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Exercises 2.1 (page 201)

1. function **2.** relation **3.** domain **4.** range

5. $y = f(x)$ **6.** x **7.** dependent **8.** difference quotient

9. D $= \{2, 3, 4, 5\}$; R $= \{3, 4, 5, 6\}$
Each element of the domain is paired with only one element of the range. Function.

10. D $= \{5, 6, 7, 8\}$; R $= \{4\}$
Each element of the domain is paired with only one element of the range. Function.

11. D $= \{1, 2, -5\}$; R $= \{3, 4, 5, 2\}$
1 is both paired with 3 and 4. Not a function.

12. D $= \{-1, 2, 0\}$; R $= \{2, -1, 1, 3\}$
0 is both paired with 1 and 3. Not a function.

13. {(LSU, Tigers), (Georgia, Bulldogs), (MSU, Bulldogs), (Auburn, Tigers) }
D $=$ {LSU, Georgia, MSU, Auburn}; R $=$ {Tigers, Bulldogs}
Each element of the domain is paired with only one element of the range. Function.

14. {(Jackson, Louisiana), (Jackson, Mississippi), (Jackson, Tennessee), (Alexandria, Virginia) }
D $=$ {Jackson, Alexandria}; R $=$ {Louisiana, Mississippi, Tennessee, Virginia}
Jackson is paired with Louisiana, Mississippi, and Tennessee. Not a function.

15. {(76, September 9), (76, October 12), (78, May 10), (80, June 1) }
D $= \{76, 78, 80\}$; R $=$ {September 9, October 12, May 10, June 1}
76 is paired with September 9 and October 12. Not a function.

16. {(Architect, \$73,090), (Dentist, \$149,310), (Microbiologist, \$66,260), (Actuary, \$93,680) }
D $=$ {Architect, Dentist, Microbiologist, Actuary}; R $=$ {\$73,090, \$149,310, \$66,260, \$93,680}
Each element of the domain is paired with only one element of the range. Function.

17. $y = x$
Each value of x is paired with only one value of y.
function

18. $y - 2x = 0$
$y = 2x$
Each value of x is paired with only one value of y.
function

19. $y^2 = x$
$y = \pm\sqrt{x}$
At least one value of x is paired with more than one value of y. **not a function**

20. $y^2 - 4x = 1$
$y^2 = 4x + 1$
$y = \pm\sqrt{4x+1}$
At least one value of x is paired with more than one value of y. **not a function**

21. $y = x^2$
Each value of x is paired with only one value of y.
function

22. $y + 1 = 5x^3$
Each value of x is paired with only one value of y.
function

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EXERCISES 2.1

23. $|y| = x$
$y = \pm x$
At least one value of x is paired with more than one value of y. **not a function**

24. $2|y| = x - 4$
$|y| = \frac{x-4}{2}$
$y = \pm \frac{x-4}{2}$
At least one value of x is paired with more than one value of y. **not a function**

25. $|x - 2| = y$
$y = |x - 2|$
Each value of x is paired with only one value of y. **function**

26. $y - |x| = 3$
$y = |x| + 3$
Each value of x is paired with only one value of y. **function**

27. $|x| = |y|$
$|y| = |x|$
$y = \pm |x|$
At least one value of x is paired with more than one value of y. **not a function**

28. $|y| = |x - 2|$
$y = \pm (x - 2)$
At least one value of x is paired with more than one value of y. **not a function**

29. $y = 7$; Each value of x is paired with only one value of y. **function**

30. $x = 7$; At least one value of x is paired with more than one value of y. **not a function**

31. $y - 7 = \sqrt{x}$
$y = \sqrt{x} + 7$
Each value of x is paired with only one value of y. **function**

32. $y - \sqrt[3]{x} = 8$
$y = \sqrt[3]{x} + 8$
Each value of x is paired with only one value of y. **function**

33. $x^3 + y^2 = 25$
$y^2 = -x^3 + 25$
$y = \pm \sqrt{-x^3 + 25}$
At least one value of x is paired with more than one value of y. **not a function**

34. $(x - 1)^2 + y^2 = 16$
$y^2 = 16 - (x - 1)^2$
$y = \pm \sqrt{16 - (x - 1)^2}$
At least one value of x is paired with more than one value of y. **not a function**

35. $f(x) = 3x + 5 \Rightarrow$ domain $= (-\infty, \infty)$

36. $f(x) = -5x + 2 \Rightarrow$ domain $= (-\infty, \infty)$

37. $f(x) = x^2 - x + 1 \Rightarrow$ domain $= (-\infty, \infty)$

38. $f(x) = x^3 - 3x + 2 \Rightarrow$ domain $= (-\infty, \infty)$

39. $f(x) = \sqrt{x - 2} \Rightarrow x - 2 \geq 0$
domain $= [2, \infty)$

40. $f(x) = \sqrt{2x + 3} \Rightarrow 2x + 3 \geq 0$
domain $= \left[-\frac{3}{2}, \infty\right)$

41. $f(x) = \sqrt{4 - x} \Rightarrow 4 - x \geq 0$
domain $= (-\infty, 4]$

42. $f(x) = 3\sqrt{2 - x} \Rightarrow 2 - x \geq 0$
domain $= (-\infty, 2]$

43. $f(x) = \sqrt{x^2 - 1} \Rightarrow x^2 - 1 \geq 0$
domain $= (-\infty, -1] \cup [1, \infty)$

44. $f(x) = \sqrt{x^2 - 2x - 3} \Rightarrow x^2 - 2x - 3 \geq 0$
domain $= (-\infty, -1] \cup [3, \infty)$

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45. $f(x) = \sqrt[3]{x+1} \Rightarrow \text{domain} = (-\infty, \infty)$

46. $f(x) = \sqrt[3]{5-x} \Rightarrow \text{domain} = (-\infty, \infty)$

47. $f(x) = \dfrac{3}{x+1} \Rightarrow x \neq -1$
$\text{domain} = (-\infty, -1) \cup (-1, \infty)$

48. $f(x) = \dfrac{-7}{x+3} \Rightarrow x \neq -3$
$\text{domain} = (-\infty, -3) \cup (-3, \infty)$

49. $f(x) = \dfrac{x}{x-3} \Rightarrow x \neq 3$
$\text{domain} = (-\infty, 3) \cup (3, \infty)$

50. $f(x) = \dfrac{x+2}{x-1} \Rightarrow x \neq 1$
$\text{domain} = (-\infty, 1) \cup (1, \infty)$

51. $f(x) = \dfrac{x}{x^2-4} = \dfrac{x}{(x+2)(x-2)}$
$x \neq -2, x \neq 2$
$\text{domain} = (-\infty, -2) \cup (-2, 2) \cup (2, \infty)$

52. $f(x) = \dfrac{2x}{x^2-9} = \dfrac{2x}{(x+3)(x-3)}$
$x \neq -3, x \neq 3$
$\text{domain} = (-\infty, -3) \cup (-3, 3) \cup (3, \infty)$

53. $f(x) = \dfrac{1}{x^2-4x-5} = \dfrac{1}{(x+1)(x-5)}$
$x \neq -1, x \neq 5$
$\text{domain} = (-\infty, -1) \cup (-1, 5) \cup (5, \infty)$

54. $f(x) = \dfrac{x}{2x^2-16x+30} = \dfrac{x}{2(x-3)(x-5)}$
$x \neq 3, x \neq 5$
$\text{domain} = (-\infty, 3) \cup (3, 5) \cup (5, \infty)$

