Solution Manual for College Algebra and Trigonometry 3rd Edition by Ratti McWaters ISBN 0321867416 9780321867414

Chapter 2: Analysis of Graphs and Functions

2.1: Graphs of Basic Functions and Relations; Symmetry

1. (,).
2. (,); [0,)
3. (0, 0)
4. [0,); [0,)
5. increases
6. (, 0]; [0,)
7. *x*-axis
8. even
9. odd
10. *y*-axis; origin
11. The domain can be all real numbers; therefore, the function is continuous for the interval (,) .
12. The domain can be all real numbers; therefore, the function is continuous for the interval (,) .
13. The domain can only be values where *x* 0; therefore, the function is continuous for the interval [0,).
14. The domain can only be values where *x* 0; therefore, the function is continuous for the interval (, 0].
15. The domain can be all real numbers except 3; therefore, the function is continuous for the interval (, 3) (3,).
16. The domain can be all real numbers except 1; therefore, the function is continuous for the interval (,1) (1,).
17. (a) The function is increasing for the interval 3, (b) The function is decreasing for the interval ,3 (c) The function is never constant; therefore, none.
    (d) The domain can be all real numbers; therefore, the interval (,).

(e) The range can only be values where y 0; therefore, the interval [0,).

18. (a) The function is increasing for the interval 4,

(b) The function is decreasing for the interval , 1

(c) The function is constant for the interval 1, 4

(d) The domain can be all real numbers; therefore, the interval (,).

(e) The range can only be values where y 3; therefore, the interval [3,).

19. (a) The function is increasing for the interval ,1

(b) The function is decreasing for the interval 4,

(c) The function is constant for the interval 1, 4

(d) The domain can be all real numbers; therefore, the interval (,).

(e) The range can only be values where y 3; therefore, the interval (, 3].

20. (a) The function is never increasing; therefore, none.

(b) The function is always decreasing; therefore, the interval (,). (c)

(d) The domain can be all real numbers; therefore, the interval (,).

(e) The range can be all real numbers; therefore, the interval (,).

21. (a) The function is never increasing; therefore, none

(b) The function is decreasing for the intervals , 2 and 3,

(c) The function is constant for the interval (2, 3).

(d) The domain can be all real numbers; therefore, the interval (,).

(e) The range can only be values where y 1.5 or y 2; therefore, the interval (,1.5] [2,).

22. (a) The function is increasing for the interval (3,).

(b) The function is decreasing for the interval (, 3). (c)

(d) The domain can be all real numbers except 3; therefore, the interval (, 3) (3,).

(e) The range can only be values where y 1; therefore, the interval (1,).

23. Graph $f(x)\ x^5$. See Figure 23. As x increases for the interval (,), y increases; therefore, the function is increasing.

24. Graph $f(x)\ x^3$. See Figure 24. As x increases for the interval (,), y decreases; therefore, the function is decreasing.

25. Graph $f(x)\ x^4$. See Figure 25. As x increases for the interval , 0 y decreases; therefore, the function is decreasing on , 0

26. Graph $f(x)\ x^4$. See Figure 26. As x increases for the interval 0, , y increases; therefore, the function is increasing on 0,

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

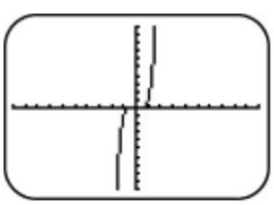

Figure 23

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

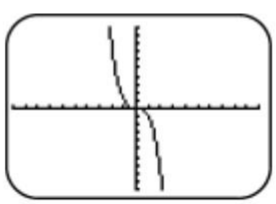

Figure 24

[-10,10] by [-10,10] Xscl= 1 Yscl = 1

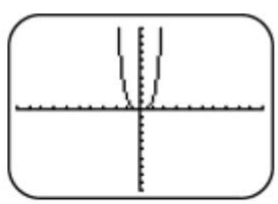

Figure 25

[-10,10] by [-10,10] Xscl = 1 Yscl= 1

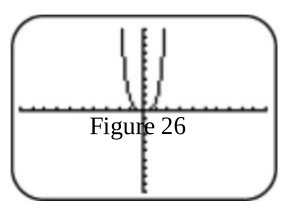

Figure 26

27. Graph $f(x)$ $|x|$. See Figure 27. As x increases for the interval , 0 , y increases; therefore, the function is increasing on , 0.

28. Graph $f(x)$ $|x|$. See Figure 28. As x increases for the interval 0, , y decreases; therefore, the function is decreasing on 0, .

29. Graph $f(x)$ $\sqrt[3]{x}$ See Figure 29. As x increases for the interval (,), y decreases; therefore, the function is decreasing.

30. Graph $f(x)$ $\sqrt{x}$. See Figure 30. As x increases for the interval 0, y decreases; therefore, the function is decreasing.

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

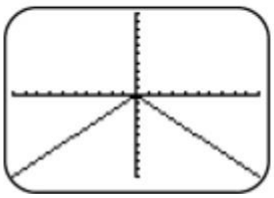

Figure 27

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

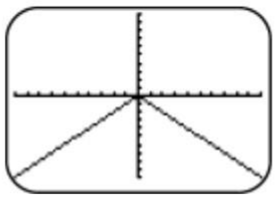

Figure 28

[-10,10] by [-10,10] Xscl= 1 Yscl = 1

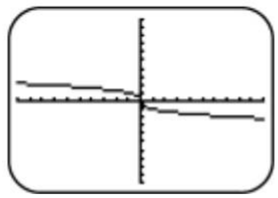

Figure 29

[-10,10] by [-10,10] Xscl = 1 Yscl= 1

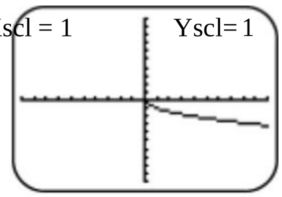

Figure 30

31. Graph $f(x)$ 1 x^3 . See Figure 31. As x increases for the interval (,), y decreases; therefore, the function is decreasing.

