x + 3$

74. $f(5+h) = (5+h)^2 - 1 = 24 + 10h + h^2$

76.
$$\begin{aligned} f(5+h) - f(5) &= \left((5+h)^2 - 1\right) - \left(5^2 - 1\right) \\ &= \left(24 + 10h + h^2\right) - 24 \\ &= 10h + h^2 \end{aligned}$$

78. (A) $f(x+h) = -3(x+h) + 9 = -3x - 3h + 9$

(B) $f(x+h) - f(x) = \left(-3x - 3h + 9\right) - \left(-3x + 9\right) = -3h$

(C) $\dfrac{f(x+h) - f(x)}{h} = \dfrac{-3h}{h} = -3$

80. (A)
$$\begin{aligned} f(x+h) &= 3(x+h)^2 + 5(x+h) - 8 \\ &= 3(x^2 + 2xh + h^2) + 5x + 5h - 8 \\ &= 3x^2 + 6xh + 3h^2 + 5x + 5h - 8 \end{aligned}$$

(B)
$$\begin{aligned} f(x+h) - f(x) &= \left(3x^2 + 6xh + 3h^2 + 5x + 5h - 8\right) - \left(3x^2 + 5x - 8\right) \\ &= 6xh + 3h^2 + 5h \end{aligned}$$

(C) $\dfrac{f(x+h) - f(x)}{h} = \dfrac{6xh + 3h^2 + 5h}{h} = 6x + 3h + 5$

82. (A) $f(x + h) = x^2 + 2xh + h^2 + 40x + 40h$

(B) $f(x + h) - f(x) = 2xh + h^2 + 40h$

(C) $\frac{f(x+h) - f(x)}{h} = 2x + h + 40$

84. Given $A = \ell w = 81$.

Thus, $w = \frac{81}{\ell}$. Now $P = 2\ell + 2w = 2\ell + 2\left(\frac{81}{\ell}\right) = 2\ell + \frac{162}{\ell}$.

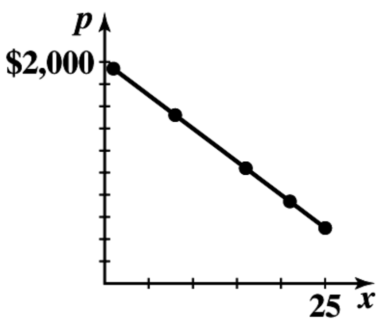
The domain is $\ell > 0$.

86. Given $P = 2\ell + 2w = 160$ or $\ell + w = 80$ and $\ell = 80 - w$.

Now $A = \ell w = (80 - w)w$ and $A = 80w - w^2$.

The domain is $0 \le w \le 80$. [Note: $w \le 80$ since $w > 80$ implies $\ell < 0$.]

88. (A)



(B) $p(11) = 1{,}340$ dollars per computer
$p(18) = 920$ dollars per computer

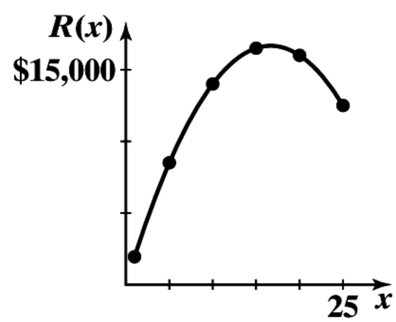
90. (A) $R(x) = xp(x)$
$= x(2{,}000 - 60x)$ thousands of dollars

Domain: $1 \le x \le 25$

(B) Table 11 Revenue

x(thousands)	$R(x)$(thousands)
1	$1,940
5	8,500
10	14,000
15	16,500
20	16,000
25	12,500

(C)



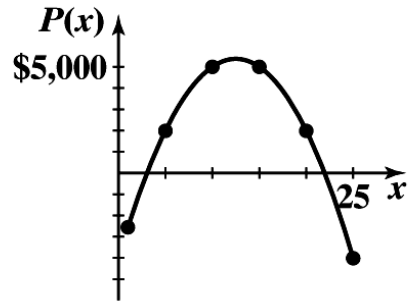
92. (A) $P(x) = R(x) - C(x)$
$= x(2{,}000 - 60x) - (4{,}000 + 500x)$ thousand dollars
$= 1{,}500x - 60x^2 - 4{,}000$

Domain: $1 \le x \le 25$

(B) Table 13 Profit

x (thousands)	$P(x)$ (thousands)
1	-$2,560
5	2,000
10	5,000
15	5,000
20	2,000
25	-4,000

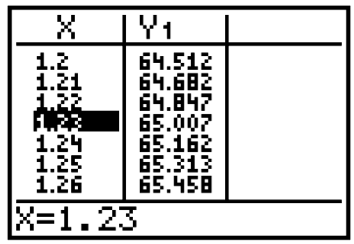
(C)



94. (A) 1.2 inches

(B) Evaluate the volume function for x = 1.21, 1.22, …, and choose the value of x whose volume is closest to 65.

(C) x = 1.23 to two decimal places



X	Y1
1.2	64.512
1.21	64.682
1.22	64.847
1.23	65.007
1.24	65.162
1.25	65.313
1.26	65.458

X=1.23

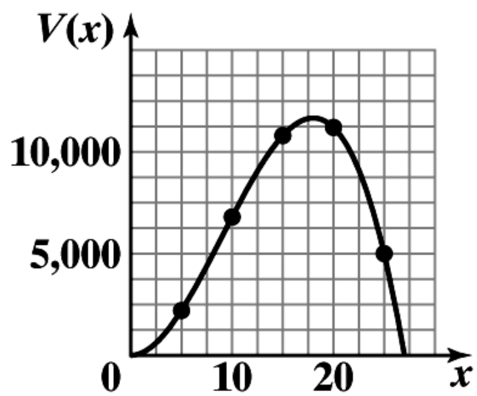
96. (A) $V(x) = x^2(108 - 4x)$

(B) $0 \le x \le 27$

(C) Table 16 Volume

x	$V(x)$
5	2,200
10	6,800
15	10,800
20	11,200
25	5,000

(D)



98. (A) Given $5v - 2s = 1.4$. Solving for v, we have:
$v = 0.4s + 0.28$.
If $s = 0.51$, then $v = 0.4(0.51) + 0.28 = 0.484$ or 48.4%.

(B) Solving the equation for s, we have:
$s = 2.5v - 0.7$.
If $v = 0.51$, then $s = 2.5(0.51) - 0.7 = 0.575$ or 57.5%.

EXERCISE 2-2

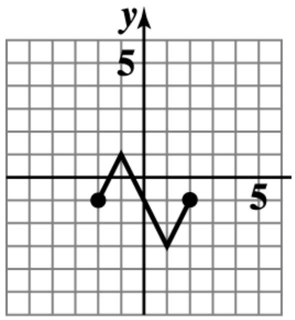
2. $f(x) = x^2 - 4$ Domain: all real numbers; Range: all $y \ge -4$.

4. $k(x) = -2|x|$ Domain: all real numbers; Range: all nonnegative real numbers.

6. $n(x) = -6\sqrt{x}$ Domain: all $x \ge 0$; Range: all $y \le 0$.

8. $s(x) = 1 + \sqrt[3]{x}$ Domain: all real numbers; Range: all real numbers.

10.



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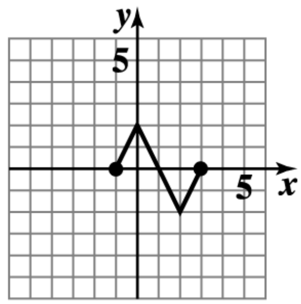

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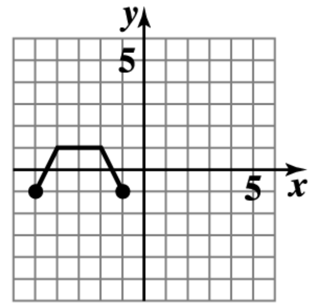

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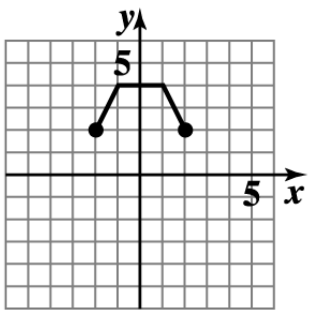

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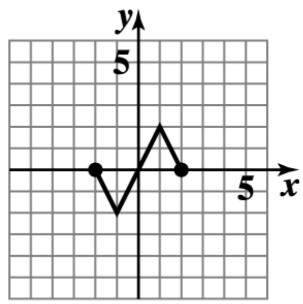

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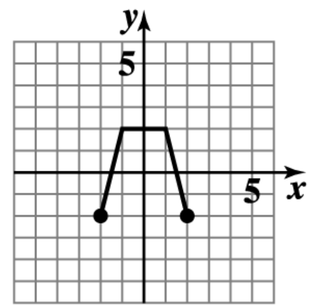
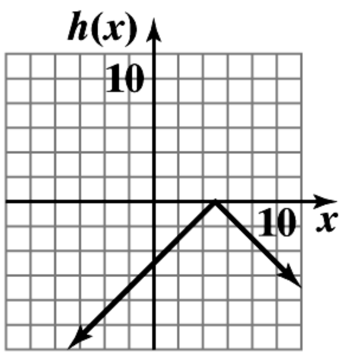
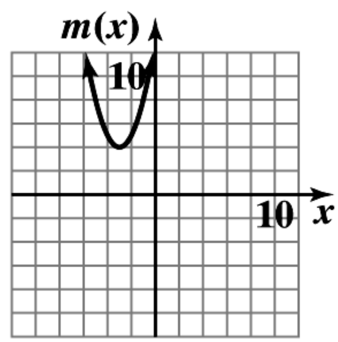


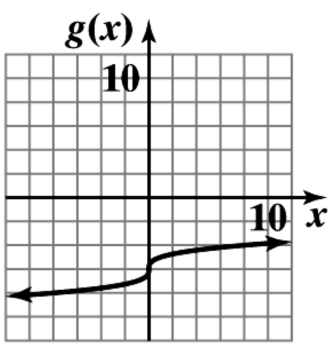
22. The graph of $h(x) = -|x - 5|$ is the graph of $y = |x|$ reflected in the x axis and shifted 5 units to the right.