55. $f(x) = |x| + 3 \Rightarrow \text{domain} = (-\infty, \infty)$

56. $f(x) = 2|x-1| \Rightarrow \text{domain} = (-\infty, \infty)$

57. $f(x) = 3x - 2$

$f(2) = 3(2) - 2$ $= 6 - 2$ $= 4$	$f(-3) = 3(-3) - 2$ $= -9 - 2$ $= -11$	$f(k) = 3k - 2$	$f(k^2-1) = 3(k^2-1) - 2$ $= 3k^2 - 3 - 2$ $= 3k^2 - 5$

58. $f(x) = 5x + 7$

$f(2) = 5(2) + 7$ $= 10 + 7$ $= 17$	$f(-3) = 5(-3) + 7$ $= -15 + 7$ $= -8$	$f(k) = 5k + 7$	$f(k^2-1) = 5(k^2-1) + 7$ $= 5k^2 - 5 + 7$ $= 5k^2 + 2$

59. $f(x) = \frac{1}{2}x + 3$

$f(2) = \frac{1}{2}(2) + 3$ $= 1 + 3$ $= 4$	$f(-3) = \frac{1}{2}(-3) + 3$ $= -\frac{3}{2} + 3$ $= \frac{3}{2}$	$f(k) = \frac{1}{2}k + 3$	$f(k^2-1) = \frac{1}{2}(k^2-1) + 3$ $= \frac{1}{2}k^2 - \frac{1}{2} + 3$ $= \frac{1}{2}k^2 + \frac{5}{2}$

60. $f(x) = \frac{2}{3}x + 5$

$f(2) = \frac{2}{3}(2) + 5$ $= \frac{4}{3} + 5$ $= \frac{19}{3}$	$f(-3) = \frac{2}{3}(-3) + 5$ $= -2 + 5$ $= 3$	$f(k) = \frac{2}{3}k + 5$	$f(k^2-1) = \frac{2}{3}(k^2-1) + 5$ $= \frac{2}{3}k^2 - \frac{2}{3} + 5$ $= \frac{2}{3}k^2 + \frac{13}{3}$

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61. $f(x) = x^2$

$f(2) = 2^2$ $= 4$	$f(-3) = (-3)^2$ $= 9$	$f(k) = k^2$	$f(k^2-1) = (k^2-1)^2$ $= (k^2-1)(k^2-1)$ $= k^4 - 2k^2 + 1$

62. $f(x) = 3 - x^2$

$f(2) = 3 - 2^2$ $= 3 - 4$ $= -1$	$f(-3) = 3 - (-3)^2$ $= 3 - 9$ $= -6$	$f(k) = 3 - k^2$	$f(k^2-1) = 3 - (k^2-1)^2$ $= 3 - (k^2-1)(k^2-1)$ $= 3 - (k^4 - 2k^2 + 1)$ $= -k^4 + 2k^2 + 2$

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

$f(2) = 2^2 + 3(2) - 1$ $= 4 + 6 - 1$ $= 9$	$f(-3) = (-3)^2 + 3(-3) - 1$ $= 9 - 9 - 1$ $= -1$	$f(k) = k^2 + 3k - 1$

$$\begin{aligned} f(k^2-1) &= (k^2-1)^2 + 3(k^2-1) - 1 \\ &= k^4 - 2k^2 + 1 + 3k^2 - 3 - 1 \\ &= k^4 + k^2 - 3 \end{aligned}$$

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

$f(2) = -(2)^2 - 2(2) + 1$ $= -4 - 4 + 1$ $= -7$	$f(-3) = -(-3)^2 - 2(-3) + 1$ $= -9 + 6 + 1$ $= -2$	$f(k) = -k^2 - 2k + 1$

$$\begin{aligned} f(k^2-1) &= -(k^2-1)^2 - 2(k^2-1) + 1 \\ &= -(k^4 - 2k^2 + 1) - 2k^2 + 2 + 1 \\ &= -k^4 + 2k^2 - 1 - 2k^2 + 3 \\ &= -k^4 + 2 \end{aligned}$$

65. $f(x) = x^3 - 2$

$f(2) = 2^3 - 2$ $= 8 - 2$ $= 6$	$f(-3) = (-3)^3 - 2$ $= -27 - 2$ $= -29$	$f(k) = k^3 - 2$	$f(k^2-1) = (k^2-1)^3 - 2$ $= (k^2-1)(k^2-1)(k^2-1) - 2$ $= k^6 - 3k^4 + 3k^2 - 1 - 2$ $= k^6 - 3k^4 + 3k^2 - 3$

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66. $f(x) = -x^3$

$f(2) = -(2^3)$ $= -8$	$f(-3) = -(-3)^3$ $= -(-27)$ $= 27$	$f(k) = -(k)^3$ $= -k^3$	$f(k^2-1) = -(k^2-1)^3$ $= -(k^2-1)(k^2-1)(k^2-1)$ $= -(k^6 - 3k^4 + 3k^2 - 1)$ $= -k^6 + 3k^4 - 3k^2 + 1$

67. $f(x) = |x^2 + 1|$

$f(2) = \|2^2 + 1\|$ $= \|5\|$ $= 5$	$f(-3) = \|(-3)^2 + 1\|$ $= \|10\|$ $= 10$	$f(k) = \|k^2 + 1\|$ $= k^2 + 1$ $[k^2 + 1 \geq 0]$	$f(k^2-1) = \left\|(k^2-1)^2 + 1\right\|$ $= (k^2-1)^2 + 1$ $= k^4 - 2k^2 + 1 + 1$ $= k^4 - 2k^2 + 2$ $\left[(k^2-1)^2 + 1 \geq 0\right]$

68. $f(x) = |x^2 + x + 4|$

$f(2) = \|2^2 + 2 + 4\|$ $= \|4 + 2 + 4\|$ $= \|10\|$ $= 10$	$f(-3) = \|(-3)^2 + (-3) + 4\|$ $= \|9 - 3 + 4\|$ $= \|10\|$ $= 10$	$f(k) = \|k^2 + k + 4\|$ $= k^2 + k + 4$ $[k^2 + k + 4 \geq 0]$

$$
\begin{aligned}
f(k^2-1) &= \left|(k^2-1)^2 + (k^2-1) + 4\right| \\
&= \left|(k^2-1)^2 + k^2 + 3\right| \\
&= (k^2-1)^2 + k^2 + 3 \\
&= k^4 - 2k^2 + 1 + k^2 + 3 \\
&= k^4 - k^2 + 4 \\
&\left[(k^2-1)^2 + k^2 + 3 \geq 0\right]
\end{aligned}
$$

69. $f(x) = \dfrac{2}{x+4}$

$f(2) = \dfrac{2}{2+4}$ $= \dfrac{2}{6} = \dfrac{1}{3}$	$f(-3) = \dfrac{2}{-3+4}$ $= \dfrac{2}{1} = 2$	$f(k) = \dfrac{2}{k+4}$	$f(k^2-1) = \dfrac{2}{k^2-1+4}$ $= \dfrac{2}{k^2+3}$

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70. $f(x) = \dfrac{3}{x-5}$

$f(2) = \dfrac{3}{2-5}$ $= \dfrac{3}{-3} = -1$	$f(-3) = \dfrac{3}{-3-5}$ $= \dfrac{3}{-8} = -\dfrac{3}{8}$	$f(k) = \dfrac{3}{k-5}$	$f\left(k^2-1\right) = \dfrac{3}{k^2-1-5}$ $= \dfrac{3}{k^2-6}$