32. Graph $f(x)$ x^2 2 x. See Figure 32. As x increases for the interval 1, y increases; therefore, the function is increasing on 1, .

33. Graph $f(x)$ 2 x^2 . See Figure 33. As x increases for the interval , 0 y increases; therefore, the function is increasing on , 0 .

34. Graph $f(x)$ | x 1 | . See Figure 34. As x increases for the interval , 1 y decreases; therefore, the function is decreasing on , 1 .

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

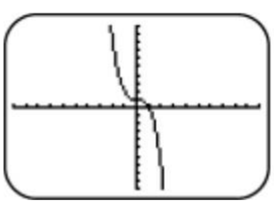

Figure 31

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

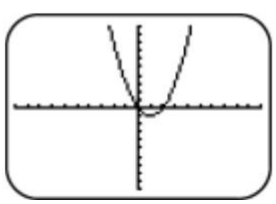

Figure 32

[-10,10] by [-10,10] Xscl= 1 Yscl = 1

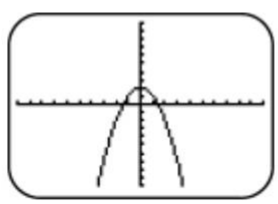

Figure 33

[-10,10] by [-10,10] Xscl = 1 Yscl= 1

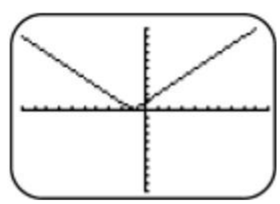

Figure 34

35. (a) No (b) Yes (c) No
36. (a) Yes (b) No (c) No
37. (a) Yes (b) No (c) No
38. (a) No (b) No (c) Yes
39. (a) Yes (b) Yes (c) Yes
40. (a) Yes (b) Yes (c) Yes
41. (a) No (b) No (c) Yes
42. (a) No (b) Yes (c) No
43. (a) Since $f(x)\ \ f(x)$, this is an even function and is symmetric with respect to the y-axis. See Figure 43a.
    (b) Since $f(x)\ \ f(x)$, this is an odd function and is symmetric with respect to the origin. See Figure 43b.

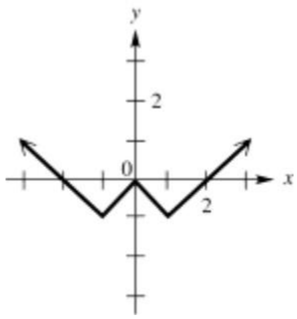

Figure 43a

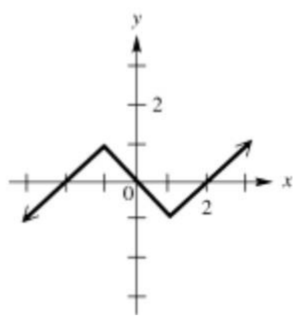

Figure 43b

44. (a) Since this is an odd function and is symmetric with respect to the origin. See Figure 44a.
    (b) Since this is an even function and is symmetric with respect to the y-axis. See Figure 44b

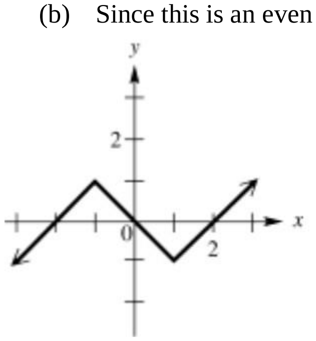

Figure 44a

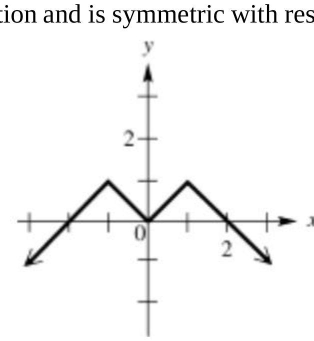

Figure 44b

45. If f is an even function then $f(x)\ \ f(x)$ or opposite domains have the same range. See Figure 45
46. If g is an odd function then $g(x)\ \ g(x)$ or opposite domains have the opposite range. See Figure 46

x	$f(x)$
−3	21
−2	−12
−1	−25
1	−25
2	−12
3	21

Figure 45

x	$g(x)$
−5	13
−3	1
−2	−5
0	0
2	5
3	−1
5	−13

Figure 46

47. This is an even function since opposite domains have the same range.

48. This is an even function since opposite domains have the same range.

49. This is an odd function since opposite domains have the opposite range.

50. This is an odd function since opposite domains have the opposite range.

51. This is neither even nor odd since the opposite domains are neither the opposite or same range.

52. This is neither even nor odd since the opposite domains are neither the opposite or same range.

53. If $f(x)\ x^4\ 7x^2\ 6$, then $f(x)\ (x)^4\ 7(x)^2\ 6 \Rightarrow f(x)\ x^4\ 7x^2\ 6$. Since $f(x)\ f(x)$, the function is even.

54. If $f(x)\ 2x^6\ 8x^2$, then $f(x)\ 2(x)^6\ 8(x)^2 \Rightarrow f(x)\ 2x^6\ 8x^2$. Since $f(x)\ f(x)$, the function is even.

55. If $f(x)\ 3x^3\ x$, then $f(x)\ 3(x)^3\ (x) \Rightarrow f(x)\ 3x^3\ x$ and $f(x)\ (3x^3\ x) \Rightarrow f(x)\ 3x^3\ x$. Since $f(x)\ f(x)$, the function is odd.

56. If $f(x)\ x^5\ 2x^3\ 3x$, then $f(x)\ (x)^5\ 2(x)^3\ 3(x) \Rightarrow f(x)\ x^5\ 2x^3\ 3x$ and $f(x)\ (x^5\ 2x^3\ 3x) \Rightarrow f(x)\ x^5\ 2x^3\ 3x$. Since $f(x)\ f(x)$, the function is odd.

