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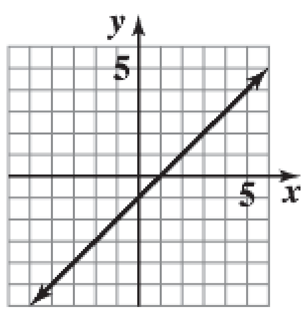
2 01.FUNCTIONS AND GRAPHS

EXERCISE 2-1

2.



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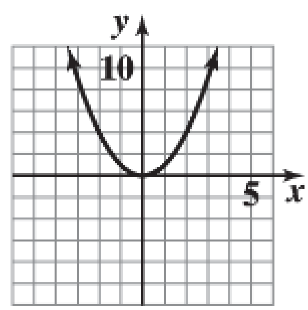

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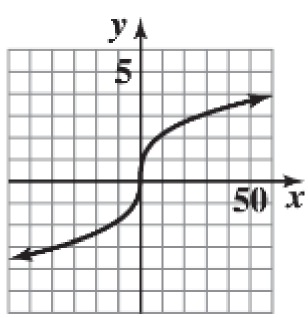

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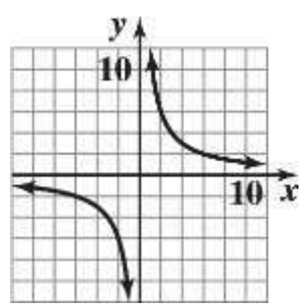


10. The table specifies a function, since for each domain value there corresponds one and only one range value.

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 103x is linear.

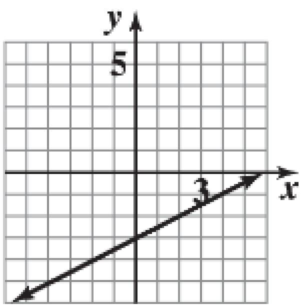
24. x^2 y 8 is neither linear nor constant.

26. $y \frac{2\ x\ 2\ x}{}$ 2 x 2x3

□ $\frac{4}{3}$ which is constant.

28. 9x 2y 6 0 is linear.

30.



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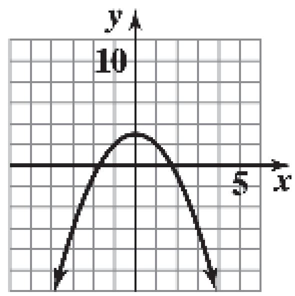
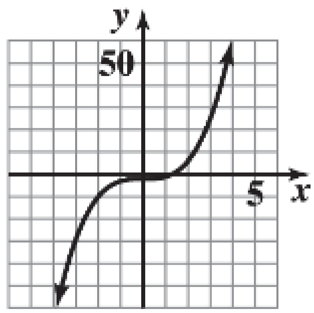
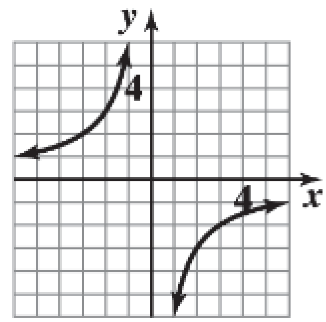


34. 

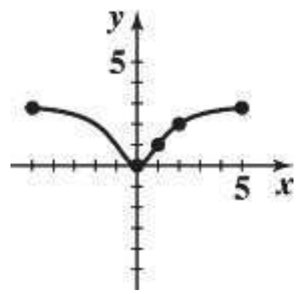
36. 

38. $f(x) = \frac{3x^2}{x^2 \square 2}$. 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. All real numbers

50. All real numbers except $x = 2$

52. $x > -5$

54. Given $6x - 7y = 21$. Solving for y we have: $-7y = 21 - 6x$ and $y = \frac{6}{7}x - 3$.

This equation specifies a function. The domain is R, the set of real numbers.

56. Given $x(x + y) = 4$. Solving for y we have: $xy + x^2 = 4$ and $y = \frac{4 - x^2}{x}$.

This equation specifies a function. The domain is all real numbers except 0.

58. Given $x^2 + y^2 = 9$. Solving for y we have: $y^2 = 9 - x^2$ and $y = \pm\sqrt{9 - x^2}$.

This equation does not define y as a function of x. For example, when $x = 0$, $y = \pm 3$.

60. Given $\sqrt{x} - y^3 = 0$. . Solving for y we have: $y^3 = \sqrt{x}$ and $y = x^{1/6}$.

This equation specifies a function. The domain is all nonnegative real numbers, i.e., $x \geq 0$.

62. $f(-5) = (-5)^2 - 4 = 25 - 4 = 21$

64. $f(x - 2) = (x - 2)^2 - 4 = x^2 - 4x + 4 - 4 = x^2 - 4x$

66. $f(10x) = (10x)^2 - 4 = 100x^2 - 4$

68. $f(\sqrt{x}) = (\sqrt{x})^2 - 4 = x - 4$

70. $f(-3) + f(h) = (-3)^2 - 4 + h^2 - 4 = 5 + h^2 - 4 = h^2 + 1$

72. $f(-3 + h) = (-3 + h)^2 - 4 = 9 - 6h + h^2 - 4 = 5 - 6h + h^2$

74. $f(-3 + h) - f(-3) = \left[(-3 + h)^2 - 4\right] - \left[(-3)^2 - 4\right] = (9 - 6h + h^2 - 4) - (9 - 4) = -6h + h^2$

(A)

76.