71. $f(x) = \dfrac{1}{x^2-1}$

$f(2) = \dfrac{1}{2^2-1}$ $= \dfrac{1}{4-1}$ $= \dfrac{1}{3}$	$f(-3) = \dfrac{1}{(-3)^2-1}$ $= \dfrac{1}{9-1}$ $= \dfrac{1}{8}$	$f(k) = \dfrac{1}{k^2-1}$	$f\left(k^2-1\right) = \dfrac{1}{\left(k^2-1\right)^2-1}$ $= \dfrac{1}{k^4-2k^2+1-1}$ $= \dfrac{1}{k^4-2k^2}$

72. $f(x) = \dfrac{3}{x^2+3}$

$f(2) = \dfrac{3}{2^2+3}$ $= \dfrac{3}{4+3}$ $= \dfrac{3}{7}$	$f(-3) = \dfrac{3}{(-3)^2+3}$ $= \dfrac{3}{9+3}$ $= \dfrac{3}{12} = \dfrac{1}{4}$	$f(k) = \dfrac{3}{k^2+3}$	$f\left(k^2-1\right) = \dfrac{3}{\left(k^2-1\right)^2+3}$ $= \dfrac{3}{k^4-2k^2+1+3}$ $= \dfrac{3}{k^4-2k^2+4}$

73. $f(x) = \sqrt{x^2+1}$

$f(2) = \sqrt{2^2+1}$ $= \sqrt{4+1}$ $= \sqrt{5}$	$f(-3) = \sqrt{(-3)^2+1}$ $= \sqrt{9+1}$ $= \sqrt{10}$	$f(k) = \sqrt{k^2+1}$	$f\left(k^2-1\right) = \sqrt{\left(k^2-1\right)^2+1}$ $= \sqrt{k^4-2k^2+1+1}$ $= \sqrt{k^4-2k^2+2}$

74. $f(x) = \sqrt{x^2-1}$

$f(2) = \sqrt{2^2-1}$ $= \sqrt{4-1}$ $= \sqrt{3}$	$f(-3) = \sqrt{(-3)^2-1}$ $= \sqrt{9-1}$ $= \sqrt{8} = 2\sqrt{2}$	$f(k) = \sqrt{k^2-1}$	$f\left(k^2-1\right) = \sqrt{\left(k^2-1\right)^2-1}$ $= \sqrt{k^4-2k^2+1-1}$ $= \sqrt{k^4-2k^2}$ $= \sqrt{k^2(k^2-2)}$ $= \lvert k\rvert\sqrt{k^2-2}$

75. $f(x) = \sqrt[3]{x} - 1$

$f(2) = \sqrt[3]{2} - 1$	$f(-3) = \sqrt[3]{-3} - 1$ $= -\sqrt[3]{3} - 1$	$f(k) = \sqrt[3]{k} - 1$	$f\left(k^2-1\right) = \sqrt[3]{k^2-1} - 1$

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76. $f(x) = \sqrt[3]{x+1}$

$f(2) = \sqrt[3]{2+1}$ $= \sqrt[3]{3}$	$f(-3) = \sqrt[3]{-3+1}$ $= \sqrt[3]{-2}$ $= -\sqrt[3]{2}$	$f(k) = \sqrt[3]{k+1}$	$f(k^2-1) = \sqrt[3]{k^2-1+1}$ $= \sqrt[3]{k^2}$

77. $$\frac{f(x+h)-f(x)}{h} = \frac{[3(x+h)+1]-[3x+1]}{h} = \frac{[3x+3h+1]-[3x+1]}{h}$$
$$= \frac{3x+3h+1-3x-1}{h} = \frac{3h}{h} = 3$$

78. $$\frac{f(x+h)-f(x)}{h} = \frac{[5(x+h)-1]-[5x-1]}{h} = \frac{[5x+5h-1]-[5x-1]}{h}$$
$$= \frac{5x+5h-1-5x+1}{h} = \frac{5h}{h} = 5$$

79. $$\frac{f(x+h)-f(x)}{h} = \frac{[-7(x+h)+8]-[-7x+8]}{h} = \frac{[-7x-7h+8]-[-7x+8]}{h}$$
$$= \frac{-7x-7h+8+7x-8}{h} = \frac{-7h}{h} = -7$$

80. $$\frac{f(x+h)-f(x)}{h} = \frac{[-8(x+h)-1]-[-8x-1]}{h} = \frac{[-8x-8h-1]-[-8x-1]}{h}$$
$$= \frac{-8x-8h-1+8x+1}{h} = \frac{-8h}{h} = -8$$

81. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2+1\right]-[x^2+1]}{h} = \frac{[x^2+2xh+h^2+1]-[x^2+1]}{h}$$
$$= \frac{x^2+2xh+h^2+1-x^2-1}{h}$$
$$= \frac{2xh+h^2}{h} = \frac{h(2x+h)}{h} = 2x+h$$

82. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2-3\right]-[x^2-3]}{h} = \frac{[x^2+2xh+h^2-3]-[x^2-3]}{h}$$
$$= \frac{x^2+2xh+h^2-3-x^2+3}{h}$$
$$= \frac{2xh+h^2}{h} = \frac{h(2x+h)}{h} = 2x+h$$

83. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[4(x+h)^2-6\right]-[4x^2-6]}{h} = \frac{[4x^2+8xh+4h^2-6]-[4x^2-6]}{h}$$
$$= \frac{4x^2+8xh+4h^2-6-4x^2+6}{h}$$
$$= \frac{8xh+4h^2}{h} = \frac{h(8x+4h)}{h} = 8x+4h$$

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84. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[5(x+h)^2+3\right]-\left[5x^2+3\right]}{h} = \frac{\left[5x^2+10xh+5h^2+3\right]-\left[5x^2+3\right]}{h}$$
$$= \frac{5x^2+10xh+5h^2+3-5x^2-3}{h}$$
$$= \frac{10xh+5h^2}{h} = \frac{h(10x+5h)}{h} = 10x+5h$$

85. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2+3(x+h)-7\right]-\left[x^2+3x-7\right]}{h}$$
$$= \frac{[x^2+2xh+h^2+3x+3h-7]-[x^2+3x-7]}{h}$$
$$= \frac{x^2+2xh+h^2+3x+3h-7-x^2-3x+7}{h}$$
$$= \frac{2xh+h^2+3h}{h} = \frac{h(2x+h+3)}{h} = 2x+h+3$$

86. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2-5(x+h)+1\right]-\left[x^2-5x+1\right]}{h}$$
$$= \frac{[x^2+2xh+h^2-5x-5h+1]-[x^2-5x+1]}{h}$$
$$= \frac{x^2+2xh+h^2-5x-5h+1-x^2+5x-1}{h}$$
$$= \frac{2xh+h^2-5h}{h} = \frac{h(2x+h-5)}{h} = 2x+h-5$$

87. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[2(x+h)^2-4(x+h)+2\right]-\left[2x^2-4x+2\right]}{h}$$
$$= \frac{[2x^2+4xh+2h^2-4x-4h+2]-[2x^2-4x+2]}{h}$$
$$= \frac{2x^2+4xh+2h^2-4x-4h+2-2x^2+4x-2}{h}$$
$$= \frac{4xh+2h^2-4h}{h} = \frac{h(4x+2h-4)}{h} = 4x+2h-4$$

88. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[3(x+h)^2+2(x+h)-3\right]-\left[3x^2+2x-3\right]}{h}$$
$$= \frac{[3x^2+6xh+3h^2+2x+2h-3]-[3x^2+2x-3]}{h}$$
$$= \frac{3x^2+6xh+3h^2+2x+2h-3-3x^2-2x+3}{h}$$
$$= \frac{6xh+3h^2+2h}{h} = \frac{h(6x+3h+2)}{h} = 6x+3h+2$$