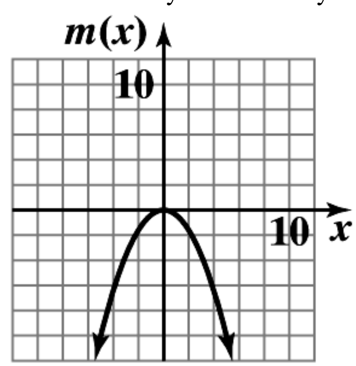
24. The graph of $m(x) = (x + 3)^2 + 4$ is the graph of $y = x^2$ shifted 3 units to the left and 4 units up.



26. The graph of $g(x) = -6 + \sqrt[3]{x}$ is the graph of $y = \sqrt[3]{x}$ shifted 6 units down.



28. The graph of $m(x) = -0.4x^2$ is the graph of $y = x^2$ reflected in the x axis and vertically contracted by a factor of 0.4.



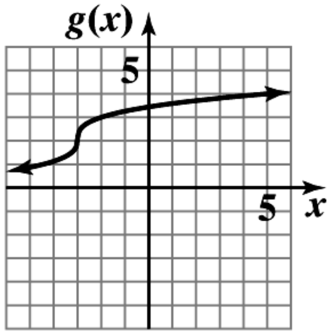
30. The graph of the basic function $y = |x|$ is shifted 3 units to the right and 2 units up. $y = |x - 3| + 2$

32. The graph of the basic function $y = |x|$ is reflected in the x axis, shifted 2 units to the left and 3 units up.
Equation: $y = 3 - |x + 2|$

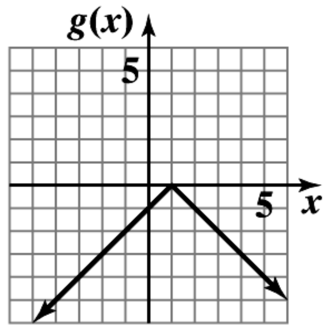
34. The graph of the basic function $\sqrt[3]{x}$ is reflected in the x axis and shifted up 2 units. Equation: $y = 2 - \sqrt[3]{x}$

36. The graph of the basic function $y = x^3$ is reflected in the x axis, shifted to the right 3 units and up 1 unit.
Equation: $y = 1 - (x - 3)^3$

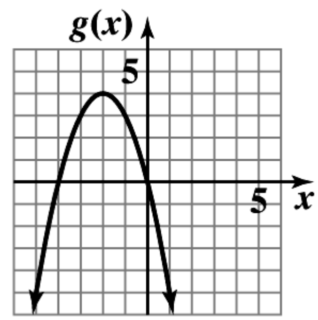
38. $g(x) = \sqrt[3]{x+3} + 2$



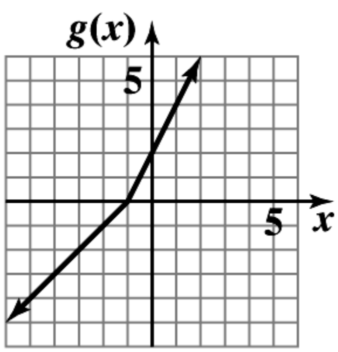
40. $g(x) = -|x - 1|$



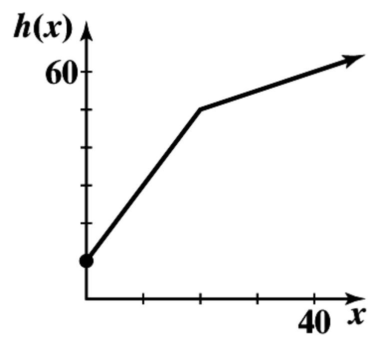
42. $g(x) = 4 - (x + 2)^2$



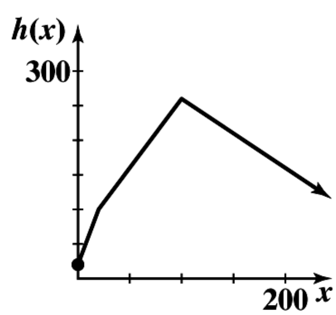
44. $g(x) = \begin{cases} x+1 & \text{if } x < -1 \\ 2+2x & \text{if } x \geq -1 \end{cases}$



46. $h(x) = \begin{cases} 10+2x & \text{if } 0 \leq x \leq 20 \\ 40+0.5x & \text{if } x > 20 \end{cases}$



48. $h(x) = \begin{cases} 4x+20 & \text{if } 0 \leq x \leq 20 \\ 2x+60 & \text{if } 20 < x \leq 100 \\ -x+360 & \text{if } x > 100 \end{cases}$



50. The graph of the basic function $y = x$ is reflected in the x axis and vertically expanded by a factor of 2.
Equation: $y = -2x$

52. The graph of the basic function $y = |x|$ is vertically expanded by a factor of 4. Equation: $y = 4|x|$

54. The graph of the basic function $y = x^3$ is vertically contracted by a factor of 0.25. Equation: $y = 0.25x^3$.

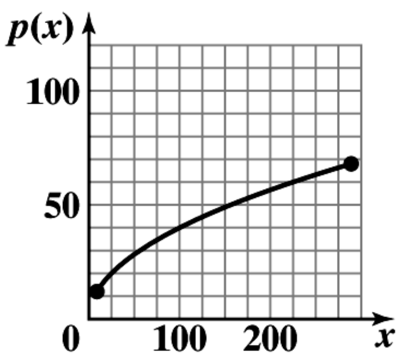
56. Vertical shift, reflection in y axis.
Reversing the order does not change the result. Consider a point (a, b) in the plane. A vertical shift of k units followed by a reflection in y axis moves (a, b) to $(a, b + k)$ and then to $(-a, b + k)$. In the reverse order, a reflection in y axis followed by a vertical shift of k units moves (a, b) to $(-a, b)$ and then to $(-a, b + k)$. The results are the same.

58. Vertical shift, vertical expansion.
Reversing the order can change the result. For example, let (a, b) be a point in the plane. A vertical shift of k units followed by a vertical expansion of h $(h > 1)$ moves (a, b) to $(a, b + k)$ and then to $(a, bh + kh)$. In the reverse order, a vertical expansion of h followed by a vertical shift of k units moves (a, b) to (a, bh) and then to $(a, bh + k)$; $(a, bh + kh) \neq (a, bh + k)$.

60. Horizontal shift, vertical contraction.
Reversing the order does not change the result. Consider a point (a, b) in the plane. A horizontal shift of k units followed by a vertical contraction of h $(0 < h < 1)$ moves (a, b) to $(a + k, b)$ and then to $(a + k, bh)$. In the reverse order, a vertical contraction of h followed by a horizontal shift of k units moves (a, b) to (a, bh) and then to $(a + k, bh)$. The results are the same.

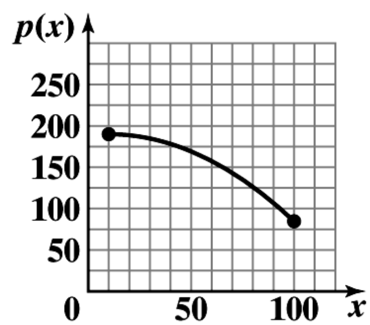
62. (A) The graph of the basic function $y = \sqrt{x}$ is vertically expanded by a factor of 4.

(B)



64. (A) The graph of the basic function $y = x^2$ is reflected in the x axis, vertically contracted by a factor of 0.013, and shifted 10 units to the right and 190 units up.

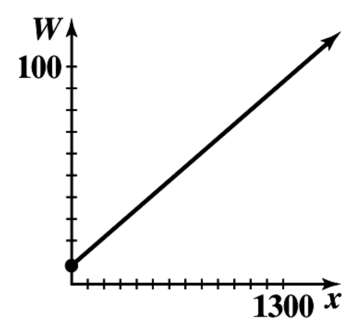
(B)



66. (A) Let x = number of kwh used in a winter month. For $0 \le x \le 700$, the charge is $8.5 + .065x$. At $x = 700$, the charge is \$54. For $x > 700$, the charge is
$54 + .053(x - 700) = 16.9 + 0.053x$.
Thus,

$$W(x) = \begin{cases} 8.5 + .065x & \text{if } 0 \le x \le 700 \\ 16.9 + 0.053x & \text{if } x > 700 \end{cases}$$

(B)

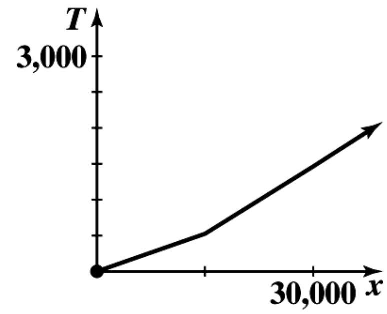


68. (A) Let x = taxable income.
If $0 \le x \le 15{,}000$, the tax due is \$$.035x$. At $x = 15{,}000$, the tax due is \$525. For $15{,}000 < x \le 30{,}00$, the tax due is $525 + .0625(x - 15{,}000) = .0625x - 412.5$. For $x > 30{,}000$, the tax due is $1{,}462.5 + .0645(x - 30{,}000) = .0645x - 472.5$.