(B)

(C)

78. (A)

(B)

(C)

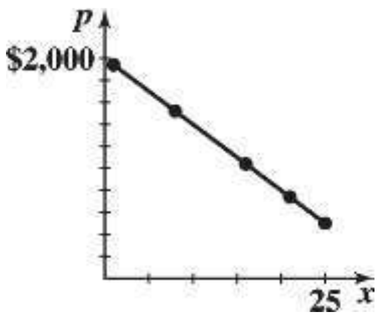
82. Given $A = lw = 81$.
Thus, $w = \frac{81}{l}$. Now $P = 2l + 2w = 2l + 2\left(\frac{81}{l}\right) = 2l + \frac{162}{l}$.

The domain is $l > 0$.

84. Given $P = 2l + 2w = 160$ or $l + w = 80$ and $l = 80 - w$.
Now $A = lw = (80 - w)w$ and $A = 80w - w^2$.

The domain is $0 < w < 80$. [Note: $w < 80$ since $w \geq 80$ implies $l \leq 0$.]

86. (A)



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

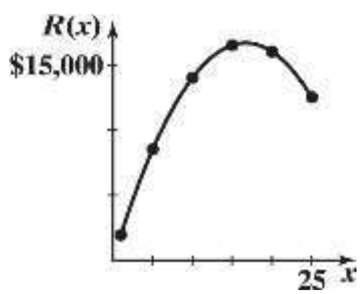
88. (A) $R(x) = xp(x)$
$= x(2{,}000 - 60x)$ thousands of dollars

Domain: $1 \leq x \leq 25$

(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)



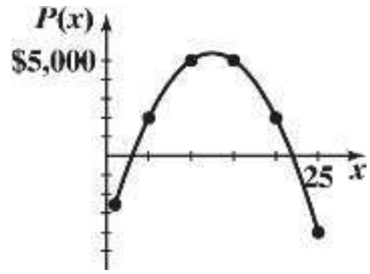
90. (A) $P(x) = R(x) - C(x)$
$= x(2{,}000 - 60x) - (4{,}000 + 500x)$ thousand dollars
$= 1{,}500x - 60x^2 - 4{,}000$

Domain: $1 \leq x \leq 25$

(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

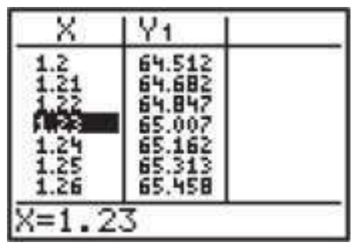
(C)



92. (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



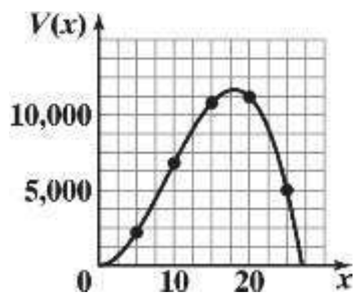
94. (A) $V(x) = x^2(108□4x)$

(B) $0 < x < 27$

(C) Table 16 Volume

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

(D)(D)



96. (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

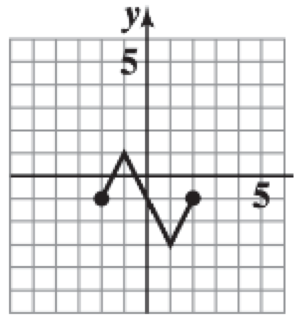
2. $f(x) = -4x + 12$ Domain: all real numbers; range: all real numbers.

4. $f(x) = 3 + \sqrt{x}$ Domain: $[0, \infty)$; range: $[3, \infty)$.

6. $f(x) = -5|x| + 2$ Domain: all real numbers; range: $(-\infty, 2]$.

8. $f(x) = 20 - 10\sqrt[3]{x}$ Domain: all real numbers; range: all real numbers.

10.



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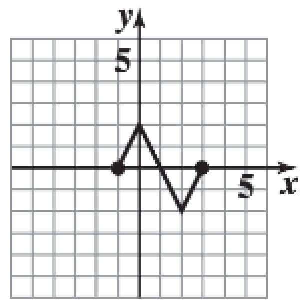

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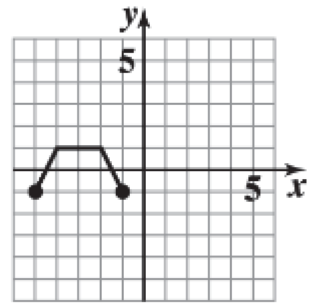

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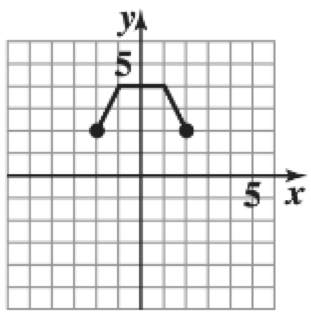

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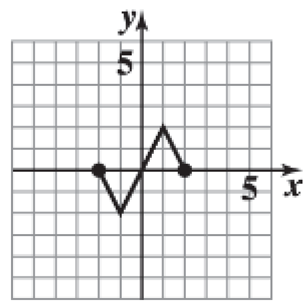

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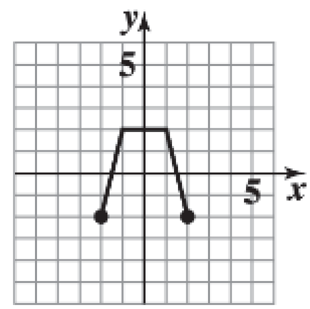