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89. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[-(x+h)^2+(x+h)-3\right]-\left[-x^2+x-3\right]}{h}$$
$$= \frac{\left[-x^2-2xh-h^2+x+h-3\right]-\left[-x^2+x-3\right]}{h}$$
$$= \frac{-x^2-2xh-h^2+x+h-3+x^2-x+3}{h}$$
$$= \frac{-2xh-h^2+h}{h} = \frac{h(-2x-h+1)}{h} = -2x-h+1$$

90. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[-3(x+h)^2+5(x+h)-1\right]-\left[-3x^2+5x-1\right]}{h}$$
$$= \frac{\left[-3x^2-6xh-3h^2+5x+5h-1\right]-\left[-3x^2+5x-1\right]}{h}$$
$$= \frac{-3x^2-6xh-3h^2+5x+5h-1+3x^2-5x+1}{h}$$
$$= \frac{-6xh-3h^2+5h}{h} = \frac{h(-6x-3h+5)}{h} = -6x-3h+5$$

91. $$\frac{f(x+h)-f(x)}{h} = \frac{(x+h)^3-x^3}{h} = \frac{\left[x^3+3x^2h+3xh^2+h^3\right]-\left[x^3\right]}{h}$$
$$= \frac{3x^2h+3xh^2+h^3}{h}$$
$$= \frac{h(3x^2+3xh+h^2)}{h} = 3x^2+3xh+h^2$$

92. $$\frac{f(x+h)-f(x)}{h} = \frac{-(x+h)^3-(-x^3)}{h} = \frac{\left[-x^3-3x^2h-3xh^2-h^3\right]+x^3}{h}$$
$$= \frac{-3x^2h-3xh^2-h^3}{h}$$
$$= \frac{h(-3x^2-3xh-h^2)}{h} = -3x^2-3xh-h^2$$

93. $$\frac{f(x+h)-f(x)}{h} = \frac{\frac{1}{x+h}-\frac{1}{x}}{h} = \frac{\left(\frac{1}{x+h}-\frac{1}{x}\right)\cdot x(x+h)}{h\cdot x(x+h)}$$
$$= \frac{x-(x+h)}{xh(x+h)} = \frac{-h}{xh(x+h)} = -\frac{1}{x(x+h)}$$

94. $$\frac{f(x+h)-f(x)}{h} = \frac{\sqrt{x+h}-\sqrt{x}}{h}$$

95. $f(x) = -0.6x + 132$
$f(25) = -0.6(25) + 132 = 117$

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

$F(0) = \frac{9}{5}(0) + 32 = 32$

$F(-40) = \frac{9}{5}(-40) + 32 = -40$

$F(10) = \frac{9}{5}(10) + 32 = 50$

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97. $s(t) = -16t^2 + 10t + 300$
$s(3) = -16(3)^2 + 10(3) + 300 = 186$ ft

98. $v(t) = -32t + 15$
$v(t) = 0$
$-32t + 15 = 0$
$t = \frac{15}{32}$ seconds

99. $g(d) = 300d$
$g(365) = 300(365) = 109{,}500$ gallons

100. $V(r) = \frac{4}{3}\pi r^3$
$V(29.5) = \frac{4}{3}\pi\left(\frac{29.5}{2}\right)^3 \approx 13{,}442$ cm^3

101. Let $x =$ the length. Then $x + 5 =$ the width.
$A(x) = x(x + 5) = x^2 + 5x$

102. $V(x) = x(3x)(4) = 12x^2$

103. **a.** $C(x) = 8x + 75$
b. $C(85) = 8(85) + 75 = \$755$

104. $C(x) = 45x + 60$

105. **a.** $C(x) = 0.07x + 9.99$
b. $C(20) = 0.07(20) + 9.99 = \$11.39$

106. **a.** $I(x) = 2.5x - 40$
b. $I(175) = 2.5(175) - 40 = \$397.50$

107-110. Answers may vary.

111. They are different. 10 is in the domain of $f(x)$, but not in the domain of $g(x)$.

112-113. Answers may vary.

114. They are different. The domain of $f(x)$ is the set of all real numbers, but 3 is not in the domain of $g(x)$.

115. $\dfrac{f(x+h) - f(x)}{h} = \dfrac{5-5}{h} = \dfrac{0}{h} = 0.$

116. e **117.** d **118.** b **119.** e

120. f **121.** c **122.** e **123.** a

Exercises 2.2 (page 216)

1. quadrants **2.** origin **3.** to the right **4.** upward

5. first **6.** second **7.** linear **8.** y-axis

9. x-intercept **10.** vertical **11.** horizontal

12. $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ **13.** midpoint **14.** $M\left(\dfrac{x_1 + x_2}{2}, \dfrac{y_1 + y_2}{2}\right)$

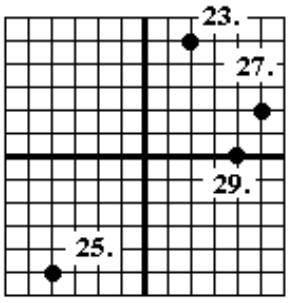
15. $A(2, 3)$ **16.** $B(-3, 5)$ **17.** $C(-2, -3)$ **18.** $D(4, -5)$

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EXERCISES 2.2

19. $E(0, 0)$ **20.** $F(-4, 0)$ **21.** $G(-5, -5)$ **22.** $H(2, -2)$

23, 25, 27, 29.



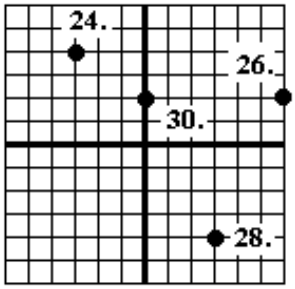
23. QI

25. QIII

27. QI

29. $+x$-axis

24, 26, 28, 30.



24. QII

26. QI

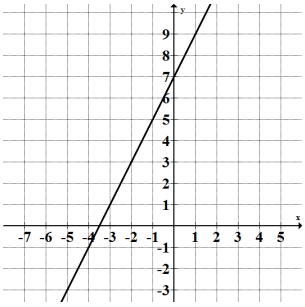
28. QIV

30. $+y$-axis

31. $y - 2x = 7$

$y = 2x + 7$

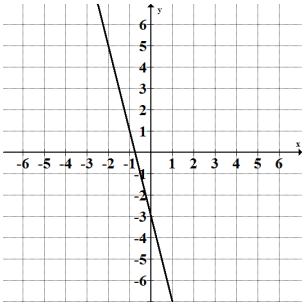
x	y
0	7
-2	3



32. $y + 3 = -4x$

$y = -4x - 3$

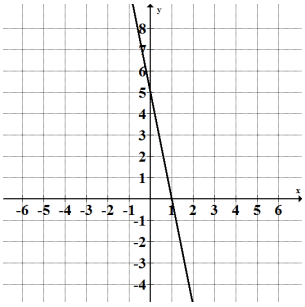
x	y
0	-3
-1	1



33. $y + 5x = 5$

$y = -5x + 5$

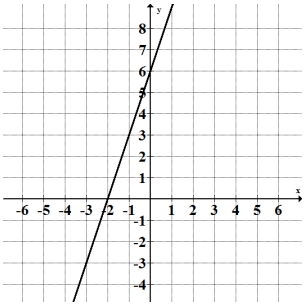
x	y
0	5
1	0



34 . $y - 3x = 6$

$y = 3x + 6$

x	y
0	6
-2	0



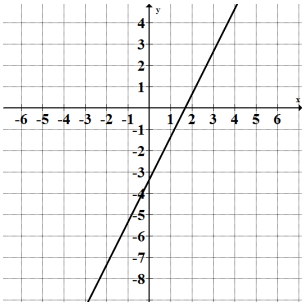
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35. $6x - 3y = 10$