57. If $f(x)\ x^6\ 4x^4\ 5$ then $f(x)\ (x)^6\ 4(x)^4\ 5 \Rightarrow f(x)\ x^6\ 4x^4\ 5$. Since $f(x)\ f(x)$, the function is even.

58. If $f(x)\ 8$, then $f(x)\ 8$. Since $f(x)\ f(x)$, the function is even.

59. If $f(x)\ 3x^5\ x^3\ 7x$, then $f(x)\ 3(x)^5\ (x)^3\ 7(x) \Rightarrow f(x)\ 3x^5\ x^3\ 7x$ and $f(x)\ (3x^5\ x^3\ 7x) \Rightarrow f(x)\ 3x^5\ x^3\ 7x$. Since $f(x)\ f(x)$, the function is odd.

60. If $f(x)\ x^3\ 4x$, then $f(x)\ (x)^3\ 4(x) \Rightarrow f(x)\ x^3\ 4x$ and $f(x)\ (x^3\ 4x) \Rightarrow f(x)\ x^3\ 4x$. Since $f(x)\ f(x)$, the function is odd.

61. If $f(x)\ |5x|$, then $f(x)\ |5(x)| \Rightarrow f(x)\ |5x|$. Since $\sqrt{f(x)}\ f(x)$, the function is even.

62. If $f(x)\ \sqrt{x^2\ 1}$, then $f(x)\ \sqrt{(x)^2\ 1}\ f(x)\ x^2\ 1$. Since $f(x)\ f(x)$, the functio n is even.

63. If (3,11) and (2,9) then $f(x)\ \frac{1}{2(x)} \Rightarrow f(x)\ \frac{1}{2x}$ and $f(x)\ \left(\frac{1}{2x}\right) \Rightarrow f(x)\ \frac{1}{2x}$ Since $f(x)\ f(x)$, the function is odd.

64. If $f(x)\ 4x\frac{1}{x}$, then $f(x)\ 4(x)\ \frac{1}{(x)} \Rightarrow f(x)\ 4x\frac{1}{x}$ and $f(x)\ \left(4x\ \frac{1}{x}\right) \Rightarrow f(x)\ 4x\ \frac{1}{x}$. Since $f(x)\ f(x)$, the function is odd.

65. If $f(x)\ x^3\ 2x$, then $f(x)\ (x)^3\ 2(x) \Rightarrow f(x)\ x^3\ 2x$ and

$f(x)(x^3\ 2x) \Rightarrow f(x)\ x^3\ 2x.$ Since $f(x)\ f(x)$, the function is symmetric with respect to the origin. Graph $f(x)\ x^3\ 2x$; the graph supports symmetry with respect to the origin.

66. If $f(x)\ x^5\ 2x^3$, then $f(x)(x)^5\ 2(x)^3 \Rightarrow f(x)\ x^5\ 2x^3$ and $f(x)\ (x^5\ 2x^3) \Rightarrow f(x)\ x^5\ 2x^3$. Since $f(x)\ f(x)$, the function is symmetric with respect to the origin. Graph $f(x)\ x^5\ 2x^3$; the graph supports symmetry with respect to the origin.

67. If $f(x)\ 0.5x^4\ 2x^2\ 1$, then $f(x)\ 0.5(x)^4\ 2(x)^2\ 1 \Rightarrow f(x)\ 0.5x^4\ 2x^2\ 1$.
Since $f(x)\ f(x)$, the function is symmetric with respect to the y-axis. Graph $f(x)\ 0.5x^4\ 2x^2\ 1$; the graph supports symmetry with respect to the y-axis.

68. If $f(x)\ 0.75x^2\ |x|\ 1$, then $f(x)\ 0.75(x)^2\ |(x)|\ 1 \Rightarrow f(x)\ 0.75x^2\ |x|\ 1$.
Since $f(x)\ f(x)$, the function is symmetric with respect to the y-axis. Graph $f(x)\ .75x^4\ |x|\ 1$; the graph supports symmetry with respect to the y-axis.

69. If $f(x)\ x^3\ x\ 3$, then $f(x)(x)^3\ (x)\ 3 \Rightarrow f(x)\ x^3\ x\ 3$ and $f(x)\ (x^3\ x\ 3) \Rightarrow f(x)\ x^3\ x\ 3$. Since $f(x)\ f(x)\ f(x)$, the function is not symmetric with respect to the y-axis or the origin.

70. If $f(x)\ x^4\ 5x\ 2$, then $f(x)(x)^4\ 5(x)\ 2 \Rightarrow f(x)\ x^4\ 5x\ 2$ and $f(x)\ (x^4\ 5x\ 2) \Rightarrow f(x)\ x^4\ 5x\ 2$. Since $f(x)\ f(x)\ f(x)$, the function is not symmetric with respect to the y-axis or the origin. Graph $f(x)\ x^4\ 5x\ 2$; the graph supports no symmetry with respect to the y-axis or the origin.

71. If $f(x)\ x^6\ 4x^3$, then $f(x)(x)^6\ 4(x)^3 \Rightarrow f(x)\ x^6\ 4x^3$ and $f(x)\ (x^6\ 4x^3) \Rightarrow f(x)\ x^6\ 4x^3$. Since $f(x)\ f(x)\ f(x)$, the function is not symmetric with respect to the y-axis or the origin. Graph $f(x)\ x^6\ 4x^3$; the graph supports no symmetry with respect to the y-axis or the origin.

72. If $f(x)\ x^3\ 3x$, then $f(x)(x)^3\ 3(x) \Rightarrow f(x)\ x^3\ 3x$ and $f(x)\ (x^3\ 3x) \Rightarrow f(x)\ x^3\ 3x$. Since $f(x)\ f(x)$, the function is symmetric with respect to the origin. Graph $f(x)\ x^3\ 3x$; the graph supports symmetry with respect to the origin.