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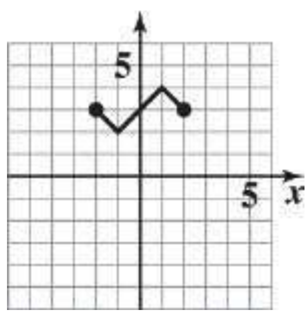

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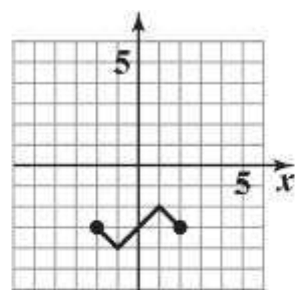
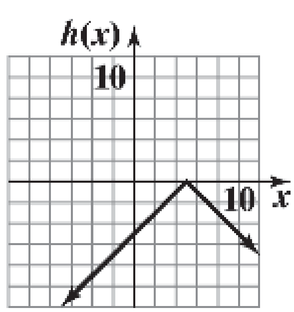
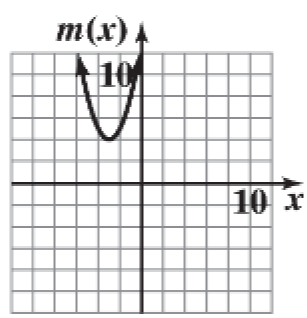


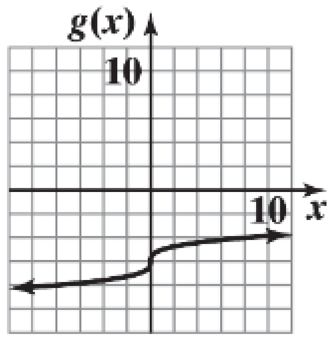
26. The graph of $h(x) = -|x - 5|$ is the graph of $y = |x|$ reflected in the x axis and shifted 5 units to the right.



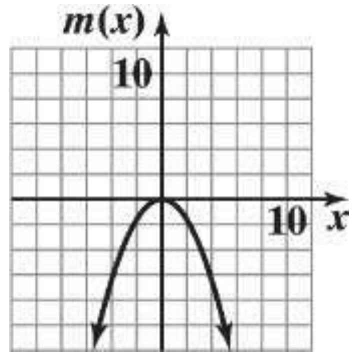
28. The graph of $m(x) = (x + 3)^2 + 4$ is the graph of $y = x^2$ shifted 3 units to the left and 4 units up.



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



32. 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.



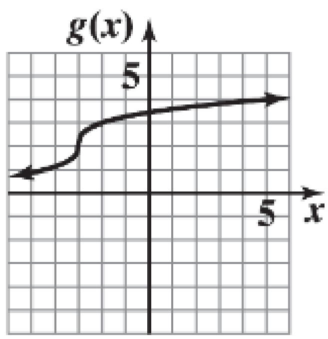
34. The graph of the basic function $y = |x|$ is shifted 3 units to the right and 2 units up. $y = |x - 3| + 2$

36. 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: $y = 3 - |x + 2|$

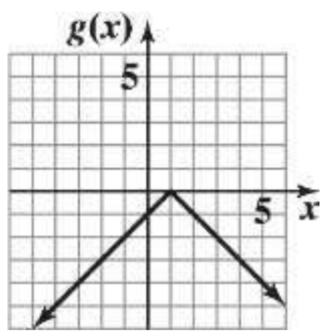
38. The graph of the basic function $\sqrt[3]{x}$ is reflected in the x axis and shifted up 2 units. Equation: $y = 2 - \sqrt[3]{x}$

40. 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: $y = 1 - (x - 3)^3$

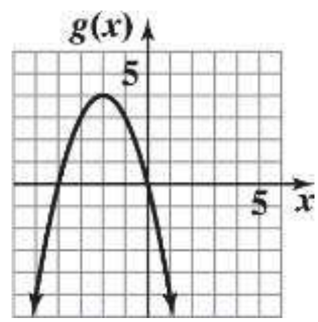
42. $g(x) = \sqrt[3]{x \square 3} + 2$



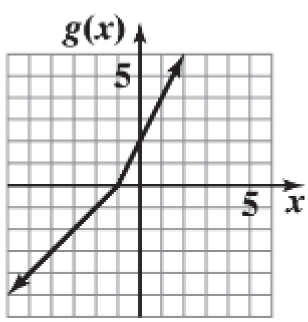
44. $g(x) = -|x - 1|$

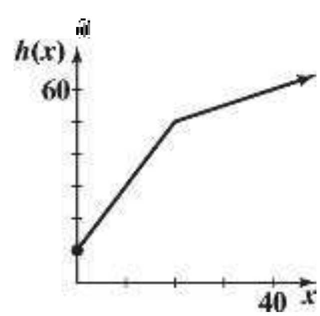


46. $g(x) = 4 - (x + 2)^2$



48. g





52.

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

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

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

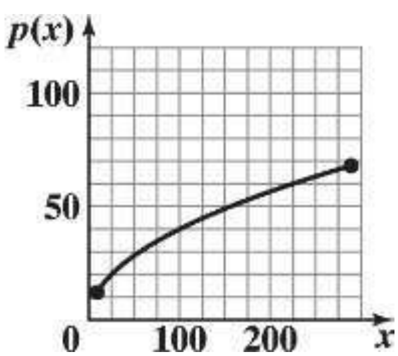
60. Vertical shift, reflection in y axis.
Reversing the order does not change the result. Consider a point (a, b) in the plane. A vertical shift of k units followed by a reflection in y axis moves (a, b) to $(a, b + k)$ and then to $(-a, b + k)$. In the reverse order, a reflection in y axis followed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

62. 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 $(a, bh + k)$; $(a, bh + kh) \neq (a, bh + k)$.

