## Technology Highlight

1. $y = \pm 4.8; y = \pm 3.6$ , Answers will vary.

2. $(x-3)^2 + y^2 = 16$
   Center (3,0), $r = 4$
   If $x = 0$, $(0-3)^2 + y^2 = 16$
   $9 + y^2 = 16$
   $y^2 = 7$
   $y = \pm\sqrt{7}$
   $y$-intercepts: $(0, \pm\sqrt{7})$; $(0, \pm 2.6457513)$

## 2.1 Exercises

1. First, second

2. independent, output

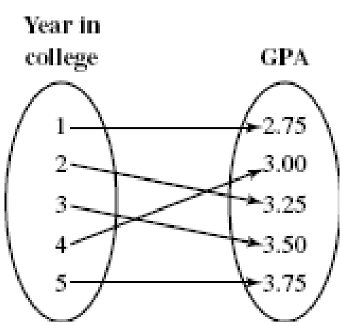
3. Radius, center

4. (0,0), five, central

5. Answers will vary.

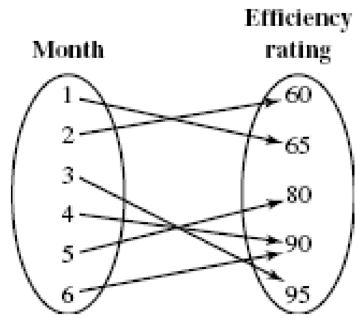
6. Answers will vary.

7.




Domain = {1, 2, 3, 4, 5}
Range = {2.75, 3.00, 3.25, 3.50, 3.75}

8.




Domain = {1, 2, 3, 4, 5, 6}
Range = {60, 65, 80, 90, 95}

9. D = {1, 3, 5, 7, 9}
   R = {2, 4, 6, 8, 10}

10. D = {$-2$, -3, $-1$, 4, 2}
    R = {4, $-5$, 3, $-3$}

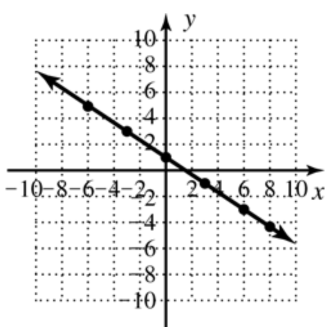
11. D = {4, $-1$, 2, $-3$}
    R = {0, 5, 4, 2, 3}

12. D = {$-1$, 0 , 2, $-3$}
    R = {1, 4, $-5$, 3}

# 2.1 Exercises

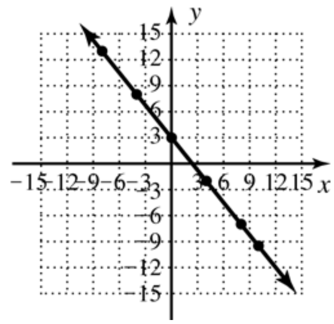
13. $y = -\frac{2}{3}x + 1$

| x | y |
|---|---|
| $-6$ | $-\frac{2}{3}(-6)+1 = 4+1 = 5$ |
| $-3$ | $-\frac{2}{3}(-3)+1 = 2+1 = 3$ |
| 0 | $-\frac{2}{3}(0)+1 = 0+1 = 1$ |
| 3 | $-\frac{2}{3}(3)+1 = -2+1 = -1$ |
| 6 | $-\frac{2}{3}(6)+1 = -4+1 = -3$ |
| 8 | $-\frac{2}{3}(8)+1 = -\frac{16}{3}+1 = -\frac{13}{3}$ |




14. $y = -\frac{5}{4}x + 3$

| x | y |
|---|---|
| $-8$ | $-\frac{5}{4}(-8)+3 = 10+3 = 13$ |
| $-4$ | $-\frac{5}{4}(-4)+3 = 5+3 = 8$ |
| 0 | $-\frac{5}{4}(0)+3 = 0+3 = 3$ |
| 4 | $-\frac{5}{4}(4)+3 = -5+3 = -2$ |
| 8 | $-\frac{5}{4}(8)+3 = -10+3 = -7$ |
| 10 | $-\frac{5}{4}(10)+3 = -\frac{25}{2}+3 = -\frac{19}{2}$ |




15. $x + 2 = |y|$

| x | y |
|---|---|
| $-2$ | 0 |
| 0 | 2, -2 |
| 1 | 3, -3 |
| 3 | 5, -5 |
| 6 | 8, -8 |
| 7 | 9, -9 |

$-2+2 = |y|$
$0 = |y|$
$0 = y;$

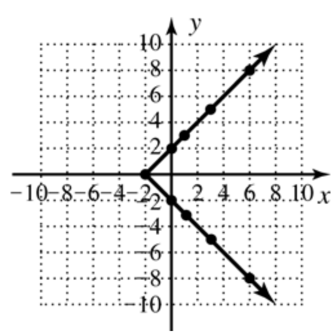
$0+2 = |y|$
$2 = |y|$
$\pm 2 = y;$

$1+2 = |y|$
$3 = |y|$
$\pm 3 = y;$

$3+2 = |y|$
$5 = |y|$
$\pm 5 = y;$

$6+2 = |y|$
$8 = |y|$
$\pm 8 = y;$

$7+2 = |y|$
$9 = |y|$
$\pm 9 = y;$



16. $|y+1|=x$

| x | y |
|---|---|
| 0 | -1 |
| 1 | 0, -2 |
| 3 | 2, -4 |
| 5 | 4, -6 |
| 6 | 5, -7 |
| 7 | 6, -8 |

$|y+1|=0$
$y+1=0$
$y=-1;$

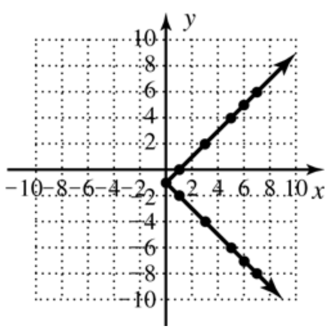
$|y+1|=1$
$y+1=\pm 1$
$y=-1\pm 1;$
$y=0$
$y=-2$

$|y+1|=3$
$y+1=\pm 3$
$y=-1\pm 3$
$y=2$
$y=-4;$

$|y+1|=5$
$y+1=\pm 5$
$y=-1\pm 5$
$y=4$
$y=-6;$

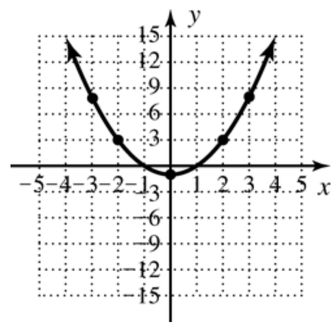
$|y+1|=6$
$y+1=\pm 6$
$y=-1\pm 6$
$y=5$
$y=-7;$

$|y+1|=7$
$y+1=\pm 7$
$y=-1\pm 7$
$y=6$
$y=-8$



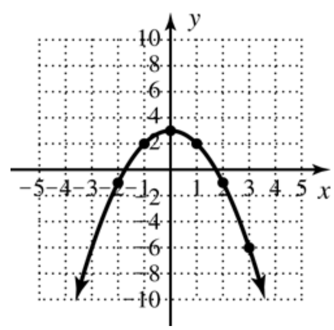
17. $y=x^2-1$

| x | y |
|---|---|
| $-3$ | $(-3)^2-1=9-1=8$ |
| $-2$ | $(-2)^2-1=4-1=3$ |
| 0 | $(0)^2-1=0-1=-1$ |
| 2 | $(2)^2-1=4-1=3$ |
| 3 | $(3)^2-1=9-1=8$ |
| 4 | $(4)^2-1=16-1=15$ |



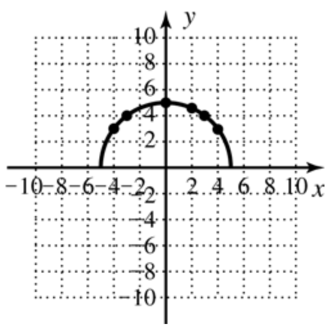
18. $y=-x^2+3$

| x | y |
|---|---|
| $-2$ | $-(-2)^2+3=-4+3=-1$ |
| $-1$ | $-(-1)^2+3=-1+3=2$ |
| 0 | $-(0)^2+3=0+3=3$ |
| 1 | $-(1)^2+3=-1+3=2$ |
| 2 | $-(2)^2+3=-4+3=-1$ |
| 3 | $-(3)^2+3=-9+3=-6$ |



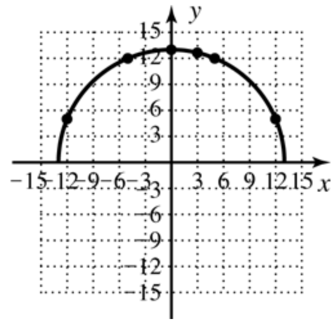
19. $y = \sqrt{25 - x^2}$

| x | y |
|---|---|
| $-4$ | $\sqrt{25-(-4)^2} = \sqrt{25-16} = \sqrt{9} = 3$ |
| $-3$ | $\sqrt{25-(-3)^2} = \sqrt{25-9} = \sqrt{16} = 4$ |
| 0 | $\sqrt{25-(0)^2} = \sqrt{25} = 5$ |
| 2 | $\sqrt{25-(2)^2} = \sqrt{25-4} = \sqrt{21}$ |
| 3 | $\sqrt{25-(3)^2} = \sqrt{25-9} = \sqrt{16} = 4$ |
| 4 | $\sqrt{25-(4)^2} = \sqrt{25-16} = \sqrt{9} = 3$ |




20. $y = \sqrt{169 - x^2}$

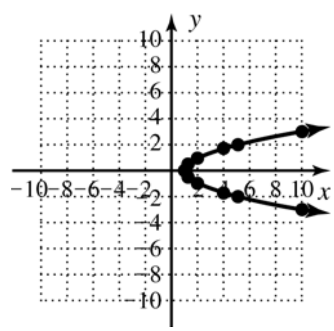
| x | y |
|---|---|
| $-12$ | $\sqrt{169-(-12)^2} = \sqrt{169-144}$ <br> $= \sqrt{25} = 5$ |
| $-5$ | $\sqrt{169-(-5)^2} = \sqrt{169-25}$ <br> $= \sqrt{144} = 12$ |
| 0 | $\sqrt{169-(0)^2} = \sqrt{169} = 13$ |
| 3 | $\sqrt{169-(3)^2} = \sqrt{169-9}$ <br> $= \sqrt{160} = 4\sqrt{10}$ |
| 5 | $\sqrt{169-(5)^2} = \sqrt{169-25}$ <br> $= \sqrt{144} = 12$ |
| 12 | $\sqrt{169-(12)^2} = \sqrt{169-144}$ <br> $= \sqrt{25} = 5$ |




21. $x - 1 = y^2$

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

| x | y |
|---|---|
| 10 | $\sqrt{(10)-1} = \sqrt{9} = \pm 3$ |
| 5 | $\sqrt{(5)-1} = \sqrt{4} = \pm 2$ |
| 4 | $\sqrt{(4)-1} = \pm\sqrt{3}$ |
| 2 | $\sqrt{(2)-1} = \sqrt{1} = \pm 1$ |
| 1.25 | $\sqrt{(1.25)-1} = \sqrt{0.25} = \pm 0.5$ |
| 1 | $\sqrt{(1)-1} = \sqrt{0} = 0$ |

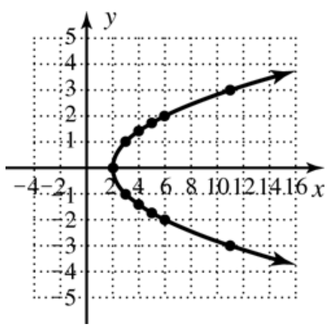


22. $y^2 + 2 = x$

$y^2 = x - 2$

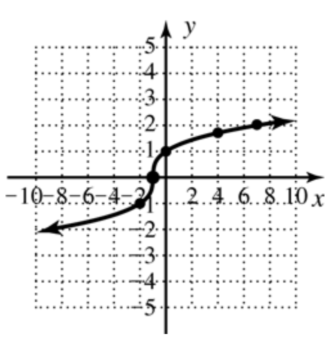
$y = \pm\sqrt{x-2}$

| x | y |
|---|---|
| 2 | $\sqrt{(2)-2} = \sqrt{0} = 0$ |
| 3 | $\sqrt{(3)-2} = \sqrt{1} = \pm 1$ |
| 4 | $\sqrt{(4)-2} = \pm\sqrt{2}$ |
| 5 | $\sqrt{(5)-2} = \pm\sqrt{3}$ |
| 6 | $\sqrt{(6)-2} = \sqrt{4} = \pm 2$ |
| 11 | $\sqrt{(11)-2} = \sqrt{9} = \pm 3$ |



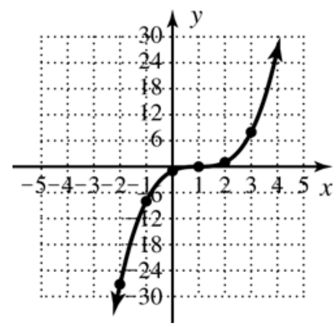

23. $y = \sqrt[3]{x+1}$

| x | y |
|---|---|
| −9 | $\sqrt[3]{(-9)+1} = \sqrt[3]{-8} = -2$ |
| −2 | $\sqrt[3]{(-2)+1} = \sqrt[3]{-1} = -1$ |
| -1 | $\sqrt[3]{(-1)+1} = \sqrt[3]{0} = 0$ |
| 0 | $\sqrt[3]{(0)+1} = \sqrt[3]{1} = 1$ |
| 4 | $\sqrt[3]{(4)+1} = \sqrt[3]{5}$ |
| 7 | $\sqrt[3]{(7)+1} = \sqrt[3]{8} = 2$ |




24. $y = (x-1)^3$

| x | y |
|---|---|
| −2 | $[(-2)-1]^3 = (-3)^3 = -27$ |
| −1 | $[(-1)-1]^3 = (-2)^3 = -8$ |
| 0 | $[(0)-1]^3 = (-1)^3 = -1$ |
| 1 | $[(1)-1]^3 = (0)^3 = 0$ |
| 2 | $[(2)-1]^3 = (1)^3 = 1$ |
| 3 | $[(3)-1]^3 = (2)^3 = 8$ |




25. $M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$

$M = \left(\frac{1+5}{2}, \frac{8+(-6)}{2}\right)$

$M = \left(\frac{6}{2}, \frac{2}{2}\right)$

$M = (3,1)$

26. $M = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$

$M = \left(\frac{5+6}{2}, \frac{6+(-8)}{2}\right)$

$M = \left(\frac{11}{2}, \frac{-2}{2}\right)$

$M = \left(\frac{11}{2}, -1\right)$

## 2.1 Exercises

27. $M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-4.5+3.1}{2},\frac{9.2+(-9.8)}{2}\right)$

$M=\left(\frac{-1.4}{2},\frac{-0.6}{2}\right)$

$M=(-0.7,-0.3)$

28. $M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{5.2+6.3}{2},\frac{7.1+(-7.1)}{2}\right)$

$M=\left(\frac{11.5}{2},\frac{0}{2}\right)$

$M=(5.75,0)$

29. $M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{\frac{1}{5}+\left(\frac{-1}{10}\right)}{2},\frac{\frac{-2}{3}+\frac{3}{4}}{2}\right)$

$M=\left(\frac{\frac{1}{10}}{2},\frac{\frac{1}{12}}{2}\right)$

$M=\left(\frac{1}{20},\frac{1}{24}\right)$

30. $M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-\frac{3}{4}+\frac{3}{8}}{2},\frac{-\frac{1}{3}+\frac{5}{6}}{2}\right)$

$M=\left(\frac{-\frac{3}{8}}{2},\frac{\frac{1}{2}}{2}\right)$

$M=\left(-\frac{3}{16},\frac{1}{4}\right)$

31. $(-5,\ -4)\ (5,\ 2)$

$M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-5+5}{2},\frac{-4+2}{2}\right)$

$M=\left(\frac{0}{2},\frac{-2}{2}\right)$

$M=(0,-1)$

32. $(-5,\ 4)\ (3,\ -2)$

$M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-5+3}{2},\frac{4+(-2)}{2}\right)$

$M=\left(\frac{-2}{2},\frac{2}{2}\right)$

$M=(-1,1)$

33. $(-4,\ -4)\ (2,\ 4)$

$M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-4+2}{2},\frac{-4+4}{2}\right)$

$M=\left(\frac{-2}{2},\frac{0}{2}\right)$

$M=(-1,0)$

The center of the circle is $(-1,\ 0)$.

34. $(-5,\ 3)\ (1,\ -1)$

$M=\left(\frac{x_1+x_2}{2},\frac{y_1+y_2}{2}\right)$

$M=\left(\frac{-5+1}{2},\frac{3+(-1)}{2}\right)$

$M=\left(\frac{-4}{2},\frac{2}{2}\right)$

$M=(-2,1)$

The center of the circle is $(-2,\ 1)$.

35. $(-5, -4)\ (5, 2)$

$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$d=\sqrt{(5-(-5))^2+(2-(-4))^2}$

$d=\sqrt{(10)^2+(6)^2}$

$d=\sqrt{100+36}$

$d=\sqrt{136}$

$d=2\sqrt{34}$

36. $(-5, 4)\ (3, -2)$

$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$d=\sqrt{(3-(-5))^2+(-2-4)^2}$

$d=\sqrt{8^2+(-6)^2}$

$d=\sqrt{64+36}$

$d=\sqrt{100}$

$d=10$

37. $(-4, -4)\ (2, 4)$

$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$d=\sqrt{(2-(-4))^2+(4-(-4))^2}$

$d=\sqrt{6^2+8^2}$

$d=\sqrt{36+64}$

$d=\sqrt{100}$

$d=10$

38. $(-5, 3)\ (1, -1)$

$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$

$d=\sqrt{(1-(-5))^2+(-1-3)^2}$

$d=\sqrt{6^2+(-4)^2}$

$d=\sqrt{36+16}$

$d=\sqrt{52}$

$d=2\sqrt{13}$

39. $(5, 2)\ (0, -3)$

$m=\frac{-3-2}{0-5}=\frac{-5}{-5}=1;$

(0, -3) (4, -4)

$m=\frac{-4-(-3)}{4-0}=\frac{-4+3}{4}=\frac{-1}{4};$

(5, 2) (4, -4)

$m=\frac{-4-2}{4-5}=\frac{-6}{-1}=6$

Not a right triangle. Lines are not perpendicular. Slopes: 1; $\frac{-1}{4}$; 6

40. $(7, 0)\ (-1, 0)$

$m=\frac{0-0}{-1-7}=0;$

(7, 0) (7, 4)

$m=\frac{4-0}{7-7}$ Undefined

Right triangle because these two lines are perpendicular. Slopes: 0; undefined.

41. $(-4, 3)\ (-7, -1)$

$m=\frac{-1-3}{-7-(-4)}=\frac{-4}{-7+4}=\frac{-4}{-3}=\frac{4}{3};$

$(-7, -1)\ (3, -2)$

$m=\frac{-2-(-1)}{3-(-7)}=\frac{-2+1}{3+7}=\frac{-1}{10};$

$(-4, 3)\ (3, -2)$

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

Not a right triangle. Lines are not perpendicular. Slopes: $\frac{4}{3}$; $\frac{-1}{10}$; $\frac{-5}{7}$

42. $(-3, 7)\ (2, 2)$

$m=\frac{2-7}{2-(-3)}=\frac{-5}{2+3}=\frac{-5}{5}=-1;$

(2, 2) (5, 5)

$m=\frac{5-2}{5-2}=\frac{3}{3}=1$

Right triangle because these two lines are perpendicular. Slopes: $-1$; 1

## 2.1 Exercises

43. $(-3, 2)\ (-1, 5)$

$m = \dfrac{5-2}{-1-(-3)} = \dfrac{3}{-1+3} = \dfrac{3}{2}$;

$(-3, 2)\ (-6, 4)$

$m = \dfrac{4-2}{-6-(-3)} = \dfrac{2}{-6+3} = -\dfrac{2}{3}$

Right triangle because these two lines are perpendicular. Slopes: $\dfrac{3}{2}$; $\dfrac{-2}{3}$

44. $(0, 0)\ (-5, 2)$

$m = \dfrac{2-0}{-5-0} = \dfrac{2}{-5} = -\dfrac{2}{5}$;

$(-5, 2)\ (2, -5)$

$m = \dfrac{-5-2}{2-(-5)} = \dfrac{-7}{2+5} = \dfrac{-7}{7} = -1$;

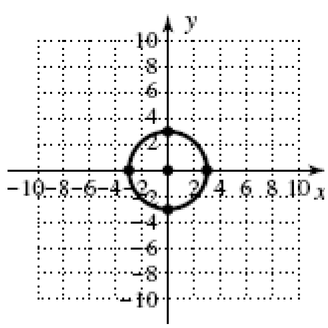
$(0, 0)\ (2, -5)$

$m = \dfrac{-5-0}{2-0} = \dfrac{-5}{2}$

Not a right triangle. Lines are not perpendicular. Slopes: $-\dfrac{2}{5}, -1, -\dfrac{5}{2}$

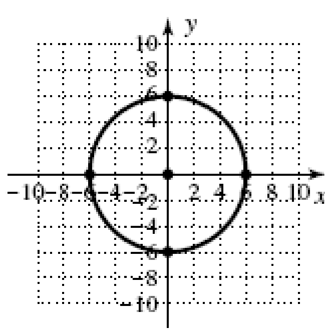
45. Center (0,0), radius 3

$x^2 + y^2 = 9$



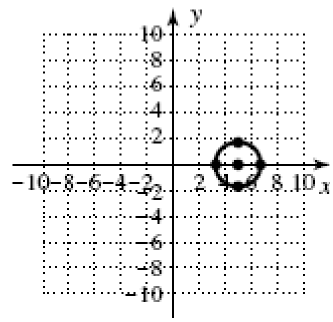
46. Center (0,0), radius 6

$x^2 + y^2 = 36$



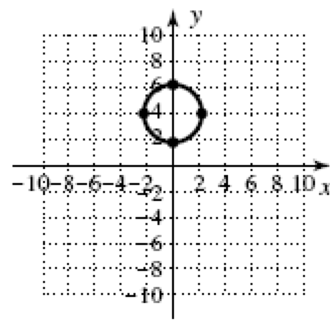
47. Center (5,0), radius $\sqrt{3}$

$(x-5)^2 + y^2 = 3$



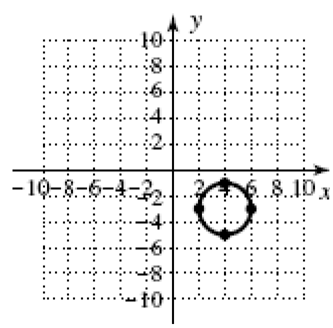
48. Center (0,4), radius $\sqrt{5}$

$x^2 + (y-4)^2 = 5$



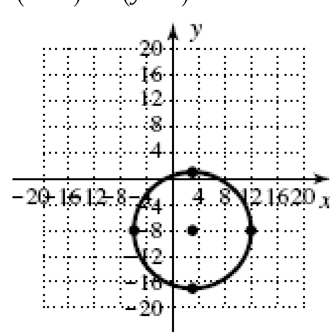
49. Center $(4, -3)$, radius 2

$(x-4)^2 + (y+3)^2 = 4$



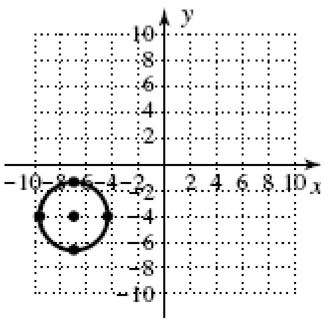
50. Center $(3, -8)$, radius 9

$(x-3)^2 + (y+8)^2 = 81$



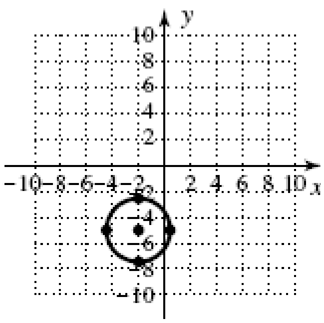
51. Center $(-7, -4)$, radius $\sqrt{7}$

$(x+7)^2+(y+4)^2=7$



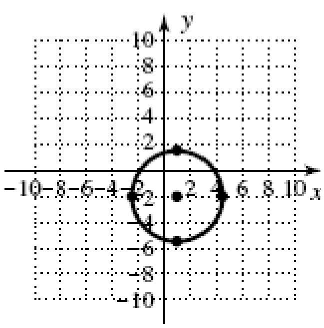
52. Center $(-2,-5)$, radius $\sqrt{6}$

$(x+2)^2+(y+5)^2=6$



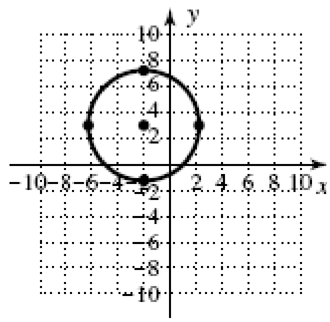
53. Center $(1, -2)$, radius $2\sqrt{3}$

$(x-1)^2+(y+2)^2=12$



54. Center $(-2,3)$, radius $3\sqrt{2}$

$(x+2)^2+(y-3)^2=18$



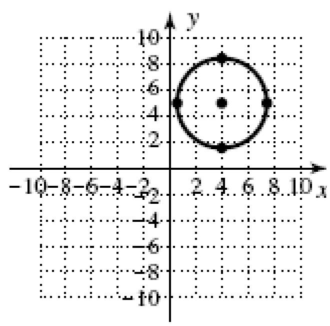
55. Center $(4,5)$, diameter $4\sqrt{3}$

$\text{radius} = \frac{1}{2}\cdot\text{diameter}$

$r=\frac{1}{2}\left(4\sqrt{3}\right)=2\sqrt{3}$

$(x-4)^2+(y-5)^2=\left(2\sqrt{3}\right)^2$

$(x-4)^2+(y-5)^2=12$



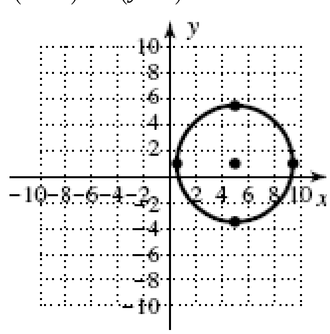
56. Center $(5,1)$, diameter $4\sqrt{5}$

$\text{radius} = \frac{1}{2}\cdot\text{diameter}$

$r=\frac{1}{2}\left(4\sqrt{5}\right)=2\sqrt{5}$

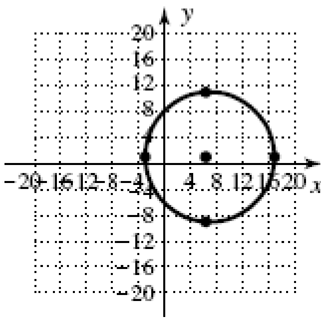
$(x-5)^2+(y-1)^2=\left(2\sqrt{5}\right)^2$

$(x-5)^2+(y-1)^2=20$

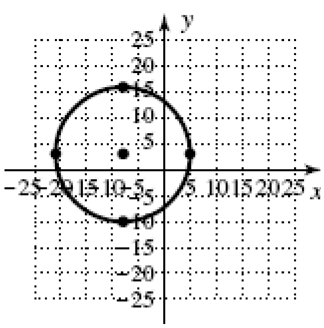


# 2.1 Exercises

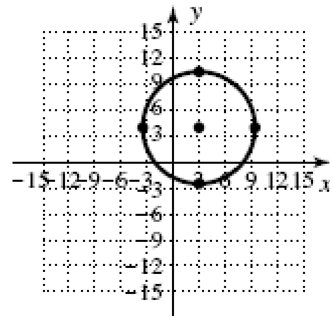
57. Center at (7,1),
graph contains the point (1, −7)
$(x-7)^2+(y-1)^2=r^2$;
$(1-7)^2+(-7-1)^2=r^2$
$36+64=r^2$
$100=r^2$;
$(x-7)^2+(y-1)^2=100$



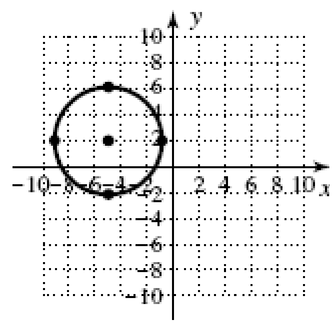
58. Center at (−8,3),
graph contains the point (−3,15)
$(x+8)^2+(y-3)^2=r^2$;
$(-3+8)^2+(15-3)^2=r^2$
$25+144=r^2$
$169=r^2$;
$(x+8)^2+(y-3)^2=169$



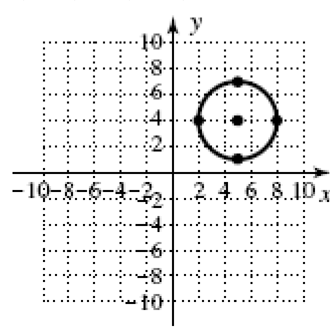
59. Center at (3,4),
graph contains the point (7,9)
$(x-3)^2+(y-4)^2=r^2$;
$(7-3)^2+(9-4)^2=r^2$
$16+25=r^2$
$41=r^2$;
$(x-3)^2+(y-4)^2=41$



60. Center at (−5,2),
graph contains the point (−1,3)
$(x+5)^2+(y-2)^2=r^2$;
$(-1+5)^2+(3-2)^2=r^2$
$16+1=r^2$
$17=r^2$;
$(x+5)^2+(y-2)^2=17$



61. Diameter has endpoints (5,1) and (5,7);
midpoint of diameter = center of circle
$\left(\frac{5+5}{2},\frac{1+7}{2}\right)=(5,4)$;
radius = distance from center to endpt
$r=\sqrt{(5-5)^2+(1-4)^2}=3$;
$(x-5)^2+(y-4)^2=9$



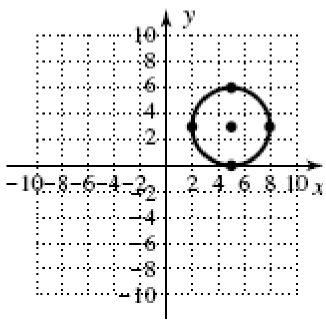
62. Diameter has endpoints (2,3) and (8,3); midpoint of diameter = center of circle

$\left(\frac{2+8}{2}, \frac{3+3}{2}\right) = (5,3);$

radius = distance from center to endpt

$r = \sqrt{(2-5)^2 + (3-3)^2} = 3;$

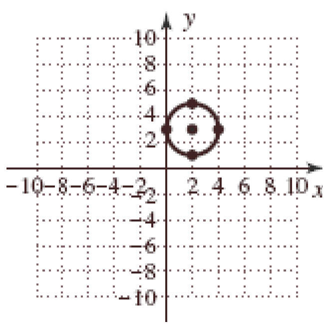
$(x-5)^2 + (y-3)^2 = 9$




63. Center: $(2,3), r = 2$

$D: x \in [0,4]$

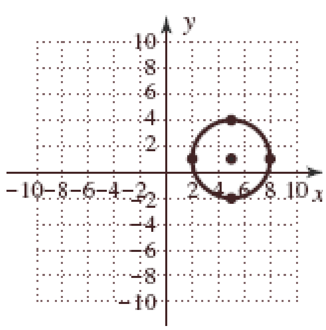
$R: y \in [1,5]$




64. Center: $(5,1), r = 3$

$D: x \in [2,8]$

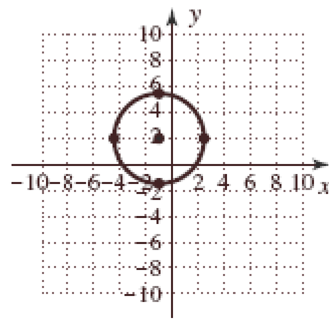
$R: y \in [-2,4]$




65. Center: $(-1,2), r = 2\sqrt{3}$

$D: x \in \left[-1-2\sqrt{3}, -1+2\sqrt{3}\right]$

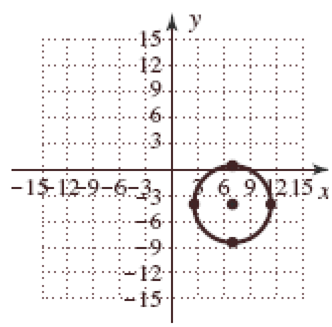
$R: y \in \left[2-2\sqrt{3}, 2+2\sqrt{3}\right]$




66. Center: $(7,-4), r = 2\sqrt{5}$

$D: x \in \left[7-2\sqrt{5}, 7+2\sqrt{5}\right]$

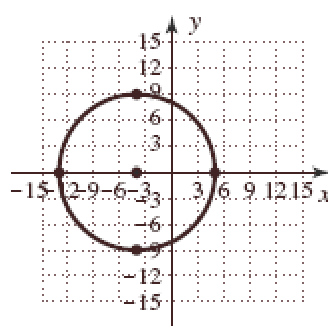
$R: y \in \left[-4-2\sqrt{5}, -4+2\sqrt{5}\right]$




67. Center: $(-4,0), r = 9$

$D: x \in [-13,5]$

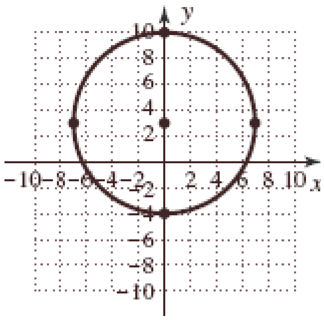
$R: y \in [-9,9]$



68. Center: $(0,3)$, $r = 7$

$D: x \in [-7,7]$

$R: y \in [-4,10]$



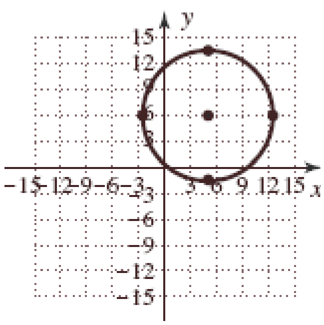
69. $x^2 + y^2 - 10x - 12y + 4 = 0$

$x^2 - 10x + y^2 - 12y = -4$

$x^2 - 10x + 25 + y^2 - 12y + 36 = -4 + 25 + 36$

$(x-5)^2 + (y-6)^2 = 57$

Center: $(5,6)$, Radius: $r = \sqrt{57}$



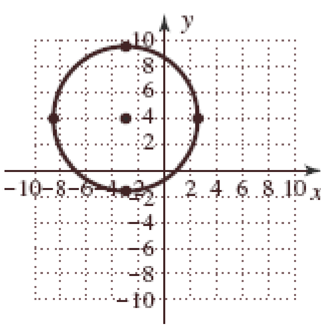
70. $x^2 + y^2 + 6x - 8y - 6 = 0$

$x^2 + 6x + y^2 - 8y = 6$

$x^2 + 6x + 9 + y^2 - 8y + 16 = 6 + 9 + 16$

$(x+3)^2 + (y-4)^2 = 31$

Center: $(-3,4)$, Radius: $r = \sqrt{31}$



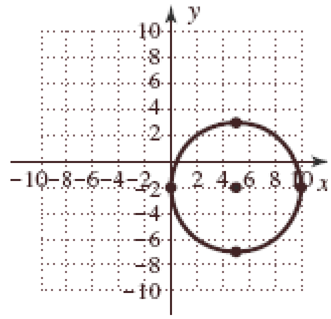
71. $x^2 + y^2 - 10x + 4y + 4 = 0$

$x^2 - 10x + y^2 + 4y = -4$

$x^2 - 10x + 25 + y^2 + 4y + 4 = -4 + 25 + 4$

$(x-5)^2 + (y+2)^2 = 25$

Center: $(5,-2)$, Radius: $r = 5$



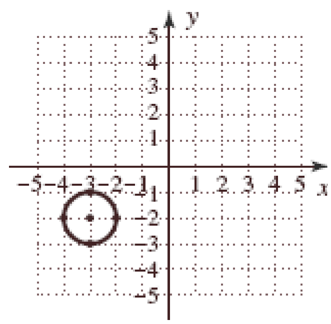
72. $x^2 + y^2 + 6x + 4y + 12 = 0$

$x^2 + 6x + y^2 + 4y = -12$

$x^2 + 6x + 9 + y^2 + 4y + 4 = -12 + 9 + 4$

$(x+3)^2 + (y+2)^2 = 1$

Center: $(-3,-2)$, Radius: $r = 1$



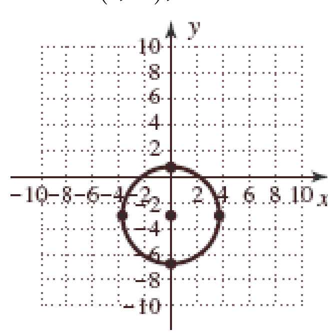
73. $x^2 + y^2 + 6y - 5 = 0$

$x^2 + y^2 + 6y = 5$

$x^2 + y^2 + 6y + 9 = 5 + 9$

$x^2 + (y+3)^2 = 14$

Center: $(0,-3)$, Radius: $r = \sqrt{14}$



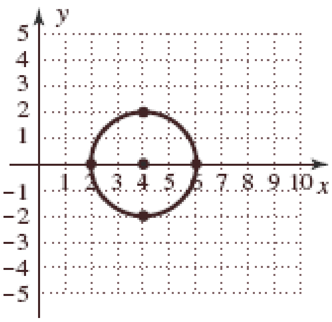
74. $x^2+y^2-8x+12=0$

$x^2-8x+y^2=-12$

$x^2-8x+16+y^2=-12+16$

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

Center: $(4,0)$, Radius: $r=2$



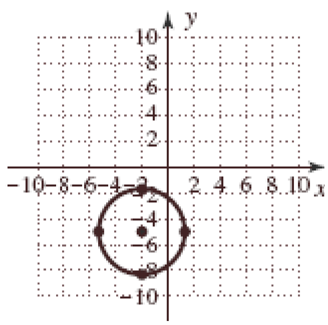
75. $x^2+y^2+4x+10y+18=0$

$x^2+4x+y^2+10y=-18$

$x^2+4x+4+y^2+10y+25=-18+4+25$

$(x+2)^2+(y+5)^2=11$

Center: $(-2,-5)$, Radius: $r=\sqrt{11}$



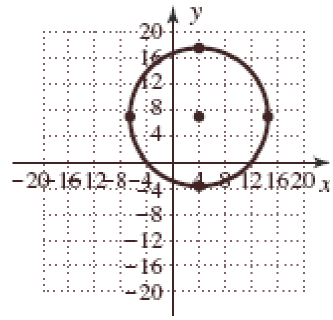
76. $x^2+y^2-8x-14y-47=0$

$x^2-8x+y^2-14y=47$

$x^2-8x+16+y^2-14y+49=47+16+49$

$(x-4)^2+(y-7)^2=112$

Center: $(4,7)$, Radius: $r=4\sqrt{7}$



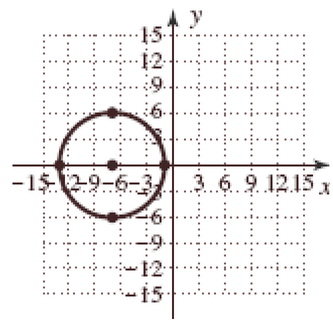
77. $x^2+y^2+14x+12=0$

$x^2+14x+y^2=-12$

$x^2+14x+49+y^2=-12+49$

$(x+7)^2+y^2=37$

Center: $(-7,0)$, Radius: $r=\sqrt{37}$



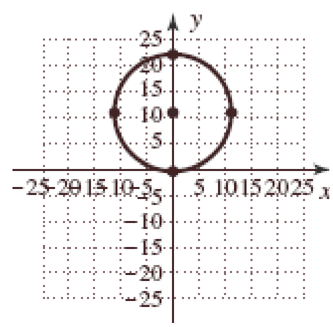
78. $x^2+y^2-22y-5=0$

$x^2+y^2-22y=5$

$x^2+y^2-22y+121=5+121$

$x^2+(y-11)^2=126$

Center: $(0,11)$, Radius: $r=3\sqrt{14}$



79. $2x^2 + 2y^2 - 12x + 20y + 4 = 0$

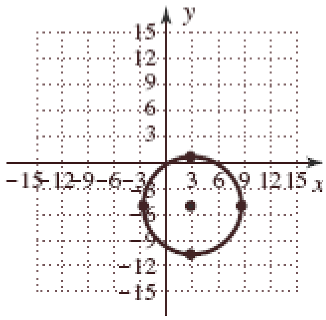
$x^2 + y^2 - 6x + 10y + 2 = 0$

$x^2 - 6x + y^2 + 10y = -2$

$x^2 - 6x + 9 + y^2 + 10y + 25 = -2 + 9 + 25$

$(x-3)^2 + (y+5)^2 = 32$

Center: $(3,-5)$, Radius: $r = 4\sqrt{2}$



80. $3x^2 + 3y^2 - 24x + 18y + 3 = 0$

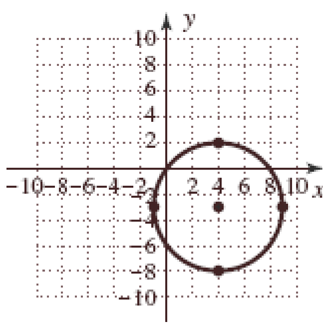
$x^2 + y^2 - 8x + 6y + 1 = 0$

$x^2 - 8x + y^2 + 6y = -1$

$x^2 - 8x + 16 + y^2 + 6y + 9 = -1 + 16 + 9$

$(x-4)^2 + (y+3)^2 = 24$

Center: $(4,-3)$, Radius: $r = \sqrt{24} = 2\sqrt{6}$



81. $s = 12.5t + 59$

a. Let $t = 1, s = 12.5(1) + 59 = 71.5$;

Let $t = 2, s = 12.5(2) + 59 = 84$;

Let $t = 3, s = 12.5(3) + 59 = 96.5$;

Let $t = 5, s = 12.5(5) + 59 = 121.5$;

Let $t = 7, s = 12.5(7) + 59 = 146.5$;

$(1,71.5),(2,84),(3,96.5),(5,121.5),(7,146.5)$

b. Let $t = 8, s = 12.5(8) + 59 = 159$

Average amount spend in 2008 is \$159.

c. Let $s = 196$,

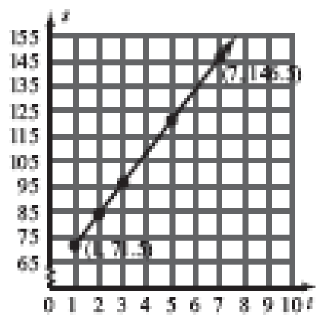
$196 = 12.5t + 59$

$137 = 12.5t$

$10.96 = t$

In 2011, annual spending surpasses \$196.

d.



82. $A = 2r^2$

$A = 2(5)^2 = 50 \text{ units}^2$

83. a. $(x-5)^2 + (y-12)^2 = 25^2$

$(x-5)^2 + (y-12)^2 = 625$

b. $d = \sqrt{(15-5)^2 + (36-12)^2}$

$d = \sqrt{10^2 + 24^2} = \sqrt{676} = 26$

No, radar cannot pick up the liner's sister ship.

84. a. $(x-3)^2 + (y-7)^2 = 12^2$

$(x-3)^2 + (y-7)^2 = 144$

b. $d = \sqrt{(13-3)^2 + (1-7)^2}$

$d = \sqrt{(10)^2 + (-6)^2} = \sqrt{100+36}$

$= \sqrt{136} \approx 11.66$

Yes, they would have felt the quake.

85. Red: $(x-2)^2 + (y-2)^2 = 4$;

Center: (2,2), Radius: 2

Blue: $(x-2)^2 + y^2 = 16$;

Center: (2,0), Radius: 4

Area of blue: $\pi(16) - \pi(4) = 12\pi \text{ units}^2$

86. $x^2 + y^2 = r^2$

$(3)^2 + (4)^2 = r^2$

$5 = r$;

$A = \frac{3\sqrt{3}}{4}(5)^2 = \frac{75\sqrt{3}}{4} \text{ units}^2$

87. $x^2 + y^2 + 8x - 6y = 0$

$x^2 + 8x + y^2 - 6y = 0$

$x^2 + 8x + 16 + y^2 - 6y + 9 = 0 + 16 + 9$

$(x+4)^2 + (y-3)^2 = 25$;

$x^2 + y^2 - 10x + 4y = 0$

$x^2 - 10x + y^2 + 4y = 0$

$x^2 - 10x + 25 + y^2 + 4y + 4 = 0 + 25 + 4$

$(x-5)^2 + (y+2)^2 = 29$;

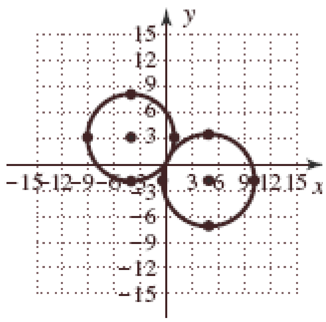
Distance between centers: $(-4,3)$, $(5, -2)$

$d = \sqrt{(-4-5)^2 + (3-(-2))^2}$

$= \sqrt{81+25} = \sqrt{106} \approx 10.30$;

Sum of the radii: $5 + \sqrt{29} \approx 10.39$

No, Distance between the centers is less than the sum of the radii.



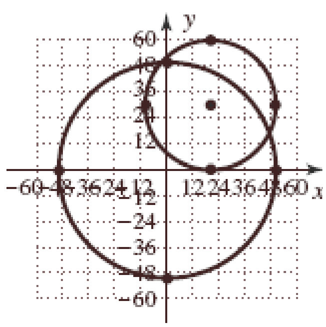
88. $x^2 + y^2 = 2500$;

$(x-20)^2 + (y-30)^2 = 900$;

$20^2 + 30^2 = h^2$

$\sqrt{1300} = h$;

$10\sqrt{13} + 30 \approx 66$ miles



89. Answers will vary.

90. Statement is true. Answers will vary.

91. a. $x^2 + y^2 - 12x + 4y + 40 = 0$

$x^2 - 12x + y^2 + 4y = -40$

$x^2 - 12x + 36 + y^2 + 4y + 4 = -40 + 36 + 4$

$(x-6)^2 + (y+2)^2 = 0$

Center $(6, -2)$, $r = 0$, degenerate case

b. $x^2 + y^2 - 2x - 8y - 8 = 0$

$x^2 - 2x + y^2 - 8y = 8$

$x^2 - 2x + 1 + y^2 - 8y + 16 = 8 + 1 + 16$

$(x-1)^2 + (y-4)^2 = 25$

Center $(1, 4)$, $r = 5$

c. $x^2 + y^2 - 6x - 10y + 35 = 0$

$x^2 - 6x + y^2 - 10y = -35$

$x^2 - 6x + 9 + y^2 - 10y + 25 = -35 + 9 + 25$

$(x-3)^2 + (y-5)^2 = -1$

Center $(3, 5)$, $r^2 = -1$, degenerate case

92. $\frac{|w-2|}{3} + \frac{1}{4} \ge \frac{5}{6}$

$12\left(\frac{|w-2|}{3} + \frac{1}{4}\right) \ge 12\left(\frac{5}{6}\right)$

$4|w-2| + 3 \ge 10$

$4|w-2| \ge 7$

$|w-2| \ge \frac{7}{4}$

$w - 2 \ge \frac{7}{4}$ or $w - 2 \le -\frac{7}{4}$

$w \ge \frac{15}{4}$ or $w \le \frac{1}{4}$

$w \in \left(-\infty, \frac{1}{4}\right] \cup \left[\frac{15}{4}, \infty\right)$

93. a. 0
b. not possible
c. $0.\overline{3}$ ;many answers possible
d. not possible
e. not possible
f. $\sqrt{3}$ ;many answers possible

94. $x^2+13=6x$
$x^2-6x+13=0$
$a=1, b=-6, c=13$
$x=\dfrac{-(-6)\pm\sqrt{(-6)^2-4(1)(13)}}{2(1)}$
$x=\dfrac{6\pm\sqrt{36-52}}{2}$
$x=\dfrac{6\pm\sqrt{-16}}{2}$
$x=\dfrac{6\pm 4i}{2}=3\pm 2i$

95. $1-\sqrt{n+3}=-n$
$-\sqrt{n+3}=-n-1$
$\sqrt{n+3}=n+1$
$\left(\sqrt{n+3}\right)^2=(n+1)^2$
$n+3=n^2+2n+1$
$0=n^2+n-2$
$0=(n+2)(n-1)$
$n+2=0$ or $n-1=0$
$n=-2$ or $n=1$
Check: $n=-2$
$1-\sqrt{-2+3}=-(-2)$
$1-\sqrt{1}=2$
$0\neq 2$ ;
Check: $n=1$
$1-\sqrt{1+3}=-1$
$1-\sqrt{4}=-1$
$-1=-1$ ;
$n=1$ is a solution, $n=-2$ is extraneous.

## 2.2 Technology Highlight

Exercise 1: $Y_1=\dfrac{2}{3}x+1$; $(-1.5,0)$, $(0,1)$

Exercise 2: $79x-55y=869$
$-55y=-79x+869$
$y=\dfrac{-79}{55}x-\dfrac{79}{5}$
x-intercept: $(-11,0)$
y-intercept: $(0,-15.8)$

## 2.2 Exercises

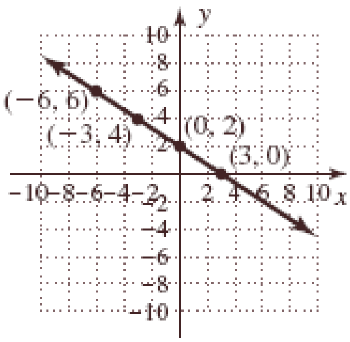
1. 0; 0.
2. $\dfrac{y_2-y_1}{x_2-x_2}=\dfrac{\Delta y}{\Delta x}$
3. negative, downward
4. zero, undefined, equal
5. yes; slopes are not equal $m_1\neq m_2$ ;
No; $m_1\cdot m_2\neq -1$
6. Answers will vary.