$-3y = -6x + 10$

$y = 2x - \frac{10}{3}$

x	y
0	$-\frac{10}{3}$
2	$\frac{2}{3}$

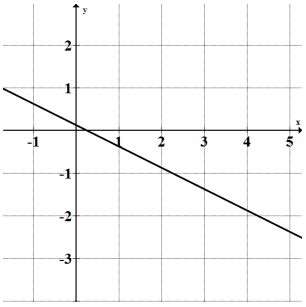


36. $4x + 8y - 1 = 0$

$8y = -4x + 1$

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

x	y
0	$\frac{1}{8}$
4	$-\frac{15}{8}$

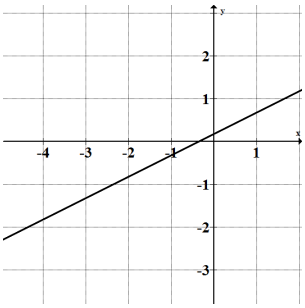


37. $3x = 6y - 1$

$-6y = -3x - 1$

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

x	y
0	$\frac{1}{6}$
-2	$-\frac{5}{6}$

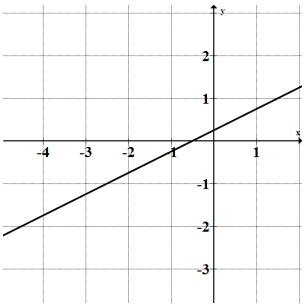


38. $2x + 1 = 4y$

$-4y = -2x - 1$

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

x	y
0	$\frac{1}{4}$
-2	$-\frac{3}{4}$



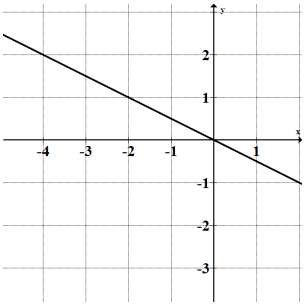
39. $2(x + y + 1) = x + 2$

$2x + 2y + 2 = x + 2$

$2y = -x$

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

x	y
0	0
-2	1



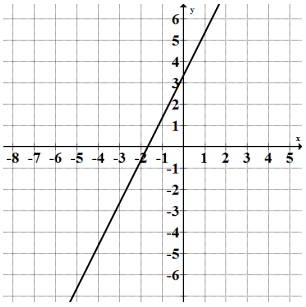
40. $5(x + 2) = 3y - x$

$5x + 10 = 3y - x$

$-3y = -6x - 10$

$y = 2x + \frac{10}{3}$

x	y
0	$\frac{10}{3}$
-2	$-\frac{2}{3}$



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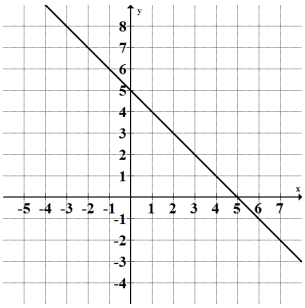
EXERCISES 2.2

41. $x + y = 5$ $\quad x + y = 5$

$x + 0 = 5 \quad 0 + y = 5$

$x = 5 \quad y = 5$

$(5, 0) \quad (0, 5)$



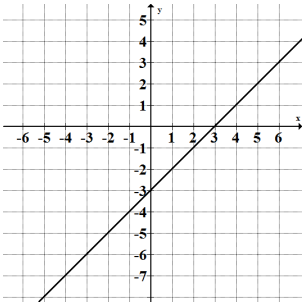
42. $x - y = 3 \quad x - y = 3$

$x - 0 = 3 \quad 0 - y = 3$

$x = 3 \quad -y = 3$

$(3, 0) \quad y = -3$

$(0, -3)$



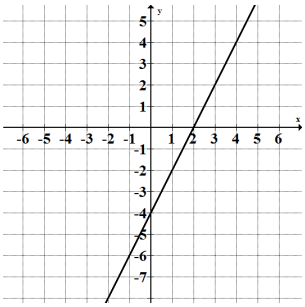
43. $2x - y = 4 \quad 2x - y = 4$

$2x - 0 = 4 \quad 2(0) - y = 4$

$2x = 4 \quad -y = 4$

$x = 2 \quad y = -4$

$(2, 0) \quad (0, -4)$



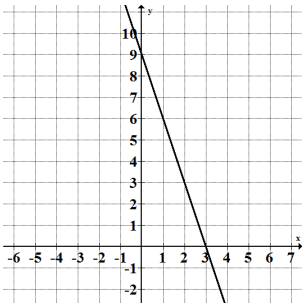
44. $3x + y = 9 \quad 3x + y = 9$

$3x + 0 = 9 \quad 3(0) + y = 9$

$3x = 9 \quad y = 9$

$x = 3 \quad (0, 9)$

$(3, 0)$



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45.

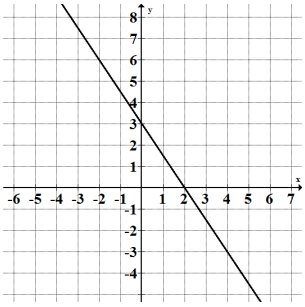
$3x + 2y = 6$ $\quad$ $3x + 2y = 6$

$3x + 2(0) = 6$ $\quad$ $3(0) + 2y = 6$

$3x = 6$ $\quad$ $2y = 6$

$x = 2$ $\quad$ $y = 3$

$(2, 0)$ $\quad$ $(0, 3)$



46.

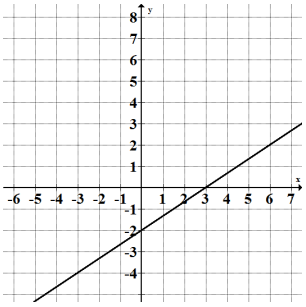
$2x - 3y = 6$ $\quad$ $2x - 3y = 6$

$2x - 3(0) = 6$ $\quad$ $2(0) - 3y = 6$

$2x = 6$ $\quad$ $-3y = 6$

$x = 3$ $\quad$ $y = -2$

$(3, 0)$ $\quad$ $(0, -2)$



47.

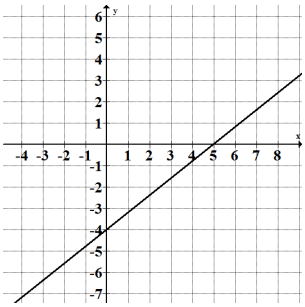
$4x - 5y = 20$ $\quad$ $4x - 5y = 20$

$4x - 5(0) = 20$ $\quad$ $4(0) - 5y = 20$

$4x = 20$ $\quad$ $-5y = 20$

$x = 5$ $\quad$ $y = -4$

$(5, 0)$ $\quad$ $(0, -4)$



48.