64. 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.

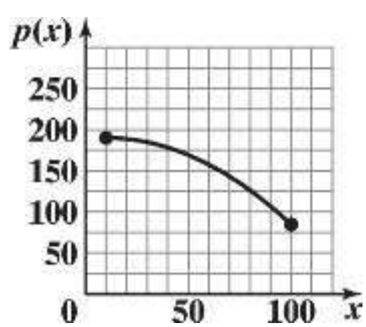
66. (A) The graph of the basic function $y = \sqrt{x}$ is vertically expanded by a factor of 4.

(B)



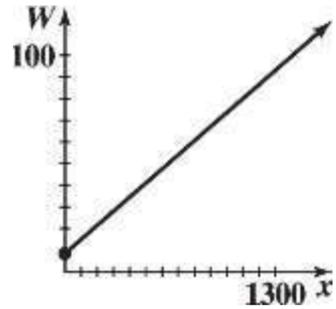
68. (A) The graph of the basic function $y = x^2$ is reflected in the x axis, vertically contracted by a factor of 0.013, and shifted 10 units to the right and 190 units up.

(B)



70. (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,

(B)



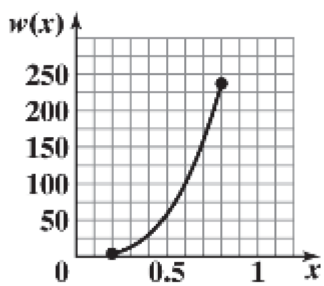
72. (A) Let x = taxable income.
If $0 \le x \le 15{,}000$, the tax due is \$$.035x$. At $x = 15{,}000$, the tax due is \$525. For $15{,}000 < x \le 30{,}000$, the tax due is $525 + .0625(x - 15{,}000) = .0625x - 412.5$. For $x > 30{,}000$, the tax due is $1{,}462.5 + .0645(x - 30{,}000) = .0645x - 472.5$.

Thus,

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

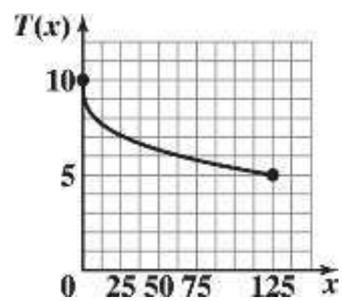
74. (A) The graph of the basic function $y = x^3$ is vertically expanded by a factor of 463.

(B)



76. (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. $x^2 + 16x$ (standard form)
$x^2 + 16x + 64 - 64$ (completing the square)
$(x + 8)^2 - 64$ (vertex form)

4. $x^2 - 12x - 8$ (standard form)
$(x^2 - 12x) - 8$
$(x^2 - 12x + 36) + 8 - 36$ (completing the square)
$(x - 6)^2 - 44$ (vertex form)

6. $3x^2 + 18x + 21$ (standard form)

$3(x^2 + 6x) + 21$

$3(x^2 + 6x + 9 - 9) + 21$ (completing the square)

$3(x + 3)^2 + 21 - 27$

$3(x + 3)^2 - 6$ (vertex form)

8. $-5x^2 + 15x - 11$ (standard form)

$-5(x^2 - 3x) - 11$

$-5(x^2 - 3x + \frac{9}{4} - \frac{9}{4}) - 11$ (completing the square)

$-5(x - \frac{3}{2})^2 - 11 + \frac{45}{4}$

$-5(x - \frac{3}{2})^2 + \frac{1}{4}$ (vertex form)

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

12. 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; $n(x) = -(x - 4)^2 + 7$.

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

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

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

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

(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: $y \le 3$ or $(-\infty, 3]$

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

(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 $[-3, \infty)$

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

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

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

(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: $y \ge -4$ or $[-4, \infty)$

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

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

(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: $y \le 1$ or $(-\infty, 1]$

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

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

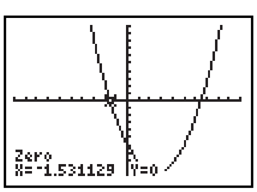
(A) x intercepts: none
y intercept: 10

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

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

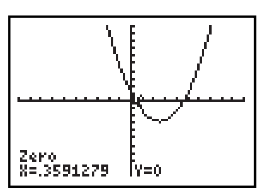
(A) $g(x) = -2$: $-0.6x^2 + 3x + 4 = -2$

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



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

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



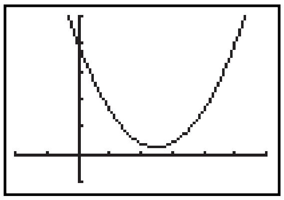
$x = -1.53, 6.53$

$x = 0.36, 4.64$

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

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

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



No solution

36. 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.

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

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

(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 $[-4.2, \infty)$

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

(A) x intercepts:

$-0.15(x+3)^2 + 4.65 = 0$

$(x+3)^2 = 31$

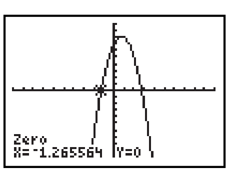
$x + 3 = \pm\sqrt{31}$

$x = -3 - \sqrt{31} = -8.6, -3 + \sqrt{31} = 2.6$;

y intercept: 3.30

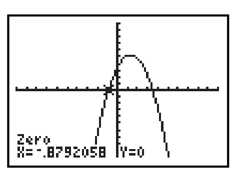
(B) Vertex: (–3, 4.65) (C) Maximum: 4.65 (D) Range: $x \leq 4.65$ or $(-\infty, 4.65]$

42.