7. $2x+3y=6$

$3y=-2x+6$

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

| x | y |
|---|---|
| $-6$ | $-\frac{2}{3}(-6)+2=4+2=6$ |
| $-3$ | $-\frac{2}{3}(-3)+2=2+2=4$ |
| 0 | $-\frac{2}{3}(0)+2=0+2=2$ |
| 3 | $-\frac{2}{3}(3)+2=-2+2=0$ |

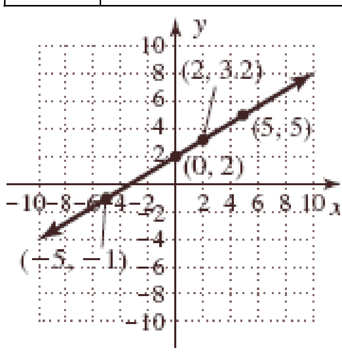



8. $-3x+5y=10$

$5y=3x+10$

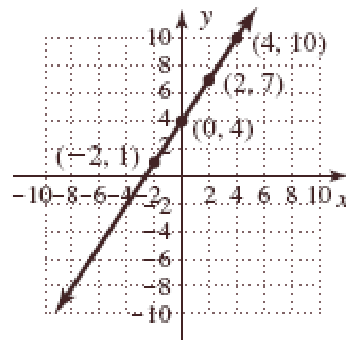
$y=\frac{3}{5}x+2$

| x | y |
|---|---|
| $-5$ | $\frac{3}{5}(-5)+2=-3+2=-1$ |
| 0 | $\frac{3}{5}(0)+2=0+2=2$ |
| 2 | $\frac{3}{5}(2)+2=1.2+2=3.2$ |
| 5 | $\frac{3}{5}(5)+2=3+2=5$ |



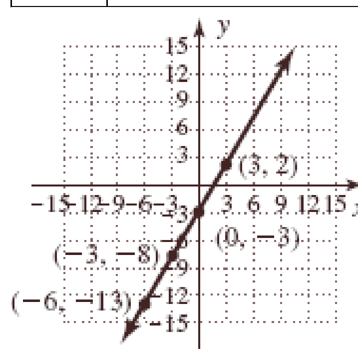

9. $y=\frac{3}{2}x+4$

| x | y |
|---|---|
| $-2$ | $\frac{3}{2}(-2)+4=-3+4=1$ |
| 0 | $\frac{3}{2}(0)+4=0+4=4$ |
| 2 | $\frac{3}{2}(2)+4=3+4=7$ |
| 4 | $\frac{3}{2}(4)+4=6+4=10$ |




10. $y=\frac{5}{3}x-3$

| x | y |
|---|---|
| $-6$ | $\frac{5}{3}(-6)-3=-10-3=-13$ |
| $-3$ | $\frac{5}{3}(-3)-3=-5-3=-8$ |
| 0 | $\frac{5}{3}(0)-3=0-3=-3$ |
| 3 | $\frac{5}{3}(3)-3=5-3=2$ |



11. $y = \frac{3}{2}x + 4$

$-0.5 = \frac{3}{2}(-3) + 4$

$-0.5 = -\frac{9}{2} + 4$

$-0.5 = -0.5$ ;

$\frac{19}{4} = \frac{3}{2}\left(\frac{1}{2}\right) + 4$

$\frac{19}{4} = \frac{3}{4} + 4$

$\frac{19}{4} = \frac{19}{4}$

12. $y = \frac{5}{3}x - 3$

$-5.5 = \frac{5}{3}(-1.5) - 3$

$-5.5 = -2.5 - 3$

$-5.5 = -5.5$ ;

$\frac{37}{6} = \frac{5}{3}\left(\frac{11}{2}\right) - 3$

$\frac{37}{6} = \frac{55}{6} - 3$

$\frac{37}{6} = \frac{37}{6}$

13. $3x + y = 6$

$x$-intercept: (2, 0)

$3x + 0 = 6$

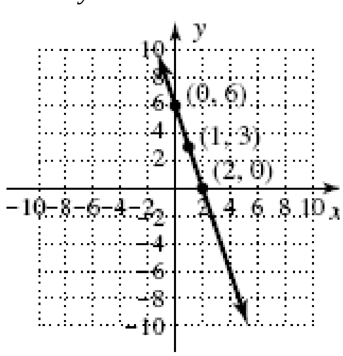
$3x = 6$

$x = 2$

$y$-intercept: (0, 6)

$3(0) + y = 6$

$y = 6$




14. $-2x + y = 12$

$x$-intercept: $(-6, 0)$

$-2x + 0 = 12$

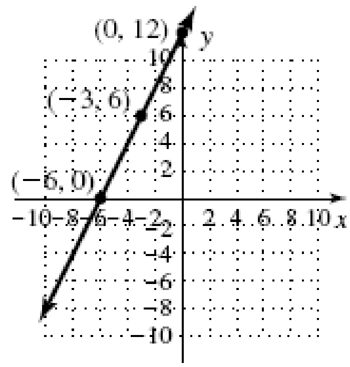
$-2x = 12$

$x = -6$

$y$-intercept: (0, 12)

$-2(0) + y = 12$

$y = 12$




15. $5y - x = 5$

$x$-intercept: $(-5, 0)$

$5(0) - x = 5$

$-x = 5$

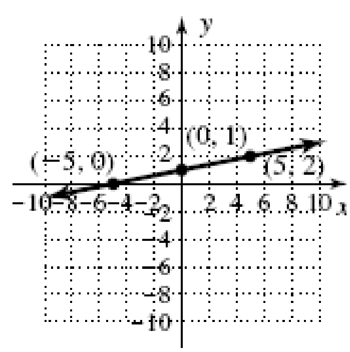
$x = -5$

$y$-intercept: (0, 1)

$5y - 0 = 5$

$5y = 5$

$y = 1$



16. $-4y+x=8$

$x$-intercept: (8, 0)

$-4(0)+x=8$

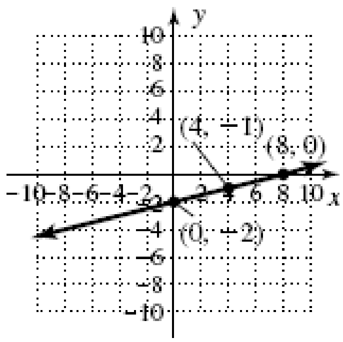
$x=8$

$y$-intercept: (0, −2)

$-4y+0=8$

$-4y=8$

$y=-2$




17. $-5x+2y=6$

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

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

$-5x=6$

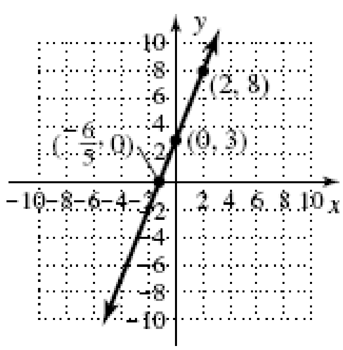
$x=-\frac{6}{5}$

$y$-intercept: (0, 3)

$-5(0)+2y=6$

$2y=6$

$y=3$




18. $3y+4x=9$

$x$-intercept: $\left(\frac{9}{4},0\right)$

$3(0)+4x=9$

$4x=9$

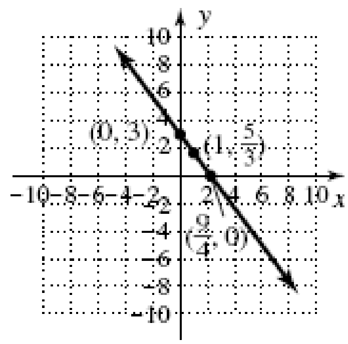
$x=\frac{9}{4}$

$y$-intercept: (0, 3)

$3y+4(0)=9$

$3y=9$

$y=3$




19. $2x-5y=4$

$x$-intercept: (2, 0)

$2x-5(0)=4$

$2x=4$

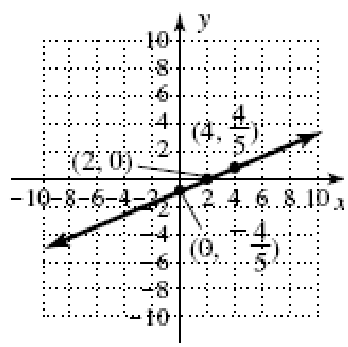
$x=2$

$y$-intercept: $\left(0,-\frac{4}{5}\right)$

$2(0)-5y=4$

$-5y=4$

$y=-\frac{4}{5}$



# 2.2 Exercises

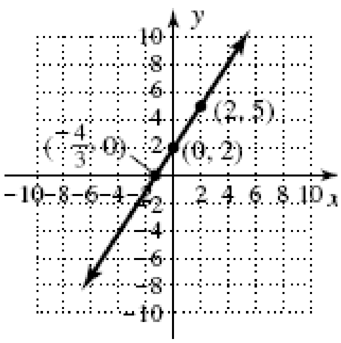
20. $-6x+4y=8$

$x$-intercept: $\left(-\frac{4}{3},0\right)$

$$-6x+4(0)=8$$
$$-6x=8$$
$$x=-\frac{4}{3}$$

$y$-intercept: $(0, 2)$

$$-6(0)+4y=8$$
$$4y=8$$
$$y=2$$



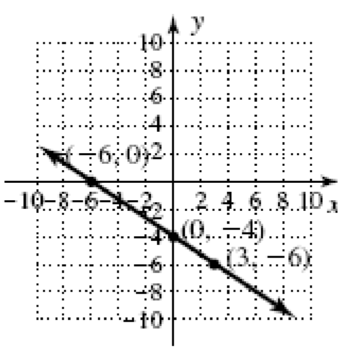

21. $2x+3y=-12$

$x$-intercept: $(-6, 0)$

$$2x+3(0)=-12$$
$$2x=-12$$
$$x=-6$$

$y$-intercept: $(0, -4)$

$$2(0)+3y=-12$$
$$3y=-12$$
$$y=-4$$



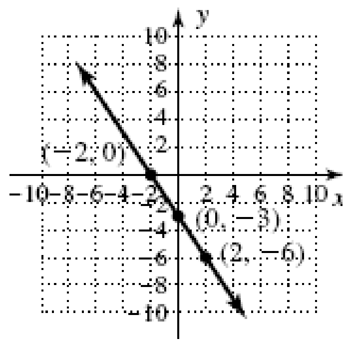

22. $-3x-2y=6$

$x$-intercept: $(-2, 0)$

$$-3x-2(0)=6$$
$$-3x=6$$
$$x=-2$$

$y$-intercept: $(0, -3)$

$$-3(0)-2y=6$$
$$-2y=6$$
$$y=-3$$




23. $y=-\frac{1}{2}x$

$$y=-\frac{1}{2}(2)$$
$$y=-1$$

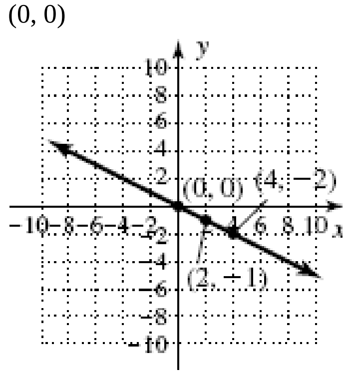
$(2, -1)$;

$$y=-\frac{1}{2}x$$
$$y=-\frac{1}{2}(4)$$
$$y=-2$$

$(4, -2)$;

$$y=-\frac{1}{2}x$$
$$y=-\frac{1}{2}(0)$$
$$y=0$$

$(0, 0)$



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

$y = \frac{2}{3}(3)$

$y = 2$

(3, 2);

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

$y = \frac{2}{3}(6)$

$y = 4$

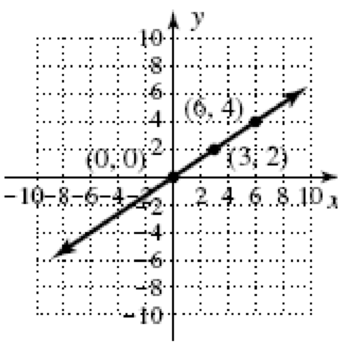
(6, 4);

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

$y = \frac{2}{3}(0)$

$y = 0$

(0, 0)




25. $y - 25 = 50x$

$y - 25 = 50(-1)$

$y - 25 = -50$

$y = -25$

$(-1, -25)$;

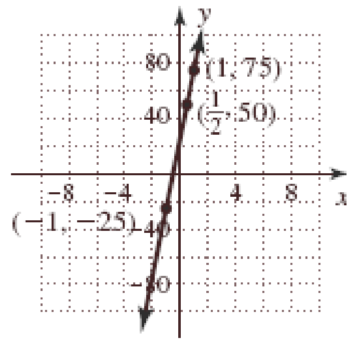
$y - 25 = 50x$

$y - 25 = 50(1)$

$y - 25 = 50$

$y = 75$

(1, 75)




26. $y + 30 = 60x$

$y + 30 = 60(-1)$

$y + 30 = -60$

$y = -90$

$(-1, -90)$;

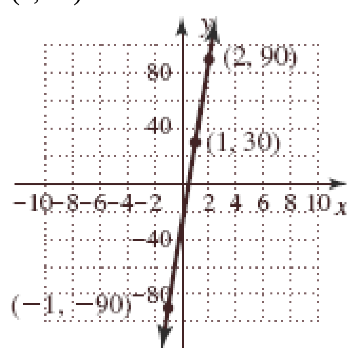
$y + 30 = 60x$

$y + 30 = 60(1)$

$y + 30 = 60$

$y = 30$

(1, 30)



## 2.2 Exercises

27. $y = -\frac{2}{5}x - 2$

*x*-intercept: $(-5, 0)$

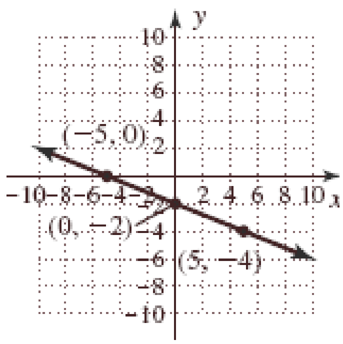
$$0 = -\frac{2}{5}x - 2$$
$$2 = -\frac{2}{5}x$$
$$\left(-\frac{5}{2}\right)(2) = \left(-\frac{5}{2}\right)\left(-\frac{2}{5}x\right)$$
$$-5 = x$$

$(-5, 0)$;

*y*-intercept: $(0, -2)$

$$y = -\frac{2}{5}(0) - 2$$
$$y = -2$$

$(0, -2)$



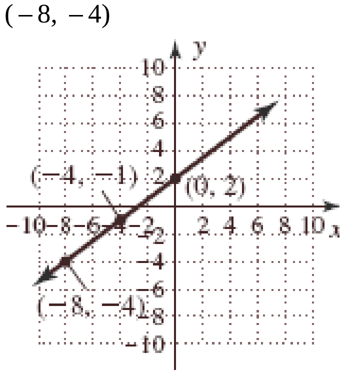

28. $y = \frac{3}{4}x + 2$

$$y = \frac{3}{4}(-4) + 2$$
$$y = -3 + 2$$
$$y = -1$$

$(-4, -1)$;

$$y = \frac{3}{4}x + 2$$
$$y = \frac{3}{4}(-8) + 2$$
$$y = -6 + 2$$
$$y = -4$$

$(-8, -4)$




29. $2y - 3x = 0$

$$2y - 3(2) = 0$$
$$2y - 6 = 0$$
$$2y = 6$$
$$y = 3$$

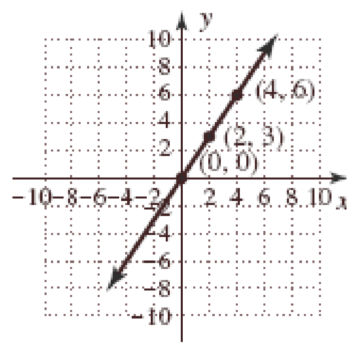
$(2, 3)$;

$$2y - 3x = 0$$
$$2y - 3(4) = 0$$
$$2y - 12 = 0$$
$$2y = 12$$
$$y = 6$$

$(4, 6)$;

$$2y - 3x = 0$$
$$2y - 3(0) = 0$$
$$2y = 0$$
$$y = 0$$

$(0, 0)$



30. $y+3x=0$

$y+3(-1)=0$

$y-3=0$

$y=3$

$(-1,\ 3)$;

$y+3x=0$

$y+3(1)=0$

$y+3=0$

$y=-3$

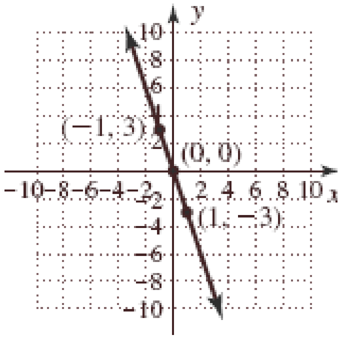
$(1,\ -3)$;

$y+3x=0$

$y+3(0)=0$

$y=0$

$(0,\ 0)$




31. $3y+4x=12$

$x$-intercept: $(3,\ 0)$

$3(0)+4x=12$

$4x=12$

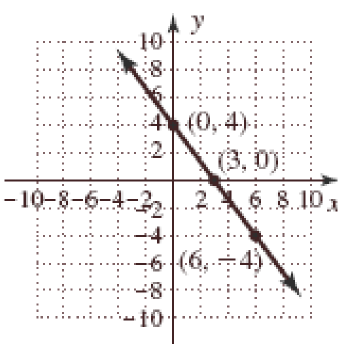
$x=3$

$y$-intercept: $(0,\ 4)$

$3y+4(0)=12$

$3y=12$

$y=4$




32. $-2x+5y=8$

$x$-intercept: $(-4,\ 0)$

$-2x+5(0)=8$

$-2x=8$

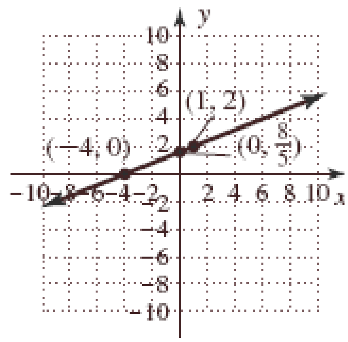
$x=-4$

$y$-intercept: $\left(0, \dfrac{8}{5}\right)$

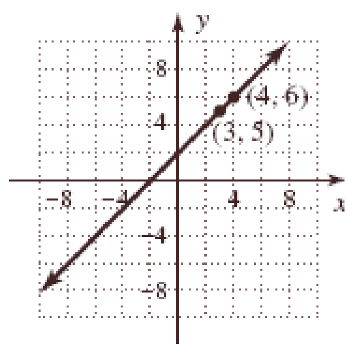
$-2(0)+5y=8$

$5y=8$

$y=\dfrac{8}{5}$



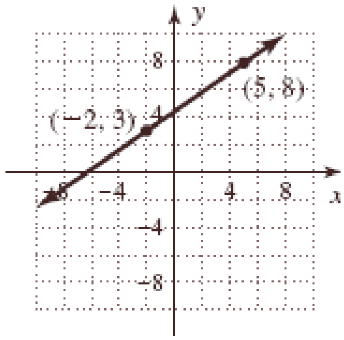

33. $m=\dfrac{6-5}{4-3}=\dfrac{1}{1}=1$




(2,4), (1,3)

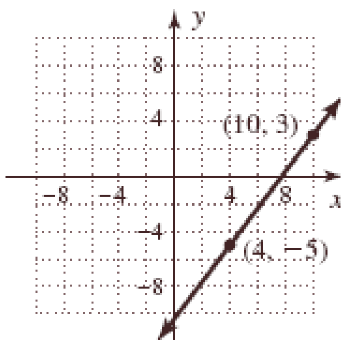
# 2.2 Exercises

34. $m = \frac{8-3}{5-(-2)} = \frac{5}{7}$



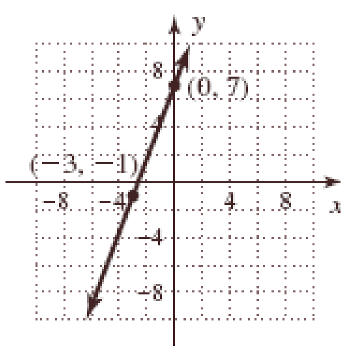

$(-9, -2), (13, 12)$

35. $m = \frac{3-(-5)}{10-4} = \frac{8}{6} = \frac{4}{3}$




$(7, -1), (1, -9)$

36. $m = \frac{-1-7}{-3-0} = \frac{-8}{-3} = \frac{8}{3}$




$(-6, -9), (3, 15)$

37. $m = \frac{-8-7}{1-(-3)} = \frac{-15}{4} = -\frac{15}{4}$

$(1, -8), \left(-1, -\frac{1}{2}\right)$

38. $m = \frac{-5-5}{0-(-5)} = \frac{-10}{5} = -2$

$(-3, 1), (-7, 9)$

39. $m = \frac{2-6}{4-(-3)} = \frac{-4}{7} = -\frac{4}{7}$

$(-10, 10), (11, -2)$

40. $m = \frac{-1-(-4)}{-3-(-2)} = \frac{-1+4}{-3+2} = \frac{3}{-1} = -3$

$(-4, 2), (-1, -7)$

41. a. $m = \frac{500-250}{4-2} = \frac{250}{2} = 125$

Cost increased \$125,000 per 1000 square feet.

b. \$375,000

42. a. $m = \frac{960-360}{80-30} = \frac{600}{50} = 12$

12 $m^3$ dumped per garbage truck.

b. 83 trucks

43. a. $m = \frac{270-90}{12-4} = \frac{180}{8} = 22.5$

Distance increases 22.5 miles per hour.

b. 186 miles

44. a. $m = \frac{300-150}{8-4} = \frac{150}{4} = 37.5$

37.5 circuit boards are assembled per hour.

b. 6 hours

45. a. $m = \frac{165-142}{70-64} = \frac{23}{6}$

A person weighs 23 pounds more for each additional 6 inches in height.

b. $\frac{23}{6} \approx 3.8$ pounds

46. a. $m = \dfrac{32000 - 10000}{15 - 5} = \dfrac{22000}{10} = 2200$

A plane climbs 2200 feet in 1 minute.

b. $25400 - 12200 = 13200$

$\dfrac{13200}{2200} = 6 \text{ minutes}$

47. Convert 48 feet to inches: $48(12) = 576$;

(0, −6) represents position of the sewer line at edge of house;

(576, −18) represents position of sewer line at the main line.

$m = \dfrac{-18 - (-6)}{576 - 0} = \dfrac{-12}{576} = -\dfrac{1}{48}$

The sewer line is one inch deeper for each 48 inches in length.

48. (0,4) represents height of 4 ft from ridge; (12,0) represents 12 ft from ridge at height of 0 ft.

$m = \dfrac{0 - 4}{12 - 0} = \dfrac{-4}{12} = -\dfrac{1}{3}$

The roof decreases 1 foot in height for every 3 feet in horizontal distance from the ridge.

49. $x = -3$

$x + 0y = -3$

$x + 0(4) = -3$

$x = -3$

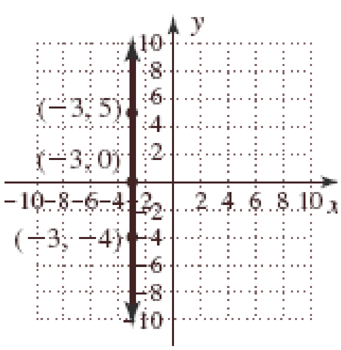
(-3, 4);

$x + 0y = -3$

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

$x = -3$

(−3, −4)




50. $y = 4$

$0x + y = 4$

$0(3) + y = 4$

$y = 4$

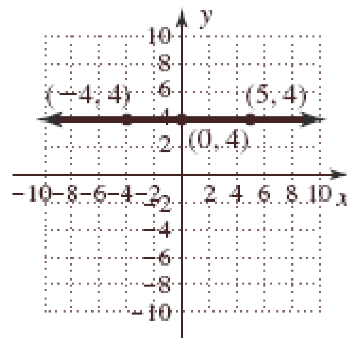
(3, 4);

$0x + y = 4$

$0(-3) + y = 4$

$y = 4$

(−3, 4)




51. $x = 2$

$x + 0y = 2$

$x + 0(2) = 2$

$x = 2$

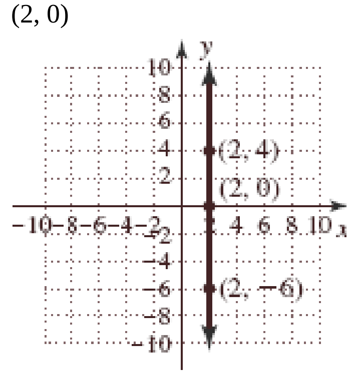
(2, 0)

$x + 0y = 2$

$x + 0(-2) = 2$

$x = 2$

(2, 0)



## 2.2 Exercises

52. $y = -2$

$0x + y = -2$

$0(2) + y = -2$

$y = -2$

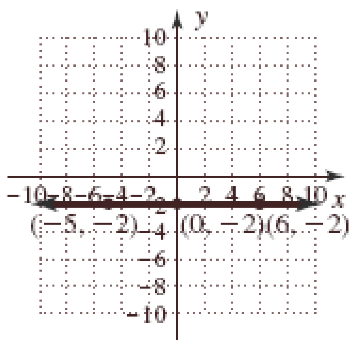
$(0, -2)$

$0x + y = -2$

$0(-2) + y = -2$

$y = -2$

$(0, -2)$




53. $L_1 : x = 2$

$L_2 : y = 4$

Point of intersection: (2, 4)

54. $L_1 : x = -3$

$L_2 : y = 1$

Point of intersection: (−3, 1)

55. a. Choose any two points (*t*,*j*).

(0,9), (10,9)

$$m = \frac{9-9}{10-0} = \frac{0}{10} = 0$$

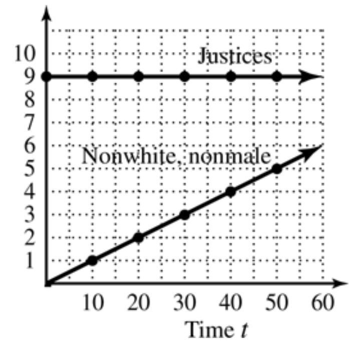
Which indicates there is no increase or decrease in the number of Supreme Court justices.

b. Choose any two points (*t*,*n*).

(0,0), (10,1)

$$m = \frac{1-0}{10-0} = \frac{1}{10}$$

Which indicates that over the last 5 decades, one non-white or non-female justice has been added to the court every ten years.

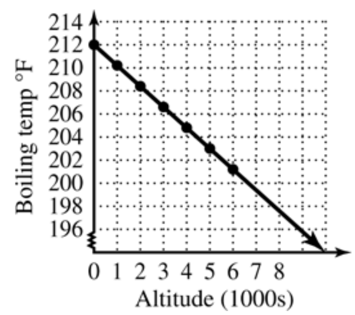



56. Choose any two points (*h*,*t*).

(0,212), (5000,203)

$$m = \frac{203-212}{5000-0} = \frac{-9}{5000}$$

which indicates that the boiling point of water decreases by $9^\circ$ F for each increase in 5000 feet in altitude.




57. $L_1 : m = \frac{6-0}{0-(-2)} = \frac{6}{2} = 3$

$L_2 : m = \frac{5-8}{0-1} = \frac{-3}{-1} = 3$

Parallel

58. $L_1 : m = \frac{7-10}{-1-1} = \frac{-3}{-2} = \frac{3}{2}$

$L_2 : m = \frac{5-3}{1-0} = \frac{2}{1} = 2$

Neither

59. $L_1: m = \frac{-4-1}{-3-0} = \frac{-5}{-3} = \frac{5}{3}$

$L_2: m = \frac{4-0}{-4-0} = \frac{4}{-4} = -1$

Neither

60. $L_1: m = \frac{-2-2}{8-6} = \frac{-4}{2} = -2$

$L_2: m = \frac{1-0}{5-3} = \frac{1}{2}$

Perpendicular

61. $L_1: m = \frac{7-3}{8-6} = \frac{4}{2} = 2$

$L_2: m = \frac{2-0}{7-6} = \frac{2}{1} = 2$

Parallel

62. $L_1: m = \frac{-1-4}{-5-4} = \frac{-5}{-9} = \frac{5}{9}$

$L_2: m = \frac{-7-10}{4-8} = \frac{-17}{-4} = \frac{17}{4}$

Neither

63. $(5, 2)\ (0, -3)$

$m = \frac{-3-2}{0-5} = \frac{-5}{-5} = 1;$

$(0, -3)\ (4, -4)$

$m = \frac{-4-(-3)}{4-0} = \frac{-4+3}{4} = \frac{-1}{4};$

$(5, 2)\ (4, -4)$

$m = \frac{-4-2}{4-5} = \frac{-6}{-1} = 6$

Not a right triangle. Lines are not perpendicular. Slopes: 1; $\frac{-1}{4}$; 6

64. $(7, 0)\ (-1, 0)$

$m = \frac{0-0}{-1-7} = 0;$

$(7, 0)\ (7, 4)$

$m = \frac{4-0}{7-7}$ Undefined

Right triangle because these two lines are perpendicular. Slopes: 0; undefined.

65. $(-4, 3)\ (-7, -1)$

$m = \frac{-1-3}{-7-(-4)} = \frac{-4}{-7+4} = \frac{-4}{-3} = \frac{4}{3};$

$(-7, -1)\ (3, -2)$

$m = \frac{-2-(-1)}{3-(-7)} = \frac{-2+1}{3+7} = \frac{-1}{10};$

$(-4, 3)\ (3, -2)$

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

Not a right triangle. Lines are not perpendicular. Slopes: $\frac{4}{3}$; $\frac{-1}{10}$; $\frac{-5}{7}$

66. $(-3, 7)\ (2, 2)$

$m = \frac{2-7}{2-(-3)} = \frac{-5}{2+3} = \frac{-5}{5} = -1;$

$(2, 2)\ (5, 5)$

$m = \frac{5-2}{5-2} = \frac{3}{3} = 1$

Right triangle because these two lines are perpendicular. Slopes: $-1$; 1

67. $(-3, 2)\ (-1, 5)$

$m = \frac{5-2}{-1-(-3)} = \frac{3}{-1+3} = \frac{3}{2};$

$(-3, 2)\ (-6, 4)$

$m = \frac{4-2}{-6-(-3)} = \frac{2}{-6+3} = -\frac{2}{3}$

Right triangle because these two lines are perpendicular. Slopes: $\frac{3}{2}$; $\frac{-2}{3}$

68. $(0, 0)\ (-5, 2)$

$m = \frac{2-0}{-5-0} = \frac{2}{-5} = -\frac{2}{5};$

$(-5, 2)\ (2, -5)$

$m = \frac{-5-2}{2-(-5)} = \frac{-7}{2+5} = \frac{-7}{7} = -1;$

$(0, 0)\ (2, -5)$

$m = \frac{-5-0}{2-0} = \frac{-5}{2}$

Not a right triangle. Lines are not perpendicular. Slopes: $-\frac{2}{5}, -1, -\frac{5}{2}$

69. $L = 0.11T + 74.2$

a. $L(20) = 0.11(20) + 74.2 = 76.4$ years

b. $77.5 = 0.11T + 74.2$
$3.3 = 0.11T$
$30 = T$
1980 + 30 = 2010

70. $I = \left(\frac{7}{100}\right)(5000)T$

a. $I(5) = \left(\frac{7}{100}\right)(5000)(5) = \$1750$

b. $I(10) = \left(\frac{7}{100}\right)(5000)(10) = \$3500$

c. $m = \frac{3500 - 1750}{10 - 5} = \frac{1750}{5} = 350$
Interest increases $350 per year.

71. $V = 8500 - 1250y$

a. $V = 8500 - 1250(4) = \$3500$

b. $2250 = 8500 - 1250y$
$-6250 = -1250y$
$5 = y$
5 years

72. $V = 85 + 1.5y$

a. $V = 85 + 1.5(7) = \$95.50$

b. $100 = 85 + 1.5y$
$15 = 1.5y$
$10 = y$
10 years

73. Let $h$ represent the water level, in inches.
Let $t$ represent the time, in months.
$h = -3t + 300$

a. $h = -3(9) + 300 = 273$ in .

b. Convert feet to inches: $20(12) = 240$;
$240 = -3t + 300$
$-60 = -3t$
$20 = t$
20 months

74. Let $w$ represent the weight of cargo, in tons.
Let $m$ represent the gas mileage per gallon.
Find two points $(w,m)$ from the given data:
(0,15), (3,14.25)
$m = \frac{14.25 - 15}{3 - 0} = -0.25$;
$m = -0.25w + 15$

a. $m = -0.25(10) + 15 = 12.5$ mpg

b. $10 = -0.25w + 15$
$-5 = -0.25w$
$20 = w$
20 tons

75. Slope of FM 1960: $\frac{38}{12}$;
Slope of FM 380: $\frac{30}{9.5}$;
Since $\frac{38}{12} \neq \frac{30}{9.5}$, the roads are not parallel and yes, the roads will meet.

76. Harbor is at (0,0). The first trawler is aat (3,12) and the second trawler is at $(8, -2)$.
Slope of first route: $m = \frac{12}{3} = 4$;
Slope of second route: $m = \frac{-2}{8} = -\frac{1}{4}$;
Yes, the routes are perpendicular.
Distance between two boats:
$d = \sqrt{(8-3)^2 + (-2-12)^2}$
$= \sqrt{221} \approx 14.9$ miles

77. $y = 144x + 621$

a. $y = 144(22) + 621$
$y = 3789$
$3,789

b. $5250 = 144x + 621$
$4629 = 144x$
$32.15 \approx x$
1980 + 32 = 2012
Year 2012

78. $y = 0.72x + 11$

a. $y = 0.72(12) + 11$

$y = 8.64 + 11$

$y = 19.64$

20%

b. $30 = 0.72x + 11$

$19 = 0.72x$

$26.38 = x$

1980 + 26.38 = 2006.38

During the year 2006

79. $y = -\frac{7}{15}x + 32$

a. $y = -\frac{7}{15}(20) + 32$

$y = \frac{-28}{3} + 32$

$y = 22\frac{2}{3}$

23%

b. $20 = -\frac{7}{15}x + 32$

$-12 = -\frac{7}{15}x$

$-180 = -7x$

$25.7 = x$

1980 + 25.7 = 2005.7

During the year 2005

80. $T = \frac{N}{4} + 40$

a. $T(48) = \frac{48}{4} + 40 = 12 + 40 = 52$

52º F

b. $70 = \frac{N}{4} + 40$

$30 = \frac{N}{4}$

$120 = N$

120 chirps per minute

81. $4y + 2x = -5$

$4y = -2x - 5$

$y = -\frac{1}{2}x - \frac{5}{4}$;

$3y + ax = -2$

$3y = -ax - 2$

$y = -\frac{a}{3}x - \frac{2}{3}$;

$-\frac{a}{3} \cdot -\frac{1}{2} = -1$

$\frac{a}{6} = -1$

$a = -6$

82. e.

83. $t_n = t_1 + (n-1)d$

a. $n = 21, t_1 = 2, d = 9 - 2 = 7$

$t_{21} = 2 + (21-1)7 = 142$

b. $n = 31, t_1 = 7, d = 4 - 7 = -3$

$t_{31} = 7 + (31-1)(-3) = -83$

c. $n = 27, t_1 = 5.10, d = 5.25 - 5.10 = 0.15$

$t_{27} = 5.10 + (27-1)(0.15) = 9$

d. $n = 17, t_1 = \frac{3}{2}, d = \frac{9}{4} - \frac{3}{2} = \frac{3}{4}$

$t_{17} = \frac{3}{2} + (17-1)\left(\frac{3}{4}\right) = \frac{27}{2}$

84. $3x^2 - 3 + 4x + 6 = 4x^2 - 3(x+5)$

$3x^2 + 4x + 3 = 4x^2 - 3x - 15$

$-x^2 + 7x + 18 = 0$

$-(x^2 - 7x - 18) = 0$

$-(x-9)(x+2) = 0$

$x = -2$ or $x = 9$

Check:

$3(-2)^2 - 3 + 4(-2) + 6 = 4(-2)^2 - 3(-2+5)$

$3(4) - 3 - 8 + 6 = 4(4) - 3(3)$

$12 - 3 - 8 + 6 = 16 - 9$

$7 = 7$;

$3(9)^2 - 3 + 4(9) + 6 = 4(9)^2 - 3(9+5)$

$3(81) - 3 + 36 + 6 = 4(81) - 3(14)$

$243 - 3 + 36 + 6 = 324 - 42$

$282 = 282$

85. $P = 2L + 2W$
Perimeter of a rectangle;
$V = LWH$
Volume of a rectangular prism;
$V = \pi r^2 h$
Volume of a cylinder;
$C = 2\pi r$
Circumference of a circle

86. Let $x$ represent the number of gallons of 35% brine solution.
Let $y$ represent the total number of gallons of 45% brine solution.

$$\begin{cases} x + 12 = y \\ 0.35x + 0.55(12) = 0.45(12 + x) \end{cases}$$

$0.35x + 0.55(12) = 0.45(12 + x)$
$0.35x + 6.6 = 5.4 + 0.45x$
$-0.1x = -1.2$
$x = 12$
12 gallons

87.

| | Distance | Rate | Time |
|---|---|---|---|
| Westbound Boat | D | 15 | t |
| Eastbound Boat | $70 - D$ | 20 | t |

$$\begin{cases} D = 15t \\ 70 - D = 20t \end{cases}$$

$70 - 15t = 20t$
$70 = 35t$
$2 = t$
2 hours

## 2.3 Exercises

1. $-\frac{7}{4}$; (0, 3)

2. Cost; time

3. 2.5

4. Point-slope

5. Answers will vary.

6. Answers will vary.

7. $4x + 5y = 10$
$5y = -4x + 10$
$y = -\frac{4}{5}x + 2$

| x | $y = -\frac{4}{5}x + 2$ |
|---|---|
| $-5$ | $y = -\frac{4}{5}(-5) + 2 = 4 + 2 = 6$ |
| $-2$ | $y = -\frac{4}{5}(-2) + 2 = \frac{8}{5} + 2 = \frac{18}{5}$ |
| 0 | $y = -\frac{4}{5}(0) + 2 = 0 + 2 = 2$ |
| 1 | $y = -\frac{4}{5}(1) + 2 = -\frac{4}{5} + 2 = \frac{6}{5}$ |
| 3 | $y = -\frac{4}{5}(3) + 2 = -\frac{12}{5} + 2 = -\frac{2}{5}$ |

8. $3y-2x=9$
$3y=2x+9$
$y=\frac{2}{3}x+3$

| x | $y=\frac{2}{3}x+3$ |
|---|---|
| $-5$ | $y=\frac{2}{3}(-5)+3=-\frac{10}{3}+3=-\frac{1}{3}$ |
| $-2$ | $y=\frac{2}{3}(-2)+3=-\frac{4}{3}+3=\frac{5}{3}$ |
| 0 | $y=\frac{2}{3}(0)+3=0+3=3$ |
| 1 | $y=\frac{2}{3}(1)+3=\frac{2}{3}+3=\frac{11}{3}$ |
| 3 | $y=\frac{2}{3}(3)+3=2+3=5$ |

9. $-0.4x+0.2y=1.4$
$0.2y=0.4x+1.4$
$y=2x+7$

| x | $y=2x+7$ |
|---|---|
| $-5$ | $y=2(-5)+7=-10+7=-3$ |
| $-2$ | $y=2(-2)+7=-4+7=3$ |
| 0 | $y=2(0)+7=0+7=7$ |
| 1 | $y=2(1)+7=2+7=9$ |
| 3 | $y=2(3)+7=6+7=13$ |

10. $-0.2x+0.7y=-2.1$
$0.7y=0.2x-2.1$
$y=\frac{2}{7}x-3$

| x | $y=\frac{2}{7}x-3$ |
|---|---|
| $-5$ | $y=\frac{2}{7}(-5)-3=-\frac{10}{7}-3=-\frac{31}{7}$ |
| $-2$ | $y=\frac{2}{7}(-2)-3=-\frac{4}{7}-3=-\frac{25}{7}$ |
| 0 | $y=\frac{2}{7}(0)-3=0-3=-3$ |
| 1 | $y=\frac{2}{7}(1)-3=\frac{2}{7}-3=-\frac{19}{7}$ |
| 3 | $y=\frac{2}{7}(3)-3=\frac{6}{7}-3=-\frac{15}{7}$ |

11. $\frac{1}{3}x+\frac{1}{5}y=-1$
$\frac{1}{5}y=-\frac{1}{3}x-1$
$y=-\frac{5}{3}x-5$

| x | $y=-\frac{5}{3}x-5$ |
|---|---|
| $-5$ | $y=-\frac{5}{3}(-5)-5=\frac{25}{3}-5=\frac{10}{3}$ |
| $-2$ | $y=-\frac{5}{3}(-2)-5=\frac{10}{3}-5=-\frac{5}{3}$ |
| 0 | $y=-\frac{5}{3}(0)-5=0-5=-5$ |
| 1 | $y=-\frac{5}{3}(1)-5=-\frac{5}{3}-5=-\frac{20}{3}$ |
| 3 | $y=-\frac{5}{3}(3)-5=-5-5=-10$ |

12. $\frac{1}{7}y-\frac{1}{3}x=2$
$\frac{1}{7}y=\frac{1}{3}x+2$
$y=\frac{7}{3}x+14$

| x | $y=\frac{7}{3}x+14$ |
|---|---|
| $-5$ | $y=\frac{7}{3}(-5)+14=\frac{-35}{3}+14=\frac{7}{3}$ |
| $-2$ | $y=\frac{7}{3}(-2)+14=-\frac{14}{3}+14=\frac{28}{3}$ |
| 0 | $y=\frac{7}{3}(0)+14=0+14=14$ |
| 1 | $y=\frac{7}{3}(1)+14=\frac{7}{3}+14=\frac{49}{3}$ |
| 3 | $y=\frac{7}{3}(3)+14=7+14=21$ |

## 2.3 Exercises

13. $6x-3y=9$

$-3y=-6x+9$

$y=2x-3$

New Coefficient: 2
New Constant: $-3$

14. $9y-4x=18$

$9y=4x+18$

$y=\frac{4}{9}x+2$

New Coefficient: $\frac{4}{9}$

New Constant: 2

15. $-0.5x-0.3y=2.1$

$-0.3y=0.5x+2.1$

$y=\frac{-5}{3}x-7$

New Coefficient: $\frac{-5}{3}$

New Constant: $-7$

16. $-0.7x+0.6y=-2.4$

$0.6y=0.7x-2.4$

$y=\frac{7}{6}x-4$

New Coefficient: $\frac{7}{6}$

New Constant: $-4$

17. $\frac{5}{6}x+\frac{1}{7}y=-\frac{4}{7}$

$\frac{1}{7}y=-\frac{5}{6}x-\frac{4}{7}$

$y=-\frac{35}{6}x-4$

New Coefficient: $-\frac{35}{6}$

New Constant: $-4$

18. $\frac{7}{12}y-\frac{4}{15}x=\frac{7}{6}$

$\frac{7}{12}y=\frac{4}{15}x+\frac{7}{6}$

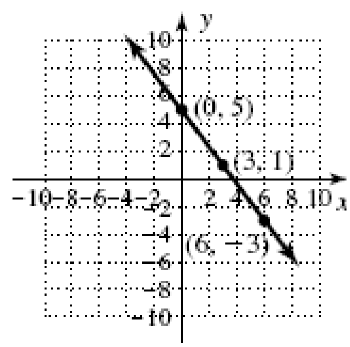
$y=\frac{16}{35}x+2$

New Coefficient: $\frac{16}{35}$

New Constant: 2

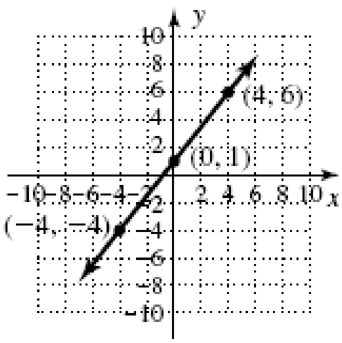
19. $y=-\frac{4}{3}x+5$

| x | $y=-\frac{4}{3}x+5$ |
|---|---|
| 0 | $y=-\frac{4}{3}(0)+5=0+5=5$ |
| 3 | $y=-\frac{4}{3}(3)+5=-4+5=1$ |
| 6 | $y=-\frac{4}{3}(6)+5=-8+5=-3$ |



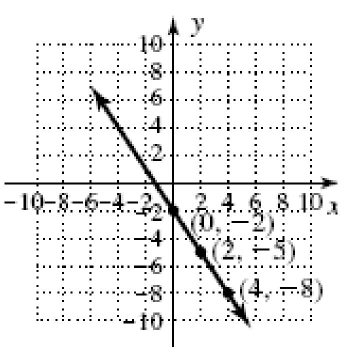
20. $y = \frac{5}{4}x + 1$

| x | $y = \frac{5}{4}x + 1$ |
|---|---|
| $-4$ | $y = \frac{5}{4}(-4) + 1 = -5 + 1 = -4$ |
| 0 | $y = \frac{5}{4}(0) + 1 = 0 + 1 = 1$ |
| 4 | $y = \frac{5}{4}(4) + 1 = 5 + 1 = 6$ |



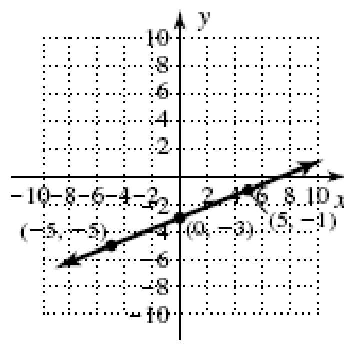

21. $y = -\frac{3}{2}x - 2$

| x | $y = -\frac{3}{2}x - 2$ |
|---|---|
| 0 | $y = -\frac{3}{2}(0) - 2 = 0 - 2 = -2$ |
| 2 | $y = -\frac{3}{2}(2) - 2 = -3 - 2 = -5$ |
| 4 | $y = -\frac{3}{2}(4) - 2 = -6 - 2 = -8$ |



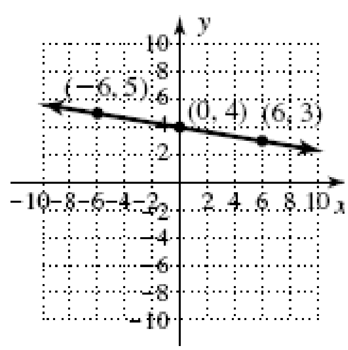

22. $y = \frac{2}{5}x - 3$

| x | $y = \frac{2}{5}x - 3$ |
|---|---|
| $-5$ | $y = \frac{2}{5}(-5) - 3 = -2 - 3 = -5$ |
| 0 | $y = \frac{2}{5}(0) - 3 = 0 - 3 = -3$ |
| 5 | $y = \frac{2}{5}(5) - 3 = 2 - 3 = -1$ |




23. $y = -\frac{1}{6}x + 4$

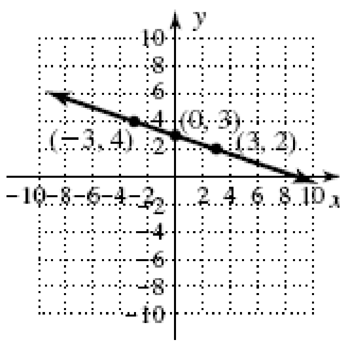
| x | $y = -\frac{1}{6}x + 4$ |
|---|---|
| $-6$ | $y = -\frac{1}{6}(-6) + 4 = 1 + 5 = 5$ |
| 0 | $y = -\frac{1}{6}(0) + 4 = 0 + 4 = 4$ |
| 6 | $y = -\frac{1}{6}(6) + 4 = -1 + 4 = 3$ |



## 2.3 Exercises

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

| x | $y=-\frac{1}{3}x+3$ |
|---|---|
| $-3$ | $y=-\frac{1}{3}(-3)+3=1+3=4$ |
| 0 | $y=-\frac{1}{3}(0)+3=0+3=3$ |
| 3 | $y=-\frac{1}{3}(3)+3=-1+3=2$ |




25. $3x+4y=12$

$x$-intercept: (4, 0)
$$3x+4(0)=12$$
$$3x=12$$
$$x=4$$

$y$-intercept: (0, 3)
$$3(0)+4y=12$$
$$4y=12$$
$$y=3$$

a. $m=\frac{0-3}{4-0}=-\frac{3}{4}$

b. $y=-\frac{3}{4}x+3$

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

26. $3y-2x=-6$

$x$-intercept: (3, 0)
$$3(0)-2x=-6$$
$$-2x=-6$$
$$x=3$$

$y$-intercept: (0, $-2$)
$$3y-2(0)=-6$$
$$3y=-6$$
$$y=-2$$

a. $m=\frac{0-(-2)}{3-0}=\frac{2}{3}$

b. $y=\frac{2}{3}x-2$

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

27. $2x-5y=10$

$x$-intercept: (5, 0)
$$2x-5(0)=10$$
$$2x=10$$
$$x=5$$

$y$-intercept: (0, $-2$)
$$2(0)-5y=10$$
$$-5y=10$$
$$y=-2$$

a. $m=\frac{0-(-2)}{5-0}=\frac{2}{5}$

b. $y=\frac{2}{5}x-2$

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

28. $2x+3y=9$

$x$-intercept: $\left(\frac{9}{2},0\right)$
$$2x+3(0)=9$$
$$2x=9$$
$$x=\frac{9}{2}$$

$y$-intercept: (0, 3)
$$2(0)+3y=9$$
$$3y=9$$
$$y=3$$

a. $m=\frac{0-3}{\frac{9}{2}-0}=\frac{-3}{\frac{9}{2}}=-\frac{6}{9}=-\frac{2}{3}$

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

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

29. $4x-5y=-15$

$x$-intercept: $\left(-\frac{15}{4},0\right)$ $y$-intercept: (0, 3)

$$4x-5(0)=-15$$
$$4x=-15$$
$$x=-\frac{15}{4}$$
$$4(0)-5y=-15$$
$$-5y=-15$$
$$y=3$$

a. $m=\dfrac{0-3}{-\frac{15}{4}-0}=\dfrac{-3}{-\frac{15}{4}}=\dfrac{12}{15}=\dfrac{4}{5}$

b. $y=\frac{4}{5}x+3$

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

30. $5y+6x=-25$

$x$-intercept: $\left(-\frac{25}{6},0\right)$ $y$-intercept: $(0,\ -5)$

$$5(0)+6x=-25$$
$$6x=-25$$
$$x=-\frac{25}{6}$$
$$5y+6(0)=-25$$
$$5y=-25$$
$$y=-5$$

a. $m=\dfrac{0-(-5)}{-\frac{25}{6}-0}=\dfrac{5}{-\frac{25}{6}}=-\dfrac{30}{25}=-\dfrac{6}{5}$

b. $y=-\frac{6}{5}x-5$

c. The coefficient of $x$ is the slope and the constant is the $y$-intercept.