Thus,

$$T(x) = \begin{cases} 0.035x & \text{if } 0 \le x \le 15{,}000 \\ 0.0625x - 412.5 & \text{if } 15{,}000 < x \le 30{,}000 \\ 0.0645x - 472.5 & \text{if } x > 30{,}000 \end{cases}$$

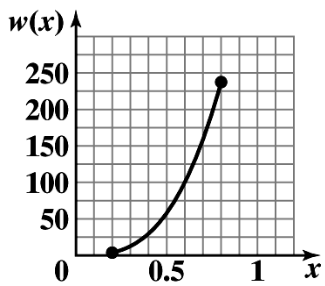
(B)



(C) $T(20{,}000) = \$837.50$
$T(35{,}000) = \$1{,}785$

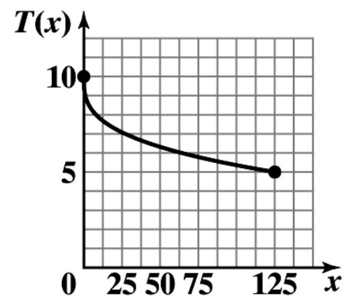
70. (A) The graph of the basic function $y = x^3$ is vertically expanded by a factor of 463.

(B)



72. (A) The graph of the basic function $y = \sqrt[3]{x}$ is reflected in the x axis and shifted up 10 units.

(B)



EXERCISE 2-3

2. $x^2 - 2x - 5 = x^2 - 2x + 1 - 6$
$= (x - 1)^2 - 6$

4. $-x^2 + 8x - 9 = -(x^2 - 8x + 9)$
$= -(x^2 - 8x + 16 - 7)$
$= -(x - 4)^2 + 7$

6. The graph of $g(x)$ is the graph of $y = x^2$ shifted right 1 unit and down 6 units.

8. The graph of $n(x)$ is the graph of $y = x^2$ reflected in the x axis, then shifted right 4 units and up 7 units.

10. (A) g (B) m (C) n (D) f

12. (A) x intercepts: -5, -1; y intercept: -5 (B) Vertex: (-3, 4)
(C) Maximum: 4 (D) Range: $y \le 4$ or $(-\infty, 4]$

14. (A) x intercepts: 1, 5; y intercept: 5 (B) Vertex: (3, -4)
(C) Minimum: -4 (D) Range: $y \ge -4$ or $[-4, \infty)$

16. $g(x) = -(x + 2)^2 + 3$

(A) x intercepts:
$$-(x + 2)^2 + 3 = 0$$
$$(x + 2)^2 = 3$$
$$x + 2 = \pm\sqrt{3}$$
$$x = -2 - \sqrt{3}, -2 + \sqrt{3}$$

y intercept: -1

(B) Vertex: (-2, 3) (C) Maximum: 3 (D) Range: $y \leq 3$ or $(-\infty, 3]$

18. $n(x) = (x - 4)^2 - 3$

(A) x intercepts:
$$(x - 4)^2 - 3 = 0$$
$$(x - 4)^2 = 3$$
$$x - 4 = \pm\sqrt{3}$$
$$x = 4 - \sqrt{3}, 4 + \sqrt{3}$$

y intercept: 13

(B) Vertex: (4, -3) (C) Minimum: -3 (D) Range: $y \geq -3$ or $[-3, \infty)$

20. $y = -(x - 4)^2 + 2$

22. $y = [x - (-3)]^2 + 1$ or $y = (x + 3)^2 + 1$

24. $g(x) = x^2 - 6x + 5 = x^2 - 6x + 9 - 4 = (x - 3)^2 - 4$

(A) x intercepts:
$$(x - 3)^2 - 4 = 0$$
$$(x - 3)^2 = 4$$
$$x - 3 = \pm 2$$
$$x = 1, 5$$

y intercept: 5

(B) Vertex: (3, -4) (C) Minimum: -4 (D) Range: $y \geq -4$ or $[-4, \infty)$

26. $s(x) = -4x^2 - 8x - 3 = -4\left[x^2 + 2x + \frac{3}{4}\right] = -4\left[x^2 + 2x + 1 - \frac{1}{4}\right]$

$$= -4\left[(x+1)^2 - \frac{1}{4}\right] = -4(x + 1)^2 + 1$$

(A) x intercepts:
$$-4(x + 1)^2 + 1 = 0$$
$$4(x + 1)^2 = 1$$
$$(x + 1)^2 = \frac{1}{4}$$
$$x + 1 = \pm\frac{1}{2}$$
$$x = -\frac{3}{2}, -\frac{1}{2}$$

y intercept: -3

(B) Vertex: (-1, 1) (C) Maximum: 1 (D) Range: $y \leq 1$ or $(-\infty, 1]$

28. $v(x) = 0.5x^2 + 4x + 10 = 0.5[x^2 + 8x + 20] = 0.5[x^2 + 8x + 16 + 4]$

$= 0.5[(x + 4)^2 + 4]$

$= 0.5(x + 4)^2 + 2$

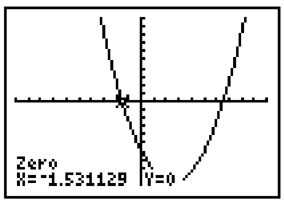
(A) x intercepts: none
y intercept: 10

(B) Vertex: (-4, 2) (C) Minimum: 2 (D) Range: $y \geq 2$ or $[2, \infty)$

30. $g(x) = -0.6x^2 + 3x + 4$

(A) $g(x) = -2$: $-0.6x^2 + 3x + 4 = -2$

$0.6x^2 - 3x - 6 = 0$

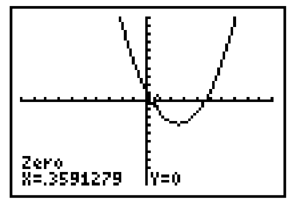


$x = -1.53, 6.53$

(B) $g(x) = 5$: $-0.6x^2 + 3x + 4 = 5$

$-0.6x^2 + 3x - 1 = 0$

$0.6x^2 - 3x + 1 = 0$

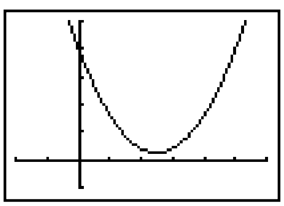


$x = 0.36, 4.64$

(C) $g(x) = 8$: $-0.6x^2 + 3x + 4 = 8$

$-0.6x^2 + 3x - 4 = 0$

$0.6x^2 - 3x + 4 = 0$



No solution

32. Using a graphing utility with $y = 100x - 7x^2 - 10$ and the calculus option with maximum command, we obtain 347.1429 as the maximum value.

34. $m(x) = 0.20x^2 - 1.6x - 1 = 0.20(x^2 - 8x - 5)$

$= 0.20[(x - 4)^2 - 21] = 0.20(x - 4)^2 - 4.2$

(A) x intercepts:

$0.20(x - 4)^2 - 4.2 = 0$

$(x - 4)^2 = 21$

$x - 4 = \pm\sqrt{21}$

$x = 4 - \sqrt{21} = -0.6, 4 + \sqrt{21} = 8.6;$

y intercept: -1

(B) Vertex: (4, -4.2) (C) Minimum: -4.2
(D) Range: $y \geq -4.2$ or $[-4.2, \infty)$

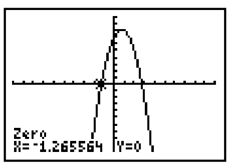
36. $n(x) = -0.15x^2 - 0.90x + 3.3$
$= -0.15(x^2 + 6x - 22)$
$= -0.15[(x + 3)^2 - 31]$
$= -0.15(x + 3)^2 + 4.65$

(A) x intercepts:

$-0.15(x + 3)^2 + 4.65 = 0$
$(x + 3)^2 = 31$
$x + 3 = \pm\sqrt{31}$
$x = -3 - \sqrt{31} = -8.6, -3 + \sqrt{31} = 2.6;$
y intercept: 3.30

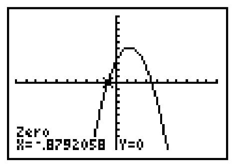
(B) Vertex: (-3, 4.65) (C) Maximum: 4.65
(D) Range: $x \le 4.65$ or $(-\infty, 4.65]$

38.



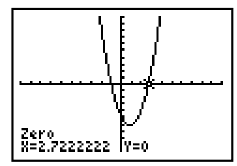
$x = -1.27, 2.77$

40.



$-0.88 \le x \le 3.52$

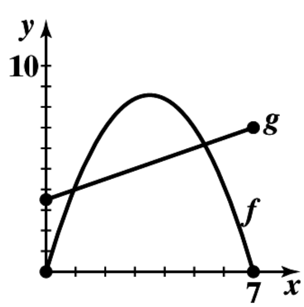
42.