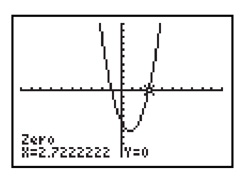
$x = -1.27, 2.77$

44.



$-0.88 \leq x \leq 3.52$

46.



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

48. *f* is a quadratic function and max $f(x) = f(-3) = -5$

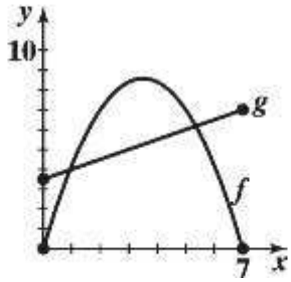
Axis: $x = -3$

Vertex: $(-3, -5)$

Range: $y \le -5$ or $(-\infty, -5]$

x intercepts: None

50. (A)



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

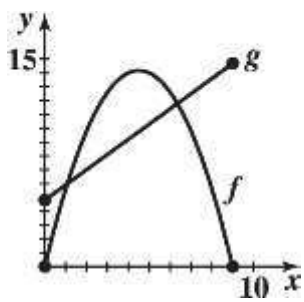
$-0.7x^2 + 4.4x - 3.5 = 0$

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

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

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

52. (A)



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

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

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

$x =$ = 1.08, 6.35

1.4

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

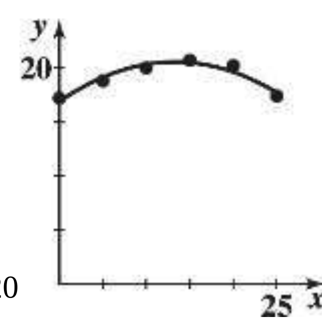
(D) $f(x) < g(x)$ for $0 \le x < 1.08$ or $6.35 < x \le 9$

54. A quadratic with no real zeros will not intersect the x–axis.

56. Such an equation will have

—
a

60.



$k = c - ah^2$

$= \underline{4ac - b}$

$4a$

$f(x) = -0.0169x^2 + 0.47x + 17.1$

(A)

x	Mkt Share	$f(x)$
0	17.2	17.1
5	18.8	19.0
10	20.0	20.1
15	20,7	20.3
20	20.2	19.7
25	17.4	18.3
30	16.4	16.0

(C) For 2020, $x = 40$ and $f(40) = -0.0169(30)^2 + 0.47(40) + 17.1 = 8.9\%$

For 2025, $x = 45$ and $f(45) = -0.0169(45)^2 + 0.47(45) + 17.1 = 4.0\%$

(D) Market share rose from 17.2% in 1980 to a maximum of 20.7% in 1995 and then fell to 16.4% in 2010.

64. Verify

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

(C) $2000 - 60(50/3) = \$1,000$

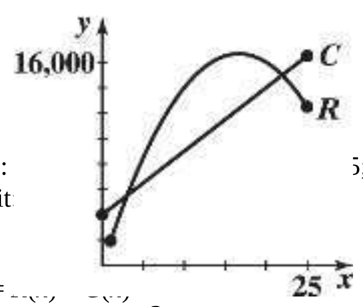
$60x - 1{,}500x + 4{,}000 = 0$

$6x^2 - 150x + 400 = 0$

$x = 3.035, 21.965$

$x = 0.10$ cm

68. (A)

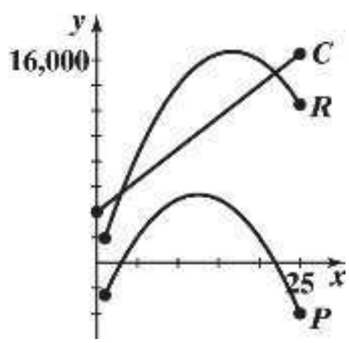


= $1,000

(C) Loss: ;
Profit

70. (A) $P(x) =$

$= 1{,}500x - 60x^2 - 4{,}000$



72. Solve: $f(x) = 1{,}000(0.04 - x^2) = 30$

$40 - 1000x^2 = 30$

$1000x^2 = 10$

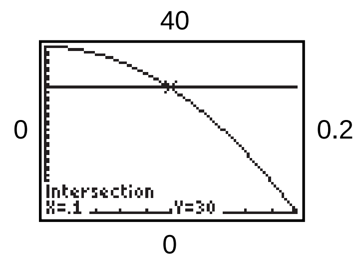
$x^2 = 0.01$

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

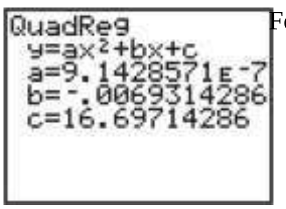
$16,666,667.

(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



74.