31. $2x+3y=6$

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

$m=-\frac{2}{3}$; $y$-intercept (0, 2)

32. $4y-3x=12$

$$4y=3x+12$$
$$y=\frac{3}{4}x+3$$

$m=\frac{3}{4}$; $y$-intercept (0, 3)

33. $5x+4y=20$

$$4y=-5x+20$$
$$y=-\frac{5}{4}x+5$$

$m=-\frac{5}{4}$; $y$-intercept (0, 5)

34. $y+2x=4$

$$y=-2x+4$$

$m=-2$; $y$-intercept (0, 4)

35. $x=3y$

$$y=\frac{1}{3}x$$

$m=\frac{1}{3}$; $y$-intercept (0, 0)

36. $2x=-5y$

$$y=-\frac{2}{5}x$$

$m=-\frac{2}{5}$; $y$-intercept (0, 0)

37. $3x+4y-12=0$

$$4y=-3x+12$$
$$y=-\frac{3}{4}x+3$$

$m=-\frac{3}{4}$; $y$-intercept (0, 3)

38. $5y-3x+20=0$

$$5y=3x-20$$
$$y=\frac{3}{5}x-4$$

$m=\frac{3}{5}$; $y$-intercept (0, -4)

## 2.3 Exercises

39. $m = \frac{2}{3}$; $y$-intercept (0, 1)

$$y = mx + b$$
$$y = \frac{2}{3}x + 1$$

40. $m = -\frac{2}{5}$; $y$-intercept (0, 3)

$$y = mx + b$$
$$y = -\frac{2}{5}x + 3$$

41. $m = 3$; $y$-intercept (0, 3)

$$y = mx + b$$
$$y = 3x + 3$$

42. $m = -2$; $y$-intercept (0, $-3$)

$$y = mx + b$$
$$y = -2x - 3$$

43. $m = 3$; $y$-intercept (0, 2)

$$y = mx + b$$
$$y = 3x + 2$$

44. $m = -\frac{3}{2}$; $y$-intercept (0, $-4$)

$$y = mx + b$$
$$y = -\frac{3}{2}x - 4$$

45. $m = 250$; (14, 4000)

$$y - y_1 = m(x - x_1)$$
$$y - 4000 = 250(x - 14)$$
$$y - 4000 = 250x - 3500$$
$$y = 250x + 500$$
$$f(x) = 250x + 500$$

46. $m = -100$; (7, 1200)

$$y - y_1 = m(x - x_1)$$
$$y - 1200 = -100(x - 7)$$
$$y - 1200 = -100x + 700$$
$$y = -100x + 1900$$
$$f(x) = -100x + 1900$$

47. $m = \frac{75}{2}$; (24,1050)

$$y - y_1 = m(x - x_1)$$
$$y - 1050 = \frac{75}{2}(x - 24)$$
$$y - 1050 = \frac{75}{2}x - 900$$
$$y = \frac{75}{2}x + 150$$
$$f(x) = \frac{75}{2}x + 150$$

48. $m = -4$; ($-3$, 2)

$$y - y_1 = m(x - x_1)$$
$$y - 2 = -4(x + 3)$$
$$y - 2 = -4x - 12$$
$$y = -4x - 10$$

49. $m = 2$; (5, $-3$)

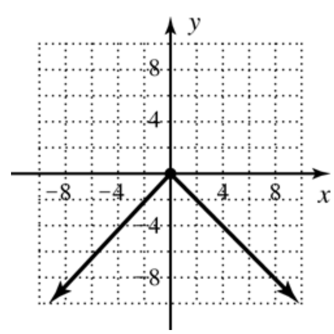
$$y - y_1 = m(x - x_1)$$
$$y + 3 = 2(x - 5)$$
$$y + 3 = 2x - 10$$
$$y = 2x - 13$$

50. $m = -\frac{3}{2}$; ($-4$, 7)

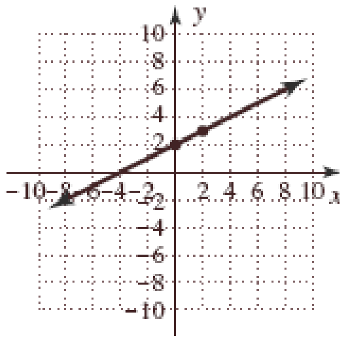
$$y - y_1 = m(x - x_1)$$
$$y - 7 = -\frac{3}{2}(x + 4)$$
$$y - 7 = -\frac{3}{2}x - 6$$
$$y = -\frac{3}{2}x + 1$$

51. $3x + 5y = 20$

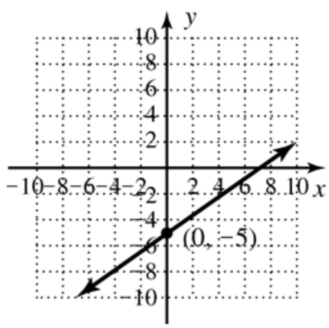
$$5y = -3x + 20$$
$$y = -\frac{3}{5}x + 4$$



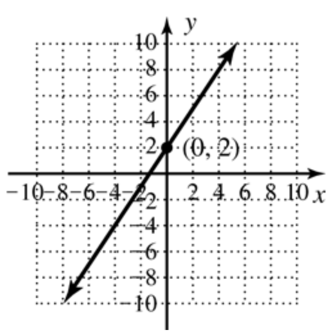
52. $2y - x = 4$
$2y = x + 4$
$y = \frac{1}{2}x + 2$




53. $2x - 3y = 15$
$-3y = -2x + 15$
$y = \frac{2}{3}x - 5$

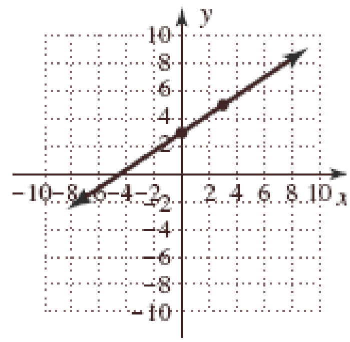



54. $-3x + 2y = 4$
$2y = 3x + 4$
$y = \frac{3}{2}x + 2$



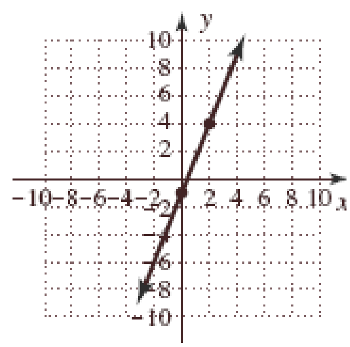

55. $y = \frac{2}{3}x + 3$

$m = \frac{2}{3}$; *y*-intercept (0, 3)



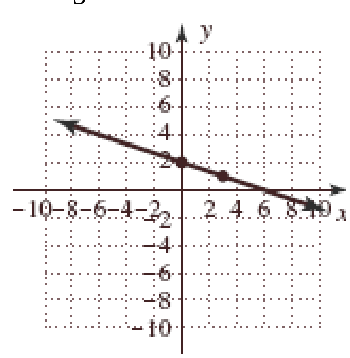

56. $y = \frac{5}{2}x - 1$

$m = \frac{5}{2}$; *y*-intercept (0, -1)




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

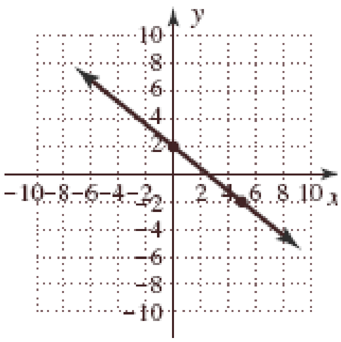
$m = \frac{-1}{3}$; *y*-intercept (0, 2)



## 2.3 Exercises

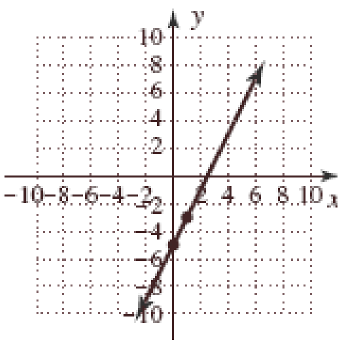
58. $y = -\frac{4}{5}x + 2$

$m = -\frac{4}{5}$; $y$-intercept $(0, 2)$



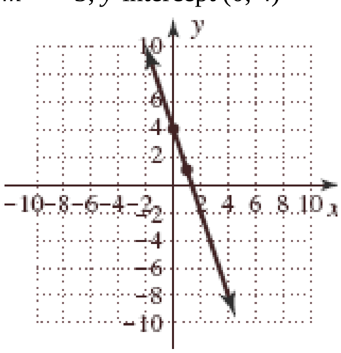
59. $y = 2x - 5$

$m = 2$; $y$-intercept $(0, -5)$



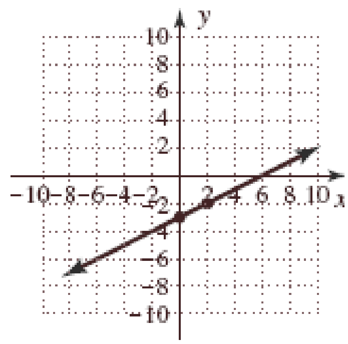
60. $y = -3x + 4$

$m = -3$; $y$-intercept $(0, 4)$



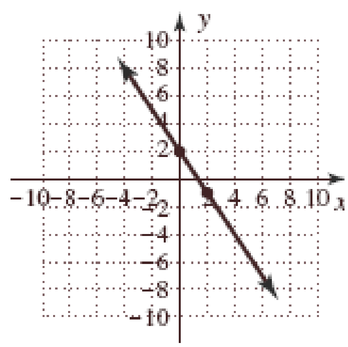
61. $f(x) = \frac{1}{2}x - 3$

$m = \frac{1}{2}$; $y$-intercept $(0, -3)$



62. $f(x) = -\frac{3}{2}x + 2$

$m = -\frac{3}{2}$; $y$-intercept $(0, 2)$



63. $2x - 5y = 10$

$$-5y = -2x + 10$$

$$y = \frac{2}{5}x - 2$$

$m = \frac{2}{5}$; $(-5, 2)$

$$y - y_1 = m(x - x_1)$$

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

$$y - 2 = \frac{2}{5}x + 2$$

$$y = \frac{2}{5}x + 4$$

64. $6x+9y=27$
$9y=-6x+27$
$y=-\frac{2}{3}x+3$
$m=-\frac{2}{3}$; $(-3,\ -5)$;
$y-y_1=m(x-x_1)$
$y+5=-\frac{2}{3}(x+3)$
$y+5=-\frac{2}{3}x-2$
$y=-\frac{2}{3}x-7$

65. $5y-3x=9$
$5y=3x+9$
$y=\frac{3}{5}x+\frac{9}{5}$
$m=-\frac{5}{3}$; $(6,\ -3)$;
$y-y_1=m(x-x_1)$
$y-(-3)\equiv-\frac{5}{3}(x-6)$
$y+3=-\frac{5}{3}x+10$
$y=-\frac{5}{3}x+7$

66. $x-4y=7$
$-4y=-x+7$
$y=\frac{1}{4}x-\frac{7}{4}$
$m=-4$; $(-5,\ 3)$
$y-y_1=m(x-x_1)$
$y-3=-4(x+5)$
$y-3=-4x-20$
$y=-4x-17$

67. $12x+5y=65$
$5y=-12x+65$
$y=-\frac{12}{5}x+13$
$m=-\frac{12}{5}$; $(-2,\ -1)$
$y-y_1=m(x-x_1)$
$y+1=-\frac{12}{5}(x+2)$
$y+1=-\frac{12}{5}x-\frac{24}{5}$
$y=-\frac{12}{5}x-\frac{29}{5}$

68. $15y-8x=50$
$15y=8x+50$
$y=\frac{8}{15}x+\frac{10}{3}$
$m=\frac{8}{15}$; $(3,\ -4)$
$y-y_1=m(x-x_1)$
$y+4=\frac{8}{15}(x-3)$
$y+4=\frac{8}{15}x-\frac{24}{15}$
$y=\frac{8}{15}x-\frac{28}{5}$

69. $y=-3$ has slope of zero.
Slope of any line parallel to this line has the same slope, 0.
$y=mx+b$
$5=0(2)+b$
$5=b$;
$y=0x+5$
$y=5$

70. $y=-3$ has slope of zero.
Slope of any line perpendicular to this line has an undefined slope. Thus, it is a vertical line. Equation of the vertical line passing through (2, 5): $x=2$

# 2.3 Exercises

71. $4y - 5x = 8$
$4y = 5x + 8$
$y = \frac{5}{4}x + 2$;
$5y + 4x = -15$
$5y = -4x - 15$
$y = -\frac{4}{5}x - 3$
perpendicular

72. $3y - 2x = 6$
$3y = 2x + 6$
$y = \frac{2}{3}x + 2$;
$-2x + 3y = -3$
$3y = 2x - 3$
$y = \frac{2}{3}x - 1$
parallel

73. $2x - 5y = 20$
$-5y = -2x + 20$
$y = \frac{2}{5}x - 4$;
$4x - 3y = 18$
$-3y = -4x + 18$
$y = \frac{4}{3}x - 6$
Neither

74. $5y = 11x + 135$
$y = \frac{11}{5}x + 27$;
$11y + 5x = -77$
$11y = -5x - 77$
$y = -\frac{5}{11}x - 7$
Perpendicular; slopes are opposite reciprocals.

75. $-4x + 6y = 12$
$6y = 4x + 12$
$y = \frac{2}{3}x + 2$;
$2x + 3y = 6$
$3y = -2x + 6$
$y = -\frac{2}{3}x + 2$
Neither

76. $3x + 4y = 12$
$4y = -3x + 12$
$y = -\frac{3}{4}x + 3$;
$6x + 8y = 2$
$8y = -6x + 2$
$y = -\frac{3}{4}x + \frac{1}{4}$
Parallel; slopes are the same.

77. $(0,1), (4,-2)$
$m = \frac{-2-1}{4-0} = -\frac{3}{4}$

a. $y - (-4) = -\frac{3}{4}(x - 2)$
$y + 4 = -\frac{3}{4}x + \frac{3}{2}$
$y = -\frac{3}{4}x - \frac{5}{2}$

b. $y - (-4) = \frac{4}{3}(x - 2)$
$y + 4 = \frac{4}{3}x - \frac{8}{3}$
$y = \frac{4}{3}x - \frac{20}{3}$

78. $(-2,2),(3,0)$

$m=\frac{0-2}{3-(-2)}=\frac{-2}{5}$

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

$y-3=\frac{-2}{5}x+\frac{2}{5}$

$y=\frac{-2}{5}x+\frac{17}{5}$

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

$y-3=\frac{5}{2}x-\frac{5}{2}$

$y=\frac{5}{2}x+\frac{1}{2}$

79. $(-4,0),(5,4)$

$m=\frac{4-0}{5-(-4)}=\frac{4}{9}$

a. $y-3=\frac{4}{9}(x-(-1))$

$y-3=\frac{4}{9}(x+1)$

$y-3=\frac{4}{9}x+\frac{4}{9}$

$y=\frac{4}{9}x+\frac{31}{9}$

b. $y-3=\frac{-9}{4}(x-(-1))$

$y-3=\frac{-9}{4}(x+1)$

$y-3=\frac{-9}{4}x-\frac{9}{4}$

$y=\frac{-9}{4}x+\frac{3}{4}$

80. $(-2,4),(4,0)$

$m=\frac{0-4}{4-(-2)}=\frac{-4}{6}=\frac{-2}{3}$

a. $y-(-2.5)=\frac{-2}{3}(x-1)$

$y+\frac{5}{2}=\frac{-2}{3}x+\frac{2}{3}$

$y=\frac{-2}{3}x-\frac{11}{6}$

b. $y-(-2.5)=\frac{3}{2}(x-1)$

$y+\frac{5}{2}=\frac{3}{2}x-\frac{3}{2}$

$y=\frac{3}{2}x-4$

81. $(-2,3),(4,0)$

$m=\frac{0-3}{4-(-2)}=\frac{-3}{6}=\frac{-1}{2}$

a. $y-(-2)=\frac{-1}{2}(x-0)$

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

$y=\frac{-1}{2}x-2$

b. $y-(-2)=2(x-0)$

$y+2=2x$

$y=2x-2$

82. $(-3,5),(2,0)$

$m=\frac{0-5}{2-(-3)}=\frac{-5}{5}=-1$

a. $y-3=-1(x-1)$

$y-3=-1x+1$

$y=-x+4$

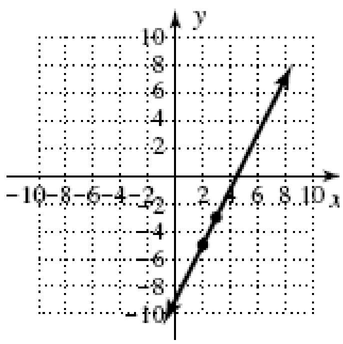
b. $y-3=1(x-1)$

$y-3=x-1$

$y=x+2$

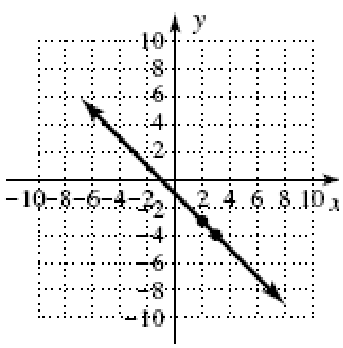
83. $m = 2;\ P_1 = (2,-5)$

$$y - y_1 = m(x - x_1)$$
$$y + 5 = 2(x - 2)$$
$$y + 5 = 2x - 4$$
$$y = 2x - 9$$



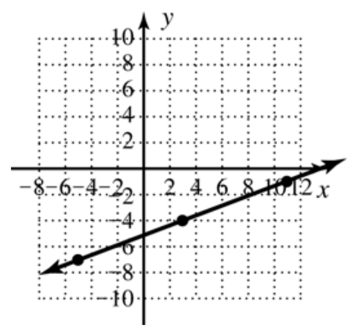

84. $m = -1;\ P_1 = (2,-3)$

$$y - y_1 = m(x - x_1)$$
$$y + 3 = -1(x - 2)$$
$$y + 3 = -x + 2$$
$$y = -x - 1$$
$$f(x) = -x - 1$$



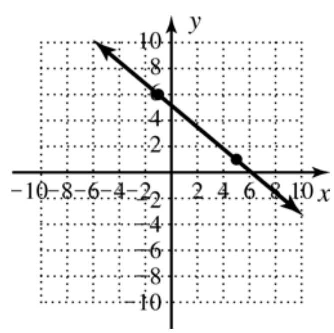

85. $P_1(3,-4), P_2(11,-1)$

$$m = \frac{-1-(-4)}{11-3} = \frac{3}{8};$$
$$y - y_1 = m(x - x_1)$$
$$y - (-4) = \frac{3}{8}(x - 3)$$
$$y + 4 = \frac{3}{8}x - \frac{9}{8}$$
$$y = \frac{3}{8}x - \frac{41}{8}$$



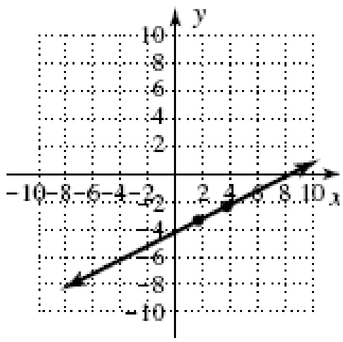

86. $P_1(-1,6), P_2(5,1)$

$$m = \frac{1-6}{5-(-1)} = -\frac{5}{6};$$
$$y - y_1 = m(x - x_1)$$
$$y - 1 = -\frac{5}{6}(x - 5)$$
$$y - 1 = -\frac{5}{6}x + \frac{25}{6}$$
$$y = -\frac{5}{6}x + \frac{31}{6}$$



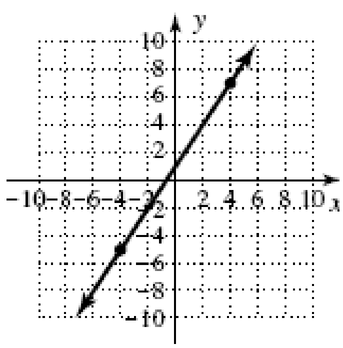
87. $m = 0.5$; $P_1 = (1.8, -3.1)$

$$y - y_1 = m(x - x_1)$$
$$y + 3.1 = 0.5(x - 1.8)$$
$$y + 3.1 = 0.5x - 0.9$$
$$y = 0.5x - 4$$



88. $m = 1.5$; $P_1 = (-0.75, -0.125)$

$$y - y_1 = m(x - x_1)$$
$$y + 0.125 = 1.5(x + 0.75)$$
$$y + 0.125 = 1.5x + 1.125$$
$$y = 1.5x + 1$$



89. $m = \frac{6}{5}$; (4, 2)

$$y - y_1 = m(x - x_1)$$
$$y - 2 = \frac{6}{5}(x - 4)$$

For each 5000 additional sales, income rises $6000.

90. $m = -\frac{3}{2}$; (3, 9)

$$y - y_1 = m(x - x_1)$$
$$y - 9 = -\frac{3}{2}(x - 3)$$

Every two years, 30,000 typewriters are no longer in service.

91. $m = -20$; (0.5, 100)

$$y - y_1 = m(x - x_1)$$
$$y - 100 = -20(x - 0.5)$$

For every hour of television, a student's final grade falls 20%.

92. $m = \frac{3}{7}$; (2, 3)

$$y - y_1 = m(x - x_1)$$
$$y - 3 = \frac{3}{7}(x - 2)$$

Every 7000 investors increases the number of online brokerage houses by 3.

93. $m = \frac{35}{2}$; (0.5, 10)

$$y - y_1 = m(x - x_1)$$
$$y - 10 = \frac{35}{2}(x - 0.5)$$

Every 2 inches of rainfall increases the number of cattle raised per acre by 35.

94. $m = \frac{2}{5}$; (60, 2)

$$y - y_1 = m(x - x_1)$$
$$y - 2 = \frac{2}{5}(x - 60)$$

For every 5° rise in temperature, there are 2 additional eggs per hen per week.

95. C

96. H

97. A

98. F

99. B

100. G

101. D

102. E

103. $ax + by = c$

$by = -ax + c$

$y = -\frac{a}{b}x + \frac{c}{b};$

Slope $-\frac{a}{b}$, $y$-intercept $\left(0, \frac{c}{b}\right)$

a. $3x + 4y = 8$

$m = -\frac{a}{b} = -\frac{3}{4};$

$y - \text{int} = \frac{c}{b} = \frac{8}{4} = 2$, $(0,2)$

b. $2x + 5y = -15$

$m = -\frac{a}{b} = -\frac{2}{5};$

$y - \text{int} = \frac{c}{b} = -\frac{15}{5} = -3$, $(0,-3)$

c. $5x - 6y = -12$

$m = -\frac{5}{-6} = \frac{5}{6};$

$y - \text{int} = \frac{c}{b} = \frac{-12}{-6} = 2$, $(0,2)$

d. $3y - 5x = 9$

$m = -\frac{a}{b} = -\frac{-5}{3} = \frac{5}{3};$

$y - \text{int} = \frac{c}{b} = \frac{9}{3} = 3$, $(0,3)$

104.a. $2x + 5y = 10$

$\frac{2}{10}x + \frac{5}{10}y = \frac{10}{10}$

$\frac{x}{5} + \frac{y}{2} = 1$

$x$-intercept: $(5, 0)$
$y$-intercept: $(0, 2)$

b. $3x - 4y = -12$

$\frac{3}{-12}x - \frac{4}{-12}y = \frac{-12}{-12}$

$\frac{x}{-4} + \frac{y}{3} = 1$

$x$-intercept: $(-4, 0)$
$y$-intercept: $(0, 3)$

c. $5x + 4y = 8$

$\frac{5}{8}x + \frac{4}{8}y = \frac{8}{8}$

$\frac{x}{\frac{8}{5}} + \frac{y}{2} = 1$

$x$-intercept: $\left(\frac{8}{5}, 0\right)$

$y$-intercept: $(0, 2)$

Slope $m$ is always equal to $\frac{-k}{h}$.

105.a. As the temperature increases 5˚C, the velocity of sound waves increases 3 m/s. At a temperature of 0˚C, the velocity is 331 m/s.

b. $V(20) = \frac{3}{5}(20) + 331 = 343 \text{ m/s}$

c. $361 = \frac{3}{5}C + 331$

$30 = \frac{3}{5}C$

$50 = C$

50˚C

106.a. Every 5 seconds the velocity is increasing 26 ft/sec. The initial velocity is 60 ft/sec.

b. $V(9.4) = \frac{26}{5}(9.4) + 60 = 108.88 \text{ ft/sec}$

c. $100 = \frac{26}{5}t + 60$

$40 = \frac{26}{5}t$

$7.7 \approx t$

Approximately 7.7 seconds

107\. a. $m = \frac{190 - 150}{6 - 0} = \frac{40}{6} = \frac{20}{3}$

$V(t) = \frac{20}{3}t + 150$

b. Every three years, the coin increased in value by \$20. The initial value was \$150.

108\. a. $m = \frac{11500 - 18500}{2 - 0} = \frac{-7000}{2} = -3500$

$V(t) = -3500t + 18500$

b. Every year the equipment decreases in value by \$3500. Its initial value was \$18500.

c. $V(4) = -3500(4) + 18500 = \$4500$

d. $6000 = -3500t + 18500$

$-12500 = -3500t$

$3.6 \approx t$

About 3.6 yr

e. $1000 = -3500t + 18500$

$-17000 = -3500t$

$5 \approx t$

About 5 yr

109\. a. $m = \frac{51 - 9}{2001 - 1995} = \frac{42}{6} = 7$

$N(t) = 7t + 9$

b. Every 1 year, the number of homes hooked to the internet increases by 7 million.

c. $0 = 7t + 9$

$-9 = 7t$

$-\frac{9}{7} = t$

$-1.29 = t$

1.29 years prior to 1995 is 1993.

110\. a. $m = \frac{146 - 72}{2000 - 1995} = \frac{74}{5} = 14.8$

$N(t) = 14.8t + 72$

b. Every 1 year, sales increase by \$14.8 billion dollars.

c. $250 = 14.8t + 72$

$178 = 14.8t$

$12.03 = t$

12.03 years after 1995 is 2007.

111 $m = \frac{1320000 - 740000}{2000 - 1990}$

$= \frac{580000}{10} = 58000$

$P(t) = 58000t + 740000$

Grows 58,000 every year.

$P(17) = 58000(17) + 740000 = 1726000$

112\. a. $m = \frac{170 - 143}{2000 - 1990} = \frac{27}{10} = 2.7$

$M(t) = 2.7t + 143$

b. Every year, the number of restaurant meals increases by about 3 meals.

c. $M(16) = 2.7(16) + 143 = 186.2$

About 186 meals per year.

113\. Answers will vary.

114\. Graph 1: D
Graph 2: A
Graph 3: C
Graph 4: B
Graph 5: F
Graph 6: H

115.a. $ax + by = c$

Find $x$-intercept by letting $y = 0$.

$ax + b(0) = c$

$x = \frac{c}{a}$

$\left(\frac{c}{a}, 0\right)$;

Find $y$-intercept by letting $x = 0$.

$a(0) + by = c$

$y = \frac{c}{b}$

$\left(0, \frac{c}{b}\right)$

The intercept method works most efficiently when a and b are factors of c.

b. Solve $ax + by = c$ for $y$.

$ax + by = c$

$by = -ax + c$

$y = -\frac{a}{b}x + \frac{c}{b}$;

$m = -\frac{a}{b}$; $y-$intercept $\left(0, \frac{c}{b}\right)$

The slope-intercet method works most efficiently when b is a factor of c.

116.a. $y = \sqrt{2x-5}$

$2x - 5 \geq 0$

$2x \geq 5$

$x \geq \frac{5}{2}$

$x \in \left[\frac{5}{2}, \infty\right)$

b. $y = \frac{5}{2x^2 + 3x - 2}$

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

$(2x-1)(x+2) = 0$

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

$x \in (-\infty, -2) \cup \left(-2, \frac{1}{2}\right) \cup \left(\frac{1}{2}, \infty\right)$

117. $3x^2 - 10x = 9$

$3x^2 - 10 - 9 = 0$

$x = \frac{10 \pm \sqrt{(-10)^2 - 4(3)(-9)}}{2(3)}$

$x = \frac{10 \pm \sqrt{100 + 108}}{6}$

$x = \frac{10 \pm \sqrt{208}}{6}$

$x = \frac{10 \pm 4\sqrt{13}}{6}$

$x = \frac{5 \pm 2\sqrt{13}}{3}$

$x \approx 4.07$ or $x \approx -0.74$

118. $2(x-5) + 13 - 1 = 9 - 7 + 2x$

$2x - 10 + 13 - 1 = 2 + 2x$

$2x + 2 = 2 + 2x$

Identity;

$2(x-4) + 13 - 1 = 9 + 7 - 2x$

$2x - 8 + 13 - 1 = 16 - 2x$

$2x + 4 = 16 - 2x$

$4x = 12$

$x = 3$

Has a solution; $x = 3$;

$2(x-5) + 13 - 1 = 9 + 7 + 2x$

$2x - 10 + 13 - 1 = 16 + 2x$

$2x + 2 = 16 + 2x$

Contradiction

119. $A = \pi r^2$

| Larger circle: | Smaller Circle |
|---|---|
| $A = \pi(10)^2$ | $A = \pi(8)^2$ |
| $A = 100\pi$ | $A = 64\pi$ |

$100\pi - 64\pi = 36\pi \approx 113.10 \text{ yds}^2$

## 2.4 Exercises

1. First

2. Domain; exactly one

3. Range

4. $f(3) = -5$

5. Answers will vary.

6. Answers will vary.

7. Function

8. Function

9. Not a function. The Shaq is paired with two heights.

10. Not a function. Canada is paired with 2 languages and Brazil is paired with 2.

11. Not a function, 4 is paired with 2 and $-5$.

12. Not a function, $-5$ is paired with 3 and 7.

13. Function

14. Function

15. Function

16. Function

17. Not a function, $-2$ is paired with 3 and $-4$.

18. Not a function, 3 is paired with 3 and $-2$.

19. Function

20. Function

21. Function

22. Function

23. Not a function, 0 is paired with 4 and $-4$.

24. Not a function, 2 is paired with $-2$ and 2.

25. Function

26. Function

27. Not a function, 5 is paired with $-1$ and 1.

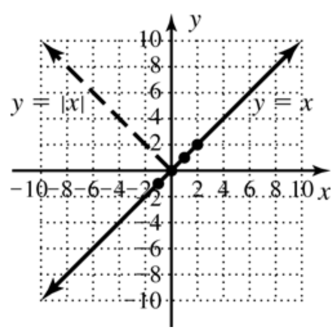
28. Not a function, 0 is paired with 4 and $-4$.

29. Function

30. Function

31.

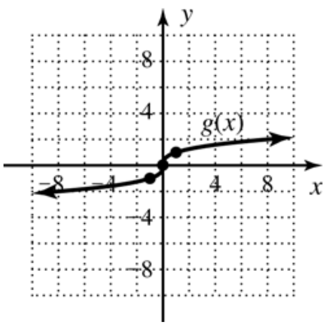
| x | $y = x$ |
|---|---|
| $-2$ | $y = -2$ |
| $-1$ | $y = -1$ |
| 0 | $y = 0$ |
| 1 | $y = 1$ |
| 2 | $y = 2$ |




Function

32.

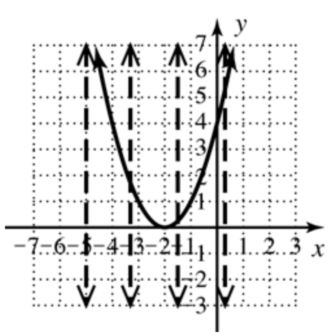
| x | $y=\sqrt[3]{x}$ |
|---|---|
| $-8$ | $y=\sqrt[3]{-8}=-2$ |
| $-1$ | $y=\sqrt[3]{-1}=-1$ |
| 0 | $y=\sqrt[3]{0}=0$ |
| 1 | $y=\sqrt[3]{1}=1$ |
| 8 | $y=\sqrt[3]{8}=2$ |




Function

33.

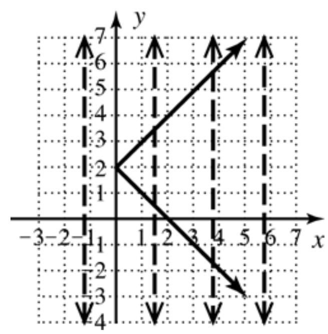
| x | $y=(x+2)^2$ |
|---|---|
| $-4$ | $y=(-4+2)^2=4$ |
| $-3$ | $y=(-3+2)^2=1$ |
| $-2$ | $y=(-2+2)^2=0$ |
| $-1$ | $y=(-1+2)^2=1$ |
| 0 | $y=(0+2)^2=4$ |
| 1 | $y=(1+2)^2=9$ |




Function

34.

| x | $x=\lvert y-2\rvert$ |
|---|---|
| 2 | $2=\lvert y-2\rvert$<br>$y-2=2$ or $y-2=-2$<br>$y=4$ or $y=0$ |
| 1 | $1=\lvert y-2\rvert$<br>$y-2=1$ or $y-2=-1$<br>$y=3$ or $y=1$ |
| 0 | $0=\lvert y-2\rvert$<br>$y-2=0$<br>$y=2$ |




Not a Function

35. Function; $x\in[-4,-5]$ $y\in[-2,3]$

36. Function; $x\in[-4,\infty)$ $y\in(-\infty,5]$

37. Function; $x\in[-4,\infty)$ $y\in[-4,\infty)$

38. Not a Function; $x\in[0,3]$ $y\in[-4,4]$

39. Function; $x\in[-4,4]$ $y\in[-5,-1]$

40. Function; $x\in(-\infty,\infty)$ $y\in(-\infty,\infty)$

41. Function; $x\in(-\infty,\infty)$ $y\in(-\infty,\infty)$

42. Not a function; $x\in[-3,4]$ $y\in[-3,4]$

43. Not a function; $x\in[-3,5]$ $y\in[-3,3]$

44. Function; $x \in (-\infty, \infty)$ $y \in [-3, \infty)$

45. Not a function; $x \in (-\infty, 3]$ $y \in (-\infty, \infty)$

46. Function; $x \in [-4, \infty)$ $y \in [0, \infty)$

47. $f(x) = \dfrac{3}{x-5}$

$x - 5 = 0$

$x = 5$

$x \in (-\infty, 5) \cup (5, \infty)$

48. $g(x) = \dfrac{-2}{3+x}$

$3 + x = 0$

$x = -3$

$x \in (-\infty, -3) \cup (-3, \infty)$

49. $h(a) = \sqrt{3a+5}$

$3a + 5 \geq 0$

$3a \geq -5$

$a \geq -\dfrac{5}{3}$

$a \in \left[-\dfrac{5}{3}, \infty\right)$

50. $p(a) = \sqrt{5a-2}$

$5a - 2 \geq 0$

$5a \geq 2$

$a \geq \dfrac{2}{5}$

$a \in \left[\dfrac{2}{5}, \infty\right)$

51. $v(x) = \dfrac{x+2}{x^2-25}$

$x^2 - 25 = 0$

$x^2 = 25$

$x = \pm 5$

$x \in (-\infty, -5) \cup (-5, 5) \cup (5, \infty)$

52. $w(x) = \dfrac{x-4}{x^2-49}$

$x^2 - 49 = 0$

$x^2 = 49$

$x = \pm 7$

$x \in (-\infty, -7) \cup (-7, 7) \cup (7, \infty)$

53. $u = \dfrac{v-5}{v^2-18}$

$v^2 - 18 = 0$

$v^2 = 18$

$v = \pm 3\sqrt{2}$

$v \in \left(-\infty, -3\sqrt{2}\right) \cup \left(-3\sqrt{2}, 3\sqrt{2}\right) \cup \left(3\sqrt{2}, \infty\right)$

54. $p = \dfrac{q+7}{q^2-12}$

$q^2 - 12 = 0$

$q^2 = 12$

$q = \pm 2\sqrt{3}$

$q \in \left(-\infty, -2\sqrt{3}\right) \cup \left(-2\sqrt{3}, 2\sqrt{3}\right) \cup \left(2\sqrt{3}, \infty\right)$

55. $y = \dfrac{17}{25}x + 123$

$x \in (-\infty, \infty)$

56. $y = \dfrac{11}{19}x - 89$

$x \in (-\infty, \infty)$

57. $m = n^2 - 3n - 10$

$n \in (-\infty, \infty)$

58. $s = t^2 - 3t - 10$

$t \in (-\infty, \infty)$

59. $y = 2|x| + 1$

$x \in (-\infty, \infty)$

60. $y = |x-2| + 3$

$x \in (-\infty, \infty)$

## 2.4 Exercises

61. $y_1 = \dfrac{x}{x^2 - 3x - 10}$

$x^2 - 3x - 10 = 0$
$(x-5)(x+2) = 0$
$x = 5$ or $x = -2$
$x \in (-\infty,-2) \cup (-2,5) \cup (5,\infty)$

62. $y_2 = \dfrac{x-4}{x^2 + 2x - 15}$

$x^2 + 2x - 15 = 0$
$(x+5)(x-3) = 0$
$x = -5$ or $x = 3$
$x \in (-\infty,-5) \cup (-5,3) \cup (3,\infty)$

63. $y = \dfrac{\sqrt{x-2}}{2x-5},\ x \ge 2$

$2x - 5 = 0$
$2x = 5$
$x = \dfrac{5}{2}$
$x \in \left[2, \dfrac{5}{2}\right) \cup \left(\dfrac{5}{2}, \infty\right)$

64. $y = \dfrac{\sqrt{x+1}}{3x+2},\ x \ge -1$

$3x + 2 = 0$
$3x = -2$
$x = -\dfrac{2}{3}$
$x \in \left[-1, -\dfrac{2}{3}\right) \cup \left(-\dfrac{2}{3}, \infty\right)$

65. $f(x) = \sqrt{\dfrac{5}{x-2}}$

Since the radicand must be non-negative, solve the inequality: $\dfrac{5}{x-2} \ge 0, x \ne 2$

Use test points to each side of 2.

If $x = 0, \dfrac{5}{0-2} \ge 0$ false

If $x = 3, \dfrac{5}{3-2} \ge 0$ true

Domain: $x \in (2,\infty)$

66. $g(x) = \sqrt{\dfrac{-4}{3-x}}$

Since the radicand must be non-negative, solve the inequality: $\dfrac{-4}{3-x} \ge 0, x \ne 3$

Use test points to each side of 3.

If $x = 0, \dfrac{-4}{3-0} \ge 0$ false

If $x = 4, \dfrac{-4}{3-4} \ge 0$ true

Domain: $x \in (3,\infty)$

67. $h(x) = \dfrac{-2}{\sqrt{4+x}}$

Since the radicand must be non-negative and the denominator cannot equal zero, solve the inequality: $4 + x > 0, x > -4$.

Domain: $x \in (-4,\infty)$

68. $p(x) = \dfrac{-7}{\sqrt{5-x}}$

Since the radicand must be non-negative and the denominator cannot equal zero, solve the inequality:
$5 - x > 0$
$-x > -5$ .
$x < 5$

Domain: $x \in (-\infty,5)$

69. $f(x) = \dfrac{1}{2}x + 3$

$f(-6) = \dfrac{1}{2}(-6) + 3 = -3 + 3 = 0$ ;

$f\left(\dfrac{3}{2}\right) = \dfrac{1}{2}\left(\dfrac{3}{2}\right) + 3 = \dfrac{3}{4} + 3 = \dfrac{15}{4}$ ;

$f(2c) = \dfrac{1}{2}(2c) + 3 = c + 3$

70. $f(x) = \dfrac{2}{3}x - 5$

$f(-6) = \dfrac{2}{3}(-6) - 5 = -4 - 5 = -9$ ;

$f\left(\dfrac{3}{2}\right) = \dfrac{2}{3}\left(\dfrac{3}{2}\right) - 5 = 1 - 5 = -4$ ;

$f(2c) = \dfrac{2}{3}(2c) - 5 = \dfrac{4}{3}c - 5$

71. $f(x) = 3x^2 - 4x$

$f(-6) = 3(-6)^2 - 4(-6) = 108 + 24 = 132$;

$f\left(\frac{3}{2}\right) = 3\left(\frac{3}{2}\right)^2 - 4\left(\frac{3}{2}\right) = 3\left(\frac{9}{4}\right) - 6$

$= \frac{27}{4} - 6 = \frac{3}{4}$;

$f(2c) = 3(2c)^2 - 4(2c) = 3(4c^2) - 8c$

$= 12c^2 - 8c$

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

$f(-6) = 2(-6)^2 + 3(-6) = 2(36) - 18$

$= 72 - 18 = 54$;

$f\left(\frac{3}{2}\right) = 2\left(\frac{3}{2}\right)^2 + 3\left(\frac{3}{2}\right) = 2\left(\frac{9}{4}\right) + \frac{9}{2}$

$= \frac{9}{2} + \frac{9}{2} = \frac{18}{2} = 9$;

$f(2c) = 2(2c)^2 + 3(2c) = 2(4c^2) + 6c$

$= 8c^2 + 6c$

73. $h(x) = \frac{3}{x}$

$h(3) = \frac{3}{(3)} = 1$;

$h\left(-\frac{2}{3}\right) = \frac{3}{\left(-\frac{2}{3}\right)} = -\frac{9}{2}$;

$h(3a) = \frac{3}{3a} = \frac{1}{a}$

74. $h(x) = \frac{2}{x^2}$

$h(3) = \frac{2}{(3)^2} = \frac{2}{9}$;

$h\left(-\frac{2}{3}\right) = \frac{2}{\left(-\frac{2}{3}\right)^2} = \frac{2}{\frac{4}{9}} = \frac{18}{4} = \frac{9}{2}$;

$h(3a) = \frac{2}{(3a)^2} = \frac{2}{9a^2}$

75. $h(x) = \frac{5|x|}{x}$

$h(3) = \frac{5|3|}{3} = \frac{5(3)}{3} = 5$;

$h\left(-\frac{2}{3}\right) = \frac{5\left|-\frac{2}{3}\right|}{-\frac{2}{3}} = \frac{5\left(\frac{2}{3}\right)}{-\frac{2}{3}} = -5$;

$h(3a) = \frac{5|3a|}{3a} = \frac{15|a|}{3a} = \frac{5|a|}{a}$;

$-5$ if $a < 0$; $5$ if $a > 0$

76. $h(x) = \frac{4|x|}{x}$

$h(3) = \frac{4|3|}{3} = \frac{4(3)}{3} = 4$;

$h\left(-\frac{2}{3}\right) = \frac{4\left|-\frac{2}{3}\right|}{-\frac{2}{3}} = \frac{4\left(\frac{2}{3}\right)}{-\frac{2}{3}} = -4$;

$h(3a) = \frac{4|3a|}{3a} = \frac{4(3)|a|}{3a} = \frac{4|a|}{a}$;

$-4$ if $a < 0$; $4$ if $a > 0$

77. $g(r) = 2\pi r$

$g(0.4) = 2\pi(0.4) = 0.8\pi$;

$g\left(\frac{9}{4}\right) = 2\pi\left(\frac{9}{4}\right) = \frac{9}{2}\pi$;

$g(h) = 2\pi(h) = 2\pi h$;

78. $g(r) = 2\pi rh$

$g(0.4) = 2\pi(0.4)h = 0.8\pi h$;

$g\left(\frac{9}{4}\right) = 2\pi\left(\frac{9}{4}\right)h = \frac{9}{2}\pi h$;

$g(h) = 2\pi(h)h = 2\pi h^2$

79. $g(r) = \pi r^2$

$g(0.4) = \pi(0.4)^2 = 0.16\pi$;

$g\left(\frac{9}{4}\right) = \pi\left(\frac{9}{4}\right)^2 = \frac{81}{16}\pi$;

$g(h) = \pi(h)^2 = \pi h^2$

## 2.4 Exercises

80. $g(r)=\pi r^2 h$

$g(0.4)=\pi(0.4)^2 h=0.16\pi h$ ;

$g\left(\frac{9}{4}\right)=\pi\left(\frac{9}{4}\right)^2 h=\frac{81}{16}\pi h$ ;

$g(h)=\pi(h)^2 h=\pi h^3$

81. $p(x)=\sqrt{2x+3}$

$p(0.5)=\sqrt{2(0.5)+3}=\sqrt{1+3}=\sqrt{4}=2$ ;

$p\left(\frac{9}{4}\right)=\sqrt{2\left(\frac{9}{4}\right)+3}=\sqrt{\frac{9}{2}+3}=\sqrt{\frac{15}{2}}=\frac{\sqrt{30}}{2}$ ;

$p(a)=\sqrt{2(a)+3}=\sqrt{2a+3}$

82. $p(x)=\sqrt{4x-1}$

$p(0.5)=\sqrt{4(0.5)-1}=\sqrt{2-1}=\sqrt{1}=1$ ;

$p\left(\frac{9}{4}\right)=\sqrt{4\left(\frac{9}{4}\right)-1}=\sqrt{9-1}=\sqrt{8}=2\sqrt{2}$ ;

$p(a)=\sqrt{4(a)-1}=\sqrt{4a-1}$

83. $p(x)=\frac{3x^2-5}{x^2}$

$p(0.5)=\frac{3(0.5)^2-5}{(0.5)^2}=\frac{3(0.25)-5}{0.25}$

$=\frac{0.75-5}{0.25}=\frac{-4.25}{0.25}=-17$

$p\left(\frac{9}{4}\right)=\frac{3\left(\frac{9}{4}\right)^2-5}{\left(\frac{9}{4}\right)^2}=\frac{3\left(\frac{81}{16}\right)-5}{\frac{81}{16}}$

$=\frac{\frac{243}{16}-5}{\frac{81}{16}}=\frac{\frac{163}{16}}{\frac{81}{16}}=\frac{163}{81}$ ;

$p(a)=\frac{3(a)^2-5}{(a)^2}=\frac{3a^2-5}{a^2}$

84. $p(x)=\frac{2x^2+3}{x^2}$

$p(0.5)=\frac{2(0.5)^2+3}{(0.5)^2}=\frac{2(0.25)+3}{0.25}$

$=\frac{0.5+3}{0.25}=\frac{3.5}{0.25}=14$ ;

$p\left(\frac{9}{4}\right)=\frac{2\left(\frac{9}{4}\right)^2+3}{\left(\frac{9}{4}\right)^2}=\frac{2\left(\frac{81}{16}\right)+3}{\frac{81}{16}}$

$=\frac{\frac{81}{8}+3}{\frac{81}{16}}=\frac{\frac{105}{8}}{\frac{81}{16}}=\frac{210}{81}=\frac{70}{27}$

$p(a)=\frac{2(a)^2+3}{(a)^2}=\frac{2a^2+3}{a^2}$

85. a. D:{ – 1, 0, 1, 2, 3, 4, 5}
b. R:{ – 2, – 1, 0, 1, 2, 3, 4}
c. $f(2) = 1$
d. $f(-1) = 4$

86. a. D:{ – 5, – 4, – 3, – 2, – 1, 0, 1, 2, 3, 4, 5}
b. R:{ – 1, 0, 1, 2, 3, 4, 5}
c. $f(2) = 0$
d. $f(-3)=3,\ f(5)=3$

87. a. $x\in[-5,5]$
b. $y\in[-3,4]$
c. $f(2) = -2$
d when $y = 1$, $x = 0$ and $x = -4$.

88. a. $x\in[-3,5]$
b. $y\in[-4,5]$
c. $f(2) = -4$
d. when $y = -3$, $x = 1$ and $x = 3$.

89. a. $x\in[-3,\infty)$
b. $y\in(-\infty,4]$
c. $f(2) = 2$
d. when $y = 2$, $x = 2$ and $x = -2$

90. a. $x\in[-5,\infty)$
b. $y\in[-2,\infty)$
c. $f(2) = -2$
d. when $y = -1$, $x = 1$ and $x = 3$

91. $W(H)=\frac{9}{2}H-151$

a. $W(75)=\frac{9}{2}(75)-151=186.5\text{ lb}$

b. $W(72)=\frac{9}{2}(72)-151=173\text{ lb}$

210 – 173 = 37 lb

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

a. $C=\frac{5}{9}(41-32)=\frac{5}{9}(9)=5\,^\circ\text{C}$

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

$\frac{9}{5}C=F-32$

$\frac{9}{5}C+32=F$

$\frac{9}{5}(5)+32=F$

$9+32=F$

$41=F$

They are the same result.

93. $A=\frac{1}{2}B+I-1$

$\triangle PQR$

$P(-3,1), Q(3,9), R(7,6)$

$m=\frac{9-1}{3-(-3)}=\frac{4}{3}$

$y-1=\frac{4}{3}(x+3)$

$y-1=\frac{4}{3}x+4$

$y=\frac{4}{3}x+5$

(0,5) lies on PQ;
Lattice points are points that join vertical and horizontal grids in a Cartesian coordinate system.
There are four lattice points on the boundary; three vertices and point (0,5), thus $B$ = 8. There are 24 lattice points in the interior of the triangle, thus $I$ = 24.

$A=\frac{1}{2}(8)+22-1=25\text{ units}^2$

94. a. $N(g)=23g$

b. $g\in[0,15];\quad N\in[0,345]$

95 a. $N(g)=2.5g$

b. $g\in[0,5];\quad N\in[0,12.5]$

96. a. $D\in[0,\infty)$

b. $V(6.25)=(6.25)^3\approx 244\text{ units}^3$

c. $V(2x^2)=(2x^2)^3=8x^6$

97. a. $D\in[0,\infty)$

b. $V(7.5)=100\pi(7.5)=750\pi$

c. $V\left(\frac{8}{\pi}\right)=100\pi\left(\frac{8}{\pi}\right)=800\text{ cm}^3$

98. a. $c(t)=12.50t+19.50$

b. $c(3.5)=12.50(3.5)+19.50=\$63.25$

c. $119.75=12.50t+19.50$
$100.25=12.50t$
$8\text{ hr}\approx t$

d. $150=12.50t+19.50$
$130.5=12.50t$
$10.44\text{ hr}=t$
$t\in[0,10.44];\ c\in[0,150]$

99. a. $c(t)=42.50t+50$

b. $c(2.5)=42.50(2.5)+50=\$156.25$

c. $262.50=42.50t+50$
$212.50=42.50t$
$5\text{ hr}=t$

d. $500=42.50t+50$
$450=42.50t$
$10.6\text{ hr}\approx t$
$t\in[0,10.6];\ c\in[0,500]$

## 2.4 Exercises

100.a. Yes.
Each "*x*" is paired with exactly one "*y*".

b. 9 P.M.

c. $3\frac{1}{2}$ m

d. 5 P.M. and 1 A.M.

101.a. Yes.
Each "*x*" is paired with exactly one "*y*".

b. 10 P.M.

c. 0.9 m

d. 7 P.M. and 1 A.M.

102.a. Use (25,900) and (29,1100) for the $25^{th}$ to $29^{th}$ .
The average weight of change:
$\frac{\Delta weight}{\Delta time} = \frac{1100-900}{29-25} = \frac{50}{1}$; Positive;
50 grams are gained each week.

b. Use (32,1600) and (36,2600) for the $32^{nd}$ to $36^{th}$ .
The average weight of change:
$\frac{\Delta weight}{\Delta time} = \frac{2600-1600}{36-32} = \frac{250}{1}$;
The weight gain is five times greater in the later weeks.

103.a. Average rate of change from 1920 to 1940, use (20,3.2) and (40,2.2).
$\frac{\Delta fertility}{\Delta time} = \frac{2.2-3.2}{40-20} = -\frac{1}{20}$; Negative;
Fertility is decreasing by one child every 20 years.

b. Average rate of change from 1940 to 1950, use (40,2.2).and (50,3.0).
$\frac{\Delta fertility}{\Delta time} = \frac{3.0-2.2}{50-40} = \frac{0.8}{10}$; Positive;
Fertility is increasing by less than one child every 10 years.

c. from 1980 to 1990, use (80,1.8).and (90,2.0).
$\frac{\Delta fertility}{\Delta time} = \frac{2.0-1.8}{90-80} = \frac{0.2}{10}$; The fertility rate was increasing four times as fast from 1940 to 1950.

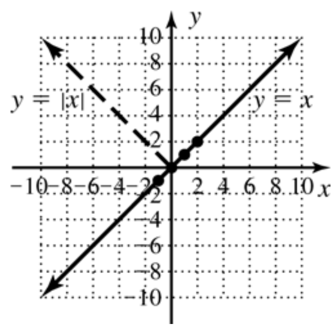
104.a. Father, 70 seconds

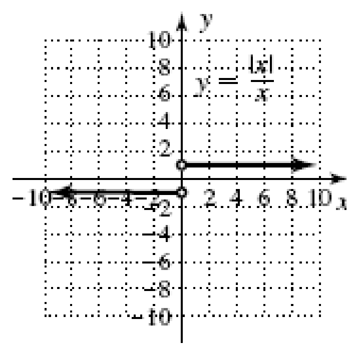
b. 50 meters

c. ≈ 40 seconds

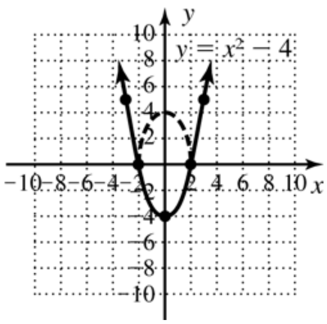
d. 3 times since the graphs intersect three times.

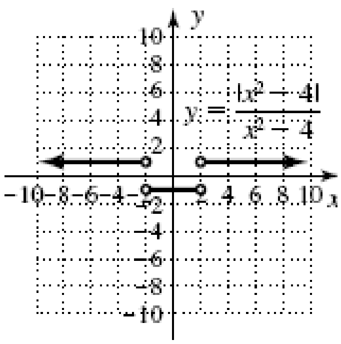
105. The *y*-values of the negative *x* integers would become positive.
All points would be in Quadrants I and III.



106. Negative outputs become positive.




107.a. $y = \dfrac{x-3}{x+2}, x \neq -2$

Domain: $x \in (-\infty, -2) \cup (-2, \infty)$;

$(x+2)y = (x+2)\left(\dfrac{x-3}{x+2}\right)$

$xy + 2y = x - 3$

$xy - x = -2y - 3$

$x(y-1) = -2y - 3$

$x = \dfrac{-2y-3}{y-1} = \dfrac{2y+3}{1-y}, y \neq 1$

Range: $y \in (-\infty, 1) \cup (1, \infty)$

b. $y = x^2 - 3$

Domain: $x \in \mathbb{R}$;

$y = x^2 - 3$

$y + 3 = x^2$

$\pm\sqrt{y+3} = x$;

$y + 3 \geq 0$

$y \geq -3$

Range: $y \in [-3, \infty)$

108. $m = \dfrac{3-6}{-5-2} = \dfrac{-3}{-7} = \dfrac{3}{7}$

$m = \dfrac{-4-4}{0-9} = \dfrac{-8}{-9} = \dfrac{8}{9}$

The line through (0, −4) and (9, 4) has a steeper slope.