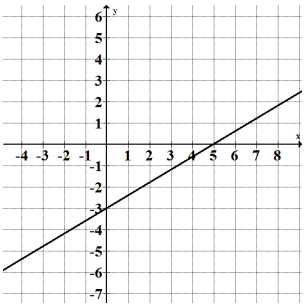
$3x - 5y = 15$ $\quad$ $3x - 5y = 15$

$3x - 5(0) = 15$ $\quad$ $3(0) - 5y = 15$

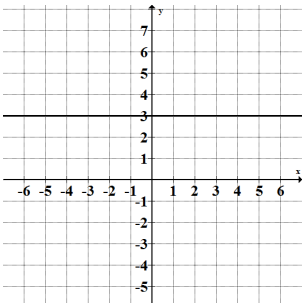
$3x = 15$ $\quad$ $-5y = 15$

$x = 5$ $\quad$ $y = -3$

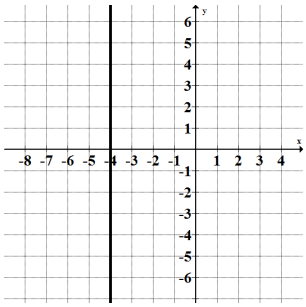
$(5, 0)$ $\quad$ $(0, -3)$



49. $y = 3$

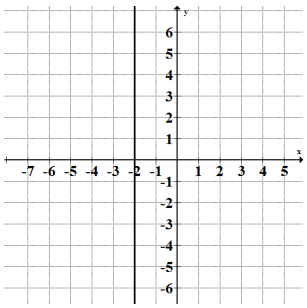


50. $x = -4$



51. $3x + 5 = -1$

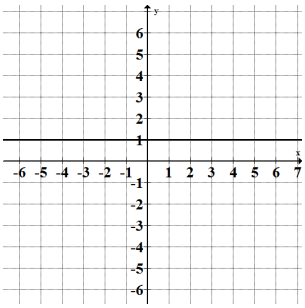
$3x = -6 \Rightarrow x = -2$



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52. $7y - 1 = 6$

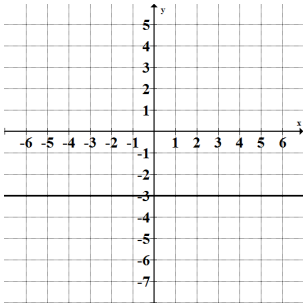
$7y = 7 \Rightarrow y = 1$



53. $3(y + 2) = y$

$3y + 6 = y$

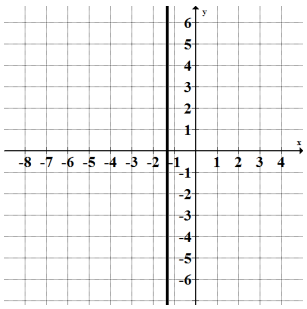
$2y = -6 \Rightarrow y = -3$



54. $4 + 3y = 3(x + y)$

$4 + 3y = 3x + 3y$

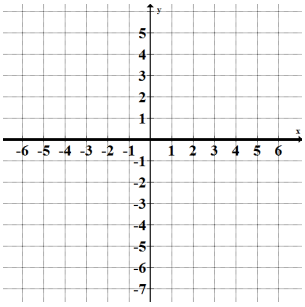
$4 = 3x \Rightarrow x = \frac{4}{3}$



55. $3(y + 2x) = 6x + y$

$3y + 6x = 6x + y$

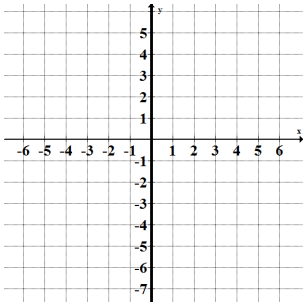
$2y = 0 \Rightarrow y = 0$



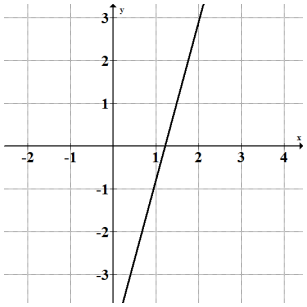
56. $5(y - x) = x + 5y$

$5y - 5x = x + 5y$

$0 = 6x \Rightarrow x = 0$

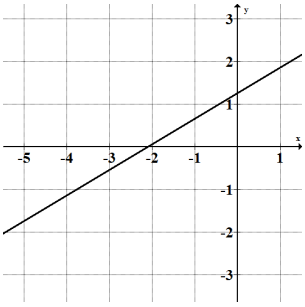


57. $y = 3.7x - 4.5$



x-int: $x = 1.22$

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

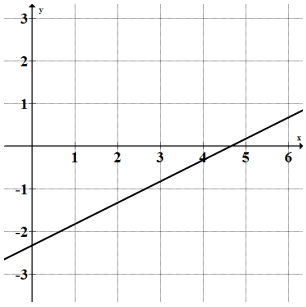


x-int: $x = -2.08$

59. $1.5x - 3y = 7$

$-3y = -1.5x + 7$

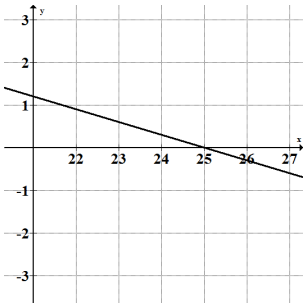
$y = 0.5x - \frac{7}{3}$



x-int: $x = 4.67$

60. $0.3x + y = 7.5$

$y = -0.3x + 7.5$



x-int: $x = 25.00$

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61. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(4-0)^2+(-3-0)^2} \\ &= \sqrt{4^2+(-3)^2} \\ &= \sqrt{16+9} = \sqrt{25} = 5 \end{aligned}$$

62. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(-5-0)^2+(12-0)^2} \\ &= \sqrt{(-5)^2+(12)^2} \\ &= \sqrt{25+144} = \sqrt{169} = 13 \end{aligned}$$

63. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(-3-0)^2+(2-0)^2} \\ &= \sqrt{(-3)^2+(2)^2} \\ &= \sqrt{9+4} = \sqrt{13} \end{aligned}$$

64. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(5-0)^2+(0-0)^2} \\ &= \sqrt{(5)^2+(0)^2} \\ &= \sqrt{25+0} = \sqrt{25} = 5 \end{aligned}$$

65. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(1-0)^2+(1-0)^2} \\ &= \sqrt{(1)^2+(1)^2} \\ &= \sqrt{1+1} = \sqrt{2} \end{aligned}$$

66. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(6-0)^2+(-8-0)^2} \\ &= \sqrt{(6)^2+(-8)^2} \\ &= \sqrt{36+64} = \sqrt{100} = 10 \end{aligned}$$

67. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{\left(\sqrt{3}-0\right)^2+(1-0)^2} \\ &= \sqrt{\left(\sqrt{3}\right)^2+(1)^2} \\ &= \sqrt{3+1} = \sqrt{4} = 2 \end{aligned}$$

68. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{\left(\sqrt{7}-0\right)^2+\left(\sqrt{2}-0\right)^2} \\ &= \sqrt{\left(\sqrt{7}\right)^2+\left(\sqrt{2}\right)^2} \\ &= \sqrt{7+2} = \sqrt{9} = 3 \end{aligned}$$

69. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(3-6)^2+(7-3)^2} \\ &= \sqrt{(-3)^2+(4)^2} \\ &= \sqrt{9+16} = \sqrt{25} = 5 \end{aligned}$$

70. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{(4-9)^2+(9-21)^2} \\ &= \sqrt{(-5)^2+(-12)^2} \\ &= \sqrt{25+144} = \sqrt{169} = 13 \end{aligned}$$

71. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[4-(-1)]^2+[-6-6]^2} \\ &= \sqrt{(5)^2+(-12)^2} \\ &= \sqrt{25+144} = \sqrt{169} = 13 \end{aligned}$$

72. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[0-6]^2+[5-(-3)]^2} \\ &= \sqrt{(-6)^2+(8)^2} \\ &= \sqrt{36+64} = \sqrt{100} = 10 \end{aligned}$$

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73. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[-2-(-6)]^2+[-15-(-21)]^2} \\ &= \sqrt{(4)^2+(6)^2} \\ &= \sqrt{16+36} = \sqrt{52} = 2\sqrt{13} \end{aligned}$$

74. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[-7-(-11)]^2+[11-7]^2} \\ &= \sqrt{(4)^2+(4)^2} \\ &= \sqrt{16+16} = \sqrt{32} = 4\sqrt{2} \end{aligned}$$

75. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[3-(-5)]^2+[-3-5]^2} \\ &= \sqrt{(8)^2+(-8)^2} \\ &= \sqrt{64+64} = \sqrt{128} = 8\sqrt{2} \end{aligned}$$

76. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[6-(-3)]^2+[-3-2]^2} \\ &= \sqrt{(9)^2+(-5)^2} \\ &= \sqrt{81+25} = \sqrt{106} \end{aligned}$$

77. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{[\pi-\pi]^2+[-2-5]^2} \\ &= \sqrt{(0)^2+(-7)^2} \\ &= \sqrt{0+49} = \sqrt{49} = 7 \end{aligned}$$

78. $$\begin{aligned} d &= \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \\ &= \sqrt{\left[\sqrt{5}-0\right]^2+[0-2]^2} \\ &= \sqrt{\left(\sqrt{5}\right)^2+(-2)^2} \\ &= \sqrt{5+4} = \sqrt{9} = 3 \end{aligned}$$

79. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{2+6}{2}, \frac{4+8}{2}\right) = M\left(\frac{8}{2}, \frac{12}{2}\right) = M(4, 6)$

80. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{3+(-1)}{2}, \frac{-6+(-6)}{2}\right) = M\left(\frac{2}{2}, \frac{-12}{2}\right) = M(1, -6)$

81. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{2+(-2)}{2}, \frac{-5+7}{2}\right) = M\left(\frac{0}{2}, \frac{2}{2}\right) = M(0, 1)$

82. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{0+(-10)}{2}, \frac{3+(-13)}{2}\right) = M\left(\frac{-10}{2}, \frac{-10}{2}\right) = M(-5, -5)$

83. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{-8+6}{2}, \frac{5+(-4)}{2}\right) = M\left(\frac{-2}{2}, \frac{1}{2}\right) = M\left(-1, \frac{1}{2}\right)$

84. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{3+2}{2}, \frac{-2+(-3)}{2}\right) = M\left(\frac{5}{2}, \frac{-5}{2}\right) = M\left(\frac{5}{2}, -\frac{5}{2}\right)$

85. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{0+\sqrt{5}}{2}, \frac{0+\sqrt{5}}{2}\right) = M\left(\frac{\sqrt{5}}{2}, \frac{\sqrt{5}}{2}\right)$

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86. $M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = M\left(\frac{\sqrt{3}+0}{2}, \frac{0+\left(-\sqrt{5}\right)}{2}\right) = M\left(\frac{\sqrt{3}}{2}, \frac{-\sqrt{5}}{2}\right) = M\left(\frac{\sqrt{3}}{2}, -\frac{\sqrt{5}}{2}\right)$

87. Let Q have coordinates (x, y):

$M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = (3, 5)$

$\frac{x_1+x_2}{2} = 3 \quad \frac{y_1+y_2}{2} = 5$

$\frac{1+x}{2} = 3 \quad \frac{4+y}{2} = 5$

$1+x = 6 \quad 4+y = 10$

$x = 5 \quad y = 6$

$Q(5, 6)$

88. Let Q have coordinates (x, y):

$M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = (-5, 6)$

$\frac{x_1+x_2}{2} = -5 \quad \frac{y_1+y_2}{2} = 6$

$\frac{2+x}{2} = -5 \quad \frac{-7+y}{2} = 6$

$2+x = -10 \quad -7+y = 12$

$x = -12 \quad y = 19$

$Q(-12, 19)$

89. Let Q have coordinates (x, y):

$M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = (5, 5)$

$\frac{x_1+x_2}{2} = 5 \quad \frac{y_1+y_2}{2} = 5$

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

$5+x = 10 \quad -5+y = 10$

$x = 5 \quad y = 15$

$Q(5, 15)$

90. Let Q have coordinates (x, y):

$M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) = (0, 0)$

$\frac{x_1+x_2}{2} = 0 \quad \frac{y_1+y_2}{2} = 0$

$\frac{-7+x}{2} = 0 \quad \frac{3+y}{2} = 0$

$-7+x = 0 \quad 3+y = 0$

$x = 7 \quad y = -3$

$Q(7, -3)$

91. Let the points be identified as $A(13, -2)$, $B(9, -8)$ and $C(5, -2)$.

$AB = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} = \sqrt{(13-9)^2+(-2-(-8))^2} = \sqrt{16+36} = \sqrt{52} = 2\sqrt{13}$

$BC = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} = \sqrt{(9-5)^2+(-8-(-2))^2} = \sqrt{16+36} = \sqrt{52} = 2\sqrt{13}$

Since AB and BC have the same length, the triangle is isosceles.

92. Let the points be identified as $A(-1, 2)$, $B(3, 1)$ and $C(4, 5)$.

$AB = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} = \sqrt{(-1-3)^2+(2-1)^2} = \sqrt{16+1} = \sqrt{17}$

$BC = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} = \sqrt{(3-4)^2+(1-5)^2} = \sqrt{1+16} = \sqrt{17}$

Since AB and BC have the same length, the triangle is isosceles.

93. $M = \left(\frac{2+6}{2}, \frac{4+10}{2}\right) = \left(\frac{8}{2}, \frac{14}{2}\right) = (4, 7)$; $N = \left(\frac{4+6}{2}, \frac{6+10}{2}\right) = \left(\frac{10}{2}, \frac{16}{2}\right) = (5, 8)$

$MN = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2} = \sqrt{(4-5)^2+(7-8)^2} = \sqrt{1+1} = \sqrt{2}$

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EXERCISES 2.2

94. $M = \left(\frac{0+b}{2}, \frac{0+c}{2}\right) = \left(\frac{b}{2}, \frac{c}{2}\right)$; $N = \left(\frac{a+b}{2}, \frac{0+c}{2}\right) = \left(\frac{a+b}{2}, \frac{c}{2}\right)$

$AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} = \sqrt{(0-a)^2 + (0-0)^2} = \sqrt{a^2} = a$

$MN = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} = \sqrt{\left(\frac{b}{2} - \frac{a+b}{2}\right)^2 + \left(\frac{c}{2} - \frac{c}{2}\right)^2} = \sqrt{\frac{a^2}{4} + 0} = \frac{a}{2} = \frac{1}{2}AB$

95. $M = \left(\frac{0+a}{2}, \frac{b+0}{2}\right) = \left(\frac{a}{2}, \frac{b}{2}\right)$; $L = \left(\frac{a}{2}, 0\right)$; $N = \left(0, \frac{b}{2}\right)$

Area of $AOB = \frac{1}{2} \cdot$ base $\cdot$ height $= \frac{1}{2}(OA)(OB) = \frac{1}{2}(a)(b) = \frac{1}{2}ab$

Area of $OLMN =$ length $\cdot$ width $= (OL)(ON) = \frac{a}{2} \cdot \frac{b}{2} = \frac{1}{4}ab = \frac{1}{2}$(Area of AOB)

96. Let $x =$ the width (from A to D). Then the length (from A to B) $= 2x$.

$$\text{Perimeter} = 42$$
$$x + 2x + x + 2x = 42$$
$$6x = 42$$
$$x = 7$$

Thus, the distance from A to D is 7 and the distance from A to B is $2(7) = 14$. Thus, the x-coordinate of C is $-3 + 14$, or 11. The y-coordinate of C is $-2 + 7$, or 5. Point C then has coordinates $(11, 5)$.

97. $y = 17500x + 325000$

$y = 17500(5) + 325000$

$y = 87500 + 325000$

$y = 412500$

The value will be \$412,500.