73. If $f(x)\ 6$, then $f(x)\ 6$, Since $f(x)\ f(x)$, the function is symmetric with respect to the y-axis. Graph $f(x)\ 6$; the graph supports symmetry with respect to the y-axis.

74. If $f(x)\ |x|$, then $f(x)\ |(x)| \Rightarrow f(x)\ |x|$. Since $f(x)\ f(x)$, the function is symmetric with respect to the y-axis. Graph $f(x)\ |x|$; the graph supports symmetry with respect to the y-axis.

75. If $f(x) = \frac{1}{4x^3}$, then $f(-x) = \frac{1}{4(-x)^3} \Rightarrow f(-x) = -\frac{1}{4x^3}$ and $-f(x) = -\left(\frac{1}{4x^3}\right) \Rightarrow -f(x) = -\frac{1}{4x^3}$. Since $f(-x) = -f(x)$, the function is symmetric with respect to the origin. Graph $f(x) = \frac{1}{4x^3}$; the graph supports symmetry with respect to the origin.

76. If $f(x) = \sqrt{x^2} \Rightarrow f(x) = |x|$, then $f(-x) = \sqrt{(-x)^2} \Rightarrow f(-x) = \sqrt{x^2} \Rightarrow f(-x) = |x|$. Since $f(x) = f(-x)$, the function is symmetric with respect to the y-axis. Graph $f(x) = \sqrt{x^2}$; the graph

2.2: Vertical and Horizontal Shifts of Graphs

1. The equation $y = x^2$ shifted 3 units upward is $y = x^2 + 3$.
2. The equation $y = x^3$ shifted 2 units downward is $y = x^3 - 2$.
3. The equation $y = \sqrt{x}$ shifted 4 units downward is $y = \sqrt{x} - 4$.
4. The equation $y = \sqrt[3]{x}$ shifted 6 units upward is $y = \sqrt[3]{x} + 6$.
5. The equation $y = |x|$ shifted 4 units to the right is $y = |x - 4|$.
6. The equation $y = |x|$ shifted 3 units to the left is $y = |x + 3|$.
7. The equation $y = x^3$ shifted 7 units to the left is $y = (x + 7)^3$.
8. The equation $y = \sqrt{x}$ shifted 9 units to the right is $y = \sqrt{x - 9}$.
9. The equation $y = x^2$ shifted 2 units downward and 3 units right is $y = (x - 3)^2 - 2$.
10. The equation $y = x^2$ shifted 4 units upward and 1 unit left is $y = (x + 1)^2 + 4$.
11. The equation $y = \sqrt{x}$ shifted 3 units upward and 6 units to the left is $y = \sqrt{x + 6} + 3$.
12. The equation $y = |x|$ shifted 1 unit downward and 5 units to the right is $y = |x - 5| - 1$.
13. The equation $y = x^2$ shifted 500 units upward and 2000 units right is $y = (x - 2000)^2 + 500$.
14. The equation $y = x^2$ shifted 255 units downward and 1000 units left is $y = (x + 1000)^2 - 255$.
15. Shift the graph of f 4 units upward to obtain the graph of g.
16. Shift the graph of f 4 units to the left to obtain the graph of g.
17. The equation $y = x^2 - 3$ is $y = x^2$ shifted 3 units downward; therefore, graph B.
18. The equation $y = (x - 3)^2$ is $y = x^2$ shifted 3 units to the right; therefore, graph C.
19. The equation $y = (x + 3)^2$ is $y = x^2$ shifted 3 units to the left; therefore, graph A.
20. The equation $y = |x| + 4$ is $y = |x|$ shifted 4 units upward; therefore; graph A.

21. The equation $y \mid x \; 4 \mid \; 3$ is $y \mid x \mid$ shifted 4 units to the left and 3 units downward; therefore, graph B.

22. The equation $y \mid x \; 4 \mid \; 3$ is $y \; f(x)$ shifted 4 units to the right and 3 units downward; therefore, graph C.

23. The equation $y \; (x \; 3)^3$ is $y \; x^3$ shifted 3 units to the right; therefore, graph C.

24. The equation $y \; (x \; 2)^3 \; 4$ is $y \; x^3$ shifted 2 units to the right and 4 units downward; therefore, graph A.

25. The equation $y \; (x \; 2)^3 \; 4$ is a, b. shifted 2 units to the left and 4 units downward; therefore, graph B.

26. Using $Y_2 \; Y_1 \; k$ and $x \; 0$. we get $19 \; 15 \; k \Rightarrow k \; 4$.

27. Using $Y_2 \; Y_1 \; k$ and $x \; 0$, we get $5 \; 3 \; k \Rightarrow k \; 2$.

28. Using $Y_2 \; Y_1 \; k$ and $x \; 0$, we get $5.5 \; 4 \; 1.5 \Rightarrow k \; 1.5$.

29. From the graphs, (6, 2) is a point on Y_1 and (6, 1) a point on Y_2. Using $Y_2 \; Y_1 \; k$ and $x \; 6$, we get $1 \; 2 \; k \Rightarrow k \; 3$.

30. From the graphs, (4, 3) is a point on Y_1 and (4, 8) a point on Y_2. Using $Y_2 \; Y_1 \; k$ and $x \; 4$, we get $8 \; 3 \; k \Rightarrow k \; 5$.

31. For the equation $y \; x^2$, the Domain is (,) and the Range is [0,). Shifting this 3 units downward gives us: (a) Domain: (,) (b) Range: [3,).

32. For the equation $y \; x^2$, the Domain is (,) and the Range is [0,). Shifting this 3 units to the right gives us: (a) Domain: (,) (b) Range: [0,) .

33. For the equation $y \mid x \mid$, the Domain is (,) and the Range is [0,). Shifting this 4 units to the left and 3 units downward gives us: (a) Domain: (,) (b) Range: [3,) .