109.a. $\sqrt{24} + 6\sqrt{54} - \sqrt{6}$

$= 2\sqrt{6} + 6 \cdot 3\sqrt{6} - \sqrt{6}$

$= 2\sqrt{6} + 18\sqrt{6} - \sqrt{6}$

$= 19\sqrt{6}$

b. $(2+\sqrt{3})(2-\sqrt{3})$

$= 4 - 2\sqrt{3} + 2\sqrt{3} - 3$

$= 1$

110. $x^2 - 4x + 1 = 0$

$x = \dfrac{4 \pm \sqrt{(-4)^2 - 4(1)(1)}}{2(1)}$

$x = \dfrac{4 \pm \sqrt{16-4}}{2}$

$x = \dfrac{4 \pm \sqrt{12}}{2}$

$x = \dfrac{4 \pm 2\sqrt{3}}{2}$

$x = 2 \pm \sqrt{3}$

111.a. $x^3 - 3x^2 - 25x + 75$

$= (x^3 - 3x^2) - (25x - 75)$

$= x^2(x-3) - 25(x-3)$

$= (x-3)(x^2 - 25)$

$= (x-3)(x-5)(x+5)$

b. $2x^2 - 13x - 24 = (2x+3)(x-8)$

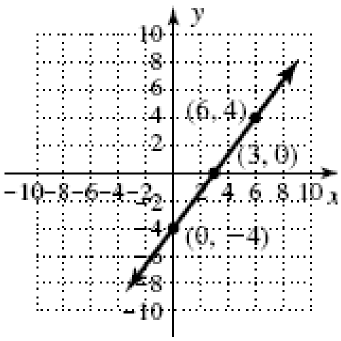
c. $8x^3 - 125 = (2x-5)(4x^2 + 10x + 25)$

# Chapter 2 Mid-Chapter Check

1. $4x-3y=12$

$-3y=-4x+12$

$y=\frac{4}{3}x-4$



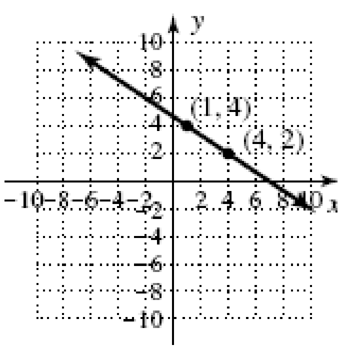

2. (–3, 8) and (4, –10)

$m=\frac{-10-8}{4-(-3)}=\frac{-18}{7}$

3. $m=\frac{-0.5-(-2)}{2003-2002}=\frac{1.5}{1}=1.5$;

Positive, loss is decreasing, profit is increasing.
Data.com's loss decreases by 1.5 million dollars per year.

4. (1, 4); $m=-\frac{2}{3}$




$m=\frac{3}{2}$; (1, 4)

$y-y_1=m(x-x_1)$

$y-4=\frac{3}{2}(x-1)$

$y-4=\frac{3}{2}x-\frac{3}{2}$

$y=\frac{3}{2}x+\frac{5}{2}$

5. $x$ = –3; not a function. Input –3 is paired with more than one output.

6. $m=-\frac{4}{3}$; $y$-intercept (0, 4)

$y=-\frac{4}{3}x+4$; is a function. Each input is paired with only one output.

7. a. $h(2)=0$

b. $x\in[-3,5]$

c. $x=-1$ when $h(x)=-3$

d. $y\in[-4,5]$

8. Rate of change from $x$ = 1 to $x$ = 2 is larger. It is steeper.

9. $m=\frac{3}{4}$; (1, 2)

$y-y_1=m(x-x_1)$

$y-2=\frac{3}{4}(x-1)$

$y-2=\frac{3}{4}x-\frac{3}{4}$

$y=\frac{3}{4}x+\frac{5}{4}$

$F(p)=\frac{3}{4}p+\frac{5}{4}$

For every 4000 pheasants, the fox population increases by 300.

$F(20)=\frac{3}{4}(20)+\frac{5}{4}=15+1.25=16.25$

Fox population is 1625 when the pheasant population is 20,000.

10. a. D = {-3, -2, -1, 0, 1, 2, 3, 4}
R = {-3, -2, -1, 0, 1, 2, 3, 4}

b. $x\in[-3,4]$
$y\in[-3,4]$

c. $x\in(-\infty,\infty)$
$y\in(-\infty,\infty)$

# Chapter 2 Reinforcing Basic Concepts

1. $P_1(0,5)$; $P_2(6,7)$

a. $m=\frac{7-5}{6-0}=\frac{2}{6}=\frac{1}{3}$; increasing

b. $y-5=\frac{1}{3}(x-0)$

c. $y=\frac{1}{3}x+5$

d. $y=\frac{1}{3}x+5$

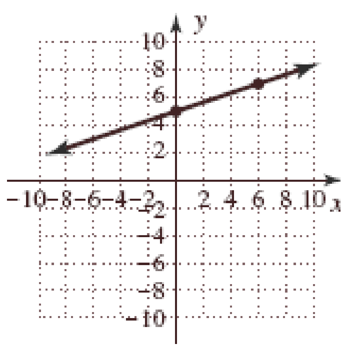
$-\frac{1}{3}x+y=5$

$x-3y=-15$

e. $x$-intercept: $(-15, 0)$ $y$-intercept: $(0, 5)$

$x-3(0)=-15$; $x=-15$

$0-3y=-15$; $-3y=-15$; $y=5$



2. $P_1(3,2)$ $P_2(0,9)$

a. $m=\frac{9-2}{0-3}=\frac{7}{-3}=-\frac{7}{3}$; decreasing

b. $y-9=-\frac{7}{3}(x-0)$

c. $y=-\frac{7}{3}x+9$

d. $y=-\frac{7}{3}x+9$

$\frac{7}{3}x+y=9$

$7x+3y=27$

e. $x$-intercept: $\left(\frac{27}{7},0\right)$ $y$-intercept: $(0, 9)$

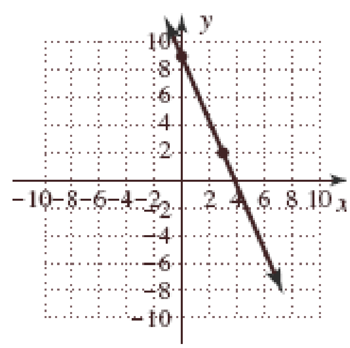
$7x+3(0)=27$

$x=\frac{27}{7}$

$7(0)+3y=27$

$3y=27$

$y=9$



## Reinforcing Basic Concepts

3. $P_1(3,2)$; $P_2(9,5)$

a. $m=\frac{5-2}{9-3}=\frac{3}{6}=\frac{1}{2}$; increasing

b. $y-2=\frac{1}{2}(x-3)$

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

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

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

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

$x-2y=-1$

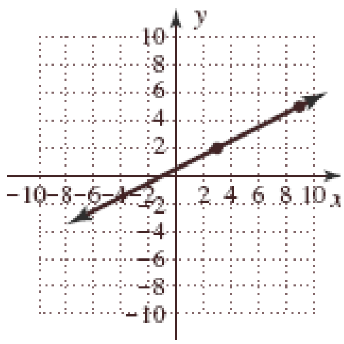
e. $x$-intercept: $(-1, 0)$ $y$-intercept: $\left(0,\frac{1}{2}\right)$

$x-2(0)=-1$

$x=-1$

$0-2y=-1$

$y=\frac{1}{2}$




4. $P_1(-5,-4)$; $P_2(3,2)$

a. $m=\frac{2-(-4)}{3-(-5)}=\frac{6}{8}=\frac{3}{4}$; increasing

b. $y+4=\frac{3}{4}(x+5)$

c. $y+4=\frac{3}{4}x+\frac{15}{4}$

$y=\frac{3}{4}x-\frac{1}{4}$

d. $y=\frac{3}{4}x-\frac{1}{4}$

$-\frac{3}{4}x+y=-\frac{1}{4}$

$3x-4y=1$

e. $x$-intercept: $\left(\frac{1}{3},0\right)$

$y$-intercept: $\left(0,-\frac{1}{4}\right)$

$3x-4(0)=1$

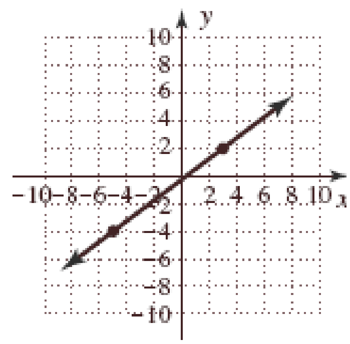
$3x=1$

$x=\frac{1}{3}$

$3(0)-4y=1$

$-4y=1$

$y=-\frac{1}{4}$



5. $P_1(-2,5)$ ; $P_2(6,-1)$

a. $m = \frac{-1-5}{6-(-2)} = \frac{-6}{8} = -\frac{3}{4}$ ; decreasing

b. $y-5 = -\frac{3}{4}(x+2)$

c. $y-5 = -\frac{3}{4}x - \frac{3}{2}$

$y = -\frac{3}{4}x + \frac{7}{2}$

d. $y = -\frac{3}{4}x + \frac{7}{2}$

$\frac{3}{4}x + y = \frac{7}{2}$

$3x + 4y = 14$

e. $x$-intercept: $\left(\frac{14}{3}, 0\right)$ $y$-intercept: $\left(0, \frac{7}{2}\right)$

$3x + 4(0) = 14$

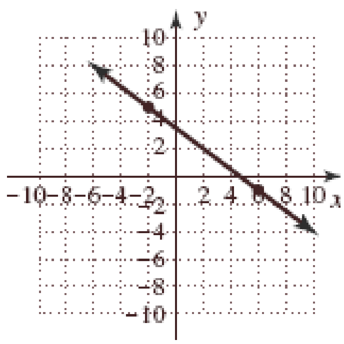
$3x = 14$

$x = \frac{14}{3}$

$3(0) + 4y = 14$

$4y = 14$

$y = \frac{7}{2}$




6. $P_1(2,-7)$ ; $P_2(-8,-2)$

a. $m = \frac{-2-(-7)}{-8-2} = \frac{5}{-10} = -\frac{1}{2}$ ;
decreasing

b. $y+7 = -\frac{1}{2}(x-2)$

c. $y+7 = -\frac{1}{2}x + 1$

$y = -\frac{1}{2}x - 6$

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

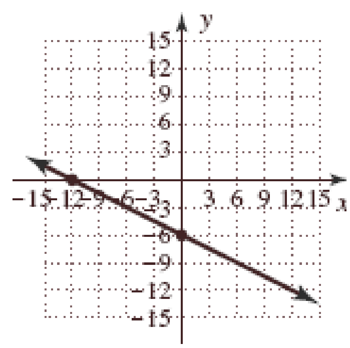
$\frac{1}{2}x + y = -6$

$x + 2y = -12$

e. $x$-intercept:$(-12, 0)$ $y$-intercept: $(0, -6)$

$x + 2(0) = -12$ $\quad$ $0 + 2y = -12$

$x = -12$ $\quad$ $y = -6$



## 2.5 Technology Highlight

Exercise 1: $x \approx -2.87$, $x \approx 0.87$,
min : $y = -7$ at $(-1, -7)$, no max

Exercise 2: $x \approx -1.88$, $x \approx 0.35$, $x \approx 1.53$,
max : $y = 3$ at $(-1, 3)$, min : $y = -1$ at $(1, -1)$

Exercise 3: $x \approx 1.35$, $x \approx 6.65$,
min : $y = -7$ at $(4, -7)$, no max

Exercise 4: $x = -2$, $x = 2$,
min : $y = 0$ at $(2, 0)$,
max : $y \approx 9.48$ at $(-0.67, 9.48)$

Exercise 5: $x = -2$, $x = 0$, $x \approx 2.41$,
min : $y = -3.20$ at $(-1.47, -3.20)$,
min : $y \approx -9.51$ at $(1.67, -9.51)$,
max : $y = 0$ at $(0, 0)$

Exercise 6: $x = -4$, $x = 0$,
min : $y = -3.08$ at $(-2.67, -3.08)$

## 2.5 Exercises

1. Linear; bounce

2. Even; $y$; odd; origin

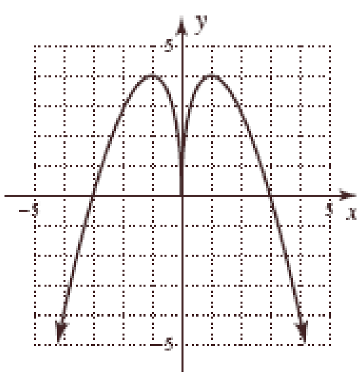
3. Increasing

4. Maximum

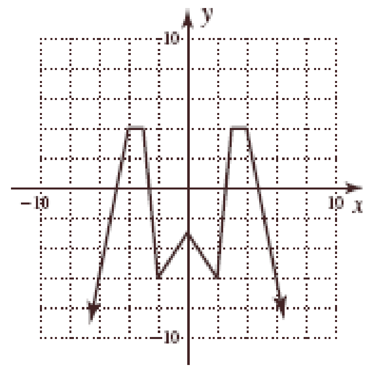
5. Answers will vary.

6. Answers will vary.

7.




8.




9. $f(x) = -7|x| + 3x^2 + 5$

$f(k) = -7|k| + 3(k)^2 + 5;$

$f(-k) = -7|-k| + 3(-k)^2 + 5$

$= -7|k| + 3(k)^2 + 5 = f(k);$

Even

10. $p(x) = 2x^4 - 6x + 1$

$p(k) = 2(k)^4 - 6(k) + 1$
$= 2k^4 - 6k + 1;$

$p(-k) = 2(-k)^4 - 6(-k) + 1$
$= 2k^4 + 6k + 1$
$p(k) \neq p(-k)$; Not even

11. $g(x) = \frac{1}{3}x^4 - 5x^2 + 1$

$g(k) = \frac{1}{3}(k)^4 - 5(k)^2 + 1$

$= \frac{1}{3}k^4 - 5k^2 + 1;$

$g(-k) = \frac{1}{3}(-k)^4 - 5(-k)^2 + 1$

$= \frac{1}{3}k^4 - 5k^2 + 1;$

$g(k) = g(-k)$

Even

12. $q(x)=\dfrac{1}{x^2}-|x|$

$q(k)=\dfrac{1}{(k)^2}-|k|$

$=\dfrac{1}{k^2}-|k|;$

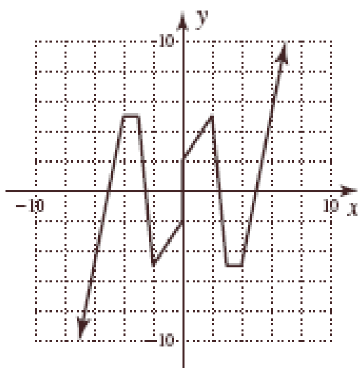
$q(-k)=\dfrac{1}{(-k)^2}-|-k|$

$=\dfrac{1}{k^2}-|k|$

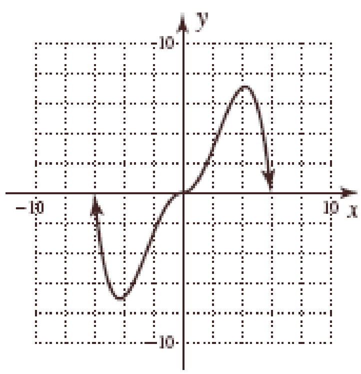
$q(k)=q(-k)$

Even

13.




14.




15. $f(x)=4\sqrt[3]{x}-x$

$f(k)=4\sqrt[3]{k}-k$

$f(-k)=4\sqrt[3]{-k}-(-k)$

$=-4\sqrt[3]{k}+k=-\left(4\sqrt[3]{k}-k\right);$

$f(k)=-f(k)$

Odd

16. $g(x)=\dfrac{1}{2}x^3-6x$

$g(k)=\dfrac{1}{2}(k)^3-6(k)$

$=\dfrac{k^3}{2}-6k;$

$g(-k)=\dfrac{1}{2}(-k)^3-6(-k)$

$=-\dfrac{k^3}{2}+6k=-\left(\dfrac{k^3}{2}-6k\right);$

$g(k)=-g(k)$

Odd

17. $p(x)=3x^3-5x^2+1$

$p(k)=3(k)^3-5(k)^2+1$

$=3k^3-5k^2+1$

$p(-k)=3(-k)^3-5(-k)^2+1$

$=-3k^3-5k^2+1$

$p(k)\neq -p(k)$; Not Odd

18. $q(x)=\dfrac{1}{x}-x$

$q(k)=\dfrac{1}{k}-(k)$

$=\dfrac{1}{k}-k;$

$q(-k)=\dfrac{1}{-k}-(-k)$

$=-\dfrac{1}{k}+k=-\left(\dfrac{1}{k}-k\right);$

$q(k)=-q(k)$; odd

19. $w(x)=x^3-x^2$

$w(-x)=(-x)^3-(-x)^2$

$=-x^3-x^2$; neither

20. $q(x)=\dfrac{3}{4}x^2+3|x|$

$q(-x)=\dfrac{3}{4}(-x)^2+3|-x|$

$=\dfrac{3}{4}x^2+3|x|$; even

## 2.5 Exercises

21. 20. $p(x) = 2\sqrt[3]{x} - \frac{1}{4}x^3$

$p(-x) = 2\sqrt[3]{(-x)} - \frac{1}{4}(-x)^3$

$= -2\sqrt[3]{x} + \frac{1}{4}x^3 = -\left(2\sqrt[3]{x} - \frac{1}{4}x^3\right)$; odd

22. $g(x) = x^3 + 7x$

$g(-x) = (-x)^3 + 7(-x)$

$= -x^3 - 7x = -\left(x^3 + 7x\right)$; odd

23. $v(x) = x^3 + 3|x|$

$v(-x) = (-x)^3 + 3|-x|$

$= -x^3 + 3|x|$; neither

24. $f(x) = x^4 + 7x^2 - 30$

$f(-x) = (-x)^4 + 7(-x)^2 - 30$

$= x^4 + 7x^2 - 30$; even

25. $f(x) = x^3 - 3x^2 - x + 3$

Verify Zeros: Let $f(x) = 0$

$0 = x^2(x-3) - (x-3)$

$0 = (x-3)(x^2 - 1)$

$0 = (x-3)(x+1)(x-1)$

Zeros: $(-1,0), (1,0), (3,0)$

For $f(x) \geq 0$, $x \in [-1,1], \ [3,\infty)$

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

Verify Zeros: Let $f(x) = 0$

$0 = x^3 - 2x^2 - 4x + 8$

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

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

$0 = (x-2)(x-2)(x+2)$

Zeros: $(-2,0), (2,0)$

For $f(x) > 0$, $x \in (-2,2) \cup (2,\infty)$

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

Verify Zeros: Let $f(x) = 0$

$0 = x^4 - 2x^2 + 1$

$0 = (x^2 - 1)(x^2 - 1)$

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

Zeros: $(-1,0), (1,0)$

For $f(x) > 0$, $x \in (-\infty,-1) \cup (-1,1) \cup (1,\infty)$

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

Verify Zeros: Let $f(x) = 0$

$0 = x^3 + 2x^2 - 4x - 8$

$0 = x^2(x+2) - 4(x+2)$

$0 = (x+2)(x^2 - 4)$

$0 = (x+2)(x+2)(x-2)$

Zeros: $(-2,0), (2,0)$

For $f(x) \geq 0$, $x \in \{-2\} \cup [2,\infty)$

29. $p(x) = \sqrt[3]{x-1} - 1$

$p(x) \geq 0$ for $x \in [2,\infty)$

30. $q(x) = \sqrt{x+1} - 2$

$q(x) > 0$ for $x \in (3,\infty)$

31. $f(x) = (x-1)^3 - 1$

$f(x) \leq 0$ for $x \in (-\infty, 2]$

32. $g(x) = -(x+1)^3 - 1$

$g(x) < 0$ for $x \in (-2,\infty)$

33. $f(x)\uparrow: (-3,1) \cup (4,6)$

$f(x)\downarrow: (-\infty,-3), (1,4)$

Constant : None

34. $H(x)\uparrow: x \in (-2,0) \cup (4,5)$

$H(x)\downarrow: x \in (-\infty,-2)$

Constant: $H(x) = -1 : x \in (0,4)$

35. $f(x)\uparrow: (1,4)$

$f(x)\downarrow: (-2,1) \cup (4,\infty)$

Constant: $(-\infty,-2)$

36. $g(x)\uparrow: (0,3)\cup(5,9)$
$g(x)\downarrow: (3,5)\cup(9,\infty)$
Constant: None

37. $p(x)=0.5(x+2)^3$
a. $p(x)\uparrow: x\in(-\infty,\infty)$
$p(x)\downarrow:$ None
b. down, up

38. $q(x)=-\sqrt[3]{x+1}$
a. $q(x)\uparrow:$ None
$q(x)\downarrow: x\in(-\infty,\infty)$
b. up, down

39. $y=p(x)$
a. $p(x)\uparrow: x\in(-3,0)\cup(3,\infty)$
$p(x)\downarrow: x\in(-\infty,-3)\cup(0,3)$
b. up, up

40. $y=q(x)$
a. $q(x)\uparrow: x\in(-\infty,-2)\cup(1,6)\cup(8,\infty)$
$q(x)\downarrow: x\in(-2,1)\cup(6,8)$
b. down, up

41. $H(x)=-5|x-2|+5$
a. $x\in(-\infty,\infty)$
$y\in(-\infty,5]$
b. (1, 0), (3, 0)
c. $H(x)\geq 0: x\in[1,3]$
$H(x)\leq 0: x\in(-\infty,1]\cup[3,\infty)$
d. $H(x)\uparrow: x\in(-\infty,2)$
$H(x)\downarrow: x\in(2,\infty)$
e.local maximum: $y$ = 2 at (2, 5)

42. $y=f(x)$
a. $x\in(-\infty,\infty)$
$y\in(-\infty,\infty)$
b.(–3.5, 0), (3.5, 0),(0,0)
c. $f(x)\geq 0: x\in[-3.5,0]\cup[3.5,\infty)$
$f(x)\leq 0: x\in(-\infty,-3.5]\cup[0,3.5]$
d. $f(x)\uparrow: x\in(-\infty,-2)\cup(2,\infty)$
$f(x)\downarrow: x\in(-2,2)$
e.local maximum: $y=3$ at (–2, 3)
local minimum: $y=-3$ at (2, –3)

43. $y=g(x)$
a. $x\in(-\infty,\infty)$
$y\in(-\infty,\infty)$
b. (–1,0), (5, 0)
c. $g(x)\geq 0: x\in[-1,\infty)$
$g(x)\leq 0: x\in(-\infty,-1]\cup\{5\}$
d. $g(x)\uparrow: x\in(-\infty,1)\cup(5,\infty)$
$g(x)\downarrow: x\in(1,5)$
e.local maximum: $y=6$ at (1,6)
local minimum: $y=0$ at (5, 0)

44. $y=Y_1$
a. $x\in[-4,\infty)$
$y\in(-\infty,3]$
b. (–4, 0), (2, 0)
c. $Y_1\geq 0: x\in[-4,2]$
$Y_1\leq 0: x\in[2,\infty)$
d. $Y_1\uparrow: x\in(-4,-2)$
$Y_1\downarrow: x\in(-2,\infty)$
e.local maximum: $y=3$ at (–2, 3);

45. $y=Y_2$
a. $x\in(-\infty,\infty)$
$y\in(-\infty,3]$
b. (0, 0), (2, 0)
c. $Y_2\geq 0: x\in[0,2]$
$Y_2\leq 0: x\in(-\infty,0]\cup[2,\infty)$
d. $Y_2\uparrow: x\in(-\infty,1)$
$Y_2\downarrow: x\in(1,\infty)$
e.local maximum: $y=3$ at (1, 3)

46. $y=g(x)$
a. $x\in(-\infty,5]$
$y\in(-\infty,5]$
b. $x=-5,-3,1$
c. $g(x)\geq 0: x\in[-5,-3]\cup[1,5]$;
$g(x)\leq 0: x\in(-\infty,-5]\cup[-3,1]$
d. $g(x)\uparrow: x\in(-\infty,-4)\cup(-1,2)\cup(4,5)$
$g(x)\downarrow: x\in(-4,-1)\cup(2,4)$
e.Local max: $y=3$ at (–4, 3), $y=4$ at (2, 4),

Local min: $y = -4$ at (–1, –4), $y = 1$ at (4, 1),

47. $p(x) = (x+3)^3 + 1$

a. $x \in \mathbb{R}$ , $y \in \mathbb{R}$

b. $x = -4$

c. $p(x) \geq 0 : x \in [-4, \infty)$ ;

$p(x) \leq 0 : x \in (-\infty, -4]$

d. $p(x)\uparrow: x \in (-\infty, -3) \cup (-3, \infty)$

$p(x)\downarrow$: never decreasing

e.Local max: none

Local min: none

48. $q(x) = |x-5| + 3$

a. $x \in (-\infty, \infty)$

$y \in [3, \infty)$

b. none

c. $q(x) \geq 0 : x \in (-\infty, \infty)$ ; $q(x) \leq 0 : q(x)$ is always positive.

d. $q(x)\uparrow: x \in (5, \infty)$

$g(x)\downarrow: x \in (-\infty, 5)$

e.Local max: none

Local min: $y = 3$ at (5, 3)

49. $y = \frac{1}{3}\sqrt{4x^2 - 36}$

a. $x \in (-\infty, -3] \cup [3, \infty)$

$y \in [0, \infty)$

b. (–3, 0), (3, 0)

c. $f(x)\uparrow: x \in (3, \infty)$

$f(x)\downarrow: x \in (-\infty, -3)$

d. Even

50. $y = \sin(x)$

a. $y \in [-1, 1]$

b.(–180, 0), (0, 0), (180, 0), (360, 0)

c. $y\uparrow: x \in (-90, 90) \cup (270, 360)$

$y\downarrow: x \in (-180, -90) \cup (90, 270)$

d.Minimum: (–90, –1); (270, –1)

Maximum: (90, 1)

e. Odd

$y = \cos(x)$

a. $y \in [-1, 1]$

b.(–90, 0), (90, 0), (270, 0)

c. $y\uparrow: x \in (-180, 0) \cup (180, 360)$

$y\downarrow: x \in (0, 180)$

d.Minimum: (–180, –1); (180, –1)

Maximum: (0, 1); (360, 1)

e. Even

51. a. $x \in [0, 260]$

$y \in [0, 80]$

b. 80 feet

c. 120 feet

d. Yes

e. (0, 120)

f. (120, 260)

52. a.Increasing: $t \in$ (0, 1) ∪ (3, 4) ∪ (7, 10)

b.Decreasing: $t \in$ (4, 7)

c.Constant: $t \in$ (1, 3)

d.Maximum: (4, 12), (10, 16)

e.Minimum: (7, –4)

f.Positive: $t \in$ (0,6), (8, 10)

g.Negative: $t \in$ (6, 8)

h.Zero: (6, 0), (8, 0)

53. $f(x) = x^{\frac{2}{3}} - 1$

a. $x \in (-\infty, \infty)$

$y \in [-1, \infty)$

b. (–1, 0), (1, 0)

c. $f(x) \geq 0 : x \in (-\infty, -1] \cup [1, \infty)$

$f(x) < 0 : x \in (-1, 1)$

d. $f(x)\uparrow: x \in (0, \infty)$

$f(x)\downarrow: x \in (-\infty, 0)$

e.Minimum: (0, –1)

54. $h(x) = |x^2 - 4| - 5$

a. $x \in (-\infty, \infty)$

$y \in [-5, \infty)$

b. (–3, 0), (3, 0)

c. $h(x) \geq 0 : x \in (-\infty, -3] \cup [3, \infty)$

$h(x) \leq 0 : x \in [-3, 3]$

d. $h(x)\uparrow: x \in (-2, 0) \cup (2, \infty)$

$h(x)\downarrow: x \in (-\infty, -2) \cup (0, 2)$

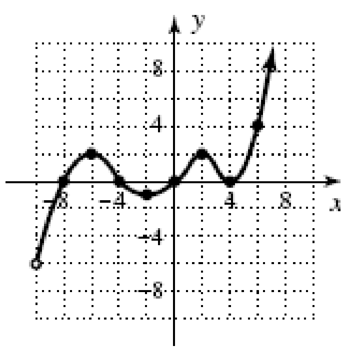
e.Maximum: (0, –1)

Minimum: (–2, –5), (2, –5)

55. a. $D: t \in [72, 96]$
$R: I \in [7.25, 16]$
b. $I(t)\uparrow$ for $t \in$ (72,74) $\cup$ (77,81) $\cup$ (83, 84) $\cup$ (93, 94)
$I(t)\downarrow$ for $t \in$ (74, 75) $\cup$ (81, 83) $\cup$ (84, 86) $\cup$ (90, 93) $\cup$ (94, 95)
$I(t)$ constant for $t \in$ (75, 77) $\cup$ (86, 90) $\cup$ (95, 96)
c. Maximum: (74, 9.25), (81, 16) (global max), (84, 13), (94, 8.5)
Minimum: (72, 7.5), (83, 12.75), (93, 7.2)
d. Increase: 1980 to 1981
Decrease: 1982 to 1983 or 1985 to 1986

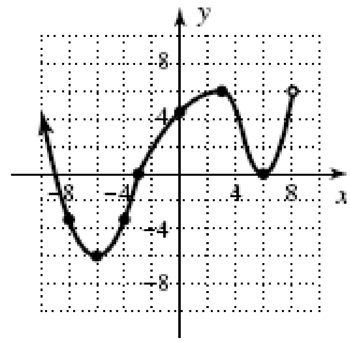
56. a. $t \in [75, 102]$
$D \in [-300, 230]$
b. $D(t)\uparrow$ for
$t \in (76, 77) \cup (83, 84) \cup (86, 87) \cup (92, 100)$
$D(t)\downarrow$ for
$t \in (75, 76) \cup (77, 83) \cup (84, 86) \cup (89, 92) \cup (100, 102)$
$D(t)$ is constant for $t \in (87, 89)$
c. Maximum: (75, –40), (77, –50), (84, –170), (100, 240) (global maximum)
Minimum: (76, –70), (83, –210), (86, –220), (92, –300), (102, –140)
d. Increase: 1996 to 1997 or 1999 to 2000
Decrease: 2001 to 2002

57.



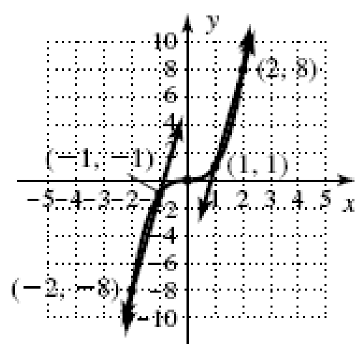

Zeroes: (–8, 0), (–4, 0), (0, 0), (4, 0)
Maximum: (−6, 2), (2, 2)
Minimum: (−2, −1), (4, 0)

58.




Zeroes: (−9, 0), (−3, 0), (6, 0)
Min: (−6, −6), (6, 0)
Max: (3, 6)

59. $f(x) = x^3$
a. $\frac{\Delta f}{\Delta x} = \frac{f(-1) - f(-2)}{-1-(-2)} = \frac{-1-(-8)}{1} = 7$
b. $\frac{\Delta f}{\Delta x} = \frac{f(2) - f(1)}{2-1} = \frac{8-1}{1} = 7$
c. They are the same.
d. Slopes of the lines are the same.




60. $f(x) = \sqrt[3]{x}$
a. Between $x = 0$ and $x = 1$
b. $\frac{\Delta f}{\Delta x} = \frac{f(1) - f(0)}{1-0} = \frac{1-0}{1} = 1$
$\frac{\Delta f}{\Delta x} = \frac{f(8) - f(7)}{8-7} = \frac{2-1.91}{1} = 0.09$
c. 11 times greater

61. $h(t) = -16t^2 + 192t$

a. $h(1) = -16(1)^2 + 192(1) = 176$ ft

b. $h(2) = -16(2)^2 + 192(2) = 320$ ft

c. $\frac{\Delta h}{\Delta t} = \frac{h(2) - h(1)}{2 - 1} = \frac{320 - 176}{1}$
= 144 ft/sec

d. $\frac{\Delta h}{\Delta t} = \frac{h(11) - h(10)}{11 - 10} = \frac{176 - 320}{1}$
= –144 ft/sec
The arrow is going down.

62. $h(t) = -16t^2 + 96t$

a. $h(1) = -16(1)^2 + 96(1) = 80$ ft

$h(2) = -16(2)^2 + 96(2) = 128$ ft

b. $h(3) = -16(3)^2 + 96(3) = 144$ ft

c. Between $t$ = 1 and $t$ = 2; the rocket is decelerating.

d. $\frac{\Delta h}{\Delta t} = \frac{h(2) - h(1)}{2 - 1} = \frac{128 - 80}{1}$
= 48 ft/sec;
$\frac{\Delta h}{\Delta t} = \frac{h(3) - h(2)}{3 - 2} = \frac{144 - 128}{1}$
= 16 ft/sec

63. $v = \sqrt{2gs}$, $v = \sqrt{2(32)s} = 8\sqrt{s}$

a. $v = \sqrt{2(32)(5)} = \sqrt{320} = 17.89$ ft/sec ;

$v = \sqrt{2(32)(10)} = \sqrt{640} = 25.30$ ft/sec

b. $v = \sqrt{2(32)(15)} = \sqrt{960} = 30.98$ ft/sec ;

$v = \sqrt{2(32)(20)} = \sqrt{1280} = 35.78$ ft/sec

c. Between $s$ = 5 and $s$ = 10

d. $\frac{\Delta v}{\Delta s} = \frac{v(10) - v(5)}{10 - 5} = \frac{25.3 - 17.89}{5}$
= 1.482 ft/sec;
$\frac{\Delta v}{\Delta s} = \frac{v(20) - v(15)}{20 - 15} = \frac{35.78 - 30.98}{5}$
= 0.96 ft/sec

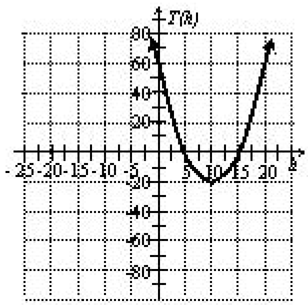
64. $T(h) = 0.8h^2 - 16h + 60$

a. $T(0) = 0.8(0)^2 - 16(0) + 60 = 60$
60˚F

b. $0 = 0.8h^2 - 16h + 60$
$0 = 8h^2 - 160h + 600$
$0 = 8(h^2 - 20h + 75)$
$0 = 8(h - 5)(h - 15)$
$h = 5; \quad h = 15$
5 hours

c. 15 – 5 = 10 hours

d. –20˚F




65. $f(x) = 2x - 3$

$\frac{\Delta f}{\Delta x} = \frac{f(x+h) - f(x)}{h}$
$= \frac{[2(x+h) - 3] - (2x - 3)}{h}$
$= \frac{2x + 2h - 3 - 2x + 3}{h}$
$= \frac{2h}{h} = 2$

66. $g(x) = 4x + 1$

$\frac{g(x+h) - g(x)}{h} = \frac{[4(x+h) + 1] - (4x + 1)}{h}$
$= \frac{4x + 4h + 1 - 4x - 1}{h}$
$= \frac{4h}{h} = 4$

67. $h(x) = x^2 + 3$

$$\frac{\Delta f}{\Delta x} = \frac{h(x+h) - h(x)}{h} = \frac{[(x+h)^2 + 3] - (x^2 + 3)}{h}$$
$$= \frac{x^2 + 2xh + h^2 + 3 - x^2 - 3}{h}$$
$$= \frac{2xh + h^2}{h} = \frac{h(2x+h)}{h} = 2x + h$$

68. $p(x) = x^2 - 2$

$$\frac{\Delta p}{\Delta x} = \frac{p(x+h) - p(x)}{h} = \frac{[(x+h)^2 - 2] - (x^2 - 2)}{h}$$
$$= \frac{x^2 + 2xh + h^2 - 2 - x^2 + 2}{h}$$
$$= \frac{2xh + h^2}{h} = \frac{h(2x+h)}{h} = 2x + h$$

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

$$\frac{\Delta g}{\Delta x} = \frac{g(x+h) - g(x)}{h}$$
$$= \frac{[(x+h)^2 + 2(x+h) - 3] - (x^2 + 2x - 3)}{h}$$
$$= \frac{x^2 + 2xh + h^2 + 2x + 2h - 3 - x^2 - 2x + 3}{h}$$
$$= \frac{2xh + h^2 + 2h}{h} = \frac{h(2x+h+2)}{h} = 2x + 2 + h$$

70. $r(x) = x^2 - 5x + 2$

$$\frac{\Delta r}{\Delta x} = \frac{r(x+h) - r(x)}{h}$$
$$= \frac{[(x+h)^2 - 5(x+h) + 2] - (x^2 - 5x + 2)}{h}$$
$$= \frac{x^2 + 2xh + h^2 - 5x - 5h + 2 - x^2 + 5x - 2}{h}$$
$$= \frac{2xh + h^2 - 5h}{h} = \frac{h(2x+h-5)}{h} = 2x - 5 + h$$

71. $f(x) = \frac{2}{x}$

$$\frac{\Delta f}{\Delta x} = \frac{f(x+h) - f(x)}{h}$$
$$= \frac{\frac{2}{x+h} - \frac{2}{x}}{h} = \frac{\frac{2x - 2(x+h)}{x(x+h)}}{h}$$
$$= \frac{\frac{2x - 2x - 2h}{x(x+h)}}{h} = \frac{-2h}{x(x+h)} \cdot \frac{1}{h} = \frac{-2}{x(x+h)}$$

72. $g(x) = \frac{-3}{x}$

$$\frac{\Delta g}{\Delta x} = \frac{g(x+h) - g(x)}{h}$$
$$= \frac{\frac{-3}{x+h} - \frac{-3}{x}}{h} = \frac{\frac{-3x + 3(x+h)}{x(x+h)}}{h}$$
$$= \frac{\frac{-3x + 3x + 3h}{x(x+h)}}{h} = \frac{3h}{x(x+h)} \cdot \frac{1}{h} = \frac{3}{x(x+h)}$$

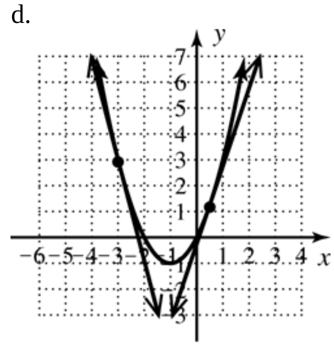
73. a. $g(x) = x^2 + 2x$

$$\frac{\Delta g}{\Delta x} = \frac{g(x+h) - g(x)}{h}$$
$$= \frac{[(x+h)^2 + 2(x+h)] - (x^2 + 2x)}{h}$$
$$= \frac{x^2 + 2xh + h^2 + 2x + 2h - x^2 - 2x}{h}$$
$$= \frac{2xh + h^2 + 2h}{h} = \frac{h(2x+h+2)}{h} = 2x + 2 + h$$

b. For [–3.0, –2.9], $x = -3.0$ and $h = 0.1$
Rate of change: $2(-3.0) + 2 + 0.1 = -3.9$

c. For [0.50, 0.51], $x = 0.50$ and $h = 0.01$
Rate of change: $2(0.50) + 2 + 0.01 = 3.01$

d.




The rates of change have opposite signs, with the secant line to the left being more steep.

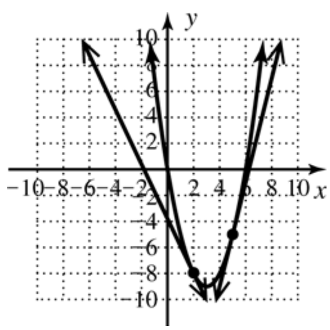
74. a. $h(x) = x^2 - 6x$

$$\frac{\Delta h}{\Delta x} = \frac{h(x+h) - h(x)}{h}$$
$$= \frac{[(x+h)^2 - 6(x+h)] - (x^2 - 6x)}{h}$$
$$= \frac{x^2 + 2xh + h^2 - 6x - 6h - x^2 + 6x}{h}$$
$$= \frac{2xh + h^2 - 6h}{h} = \frac{h(2x+h-6)}{h} = 2x - 6 + h$$

b. For [1.9, 2.0], $x = 1.9$ and $h = 0.1$
Rate of change: $2(1.9) - 6 + 0.1 = -2.1$

c. For [5.0, 5.01], $x = 5.0$ and $h = 0.01$
Rate of change: $2(5.0) - 6 + 0.01 = 4.01$

d.



The rates of change have opposite signs, with the secant line to the right being more steep.

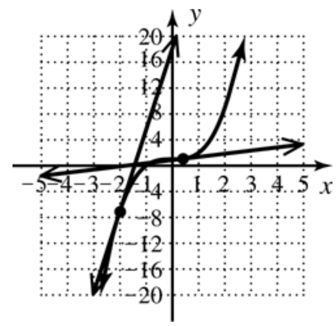
75. a. $g(x) = x^3 + 1$

$$\frac{\Delta g}{\Delta x} = \frac{g(x+h) - g(x)}{h}$$
$$= \frac{[(x+h)^3 + 1] - (x^3 + 1)}{h}$$
$$= \frac{x^3 + 3x^2h + 3xh^2 + h^3 + 1 - x^3 - 1}{h}$$
$$= \frac{3x^2h + 3xh^2 + h^3}{h}$$
$$= \frac{h(3x^2 + 3xh + h^2)}{h} = 3x^2 + 3xh + h^2$$

b. For [–2.1, –2], $x = -2.1$ and $h = 0.1$
Rate of change:
$3(-2.1)^2 + 3(-2.1)(0.1) + (0.1)^2 = 12.61$

c. For [0.40, 0.41], $x = 0.40$ and $h = 0.01$
Rate of change:
$3(0.40)^2 + 3(0.40)(0.01) + (0.01)^2 \approx 0.49$

d.



Both lines have a positive slope, but the line at $x = -2$ is much steeper.

76. a. $r(x) = \sqrt{x}$

$$\frac{\Delta r}{\Delta x} = \frac{r(x+h) - r(x)}{h}$$
$$= \frac{\sqrt{x+h} - \sqrt{x}}{h}$$
$$= \frac{\sqrt{x+h} - \sqrt{x}}{h} \cdot \frac{\sqrt{x+h} + \sqrt{x}}{\sqrt{x+h} + \sqrt{x}}$$
$$= \frac{x+h-x}{h\left(\sqrt{x+h} + \sqrt{x}\right)} = \frac{h}{h\left(\sqrt{x+h} + \sqrt{x}\right)}$$
$$= \frac{1}{\sqrt{x+h} + \sqrt{x}}$$

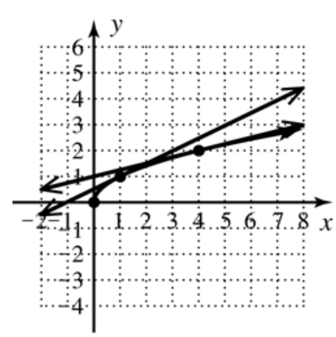
b. For [1, 1.1], $x = 1$ and $h = 0.1$

Rate of change: $\dfrac{1}{\sqrt{1+0.1} + \sqrt{1}} \approx 0.49$

c. For [4, 4.1], $x = 4$ and $h = 0.1$

Rate of change: $\dfrac{1}{\sqrt{4+0.1} + \sqrt{4}} \approx 0.25$

d.



Both lines have a positive slope, but the line at $x = 4$ is less steep.

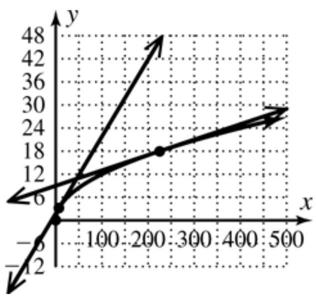
77. $d(x) = 1.5\sqrt{x}$

$$\frac{\Delta d}{\Delta x}=\frac{d(x+h)-d(x)}{h}$$
$$=\frac{1.5\sqrt{x+h}-1.5\sqrt{x}}{h}$$

a. For [9, 9.01], $x$ = 9 and $h$ = 0.01
Rate of change:
$$\frac{1.5\sqrt{9+0.01}-1.5\sqrt{9}}{0.01}\approx 0.25$$

b.For [225, 225.01], $x$ = 225 and $h$ = 0.01
Rate of change:
$$\frac{1.5\sqrt{225+0.01}-1.5\sqrt{225}}{0.01}\approx 0.05$$

c.



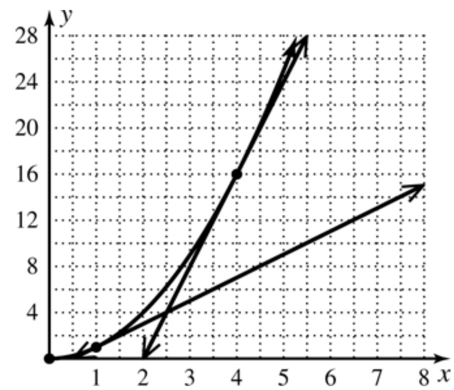

As height increases, you can see farther, the sight distance is increasing much slower.

78. $P(x)=x^2$
$$\frac{\Delta P}{\Delta x}=\frac{P(x+h)-P(x)}{h}$$
$$=\frac{[(x+h)^2]-x^2}{h}$$
$$=\frac{x^2+2xh+h^2-x^2}{h}$$
$$=\frac{2xh+h^2}{h}=\frac{h(2x+h)}{h}=2x+h$$

a.For [1, 1.01], $x$ = 1 and $h$ = 0.01
Rate of change: $2(1)+0.01=2.01$

b.For [4, 4.01], $x$ = 4 and $h$ = 0.01
Rate of change: $2(4)+0.01=8.01$

c.

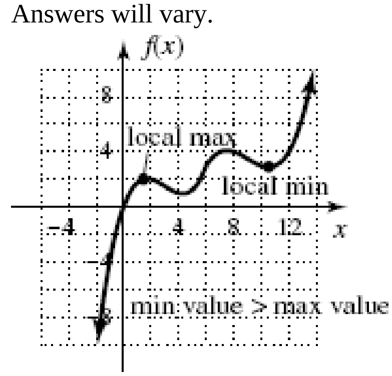



The projected image grows at a faster rate, the farther you move away from the screen.

79. No; No; Answers will vary.

80. a.Daughter; her graph line reaches 400 meters before her mother's.
b.20 meters; mother is at 380 meters when daughter reaches 400 meters.
c.10 seconds; daughter finishes in 65 seconds, mother finishes in 75 seconds.
d. Mother
e.37 seconds; 0–30; 58–65
f.28 seconds; 58 seconds – 38 seconds = 28 seconds

81. Answers will vary.




82. $h(-k)=h(k)$
$$\left[(-k)^{\frac{1}{3}}\right]^2=\left(k^{\frac{1}{3}}\right)^2$$
$$\left(\sqrt[3]{-k}\right)^2=\left(\sqrt[3]{k}\right)^2$$
$$\left(-\sqrt[3]{k}\right)^2=\left(\sqrt[3]{k}\right)^2$$
$$\left(\sqrt[3]{k}\right)^2=\left(\sqrt[3]{k}\right)^2$$
$h(x)$ is an even function.

83. $x^2 - 8x - 20 = 0$

a. $(x-10)(x+2) = 0$

$x = 10;\quad x = -2$

b. $(x^2 - 8x) - 20 = 0$

$(x^2 - 8x + 16) - 20 - 16 = 0$

$(x-4)^2 - 36 = 0$

$(x-4)^2 = 36$

$x - 4 = \pm 6$

$x = 4 \pm 6$

$x = 10;\quad x = -2$

c. $x = \dfrac{8 \pm \sqrt{(-8)^2 - 4(1)(-20)}}{2(1)}$

$x = \dfrac{8 \pm \sqrt{64+80}}{2}$

$x = \dfrac{8 \pm \sqrt{144}}{2}$

$x = \dfrac{8 \pm 12}{2}$

$x = 10;\quad x = -2$

84. a. $\dfrac{3}{x+2} + \dfrac{3}{2-x}$

$\dfrac{3(2-x)}{(x+2)(2-x)} + \dfrac{3(x+2)}{(x+2)(2-x)}$

$\dfrac{6-3x+3x+6}{(x+2)(2-x)}$

Sum: $\dfrac{12}{4-x^2}$

b. $\dfrac{3}{x+2} \cdot \dfrac{3}{2-x}$

Product: $\dfrac{9}{4-x^2}$

85. $y = \dfrac{2}{3}x - 1$

86. $SA = 2\pi rh + 2\pi r^2$

$SA = 2\pi(12)(36) + 2\pi(12)^2$

$SA = 864\pi + 288\pi$

$SA = 1152\pi \text{ cm}^2$;

$V = \pi r^2 h$

$V = \pi(12)^2(36)$

$V = 5184\pi \text{ cm}^3$

## 2.6 Technology Highlight

Exercise 1: Shifted right 3 units; answers will vary.

Exercise 2: Shifted right 3 units; answers will vary.