For $x = 2{,}300$, the estimated fuel consumption is

$$y = a(2{,}300)^2 + b(2{,}300) + c = 5.6 \text{ mpg}.$$

EXERCISE 2-4

2. $f(x) = 72 + 12x$

(A) Degree: 1

(B) $72 + 12x = 0$

$12x = -72$

$x = -6$

x-intercept: $x = -6$

4. $f(x) = x^3(x+5)$

(A) Degree: 4

(B) $x^3(x + 5) = 0$

$x = 0, -5$

x-intercepts: $0, -5$

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

y-intercept: 0

6. $f(x) = x^2 - 4x - 5$

(A) Degree: 2

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

$x = -1, 5$

x-intercepts: –1, 5

(C) $f(0) = -5$

y-intercept: –5

8. $f(x) = (x^2 - 4)(x^3 + 27)$

(A) Degree: 5

(B) $(x^2 - 4)(x^3 + 27) = 0$

$x = -2, 2, -3$

x-intercepts: $x = -2, 2, -3$

(C) $f(0) = -4(27) = -108$

y-intercept: –108

10. $f(x) = (x+3)^2(8x-4)^6$

(A) Degree: 8

(B) $(x+3)(8x-4) = 0$

$x = -3, \frac{1}{2}$

x-intercepts: $-3, 1/2$

(C) $f(0) = 3^2(-4)^6 = 36{,}864$

y-intercept: 36,864

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.

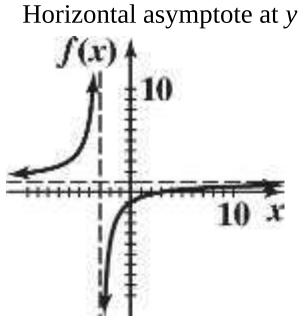
22. A polynomial of degree 6 may have no *x* intercepts. For example, the polynomial $f(x) = x^6 + 1$ has no *x*- intercepts.

24. (A) Intercepts:

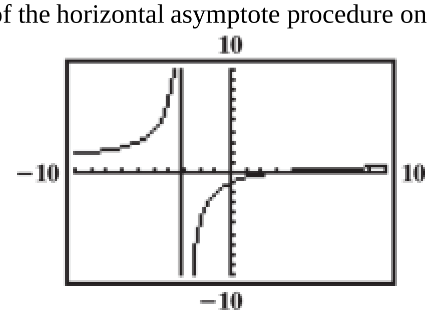
(B) Domain: all real numbers except $x = -3$

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

(D)



(E)

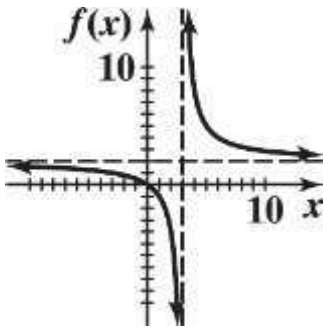


26. (A) Intercepts:

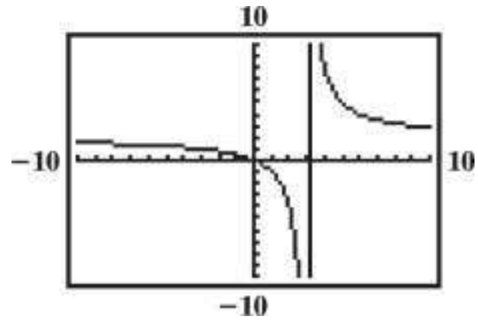
(B) Domain: all real numbers except $x = 3$.

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

(D)

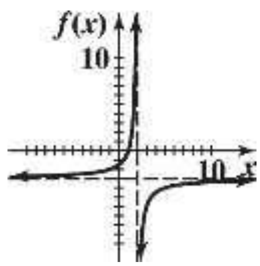


(E)

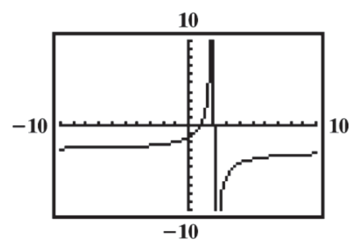


28. (A) Intercepts:
(B) Domain: all real numbers except $x \neq 2$
(C) Vertical asymptote at $x = 2$ by case 1 of the vertical asymptote procedure on page 90.
Horizontal asymptote at $y = -3$ by case 2 of the horizontal asymptote procedure on page 90.

(D)

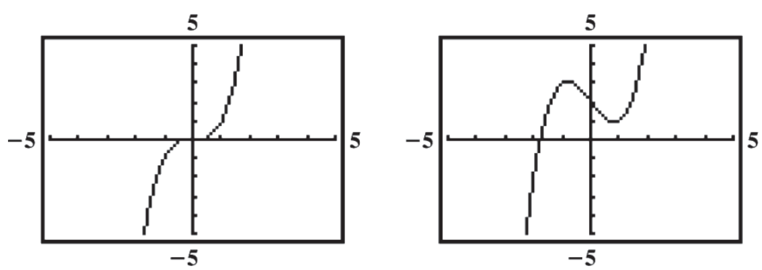


(E)

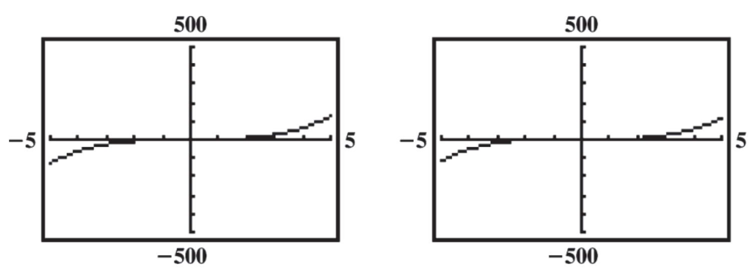


30.