$x < -1$ or $x > 2.72$

44. f is a quadratic function and max $f(x) = f(-3) = -5$
Axis: $x = -3$
Vertex: (-3, -5)
Range: $y \le -5$ or $(-\infty, -5]$
x intercepts: None

46. (A)



(B) $f(x) = g(x)$: $-0.7x(x - 7) = 0.5x + 3.5$

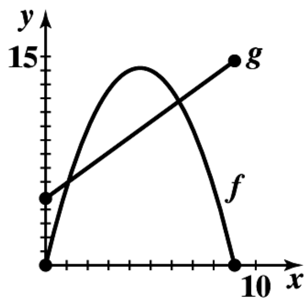
$-0.7x^2 + 4.4x - 3.5 = 0$

$$x = \frac{-4.4 \pm \sqrt{(4.4)^2 - 4(0.7)(3.5)}}{-1.4} = 0.93, 5.35$$

(C) $f(x) > g(x)$ for $0.93 < x < 5.35$

(D) $f(x) < g(x)$ for $0 \le x < 0.93$ or $5.35 < x \le 7$

48. (A)



(B) $f(x) = g(x)$: $-0.7x^2 + 6.3x = 1.1x + 4.8$

$-0.7x^2 + 5.2x - 4.8 = 0$

$0.7x^2 - 5.2x + 4.8 = 0$

$$x = \frac{-(-5.2) \pm \sqrt{(-5.2)^2 - 4(0.7)(4.8)}}{1.4} = 1.08,\ 6.35$$

(C) $f(x) > g(x)$ for $1.08 < x < 6.35$

(D) $f(x) < g(x)$ for $0 \le x < 1.08$ or $6.35 < x \le 9$

50. A quadratic with no real zeros will not intersect the x-axis.

52. Such an equation will have $b^2 - 4ac = 0$.

54. Such an equation will have $\frac{k}{a} < 0$.

56. $ax^2 + bx + c = a(x-h)^2 + k$

$= a(x^2 - 2hx + h^2) + k$

$= ax^2 - 2ahx + ah^2 + k$

Equating constant terms gives $k = c - ah^2$. Since h is the vertex, we have $h = -\frac{b}{2a}$. Substituting then

gives $$k = c - ah^2 = c - a\left(\frac{b^2}{4a^2}\right) = c - \frac{b^2}{4a}$$

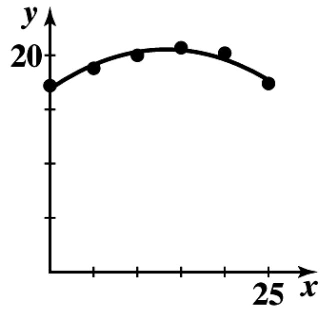
$$= \frac{4ac - b^2}{4a}$$

58. $f(x) = -0.0206x^2 + 0.548x + 16.9$

(A)

x	0	5	10	15	20	25
Market share	17.2	18.8	20.0	20.7	20.2	17.4
$f(x)$	16.9	19.1	20.3	20.5	19.6	17.7

(B)



(C) For 2010, $x = 30$ and

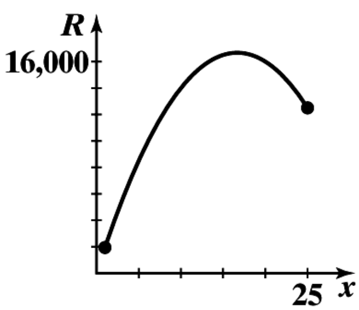
$f(30) = -0.0206(30)^2 + 0.548(30) + 16.9 = 14.8\%$

For 2015, $x = 35$ and

$f(35) = -0.0206(35)^2 + 0.548(30) + 16.9 = 10.8\%$

60. Verify

62. (A)



(B) $R(x) = 2{,}000x - 60x^2$

$$= -60\left(x^2 - \frac{100}{3}x\right)$$

$$= -60\left[x^2 - \frac{100}{3}x + \frac{2500}{9} - \frac{2500}{9}\right]$$

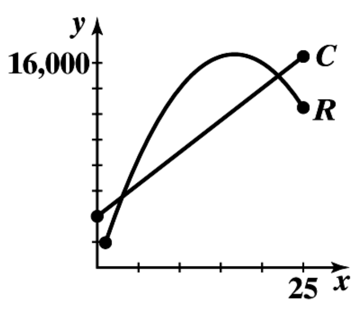
$$= -60\left[\left(x - \frac{50}{3}\right)^2 - \frac{2500}{9}\right]$$

$$= -60\left(x - \frac{50}{3}\right) + \frac{50{,}000}{3}$$

16.667 thousand computers(16,667 computers);
16,666.667 thousand dollars ($16,666,667)

(C) $1,000

64. (A)



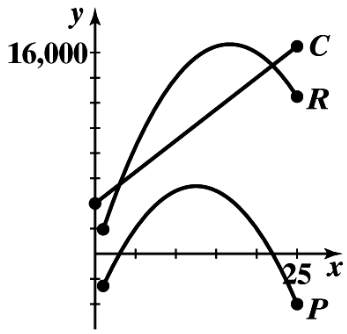
(B) $R(x) = C(x)$

$x(2{,}000 - 60x)$	$= 4{,}000 + 500x$
$2{,}000x - 60x^2$	$= 4{,}000 + 500x$
$60x^2 - 1{,}500x + 4{,}000$	$= 0$
$6x^2 - 150x + 400$	$= 0$
x	$= 3.035, 21.965$

Break-even at 3.035 thousand (3,035)
and 21.965 thousand (21,965)

(C) Loss: $1 \le x < 3.035$ or $21.965 < x \le 25$;
Profit: $3.035 < x < 21.965$

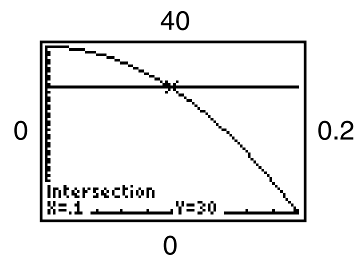
66. (A) $P(x) = R(x) - C(x)$
$= 1{,}500x - 60x^2 - 4{,}000$



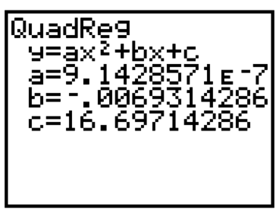
(B) and (C) Intercepts and break-even points: 3,035 computers and 21,965 computers

(D) and (E) Maximum profit is $5,375,000 when 12,500 computers are produced. This is much smaller than the maximum revenue of $16,666,667.

68. Solve: $f(x) = 1{,}000(0.04 - x^2) = 30$
$40 - 1000x^2 = 30$
$1000x^2 = 10$
$x^2 = 0.01$
$x = 0.10$ cm



70.



For $x = 2{,}300$, the estimated fuel consumption is
$y = a(2{,}300)^2 + b(2{,}300) + c = 5.6$ mpg.

EXERCISE 2-4

2. (A) Degree: 1
(B) $4 - 3x = 0$
$3x = 4$
$x = \frac{4}{3}$
x-intercept: $\left(\frac{4}{3}, 0\right)$
(C) $f(0) = 4 - 3(0) = 4$
y-intercept: (0,4)

4. (A) Degree: 2
(B) $5x - x^2 - 6 = 0$
$-(x^2 - 5x + 6) = 0$
$-(x-3)(x-2) = 0$
$x = 2, 3$
x-intercepts: (2,0), (3,0)
(C) $f(0) = 5(0) - (0)^2 - 6 = -6$
y-intercept: (0,6)

6. (A) Degree: 2

(B) $(x+7)(x-4)=0$

$x=-7,4$

x-intercepts: (-7,0), (4,0)

(C) $f(0)=(0+7)(0-4)=-28$

y-intercept: (0, -28)

8. (A) Degree: 3

(B) $(2-5x)(x-6)(x+1)=0$

$x=\frac{2}{5},6,-1$

x-intercepts: $\left(\frac{2}{5},0\right)$, (6,0), (-1,0)

(C) $f(0)=(2-5(0))(0-6)(0+1)=(2)(-6)(1)=-12$

y-intercept: (0,-12)

10. (A) Degree: 20

(B) $(x^8+5)\left(x^{12}+7\right)=0$

Has no solutions, so this polynomial has no x-intercepts.

(C) $f(0)=(0+5)(0+7)=35$

y-intercept: (0, 35)

12. (A) Minimum degree: 2

(B) Negative – it must have even degree, and positive values in the domain are mapped to negative values in the range.

14. (A) Minimum degree: 3

(B) Negative – it must have odd degree, and positive values in the domain are mapped to negative values in the range.

16. (A) Minimum degree: 4

(B) Positive – it must have even degree, and positive values in the domain are mapped to positive values in the range.

18. (A) Minimum degree: 5

(B) Positive – it must have odd degree, and positive values in the domain are mapped to positive values in the range.

20. A polynomial of degree 7 can have at most 7 x intercepts.

22. A polynomial of degree 6 may have no x intercepts. For example, the polynomial $f(x)=x^6+1$ has no x intercepts.

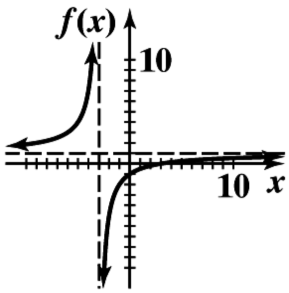
24. (A) Intercepts:

x-intercept(s):	y-intercept:
$x-3=0$ $x=3$ (3, 0)	$f(0)=\frac{0-3}{0+3}=-1$ (0, -1)

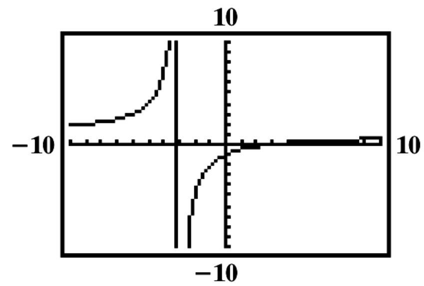
(B) Domain: all real numbers except x = -3

(C) Vertical asymptote at x = -3 by case 1 of the vertical asymptote procedure on page 90. Horizontal asymptote at x = 1 by case 2 of the horizontal asymptote procedure on page 90.

(D)



(E)



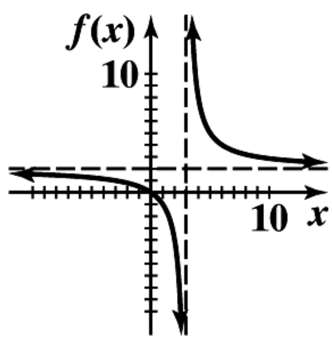
26. (A) Intercepts:

x-intercept(s):	y-intercept:
$2x = 0$	$f(0) = \frac{2(0)}{0-3} = 0$
$x = 0$	
(0, 0)	(0, 0)

(B) Domain: all real numbers except $x = 3$.

(C) Vertical asymptote at $x = 3$ by case 1 of the vertical asymptote procedure on page 90.
Horizontal asymptote at $x = 2$ by case 2 of the horizontal asymptote procedure on page 90.