## 2.6 Exercises

1. Stretch; compression
2. Translations; reflections
3. (–5, –9); upward
4. (4, 11); up; down
5. Answers will vary.
6. Answers will vary.
7. $f(x) = x^2 + 4x$
   a. quadratic
   b. up/up, Vertex (–2,–4), Axis of symmetry *x* = –2, *x*–intercepts (–4, 0) and (0,0), *y*–intercept (0,0)
   c. D: $x \in \mathbb{R}$, R: $y \in [-4, \infty)$
8. $g(x) = -x^2 + 2x$
   a. quadratic
   b. down/down, Vertex (1,1), Axis of symmetry *x* = 1, *x*–intercepts (2, 0) and (0,0), *y*–intercept (0,0)
   c. D: $x \in \mathbb{R}$, R: $y \in (-\infty, 1]$

9. $p(x) = x^2 - 2x - 3$
   a. quadratic
   b. up/up, Vertex (1,–4),
      Axis of symmetry $x = 1$,
      $x$–intercepts (–1, 0) and (3,0),
      $y$–intercept (0,–3)
   c. D: $x \in \mathbb{R}$ , R: $y \in [-4, \infty)$

10. $q(x) = -x^2 + 2x + 8$
   a. quadratic
   b. down/down, Vertex (1,9),
      Axis of symmetry $x = 1$,
      $x$–intercepts (–2, 0) and (4,0),
      $y$–intercept (0,8)
   c. D: $x \in \mathbb{R}$ , R: $y \in (-\infty, 9]$

11. $f(x) = x^2 - 4x - 5$
   a. quadratic
   b. up/up, Vertex (2,–9),
      Axis of symmetry $x = 2$,
      $x$–intercepts (–1, 0) and (5,0),
      $y$–intercept (0,–5)
   c. D: $x \in \mathbb{R}$ , R: $y \in [-9, \infty)$

12. $g(x) = x^2 + 6x + 5$
   a. quadratic
   b. up/up, Vertex (–3,–4),
      Axis of symmetry $x = -3$,
      $x$–intercepts (–5, 0) and (–1,0),
      $y$–intercept (0,5)
   c. D: $x \in \mathbb{R}$ , R: $y \in [-4, \infty)$

13. $p(x) = 2\sqrt{x+4} - 2$
   a. square root
   b. up to the right, Initial point (–3,–4),
      $x$–intercept (–3, 0),
      $y$–intercept (0,2)
   c. D: $x \in [-4, \infty)$, R: $y \in [-2, \infty)$

14. $q(x) = -2\sqrt{x+4} + 2$
   a. square root
   b. down to the right, Initial point (–4,2),
      $x$–intercept (–3, 0),
      $y$–intercept (0,–2)
   c. D: $x \in [-4, \infty)$, R: $y \in (-\infty, 2]$

15. $r(x) = -3\sqrt{4-x} + 3$
   a. square root
   b. down to the left, Initial point (4,3),
      $x$–intercept (3, 0),
      $y$–intercept (0,–3)
   c. D: $x \in (-\infty, 4]$, R: $y \in (-\infty, 3]$

16. $p(x) = 2\sqrt{x+1} - 4$
   a. square root
   b. up to the right, Initial point (–1,–4),
      $x$–intercept (3, 0),
      $y$–intercept (0,–2)
   c. D: $x \in [-1, \infty)$, R: $y \in [-4, \infty)$

17. $g(x) = 2\sqrt{4-x}$
   a. square root
   b. up to the left, Initial point (4,0),
      $x$–intercept (4, 0),
      $y$–intercept (0,4)
   c. D: $x \in (-\infty, 4]$, R: $y \in [0, \infty)$

18. $h(x) = -2\sqrt{x+1} + 4$
   a. square root
   b. down to the right, Initial point (–1,4),
      $x$–intercept (3, 0),
      $y$–intercept (0,2)
   c. D: $x \in [-1, \infty)$, R: $y \in (-\infty, 4]$

19. $p(x) = 2|x+1| - 4$
   a. absolute value
   b. up/up, Vertex (–1,–4),
      Axis of symmetry $x = -1$,
      $x$–intercepts (–3, 0) and (1,0),
      $y$–intercept (0,–2)
   c. D: $x \in \mathbb{R}$ , R: $y \in [-4, \infty)$

20. $q(x) = -3|x-2| + 3$
   a. absolute value
   b. down/down, Vertex (2,3),
      Axis of symmetry $x = 2$,
      $x$–intercepts (3, 0) and (1,0),
      $y$–intercept (0,–3)
   c. D: $x \in \mathbb{R}$ , R: $y \in (-\infty, 3]$

# 2.6 Exercises

21. $r(x) = -2|x+1|+6$
    a. absolute value
    b. down/down, Vertex (–1,6),
    Axis of symmetry $x = -1$,
    $x$–intercepts (–4, 0) and (2,0),
    $y$–intercept (0,4)
    c. D: $x \in \mathbb{R}$ , R: $y \in (-\infty, 6]$

22. $f(x) = 3|x-2|-6$
    a. absolute value
    b. up/up, Vertex (2,–6),
    Axis of symmetry $x = 2$,
    $x$–intercepts (0, 0) and (4,0),
    $y$–intercept (0,0)
    c. D: $x \in \mathbb{R}$ , R: $y \in [-6, \infty)$

23. $g(x) = -3|x|+6$
    a. absolute value
    b. down/down, Vertex (0,6),
    Axis of symmetry $x = 0$,
    $x$–intercepts (–2, 0) and (2,0),
    $y$–intercept (0,6)
    c. D: $x \in \mathbb{R}$ , R: $y \in (-\infty, 6]$

24. $h(x) = 2|x+1|$
    a. absolute value
    b. up/up, Vertex (–1,0),
    Axis of symmetry $x = -1$,
    $x$–intercept (–1, 0),
    $y$–intercept (0,2)
    c. D: $x \in \mathbb{R}$ , R: $y \in [0, \infty)$

25. $f(x) = -(x-1)^3$
    a. cubic
    b. up/down, Inflection point (1,0),
    $x$–intercept (1, 0),
    $y$–intercept (0,1)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

26. $g(x) = (x+1)^3$
    a. cubic
    b. down/up, Inflection point (0,–1),
    $x$–intercept (–1, 0),
    $y$–intercept (0,1)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

27. $h(x) = x^3 + 1$
    a. cubic
    b. down/up, Inflection point (0,1),
    $x$–intercept (–1, 0),
    $y$–intercept (0,1)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

28. $p(x) = -\sqrt[3]{x} + 1$
    a. cube root
    b. up/down, Inflection point (0,1),
    $x$–intercept (1, 0),
    $y$–intercept (0,1)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

29. $q(x) = \sqrt[3]{x-1} - 1$
    a. cube root
    b. down/up, Inflection point (1,–1),
    $x$–intercept (2, 0),
    $y$–intercept (0,–2)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

30. $r(x) = -\sqrt[3]{x+1} - 1$
    a. cube root
    b. up/down, Inflection point (–1,–1),
    $x$–intercept (–2, 0),
    $y$–intercept (0,–2)
    c. D: $x \in \mathbb{R}$ , R: $y \in \mathbb{R}$

31. Function family: Square root
    $x$–intercept: (–3, 0)
    $y$–intercept: (0, 2)
    Initial point: (–4, –2)
    End behavior: Up on right

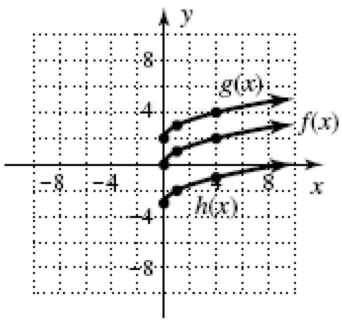
32. Function family: Quadratic
    $x$–intercepts: (–3, 0), (1, 0)
    $y$–intercept: (0, 3)
    Vertex: (–1, 4)
    End behavior: Down/down

33. Function family: Cubic
    $x$–intercept: (–2, 0)
    $y$–intercept: (0, –2)
    Inflection point: (–1, –1)
    End behavior: Up/down

34. Function family: Absolute Value
    $x$–intercepts: (–1, 0), (3, 0)
    $y$–intercept: (0, –2)
    Vertex: (1, –4)
    End behavior: Up/up

35. $f(x)=\sqrt{x}$ ; $g(x)=\sqrt{x}+2$ ; $h(x)=\sqrt{x}-3$

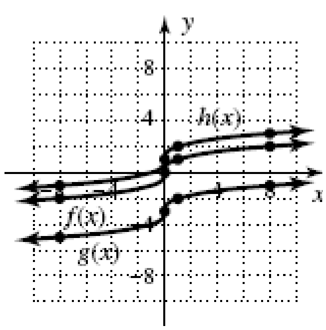
| x | f(x) | g(x) | h(x) |
|---|---|---|---|
| 0 | 0 | 2 | –3 |
| 4 | 2 | 4 | –1 |
| 9 | 3 | 5 | 0 |
| 16 | 4 | 6 | 1 |
| 25 | 5 | 7 | 2 |




From the parent graph $f(x)=\sqrt{x}$ , $g(x)$ shifts
up 2 units and $h(x)$ shifts down 3 units.

36. $f(x)=\sqrt[3]{x}$ ; $g(x)=\sqrt[3]{x}-3$ ; $h(x)=\sqrt[3]{x}+1$

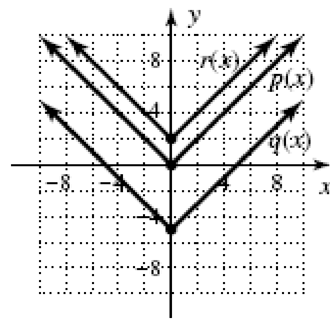
| x | f(x) | g(x) | h(x) |
|---|---|---|---|
| 0 | 0 | –3 | 1 |
| 1 | 1 | –2 | 2 |
| 8 | 2 | –1 | 3 |
| 27 | 3 | 0 | 4 |
| 64 | 4 | 1 | 5 |




From the parent graph $f(x)=\sqrt[3]{x}$ , $g(x)$ shifts
down 3 units and $h(x)$ shifts up 1 unit.

37. $p(x)=|x|$ ; $q(x)=|x|-5$ ; $r(x)=|x|+2$

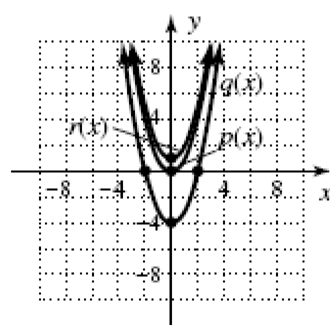
| x | p(x) | q(x) | r(x) |
|---|---|---|---|
| –2 | 2 | –3 | 4 |
| –1 | 1 | –4 | 3 |
| 0 | 0 | –5 | 2 |
| 1 | 1 | –4 | 3 |
| 2 | 2 | –3 | 4 |




From the parent graph $p(x)=|x|$ , $q(x)$ shifts down 5 units and $r(x)$ shifts up 2 units.

38. $p(x)=x^2$ ; $q(x)=x^2-4$ ; $r(x)=x^2+1$

| x | p(x) | q(x) | h(x) |
|---|---|---|---|
| –2 | 4 | 0 | 5 |
| –1 | 1 | –3 | 2 |
| 0 | 0 | –4 | 1 |
| 1 | 1 | –3 | 2 |
| 2 | 4 | 0 | 5 |

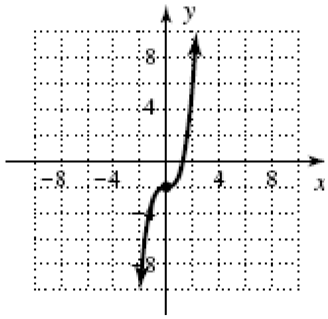



From the parent graph $p(x)=x^2$ , $q(x)$ shifts down 4 units and $r(x)$ shifts up 1 unit.

## 2.6 Exercises

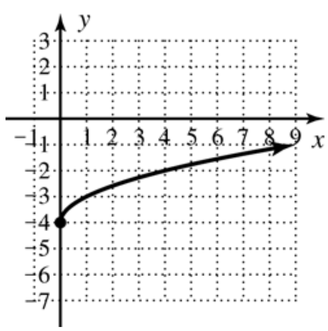
39. $f(x) = x^3 - 2$

Shifts down 2 units.



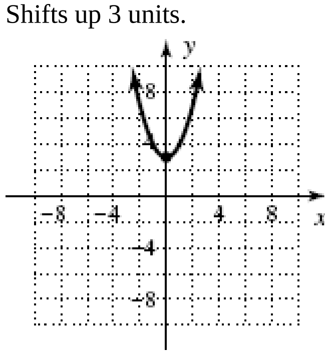
40. $g(x) = \sqrt{x} - 4$

Shifts down 4 units.



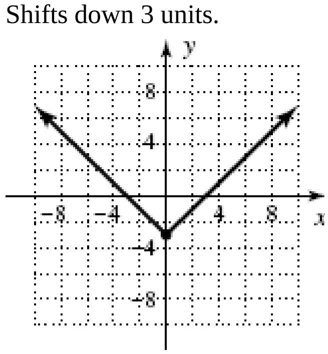
41. $h(x) = x^2 + 3$

Shifts up 3 units.



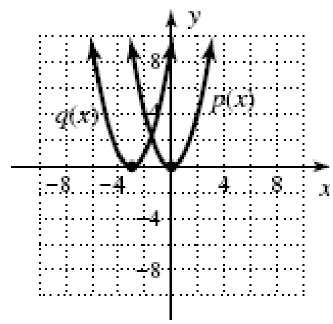
42. $Y_1 = |x| - 3$

Shifts down 3 units.



43. $p(x) = x^2$ ; $q(x) = (x+3)^2$

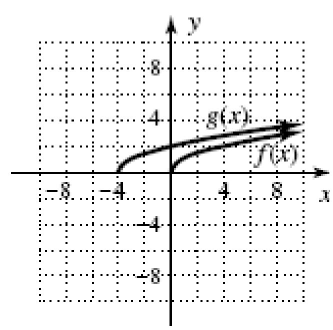
| x | $p(x) = x^2$ | $q(x) = (x+3)^2$ |
|---|---|---|
| –5 | 25 | 4 |
| –3 | 9 | 0 |
| –1 | 1 | 4 |
| 1 | 1 | 16 |
| 3 | 9 | 36 |




From the parent graph $p(x) = x^2$, $q(x)$ shifts left 3 units.

44. $f(x) = \sqrt{x}$ ; $g(x) = \sqrt{x+4}$

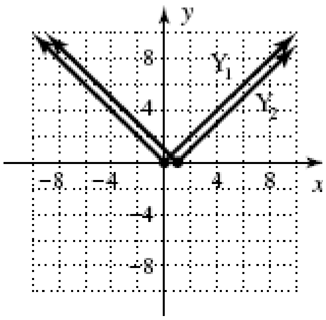
| x | $f(x) = \sqrt{x}$ | $g(x) = \sqrt{x+4}$ |
|---|---|---|
| 0 | 0 | 2 |
| 1 | 1 | $\sqrt{5}$ |
| 4 | 2 | $2\sqrt{2}$ |
| 9 | 3 | $\sqrt{13}$ |
| 16 | 4 | $2\sqrt{5}$ |




From the parent graph $f(x) = \sqrt{x}$, $g(x)$
shifts
left 4 units.

45. $Y_1 = |x|$; $Y_2 = |x-1|$

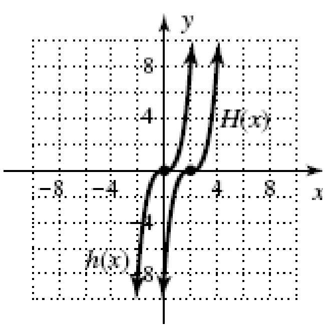
| x | $Y_1 = \|x\|$ | $Y_2 = \|x-1\|$ |
|---|---|---|
| –2 | 2 | 3 |
| –1 | 1 | 2 |
| 0 | 0 | 1 |
| 1 | 1 | 0 |
| 2 | 2 | 1 |




From the parent graph $Y_1 = |x|$, $Y_2$ shifts right 1 unit.

46. $h(x) = x^3$; $H(x) = (x-2)^3$

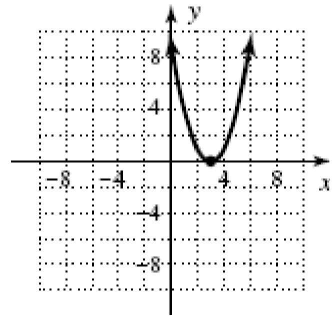
| x | $h(x) = x^3$ | $H(x) = (x-2)^3$ |
|---|---|---|
| –2 | –8 | –64 |
| –1 | –1 | –27 |
| 0 | 0 | –8 |
| 1 | 1 | –1 |
| 2 | 8 | 0 |




From the parent graph $h(x) = x^3$, $H(x)$ shifts right 2 units.

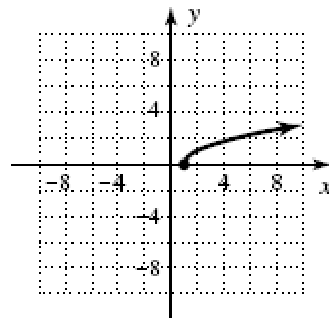
47. $p(x) = (x-3)^2$

Shifts right 3 units.



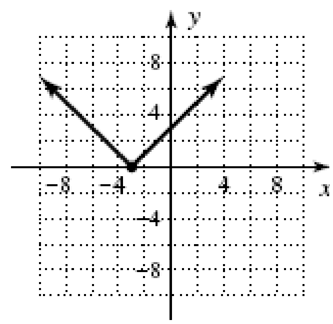

48. $Y1 = \sqrt{x-1}$

Shifts right 1 unit.



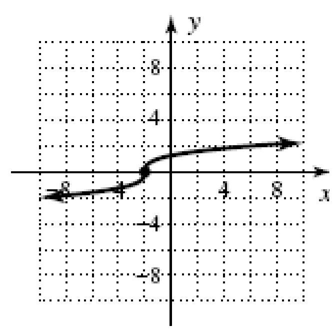

49. $h(x) = |x+3|$

Shifts left 3 units.



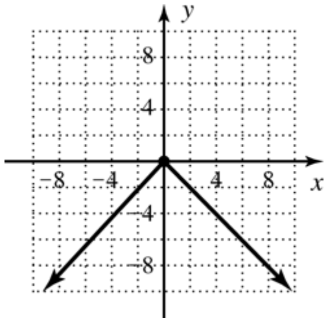

50. $f(x) = \sqrt[3]{x+2}$

Shifts left 2 units.

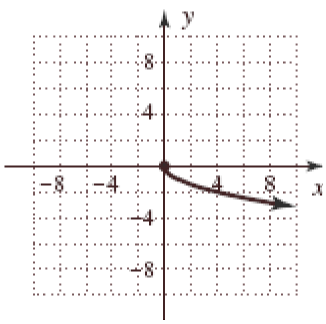


## 2.6 Exercises

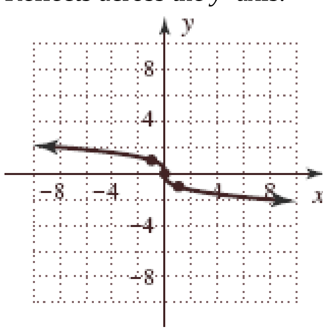
51. $g(x) = -|x|$
Reflects across the $x$–axis.



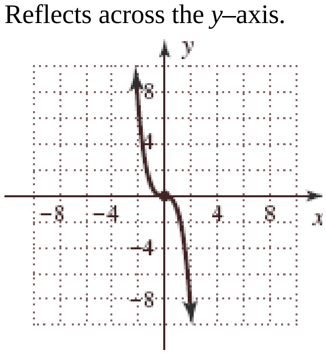

52. $Y_2 = -\sqrt{x}$
Reflects across the $x$–axis.




53. $f(x) = \sqrt[3]{-x}$
Reflects across the $y$–axis.

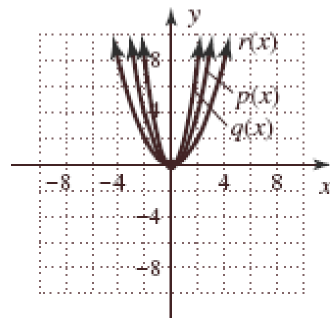



54. $g(x) = (-x)^3$
Reflects across the $y$–axis.




55. $p(x) = x^2$ ; $q(x) = 2x^2$ ; $r(x) = \frac{1}{2}x^2$

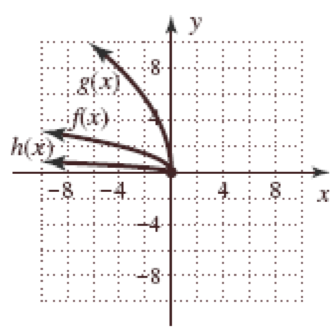
| x | p(x) | q(x) | r(x) |
|---|---|---|---|
| –2 | 4 | 8 | 2 |
| –1 | 1 | 2 | ½ |
| 0 | 0 | 0 | 0 |
| 1 | 1 | 2 | ½ |
| 2 | 4 | 8 | 2 |




From the parent graph $p(x) = x^2$, $q(x)$ stretches upward and $r(x)$ compresses downward.

56. $f(x) = \sqrt{-x}$ ; $g(x) = 4\sqrt{-x}$ ;
$h(x) = \frac{1}{4}\sqrt{-x}$

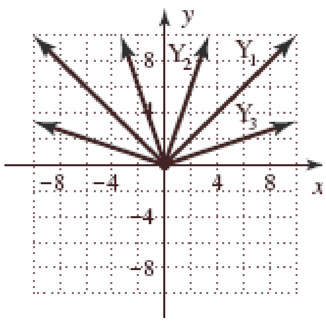
| x | f(x) | g(x) | h(x) |
|---|---|---|---|
| –25 | 5 | 20 | 5/4 |
| –16 | 4 | 16 | 1 |
| –9 | 3 | 12 | ¾ |
| –4 | 2 | 8 | ½ |
| –1 | 1 | 4 | ¼ |




From the parent graph $f(x) = \sqrt{-x}$, $g(x)$ stretches upward and $h(x)$ compresses downward.

57. $Y_1 = |x|$; $Y_2 = 3|x|$; $Y_3 = \frac{1}{3}|x|$

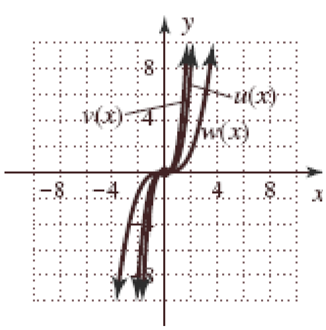
| x | $Y_1$ | $Y_2$ | $Y_3$ |
|---|---|---|---|
| –2 | 2 | 6 | 2/3 |
| –1 | 1 | 3 | 1/3 |
| 0 | 0 | 0 | 0 |
| 1 | 1 | 3 | 1/3 |
| 2 | 2 | 6 | 2/3 |




From the parent graph $Y_1 = |x|$, $Y_2$ stretches upward and $Y_3$ compresses downward.

58. $u(x) = x^3$; $v(x) = 2x^3$; $w(x) = \frac{1}{5}x^3$

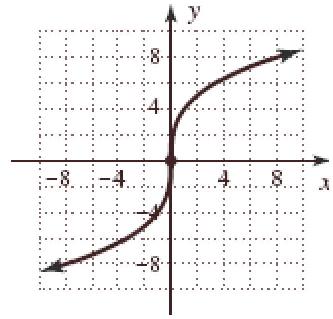
| x | u(x) | v(x) | w(x) |
|---|---|---|---|
| –2 | –8 | –16 | –8/5 |
| –1 | –1 | –2 | –1/5 |
| 0 | 0 | 0 | 0 |
| 1 | 1 | 2 | 1/5 |
| 2 | 8 | 16 | 8/5 |




From the parent graph $u(x) = x^3$, $v(x)$ stretches upward and $w(x)$ compresses downward.

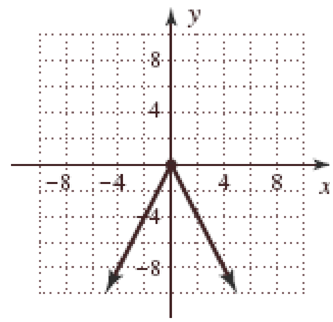
59. $f(x) = 4\sqrt[3]{x}$

Stretches upward and downward.



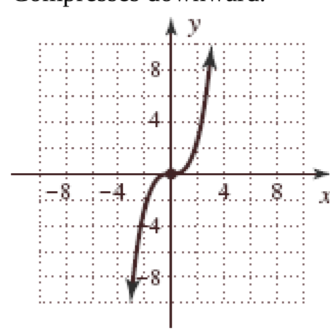

60. $g(x) = -2|x|$

Stretches upward; reflects over $x$-axis.




61. $p(x) = \frac{1}{3}x^3$

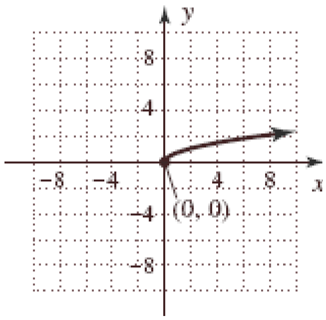
Compresses downward.



## 2.6 Exercises

62. $q(x)=\dfrac{3}{4}\sqrt{x}$

Compresses downward.




63. $f(x)=\dfrac{1}{2}x^3$; g

64. $f(x)=-\dfrac{2}{3}x+2$; h

65. $f(x)=-(x-3)^2+2$; i

66. $f(x)=-\sqrt[3]{x-1}-1$; d

67. $f(x)=|x+4|+1$; e

68. $f(x)=-\sqrt{x+6}$; f

69. $f(x)=-\sqrt{x+6}-1$; j

70. $f(x)=x+1$; k

71. $f(x)=(x-4)^2-3$; l

72. $f(x)=|x-2|-5$; b

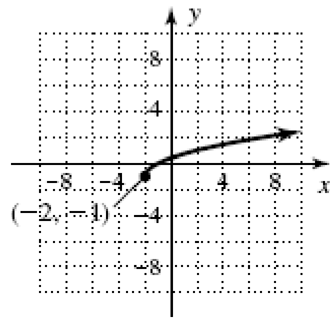
73. $f(x)=\sqrt{x+3}-1$; c

74. $f(x)=-(x+3)^2+5$; a

75. $f(x)=\sqrt{x+2}-1$

Left 2, down 1

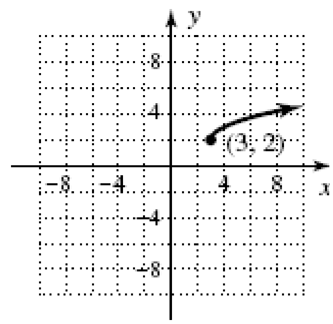
Initial point: (–2, –1)




76. $g(x)=\sqrt{x-3}+2$

Right 3, up 2

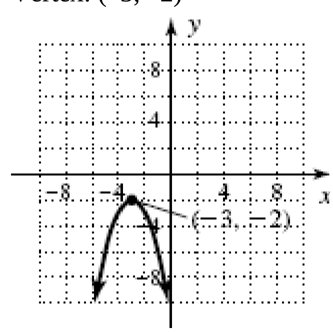
Initial point: (3, 2)




77. $h(x)=-(x+3)^2-2$

Left 3, reflected across *x*–axis, down 2

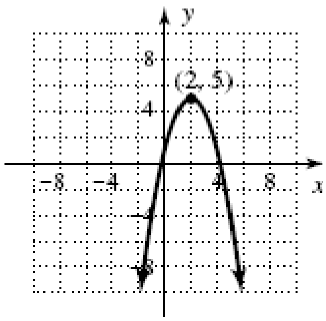
Vertex: (–3, –2)



78. $H(x) = -(x-2)^2 + 5$

Right 2, reflected across $x$–axis, up 5

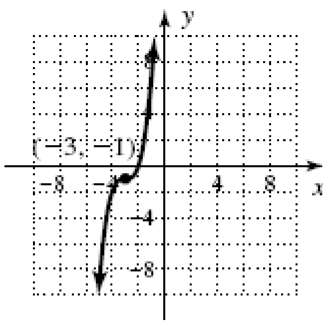
Vertex: (2, 5)




79. $p(x) = (x+3)^3 - 1$

Left 3, down 1

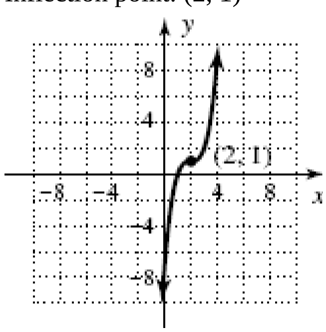
Inflection point: (–3, –1)




80. $q(x) = (x-2)^3 + 1$

Right 2, up 1

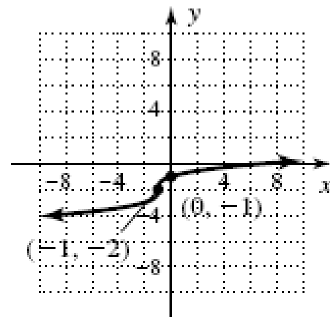
Inflection point: (2, 1)




81. $Y_1 = \sqrt[3]{x+1} - 2$

Left 1, down 2

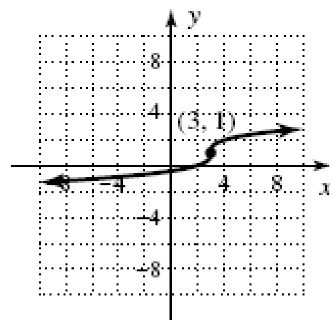
Inflection point: (–1, –2)




82. $Y_2 = \sqrt[3]{x-3} + 1$

Right 3, up 1

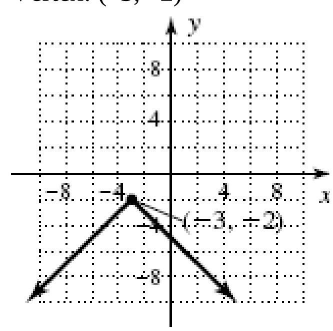
Inflection point: (3, 1)




83. $f(x) = -|x+3| - 2$

Left 3, reflected across $x$–axis, down 2

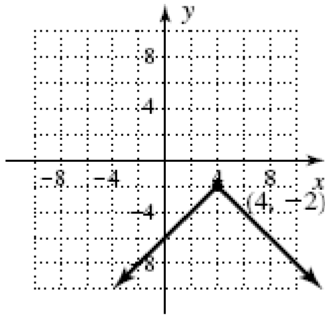
Vertex: (–3, –2)



## 2.6 Exercises

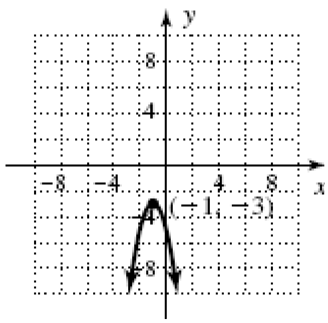
84. $g(x) = -|x-4| - 2$

Right 4, reflected across *x*–axis, down 2
Vertex: (4, –2)



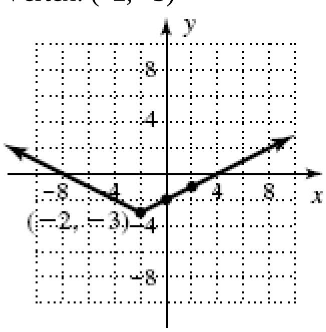

85. $h(x) = -2(x+1)^2 - 3$

Left 1, stretched vertically, reflected across *x*–axis, down 3
Vertex: (–1, –3)



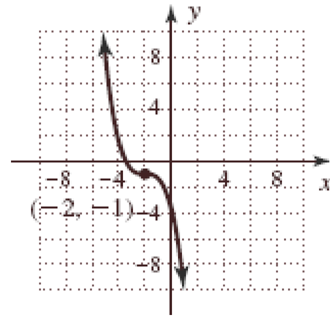

86. $H(x) = \frac{1}{2}|x+2| - 3$

Left 2 , compressed vertically, down 3
Vertex: (–2, –3)



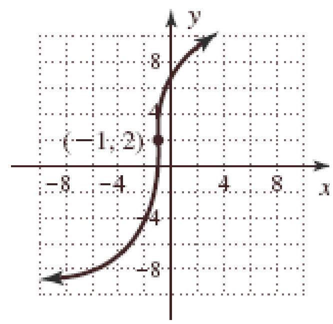

87. $p(x) = -\frac{1}{3}(x+2)^3 - 1$

Left 2, compressed vertically, reflected across *x*–axis, down 1
Inflection point: (–2, –1)



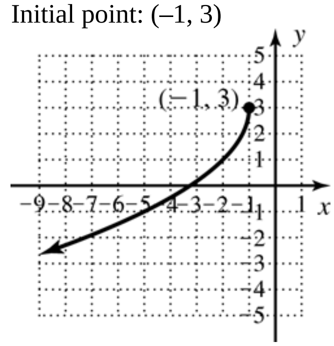

88. $q(x) = 5\sqrt[3]{x+1} + 2$

Left 1, stretched vertically, up 2
Inflection point: (–1, 2)




89. $Y_1 = -2\sqrt{-x-1} + 3$

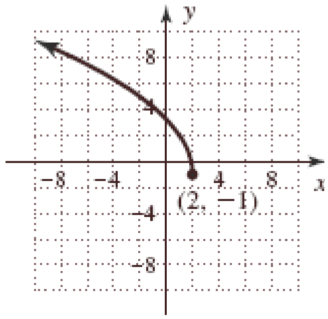
Reflected across *y*–axis, left 1, reflected across *x*–axis, stretched vertically, up 3
Initial point: (–1, 3)



90. $Y_2 = 3\sqrt{-x+2} - 1$

Reflected across $y$–axis, right 2, stretched vertically, down 1

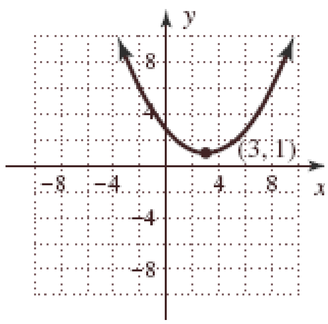
Initial point: (2, –1)




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

Right 3, compressed vertically, up 1

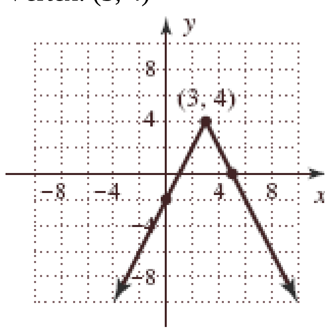
Vertex: (3, 1)



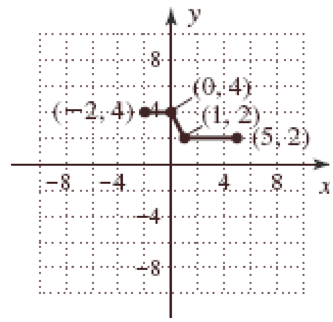

92. $H(x) = -2|x-3| + 4$

Right 3, reflected across $x$–axis, stretched vertically, up 4

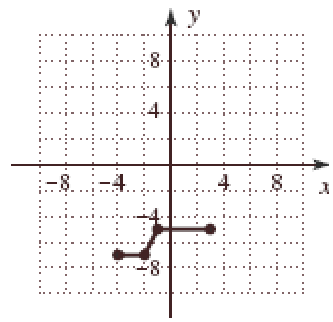
Vertex: (3, 4)



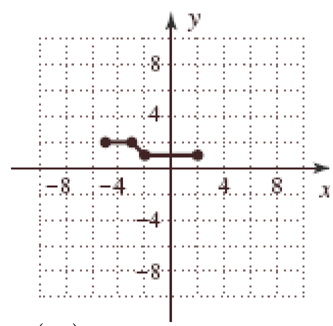

93. a. $f(x-2)$



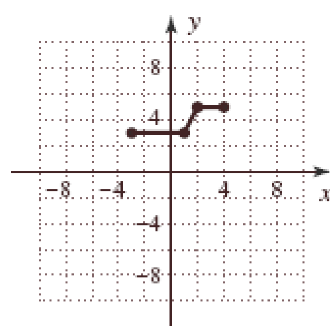

b. $-f(x) - 3$



c. $\frac{1}{2} f(x+1)$

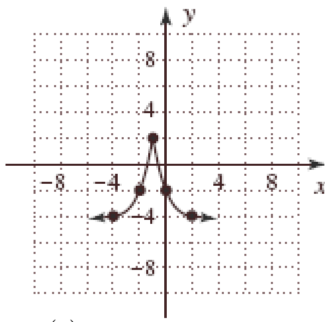


d. $f(-x) + 1$

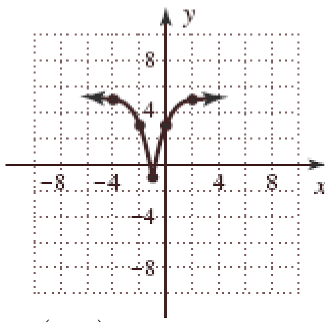


## 2.6 Exercises

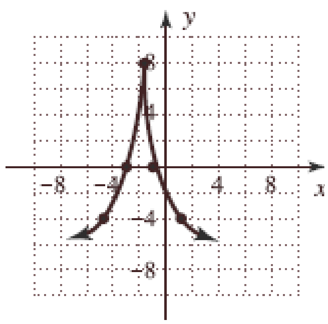
94. a. $g(x)-2$



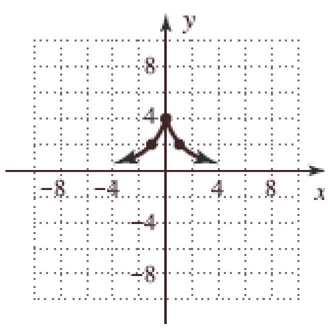
b. $-g(x)+3$



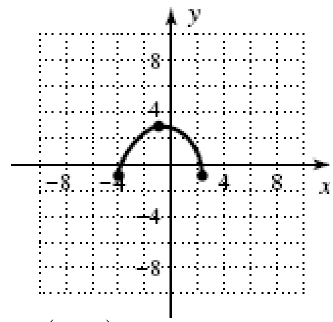
c. $2g(x+1)$



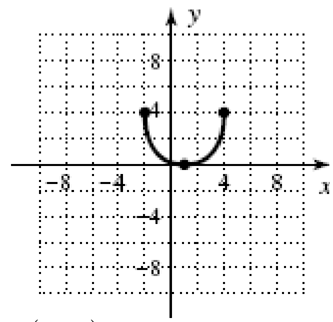
d. $\frac{1}{2}g(x-1)+2$



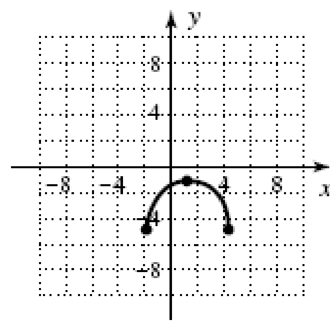
95. a. $h(x)+3$



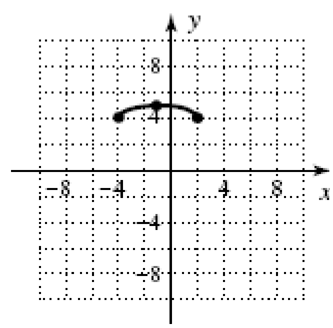
b. $-h(x-2)$



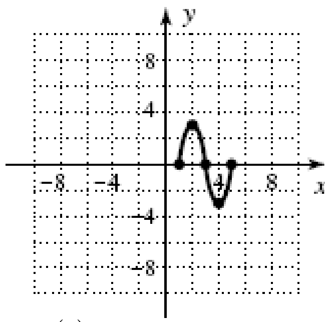
c. $h(x-2)-1$



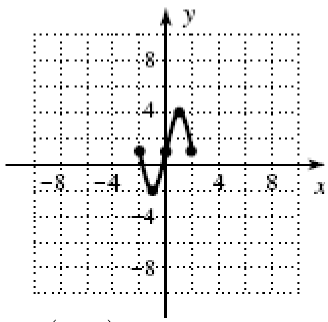
d. $\frac{1}{4}h(x)+5$



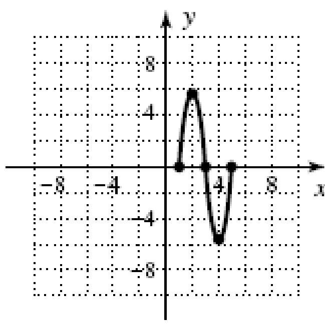
96. a. $H(x-3)$



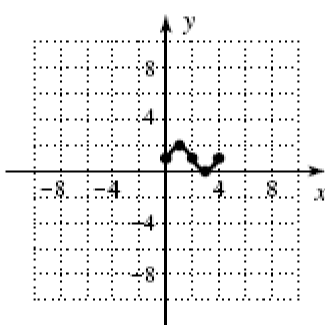

b. $-H(x)+1$




c. $2H(x-3)$




d. $\frac{1}{3}H(x-2)+1$




97. Vertex: (2, 0)
Point: (0, –4)

$$y = a(x-h)^2 + k$$
$$-4 = a(0-2)^2 + 0$$
$$-4 = 4a$$
$$-1 = a;$$
$$y = -(x-2)^2$$

98. Vertex: (0, –4)
Point: (–5, 6)

$$y = a(x-h)^2 + k$$
$$6 = a(-5-0)^2 - 4$$
$$6 = 25a - 4$$
$$10 = 25a$$
$$\frac{2}{5} = a;$$
$$y = \frac{2}{5}x^2 - 4$$

99. Node: (–3, 0)
Point: (6, 4.5)

$$y = a\sqrt{x-h} + k$$
$$4.5 = a\sqrt{6-(-3)} + 0$$
$$4.5 = 3a$$
$$1.5 = a;$$
$$y = 1.5\sqrt{x+3}$$

100. Initial point: (–4, 5)
Point: (5, –1)

$$y = a\sqrt{x-h} + k$$
$$-1 = a\sqrt{5-(-4)} + 5$$
$$-6 = 3a$$
$$-2 = a;$$
$$y = -2\sqrt{x+4} + 5$$

101. Vertex: (–4, 0)
Point: (1, 4)

$$y = a|x-h| + k$$
$$4 = a|1+4| + 0$$
$$4 = 5a$$
$$\frac{4}{5} = a;$$
$$y = \frac{4}{5}|x+4|$$

# 2.6 Exercises

102. Vertex: (3, 7)
Point: (0, –2)

$y = a|x - h| + k$

$-2 = a|0 - 3| + 7$

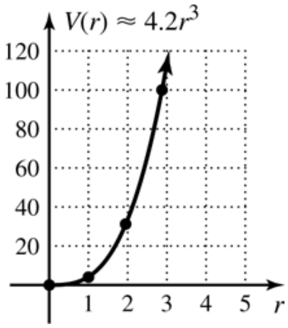
$-9 = 3a$

$-3 = a;$

$y = -3|x - 3| + 7$

103. $V = \frac{4}{3}\pi r^3$

$\frac{4}{3}\pi \approx 4.2$




Volume estimate: 70 $in^3$

$V = \frac{4}{3}\pi r^3$

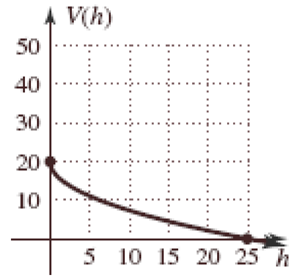
$V = \frac{4}{3}\pi (2.5)^3$

$V = \frac{4}{3}\pi (15.625) \approx 65.4\,in^3$

Yes

104. $V(h) = -4\sqrt{h} + 20$

| $h$ | $V(h) = -4\sqrt{h} + 20$ |
|---|---|
| 1 | $V(1) = -4\sqrt{1} + 20 = -4 + 20 = 16$ |
| 4 | $V(4) = -4\sqrt{4} + 20 = -8 + 20 = 12$ |
| 9 | $V(9) = -4\sqrt{9} + 20 = -12 + 20 = 8$ |
| 16 | $V(16) = -4\sqrt{16} + 20 = -16 + 20 = 4$ |
| 25 | $V(25) = -4\sqrt{25} + 20 = -20 + 20 = 0$ |




Velocity estimate: 9 ft/sec

$V(7) = -4\sqrt{7} + 20 \approx 9.4$ ft / sec

Answers are close.

$5 = -4\sqrt{h} + 20$

$-15 = -4\sqrt{h}$

$3.75 = \sqrt{h}$

$14.0625 = h$

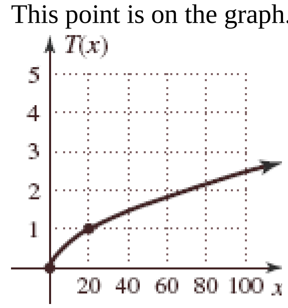
At 5 ft/sec, the water level is about 14 feet.

105. $T(x) = \frac{1}{4}\sqrt{x}$

The graph can be obtained from $y = \sqrt{x}$ if it is compressed vertically.

$T(81) = \frac{1}{4}\sqrt{81} = \frac{1}{4}(9) = 2.25$sec

This point is on the graph.

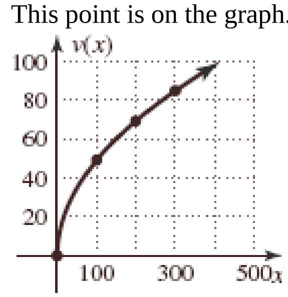



106. $v(x) = 4.9\sqrt{x}$

The graph can be obtained from $y = \sqrt{x}$ if it is stretched vertically.

$v(225) = 4.9\sqrt{225} = 73.5$ mph

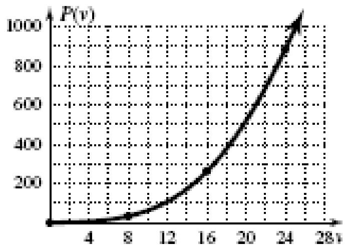
This point is on the graph.



107. $P(v) = \frac{8}{125}v^3$

a. The graph can be obtained from $y = v^3$ if it is compressed vertically.

b.



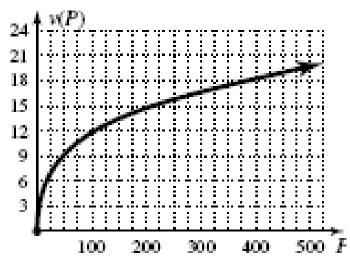

$P(15) = \frac{8}{125}(15)^3 = 216$ watts

c. About 15.6, 161.5, Power increases dramatically at higher windspeeds.

108. $v(P) = \left(\frac{5}{2}\right)\sqrt[3]{P}$

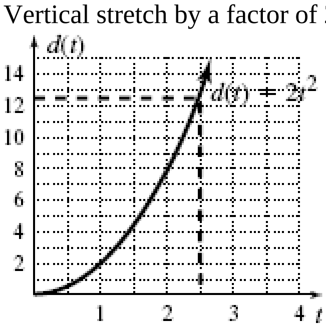
Stretched vertically

$v(343) = \left(\frac{5}{2}\right)\sqrt[3]{343} = \frac{5}{2}(7) = 17.5$ mph




109. $d(t) = 2t^2$

a. Vertical stretch by a factor of 2

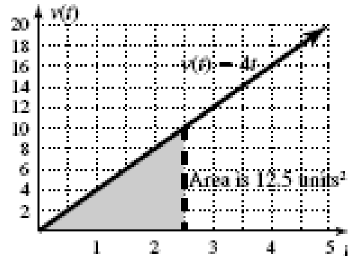



b. $d(2.5) = 2(2.5)^2 = 2(6.25) = 12.5$ ft

c. 5, 13, distance fallen per unit time increases very fast.

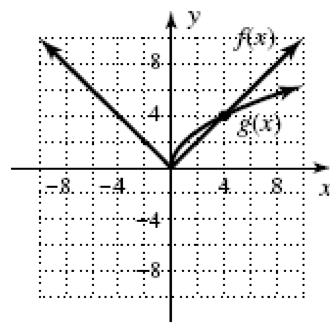
110. $v(t) = 4t$

Vertical stretch by a factor of 4.




$v(2.5) = 4(2.5) = 10$ ft / sec

111. $f(x) = |x|$ and $g(x) = 2\sqrt{x}$




Interval: $x \in (0, 4)$

$x = 1$

$f(1) = |1| = 1$ and $g(1) = 2\sqrt{1} = 2$

$g(h) > f(h)$

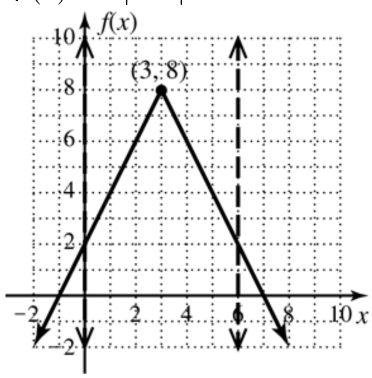
Interval: $x \in (4, \infty)$

$x = 9$

$f(9) = |9| = 9$ and $g(1) = 2\sqrt{9} = 6$

$g(k) < f(k)$

112. $f(x) = -2|x-3|+8$




A=Area of rectangle + Area of triangular segment

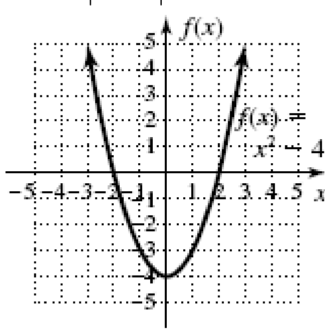
$A = lw + \frac{1}{2}ab$

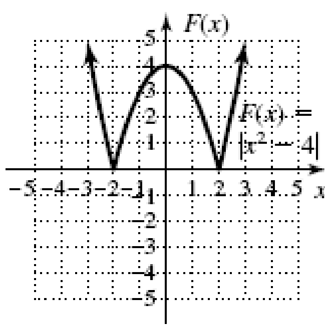
$A = 2(6-0) + \frac{1}{2}(6-0)(8-2)$

$A = 30 \text{ units}^2$

113. $f(x) = x^2 - 4$

$F(x) = |x^2 - 4|$




Any points in QIII and IV will reflected across the *x*–axis and thus move to QI and II.

114. $(-13, 9)$ and $(7, -12)$

$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

$d = \sqrt{(7+13)^2 + (-12-9)^2}$

$d = \sqrt{(20)^2 + (-21)^2}$

$d = \sqrt{400 + 441}$

$d = \sqrt{841} = 29$ miles

$M = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-12-9}{7+13} = \frac{-21}{20}$

115. $P = 32 + 32 + 38 + 24 + 6 + 8 = 140$ in.

$A = 32(32) + 24(6) = 1024 + 144 = 1168 \text{ in}^2$

116. $\frac{2}{3}x + \frac{1}{4} = \frac{1}{2}x - \frac{7}{12}$

$12\left(\frac{2}{3}x + \frac{1}{4} = \frac{1}{2}x - \frac{7}{12}\right)$

$8x + 3 = 6x - 7$

$2x = -10$

$x = -5$

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

Quadratic, opens upward, Vertex (4,3)

$f(x) \downarrow : (-\infty, 4)$;

$f(x) \uparrow : (4, \infty)$

## 2.7 Technology Highlight

Exercise 1: They are approaching 4; not defined.

Exercise 2: $Y_1 = 4$, $Y_2$ has a rounding error. Calculator is rounding to 4; No.

## 2.7 Exercises

1. Continuous

2. Domain

3. Smooth

4. Open

5. Each piece must be continuous on the corresponding interval, and the function values at the endpoints of each interval must be equal. Answers will vary.