(A)

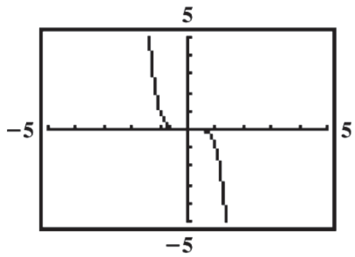


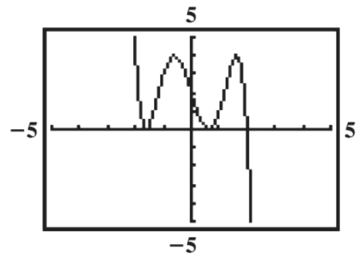
(B)



32.

(A)





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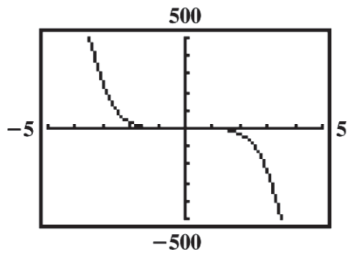
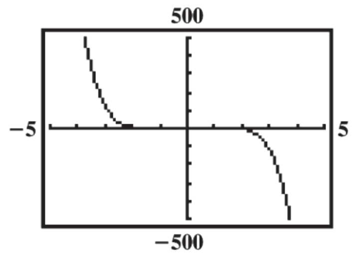
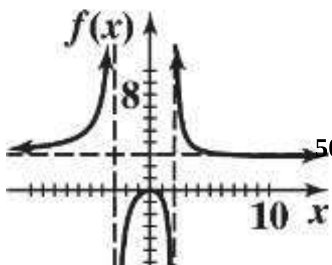
(B)

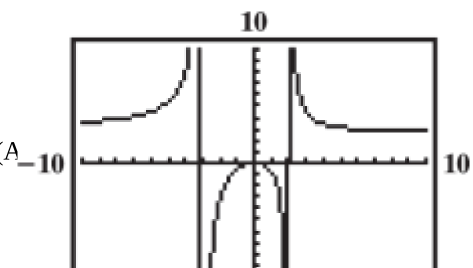




(B)

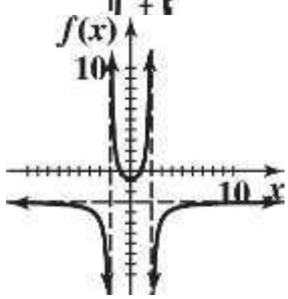


(D)

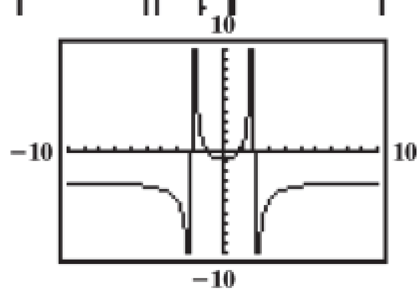


50. (A

(B)



(D

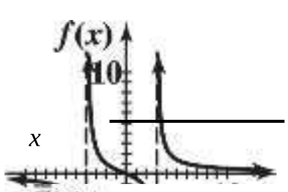


52. (A) Intercepts:

x-intercept(s):	*y*-intercept:
$5x - 10 = 0$ $x = 2$ (2,0)	$f(0) = \frac{-10}{-12} = \frac{5}{6}$ (0,5/6)

(B) Vertical asymptote

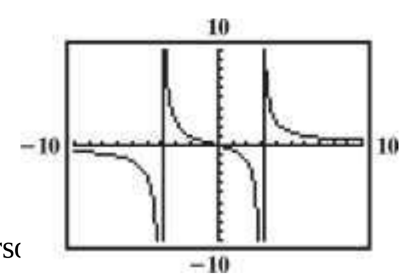
(C)



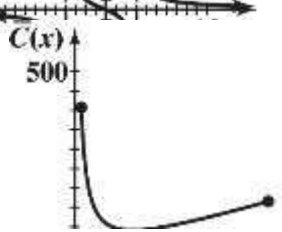
54.

x

(D)

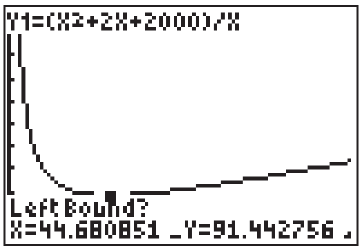


(B)



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

(D)

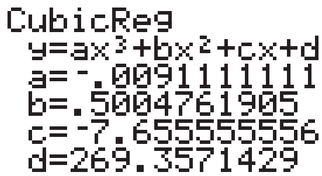


62. (A) (B)

–

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

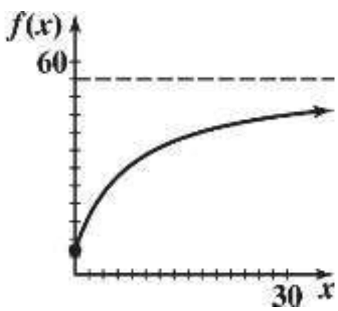
64. (A)



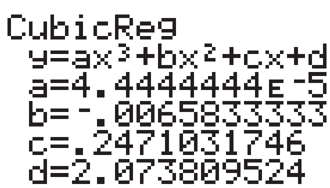
(B) $y(42) = 156$ eggs

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

(B)



68. (A)



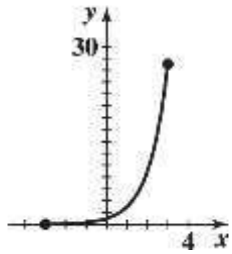
(B) This model gives an estimate of 2.5 divorces per 1,000 marriages.