34. For the equation $y \mid x \mid$, the Domain is (,) and the Range is [0,). Shifting this 4 units to the right and 3 units downward gives us: (a) Domain: (,) (b) Range: [3,).

35. For the equation $y \; x^3$, the Domain is (,) and the Range is (,). Shifting this 3 units to the right gives us: (a) Domain: (,) (b) Range: (,)

36. For the equation $y \; x^3$, the Domain is (,) and the Range is (,) . Shifting this 2 units to the right and 4 units downward gives us: (a) Domain: (,) (b) Range: (,)

37. For the equation $y \; x^2$, the Domain is (,) and the Range is [0,). Shifting this 1 unit to the right and 5 units downward gives us: (a) Domain: (,) (b) Range: [5,) .

38. For the equation $y \; x^2$, the Domain is (,) and the Range is [0,). Shifting this 8 units to the left and 3 units upward gives us: (a) Domain: (,) (b) Range: [3,) .

39. For the equation $y \; \sqrt{x}$, the Domain is [0,). and the Range is [0,). Shifting this 4 units to the right gives us: (a) Domain: [4,). (b) Range: [0,) .

40. For the equation $y \quad \sqrt{x}$, the Domain is [0,). and the Range is [0,). Shifting this 1 units to the left and 10 units downward gives us: (a) Domain: [1,). (b) Range: [10,) .

41. For the equation $y \; x^3$, the Domain is (,) and the Range is (,) . Shifting this 1 unit to the right and 4 units upward gives us: (a) Domain: (,) (b) Range: (,)

42. For the equation $y \; \sqrt[3]{x}$, the Domain is (,) and the Range is (,) . Shifting this 7 units to the left and 10 units downward gives us: (a) Domain: (,) (b) Range: (,)

43. The graph of $y \; f(x)$ is the graph of the equation $y \; x^2$ shifted 1 unit to the right. See Figure 43.

44. The graph of $y \quad \sqrt{x\ 2}$ is the graph of the equation $y \quad \sqrt{\ }\ x$ shifted 2 units to the left. See Figure 44.

45. The graph of $y \; x^3 \; 1$ is the graph of the equation $y \; x^3$ shifted 1 unit upward. See Figure 45.

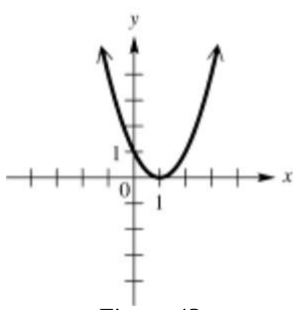

Figure 43

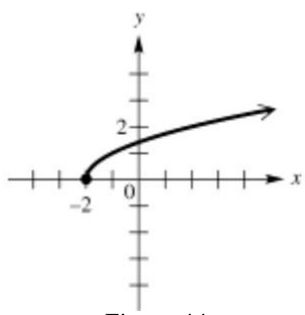

Figure 44

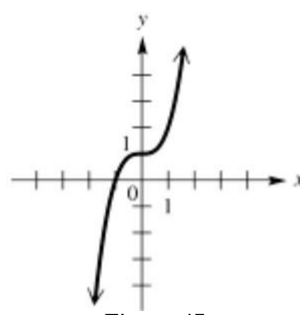

Figure 45

46. The graph of $y \; | x\ 2 |$ is the graph of the equation $y \; | x |$ shifted 2 units to the left. See Figure 46.

47. The graph of $y \; (x\ 1)^3$ is the graph of the equation $y \; x^3$ shifted 1 unit to the right. See Figure 47.

48. The graph of $y \; | x | \;\; 3$ is the graph of the equation $y \; | x |$ shifted 3 units downward. See Figure 48.

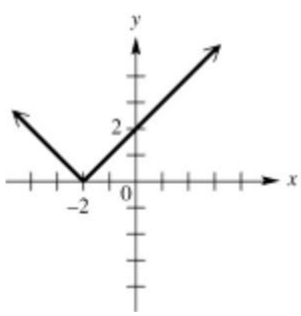

Figure 46

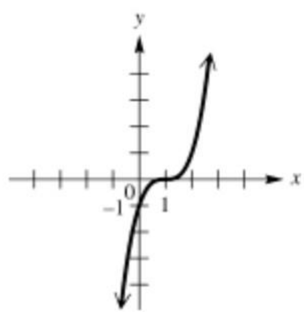

Figure 47

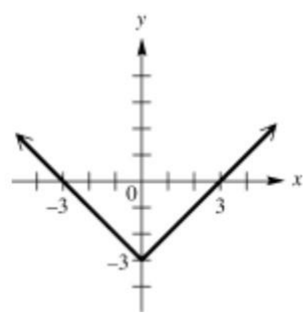

Figure 48

49. The graph of $y \quad \sqrt{x\ 2} \quad 1$ is the graph of the equation $y \quad \sqrt{x}$ shifted 2 units to the right and 1 unit downward. See Figure 49.

50. The graph of $y \quad \sqrt{x\ 3} \quad 4$ is the graph of the equation $y \quad \sqrt{\ }\ x$ shifted 3 units to the left and 4 units downward. See Figure 50.

51. The graph of $f(x)$ is the graph of the equation $y\ x^2$ shifted 2 units to the left and 3 units upward. See Figure 51.