6. Answers will vary.

7. a. $f(x)=\begin{cases} x^2-6x+10 & 0\le x\le 5 \\ \frac{3}{2}x-\frac{5}{2} & 5<x\le 9 \end{cases}$

   b. $y\in[1,11]$

8. a. $f(x)=\begin{cases} -1.5|x-5|+10 & 1\le x<7 \\ -\sqrt{x-7}+5 & x\ge 7 \end{cases}$

   b. $y\in(-\infty,10]$

9. $h(x)=\begin{cases} -2 & x<-2 \\ |x| & -2\le x<3 \\ 5 & x\ge 3 \end{cases}$

$h(-5)=-2$;
$h(-2)=|-2|=2$;
$h\left(-\frac{1}{2}\right)=\left|-\frac{1}{2}\right|=\frac{1}{2}$;
$h(0)=|0|=0$;
$h(2.999)=|2.999|=2.999$;
$h(3)=5$

10. $H(x)=\begin{cases} 2x+3 & x<0 \\ x^2+1 & 0\le x<2 \\ 5 & x>2 \end{cases}$

$H(-3)=2(-3)+3=-6+3=-3$;
$H\left(\frac{-3}{2}\right)=2\left(\frac{-3}{2}\right)+3=-3+3=0$;
$H(-0.001)=2(-0.001)+3=2.998$;
$H(1)=(1)^2+1=2$;
$H(2)=\text{not defined}$;
$H(3)=5$

11. $p(x)=\begin{cases} 5 & x<-3 \\ x^2-4 & -3\le x\le 3 \\ 2x+1 & x>3 \end{cases}$

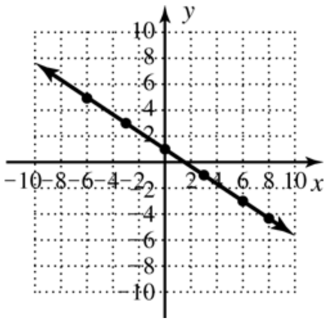
$p(-5)=5$;
$p(-3)=(-3)^2-4=9-4=5$;
$p(-2)=(-2)^2-4=4-4=0$;
$p(0)=(0)^2-4=0-4=-4$;
$p(3)=(3)^2-4=9-4=5$;
$p(5)=2(5)+1=10+1=11$

12. $q(x)=\begin{cases} -x-3 & x<-1 \\ 2 & -1\le x<2 \\ -\frac{1}{2}x^2+3x-2 & x\ge 2 \end{cases}$

$q(-3)=-(-3)-3=3-3=0$;
$q(-1)=2$;
$q(0)=2$;
$q(1.999)=2$;
$q(2)=-\frac{1}{2}(2)^2+3(2)-2=-2+6-2=2$;
$q(4)=-\frac{1}{2}(4)^2+3(4)-2=-8+12-2=2$

# 2.7 Exercises

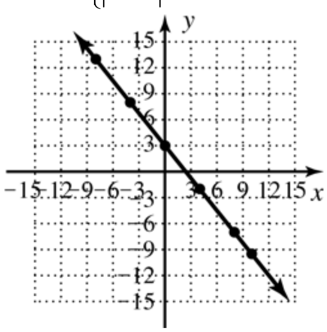
13. $p(x)=\begin{cases} x+2 & -6\le x\le 2 \\ 2|x-4| & x>2 \end{cases}$




D: $x\in[-6,\infty)$

R: $y\in[-4,\infty)$

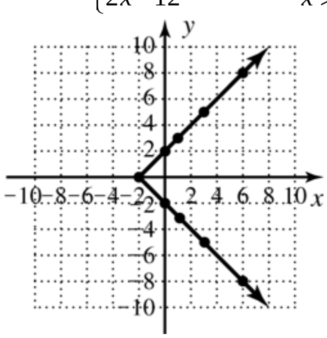
14. $q(x)=\begin{cases} \sqrt{x+4} & -4\le x\le 0 \\ |x-2| & 0<x\le 7 \end{cases}$




D: $x\in[-4,7]$

R: $y\in[0,5]$

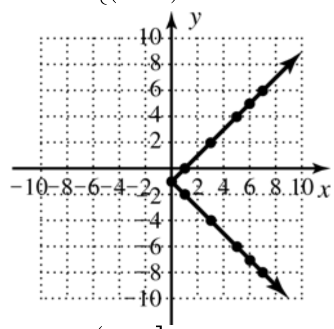
15. $g(x)=\begin{cases} -(x-1)^2+5 & -2\le x\le 4 \\ 2x-12 & x>4 \end{cases}$




$D: x\in[-2,\infty)$

$R: y\in[-4,\infty)$

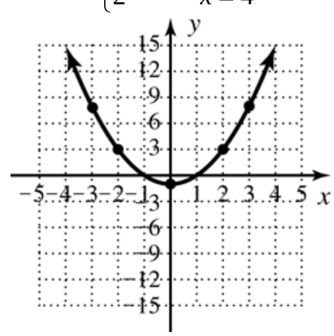
16. $h(x)=\begin{cases} \frac{1}{2}x+1 & x\le 0 \\ (x-2)^2-3 & 0< x\le 5 \end{cases}$




$D: x\in(-\infty,5]$

$R: y\in(-\infty,6]$

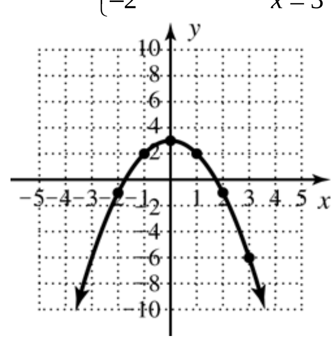
17. $p(x)=\begin{cases} \frac{1}{2}x+1 & x\ne 4 \\ 2 & x=4 \end{cases}$




$D: x\in(-\infty,\infty)$

$R: y\in(-\infty,3)\cup(3,\infty)$

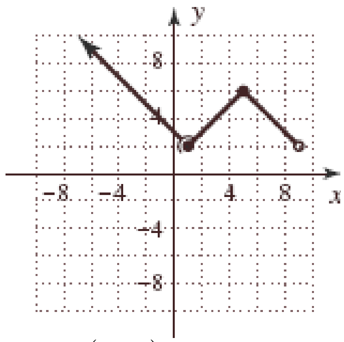
18. $q(x)=\begin{cases} \frac{1}{2}(x-1)^3-1 & x\ne 3 \\ -2 & x=3 \end{cases}$




$D: x\in(-\infty,\infty)$

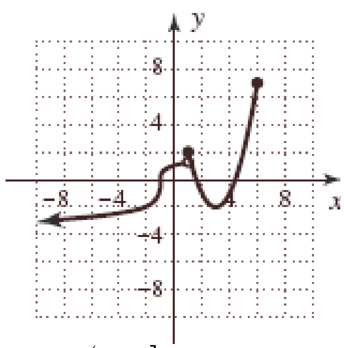
$R: y\in(-\infty,3)\cup(3,\infty)$

19. $H(x)=\begin{cases}-x+3 & x<1\\ -|x-5|+6 & 1\le x<9\end{cases}$



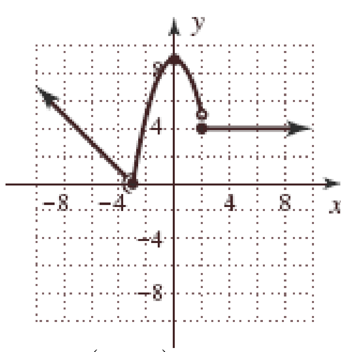

$D: x\in(-\infty,9)$
$R: y\in[2,\infty)$

20. $w(x)=\begin{cases}\sqrt[3]{x+1} & x<1\\ (x-3)^2-2 & 1\le x\le 6\end{cases}$



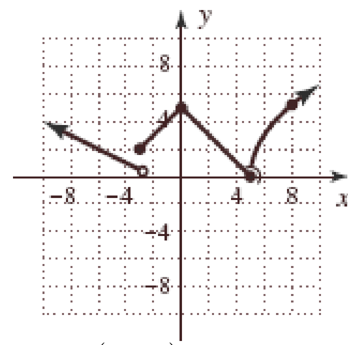

$D: x\in(-\infty,6]$
$R: y\in(-\infty,7]$

21. $f(x)=\begin{cases}-x-3 & x<-3\\ 9-x^2 & -3\le x<2\\ 4 & x\ge 2\end{cases}$



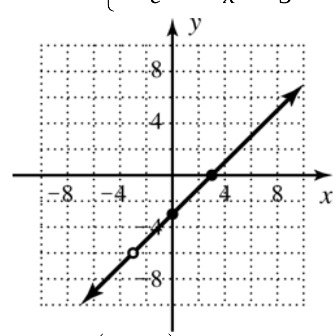

$D: x\in(-\infty,\infty)$
$R: y\in[0,\infty)$

22. $h(x)=\begin{cases}-\frac{1}{2}x-1 & x<-3\\ -|x|+5 & -3\le x\le 5\\ 3\sqrt{x-5} & x>5\end{cases}$




$D: x\in(-\infty,\infty)$
$R: y\in[0,\infty)$

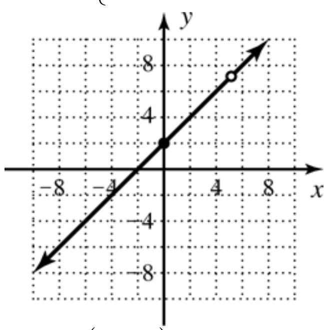
23. $f(x)=\begin{cases}\dfrac{x^2-9}{x+3} & x\ne -3\\ c & x=-3\end{cases}$




$D: x\in(-\infty,\infty)$
$R: y\in(-\infty,-6)\cup(-6,\infty)$
Discontinuity at $x=-3$
Redefine $f(x)=-6$ at $x=-3$; $c=-6$

# 2.7 Exercises

24. $f(x)=\begin{cases}\dfrac{x^2-3x-10}{x-5} & x\neq 5\\ c & x=5\end{cases}$



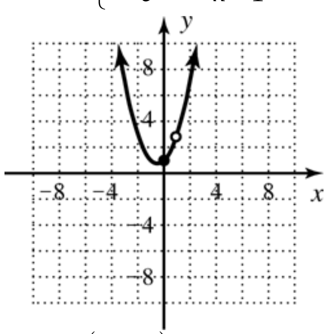
$D: x\in(-\infty,\infty)$

$R: y\in(-\infty,7)\cup(7,\infty)$

Discontinuity at $x = 5$

Redefine $f(x)=7$ at $x=5$; $c=7$

25. $f(x)=\begin{cases}\dfrac{x^3-1}{x-1} & x\neq 1\\ c & x=1\end{cases}$



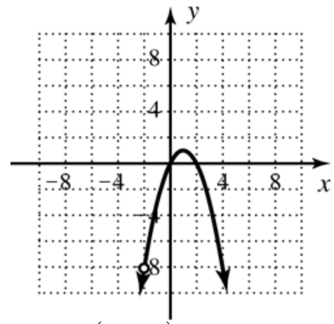
$D: x\in(-\infty,\infty)$

$R: y\in[0.75,\infty)$

Discontinuity at $x = 1$

Redefine $f(x)=3$ at $x=1$; $c=3$

26. $f(x)=\begin{cases}\dfrac{4x-x^3}{x+2} & x\neq -2\\ c & x=-2\end{cases}$



$D: x\in(-\infty,\infty)$

$R: y\in(-\infty,1]$

Discontinuity at $x = -2$

Redefine $f(x)=-8$ at $x=-2$; $c=-8$

27. Left line contains the points ( – 4, – 3) and (2,0).

$m=\dfrac{0-(-3)}{2-(-4)}=\dfrac{1}{2}$;

$y-0=\dfrac{1}{2}(x-2)$

$y=\dfrac{1}{2}x-1$;

Right line contains the points (2,0) and (3,3).

$m=\dfrac{3-0}{3-2}=3$;

$y-0=3(x-2)$

$y=3x-6$;

$f(x)=\begin{cases}\dfrac{1}{2}x-1 & -4\leq x<2\\ 3x-6 & x\geq 2\end{cases}$

28. Left line contains the points (–4,2) and ( – 2,0).

$m=\dfrac{0-2}{-2-(-4)}=-1$;

$y-0=-1(x-(-2))$

$y=-x-2$;

The second equation is an absolute value function with vertex (1,3) and reflected across the $x$–axis.

$g(x)=\begin{cases}-x-2 & x\leq -2\\ -|x-1|+3 & -2\leq x\leq 5\end{cases}$

29. The first equation is a quadratic with vertex $(-1,-4)$, opening up.

$y=(x+1)^2-4$

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

The line is bounded by (1,2) and contains (4,5).

$m=\frac{5-2}{4-1}=1$

$y-2=1(x-1)$

$y=x+1;$

$$p(x)=\begin{cases} x^2+2x-3 & x\le 1 \\ x+1 & x>1 \end{cases}$$

30. The first equation is a horizontal line: $y=-2;$

The second equation is a line with slope 1 and $y$–intercept (0,0). $y=x;$

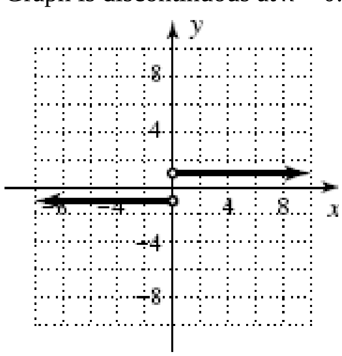
The third equation is a square root function with the vertex (1,1). $y=\sqrt{x-1}+1;$

$$q(x)=\begin{cases} -2 & x\le -1 \\ x & -1\le x\le 1 \\ \sqrt{x-1}+1 & x>1 \end{cases}$$

31. $$|x|=\begin{cases} -x & x<0 \\ x & x\ge 0 \end{cases}$$

$f(x)=\frac{|x|}{x}$

Graph is discontinuous at $x=0$.




If $x<0$, $f(x)=-1$.

If $x>0$, $f(x)=1$.

32.

$$f(x)=\begin{cases} -|x-2|+1 & 1\le x<3 \\ -|x-4|+1 & 3\le x<5 \\ -|x-2k|+1 & 2k-1\le x<2k+1 \text{ for } k\in N \end{cases}$$

Answers will vary.

33. a. $$S(t)=\begin{cases} -t^2+6t & 0\le t\le 5 \\ 500 & t>5 \end{cases}$$

b. $S(t)\in[0,9]$

34. a. $$f(t)=\begin{cases} -0.13t^2+8.1t+208 & 4\le t\le 38 \\ -5.75|t-46|+374 & 38<t<54 \\ -2.45x+460 & t\ge 54 \end{cases}$$

b. $f(t)\in[0,374]$

35. $$P(t)=\begin{cases} -0.03t^2+1.28t+1.68 & 0\le t\le 30 \\ 1.89t-43.5 & t>30 \end{cases}$$

a. $P(5)=-0.03(5)^2+1.28(5)+1.68=7.33$

$P(15)=-0.03(15)^2+1.28(15)+1.68=14.13$

$P(25)=-0.03(25)^2+1.28(25)+1.68=14.93$

$P(35)=1.89(35)-43.5=22.65$

$P(45)=1.89(45)-43.5=41.55$

$P(55)=1.89(55)-43.5=60.45$

b. Each piece gives a slightly different value due to rounding of coefficients in each model. At $t=30$ we use the "first" piece: $P(30)=13.08$.

36. $$\begin{cases} 0.047t^2-0.38t+1.9 & 0\le t<8 \\ -0.075t^2+1.495t-5.265 & 8\le t\le 11 \\ 0.133t+0.685 & t>11 \end{cases}$$

a. $A(3)=0.047(3)^2-0.38(3)+1.9=1.183$

$A(9)=-0.075(9)^2+1.495(9)-5.265=2.115$

$A(15)=0.133(15)+0.685=2.68$

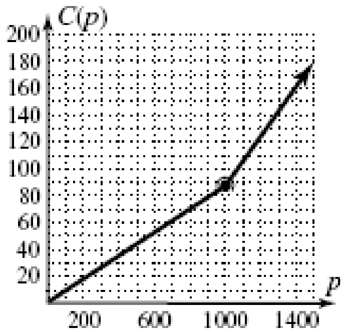
$A(25)=0.133(25)+0.685=4.01$

b. $A(4)=0.047(4)^2-0.38(4)+1.9=1.1$

About 1.1 billion barrels

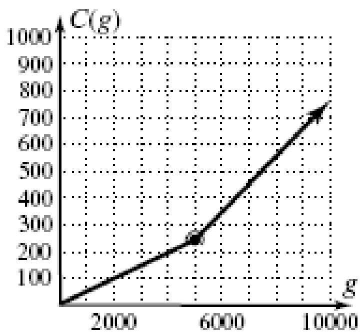
# 2.7 Exercises

37. $C(h)=\begin{cases}0.09h & 0\le h\le 1000\\ 0.18h-90 & h>1000\end{cases}$



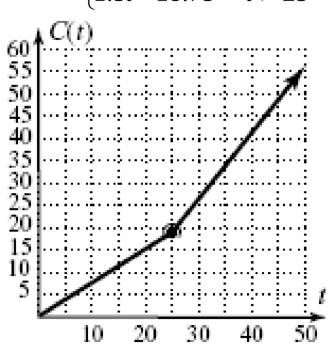

$C(1200)=0.18(1200)-90=216-90=\$126$

38. $C(w)=\begin{cases}0.05w & 0\le w\le 5000\\ 0.10w-250 & w>5000\end{cases}$



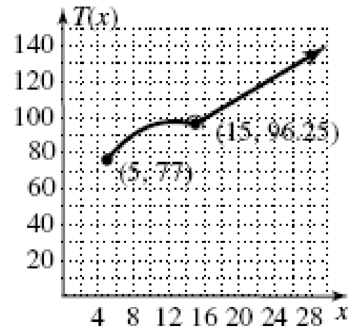

$C(9500)=0.10(9500)-250$
$=950-250=\$700$

39. $C(t)=\begin{cases}0.75t & 0\le t\le 25\\ 1.5t-18.75 & t>25\end{cases}$




$C(45)=1.5(45)-18.75=\$48.75$

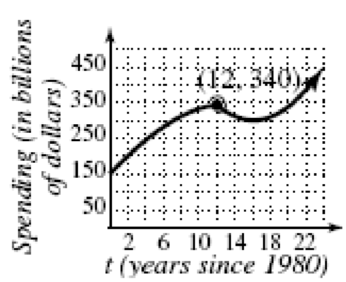
40. $T(x)=\begin{cases}-0.21x^2+6.1x+52 & 5\le x\le 15\\ 4.53x+28.3 & x>15\end{cases}$



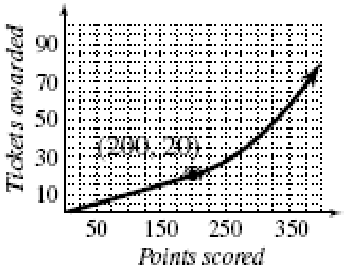

$f(10)=-0.21(10)^2+6.1(10)+52=92$
92,000 births;
$f(20)=4.53(20)+28.3=118.9$
$\approx$ 119,000 births;
$f(25)=4.53(25)+28.3=141.55$
$\approx$ 142,000 births;
$f(30)=4.53(30)+28.3=164.2$
$\approx$ 164,000 births

41. $S(t)=\begin{cases}-1.35t^2+31.9t+152 & 0\le t\le 12\\ 2.5t^2-80.6t+950 & 12<t\le 22\end{cases}$

$S(25)=2.5(25)^2-80.6(25)+950$
$=2.5(625)-2015+950=497.5$
$\approx$ \$498 billion;
$S(28)=2.5(28)^2-80.6(28)+950$
$=2.5(784)-2256.8+950=653.2$
$\approx$ \$653 billion;
$S(30)=2.5(30)^2-80.6(30)+950$
$=2.5(900)-2418+950=782$
$\approx$ \$782 billion



42. $T(x)=\begin{cases}\dfrac{x}{10} & 0\le x\le 200\\ 0.001x^2-0.3x+40 & x>200\end{cases}$

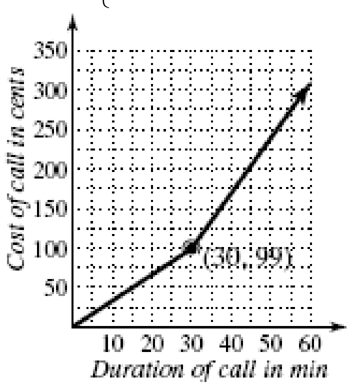



$T(390)=0.001(390)^2-0.3(390)+40$

$=75$ tickets

43. $C(m)=\begin{cases}3.3m & 0\le m\le 30\\ 3.3(30)+7(m-30) & m>30\end{cases}$

$C(m)=\begin{cases}3.3m & 0\le m\le 30\\ 7m-111 & m>30\end{cases}$

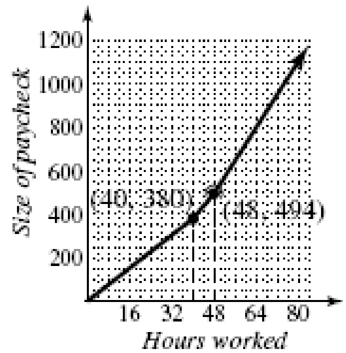



$C(46)=7(46)-111=\$2.11$

44. $W(h)$

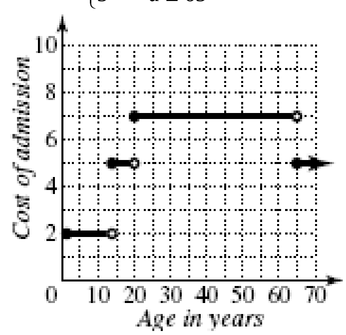
$=\begin{cases}9.50h & 0\le h\le 40\\ 9.50(40)+14.25(h-40) & 41\le h\le 48\\ 9.50(40)+14.25(8)+19.00(h-48) & 48<h<84\end{cases}$

$=\begin{cases}9.50h & 0\le h\le 40\\ 14.25h-190 & 40<h\le 48\\ 19h-418 & 48<h<84\end{cases}$




$W(54)=19(54)-418=\$608$

45. $C(a)=\begin{cases}0 & a<2\\ 2 & 2\le a<13\\ 5 & 13\le a<20\\ 7 & 20\le a<65\\ 5 & a\ge 65\end{cases}$




One grandparent:
$C(70)=5$;
Two adults:
$C(44)=7; C(45)=7$;
Three teenagers:
$3\cdot 5=15$;
Two children:
$2\cdot 2=4$;
One infant: 0
Total Cost: $5+7+7+15+4+0=\$38$

## 2.7 Exercises

46. a. $A(t)=\lfloor t \rfloor$

b. $0 \le t < 123$

c. 36 years

d. 36 years

e. 37 years

f. 37 years

47. a. $C(w)=17\lceil w-1 \rceil+80$

For an envelope weighing between 0 and 1 oz, the cost is \$0.80. Each step interval increases by 0.17.

b. $0 < w \le 13$

c. 80 cents

d. 165 cents

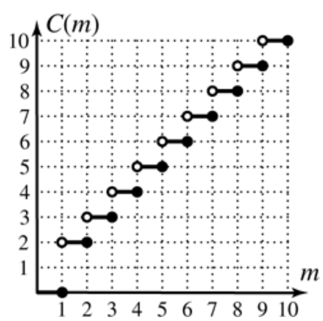
e. 165 cents

f. 165 cents

g. 182 cents

48. a. $C(m)=\begin{cases} 0 & 0 < m \le 1 \\ \lceil m \rceil & m > 1 \end{cases}$

b.

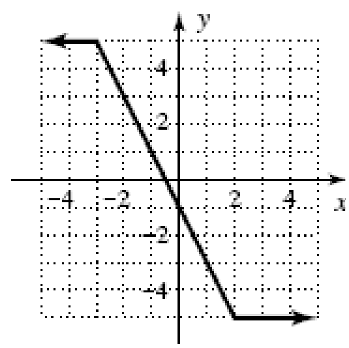



c. 2 min 3 sec $\rightarrow$ 3;
13 min 46 sec $\rightarrow$ 14;
1 min 5 sec $\rightarrow$ 2;
3 min 59 sec $\rightarrow$ 4;
8 min 2 sec $\rightarrow$ 9;
3+14+2+4+9=32 min
Yes, free 30 min has been exceeded.

d. 2 +13+1+3+8 = 27 min;
3+46+5+59+2=115 sec;
27 min 115 sec = 28 min 55 sec

49. $h(x)=|x-2|-|x+3|$

| x | $h(x)=\lvert x-2\rvert-\lvert x+3\rvert$ |
|---|---|
| –5 | $h(-5)=\lvert -5-2\rvert-\lvert -5+3\rvert=7-2=5$ |
| –4 | $h(-4)=\lvert -4-2\rvert-\lvert -4+3\rvert=6-1=5$ |
| –3 | $h(-3)=\lvert -3-2\rvert-\lvert -3+3\rvert=5-0=5$ |
| –2 | $h(-2)=\lvert -2-2\rvert-\lvert -2+3\rvert=4-1=3$ |
| –1 | $h(-1)=\lvert -1-2\rvert-\lvert -1+3\rvert=3-2=1$ |
| 0 | $h(0)=\lvert 0-2\rvert-\lvert 0+3\rvert=2-3=-1$ |
| 1 | $h(1)=\lvert 1-2\rvert-\lvert 1+3\rvert=1-4=-3$ |
| 2 | $h(2)=\lvert 2-2\rvert-\lvert 2+3\rvert=0-5=-5$ |
| 3 | $h(3)=\lvert 3-2\rvert-\lvert 3+3\rvert=1-6=-5$ |
| 4 | $h(4)=\lvert 4-2\rvert-\lvert 4+3\rvert=2-7=-5$ |
| 5 | $h(5)=\lvert 5-2\rvert-\lvert 5+3\rvert=3-8=-5$ |

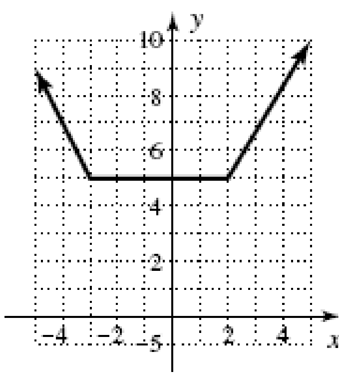



The function is continuous.

$$h(x)=\begin{cases} 5 & x \le -3 \\ -2x-1 & -3 < x < 2 \\ -5 & x \ge 2 \end{cases}$$

50. $H(x)=|x-2|+|x+3|$

| x | $H(x)=\|x-2\|+\|x+3\|$ |
|---|---|
| $-5$ | $H(-5)=\|-5-2\|+\|-5+3\|=7+2=9$ |
| $-4$ | $H(-4)=\|-4-2\|+\|-4+3\|=6+1=7$ |
| $-3$ | $H(-3)=\|-3-2\|+\|-3+3\|=5+0=5$ |
| $-2$ | $H(-2)=\|-2-2\|+\|-2+3\|=4+1=5$ |
| $-1$ | $H(-1)=\|-1-2\|+\|-1+3\|=3+2=5$ |
| 0 | $H(0)=\|0-2\|+\|0+3\|=2+3=5$ |
| 1 | $H(1)=\|1-2\|+\|1+3\|=1+4=5$ |
| 2 | $H(2)=\|2-2\|+\|2+3\|=0+5=5$ |
| 3 | $H(3)=\|3-2\|+\|3+3\|=1+6=7$ |
| 4 | $H(4)=\|4-2\|+\|4+3\|=2+7=9$ |
| 5 | $H(5)=\|5-2\|+\|5+3\|=3+8=11$ |




The function is continuous.

$$h(x)=\begin{cases}-2x-1 & x<-3\\ 5 & -3\le x\le 2\\ 2x+1 & x>2\end{cases}$$

51. $Y_1=\dfrac{x+2}{x+2}$, $Y_2=\dfrac{|x+2|}{x+2}$

$Y_1$ has a removable discontinuity at $x=-2$.

$Y_2$ is discontinuous at $x=-2$.

52. $f(x)=\begin{cases}x^2 & x<1\\ 4x-3 & 1\le x\le 3\\ 2x+3 & x>3\end{cases}$

53. $\dfrac{3}{x-2}+1=\dfrac{30}{x^2-4}$

$$\left(\frac{3}{x-2}+1=\frac{30}{(x-2)(x+2)}\right)(x-2)(x+2)$$

$$3(x+2)+1(x-2)(x+2)=30$$

$$3x+6+x^2-4=30$$

$$x^2+3x-28=0$$

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

$x=-7;\quad x=4$

54. $\dfrac{x^3+3x^2-4x-12}{x-3}\cdot\dfrac{2x-6}{x^2+5x+6}\div\dfrac{3x-6}{1}$

$$=\frac{x^2(x+3)-4(x+3)}{x-3}\cdot\frac{2(x-3)}{(x+2)(x+3)}\div\frac{3(x-2)}{1}$$

$$=\frac{(x+3)(x^2-4)}{x-3}\cdot\frac{2(x-3)}{(x+2)(x+3)}\div\frac{3(x-2)}{1}$$

$$=\frac{(x+3)(x+2)(x-2)}{x-3}\cdot\frac{2(x-3)}{(x+2)(x+3)}\cdot\frac{1}{3(x-2)}$$

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

55. a. $a^2+b^2=c^2$

$$8^2+b^2=12^2$$

$$64+b^2=144$$

$$b^2=80$$

$$b=4\sqrt{5}\text{ cm}$$

b. $A=\dfrac{1}{2}bh$

$$A=\frac{1}{2}\left(4\sqrt{5}\right)(8)$$

$$A=16\sqrt{5}\text{ cm}^2$$

c. $V=\left(\dfrac{bh}{2}\right)h$

$$V=\left(16\sqrt{5}\right)(20)=320\sqrt{5}\text{ cm}^3$$

56. $3x+4y=8$

$4y=-3x+8$

$y=-\frac{3}{4}x+2$

$m=-\frac{3}{4}$, slope of a line perpendicular to the given line is $\frac{4}{3}$.

Slope $\frac{4}{3}$ passing through (0,–2):

$y=\frac{4}{3}x-2$

## 2.8 Technology Highlight

Exercise 1: $Y_1=\sqrt{x}$ and $Y_2=x+7$

Yes, graph shifts 7 units to the left.

Exercise 2: $Y_1=x^3$ and

$Y_2=x-1$

Yes, the basic function $f(x)=|x|$ shifts 1 unit right.

## 2.8 Exercises

1. $(f+g)(x)$; $A\cap B$

2. $(f\cdot g)(5)$; $f(5)\cdot g(5)$

3. Intersection; $g(x)$

4. Composition; $g(x)$; $f(x)$; $f[g(x)]$

5. Answers will vary.

6. Answers will vary.

7. a. Domain:

$f(x)=2x^2-x-3; x\in\mathbb{R}$ ;

$g(x)=x^2+5x; x\in\mathbb{R}$ ;

$h(x)=f(x)-g(x); x\in\mathbb{R}$

b. $h(-2)=f(-2)-g(-2)$

$=2(-2)^2-(-2)-3-((-2)^2+5(-2))$

$=7-(-6)=13$

8. a. Domain:

$f(x)=2x^2-18; x\in\mathbb{R}$ ;

$g(x)=-3x-7; x\in\mathbb{R}$ ;

$h(x)=f(x)+g(x); x\in\mathbb{R}$

b. $h(5)=f(5)+g(5)$

$=2(5)^2-18+(-3(5)-7)$

$=32+(-22)=10$

9. $h(x)=f(x)-g(x)$

a. $h(x)=2x^2-x-3-(x^2+5x)$

$=2x^2-x-3-x^2-5x$

$=x^2-6x-3$

b. $h(-2)=(-2)^2-6(-2)-3=13$

c. Same result

10. $h(x)=f(x)+g(x)$

a. $h(x)=2x^2-18+(-3x-7)$

$=2x^2-18-3x-7$

$=2x^2-3x-25$

b. $h(5)=2(5)^2-3(5)-25=10$

c. Same result

11. a. Domain of $f(x)=\sqrt{x-3}$

$x-3\ge 0$

$x\ge 3$; $[3,\infty)$

Domain of $g(x): x\in\mathbb{R}$ ;

Domain of $h(x): x\in[3,\infty)$

b. $h(x)=(f+g)(x)$

$=f(x)+g(x)$

$=\sqrt{x-3}+2x^3-54$

c. $h(4)=\sqrt{4-3}+2(4)^3-54=75$ ;

$h(2)=\sqrt{2-3}+2(2)^3-54$

$=\sqrt{-1}+16-54$

$\sqrt{-1}$ is not a real number;

2 is not in the domain of $h(x)$.

12. a. Domain of $f(x): x \in \mathbb{R}$ ;
Domain of $g(x) = \sqrt{2x-5}$
$2x - 5 \geq 0$
$x \geq \frac{5}{2};\ x \in \left[\frac{5}{2}, \infty\right)$
Domain of $h(x): x \in \left[\frac{5}{2}, \infty\right)$

b. $h(x) = (f - g)(x)$
$= f(x) - g(x)$
$= 4x^2 - 2x + 3 - \sqrt{2x-5}$

c. $h(7) = 4(7)^2 - 2(7) + 3 - \sqrt{2(7)-5}$
$h(7) = 196 - 14 + 3 - \sqrt{9} = 182;$
$h(2) = 4(2)^2 - 2(2) + 3 - \sqrt{2(2)-5}$
$= 16 - 4 + 3 - \sqrt{-1}$
$\sqrt{-1}$ is not a real number;
2 is not in the domain of $h(x)$.

13. a. Domain of $p(x) = \sqrt{x+5}$
$x + 5 \geq 0$
$x \geq -5;\ x \in [-5, \infty)$
Domain of $q(x) = \sqrt{3-x}$
$3 - x \geq 0$
$-x \geq -3$
$x \leq 3;\ x \in (-\infty, 3]$
Domain of $r(x): x \in [-5, 3]$

b. $r(x) = (p + q)(x)$
$= p(x) + q(x)$
$= \sqrt{x+5} + \sqrt{3-x}$

c. $r(2) = \sqrt{2+5} + \sqrt{3-2} = \sqrt{7} + 1$
$r(4) = \sqrt{4+5} + \sqrt{3-4} = \sqrt{9} + \sqrt{-1}$
$\sqrt{-1}$ is not a real number;
4 is not in the domain of $r(x)$.

14. a. Domain of $p(x) = \sqrt{6-x}$
$6 - x \geq 0$
$-x \geq -6$
$x \leq 6;\ x \in (-\infty, 6]$
Domain of $q(x) = \sqrt{x+2}$
$x + 2 \geq 0$
$x \geq -2;\ x \in [-2, \infty)$
Domain of $r(x): x \in [-2, 6]$

b. $r(x) = (p - q)(x)$
$= p(x) - q(x)$
$= \sqrt{6-x} - \sqrt{x+2}$

c. $r(-3) = \sqrt{6-(-3)} - \sqrt{-3+2}$
$= \sqrt{9} + \sqrt{-1}$
$\sqrt{-1}$ is not a real number;
$-3$ is not in the domain of $r(x)$.
$r(2) = \sqrt{6-2} - \sqrt{2+2} = 0$

15. a. Domain of $f(x) = \sqrt{x+4}$
$x + 4 \geq 0$
$x \geq -4;\ x \in [-4, \infty)$
Domain of $g(x) = 2x + 3 : x \in \mathbb{R}$
Domain of $h(x): x \in [-4, \infty)$

b. $h(x) = (f \cdot g)(x)$
$= f(x) \cdot g(x)$
$= \sqrt{x+4}(2x+3)$

c. $h(-4) = \sqrt{-4+4}\left(2(-4)+3\right) = 0$ ;
$h(21) = \sqrt{21+4}\left(2(21)+3\right) = 225$

16. a. Domain of $f(x) = -3x + 5 : x \in \mathbb{R}$
Domain of $g(x) = \sqrt{x-7}$
$x - 7 \geq 0$
$x \geq 7;\ x \in [7, \infty)$
Domain of $h(x): x \in [7, \infty)$

b. $h(x) = (f \cdot g)(x)$
$= f(x) \cdot g(x)$
$= (-3x+5)\sqrt{x-7}$

c. $h(8) = \left(-3(8)+5\right)\sqrt{8-7} = -19(1) = -19$ ;
$h(11) = \left(-3(11)+5\right)\sqrt{11-7} = -28(2) = -56$

# 2.8 Exercises

17. a. Domain of $p(x)=\sqrt{x+1}$

$x+1\geq 0$

$x\geq -1;\ x\in[-1,\infty)$

Domain of $q(x)=\sqrt{7-x}$

$7-x\geq 0$

$-x\geq -7$

$x\leq 7;\ x\in(-\infty,7]$

Domain of $r(x): x\in[-1,7]$

b. $r(x)=(p\cdot q)(x)$

$=p(x)\cdot q(x)$

$=\sqrt{x+1}\cdot\sqrt{7-x}$

$=\sqrt{-x^2+6x+7}$

c. $r(15)=\sqrt{-(15)^2+6(15)+7}=\sqrt{-128}$

$\sqrt{-128}$ is not a real number;

15 is not in the domain of $r(x)$.

$r(3)=\sqrt{-(3)^2+6(3)+7}=\sqrt{16}=4$

18. a. Domain of $p(x)=\sqrt{4-x}$

$4-x\geq 0$

$-x\geq -4$

$x\leq 4;\ x\in(-\infty,4]$

Domain of $q(x)=\sqrt{x+4}$

$x+4\geq 0$

$x\geq -4;\ x\in[-4,\infty)$

Domain of $r(x): x\in[-4,4]$

b. $r(x)=(p\cdot q)(x)$

$=p(x)\cdot q(x)$

$=\sqrt{4-x}\cdot\sqrt{x+4}$

$=\sqrt{16-x^2}$

c. $r(-5)=\sqrt{16-(-5)^2}=\sqrt{-9}$

$\sqrt{-9}$ is not a real number;

–5 is not in the domain of $r(x)$.

$r(-3)=\sqrt{16-(-3)^2}=\sqrt{7}$

19. a. Domain of $f(x)=x^2-16: x\in\mathbb{R}$

Domain of $g(x)=x+4: x\in\mathbb{R}$

Domain of $h(x)=\dfrac{x^2-16}{x+4}, x\neq -4$

$x\in(-\infty,-4)\cup(-4,\infty)$

b. $h(x)=\dfrac{f}{g}(x)=\dfrac{x^2-16}{x+4}$

$h(x)=\dfrac{(x+4)(x-4)}{x+4}=x-4;\ x\neq -4$

20. a. Domain of $f(x)=x^2-49: x\in\mathbb{R}$

Domain of $g(x)=x-7: x\in\mathbb{R}$

Domain of $h(x)=\dfrac{x^2-49}{x-7}, x\neq 7$

$x\in(-\infty,7)\cup(7,\infty)$

b. $h(x)=\dfrac{f}{g}(x)=\dfrac{x^2-49}{x-7}$

$h(x)=\dfrac{(x+7)(x-7)}{x-7}=x+7;\ x\neq 7$

21. a. Domain of

$f(x)=x^3+4x^2-2x-8: x\in\mathbb{R}$

Domain of $g(x)=x+4, x\in\mathbb{R}$

Domain of

$h(x)=\dfrac{x^3+4x^2-2x-8}{x+4}, x\neq -4$

$x\in(-\infty,-4)\cup(-4,\infty)$

b. $h(x)=\dfrac{f}{g}(x)=\dfrac{x^3+4x^2-2x-8}{x+4}$

$h(x)=\dfrac{x^2(x+4)-2(x+4)}{x+4}$

$=\dfrac{(x+4)(x^2-2)}{x+4}=x^2-2;\ x\neq -4$

22. a. Domain of

$f(x)=x^3-5x^2+2x-10: x\in\mathbb{R}$

Domain of $g(x)=x-5: x\in\mathbb{R}$

Domain of

$h(x)=\dfrac{x^3-5x^2+2x-10}{x-5}, x\neq 5$

$x\in(-\infty,5)\cup(5,\infty)$

b. $h(x)=\dfrac{f}{g}(x)=\dfrac{x^3-5x^2+2x-10}{x-5}$

$h(x)=\dfrac{x^2(x-5)+2(x-5)}{x-5}$

$=\dfrac{(x-5)(x^2+2)}{x-5}=x^2+2;\ x\neq 5$

23. a. Domain of $f(x) = x^3 - 7x^2 + 6x : x \in \mathbb{R}$
Domain of $g(x) = x - 1 : x \in \mathbb{R}$
Domain of
$h(x) = \dfrac{x^3 - 7x^2 + 6x}{x - 1}, x \neq 1$
$x \in (-\infty, 1) \cup (1, \infty)$

b. $h(x) = \dfrac{f}{g}(x) = \dfrac{x^3 - 7x^2 + 6x}{x - 1}$
$h(x) = \dfrac{x(x^2 - 7x + 6)}{x - 1}$
$= \dfrac{x(x-6)(x-1)}{x - 1} = x(x - 6)$
$= x^2 - 6x;\ x \neq 1$

24. a. Domain of $f(x) = x^3 - 1 : x \in \mathbb{R}$
Domain of $g(x) = x - 1 : x \in \mathbb{R}$
Domain of $h(x) = \dfrac{x^3 - 1}{x - 1}, x \neq 1$
$x \in (-\infty, 1) \cup (1, \infty)$

b. $h(x) = \dfrac{f}{g}(x) = \dfrac{x^3 - 1}{x - 1}$
$h(x) = \dfrac{(x-1)(x^2 + x + 1)}{x - 1}$
$= x^2 + x + 1;\ x \neq 1$

25. a. Domain of $f(x) = x + 1 : x \in \mathbb{R}$
Domain of $g(x) = x - 5 : x \in \mathbb{R}$
Domain of
$h(x) = \dfrac{x + 1}{x - 5}, x \neq 5$
$x \in (-\infty, 5) \cup (5, \infty)$

b. $h(x) = \dfrac{f}{g}(x) = \dfrac{x + 1}{x - 5};\quad x \neq 1$

26. a. Domain of $f(x) = x + 3 : x \in \mathbb{R}$
Domain of $g(x) = x - 7 : x \in \mathbb{R}$
Domain of
$h(x) = \dfrac{x + 3}{x - 7}, x \neq 7$
$x \in (-\infty, 7) \cup (7, \infty)$

b. $h(x) = \dfrac{f}{g}(x) = \dfrac{x + 3}{x - 7};\quad x \neq 7$

27. a. Domain of $p(x) = 2x - 3 : x \in \mathbb{R}$
Domain of $q(x) = \sqrt{-2 - x}$,
$-2 - x \geq 0$
$-x \geq 2$
$x \leq -2;\ x \in (-\infty, -2]$
Domain of $r(x) = \dfrac{2x - 3}{\sqrt{-2 - x}}$,
$-2 - x > 0$
$-x > 2$
$x < -2;\ x \in (-\infty, -2)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{2x - 3}{\sqrt{-2 - x}}$

c. $r(6) = \dfrac{2(6) - 3}{\sqrt{-2 - 6}} = \dfrac{9}{\sqrt{-8}}$
$\sqrt{-8}$ is not a real number;
6 is not in the domain of $r(x)$.
$r(-6) = \dfrac{2(-6) - 3}{\sqrt{-2 + 6}} = \dfrac{-15}{\sqrt{4}} = -\dfrac{15}{2}$

28. a. Domain of $p(x) = 1 - x : x \in \mathbb{R}$
Domain of $q(x) = \sqrt{3 - x}$,
$3 - x \geq 0$
$-x \geq -3$
$x \leq 3;\ x \in (-\infty, 3]$
Domain of $r(x) = \dfrac{1 - x}{\sqrt{3 - x}}$,
$3 - x > 0$
$-x > -3$
$x < 3;\ x \in (-\infty, 3)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{1 - x}{\sqrt{3 - x}}$

c. $r(6) = \dfrac{1 - 6}{\sqrt{3 - 6}} = \dfrac{-5}{\sqrt{-3}}$
$\sqrt{-3}$ is not a real number;
6 is not in the domain of $r(x)$.
$r(-6) = \dfrac{1 - (-6)}{\sqrt{3 + 6}} = \dfrac{7}{\sqrt{9}} = \dfrac{7}{3}$

## 2.8 Exercises

29. a. Domain of $p(x) = x - 5 : x \in \mathbb{R}$

Domain of $q(x) = \sqrt{x-5}$,

$x - 5 \geq 0$

$x \geq 5;\ x \in [5, \infty)$

Domain of $r(x) = \dfrac{x-5}{\sqrt{x-5}}$,

$x - 5 > 0$

$x > 5;\ x \in (5, \infty)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{x-5}{\sqrt{x-5}}$

c. $r(6) = \dfrac{6-5}{\sqrt{6-5}} = \dfrac{1}{\sqrt{1}} = 1$

$r(-6) = \dfrac{-6-5}{\sqrt{-6-5}} = \dfrac{-11}{\sqrt{-11}}$

$\sqrt{-11}$ is not a real number;

$-6$ is not in the domain of $r(x)$.

30. a. Domain of $p(x) = x + 2 : x \in \mathbb{R}$

Domain of $q(x) = \sqrt{x+3}$,

$x + 3 \geq 0$

$x \geq -3;\ x \in [-3, \infty)$

Domain of $r(x) = \dfrac{x+2}{\sqrt{x+3}}$,

$x + 3 > 0$

$x > -3;\ x \in (-3, \infty)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{x+2}{\sqrt{x+3}}$

c. $r(6) = \dfrac{6+2}{\sqrt{6+3}} = \dfrac{8}{\sqrt{9}} = \dfrac{8}{3}$

$r(-6) = \dfrac{-6+2}{\sqrt{-6+3}} = \dfrac{-4}{\sqrt{-3}}$

$\sqrt{-3}$ is not a real number;

$-6$ is not in the domain of $r(x)$.

31. a. Domain of $p(x) = x^2 - 36 : x \in \mathbb{R}$

Domain of $q(x) = \sqrt{2x+13}$,

$2x + 13 \geq 0$

$2x \geq -13$

$x \geq -\dfrac{13}{2};\ x \in \left[-\dfrac{13}{2}, \infty\right)$

Domain of $r(x) = \dfrac{x^2-36}{\sqrt{2x+13}}$,

$2x + 13 > 0$

$2x > -13$

$x > -\dfrac{13}{2};\ x \in \left(-\dfrac{13}{2}, \infty\right)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{x^2-36}{\sqrt{2x+13}}$

c. $r(6) = \dfrac{6^2-36}{\sqrt{2(6)+13}} = \dfrac{0}{\sqrt{25}} = 0$

$r(-6) = \dfrac{(-6)^2-36}{\sqrt{2(-6)+13}} = \dfrac{0}{\sqrt{1}} = 0$

32. a. Domain of $p(x) = x^2 - 6x : x \in \mathbb{R}$

Domain of $q(x) = \sqrt{7+3x}$,

$7 + 3x \geq 0$

$3x \geq -7$

$x \geq -\dfrac{7}{3};\ x \in \left[-\dfrac{7}{3}, \infty\right)$

Domain of $r(x) = \dfrac{x^2-6x}{\sqrt{7+3x}}$,

$7 + 3x > 0$

$3x > -7$

$x > -\dfrac{7}{3};\ x \in \left(-\dfrac{7}{3}, \infty\right)$

b. $r(x) = \dfrac{p}{q}(x) = \dfrac{x^2-6x}{\sqrt{7+3x}}$

c. $r(6) = \dfrac{(6)^2-6(6)}{\sqrt{7+3(6)}} = \dfrac{0}{\sqrt{25}} = 0$

$r(-6) = \dfrac{(-6)^2-6(-6)}{\sqrt{7+3(-6)}} = \dfrac{72}{\sqrt{-11}}$

$\sqrt{-11}$ is not a real number;

$-6$ is not in the domain of $r(x)$.

33. a. $f(x)=\frac{6x}{x-3}, g(x)=\frac{3x}{x+2}$

$h(x)=\frac{f(x)}{g(x)}=\frac{\frac{6x}{x-3}}{\frac{3x}{x+2}}$

$=\frac{6x}{x-3}\div\frac{3x}{x+2}=\frac{6x}{x-3}\cdot\frac{x+2}{3x}$

$=\frac{2(x+2)}{x-3}=\frac{2x+4}{x-3}$

b. Domain of $h(x)=\frac{2x+4}{x-3}, x\neq 3$

$x\in(-\infty,3)\cup(3,\infty)$

c. $x+2\neq 0$

$x\neq -2;$

$\frac{3x}{x+2}\neq 0$

$x\neq 0$

34. a. $f(x)=\frac{4x}{x+1}, g(x)=\frac{2x}{x-2}$

$h(x)=\frac{f(x)}{g(x)}=\frac{\frac{4x}{x+1}}{\frac{2x}{x-2}}$

$=\frac{4x}{x+1}\div\frac{2x}{x-2}=\frac{4x}{x+1}\cdot\frac{x-2}{2x}$

$=\frac{2(x-2)}{x+1}=\frac{2x-4}{x+1}$

b. Domain of $h(x)=\frac{2x-4}{x+1}, x\neq -1$

$x\in(-\infty,-1)\cup(-1,\infty)$;

c. $x-2\neq 0$

$x\neq 2;$

$\frac{2x}{x-2}\neq 0$

$x\neq 0$

35. $f(x)=2x+3$ and $g(x)=x-2$

Sum:

$f(x)+g(x)=2x+3+x-2=3x+1$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Difference:

$f(x)-g(x)=2x+3-(x-2)$

$=2x+3-x+2=x+5$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Product:

$f(x)\cdot g(x)=(2x+3)(x-2)$

$=2x^2-4x+3x-6$

$=2x^2-x-6$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Quotient:

$\frac{f(x)}{g(x)}=\frac{2x+3}{x-2}$

$x-2\neq 0$

$x\neq 2$

$D: x\in(-\infty,2)\cup(2,\infty)$

36. $f(x)=x-5$ and $g(x)=2x-3$

Sum:

$f(x)+g(x)=x-5+2x-3=3x-8$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Difference:

$f(x)-g(x)=x-5-(2x-3)$

$=x-5-2x+3$

$=-x-2$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Product:

$f(x)\cdot g(x)=(x-5)(2x-3)$

$=2x^2-3x-10x+15$

$=2x^2-13x+15$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Quotient:

$\frac{f(x)}{g(x)}=\frac{x-5}{2x-3}$

$2x-3\neq 0$

$2x\neq 3$

$x\neq\frac{3}{2}$

$D: x\in\left(-\infty,\frac{3}{2}\right)\cup\left(\frac{3}{2},\infty\right)$

37. $f(x) = x^2 + 7$ and $g(x) = 3x - 2$

Sum:

$f(x) + g(x) = x^2 + 7 + 3x - 2 = x^2 + 3x + 5$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Difference:

$f(x) - g(x) = x^2 + 7 - (3x - 2)$

$= x^2 + 7 - 3x + 2$

$= x^2 - 3x + 9$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Product:

$f(x) \cdot g(x) = (x^2 + 7)(3x - 2)$

$= 3x^3 - 2x^2 + 21x - 14$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Quotient:

$\frac{f(x)}{g(x)} = \frac{x^2 + 7}{3x - 2}$

$3x - 2 \neq 0$

$3x \neq 2$

$x \neq \frac{2}{3}$

$D : x \in \left(-\infty, \frac{2}{3}\right) \cup \left(\frac{2}{3}, \infty\right)$

38. $f(x) = x^2 - 3x$ and $g(x) = x + 4$

Sum:

$f(x) + g(x) = x^2 - 3x + x + 4 = x^2 - 2x + 4$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Difference:

$f(x) - g(x) = x^2 - 3x - (x + 4)$

$= x^2 - 3x - x - 4$

$= x^2 - 4x - 4$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Product:

$f(x) \cdot g(x) = (x^2 - 3x)(x + 4)$

$= x^3 + 4x^2 - 3x^2 - 12x$

$= x^3 + x^2 - 12x$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Quotient:

$\frac{f(x)}{g(x)} = \frac{x^2 - 3x}{x + 4}$

$x + 4 \neq 0$

$x \neq -4$

$D : x \in (-\infty, -4) \cup (-4, \infty)$

39. $f(x) = x^2 + 2x - 3$ and $g(x) = x - 1$

Sum:

$f(x) + g(x) = x^2 + 2x - 3 + x - 1$

$= x^2 + 3x - 4$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Difference:

$f(x) - g(x) = x^2 + 2x - 3 - (x - 1)$

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

$= x^2 + x - 2$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Product:

$f(x) \cdot g(x) = (x^2 + 2x - 3)(x - 1)$

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

$= x^3 + x^2 - 5x + 3$

Domain contains all values of *x*.

$D : x \in (-\infty, \infty)$

Quotient:

$\frac{f(x)}{g(x)} = \frac{x^2 + 2x - 3}{x - 1}$

$= \frac{(x + 3)(x - 1)}{x - 1} = x + 3$

$x - 1 \neq 0$

$x \neq 1$

$D : x \in (-\infty, 1) \cup (1, \infty)$

40. $f(x)=x^2-2x-15$ and $g(x)=x+3$

Sum:

$f(x)+g(x)=x^2-2x-15+x+3$

$=x^2-x-12$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Difference:

$f(x)-g(x)=x^2-2x-15-(x+3)$

$=x^2-2x-15-x-3$

$=x^2-3x-18$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Product:

$f(x)\cdot g(x)=(x^2-2x-15)(x+3)$

$=x^3+3x^2-2x^2-6x-15x-45$

$=x^3+x^2-21x-45$

Domain contains all values of *x*.