(D)



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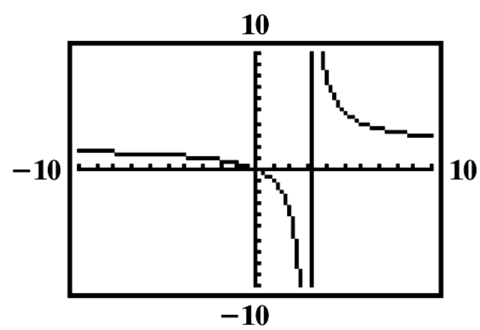


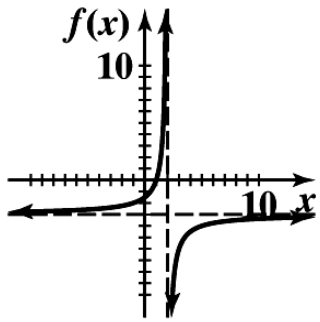
28. (A) Intercepts:

x-intercept:	y-intercept:
$3-3x = 0$	$f(0) = \frac{3-3(0)}{0-2} = -\frac{3}{2}$
$x = 1$	
(1, 0)	$\left(0, -\frac{3}{2}\right)$

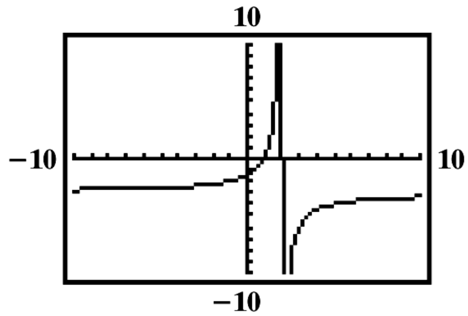
(B) Domain: all real numbers except $x = 2$

(C) Vertical asymptote at $x = 2$ by case 1 of the vertical asymptote procedure on page 90.
Horizontal asymptote at $x = -3$ by case 2 of the horizontal asymptote procedure on page 90.

(D)

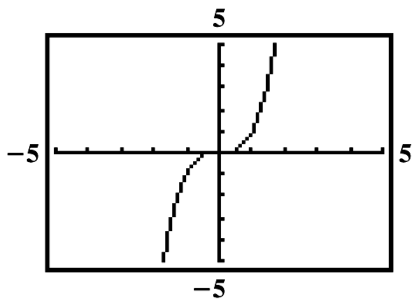


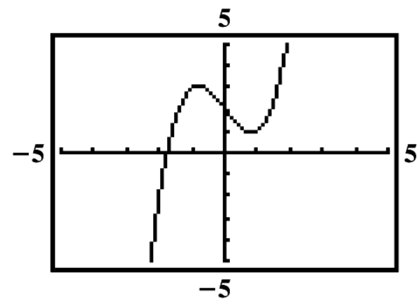
(E)



30.

(A)





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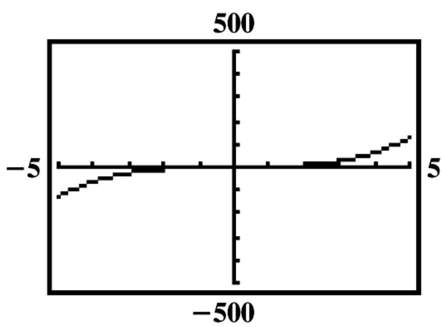
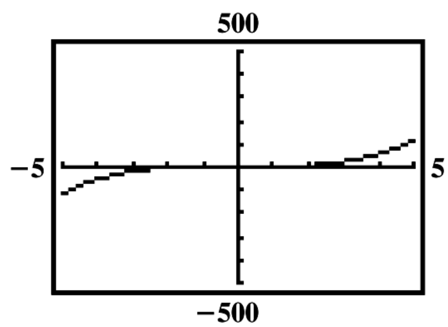
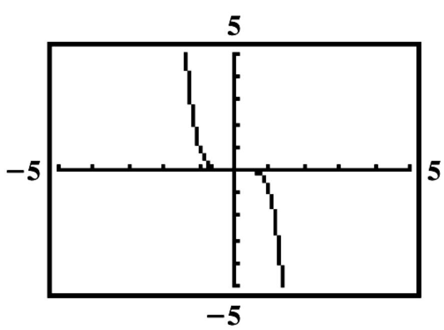
(B)

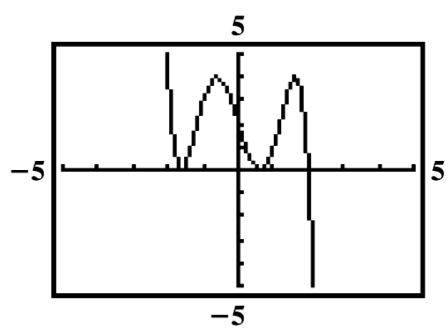




32.

(A)





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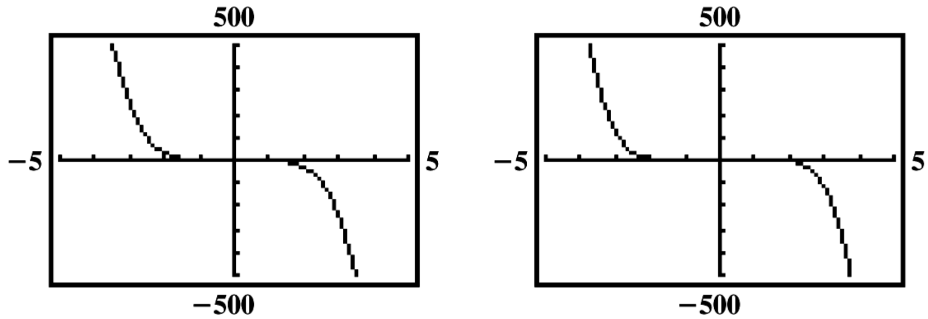
(B)



34. $y = \frac{6}{4}$, by case 2 for horizontal asymptotes on page 90.

36. $y = -\frac{1}{2}$, by case 2 for horizontal asymptotes on page 90.

38. $y = 0$, by case 1 for horizontal asymptotes on page 90.

40. No horizontal asymptote, by case 3 for horizontal asymptotes on page 90.

42. Here we have denominator $(x^2-4)(x^2-16) = (x-2)(x+2)(x-4)(x+4)$. Since none of these linear terms are factors of the numerator, the function has vertical asymptotes at x = 2, x = -2, x = 4, and x = -4.

44. Here we have denominator $x^2+7x-8 = (x-1)(x+8)$. Also, we have numerator $x^2-8x+7 = (x-1)(x-7)$. By case 2 of the vertical asymptote procedure on page 90, we conclude that the function has a vertical asymptote at x = -8.

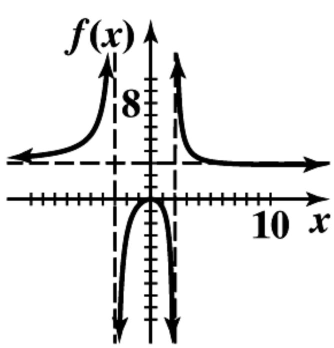
46. Here we have denominator $x^3-3x^2+2x = x(x^2-3x+2) = x(x-2)(x-1)$. We also have numerator $x^2+x-2 = (x+2)(x-1)$. By case 2 of the vertical asymptote procedure on page 90, we conclude that the function has a vertical asymptotes at x = 0 and x = 2.

48. (A) Intercepts:

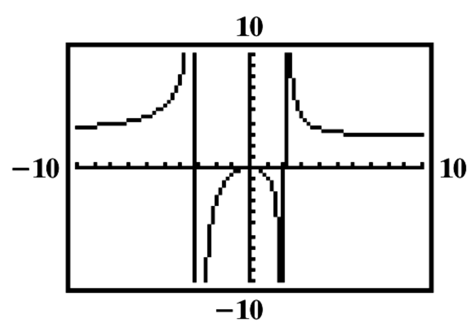
x-intercept(s):	y-intercept:
$3x^2 = 0$	$f(0) = 0$
$x = 0$	
(0, 0)	(0, 0)

(B) Vertical asymptote when $x^2+x-6 = (x-2)(x+3) = 0$; so, vertical asymptotes at x = 2, x = -3. Horizontal asymptote $y = 3$.

(C)



(D)

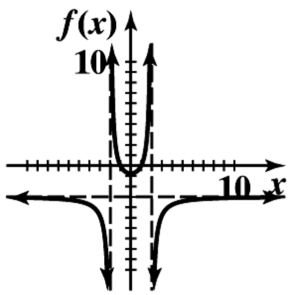


50. (A) Intercepts:

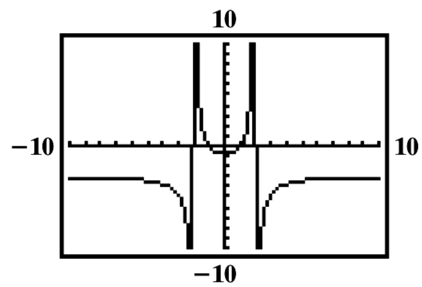
x-intercept(s):	y-intercept:
$3-3x^2=0$	$f(0)=-\frac{3}{4}$
$3x^2=3$	
$x=\pm 1$	$\left(0,-\frac{3}{4}\right)$
(1,0), (-1,0)	

(B) Vertical asymptotes when $x^2-4=0$; i.e. at x = 2 and x = -2.
Horizontal asymptote at $y=-3$

(C)



(D)

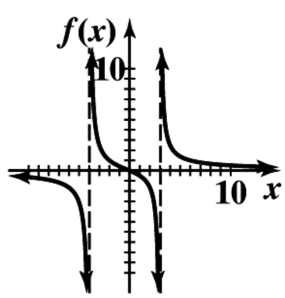


52. (A) Intercepts:

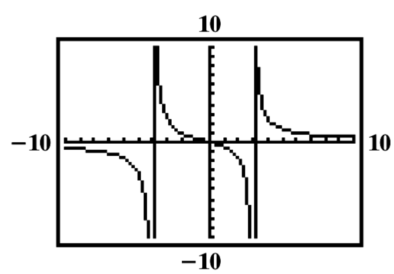
x-intercept(s):	y-intercept:
$5x=0$	$f(0)=0$
$x=0$	
(0,0)	(0, 0)

(B) Vertical asymptote when $x^2+x-12=(x+4)(x-3)=0$; i.e. when x = -4 and when x = 3.
Horizontal asymptote at y = 0.