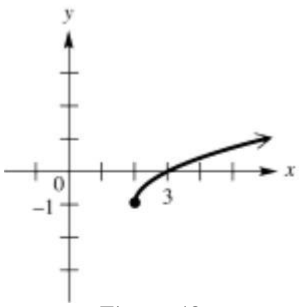

Figure 49

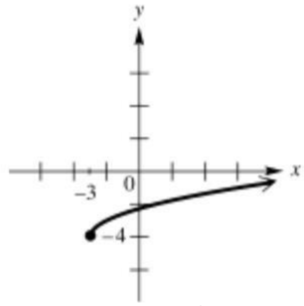

Figure 50

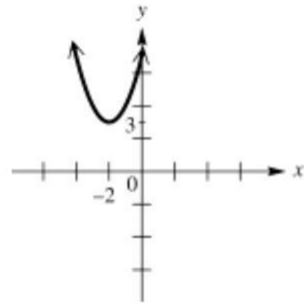

Figure 51

52. The graph of $y\ (x\ 4)^2\ \ 4$ is the graph of the equation $y\ x^2$ shifted 4 units to the right and 4 units downward. See Figure 52.

53. The graph of $y\ |x\ 4|\ \ 2$ is the graph of the equation $y\ |x|$ shifted 4 units to the left and 2 units downward. See Figure 53.

54. The graph of $y\ (x\ 3)^3\ \ 1$ is the graph of the equation $y\ x^3$ shifted 3 units to the left and 1 unit downward. See Figure 54.

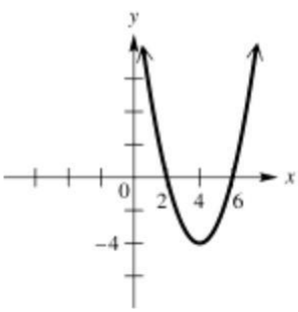

Figure 52

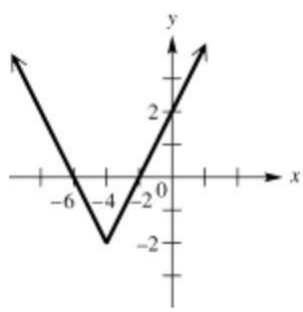

Figure 53

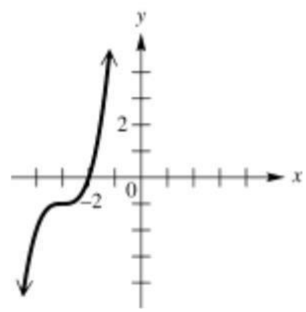

Figure 54

55. Since h and k are positive, the equation is $y\ x^2$ shifted to the right and down; therefore, B.

56. Since h and k are positive, the equation is $y\ x^2$ shifted to the left and down; therefore, D.

57. Since h and k are positive, the equation is $y\ x^2$ shifted to the left and up; therefore, A.

58. Since h and k are positive, the equation is $y\ x^2$ shifted to the right and up; therefore, C.

59. The equation $y\ f(x)\ 2$ is $y\ f(x)$ shifted up 2 units or add 2 to the y-coordinate of each point as follows: (3, 2) ⇒ (3, 0); (1, 4) ⇒ (1, 6); (5, 0) ⇒ (5, 2). See Figure 59.

60. The equation $y\ f(x)\ 2$ is $y\ f(x)$ shifted down 2 units or subtract 2 from the y-coordinate of each point as follows: (3, 2) ⇒ (3, 4); (1, 4) ⇒ (1, 2); (5, 0) ⇒ (5, 2). See Figure 60.

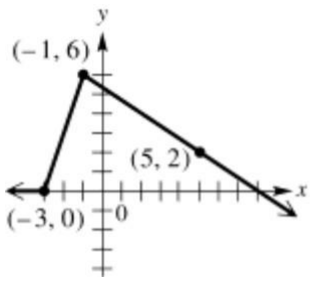

Figure 59

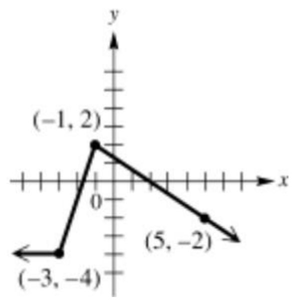

Figure 60

61. The equation $y\ f(x\ \ 2)$ is $y\ \ f(x)$ shifted left 2 units or subtract 2 from the x-coordinate of each point as follows: (3, 2) ⇒ (5, 2); (1, 4) ⇒ (3, 4); (5, 0) ⇒ (3, 0). See Figure 61.

62. The equation $y\ f(x\ \ 2)$ is $y\ \ f(x)$ shifted right 2 units or add 2 to the x-coordinate of each point as follows: (3, 2) ⇒ (1, 2); (1, 4) ⇒ (1, 4); (5, 0) ⇒ (7, 0). See Figure 62.

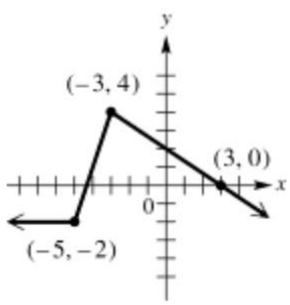

Figure 61

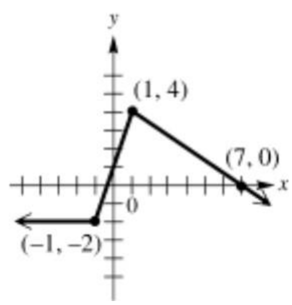

Figure 62

63. The graph is the basic function $y\ x^2$ translated 4 units to the left and 3 units up; therefore, the new equation is $y\ (\ x\ 4)^2\ 3$. The equation is now increasing for the interval: (a) 4, and decreasing for the interval: (b) , 4 .

64. The graph is the basic function $y\ \sqrt{x}$ translated 5 units to the left; therefore, the new equation is $y\ \ \sqrt{x\ 5}.$ The equation is now increasing for the interval: (a) 5, and does not decrease; therefore: (b) none.

65. The graph is the basic function $y\ \ x^3$ translated 5 units down; therefore, the new equation is $y\ \ x^3\ \ 5.$ The equation is now increasing for the interval: (a) (,) and does not decrease; therefore: (b) none.