$D: x\in(-\infty,\infty)$

Quotient:

$\dfrac{f(x)}{g(x)}=\dfrac{x^2-2x-15}{x+3}$

$=\dfrac{(x+3)(x-5)}{x+3}=x-5$

$x+3\neq 0$

$x\neq -3$

$D: x\in(-\infty,-3)\cup(-3,\infty)$

41. $f(x)=3x+1$ and $g(x)=\sqrt{x-3}$

Sum:

$f(x)+g(x)=3x+1+\sqrt{x-3}$

$x-3\geq 0$

$x\geq 3$

$D: x\in[3,\infty)$

Difference:

$f(x)-g(x)=3x+1-\sqrt{x-3}$

$x-3\geq 0$

$x\geq 3$

$D: x\in[3,\infty)$

Product:

$f(x)\cdot g(x)=(3x+1)\sqrt{x-3}$

$x-3\geq 0$

$x\geq 3$

$D: x\in[3,\infty)$

Quotient:

$\dfrac{f(x)}{g(x)}=\dfrac{3x+1}{\sqrt{x-3}}$

$x-3>0$

$x>3$

$D: x\in(3,\infty)$

42. $f(x)=x+2$ and $g(x)=\sqrt{x+6}$

Sum:

$f(x)+g(x)=x+2+\sqrt{x+6}$

$x+6\geq 0$

$x\geq -6$

$D: x\in[-6,\infty)$

Difference:

$f(x)-g(x)=x+2-\sqrt{x+6}$

$x+6\geq 0$

$x\geq -6$

$D: x\in[-6,\infty)$

Product:

$f(x)\cdot g(x)=(x+2)\sqrt{x+6}$

$x+6\geq 0$

$x\geq -6$

$D: x\in[-6,\infty)$

Quotient:

$\dfrac{f(x)}{g(x)}=\dfrac{x+2}{\sqrt{x+6}}$

$x+6>0$

$x>-6$

$D: x\in(-6,\infty)$

43. $f(x)=2x^2$ and $g(x)=\sqrt{x+1}$

Sum:

$f(x)+g(x)=2x^2+\sqrt{x+1}$

$x+1\geq 0$

$x\geq -1$

$D: x\in[-1,\infty)$

Difference:

$f(x)-g(x)=2x^2-\sqrt{x+1}$

$x+1\geq 0$

$x\geq -1$

$D: x\in[-1,\infty)$

Product:

$f(x)\cdot g(x)=2x^2\sqrt{x+1}$

$x+1\geq 0$

$x\geq -1$

$D: x\in[-1,\infty)$

Quotient:

$\dfrac{f(x)}{g(x)}=\dfrac{2x^2}{\sqrt{x+1}}$

$x+1>0$

$x>-1$

$D: x\in(-1,\infty)$

44. $f(x)=x^2+2$ and $g(x)=\sqrt{x-5}$

Sum:

$f(x)+g(x)=x^2+2+\sqrt{x-5}$

$x-5\geq 0$

$x\geq 5$

$D: x\in[5,\infty)$

Difference:

$f(x)-g(x)=x^2+2-\sqrt{x-5}$

$x-5\geq 0$

$x\geq 5$

$D: x\in[5,\infty)$

Product:

$f(x)+g(x)=(x^2+2)\sqrt{x-5}$

$x-5\geq 0$

$x\geq 5$

$D: x\in[5,\infty)$

Quotient:

$\dfrac{f(x)}{g(x)}=\dfrac{x^2+1}{\sqrt{x-5}}$

$x-5>0$

$x>5$

$D: x\in(5,\infty)$

45. $f(x)=\dfrac{2}{x-3}$ and $g(x)=\dfrac{5}{x+2}$

Sum:

$f(x)+g(x)=\dfrac{2}{x-3}+\dfrac{5}{x+2}$

$=\dfrac{2(x+2)+5(x-3)}{(x-3)(x+2)}$

$=\dfrac{2x+4+5x-15}{(x-3)(x+2)}$

$=\dfrac{7x-11}{(x-3)(x+2)}$

$x-3\neq 0 \quad x+2\neq 0$

$x\neq 3 \qquad x\neq -2$

$D: x\in(-\infty,-2)\cup(-2,3)\cup(3,\infty)$

Difference:

$f(x)-g(x)=\dfrac{2}{x-3}-\dfrac{5}{x+2}$

$=\dfrac{2(x+2)-5(x-3)}{(x-3)(x+2)}$

$=\dfrac{2x+4-5x+15}{(x-3)(x+2)}$

$=\dfrac{-3x+19}{(x-3)(x+2)}$

$x-3\neq 0 \quad x+2\neq 0$

$x\neq 3 \qquad x\neq -2$

$D: x\in(-\infty,-2)\cup(-2,3)\cup(3,\infty)$

Product:

$f(x)\cdot g(x)=\left(\dfrac{2}{x-3}\right)\left(\dfrac{5}{x+2}\right)$

$=\dfrac{10}{(x-3)(x+2)}$

$=\dfrac{10}{x^2-x-6}$

$x-3\neq 0 \quad x+2\neq 0$

$x\neq 3 \qquad x\neq -2$

$D: x\in(-\infty,-2)\cup(-2,3)\cup(3,\infty)$

Quotient:

$$\frac{f(x)}{g(x)}=\frac{\frac{2}{x-3}}{\frac{5}{x+2}}=\left(\frac{2}{x-3}\right)\left(\frac{x+2}{5}\right)$$
$$=\frac{2(x+2)}{5(x-3)}=\frac{2x+4}{5x-15}$$
$x-3\neq 0$  $x+2\neq 0$

$x\neq 3$  $x\neq -2$

$D: x\in(-\infty,-2)\cup(-2,3)\cup(3,\infty)$

46. $f(x)=\frac{4}{x-3}$ and $g(x)=\frac{1}{x+5}$

Sum:

$$f(x)+g(x)=\frac{4}{x-3}+\frac{1}{x+5}$$
$$=\frac{4(x+5)+1(x-3)}{(x-3)(x+5)}$$
$$=\frac{4x+20+x-3}{(x-3)(x+5)}$$
$$=\frac{5x+17}{(x-3)(x+5)}$$
$x-3\neq 0$  $x+5\neq 0$

$x\neq 3$  $x\neq -5$

$D: x\in(-\infty,-5)\cup(-5,3)\cup(3,\infty)$

Difference:

$$f(x)-g(x)=\frac{4}{x-3}-\frac{1}{x+5}$$
$$=\frac{4(x+5)-1(x-3)}{(x-3)(x+5)}$$
$$=\frac{4x+20-x+3}{(x-3)(x+5)}$$
$$=\frac{3x+23}{(x-3)(x+5)}$$
$x-3\neq 0$  $x+5\neq 0$

$x\neq 3$  $x\neq -5$

$D: x\in(-\infty,-5)\cup(-5,3)\cup(3,\infty)$

Product:

$$f(x)\cdot g(x)=\left(\frac{4}{x-3}\right)\left(\frac{1}{x+5}\right)$$
$$=\frac{4}{(x-3)(x+5)}$$
$$=\frac{4}{x^2+2x-15}$$
$x-3\neq 0$  $x+5\neq 0$

$x\neq 3$  $x\neq -5$

$D: x\in(-\infty,-5)\cup(-5,3)\cup(3,\infty)$

Quotient:

$$\frac{f(x)}{g(x)}=\frac{\frac{4}{x-3}}{\frac{1}{x+5}}=\left(\frac{4}{x-3}\right)\left(\frac{x+5}{1}\right)$$
$$=\frac{4(x+5)}{x-3}=\frac{4x+20}{x-3}$$
$x-3\neq 0$  $x+5\neq 0$

$x\neq 3$  $x\neq -5$

$D: x\in(-\infty,-5)\cup(-5,3)\cup(3,\infty)$

47. $f(x)=x^2-5x-14$

$f(-2)=(-2)^2-5(-2)-14=4+10-14=0;$

$f(7)=(7)^2-5(7)-14=49-35-14=0;$

$f(2)=(2)^2-5(2)-14=4-10-14=-20;$

$f(a-2)=(a-2)^2-5(a-2)-14$

$=a^2-4a+4-5a+10-14$

$=a^2-9a$

48. $g(x)=x^3-9x$

$g(-3)=(-3)^3-9(-3)=-27+27=0;$

$g(2)=(2)^3-9(2)=8-18=-10;$

$g(3)=(3)^3-9(3)=27-27=0;$

$g(t+1)=(t+1)^3-9(t+1)$

$=t^3+3t^2+3t+1-9t-9$

$=t^3+3t^2-6t-8$

49. $f(x)=\sqrt{x+3}$ and $g(x)=2x-5$

(a) $h(x)=(f\circ g)(x)=f[g(x)]$
$=\sqrt{g(x)+3}$
$=\sqrt{(2x-5)+3}$
$=\sqrt{2x-2}$

(b) $H(x)=(g\circ f)(x)=g[f(x)]$
$=2(f(x))-5$
$=2\sqrt{x+3}-5$

(c) $2x-2\ge 0$
$2x\ge 2$
$x\ge 1$
Domain of $h: x\in[1,\infty)$
$x+3\ge 0$
$x\ge -3$
Domain of $H$: $x\in[-3,\infty)$

50. $f(x)=x+3$ and $g(x)=\sqrt{9-x^2}$

(a) $h(x)=(f\circ g)(x)=f[g(x)]$
$=g(x)+3$
$=\sqrt{9-x^2}+3$

(b) $H(x)=(q\circ p)(x)=q[p(x)]$
$=\sqrt{9-\left(f(x)^2\right)}$
$=\sqrt{9-(x+3)^2}$
$=\sqrt{9-\left(x^2+6x+9\right)}$
$=\sqrt{-x^2-6x}$

(c) $9-x^2\ge 0$
$-x^2\ge -9$
$x^2\le 9$
$x\le 3$ *and* $x\ge -3$
Domain of $h$: $x\in[-3,3]$
$-x^2-6x\ge 0$
$-x(x+6)\ge 0$
$x\le 0$ *and* $x\ge -6$
Domain of $H$: $x\in[-6,0]$

51. $f(x)=\sqrt{x-3}$ and $g(x)=3x+4$

(a) $h(x)=(f\circ g)(x)$
$h(x)=f[g(x)]$
$h(x)=\sqrt{g(x)-3}$
$=\sqrt{3x+4-3}$
$=\sqrt{3x+1}$

(b) $H(x)=(g\circ f)(x)$
$H(x)=g[f(x)]$
$H(x)=3(f(x))+4$
$=3\sqrt{x-3}+4$

(c) $3x+1\ge 0$
$3x\ge -1$
$x\ge -\frac{1}{3}$
Domain of $h$: $\left\{x\middle|x\ge -\frac{1}{3}\right\}$
or $\left[-\frac{1}{3},\infty\right)$;
$x-3\ge 0$
$x\ge 3$
Domain of $H$: $\{x|x\ge 3\}$
or $[3,\infty)$

52. $f(x)=\sqrt{x+5}$ and $g(x)=4x-1$

(a) $h(x)=(f\circ g)(x)$
$h(x)=f[g(x)]$
$h(x)=\sqrt{g(x)+5}$
$=\sqrt{4x-1+5}$
$=\sqrt{4x+4}$
$=\sqrt{4(x+1)}$
$=2\sqrt{x+1}$

(b) $H(x)=(g\circ f)(x)$
$H(x)=g[f(x)]$
$H(x)=4(f(x))-1$
$=4\sqrt{x+5}-1$

(c) $4x+4\ge 0$
$4x\ge -4$
$x\ge -1$
Domain of $h$: $\{x|x\ge -1\}$
or $[-1,\infty)$;
$x+5\ge 0$
$x\ge -5$
Domain of $H$: $\{x|x\ge -5\}$
or $[-5,\infty)$

53. $f(x) = x^2 - 3x$ and $g(x) = x + 2$

(a) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = (g(x))^2 - 3(g(x))$
$= (x+2)^2 - 3(x+2)$
$= x^2 + 4x + 4 - 3x - 6$
$= x^2 + x - 2$

(b) $H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = (f(x)) + 2$
$= x^2 - 3x + 2$

(c) Domain of $h$: $(-\infty, \infty)$
Domain of $H$: $(-\infty, \infty)$

54. $f(x) = 2x^2 - 1$ and $g(x) = 3x + 2$

(a) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = 2(g(x)^2 - 1)$
$= 2(3x+2)^2 - 1$
$= 2(9x^2 + 12x + 4) - 1$
$= 18x^2 + 24x + 8 - 1$
$= 18x^2 + 24x + 7$

(b) $H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = 3(f(x)) + 2$
$= 3(2x^2 - 1) + 2$
$= 6x^2 - 3 + 2$
$= 6x^2 - 1$

(c) Domain of $h$: $(-\infty, \infty)$
Domain of $H$: $(-\infty, \infty)$

55. $f(x) = x^2 + x - 4$ and $g(x) = x + 3$

(a) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = (g(x))^2 + g(x) - 4$
$= (x+3)^2 + x + 3 - 4$
$= x^2 + 6x + 9 + x - 1$
$= x^2 + 7x + 8$

(b) $H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = f(x) + 3$
$= x^2 + x - 4 + 3$
$= x^2 + x - 1$

(c) Domain of $h$: $(-\infty, \infty)$
Domain of $H$: $(-\infty, \infty)$

56. $f(x) = x^2 - 4x + 2$ and $g(x) = x - 2$

(a) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = (g(x))^2 - 4(g(x)) + 2$
$= (x-2)^2 - 4(x-2) + 2$
$= x^2 - 4x + 4 - 4x + 8 + 2$
$= x^2 - 8x + 14$

(b) $H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = f(x) - 2$
$= x^2 - 4x + 2 - 2$
$= x^2 - 4x$

(c) Domain of $h$: $(-\infty, \infty)$
Domain of $H$: $(-\infty, \infty)$

57. $f(x) = |x| - 5$ and $g(x) = -3x + 1$

(a) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = |g(x)| - 5$
$= |-3x + 1| - 5$

(b) $H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = -3(f(x)) + 1$
$= -3(|x| - 5) + 1$
$= -3|x| + 15 + 1$
$= -3|x| + 16$

(c) Domain of $h$: $(-\infty, \infty)$
Domain of $H$: $(-\infty, \infty)$

58. $f(x)=|x-2|$ and $g(x)=3x-5$

(a) $h(x)=(f\circ g)(x)$

$h(x)=f[g(x)]$

$h(x)=|g(x)-2|$

$=|3x-5-2|$

$=|3x-7|$

(b) $H(x)=(g\circ f)(x)$

$H(x)=g[f(x)]$

$H(x)=3(f(x))-5$

$=3|x-2|-5$

(c) Domain of $h$: $(-\infty,\infty)$

Domain of $H$: $(-\infty,\infty)$

59. $f(x)=\dfrac{2x}{x+3}$ and $g(x)=\dfrac{5}{x}$

(a)

$(f\circ g)(x)$: For $g(x)$ to be defined, $x\neq 0$.

For $f[g(x)]=\dfrac{2g(x)}{g(x)+3}$,

$g(x)\neq -3$ so $x\neq -\dfrac{5}{3}$.

Domain: $\left\{x \,\middle|\, x\neq 0, x\neq -\dfrac{5}{3}\right\}$

(b)

$(g\circ f)(x)$: For $f(x)$ to be defined, $x\neq -3$.

For $g[f(x)]=\dfrac{5}{f(x)}$,

$f(x)\neq 0$ so $x\neq 0$.

Domain: $\{x \mid x\neq 0, x\neq -3\}$

(c) $(f\circ g)(x)=f[g(x)]$

$$=\frac{2(g(x))}{g(x)+3}=\frac{2\left(\frac{5}{x}\right)}{\frac{5}{x}+3}=\frac{\frac{10}{x}}{\frac{5+3x}{x}}$$

$$=\frac{10x}{x(5+3x)}=\frac{10}{5+3x}$$

$(g\circ f)(x)=g[f(x)]$

$$=\frac{5}{f(x)}=\frac{5}{\frac{2x}{x+3}}=\frac{5(x+3)}{2x}=\frac{5x+15}{2x}$$

60. $f(x)=\dfrac{-3}{x}$ and $g(x)=\dfrac{x}{x-2}$

(a)

$(f\circ g)(x)$: For $g(x)$ to be defined, $x\neq 2$.

For $f[g(x)]=\dfrac{-3}{g(x)}$,

$g(x)\neq 0$ so $x\neq 0$.

Domain: $\{x \mid x\neq 0, x\neq 2\}$

(b)

$(g\circ f)(x)$: For $f(x)$ to be defined, $x\neq 0$.

For $g[f(x)]=\dfrac{f(x)}{f(x)-2}$,

$f(x)\neq 2$ so $x\neq -\dfrac{3}{2}$.

Domain: $\left\{x \,\middle|\, x\neq -\dfrac{3}{2}, x\neq 0\right\}$

(c) $(f\circ g)(x)=f[g(x)]$

$$=\frac{-3}{g(x)}=\frac{-3}{\frac{x}{x-2}}=\frac{-3(x-2)}{x}=\frac{-3x+6}{x}$$

$(g\circ f)(x)=g[f(x)]$

$$=\frac{f(x)}{f(x)-2}=\frac{\frac{-3}{x}}{\frac{-3}{x}-2}=\frac{\frac{-3}{x}}{\frac{-3-2x}{x}}$$

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

61. $f(x)=\dfrac{4}{x}$ and $g(x)=\dfrac{1}{x-5}$

(a)

$(f\circ g)(x)$: For $g(x)$ to be defined, $x\neq 5$.

For $f[g(x)]=\dfrac{4}{g(x)}$,

$g(x)\neq 0$ and $g(x)$ is never zero.

Domain: $\{x \mid x\neq 5\}$

(b)

$(g\circ f)(x)$: For $f(x)$ to be defined, $x\neq 0$.

For $g[f(x)]=\dfrac{1}{f(x)-5}$,

$f(x)\neq 5$ so $x\neq \dfrac{4}{5}$.

Domain: $\left\{x \,\middle|\, x\neq 0, x\neq \dfrac{4}{5}\right\}$

(c) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = \dfrac{4}{g(x)}$
$= \dfrac{4}{\frac{1}{x-5}}$
$= 4(x-5)$
$= 4x - 20$
$H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = \dfrac{1}{f(x)-5}$
$= \dfrac{1}{\frac{4}{x}-5}$
$= \dfrac{1}{\frac{4-5x}{x}}$
$= \dfrac{x}{4-5x}$

62. $f(x) = \dfrac{3}{x}$ and $g(x) = \dfrac{1}{x-2}$

(a)
$(f \circ g)(x)$: For $g(x)$ to be defined, $x \neq 2$.
For $f[g(x)] = \dfrac{3}{g(x)}$,
$g(x) \neq 0$ and $g(x)$ is never zero.
Domain: $\{x | x \neq 2\}$

(b)
$(g \circ f)(x)$: For $f(x)$ to be defined, $x \neq 0$.
For $g[f(x)] = \dfrac{1}{f(x)-2}$,
$f(x) \neq 2$ so $x \neq \dfrac{3}{2}$.
Domain: $\left\{x \middle| x \neq 0, x \neq \dfrac{3}{2}\right\}$

(c) $h(x) = (f \circ g)(x)$
$h(x) = f[g(x)]$
$h(x) = \dfrac{3}{g(x)}$
$= \dfrac{3}{\frac{1}{x-2}}$
$= 3(x-2)$
$= 3x - 6$
$H(x) = (g \circ f)(x)$
$H(x) = g[f(x)]$
$H(x) = \dfrac{1}{f(x)-2}$
$= \dfrac{1}{\frac{3}{x}-2}$
$= \dfrac{1}{\frac{3-2x}{x}}$
$= \dfrac{x}{3-2x}$

63. $f(x) = x^2 - 8$ and $g(x) = x + 2$
$h(x) = (f \circ g)(x)$

a. $(f \circ g)(x) = f[g(x)]$
$= (g(x)^2) - 8$
$= (x+2)^2 - 8$
$= x^2 + 4x + 4 - 8$
$= x^2 + 4x - 4;$
$h(x) = x^2 + 4x - 4$
$h(5) = (5)^2 + 4(5) - 4 = 25 + 20 - 4 = 41$

b. $g(5) = 5 + 2 = 7$
$f[g(5)] = f(7)$
$= (7)^2 - 8 = 49 - 8 = 41$

64. $p(x) = x^2 - 8$ and $q(x) = x + 2$
$H(x) = (p \circ q)(x)$

a. $(p \circ q)(x) = p[q(x)]$
$= (q(x)^2) - 8$
$= (x+2)^2 - 8$
$= x^2 + 4x + 4 - 8$
$= x^2 + 4x - 4;$
$H(x) = x^2 + 4x - 4;$
$H(-2) = (-2)^2 + 4(-2) - 4$
$= 4 - 8 - 4 = -8$

b. $q(-2) = -2 + 2 = 0$
$p[q(-2)] = p(0)$
$= (0)^2 - 8 = 0 - 8 = -8$

65. $h(x) = \left(\sqrt{x-2} + 1\right)^3 - 5$
Answers may vary.
$g(x) = \sqrt{x-2} + 1,\ f(x) = x^3 - 5$

66. $h(x) = \sqrt[3]{x^2 - 5} + 2$
Answers may vary.
$p(x) = \sqrt[3]{x} + 2, q(x) = x^2 - 5$

67. $f(x) = 2x - 1, g(x) = x^2 - 1,$
$h(x) = x + 4$

a. $p(x) = f\left[g\left([h(x)]\right)\right]$
$p(x) = f\left[(x+4)^2 - 1\right]$
$= 2\left[(x+4)^2 - 1\right] - 1$
$= 2(x+4)^2 - 2 - 1$
$= 2(x+4)^2 - 3$

b. $q(x) = g\left[f\left([h(x)]\right)\right]$
$q(x) = g\left[2(x+4) - 1\right]$
$= g[2x + 8 - 1] = g[2x + 7]$
$= (2x+7)^2 - 1$

68. $f(x) = 2x + 3, g(x) = \dfrac{x-3}{2}$

a. $(f \circ f)(x) = f(f(x))$
$= 2(2x+3) + 3 = 4x + 9$

b. $(g \circ g)(x) = g(g(x))$
$= \dfrac{\frac{x-3}{2} - 3}{2} = \dfrac{x - 3 - 6}{4} = \dfrac{x-9}{4}$

c. $(f \circ g)(x) = f(g(x))$
$= 2\left(\dfrac{x-3}{2}\right) + 3 = x - 3 + 3 = x$

d. $(g \circ f)(x) = g(f(x))$
$= \dfrac{2x + 3 - 3}{2} = \dfrac{2x}{2} = x$

69. a. $C(5) = 6000$
b. $T(8) = 3000$
c. $C(9) + T(9) = 6000 + 2000 = 8000$
d. $C(9) - T(9) = 6000 - 2000 = 4000$

70. a. $M(2) = \$12$ million
b. $P(5) = \$12$ million
c. $M(9) + P(9) = 12 + 8 = \$20$ million
d. $P(10) - M(10) = 14 - 4 = \$10$ million

71. a. $R(2) = \$1$ billion
b. $C(8) = \$5$ billion
c. $R(t) = C(t)$
Broke even 2003, 2007, 2010
d. $C(t) > R(t)$:
$t \in (2000, 2003) \cup (2007, 2010)$
e. $R(t) > C(t), t \in (2003, 2007)$
f. $R(5) - C(5) = 5 - 1 = \$4$ billion

72. a. $D(2) = \$6$ billion
b. $R(6) = \$5$ billion
c. $R(t) = D(t)$
2001, 2004, 2007
d. $R(t) > D(t), t \in (2000, 2001) \cup (2004, 2007)$
e. $R(t) < D(t), t \in (2001, 2004) \cup (2007, 2010)$
f. $D(t) + R(t)$
$D(10) + R(10) = 6 + 3 = \$9$ billion

73\. a. $(f+g)(-4) = f(-4)+g(-4)$
$= 5+(-1) = 4$

b. $(f\cdot g)(1) = f(1)\cdot g(1)$
$= 0(3) = 0$

c. $(f-g)(4) = f(4)-g(4)$
$= 5-3 = 2$

d. $(f+g)(0) = f(0)+g(0)$
$= 1+2 = 3$

e. $\left(\frac{f}{g}\right)(2) = \frac{f(2)}{g(2)} = \frac{-1}{3}$

f. $(f\cdot g)(-2) = f(-2)\cdot g(-2)$
$= 3(2) = 6$

g. $(g\cdot f)(2) = g(2)\cdot f(2)$
$= 3(-1) = -3$

h. $(f-g)(-1) = f(-1)-g(-1)$
$= 2-1 = 1$

i. $(f+g)(8) = f(8)+g(8)$
$= -1+2 = 1$

j. $\left(\frac{f}{g}\right)(7) = \frac{f(7)}{g(7)} = \frac{1}{0}$ undefined

k. $(g\circ f)(4) = g(f(4))$
$= g(5) = \frac{1}{2} = 0.5$

l. $(f\circ g)(4) = f(g(4))$
$= f(3) = 2$

74\. a. $(p+q)(-4) = p(-4)+q(-4)$
$= 4+(-4) = 0$

b. $(p\cdot q)(1) = p(1)\cdot q(1)$
$= 4(-3) = -12$

c. $(p-q)(4) = p(4)-q(4)$
$= 2-0 = 2$

d. $(p+q)(0) = p(0)+q(0)$
$= 1+1 = 2$

e. $\left(\frac{p}{q}\right)(5) = \frac{p(5)}{q(5)} = \frac{1}{6}$

f. $(p\cdot q)(-2) = p(-2)\cdot q(-2)$
$= -3(2) = -6$

g. $(q\cdot p)(2) = q(2)\cdot p(2)$
$= -4(5) = -20$

h. $(p-q)(-1) = p(-1)-q(-1)$
$= -2-3 = -5$

i. $(p+q)(7) = p(7)+q(7)$
$= 6+(-3) = 3$

j. $\left(\frac{p}{q}\right)(6) = \frac{p(6)}{q(6)} = \frac{2}{0}$ undefined

k. $(q\circ p)(4) = q(p(4))$
$= q(2) = -4$

l. $(p\circ q)(-1) = p(q(-1))$
$= p(3) = 4 = \frac{-1}{3}$

75\. $h(x) = f(x)-g(x)$
$= 5-\left(\frac{2}{3}x+1\right) = 5-\frac{2}{3}x-1$
$= -\frac{2}{3}x+4$

76\. $h(x) = f(x)-g(x)$
$= \left(2\sqrt{x}+1\right)-3 = 2\sqrt{x}-2$

77\. $h(x) = f(x)-g(x)$
$= \left(5x-x^2\right)-x = 4x-x^2$

78\. $h(x) = f(x)-g(x)$
$= \left[-(x-3)^2+13\right]-(x-2)^2$
$= -\left(x^2-6x+9\right)+13-\left(x^2-4x+4\right)$
$= -x^2+6x-9+13-x^2+4x-4$
$= -2x^2+10x$

79\. $A = 40\pi r + 2\pi r^2$
$A = 2\pi r(20+r)$
$A(r) = (f\cdot g)(r)$
$f(r) = 2\pi r, g(r) = 20+r$
$A(5) = 2\pi(5)(20+5) = 10\pi(25) = 250\pi$ units$^2$

80\. $A(r) = P(1+r)^t$
$g(r) = 1+r,\ f(r) = 1000r^5$ Answers will vary.

## 2.8 Exercises

81. Revenue: $R(x) = 40,000x$

Cost: $C(x) = 108,000 + 28,000x$

a. $P(x) = R(x) - C(x)$

$= 40,000x - 108,000 - 28,000x$

$= 12,000x - 108,000$

b. Break even when $P(x) = 0$

$12,000x - 108,000 = 0$

$12,000x = 108,000$

$x = 9$

9 boats must be sold to break even.

82. Revenue: $R(x) = 1.50x$

Cost: $C(x) = 900 + 0.25x$

a. $P(x) = R(x) - C(x)$

$= 1.50x - (900 + 0.25x)$

$= 1.50x - 900 - 0.25x$

$= 1.25x - 900$

b. Break even when $P(x) = 0$

$1.25x - 900 = 0$

$1.25x = 900$

$x = 720$

720 newsletters must be sold to break even.

c. Let $x = 1000$

$P(1000) = 1.25(1000) - 900 = 350$

\$350 will be returned.

83. a. $P(n) = R(n) - C(n)$

$P(n) = 11.45n - 0.1n^2$

b. $P(12) = 11.45(12) - 0.1(12)^2$

$= 137.4 - 14.4 = \$123$

c. $P(60) = 11.45(60) - 0.1(60)^2$

$= 687 - 360 = \$327$

d. At $n = 115$, costs exceed revenue, $C(115) > R(115)$.

84. a. $T(t) = M(t) + C(t)$

$T(t) = 2t + 1 + 0.1t^2 + 2$

$T(t) = 0.1t^2 + 2t + 3$

b. $D(t) = C(t) - M(t)$

$D(t) = 0.1t^2 + 2 - (2t + 1)$

$D(t) = 0.1t^2 + 2 - 2t - 1$

$D(t) = 0.1t^2 - 2t + 1$

c. $C(t) = 0.1t^2 + 2$

$C(10) = 0.1(10)^2 + 2 = 10 + 2 = 12$

\$12,000

d. $D(10) = 0.1(10)^2 - 2(10) + 1$

$D(10) = 10 - 20 + 1 = -9$

\$9,000

e. $P(t) = R(t) - T(t)$

$P(t) = 10\sqrt{t} - (0.1t^2 + 2t + 3)$

$P(t) = 10\sqrt{t} - 0.1t^2 - 2t - 3$

f. $P(t) = 10\sqrt{t} - 0.1t^2 - 2t - 3$

$P(5) = 10\sqrt{5} - 0.1(5)^2 - 2(5) - 3$

$P(5) = 10\sqrt{5} - 2.5 - 10 - 3$

$P(5) = 10\sqrt{5} - 15.5$

$P(5) = 6.861$

\$6,861;

$P(10) = 10\sqrt{10} - 0.1(10)^2 - 2(10) - 3$

$P(10) = 10\sqrt{10} - 10 - 20 - 3$

$P(10) = 10\sqrt{10} - 33$

$P(10) = -1.377$

–\$1,377

No profit was made in the 10$^{th}$ month. There was a loss.

85. $f(x) = 0.5x - 14$ ; $g(x) = 2x + 23$

$h(x) = (f \circ g)(x) = f[g(x)]$

$h(x) = 0.5(g(x)) - 14$

$= 0.5(2x + 23) - 14$

$= x + 11.5 - 14$

$= x - 2.5$;

$h(13) = 13 - 2.5 = 10.5$

86. $E(x) = 1.12x$ ; $Y(x) = 1061x$

(a) $E(100) = 1.12(100) = 112$ euros

(b) $Y(112) = 1061(112) = 118832$ yen

(c) $M(x) = (Y \circ E)(x) = Y[E(x)]$

$M(x) = 1061(E(x))$

$= 1061(1.12x)$

$= 1188.32x$;

$M(100) = 1188.32(100) = 118832$ yen

Parts b and c agree.

87. $T(x) = 41.6x$; $R(x) = 10.9x$
   (a) $T(100) = 41.6(100) = 4160$ baht
   (b) $R(4160) = 10.9(4160) = 45{,}344$ rRinggit
   (c) $M(x) = (R \circ T)(x) = R[T(x)]$
   $M(x) = 10.9(T(x))$
   $= 10.9(41.6x)$
   $= 453.44x$;
   $M(100) = 453.44(100) = 45344$ ringgit
   Parts B and C agree.

88. $r(t) = 2t$; $A = \pi r^2$
   (a) $A(t) = (A \circ r)(t) = A[r(t)]$
   $= \pi(r(t))^2$
   $= \pi(2t)^2$
   $= 4\pi t^2$
   (b) $A(60) = 4\pi(60)^2 = 14400\pi$ m$^2$

89. $r(t) = 3t$; $A = \pi r^2$
   (a) $r(2) = 3(2) = 6$ ft
   (b) $A(6) = \pi(6)^2 = 36\pi$ ft$^2$
   (c) $A(t) = (A \circ r)(t) = A[r(t)]$
   $A(t) = \pi(r(t))^2$
   $= \pi(3t)^2$
   $= 9\pi t^2$;
   $A(2) = 9\pi(2)^2 = 36\pi$ ft$^2$
   The answers do agree.

90. $r(t) = 1.05t$; $SA = 4\pi r^2$
   (A) $r(2) = 1.05(2) = 2.1$ Gm
   (B) $SA = 4\pi(2.1)^2$
   $SA = 17.64\pi$ Gm$^2$
   (C) $h(t) = (S \circ r)(t) = S[r(t)]$
   $h(t) = 4\pi(1.05t)^2$
   $h(t) = 4.41\pi t^2$
   The answers do agree.

91. $C(x) = 0.0345x^4 - 0.8996x^3 + 7.5383x^2 - 21.7215x + 40$
   $L(x) = -0.0345x^4 + 0.8996x^3 - 7.5383x^2 + 21.7215x + 10$
   (a) Using the grapher, 1995 to 1996; 1999 to 2004
   (b) Using the grapher, 30 seats; 1995
   (c) Using the grapher, 20 seats; 1997
   (d) Using the grapher, the total number in the senate (50); the number of additional seats held by the majority.

92. $f(x) = x^3 + 2$ and $g(x) = \sqrt[3]{x-2}$
   $h(x) = (f \circ g)(x) = f[g(x)]$
   $h(x) = (g(x))^3 + 2$
   $= \left(\sqrt[3]{x-2}\right)^3 + 2$
   $= x - 2 + 2 = x$
   $H(x) = (g \circ f)(x) = g[f(x)]$
   $= \sqrt[3]{x^3 + 2 - 2} = x$
   Answers will vary.

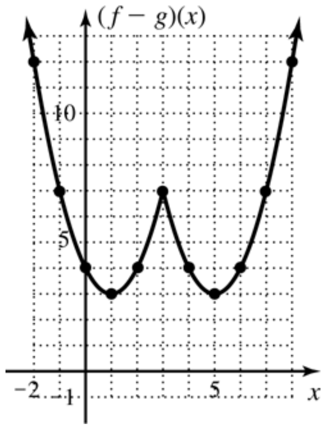
93. $f(x) = \sqrt{1-x}$ and $g(x) = \sqrt{x-2}$
   Using the grapher,
   $(f+g)(x)$ cannot be found because their domains do not overlap.

94. a. $(f \circ g)(x) = f(g(x))$
   $f\left(\sqrt{x+1}\right) = \dfrac{1}{\left(\sqrt{x+1}\right)^2 - 4} = \dfrac{1}{|x+1| - 4}$
   $h(x) = \dfrac{1}{|x+1| - 4}$
   b. Domain of $h(x)$
   $\dfrac{1}{x+1-4} = \dfrac{1}{x-3}; x \neq 3;$
   $\dfrac{1}{-(x+1)-4} = \dfrac{1}{-x-5}; x \neq -5;$
   Yes, Domain includes $x = 2$, $x = -2$, $x = -3$.
   c. Domain of $f: x \neq 2, x \neq -2;$
   Domain of $g: x + 1 \geq 0$
   $x \geq -1$
   Domain of $h: [-1, 2) \cup (2, 3) \cup (3, \infty)$
   For $x \geq -1$, 2 is not in the domain of $f$ and 3 is not in the domain of $h$. Thus, 2 and 3 are not in the domain of $h$.

# 2.8 Exercises

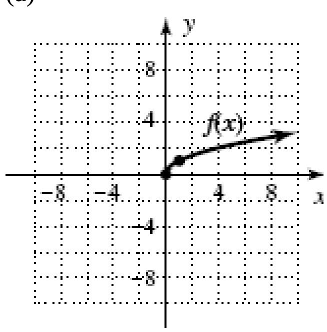
95. $f(x) = (x-3)^2 + 2, g(x) = 4|x-3| - 5$

| $x$ | $f(x)$ | $g(x)$ | $(f–g)(x)$ |
|---|---|---|---|
| –2 | 27 | 15 | 12 |
| –1 | 18 | 11 | 7 |
| 0 | 11 | 7 | 4 |
| 1 | 6 | 3 | 3 |
| 2 | 3 | –1 | 4 |
| 3 | 2 | –5 | 7 |
| 4 | 3 | –1 | 4 |
| 5 | 6 | 3 | 3 |
| 6 | 11 | 7 | 4 |
| 7 | 18 | 11 | 7 |
| 8 | 27 | 15 | 12 |

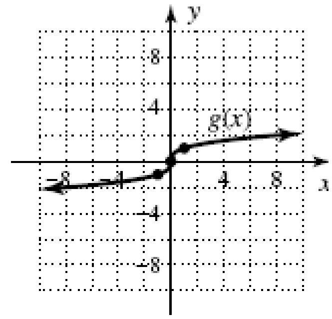



96. $2 + 3i$ and $2 - 3i$
Sum:
$(2+3i)+(2-3i)=4$
Product:
$(2+3i)(2-3i)=4-9i^2 = 4+9=13$

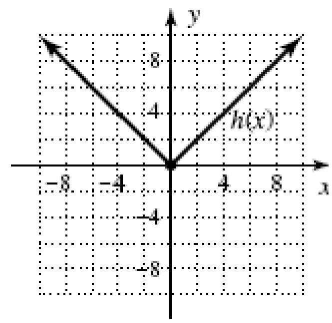
97. $f(x)=\sqrt{x}$ ; $g(x)=\sqrt[3]{x}$ ; $h(x)=|x|$
(a)




(b)




(c)




98. $2x^2 - 3x + 4 = 0$

$$x = \frac{3 \pm \sqrt{(-3)^2 - 4(2)(4)}}{2(2)}$$

$$x = \frac{3 \pm \sqrt{9-32}}{4}$$

$$x = \frac{3 \pm \sqrt{-23}}{4}$$

$$x = \frac{3}{4} \pm \frac{\sqrt{23}}{4} i$$

99. $-2x + 3y = 9$
$3y = 2x + 9$
$y = \frac{2}{3}x + 3$
$m = \frac{2}{3}$;

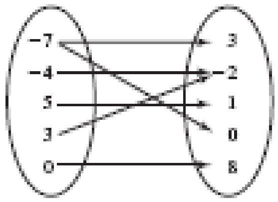
Slope of a line perpendicular is $-\frac{3}{2}$.

$y$– intercept (0,0);

Equation: $y = -\frac{3}{2}x$

# Chapter 2 Summary and Review

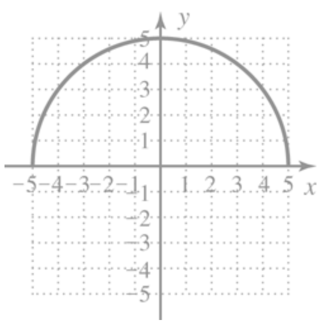
1.




$x \in \{-7,-4,0,3,5\}$

$y \in \{-2,0,1,3,8\}$

2.



| $x$ | $y$ |
|---|---|
| –5 | $y=\sqrt{25-(-5)^2}=0$ |
| –4 | $y=\sqrt{25-(-4)^2}=3$ |
| –2 | $y=\sqrt{25-(-2)^2}\approx 4.58$ |
| 0 | $y=\sqrt{25-0^2}=5$ |
| 2 | $y=\sqrt{25-(2)^2}\approx 4.58$ |
| 4 | $y=\sqrt{25-(4)^2}=3$ |
| 5 | $y=\sqrt{25-(5)^2}=0$ |

Domain: $x \in [-5,5]$

Range: $y \in [0,5]$

3. (19,25), (–14,–31)

$d=\sqrt{(-14-19)^2+(-31-25)^2}$

$=\sqrt{1089+3136}=\sqrt{4225}=65$

65 miles

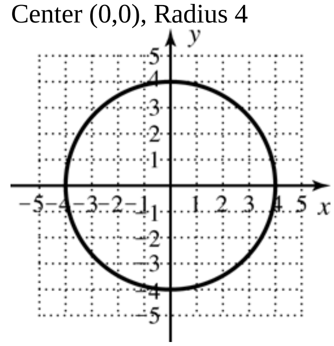
4. (19,25), (–14,–31)

Midpoint: $\left(\frac{19+(-14)}{2},\frac{25+(-31)}{2}\right)$

$=\left(\frac{5}{2},\frac{-6}{2}\right)=\left(\frac{5}{2},-3\right)$

5. $x^2+y^2=16$

Center (0,0), Radius 4

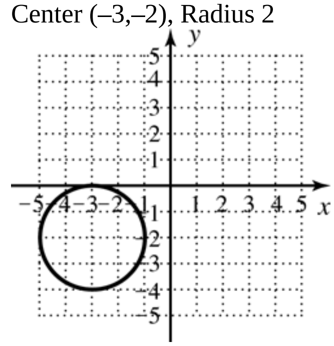


6. $x^2+y^2+6x+4y+9=0$

$x^2+6x+9+y^2+4y+4=-9+9+4$

$(x+3)^2+(y+2)^2=4$

Center (–3,–2), Radius 2



7. (–3,0) and (0,4)

To find the center, find the midpoint.

$\left(\frac{-3+0}{2},\frac{0+4}{2}\right)=\left(-\frac{3}{2},2\right)$

To find the radius, find the distance between $\left(-\frac{3}{2},2\right)$ and $(0,4)$

$d=\sqrt{\left(0-\left(-\frac{3}{2}\right)\right)^2+(4-2)^2}$

$=\sqrt{\frac{9}{4}+4}=\sqrt{\frac{25}{4}}=\frac{5}{2}=2.5$

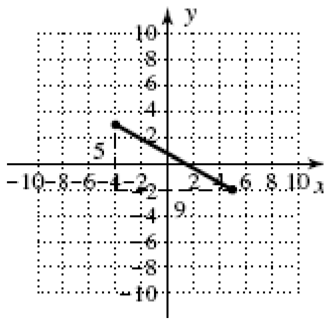
Radius: 2.5

Equation: $\left(x+\frac{3}{2}\right)^2+(y-2)^2=6.25$

8. a. (–4, 3) and (5, –2)

Slope triangle: $-\frac{5}{9}$

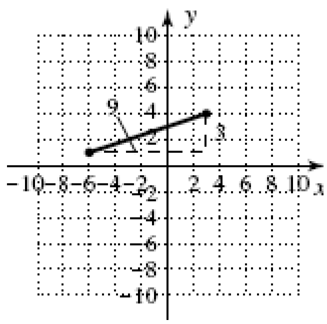
(14, –7)



b. (3, 4) and (–6, 1)

Slope triangle: $\frac{1}{3}$

(0, 3)



9. a. $L_1$: (–2, 0) and (0, 6)

$$m = \frac{6-0}{0-(-2)} = \frac{6}{2} = 3$$

$L_2$: (1, 8) and (0, 5)

$$m = \frac{5-8}{0-1} = \frac{-3}{-1} = 3$$

Parallel

b. $L_1$: (1, 10) and (–1, 7)

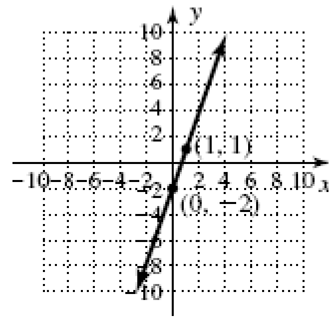
$$m = \frac{7-10}{-1-1} = \frac{-3}{-2} = \frac{3}{2}$$

$L_2$: (–2, –1) and (1, –3)

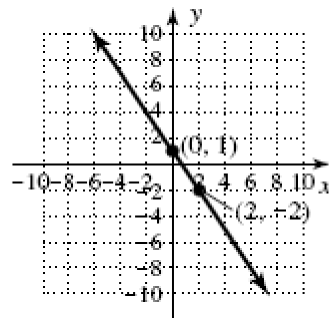
$$m = \frac{-3-(-1)}{1-(-2)} = \frac{-2}{3}$$

Perpendicular

10. a. $y = 3x - 2$



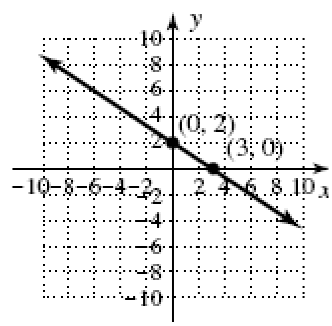

b. $y = -\frac{3}{2}x + 1$




11. a. $2x + 3y = 6$

$x$–intercept: (3, 0) $y$–intercept: (0, 2)

$$2x + 3(0) = 6 \qquad 2(0) + 3y = 6$$
$$2x = 6 \qquad 3y = 6$$
$$x = 3 \qquad y = 2$$



b. $y = \frac{4}{3}x - 2$

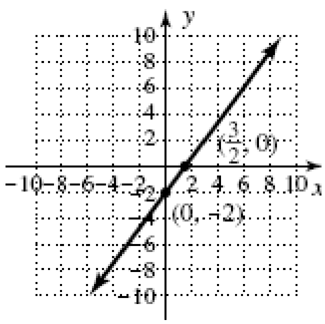
$x$–intercept: $\left(\frac{3}{2}, 0\right)$ $\quad$ $y$–intercept: (0,–2)

$0 = \frac{4}{3}x - 2$ $\qquad\qquad$ $y = \frac{4}{3}(0) - 2$

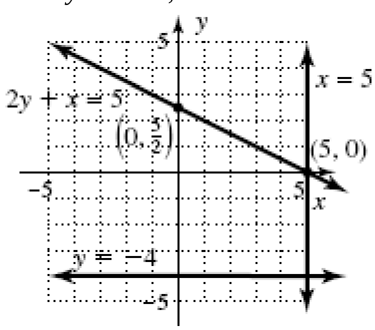
$2 = \frac{4}{3}x$ $\qquad\qquad$ $y = -2$

$\frac{6}{4} = x$

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




12. a. $x = 5$; vertical
b. $y = -4$; horizontal
c. $2y + x = 5$ ; neither




13. (–5, –4) (7, 2) (0, 16)

$m = \frac{16-2}{0-7} = \frac{14}{-7} = -2$ ;

$m = \frac{2-(-4)}{7-(-5)} = \frac{6}{12} = \frac{1}{2}$

Yes

14. $m = \frac{4}{6} = \frac{2}{3}$ ; $y$–intercept (0, 2)

When the rodent population increases by 3000, the hawk population increases by 200.

15. a. $4x + 3y - 12 = 0$

$3y = -4x + 12$

$y = -\frac{4}{3}x + 4$

$m = -\frac{4}{3}$ ; $y$–intercept (0, 4)

b. $5x - 3y = 15$

$-3y = -5x + 15$

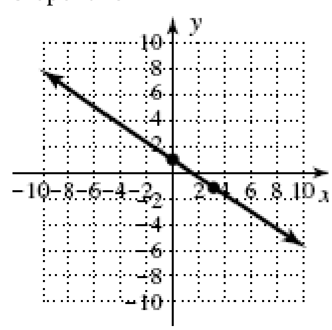
$y = \frac{5}{3}x - 5$

$m = \frac{5}{3}$ ; $y$–intercept (0, –5)

16. a. $f(x) = -\frac{2}{3}x + 1$

$m = -\frac{2}{3}$ ; $y$–intercept (0, 1)

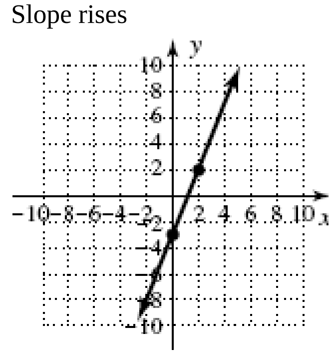
Slope falls



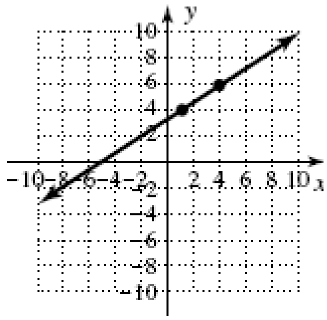

b. $h(x) = \frac{5}{2}x - 3$

$m = \frac{5}{2}$ ; $y$–intercept (0, –3)

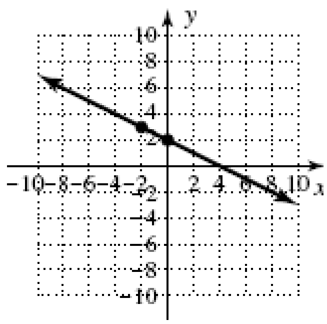
Slope rises



17. a. $m = \frac{2}{3}$ ; (1, 4)




b. $m = -\frac{1}{2}$ ; (–2, 3)




18. (–2, 5)
$x = -2$; $y = 5$
Point is on $y = 5$.

19. (1, 2) and (–3, 5)
$$m = \frac{5-2}{-3-1} = -\frac{3}{4}$$
$$y - 2 = -\frac{3}{4}(x-1)$$
$$y - 2 = -\frac{3}{4}x + \frac{3}{4}$$
$$y = -\frac{3}{4}x + \frac{11}{4}$$

20. $4x - 3y = 12$ ; (3, 4)
$$-3y = -4x + 12$$
$$y = \frac{4}{3}x - 4$$
$$y - 4 = \frac{4}{3}(x-3)$$
$$y - 4 = \frac{4}{3}x - 4$$
$$y = \frac{4}{3}x$$
$$f(x) = \frac{4}{3}x$$

21. $m = \frac{2}{5}$ ; $y$–intercept (0, 2)
$$y = \frac{2}{5}x + 2$$
When the rabbit population increases by 500, the wolf population increases by 200.