(C)



(D)



54. $f(x)=-(x+2)(x-1)=-x^2-x+2$

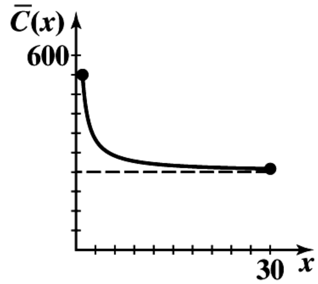
56. $f(x)=x(x+1)(x-1)=x\left(x^2-1\right)=x^3-x$

58. (A) We want $C(x) = mx + b$. Fix costs are $b = \$300$ per day. Given $C(20) = 5{,}100$ we have

$$m(20) + 300 = 5{,}100$$
$$20m = 4800$$
$$m = 240$$
$$C(x) = 240x + 300$$

(B) $\bar{C}(x) = \frac{C(x)}{x} = \frac{240x + 300}{x} = 240 + \frac{300}{x}$

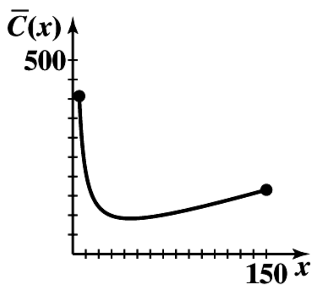
(C)



(D) Average cost tends towards \$240 as production increases.

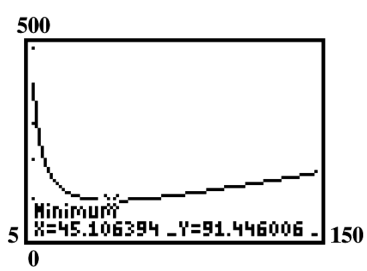
60. (A) $\bar{C}(x) = \frac{x^2 + 2x + 2{,}000}{x}$

(B)

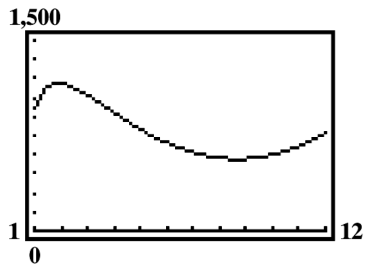


(C) A daily production level of $x = 45$ units per day, results in the lowest average cost of $\bar{C}(45) = \$91.44$ per unit

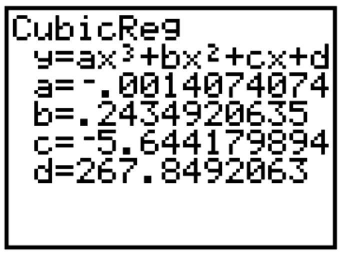
(D)



62. (A) $\bar{C}(x) = \frac{20x^3 - 360x^2 + 2{,}300x - 1{,}000}{x}$

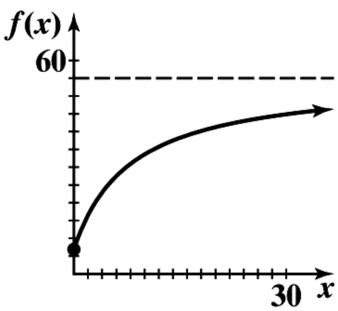
(B) 

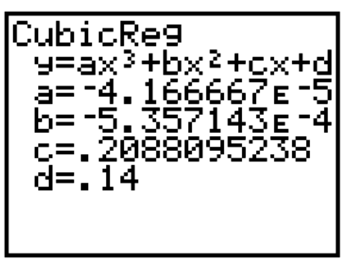
(C) A minimum average cost of \$566.84 is achieved at a production level of $x = 8.67$ thousand cases per month.

64. (A) 

(B) 342 eggs

66. (A) The horizontal asymptote is $y = 55$.

(B) 

68. (A) 

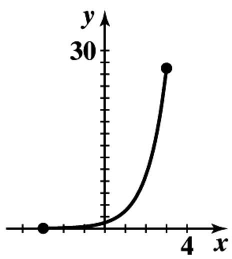
(B) This model gives an estimate of -2.2 divorces per 1,000 marriages, an unlikely estimate.

EXERCISE 2-5

2. A. graph *g*
   B. graph *f*
   C. graph *h*
   D. graph *k*

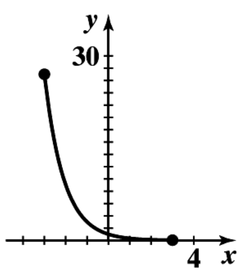
4. $y = 3^x$; [–3, 3]

x	y
–3	$\frac{1}{27}$
–1	$\frac{1}{3}$
0	1
1	3
3	27



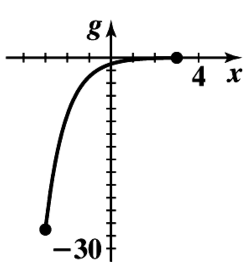
6. $y = 3^{-x}$; [–3, 3]

x	y
–3	27
–1	3
0	1
1	$\frac{1}{3}$
3	$\frac{1}{27}$



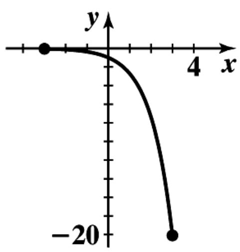
8. $g(x) = -3^{-x}$; [–3, 3]

x	$g(x)$
–3	–27
–1	–3
0	–1
1	$-\frac{1}{3}$
3	$-\frac{1}{27}$

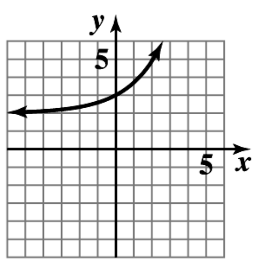


10. $y = -e^x$; $[-3, 3]$

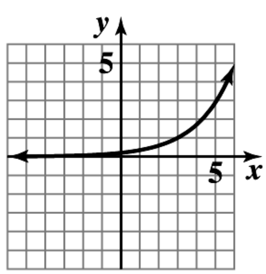
x	y
–3	≈ –0.05
–1	≈ –0.37
0	–1
1	≈ –2.72
3	≈ –20.09



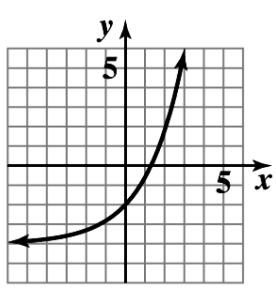
12. The graph of *g* is the graph of *f* shifted 2 units to the right.
14. The graph of *g* is the graph of *f* reflected in the *x* axis.
16. The graph of *g* is the graph of *f* shifted 2 units down.
18. The graph of *g* is the graph of *f* vertically contracted by a factor of 0.5 and shifted 1 unit to the right.
20. A. $y = f(x) + 2$



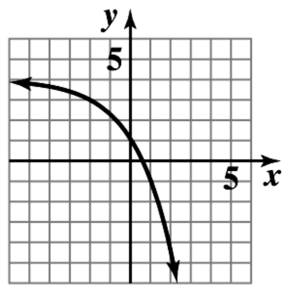
B. $y = f(x-3)$



C. $y = 2f(x) - 4$

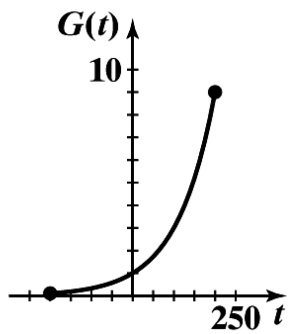


D. $y = 4 - f(x+2)$



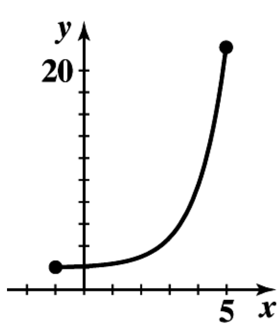
22. $G(t) = 3^{t/100}$; $[-200, 200]$

x	$G(t)$
–200	$\frac{1}{9}$
–100	$\frac{1}{3}$
0	1
100	3
200	9



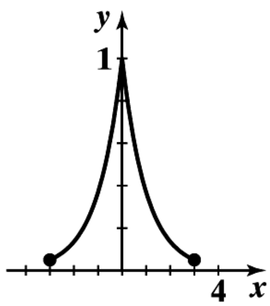
24. $y = 2 + e^{x-2}$; $[-1, 5]$

x	y
–1	≈ 2.05
0	≈ 2.14
1	≈ 2.37
3	≈ 4.72
5	≈ 22.09



26. $y = e^{-|x|}$; $[-3, 3]$

x	y
–3	≈ 0.05
–1	≈ 0.37
0	1
1	≈ 0.37
3	≈ 0.05



28. $a = 2$, $b = -2$ for example. The exponential function property: For $x \neq 0$, $a^x = b^x$ if and only if $a = b$ assumes $a > 0$ and $b > 0$.