66. The graph is the basic function $y\ \ \ |\ x\ |$ translated 10 units to the left; therefore, the new equation is $y\ |\ x\ \ \ 10\ |$. The equation is now increasing for the interval: (a) 10, and decreasing for the interval: (b) , 10

67. The graph is the basic function $y\ \sqrt{x}$ translated 2 units to the right and 1 unit up; therefore, the new equation is $y\ \ \sqrt{x\ 2}\ \ \ 1.$ The equation is now increasing for the interval: (a) 2, and does not decrease; therefore: (b) none.

68. The graph is the basic function $y\ x^2$ translated 2 units to the right and 3 units down; therefore, the new equation is $y\ (x\ 2)^2\ 3$. The equation is now increasing for the interval: (a) 2, and decreasing for the interval: (b) , 2 .

69. (a) $f(x)\ 0$: {3, 4}

    (b) $f(x)\ 0$: for the intervals (, 3) (4,).

    (c) $f(x)\ 0$: for the interval (3, 4).

70. (a) $f(x)\ 0$: { [redacted] √

    (b) $f(x)\ 0$: for the interval √2,.

    (c) $f(x)\ 0$: for the interval , 2 .√

71. (a) $f(x)\ 0$: {4, 5}

    (b) $f(x)\ 0$: for the intervals (-¥, -4]È[5, ¥)

    (c) $f(x)\ 0$: for the interval [4, 5].

72. (a) $f(x)\ 0$: never; therefore: .

    (b) $f(x)\ 0$: for the interval [1,).

    (c) $f(x)\ 0$: never; therefore: .

73. The translation is 3 units to the left and 1 unit up; therefore, the new equation is $y\ |x\ 3|\ 1$. The form $y\ |x\ h|\ k$ will equal $y\ |x\ 3|\ 1$ when: h 3 and k 1.

74. The equation $y\ x^2$ has a Domain: (,) and a Range: [0,). After the translation the Domain is still: (,) but now the Range is (38,) , a positive or upward shift of 38 units. Therefore, the horizontal shift can be any number of units, but the vertical shift is up 38. This makes h any real number and k 38.

75. (a) $B(4)$ 66.25(4) 160 425 ; In 2010, 425,000 bankruptcies were filed.

    (b) We will use the point (2006, 160) and the slope of 66.25 in the point slope form for the equation of a line. $y\ y_1\ m(x\ x_1)$ y 160 66.25(x 2006) y 66.25(x 2006) 160

    (c) y 66.25(2010 2006) 160 66.25(4) 160 425 , In 2010, 425,000 bankruptcies were filed.

    (d) 293 66.25(x 2006) 160 133 66.25(x 2006) $\frac{133}{66.25}$ x 2006 x 2006 . $\frac{133}{66.25}$

    There will be 293 thousand bankruptcies in 2008.

76. (a) $S(14)$ $\frac{3}{7}$ (14) 15 9 ; In 2013, sales were $9 billion.

(b) We will use the point (1999, 15) and the slope of $\frac{3}{7}$ in the point slope form for the equation of a line. $y\ y_1\ \ m(x\ x_1)\ \ y\ 15\ \ \frac{}{7}(x\ 1999)\ \underline{3}y\ \ \frac{}{7}(x\ 1999)\ 15\ \ \underline{3}$

(c) $y\ \ \frac{3}{7}(2013\ 1999)\ 15\ \ \frac{3}{7}(14)\ 15\ 9$; In 2013, sales were \$9 billion.

(d) $12\ \ \frac{3}{7}(x\ 1999)\ 15\ 3\ \ \ \frac{3}{7}(x\ 1999)\ 7\ \ x\ 1999\ \ x\ \ \ 2006$

77. $U(2011)\ 13(2011\ 2006)^2\ 115\ 13(25)\ 115\ 440$; The average U.S. household spent \$440 on Apple products in 2011.

78. The formula for $W(x)$ can be found by shifting $U(x)\ 13(x\ 2006)^2\ \ 115$ to the right 4 units.
$W(x)\ 13(x\ 2010)^2\ \ 115$; $W(x)\ 13(2015\ 2010)^2\ \ 115\ 13(25)\ 115\ 440$

In 2015, the average worldwide household spending on Apple products was \$440, which equaled U.S. spending 4 years earlier.

79. (a) Enter the year in L_1 and enter tuition and fees in L_2 . The year 2000 corresponds to x 0 and so on.

The regression equation is $y\ 402.5x\ 3460$.

(b) Since x 0 corresponds to 2000, the equation when the exact year is entered is

$y\ \ 402.5(x\ 2000)\ 3460$

(c) $y\ \ 402.5(2009\ 2000)\ 3460 \Rightarrow y\ \$7100$

80. (a) Enter the year in L_1 and enter the percent of women in the workforce in L_2 . The year 1970 corresponds to x 0 and so on. The regression equation is $y\ \ 0.40167\ x\ 46.36$.

(b) Since x 0 corresponds to 1970, the equation when the exact year is entered is
$y\ 0.40167\ x\ 1970\ 46.36$.

(c) $y\ \ 0.40167\ 2015\ 1970\ 46.36 \Rightarrow y\ \ 64.4$

81. See Figure 81.

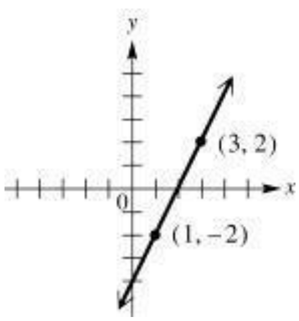

Figure 81

82. $m \frac{2}{3} \frac{(2)}{1} \Rightarrow m \frac{4}{2} 2$

83. Using slope-intercept form yields: y_1 2 2(x 3) ⇒ y_1 2 2 x 6 ⇒ y_1 2 x 4

84. (1, 2 6) and (3, 2 6) ⇒ (1, 4) and (3, 8)

85. $m \, 3 \frac{8}{1} \frac{4}{} \Rightarrow m \frac{4}{2} 2$

86. Using slope-intercept form yields: y_2 4 2(x 1) ⇒ y_2 4 2 x 2 ⇒ y_2 2 x 2 .

87. Graph y_1 2 x 4 and y_2 2 x 2 See Figure 87. The graph y_2 can be obtained by shifting the graph of y_1 upward 6 units. The constant 6, comes from the 6 we added to each *y*-value in Exercise 84.