22. a. $m = -\frac{15}{2}$ ; (6, 60)
$$y - 60 = -\frac{15}{2}(x-6)$$
$$y - 60 = -\frac{15}{2}x + 45$$
$$y = -\frac{15}{2}x + 105$$

b. $x$–intercept: (14, 0); $y$–intercept: (0,105)
$$0 = -\frac{15}{2}x + 105$$
$$-105 = -\frac{15}{2}x$$
$$-210 = -15x$$
$$14 = x$$
$$y = -\frac{15}{2}(0) + 105$$
$$y = 105$$

c. $f(x) = -\frac{15}{2}x + 105$

d. $f(20)=-\frac{15}{2}(20)+105$
$=-150+105$
$=-45;$
$15=-\frac{15}{2}x+105$
$-90=-\frac{15}{2}x$
$-180=-15x$
$12=x$

23. a. $f(x)=\sqrt{4x+5}$
$4x+5\geq 0$
$4x\geq -5$
$x\geq -\frac{5}{4}$
$x\in\left[-\frac{5}{4},\infty\right)$

b. $g(x)=\frac{x-4}{x^2-x-6}$
$x^2-x-6=0$
$(x-3)(x+2)=0$
$x-3=0$ or $x+2=0$
$x=3$ or $x=-2$
These values must be excluded because they cause division by zero.
$x\in(-\infty,-2)\cup(-2,3)\cup(3,\infty)$

24. $h(x)=2x^2-3x$
$h(-2)=2(-2)^2-3(-2)=14;$
$h\left(-\frac{2}{3}\right)=2\left(-\frac{2}{3}\right)^2-3\left(-\frac{2}{3}\right)=\frac{8}{9}+\frac{6}{3}=\frac{26}{9};$
$h(3a)=2(3a)^2-3(3a)=18a^2-9a$

25. It is a function.

26. I. a. $D=\{-1,0,1,2,3,4,5\}$
$R=\{-2,-1,0,1,2,3,4\}$
b. $f(2)=1$
c. When f($x$) = 1, $x$ = 2

II. a. $x\in(-\infty,\infty)$
$y\in(-\infty,\infty)$
b. $f(2)=-1$
c. When $f(x)=1$, $x=3$

III. a. $x\in[-3,\infty)$
$y\in[-4,\infty)$
b. $f(2)=-1.5$
c. When $f(x)=1$, $x=-3$ or 3

27. $D: x\in(-\infty,\infty)$
$R: y\in[-5,\infty)$
$f(x)\uparrow: x\in(2,\infty)$
$f(x)\downarrow: x\in(-\infty,2)$
$f(x)>0:\ x\in(-\infty,-1)\cup(5,\infty)$
$f(x)<0:\ x\in(-1,5)$

28. $D: x\in[-3,\infty)$
$R: y\in(-\infty,0)$
$f(x)\uparrow$: None
$f(x)\downarrow: x\in(-3,\infty)$
$f(x)>0$: None
$f(x)<0:\ x\in(-3,\infty)$

29. $D: x\in(-\infty,\infty)$
$R: y\in(-\infty,\infty)$
$f(x)\uparrow: x\in(-\infty,-3)\cup(1,\infty)$
$f(x)\downarrow: x\in(-3,1)$
$f(x)>0:\ x\in(-5,-1)\cup(4,\infty)$
$f(x)<0:\ x\in(-\infty,-5)\cup(-1,4)$

30. a. $f(-x)=2(-x)^5-\sqrt[3]{-x}$
$=-2x^5+\sqrt[3]{x}$, odd

b. $g(-x)=(-x)^4-\frac{\sqrt[3]{-x}}{-x}$
$=x^4-\frac{\sqrt[3]{x}}{x}$, even

c. $p(-x)=|3(-x)|-(-x)^3$
$p(-x)=|3x|+(x)^3$, neither

d. $q(-x)=\frac{(-x)^2-|-x|}{-x}$
$=\frac{(x)^2-|x|}{-x}$, odd

31. a. $\dfrac{f(x_2)-f(x_1)}{x_2-x_1}=\dfrac{\sqrt{5+4}-\sqrt{-3+4}}{5-(-3)}$

$=\dfrac{3-1}{8}=\dfrac{1}{4}$

Graph is rising to the right.

b. $\dfrac{j(x+h)-j(x)}{h}$

$=\dfrac{(x+h)^2-(x+h)-(x^2-x)}{h}$

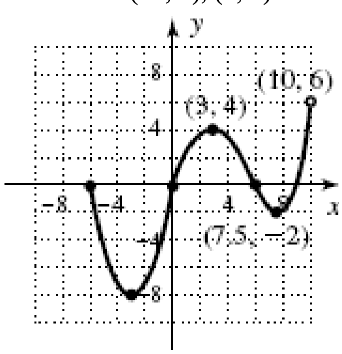
$=\dfrac{x^2+2xh+h^2-x-h-x^2+x}{h}$

$=\dfrac{2xh+h^2-h}{h}=2x-1+h$

$x=2, h=0.01$

$2(2)-1+0.01=3.01$

32. Zeroes: (–6, 0), (0, 0), (6, 0), (9, 0)
Minimum: (–3, –8), (7.5, –2)
Maximum: (–6, 0), (3, 4)




33. Squaring function
 a. up on left/up on the right
 b. $x$–intercepts: (–4,0), (0,0)
 $y$–intercept: (0,0)
 c. Vertex: (–2,–4)
 d. $x \in (-\infty,\infty), y \in [-4,\infty)$

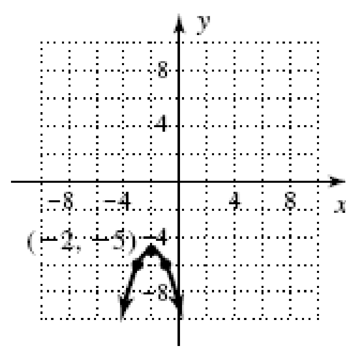
34. Square root function
 a. down on the right
 b. $x$–intercept: (0,0)
 $y$–intercept: (0,0)
 c. Initial point: (–1,2)
 d. $x \in [-1,\infty), y \in (-\infty,2]$

35. Cubing function
 a. down on left/up on right
 b. $x$–intercepts: (–2,0), (–1,0), (4,0)
 $y$–intercept: (0,2)
 c. Inflection point: (1,0)
 d. $x \in (-\infty,\infty), y \in (-\infty,\infty)$

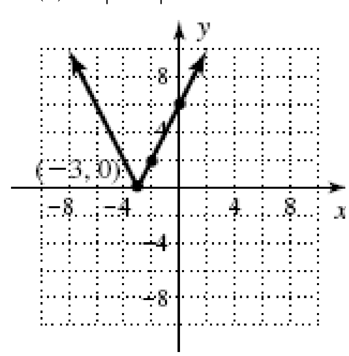
36. Absolute value function
 a. down on left/ down on right
 b. $x$–intercepts: (–1,0), (3,0)
 $y$–intercept: (0, 1)
 c. Vertex: (1,2)
 d. $x \in (-\infty,\infty), y \in (-\infty,2]$

37. Cube root
 a. up on left/ down on right
 b. $x$–intercept: (1,0)
 $y$–intercept: (0,1)
 c. Inflection: (1,0)
 d. $x \in (-\infty,\infty), y \in (-\infty,\infty)$

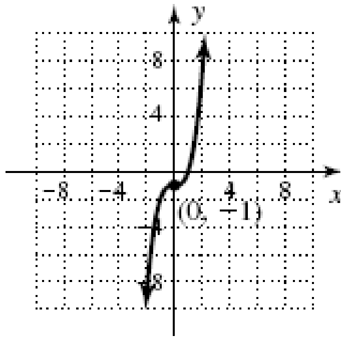
38. $f(x)=-(x+2)^2-5$ ; Quadratic



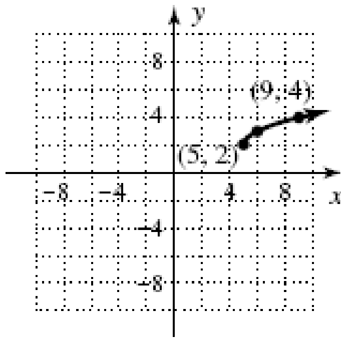

39. $f(x)=2|x+3|$ ; Absolute Value



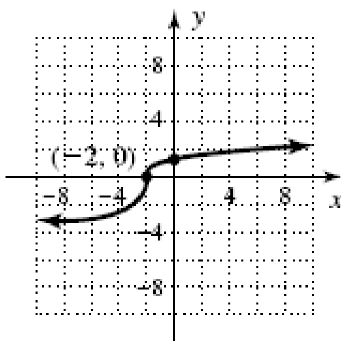
40. $f(x)=x^3-1$; Cubic




41. $f(x)=\sqrt{x-5}+2$ ; Square Root

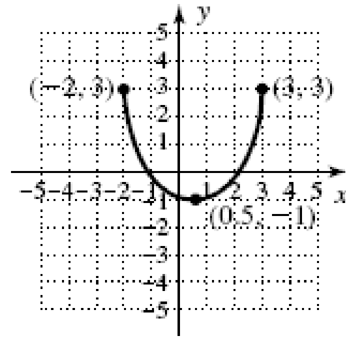



42. $f(x)=\sqrt[3]{x+2}$ ; Cube Root



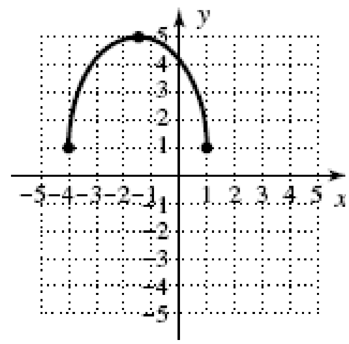

43. a. $f(x-2)$

Right 2



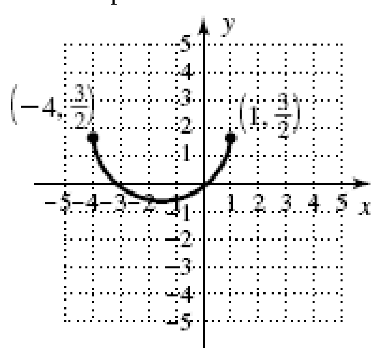

b. $-f(x)+4$

Reflect, up 4



c. $\frac{1}{2}f(x)$

Compressed down




44. a. $f(x)=\begin{cases} 5 & x\le -3 \\ -x+1 & -3<x\le 3 \\ 3\sqrt{x-3}-1 & x>3 \end{cases}$

$Y_1=5$; $Y_2=-x+1$; $Y_3=3\sqrt{x-3}-1$

b. $R: y\in[-2,\infty)$

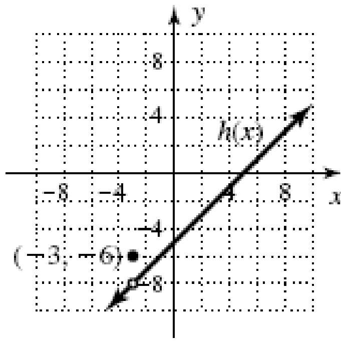
45. $h(x)=\begin{cases}\dfrac{x^2-2x-15}{x+3} & x\neq -3\\ -6 & x=-3\end{cases}$

$x\in(-\infty,\infty)$

$y\in(-\infty,-8)\cup(-8,\infty)$

Discontinuity at $x=-3$

Define $h(x)=-8$ at $x=-3$




46. $p(x)=\begin{cases}-4 & x<-2\\ -|x|-2 & -2\le x<3\\ 3\sqrt{x}-9 & x\ge 3\end{cases}$

$p(-4)=-4$;

$p(-2)=-|-2|-2=-2-2=-4$;

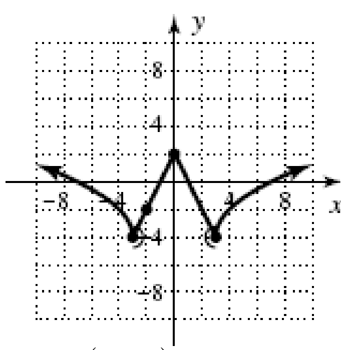
$p(2.5)=-|2.5|-2=-2.5-2=-4.5$;

$p(2.99)=-|2.99|-2=-2.99-2=-4.99$;

$p(3)=3\sqrt{3}-9$;

$p(3.5)=3\sqrt{3.5}-9$

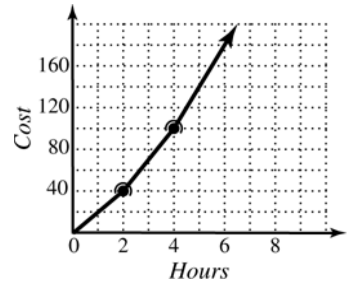
47. $q(x)=\begin{cases}2\sqrt{-x-3}-4 & x\le -3\\ -2|x|+2 & -3<x<3\\ 2\sqrt{x-3}-4 & x\ge 3\end{cases}$




$D: x\in(-\infty,\infty)$

$R: y\in[-4,\infty)$

48.




$f(x)=\begin{cases}20x & x\le 2\\ 30x-20 & 2<x\le 4\\ 40x-60 & x>4\end{cases}$

49. $f(x)=x^2+4x$ and $g(x)=3x-2$

$(f+g)(a)=f(a)+g(a)$

$=a^2+4a+3a-2$

$=a^2+7a-2$

50. $f(x)=x^2+4x$ and $g(x)=3x-2$

$(f\cdot g)(3)=f(3)\cdot g(3)$

$=\left((3)^2+4(3)\right)(3(3)-2)$

$=(9+12)(9-2)$

$=(21)(7)$

$=147$

51. $f(x)=x^2+4x$ and $g(x)=3x-2$

$\left(\dfrac{f}{g}\right)(x)=\dfrac{x^2+4x}{3x-2}$

$D: x\in\left(-\infty,\dfrac{2}{3}\right)\cup\left(\dfrac{2}{3},\infty\right)$

52. $p(x)=4x-3$; $q(x)=x^2+2x$;

$(p\circ q)(x)=p[q(x)]$

$=4(q(x))-3$

$=4\left(x^2+2x\right)-3$

$=4x^2+8x-3$

53. $p(x)=4x-3$; $q(x)=x^2+2x$;

$(q\circ p)(3)=q[p(3)]$

$p(3)=4(3)-3=12-3=9$

$q(9)=(9)^2+2(9)=81+18=99$

54. $p(x)=4x-3$; $q(x)=x^2+2x$; and

$r(x)=\frac{x+3}{4}$;

$(p\circ r)(x)=p[r(x)]$

$=4(r(x))-3$

$=4\left(\frac{x+3}{4}\right)-3$

$=x+3-3$

$=x$;

$(r\circ p)(x)=r[p(x)]$

$=\frac{p(x)+3}{4}$

$=\frac{4x-3+3}{4}$

$=\frac{4x}{4}$

$=x$

55. $h(x)=\sqrt{3x-2}+1$;

$f(x)=\sqrt{x}+1$;

$g(x)=3x-2$

56. $h(x)=x^{\frac{2}{3}}-3x^{\frac{1}{3}}-10$

$f(x)=x^2-3x-10$

$g(x)=x^{\frac{1}{3}}$

57. $r(t)=2t+3$

$A(t)=\pi(2t+3)^2$

58. a. $(f+g)(-2)=f(-2)+g(-2)$

$=-1+5=4$

b. $(g\circ f)(5)=g(f(5))$

$g(0)=7$

c. $(g-f)(7)=g(7)-f(7)$

$=5-(-1)=6$

d. $\frac{g}{f}(10)=\frac{g(10)}{f(10)}=-\frac{1}{5}$

e. $(f\cdot g)(3)=f(3)\cdot g(3)=7(2)=14$

# Chapter 2 Mixed Review

1. $4x+3y=12$

$3y=-4x+12$

$y=-\frac{4}{3}x+4$

2. $x-2y=8$

$-2y=-x+8$

$y=\frac{1}{2}x-4$

Slope: $\frac{1}{2}$; Slope of perpendicular line: –2

$y-3=-2(x-1)$

$y-3=-2x+2$

$y=-2x+5$

3. a. $f(x)=\frac{x+1}{x^2-5x+4}$

$x^2-5x+4=0$

$(x-4)(x-1)=0$

$x-4=0$ or $x-1=0$

$x=4$ or $x=1$

These values are restricted because they cause division by zero.

Domain: $(-\infty,1)\cup(1,4)\cup(4,\infty)$

b. $g(x)=\frac{1}{\sqrt{2x-3}}$

Set the radicand greater than zero. (Zero must be excluded because the radical is in the denominator.

$2x-3>0$

$2x>3$

$x>\frac{3}{2}$

Domain: $\left(\frac{3}{2},\infty\right)$

## Chapter 2 Mixed Review

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

   a. $p\left(-\frac{1}{3}\right) = -\left(-\frac{1}{3}\right)^2 + 3\left(-\frac{1}{3}\right) - 1$

   $= -\frac{1}{9} - 1 - 1 = -\frac{19}{9}$

   b. $p(3a) = -(3a)^2 + 3(3a) - 1$

   $= -9a^2 + 9a - 1$

   c. $p(a-1) = -(a-1)^2 + 3(a-1) - 1$

   $= -(a^2 - 2a + 1) + 3a - 3 - 1$

   $= -a^2 + 5a - 5$

5. $m = -\frac{3}{2}$; $y$–intercept (0,–2)

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

6. a. Domain: $[-4, 3]$

   b. $g(2) = 3$;

   c. $g(k) = -3; k = -4$

7. $L_1 : (-3,7), (2,2)$

   Slope: $\frac{2-7}{2-(-3)} = -1$;

   $L_2 : (2,2), (5,5)$

   Slope: $\frac{5-2}{5-2} = 1$;

   Lines are perpendicular. Vertex of right angle is (2, 2).
   Radius: distance between (–3,7) and (2,2).

   $d = \sqrt{(2-(-3))^2 + (2-7)^2} = \sqrt{50}$;

   Center (2,2), radius $\sqrt{50}$

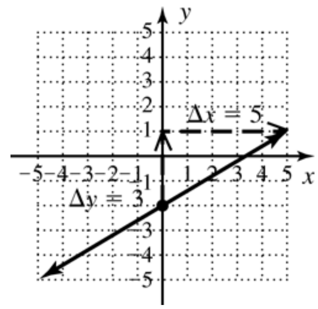
   Equation: $(x-2)^2 + (y-2)^2 = 50$

8. End behavior: up, up; Vertex: (1,–4)

   $x = 1; (-1,0), (3,0), (0,-3)$

9. $y = \frac{3}{5}x - 2$

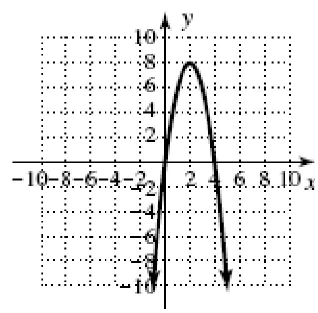
   $y$–intercept (0,–2)




10. $f(x) = 4x - \frac{4}{3}x^2$, $f(x) < 0$

    $(-\infty, 0) \cup (3, \infty)$

11. a. $p(x) = -2x^2 + 8x$




   Rate of change is positive in [–2, –1] since $p$ is increasing in $(-\infty, 2)$.
   The rate of change in [1, 2] will be less than the rate of change in [–2, –1].

   $\frac{\Delta p}{\Delta x} = \frac{p(2) - p(1)}{2-1} = \frac{8-6}{1} = 2$;

   $\frac{\Delta p}{\Delta x} = \frac{p(-1) - p(-2)}{-1-(-2)} = \frac{-10-(-24)}{1} = 14$

   b. $A(t) = 1000e^{0.07t}$

   For [10,10.01],

   $\frac{1000e^{0.07(10.01)} - 1000e^{0.07(10)}}{10.01 - 10} \approx 141.0$;

   For [15,15.01],

   $\frac{1000e^{0.07(15.01)} - 1000e^{0.07(15)}}{15.01 - 15} \approx 200.1$;

   For [20, 20.01],

   $\frac{1000e^{0.07(20.01)} - 1000e^{0.07(20)}}{20.01 - 20} \approx 284.0$;

   In the interval: [15, 15.01]

12. $f(x) = \dfrac{3}{x^2-1}, g(x) = 3x-2$

$$\frac{g}{f}\left(\frac{1}{2}\right) = \frac{3\left(\frac{1}{2}\right)-2}{\dfrac{3}{\left(\frac{1}{2}\right)^2-1}}$$

$$= \frac{\frac{3}{2}-\frac{4}{2}}{\dfrac{3}{\frac{1}{4}-\frac{4}{4}}} = -\frac{1}{2} \div \left(\frac{3}{\frac{-3}{4}}\right)$$

$$= -\frac{1}{2} \div -4 = -\frac{1}{2}\cdot -\frac{1}{4} = \frac{1}{8}$$

13. $f(x) = \dfrac{3}{x^2-1}, g(x) = 3x-2$

$$(f \circ g)(x) = \frac{3}{(3x-2)^2-1}$$

$$= \frac{3}{9x^2-12x+4-1} = \frac{3}{9x^2-12x+3}$$

$$= \frac{3}{3(3x^2-4x+1)} = \frac{1}{3x^2-4x+1}$$

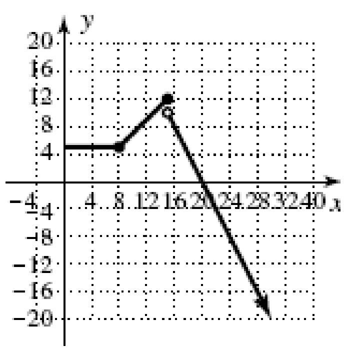
To find domain, $3x^2-4x+1=0$

$(3x-1)(x-1)=0$

$x = \dfrac{1}{3}, x = 1$

Domain: $\left(-\infty, \dfrac{1}{3}\right) \cup \left(\dfrac{1}{3}, 1\right) \cup (1, \infty)$

14. $h(x) = \begin{cases} 5 & 0 \le x < 8 \\ x-3 & 8 \le x \le 15 \\ -2x+40 & x > 15 \end{cases}$



15. $f(x) = x^2+1, g(x) = 3x-2$

$$\frac{f(x+h)-f(x)}{h}$$

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

$$= \frac{x^2+2xh+h^2+1-x^2-1}{h}$$

$$= \frac{2xh+h^2}{h} = \frac{h(2x+h)}{h} = 2x+h;$$

$$\frac{g(x+h)-g(x)}{h}$$

$$\frac{\left[3(x+h)-2\right]-\left[3x-2\right]}{h}$$

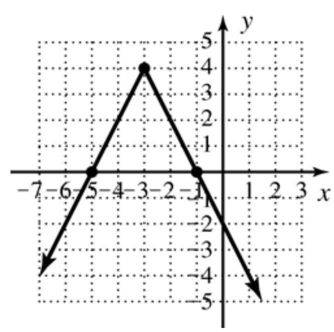
$$= \frac{3x+3h-2-3x+2}{h} = \frac{3h}{h} = 3;$$

For small $h$, $2x+h=3$

when $x \approx \dfrac{3}{2}$

16. $g(x) = -2|x+3|+4$

Absolute Value, shift left 3, reflect and stretch up 4



17. a. $D: x \in (-\infty, 6]$

$R: y \in (-\infty, 3]$

b. Min: (3, –3)

Max: $y = 3$ for $x \in (–6,–3)$; (6, 0)

c. $g(x)\uparrow$: $x \in (-\infty,-6)\cup(3,6)$

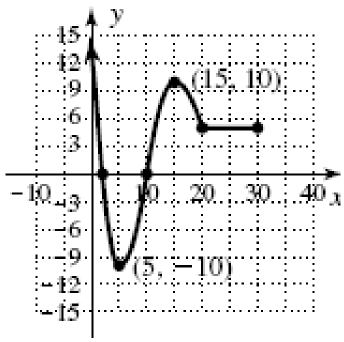
$g(x)\downarrow$: $x \in (-3,3)$

$g(x)$ constant: $x \in (-6,-3)$

d. $g(x) > 0$: $x \in (-7,-1)$

$g(x) < 0$: $x \in (-\infty,-7)\cup(-1,6)$

18. Zeroes: (2, 0), (10, 0)
Max: (15, 10)
Min: (5, –10)




19. $x$–intercepts: (–1, 0), (1.5, 0)
$y$–intercept: (0, 3)

$f(x) = a(x+1)(x-1.5)$

$f(x) = a\left(x^2 - \frac{1}{2}x - \frac{3}{2}\right)$

$3 = a\left(0^2 - \frac{1}{2}(0) - \frac{3}{2}\right)$

$3 = -\frac{3}{2}a$

$-2 = a;$

$f(x) = -2x^2 + x + 3$

20. $m = \frac{431-257}{0-25} = \frac{174}{-25} = -6.96$

$y - y_1 = m(x - x_1)$

$y - 431 = -6.96(x - 0)$

$y = -6.96x + 431$

$f(33) = -6.96(33) + 431 = 201.32$

201,320 deaths from heart disease in 2008.

## Chapter 2 Practice Test

1. a. $x = y^2 + 2y$

b. $y = \sqrt{5-2x}$

c. $|y| + 1 = x$

d. $y = x^2 + 2x$

a and c are non–functions, do not pass the vertical line test.

2. $L_1: \ 2x + 5y = -15$

$5y = -2x - 15$

$y = -\frac{2}{5}x - 3$

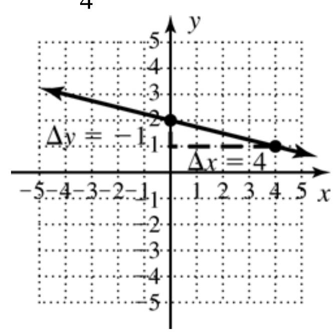
$L_2: \ y = \frac{2}{5}x + 7$

Neither

3. $x + 4y = 8$

$4y = -x + 8$

$y = -\frac{1}{4}x + 2$

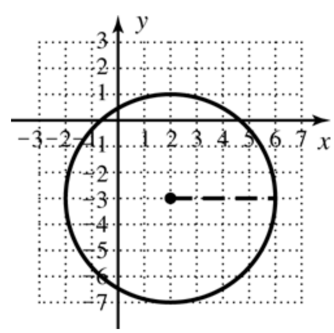



4. $x^2 - 4x + y^2 + 6y = 3$

$x^2 - 4x + 4 + y^2 + 6y + 9 = 3 + 4 + 9$

$(x-2)^2 + (y+3)^2 = 16$

Center:(2,–3); radius: 4



5. $6x+5y=3$

$6x+5y=3$

$5y=-6x+3$

$y=-\frac{6}{5}x+\frac{3}{5}$

Slope: $-\frac{6}{5}$

Point (2,–2), slope $-\frac{6}{5}$

$y-(-2)=-\frac{6}{5}(x-2)$

$y+2=-\frac{6}{5}x+\frac{12}{5}$

$y=-\frac{6}{5}x+\frac{2}{5}$

6. (–20, 15) and (35, –12)
   a. $M=\left(\frac{-20+35}{2},\frac{15-12}{2}\right)=(7.5,1.5)$
   b. $d=\sqrt{(-20-35)^2+(15+12)^2}$

   $d=\sqrt{(-55)^2+(27)^2}$

   $d=\sqrt{3025+729}$

   $d=\sqrt{3754}$

   $d\approx 61.27$ miles

7. L1: $x=-3$
   $L_2$: $y=4$

8. a. $x\in\{-4,-2,0,2,4,6\}$
   $y\in\{-2,-1,0,1,2,3\}$
   b. $x\in[-2,6]$
   $y\in[1,4]$

9. a. $W(24)=300$
   b. $h=30$ when $W(h)=375$
   c. (20, 250) and (40, 500)

   $m=\frac{500-250}{40-20}=\frac{250}{20}=\frac{25}{2}$

   $W(h)=\frac{25}{2}h$

   d. Wages are $12.50 per hour.
   e. $h\in[0,40]$
   $w\in[0,500]$

10. Graph I
   a. Square Root
   b. $x\in[-4,\infty)$
   $y\in[-3,\infty)$
   c. $x$–intercept: (–2, 0)
   $y$–intercept: (0, 1)
   d. Up on right
   e. $(-2,\infty)$
   f. $[-4,-2)$

   Graph II
   a. Cubic
   b. $x\in(-\infty,\infty)$
   $y\in(-\infty,\infty)$
   c. $x$–intercept: (2, 0)
   $y$–intercept: (0, –1)
   d. Down on left, up on right
   e. $(2,\infty)$
   f. $(-\infty,2)$

   Graph III
   a. Absolute value
   b. $x\in(-\infty,\infty)$
   $y\in(-\infty,4]$
   c. $x$–intercepts: (–1, 0) and (3, 0)
   $y$–intercept: (0, 2)
   d. Down/down
   e. (–1, 3)
   f. $(-\infty,-1)\cup(3,\infty)$

   Graph IV
   a. Quadratic
   b. $x\in(-\infty,\infty)$
   $y\in[-5.5,\infty]$
   c. $x$–intercepts: (0, 0) and (5, 0)
   $y$–intercept: (0, 0)
   d. Up/up
   e. $(-\infty,0)\cup(5,\infty)$
   f. (0, 5)

11. $f(x)=\frac{2-x^2}{x^2}$

   a. $f\left(\frac{2}{3}\right)=\frac{2-\left(\frac{2}{3}\right)^2}{\left(\frac{2}{3}\right)^2}=\frac{2-\left(\frac{4}{9}\right)}{\frac{4}{9}}$

   $=\frac{\frac{14}{9}}{\frac{4}{9}}=\frac{14}{9}\div\frac{4}{9}=\frac{7}{2}$

# Chapter 2 Practice Test

b. $f(a+3)=\dfrac{2-(a+3)^2}{(a+3)^2}$

$=\dfrac{2-(a^2+6a+9)}{a^2+6a+9}=\dfrac{2-a^2-6a-9}{a^2+6a+9}$

$=\dfrac{-a^2-6a-7}{a^2+6a+9}$

c. $f(1+2i)=\dfrac{2-(1+2i)^2}{(1+2i)^2}$

$=\dfrac{2-(1+4i+4i^2)}{1+4i+4i^2}=\dfrac{2-1-4i-4i^2}{1+4i-4}$

$=\dfrac{1-4i+4}{-3+4i}=\dfrac{5-4i}{-3+4i}$

$=\dfrac{5-4i}{-3+4i}\cdot\dfrac{-3-4i}{-3-4i}=\dfrac{-15-20i+12i+16i^2}{9-16i^2}$

$=\dfrac{-15-8i-16}{9+16}=\dfrac{-31-8i}{25}$

$=-\dfrac{31}{25}-\dfrac{8}{25}i$

12. $f(x)=x^2+2, g(x)=\sqrt{3x-1}$

$(f\circ g)(x)=\left(\sqrt{3x-1}\right)^2+2=3x-1+2$

$=3x+1$;

To find domain: $3x-1\ge 0$

$3x\ge 1$

$x\ge\dfrac{1}{3}$

Domain: $x\in\left[\dfrac{1}{3},\infty\right)$

13. $S(t)=2t^2-3t$

a. No, new company and sales should be growing.

b. For $[5,6], S(5)=2(5)^2-3(5)=35$

$S(6)=2(6)^2-3(6)=54$

Rate of Change: $\dfrac{54-35}{6-5}=19$

For $[6,7], S(7)=2(7)^2-3(7)=77$

Rate of Change: $\dfrac{77-54}{7-6}=23$

c. $\dfrac{2(t+h)^2-3(t+h)-(2t^2-3t)}{h}$

$=\dfrac{2(t^2+2th+h^2)-3t-3h-2t^2+3t}{h}$

$=\dfrac{2t^2+4th+2h^2-3h-2t^2}{h}$

$=\dfrac{4th+2h^2-3h}{h}=4t-3+2h$

For small $h$:

$4(10)-3=37, 4(18)-3=69,$

$4(24)-3=93$

For small h, sales volume is approximately

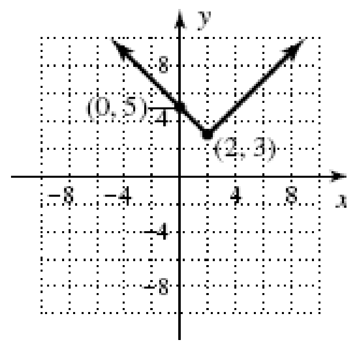
$\dfrac{37{,}000\text{ units}}{1\text{ mo}}$ in month 10,

$\dfrac{69{,}000\text{ units}}{1\text{ mo}}$ in month 18,

$\dfrac{93{,}000\text{ units}}{1\text{ mo}}$ in month 24

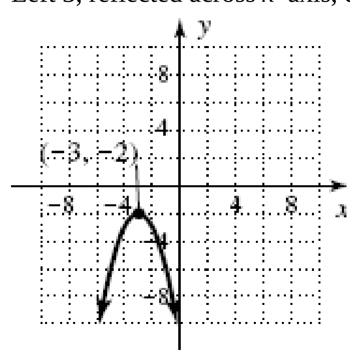
14. $f(x)=|x-2|+3$

Right 2, up 3




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

Left 3, reflected across $x$–axis, down 2



16. $r(t)=\sqrt{t}$ ; $V(r)=\frac{4}{3}\pi r^3$

a. $(V\circ r)(t)=V[r(t)]$

$V(t)=\frac{4}{3}\pi\left(\sqrt{t}\right)^3$

b. $V(9)=\frac{4}{3}\pi\left(\sqrt{9}\right)^3$

$V(9)=\frac{4}{3}\pi(27)$

$V(9)=36\pi\ \text{in}^3$

17. a. $D: x\in[-4,\infty)$

$R: y\in[-3,\infty)$

b. $f(-1)\approx 2.2$

c. $f(x)<0:\ x\in(-4,-3)$

$f(x)>0:\ x\in(-3,\infty)$

d. $f(x)\uparrow: (-4,\infty)$

$f(x)\downarrow$: none

e. Parent graph: $y=\sqrt{x}$

Graph shifts left 4, down 3

$y=a\sqrt{x+4}-3$

$3=a\sqrt{0+4}-3$

$3=a\sqrt{4}-3$

$3=2a-3$

$6=2a$

$3=a$

$y=3\sqrt{x+4}-3$

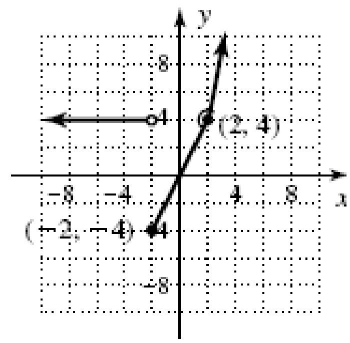
18. $h(x)=\begin{cases}4 & x<-2\\ 2x & -2\le x\le 2\\ x^2 & x>2\end{cases}$

$h(-3)=4$,

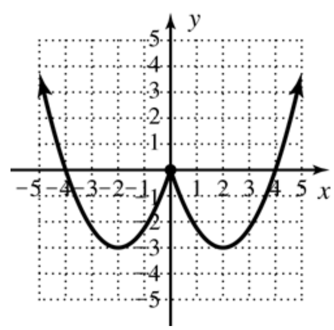
$h(-2)=2(-2)=-4$,

$h\left(\frac{5}{2}\right)=\left(\frac{5}{2}\right)^2=6.25$

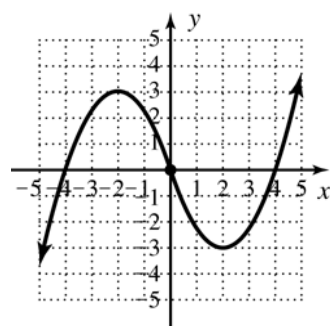
b.




19.




20.




## Ch 2 Calculator Exploration

Exercise 1: $y=-5(x+4)^2+6; (-4,6)$

Exercise 2: (2, 3), est: (0, 8),
computed: (0, 8.0396842), very close

## Ch. 2 Strengthening Core Skills

Exercise 1: $f(x)=x^2-8x-12$

$\frac{b}{2a}=\frac{-8}{2(1)}=-4$

$g(x) = x + 4$
$h(x) = f[g(x)] = f(x + 4)$
$= (x + 4)^2 - 8(x + 4) - 12$
$= x^2 + 8x + 16 - 8x - 32 - 12$
$= x^2 - 28$
$x^2 - 28 = 0$
$x^2 = 28$
$x = \pm 2\sqrt{7}$ ;
$4 \pm 2\sqrt{7}$

Exercise 2: $f(x) = x^2 + 4x + 5$

$\frac{b}{2a} = \frac{4}{2(1)} = 2$
$g(x) = x - 2$
$h(x) = f[g(x)] = f(x - 2)$
$= (x - 2)^2 + 4(x - 2) + 5$
$= x^2 - 4x + 4 + 4x - 8 + 5$
$= x^2 + 1$
$x^2 + 1 = 0$
$x^2 = -1$
$x = \pm i$
$-2 \pm i$

Exercise 3: $f(x) = 2x^2 - 10x + 11$

$\frac{b}{2a} = \frac{-10}{2(2)} = -\frac{5}{2}$
$g(x) = x + \frac{5}{2}$
$h(x) = f[g(x)] = f\left(x + \frac{5}{2}\right)$
$= 2\left(x + \frac{5}{2}\right)^2 - 10\left(x + \frac{5}{2}\right) + 11$
$= 2\left(x^2 + 5x + \frac{25}{4}\right) - 10x - \frac{50}{2} + 11$
$= 2x^2 + 10x + \frac{50}{4} - 10x - \frac{50}{2} + 11$
$= 2x^2 - \frac{3}{2}$
$2x^2 - \frac{3}{2} = 0$
$2x^2 = \frac{3}{2}$
$x^2 = \frac{3}{4}$
$x = \pm \frac{\sqrt{3}}{2}$
$\frac{5}{2} \pm \frac{\sqrt{3}}{2}$

## Cumulative Review Chapters 1–2

1. $(x^3 - 5x^2 + 2x - 10) \div (x - 5)$
$= \frac{x^2(x - 5) + 2(x - 5)}{x - 5}$
$= \frac{(x - 5)(x^2 + 2)}{x - 5}$
$= x^2 + 2$

2. $2 - x < 5$ and $3x + 2 < 8$
$-x < 3$ $\quad$ $3x < 6$
$x > -3$ $\quad$ $x < 2$
Solution set: $-3 < x < 2$

3. $A = \pi r^2$

$69 = \pi r^2$

$\dfrac{69}{\pi} = r^2$

$21.96 \approx r^2$

$4.686 \approx r;$

$C = 2\pi\ r$

$C = 2\pi(4.686)$

$C \approx 29.45$ cm

4. $A = 2\pi r^2 + 2\pi rh$

$2\pi r^2 + 2\pi rh - A = 0$

$r = \dfrac{-2\pi h \pm \sqrt{(2\pi h)^2 - 4(2\pi)(-A)}}{2(2\pi)}$

$r = \dfrac{-2\pi h \pm \sqrt{4\pi^2 h^2 + 4(2\pi A)}}{4\pi}$

$r = \dfrac{-2\pi h \pm \sqrt{4(\pi^2 h^2 + 2\pi A)}}{4\pi}$

$r = \dfrac{-2\pi h \pm 2\sqrt{\pi^2 h^2 + 2\pi A}}{4\pi}$

$r = \dfrac{-\pi h \pm \sqrt{\pi^2 h^2 + 2\pi A}}{2\pi}$

5. $-2(3-x)+5x = 4(x+1)-7$

$-6+2x+5x = 4x+4-7$

$7x-6 = 4x-3$

$3x = 3$

$x = 1$

6. $\left(\dfrac{27}{8}\right)^{\frac{-2}{3}} = \left(\dfrac{8}{27}\right)^{\frac{2}{3}} = \left(\sqrt[3]{\dfrac{8}{27}}\right)^2 = \left(\dfrac{2}{3}\right)^2 = \dfrac{4}{9}$

7. a. (–4, 7) and (2, 5)

$m = \dfrac{7-5}{-4-2} = \dfrac{2}{-6} = -\dfrac{1}{3}$

b. $3x - 5y = 20$

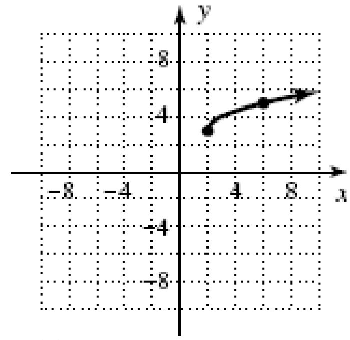
$-5y = -3x + 20$

$y = \dfrac{3}{5}x - 4$

$m = \dfrac{3}{5}$

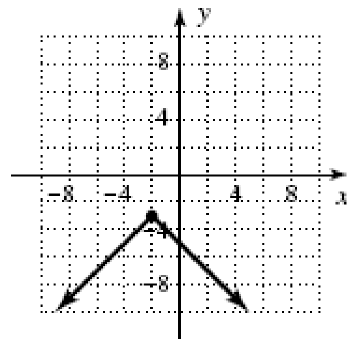
8. a. $f(x) = \sqrt{x-2} + 3$

Right 2, up 3

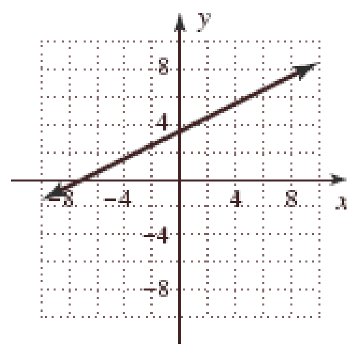



b. $f(x) = -|x+2| - 3$

Left 2, reflected across *x*-axis, down 3




9. (–3, 2); $m = \dfrac{1}{2}$




$y - 2 = \dfrac{1}{2}(x+3)$

$y - 2 = \dfrac{1}{2}x + \dfrac{3}{2}$

$y = \dfrac{1}{2}x + \dfrac{7}{2}$

# Cumulative Review Chapters 1–2

10. $x^2 - 2x + 26 = 0$

$$(1+5i)^2 - 2(1+5i) + 26 = 0$$
$$1 + 10i + 25i^2 - 2 - 10i + 26 = 0$$
$$1 + 10i - 25 - 2 - 10i + 26 = 0$$
$$0 = 0$$

11. $f(x) = 3x^2 - 6x$ and $g(x) = x - 2$

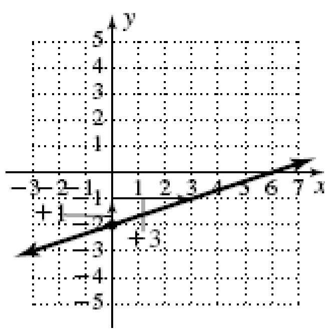
$(f \cdot g)(x) = f(x) \cdot g(x)$
$= (3x^2 - 6x)(x - 2)$
$= 3x^3 - 6x^2 - 6x^2 + 12x$
$= 3x^3 - 12x^2 + 12x$

$(f \div g)(x) = \dfrac{f(x)}{g(x)}$
$= \dfrac{3x^2 - 6x}{x - 2}$
$= \dfrac{3x(x-2)}{x-2}$
$= 3x; \quad x \neq 2;$

$(g \circ f)(-2) = g[f(-2)];$
$f(-2) = 3(-2)^2 - 6(-2) = 24;$
$g(24) = 24 - 2 = 22$

12. $y = \dfrac{1}{3}x - 2$; $y$–intercept: (0, –2);

$m = \dfrac{1}{3}$




13. $f(x) = \begin{cases} x^2 - 4 & x < 2 \\ x - 1 & 2 \le x \le 8 \end{cases}$

a. $D: x \in (-\infty, 8]$
$R: y \in [-4, \infty)$

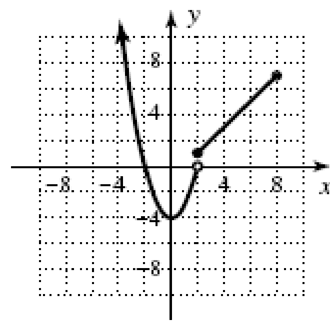
b. $f(-3) = (-3)^2 - 4 = 9 - 4 = 5$;
$f(-1) = (-1)^2 - 4 = 1 - 4 = -3$;
$f(1) = (1)^2 - 4 = 1 - 4 = -3$;
$f(2) = 2 - 1 = 1$;
$f(3) = 3 - 1 = 2$

c. (–2, 0)

d. $f(x) < 0: x \in (-2, 2)$
$f(x) > 0: x \in (-\infty, -2) \cup [2, 8]$

e. Max: (8, 7)
Min: (0, –4)

f. $f(x)\uparrow: x \in (0, 8)$
$f(x)\downarrow: x \in (-\infty, 0)$




14. $f(x) = x^2$ and $g(x) = x^3$

a. $\dfrac{\Delta f}{\Delta x} = \dfrac{f(0.6) - f(0.5)}{0.6 - 0.5} = 1.1$;
$\dfrac{\Delta g}{\Delta x} = \dfrac{g(0.6) - g(0.5)}{0.6 - 0.5} = 0.91$;
$f(x)$ increases faster.

b. $\dfrac{\Delta f}{\Delta x} = \dfrac{f(1.6) - f(1.5)}{1.6 - 1.5} = 3.1$;
$\dfrac{\Delta g}{\Delta x} = \dfrac{g(1.6) - g(1.5)}{1.6 - 1.5} = 7.21$;
$g(x)$ increases faster

15. a. $\frac{-2}{x^2-3x-10}+\frac{1}{x+2}$

$=\frac{-2}{(x-5)(x+2)}+\frac{1}{x+2}$

$=\frac{-2}{(x-5)(x+2)}+\frac{1(x-5)}{(x-5)(x+2)}$

$=\frac{-2+x-5}{(x-5)(x+2)}$

$=\frac{x-7}{(x-5)(x+2)}$

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

16. a. $\frac{-10+\sqrt{72}}{4}=\frac{-10+6\sqrt{2}}{4}=-\frac{5}{2}+\frac{3\sqrt{2}}{2}$

b. $\frac{1}{\sqrt{2}}=\frac{1}{\sqrt{2}}\cdot\frac{\sqrt{2}}{\sqrt{2}}=\frac{\sqrt{2}}{2}$

17. a. $N\subset Z\subset W\subset Q\subset R$

False

b. $W\subset N\subset Z\subset Q\subset R$

False

c. $N\subset W\subset Z\subset Q\subset R$

True

d. $N\subset R\subset Z\subset Q\subset W$

False

18. No; Raphael is grouped with The School of Athens and Parnassus. Michelangelo corresponds to no element of the second set.

19. $2x^2+49=-20x$

$2x^2+20x+49=0$

$2x^2+20x=-49$

$x^2+10x=\frac{-49}{2}$

$x^2+10x+25=-\frac{49}{2}+25$

$(x+5)^2=\frac{1}{2}$

$x+5=\pm\sqrt{\frac{1}{2}}$

$x+5=\pm\frac{\sqrt{2}}{2}$

$x=-5\pm\frac{\sqrt{2}}{2}$;

$x\approx-4.293$

$x\approx-5.707$

20. $2x^2+20x=-51$

$2x^2+20x+51=0$

$x=\frac{-20\pm\sqrt{(20)^2-4(2)(51)}}{2(2)}$

$x=\frac{-20\pm\sqrt{400-408}}{4}$

$x=\frac{-20\pm\sqrt{-8}}{4}$

$x=\frac{-20\pm 2i\sqrt{2}}{4}$

$x=-5\pm\frac{i\sqrt{2}}{2}$

21. Let $w$ represent the width.
Let $l$ represent the length.

$A=lw$

$1457=(w+16)w$

$0=w^2+16w-1457$

$0=(w-31)(w+47)$

$w$ = 31 cm; $l$ = 47 cm

# Cumulative Review Chapters 1–2

22. a. $(2+5i)^2 = 4+20i+25i^2$
$= 4+20i-25 = -21+20i$

b. $\frac{1-2i}{1+2i} = \frac{1-2i}{1+2i}\cdot\frac{1-2i}{1-2i}$
$= \frac{1-4i+4i^2}{1-4i^2} = \frac{1-4i-4}{1+4}$
$= \frac{-3-4i}{5} = -\frac{3}{5}-\frac{4}{5}i$

23. a. $6x^2-7x=20$
$6x^2-7x-20=0$
$(3x+4)(2x-5)=0$
$x=-\frac{4}{3};\quad x=\frac{5}{2}$

b. $x^3+5x^2-15=3x$
$x^3+5x^2-3x-15=0$
$(x^3+5x^2)-(3x+15)=0$
$x^2(x+5)-3(x+5)=0$
$(x+5)(x^2-3)=0$
$x=-5;\quad x=\sqrt{3};\quad x=-\sqrt{3}$

24. $m_1=\frac{1}{2}$; $m_2=-2$; (1, 2)
$y-2=-2(x-1)$
$y-2=-2x+2$
$y=-2x+4$

25. (–4, 5), (4, –1), (0, 8)
$d=\sqrt{(-4-4)^2+(5+1)^2}$
$d=\sqrt{(-8)^2+(6)^2}$
$d=\sqrt{100}$
$d=10;$
$d=\sqrt{(4-0)^2+(-1-8)^2}$
$d=\sqrt{(4)^2+(-9)^2}$
$d=\sqrt{97}$
$d\approx 9.85;$
$d=\sqrt{(-4-0)^2+(5-8)^2}$
$d=\sqrt{(-4)^2+(-3)^2}$
$d=\sqrt{25}$
$d=5;$
$P=10+\sqrt{97}+5=15+\sqrt{97}$
$\approx 15+9.85\approx 24.85$ units
No it is not a right triangle.
$5^2+(\sqrt{97})^2\neq 10^2$

## Connections to Calculus Chapter 2

1. a. $f(x) = -3x + 5$

$$\frac{f(x+h) - f(x)}{h}$$
$$= \frac{\left(-3(x+h)+5\right) - (-3x+5)}{h}$$
$$= \frac{-3x - 3h + 5 + 3x - 5}{h} = \frac{-3h}{h} = -3$$

b. $x = 2$: as $h \to 0, -3$ remains constant

2. a. $g(x) = \frac{2}{3}x - 7$

$$\frac{g(x+h) - g(x)}{h}$$
$$= \frac{\left(\frac{2}{3}(x+h) - 7\right) - \left(\frac{2}{3}x - 7\right)}{h}$$
$$= \frac{\left(\frac{2}{3}x + \frac{2}{3}h - 7\right) - \frac{2}{3}x + 7}{h}$$
$$= \frac{\frac{2}{3}h}{h} = \frac{2}{3}$$

b. $x = 2$: as $h \to 0, \frac{2}{3}$ remains constant

3. a. $h(x) = x^2 - 3x$

$$\frac{h(x+h) - h(x)}{h}$$
$$= \frac{\left((x+h)^2 - 3(x+h)\right) - \left(x^2 - 3x\right)}{h}$$
$$= \frac{x^2 + 2xh + h^2 - 3x - 3h - x^2 + 3x}{h}$$
$$= \frac{2xh + h^2 - 3h}{h} = \frac{h(2x + h - 3)}{h}$$
$$= 2x - 3 + h, \; h \neq 0$$

b. $x = 2$: as $h \to 0, 2(2) - 3 + h \to 1$

4. a. $r(x) = -2x^2 + 3x + 7$

$$\frac{r(x+h) - r(x)}{h}$$
$$= \frac{\left(-2(x+h)^2 + 3(x+h) + 7\right) - \left(-2x^2 + 3x + 7\right)}{h}$$
$$= \frac{-2\left(x^2 + 2xh + h^2\right) + 3x + 3h + 7 + 2x^2 - 3x - 7}{h}$$
$$= \frac{-2x^2 - 4xh - 2h^2 + 3x + 3h + 7 + 2x^2 - 3x - 7}{h}$$
$$= \frac{-4xh - 2h^2 + 3h}{h} = \frac{h(-4x - 2h + 3)}{h}$$
$$= -4x + 3 - 2h, \; h \neq 0$$

b. $x = 2$: as $h \to 0, -4(2) + 3 - 2h \to -5$

5. a. $f(x) = \frac{1}{x}$

$$\frac{f(x+h) - f(x)}{h}$$
$$= \frac{\frac{1}{(x+h)} - \frac{1}{x}}{h}$$
$$= \frac{\frac{x}{x} \cdot \frac{1}{x+h} - \frac{1}{x} \cdot \frac{x+h}{x+h}}{h}$$
$$= \frac{x - (x+h)}{x(x+h)} \div \frac{h}{1}$$
$$= \frac{x - x - h}{x(x+h)} \cdot \frac{1}{h}$$
$$= \frac{-h}{hx(x+h)} = \frac{-1}{x(x+h)}$$

b. $x = 2$: as $h \to 0, \frac{-1}{2(2+h)} \to -\frac{1}{4}$

6. a. $g(x)=\dfrac{3}{x+1}$

$$\frac{g(x+h)-g(x)}{h}$$

$$=\frac{\dfrac{3}{(x+h)+1}-\dfrac{3}{x+1}}{h}$$

$$=\left(\frac{x+1}{x+1}\cdot\frac{3}{x+h+1}-\frac{3}{x+1}\cdot\frac{x+h+1}{x+h+1}\right)\div\frac{h}{1}$$

$$=\left(\frac{3x+3}{(x+1)(x+h+1)}-\frac{(3x+3h+3)}{(x+1)(x+h+1)}\right)\cdot\frac{1}{h}$$

$$=\frac{3x+3-3x-3h-3}{(x+1)h(x+h+1)}$$

$$=\frac{-3h}{(x+1)h(x+h+1)}$$

$$=\frac{-3}{(x+1)(x+h+1)}$$

b. $x=2:\text{as } h\to 0,\dfrac{-3}{(2+1)(2+h+1)}\to-\dfrac{1}{3}$

7. a. $h(x)=\dfrac{1}{2x^2}$

$$\frac{h(x+h)-h(x)}{h}$$

$$=\frac{\dfrac{1}{2(x+h)^2}-\dfrac{1}{2x^2}}{h}$$

$$=\left(\frac{x^2}{x^2}\cdot\frac{1}{2(x+h)^2}-\frac{1}{2x^2}\cdot\frac{(x+h)^2}{(x+h)^2}\right)\div\frac{h}{1}$$

$$=\left(\frac{x^2-\left(x^2+2xh+h^2\right)}{2x^2(x+h)^2}\right)\cdot\frac{1}{h}$$

$$=\frac{x^2-x^2-2xh-h^2}{2x^2(x+h)^2h}$$

$$=\frac{-2xh-h^2}{2x^2(x+h)^2h}$$

$$=\frac{h(-2x-h)}{2x^2(x+h)^2h}$$

$$=\frac{-2x-h}{2x^2(x+h)^2}$$

b. $x=2:\text{as } h\to 0,\dfrac{-2(2)-h}{2(2)^2(2+h)^2}\to-\dfrac{1}{8}$

8. a. $r(x)=x^3-2x-2$

$$\frac{r(x+h)-r(x)}{h}$$

$$=\frac{(x+h)^3-2(x+h)-2-\left(x^3-2x-2\right)}{h}$$

$$=\frac{x^3+3x^2h+3xh^2+h^3-2x-2h-2-x^3+2x+2}{h}$$

$$=\frac{3x^2h+3xh^2+h^3-2h}{h}$$

$$=\frac{h\left(3x^2+3xh+h^2-2\right)}{h}$$

$$=3x^2+3xh+h^2-2,\ h\neq 0$$

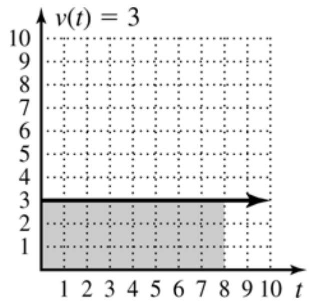
b. $x=2:$

as $h\to 0, 3(2)^2+3(2)h+h^2-2\to 10$

9. $v(t)=3, t=0$ to $t=8$

$A=LW=3\cdot 8=24$

Distance 24 ft

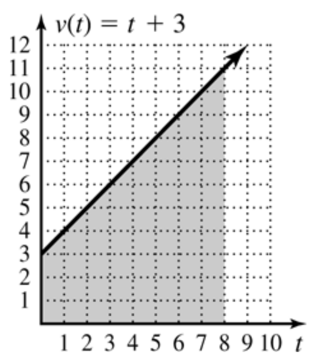



10. $v(t)=t+3, t=0$ to $t=8$

$$A=\frac{1}{2}\left(b_1+b_2\right)h$$

$$A=\frac{1}{2}\left(3+11\right)8=56$$

Distance 56 ft

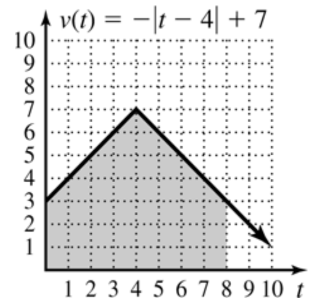



11. $v(t)=-\left|t-4\right|+7$

$$A=\frac{1}{2}bh+lw$$

$$A=\frac{1}{2}\left(8\right)4+8\cdot 3=40$$

Distance 40 ft




12. $v(t)=-\frac{1}{2}(t-4)^2+11$

$$A=\frac{4}{3}ab+lw$$

$$A=\frac{4}{3}\left(4\right)8+8\cdot 3=\frac{200}{3}=66\frac{2}{3}$$

Distance $66\frac{2}{3}$ ft