30. $5^{3x} = 5^{4x-2}$
$$3x = 4x - 2$$
$$-x = -2$$
$$x = 2$$

32. $7^{x^2} = 7^{2x+3}$
$$x^2 = 2x + 3$$
$$x^2 - 2x - 3 = 0$$
$$(x-3)(x+1) = 0$$
$$x = -1, 3$$

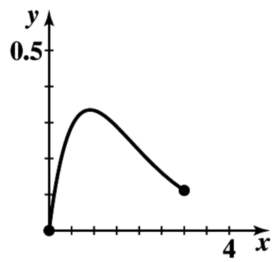
34. $(1-x)^5 = (2x-1)^5$
$$1 - x = 2x - 1$$
$$-3x = -2$$
$$x = \frac{2}{3}$$

36. $2xe^{-x} = 0$
$$(2x)(e^{-x}) = 0$$
$$2x = 0$$
$$x = 0$$

38. $x^2e^x - 5xe^x = 0$
$$e^x(x^2 - 5x) = 0$$
$$e^x(x)(x-5) = 0$$
$$x = 0, 5$$

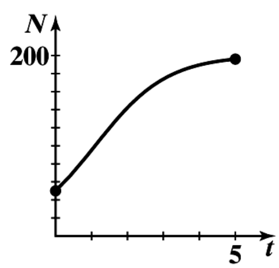
40. $m(x) = x(3^{-x})$; [0, 3]

x	$m(x)$
0	0
1	$\frac{1}{3}$
2	$\frac{2}{9}$
3	$\frac{1}{9}$



42. $N = \dfrac{200}{1+3e^{-t}}$; [0, 5]

x	N
0	50
1	≈ 95.07
2	≈ 142.25
3	≈ 174.01
5	≈ 196.04



44. $A = Pe^{rt}$

$A = (24{,}000)e^{(0.0435)(7)}$

$A = (24{,}000)e^{0.3045}$

$A = (24{,}000)(1.35594686)$

$A = \$32{,}542.72$

46. A. $A = P(1+\frac{r}{m})^{mt}$

$A = 4000(1+\frac{0.06}{52})^{(52)(0.5)}$

$A = 4000(1.0011538462)^{26}$

$A = 4000(1.030436713)$

$A = \$4121.75$

B. $A = P(1+\frac{r}{m})^{mt}$

$A = 4000(1+\frac{0.06}{52})^{(52)(10)}$

$A = 4000(1.0011538462)^{520}$

$A = 4000(1.821488661)$

$A = \$7285.95$

48. $A = P(1+\frac{r}{m})^{mt}$

$40,000 = P(1+\frac{0.055}{365})^{(365)(17)}$

$40,000 = P(1.0001506849)^{6205}$

$40,000 = P(2.547034043)$

$P = \$15,705$

50. A. $A = P(1+\frac{r}{m})^{mt}$

$A = 10,000(1+\frac{0.055}{4})^{(4)(5)}$

$A = 10,000(1.01375)^{20}$

$A = 10,000(1.314066502)$

$A = \$13,140.67$

B. $A = P(1+\frac{r}{m})^{mt}$

$A = 10,000(1+\frac{0.0512}{12})^{(12)(5)}$

$A = 10,000(1.004266667)^{60}$

$A = 10,000(1.291049451)$

$A = \$12,910.49$

C. $A = P(1+\frac{r}{m})^{mt}$

$A = 10,000(1+\frac{0.0486}{365})^{(365)(5)}$

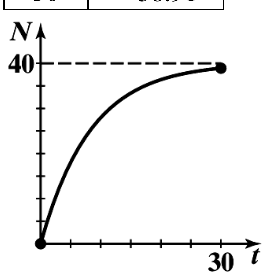
$A = 10,000(1.000133150685)^{1825}$

$A = 10,000(1.275047998)$

$A = \$12,750.48$

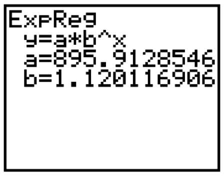
52. $N = 40(1-e^{-.012t})$; [0, 30]

x	N
0	0
10	≈ 27.95
20	≈ 36.37
30	≈ 38.91



The maximum number of boards an average employee can be expected to produce in 1 day is 40.

54. A. Using a TI – 83 graphing calculator, input the years after 1990 in column 1 and the NBA salaries in column 2. Using the STAT – CALC – ExpReg function, your calculator will display the following:



Therefore, the exponential equation that will be used is $y = 895.9128546(1.120116906^x)$.

$$y = 895.9128546(1.120116906^x)$$
$$y = 895.9128546(1.120116906^{30})$$
$$y = 895.9128546(30.05388107)$$
$$y = \$26,926 \text{ thousand} = \$26,926,000$$

B. $$y = 895.9128546(1.120116906^x)$$
$$y = 895.9128546(1.120116906^7)$$
$$y = 895.9128546(2.212297175)$$
$$y = \$1982 \text{ thousand} = \$1,982,000$$

The model gives an average salary of \$1,982,000 in 1997. Inclusion of the data from 1997 gives an annual salary of \$26,868,000 in the year 2020.

56. Given $I = I_0 e^{-0.00942d}$;

A. $I = I_0 e^{-0.00942(50)} = I_0 e^{-0.471} = I_0(0.624)$, thus, about 62% of the surface light will reach a depth of 50 feet.

B. $I = I_0 e^{-0.00942(100)} = I_0 e^{-0.942} = I_0(0.3898)$, thus, about 39% of the surface light will reach a depth of 100 feet.

58. A. $$P = P_0 e^{rt}$$
$$P = 83e^{0.032t}$$

B. In the year 2020, $t = 12$, therefore

$$P = 83e^{0.032t}$$
$$P = 83e^{0.032(12)}$$
$$P = 83e^{0.384}$$
$$P \approx 122$$

Therefore, the population in the year 2020 will be approximately 122 million people.

In the year 2030, $t = 22$, therefore

$$P = 83e^{0.032t}$$
$$P = 83e^{0.032(22)}$$
$$P = 83e^{0.704}$$
$$P \approx 168$$

Therefore, the population in the year 2030 will be approximately 168 million people.

60. A. Using a TI – 83 graphing calculator, input the years after 1970 in column 1 and the Life Expectancy in column 2. Using the STAT – CALC – ExpReg function, your calculator will display the following:

```
ExpReg
 y=a*b^x
 a=71.52589222
 b=1.002470302
```

Therefore, the exponential equation that will be used is $y = 71.52589222(1.002470302^x)$.

$$y = 71.52589222(1.002470302^x)$$
$$y = 71.52589222(1.002470302^{45})$$
$$y = 71.52589222(1.117424531)$$
$$y = 79.924$$

Therefore, according to the model, the life expectancy of a person born in 2015 is 79.9 years.

EXERCISE 2-6

2. $\log_2 32 = 5 \Rightarrow 32 = 2^5$

4. $\log_e 1 = 0 \Rightarrow e^0 = 1$

6. $\log_9 27 = \frac{3}{2} \Rightarrow 27 = 9^{3/2}$

8. $36 = 6^2 \Rightarrow \log_6 36 = 2$

10. $9 = 27^{2/3} \Rightarrow \log_{27} 9 = \frac{2}{3}$

12. $M = b^x \Rightarrow \log_b M = x$

14. $\log_e 1 = x$
$$e^x = 1$$
$$e^x = e^0$$
$$x = 0$$

16. $\log_{10} 10 = x$
$$10^x = 10$$
$$10^x = 10^1$$
$$x = 1$$

18. $\log_3 3^5 = x$
$$3^x = 3^5$$
$$x = 5$$

20. $\log_6 36 = x$
$$6^x = 36$$
$$6^x = 6^2$$
$$x = 2$$

22. $\log_b FG = \log_b F + \log_b G$

24. $\log_b w^{15} = 15\log_b w$

26. $\dfrac{\log_3 P}{\log_3 R} = \log_R P$

28. $\log_2 x = 2$

$$2^2 = x$$
$$4 = x$$

30. $\log_3 27 = y$

$$3^y = 27$$
$$3^y = 3^3$$
$$y = 3$$

32. $\log_b e^{-2} = -2$

$$e^{-2} = b^{-2}$$
$$e = b$$

34. $\log_{25} x = \dfrac{1}{2}$

$$25^{1/2} = x$$
$$5 = x$$

36. False; an example of a polynomial function of odd degree that is not one–to–one is $f(x) = x^3 - x$. $f(-1) = f(0) = f(1) = 0$.

38. True; the graph of every function (not necessarily one–to–one) intersects each vertical line exactly once.

40. False; $x = -1$ is in the domain of *f*, but cannot be in the range of *g*.

42. True; since *g* is the inverse of *f*, then (a, b) is on the graph of *f* if and only if (b, a) is on the graph of *g*. Therefore, *f* is also the inverse of *g*.

44. $\log_b x = \dfrac{2}{3}\log_b 27 + 2\log_b 2 - \log_b 3$

$$\log_b x = \log_b 27^{2/3} + \log_b 2^2 - \log_b 3$$
$$\log_b x = \log_b 9 + \log_b 4 - \log_b 3$$
$$\log_b x = \log_b \frac{(9)(4)}{3}$$
$$\log_b x = \log_b 12$$
$$x = 12$$

46. $\log_b x = 3\log_b 2 + \dfrac{1}{2}\log_b 25 - \log_b 20$

$$\log_b x = \log_b 2^3 + \log_b 25^{1/2} - \log_b 20$$
$$\log_b x = \log_b 8 + \log_b 5 - \log_b 20$$
$$\log_b x = \log_b \frac{(8)(5)}{20}$$
$$\log_b x = \log_b 2$$
$$x = 2$$

48. $\log_b(x+2)+\log_b x=\log_b 24$

$$\log_b(x+2)x=\log_b 24$$
$$\log_b(x^2+2x)=\log_b 24$$
$$x^2+2x=24$$
$$x^2+2x-24=0$$
$$(x+6)(x-4)=0$$
$$x=-6,4$$

Since the domain of a logarithmic function is $(0,\infty)$, omit the negative solution. Therefore, the solution is $x=4$.