[-10,10] by [-10,10] Xscl = 1 Yscl = 1

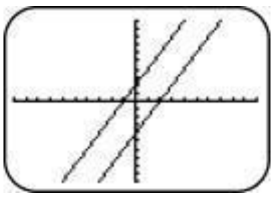

Figure 87

88. c; c; the same as; c; upward (or positive vertical)

2.3: Stretching, Shrinking, and Reflecting Graphs

1. The function y x^2 vertically stretched by a factor of 2 is y 2 x^2 .
2. The function y x^3 vertically shrunk by a factor of $\frac{1}{2}$ is y $\frac{1}{2} x^3$.
3. The function y $\sqrt{x}$ reflected across the *y*-axis is y $\sqrt{x}$.
4. The function y $\sqrt[3]{x}$ reflected across the *x*-axis is y $\sqrt[3]{x}$
5. The function y $|x|$ vertically stretched by a factor of 3 and reflected across the *x*-axis is y 3 $|x|$.
6. The function y $|x|$ vertically shrunk by a factor of $\frac{1}{3}$ and reflected across the *y*-axis is y $\frac{1}{3}|x|$.
7. The function y x^3 vertically shrunk by a factor of 0.25 and reflected across the *y*-axis is y 0.25(x^3) or y 0.25x^3.
8. The function y $\sqrt{x}$ vertically shrunk by a factor of 0.2 and reflected across the *x*-axis is y 0.2 $\sqrt{x}$.
9. Graph y_1 x , y_2 x 3 (y_1 shifted up 3 units), and y_3 x 3 (y_1 shifted down 3 units). See Figure 9.
10. Graph y_1 x^3 , y_2 x^3 4 (y_1 shifted up 4 units), and y_3 x^3 4 (y_1 shifted down units). See Figure 10.
11. Graph y_1 $|x|$, y_2 $|x$ 3$|$ (y_1 shifted right 3 units), and y_3 $|x$ 3$|$ (y_1 shifted left 3 units). See Figure 11.

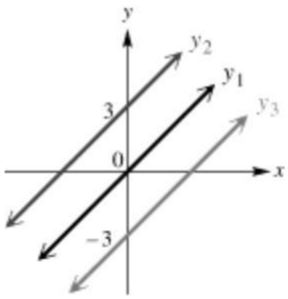

Figure 9

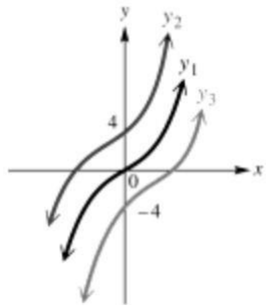

Figure 10

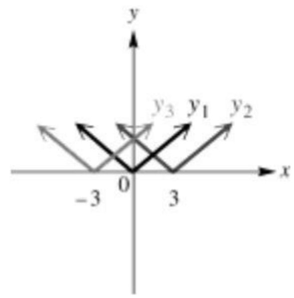

Figure 11

12. Graph $y_1\ |x|$, $y_2\ |x|\ 3$ (y_1 shifted down 3 units), and $y_3\ x\ 3$ (y_1 shifted up 3 units). See Figure 12.

13. Graph $y_1\ \sqrt{x}$, $y_2\ \sqrt{x\ 6}$ (y_1 shifted left 6 units), and $y_3\ \sqrt{x\ 6}$ (y_1 shifted right 6 units). See Figure 13.

14. Graph $y_1\ |x|$, $y_2\ 2|x|$ (y_1 stretched vertically by a factor of 2), and $y_3\ 2.5|x|$ (y_1 stretched vertically by a factor of 2.5). See Figure 14

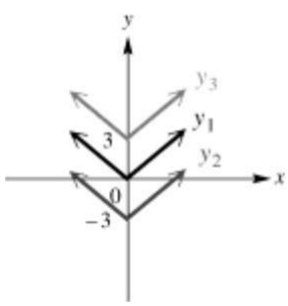

Figure 12

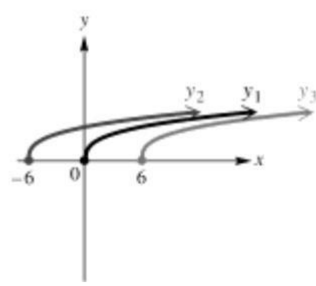

Figure 13

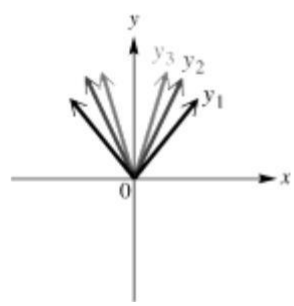

Figure 14

15. Graph $y_1\ \sqrt[3]{x}$, $y_2\ \sqrt[3]{x}$ (y_1 reflected across the x-axis), and $y_3\ 2\sqrt[3]{x}$ (y_1 reflected across the x-axis and stretched vertically by a factor of 2). See Figure 15.

16. Graph $y_1\ x^2$, $y_2\ (x\ 2)^2\ 1$ (y_1 shifted right 2 units and up 1 unit), and $y_3\ (x\ 2)^2$ (y_1 shifted left 2 units and reflected across the x-axis). See Figure 16

17. Graph $y_1\ |x|$, $y_2\ 2|x\ 1|\ 1$ (y_1 reflected across the x-axis, stretched vertically by a factor of 2, shifted right 1 unit, and shifted up 1 unit), and $y\ \frac{1}{2}|x|\ 4$ (y_1 reflected across the x-axis, shrunk by factor of $\frac{1}{2}$, and shifted down 4 units). See Figure 17