EXERCISE 2-5

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

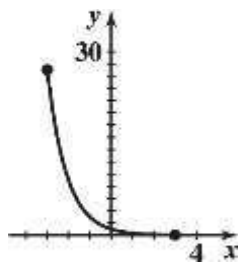
4.

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



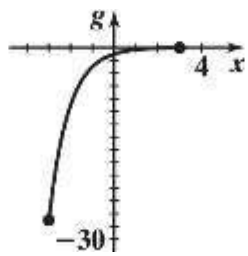
6.

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



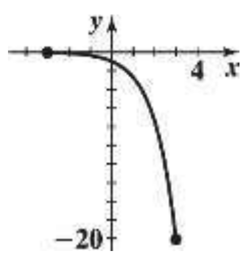
8.

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



10.

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



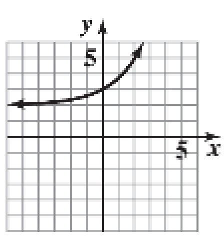
12. The graph of g is the graph of f shifted 2 units to the right.

14. The graph of g is the graph of f reflected in the x axis.

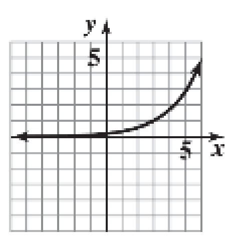
16. The graph of g is the graph of f shifted 2 units down.

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.

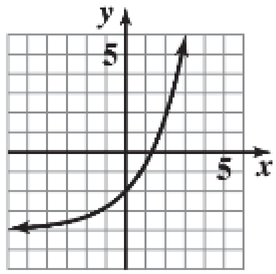
20. A.



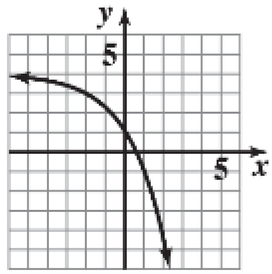
B.



C.



D.



22.

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

24.

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

26.

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

30.

32.

34.

3

36. $10xe^x - 5e^x = 0$

$e^x(10x - 5) = 0$

$10x - 5 = 0$ (since $e^x \neq 0$)

$x = 1/2$

38. $x^2e^{-x} - 9e^{-x} = 0$

$e^{-x}(x^2 - 9) = 0$

$(x^2 - 9) = 0$ (since $e^{-x} \neq 0$)

$x = -3, 3$

40. $e^{4x} + e > 0$ for all x;

$e^{4x} + e = 0$ has no solutions.

42. $e^{3x-1} - e = 0$

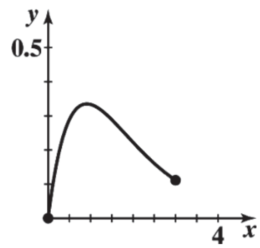
$e^{3x-1} = e^1$

$3x - 1 = 1$

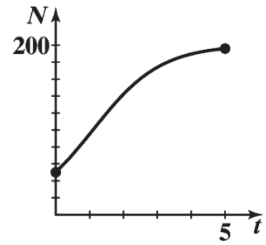
$x = 2/3$

44.

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



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



48.

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

$A = 10,000(1 + \frac{0.0135}{4})^{(4)(5)}$

$A = 10,000(1.003375)^{20}$

$A = 10,000(1.069709)$

$A = \$10,697.09$

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

$A = 10,000(1 + \frac{0.0130}{12})^{(12)(5)}$

$A = 10,000(1.00108333)^{60}$

$A = 10,000(1.067121479)$

$A = \$10,671.21$

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

$A = 10,000(1 + \frac{0.0125}{365})^{(365)(5)}$

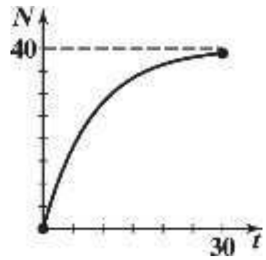
$A = 10,000(1.000034247)^{1825}$

$A = 10,000(1.06449332)$

$A = \$10,644.93$

56. $N = 40(1 - e^{-0.12t})$; $[0, 30]$

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.

58.

```
ExpReg
 y=a*b^x
 a=1008.958664
 b=1.098151058
```

(A) The average salary in 2022: $y(32) \approx \$20,186,000$.

(B) The model gives an average salary of $y(7) \approx \$1,943,000$ in 1997.

60. (A) $I(50) = I_o e^{-0.00942(50)} \approx 62\ \%$ (B) $I(100) = I_o e^{-0.00942(100)} \approx 39\ \%$

62. (A) $P = 94e^{0.032t}$.

(B) Population in 2025: $P(13) = 94e^{0.032(13)} \approx 142,000,000$;

Population in 2035: $P(23) = 94e^{0.032(23)} \approx 196,000,000$.

64.

```
ExpReg
 y=a*b^x
 a=71.63144793
 b=1.002343596
```

Life expectancy for a person born in 2025: $y(55) \approx 81.5$ 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.** $\log_{10} 100,000 = \log_{10} 10^5 = 5$ **16.** $\log_3 \frac{1}{3} = \log_3 3^{-1} = -1$

18. $\log_4 1 = \log_4 4^0 = 0$ **20.** $\ln e^{-5} = -5$ **22.** $\log_b FG$ □ $\log_b F$ □ $\log_b G$ **24.** $\log_b w^{15}$ □ $15 \log_b w$

26.

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.

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