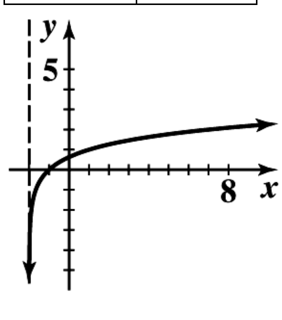
50. $\log_{10}(x+6)-\log_{10}(x-3)=1$

$$\log_{10}\frac{x+6}{x-3}=1$$
$$10^1=\frac{x+6}{x-3}$$
$$10(x-3)=x+6$$
$$10x-30=x+6$$
$$x=4$$

52. $y=\log_3(x+2)$

$$3^y=x+2$$
$$3^y-2=x$$

x	y
$-\frac{53}{27}$	-3
$-\frac{17}{9}$	-2
$-\frac{5}{3}$	-1
-1	0
1	1
7	2
25	3



54. The graph of $y=\log_3(x+2)$ is the graph of $y=\log_3 x$ shifted to the left 2 units.

56. The domain of logarithmic function is defined for positive values only. Therefore, the domain of the function is $x-1>0$ or $x>1$. The range of a logarithmic function is all real numbers. In interval notation the domain is $(1, \infty)$ and the range is $(-\infty, \infty)$.

58. A. $\log 72.604 = 1.86096$

B. $\log 0.033041 = -1.48095$

C. $\ln 40,257 = 10.60304$

D. $\ln 0.0059263 = -5.12836$

60. A. $\log x = 2.0832$

$$x = \log^{-1}(2.0832)$$
$$x = 121.1156$$

B. $\log x = -1.1577$

$$x = \log^{-1}(-1.1577)$$
$$x = 0.0696$$

C. $\ln x = 3.1336$

$$x = \ln^{-1}(3.1336)$$
$$x = 22.9565$$

D. $\ln x = -4.3281$

$$x = \ln^{-1}(-4.3281)$$
$$x = 0.0132$$

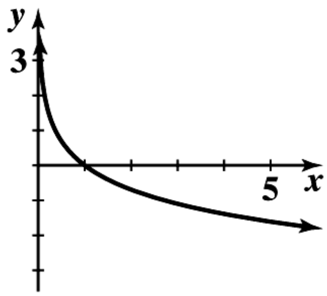
62.
$$10^x = 153$$
$$\log 10^x = \log 153$$
$$x = 2.1847$$

64.
$$e^x = 0.3059$$
$$\ln e^x = \ln 0.3059$$
$$x = -1.1845$$

66.
$$1.02^{4t} = 2$$
$$\ln 1.02^{4t} = \ln 2$$
$$4t \ln 1.02 = \ln 2$$
$$t = \frac{\ln 2}{4 \ln 1.02}$$
$$t = 8.7507$$

68. $y = -\ln x;\ \ x > 0$

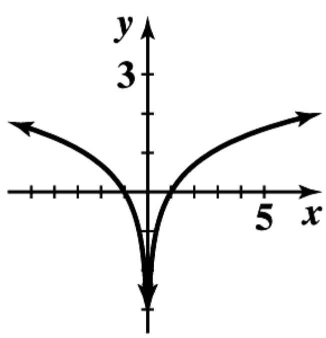
x	y
0.5	≈ 0.69
1	0
2	≈ -0.69
4	≈ -1.39
5	≈ -1.61



Based on the graph above, the function is decreasing on the interval $(0, \infty)$.

70. $y = \ln|x|$

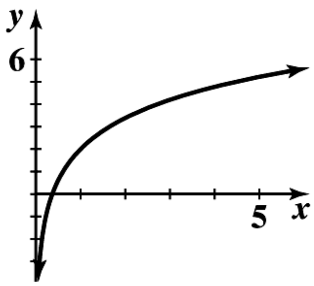
x	y
–5	≈ 1.61
–2	≈ 0.69
1	0
2	≈ 0.69
5	≈ 1.61



Based on the graph above, the function is decreasing on the interval $(-\infty, 0)$ and increasing on the interval $(0, \infty)$.

72. $y = 2\ln x + 2$

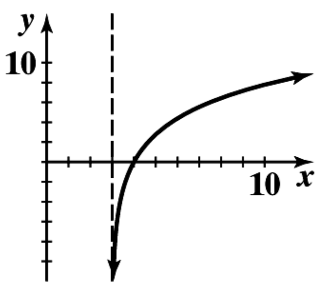
x	y
0.5	≈ 0.61
1	2
2	≈ 3.39
4	≈ 4.77
5	≈ 5.22



Based on the graph above, the function is increasing on the interval $(0, \infty)$.

74. $y = 4\ln(x - 3)$

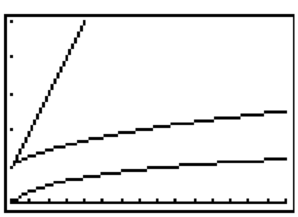
x	Y
4	0
6	≈ 4.39
8	≈ 6.44
10	≈ 7.78
12	≈ 8.79



Based on the graph above, the function is increasing on the interval $(3, \infty)$.

76. It is not possible to find a power of 1 that is an arbitrarily selected real number, because 1 raised to any power is 1.

78.



A function *f* is "smaller than" a function g on an interval $[a, b]$ if $f(x) < g(x)$ for $a \le x \le b$. Based on the graph above, $\log x < \sqrt[3]{x} < x$ for $1 < x \le 16$.

80. Use the compound interest formula: $A = P(1+r)^t$. The problem is asking for the original amount to double, therefore $A = 2P$.

$$\begin{aligned}
2P &= P(1+0.0958)^t \\
2 &= (1.0958)^t \\
\ln 2 &= \ln(1.0958)^t \\
\ln 2 &= t\ln(1.0958) \\
\frac{\ln 2}{\ln 1.0958} &= t \\
7.58 &\approx t
\end{aligned}$$

It will take approximately 8 years for the original amount to double.

82. Use the compound interest formula: $A = P(1+\frac{r}{m})^{mt}$.

A.
$$\begin{aligned}
7500 &= 5000(1+\tfrac{0.08}{2})^{2t} \\
1.5 &= (1.04)^{2t} \\
\ln 1.5 &= \ln(1.04)^{2t} \\
\ln 1.5 &= 2t\ln(1.04) \\
\frac{\ln 1.5}{2\ln 1.04} &= t \\
5.17 &\approx t
\end{aligned}$$

It will take approximately 5.17 years for \$5000 to grow to \$7500 if compounded semiannually.

B.
$$\begin{aligned}
7500 &= 5000(1+\tfrac{0.08}{12})^{12t} \\
1.5 &= (1.0066667)^{12t} \\
\ln 1.5 &= \ln(1.0066667)^{12t} \\
\ln 1.5 &= 12t\ln(1.0066667) \\
\frac{\ln 1.5}{12\ln 1.0066667} &= t \\
5.09 &\approx t
\end{aligned}$$

It will take approximately 5.09 years for \$5000 to grow to \$7500 if compounded monthly.

84. Use the compound interest formula: $A = Pe^{rt}$.

$$\begin{aligned}
41,000 &= 17,000e^{0.0295t} \\
\tfrac{41}{17} &= e^{0.0295t} \\
\ln\tfrac{41}{17} &= \ln e^{0.0295t} \\
\ln\tfrac{41}{17} &= 0.0295t \\
\frac{\ln\frac{41}{17}}{0.0295} &= t \\
29.84 &\approx t
\end{aligned}$$

It will take approximately 29.84 years for \$17,000 to grow to \$41,000 if compounded continuously.

86. Equilibrium occurs when supply and demand are equal. The models from Problem 85 have the demand and supply functions defined by $y = 256.4659159 - 24.03812068 \ln x$ and $y = -127.8085281 + 20.01315349 \ln x$, respectively. Set both equations equal to each other to yield:

$$256.4659159 - 24.03812068 \ln x = -127.8085281 + 20.01315349 \ln x$$
$$384.274444 = 44.05127417 \ln x$$
$$\frac{384.274444}{44.05127417} = \ln x$$
$$e^{384.274444/44.05127417} = e^{\ln x}$$
$$6145 \approx x$$

Substitute the value above into either equation.

$$y = 256.4659159 - 24.03812068 \ln x$$
$$y = 256.4659159 - 24.03812068 \ln(6145)$$
$$y = 256.4659159 - 24.03812068(8.723394022)$$
$$y = 46.77$$

Therefore, equilibrium occurs when 6145 units are produced and sold at a price of \$46.77.

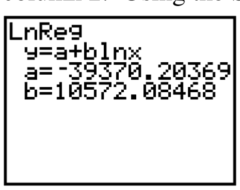
88. A. $N = 10\log\frac{I}{I_0} = 10\log\frac{10^{-13}}{10^{-16}} = 10\log 10^3 = 30$

B. $N = 10\log\frac{I}{I_0} = 10\log\frac{3.16\times10^{-10}}{10^{-16}} = 10\log 3.16\times10^6 \approx 65$

C. $N = 10\log\frac{I}{I_0} = 10\log\frac{10^{-8}}{10^{-16}} = 10\log 10^8 = 80$

D. $N = 10\log\frac{I}{I_0} = 10\log\frac{10^{-1}}{10^{-16}} = 10\log 10^{15} = 150$

90. A. Using a TI – 83 graphing calculator, input the years after 1900 in column 1 and the Total Production in column 2. Using the STAT – CALC – LnReg function, your calculator will display the following:



Therefore, the logarithmic equation that will be used is $y = -39,370.20369 + 10,572.08468 \ln x$.

$$y = -39,370.20369 + 10,572.08468 \ln x$$
$$y = -39,370.20369 + 10,572.08468 \ln(120)$$
$$y = -39,370.20369 + 10,572.08468(4.787491743)$$
$$y \approx 11,244$$

Therefore, according to the model, the total production in the year 2020 will be approximately 11,244 million bushels.

92. $A = A_0e^{-0.000124t}$

$$0.1A_0 = A_0e^{-0.000124t}$$

$$0.1 = e^{-0.000124t}$$

$$\ln 0.1 = \ln e^{-0.000124t}$$

$$\ln 0.1 = -0.000124t$$

$$18,569 \approx t$$

If 10% of the original amount is still remaining, the skull would be approximately 18,569 years old.