98. Set $y = 0$:

$y = -1920x + 24{,}000$

$0 = -1920x + 24{,}000$

$1920x = 24{,}000$

$x = 12.5$

The car will be worthless after 12.5 years.

99. $p = -\frac{1}{10}q + 170$

$150 = -\frac{1}{10}q + 170$

$\frac{1}{10}q = 20$

$q = 200$

200 scanners will be sold.

100. $p = \frac{1}{10}q + 130$

$150 = \frac{1}{10}q + 130$

$20 = \frac{1}{10}q$

$200 = q$

200 TVs will be produced.

101. $V = \frac{nv}{N}$

$60 = \frac{12v}{20}$

$1200 = 12v$

$100 = v$

The smaller gear is spinning at 100 rpm.

102. $f(x) = 430 - 0.005\text{x}$

$350 = 430 - 0.005d$

$0.005d = 80$

$d = 16{,}000$

\$16,000 would reduce the number to 350.

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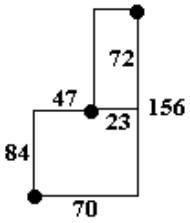
103. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{[0 - 30]^2 + [10 - 25]^2}$
$= \sqrt{(-30)^2 + (-15)^2}$
$= \sqrt{900 + 225} = \sqrt{1125} = 15\sqrt{5}$ yd

104. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{[90 - 0]^2 + [90 - 0]^2}$
$= \sqrt{(90)^2 + (90)^2}$
$= \sqrt{8100 + 8100} = \sqrt{16200} = 90\sqrt{2}$ ft

105. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{30 + 0}{2}, \frac{25 + 10}{2}\right) = M\left(\frac{30}{2}, \frac{35}{2}\right) = M(15, 17.5)$

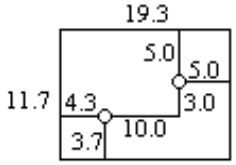
106. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{90 + 0}{2}, \frac{90 + 0}{2}\right) = M\left(\frac{90}{2}, \frac{90}{2}\right) = M(45, 45)$

107.



$d^2 = 70^2 + 156^2$
$d^2 = 4900 + 24{,}336$
$d^2 = 29{,}236$
$d = \sqrt{29{,}236}$
$d \approx 171$ miles

108.



$d^2 = 10^2 + 3^2$
$d^2 = 100 + 9$
$d^2 = 109$
$d = \sqrt{109}$
$d \approx 10.4$ mm

109-112. Answers may vary.

113. True.

114. True.

115. False. Vertical lines have equations that are not functions.

116. False. Only two points are required to graph a line.

117. False. The vertical line $x = 0$ has infinitely many y-intercepts.

118. False. Most horizontal lines have no x-intercept.

119. True.

120. True.

Exercises 2.3 (page 229)

1. divided

2. y

3. run

4. same order

5. the change in

6. horizontal

7. vertical

8. parallel

9. perpendicular

10. -1

11. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{2 - (-1)}{2 - (-1)} = \frac{3}{3} = 1$

12. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - (-1)}{5 - 3} = \frac{4}{2} = 2$

13. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - 3}{6 - (-6)} = \frac{-5}{12} = -\frac{5}{12}$

14. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{10 - 5}{3 - 2} = \frac{5}{1} = 5$

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EXERCISES 2.3

15. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-(-2)}{-1-3} = \dfrac{7}{-4} = -\dfrac{7}{4}$

16. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{16-7}{6-3} = \dfrac{9}{3} = 3$

17. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-7)}{4-8} = \dfrac{8}{-4} = -2$

18. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{17-17}{17-5} = \dfrac{0}{12} = 0$

19. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-14-(-14)}{2-(-7)} = \dfrac{0}{9} = 0$

20. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-3-3}{-4-(-4)} = \dfrac{-6}{0} \Rightarrow$ und.

21. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-2-3}{-5-(-5)} = \dfrac{-5}{0} \Rightarrow$ und.

22. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{2-\sqrt{7}}{\sqrt{7}-2} = -1$

23. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\frac{7}{3}-\frac{2}{3}}{\frac{5}{2}-\frac{3}{2}} = \dfrac{\frac{5}{3}}{\frac{2}{2}} = \dfrac{\frac{5}{3}}{1} = \dfrac{5}{3}$

24. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-\frac{5}{3}-\frac{1}{3}}{\frac{3}{5}-\left(-\frac{2}{5}\right)} = \dfrac{-\frac{6}{3}}{\frac{5}{5}} = -2$

25. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-c}{(b+c)-(a+b)} = \dfrac{a-c}{c-a} = -1$

26. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-0}{(a+b)-b} = \dfrac{a}{a} = 1$

27. $y = 3x + 2$

x	y
0	2
1	5

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-2}{1-0} = \dfrac{3}{1} = 3$

28. $y = 5x - 8$

x	y
0	-8
1	-3

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-3-(-8)}{1-0} = \dfrac{5}{1} = 5$

29. $y = 4x - 6$

x	y
0	-6
1	-2

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-2-(-6)}{1-0} = \dfrac{4}{1} = 4$

30. $y = -\dfrac{1}{3}x + 5$

x	y
0	5
3	4

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-5}{3-0} = \dfrac{-1}{3} = -\dfrac{1}{3}$

31. $5x - 10y = 3$

x	y
0	$-\frac{3}{10}$
1	$\frac{1}{5}$

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\frac{1}{5}-\left(-\frac{3}{10}\right)}{1-0} = \dfrac{\frac{5}{10}}{1} = \dfrac{1}{2}$

32. $8y + 2x = 5$

x	y
0	$\frac{5}{8}$
1	$\frac{3}{8}$

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\frac{3}{8}-\frac{5}{8}}{1-0} = \dfrac{-\frac{2}{8}}{1} = -\dfrac{1}{4}$

33. $3(y+2) = 2x - 3$

$3y - 2x = -9$

x	y
0	-3
3	-1

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-1-(-3)}{3-0} = \dfrac{2}{3}$

34. $4(x-2) = 3y + 2$

$4x - 3y = 10$

x	y
0	$-\frac{10}{3}$
1	-2

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-2-\left(-\frac{10}{3}\right)}{1-0} = \dfrac{\frac{4}{3}}{1} = \dfrac{4}{3}$

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35. $3(y+x) = 3(x-1)$
$3y = -3$
$y = -1$

x	y
0	-1
1	-1

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-1-(-1)}{1-0} = \dfrac{0}{1} = 0$

36. $2x + 5 = 2(y+x)$
$5 = 2y$
$\frac{5}{2} = y$

x	y
0	$\frac{5}{2}$
1	$\frac{5}{2}$

$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{\frac{5}{2} - \frac{5}{2}}{1-0} = \dfrac{0}{1} = 0$

37. horizontal $\Rightarrow m = 0$

38. $2y = 5$
$y = \frac{5}{2}$
horizontal $\Rightarrow m = 0$

39. $f(x) = \dfrac{1}{4} \Rightarrow y = \dfrac{1}{4}$
horizontal $\Rightarrow m = 0$

40. $f(x) = \pi \Rightarrow y = \pi$
horizontal $\Rightarrow m = 0$

41. $x = -\dfrac{1}{2}$
vertical $\Rightarrow m$ is undefined.

42. $x - 7 = 0$
$x = 7$
vertical $\Rightarrow m$ is undefined.

43. The slope is negative.

44. The slope is zero.

45. The slope is positive.

46. The slope is positive.

47. The slope is undefined.

48. The slope is negative.

49. $m_1 m_2 = 3\left(-\frac{1}{3}\right) = -1$
perpendicular

50. $m_1 \neq m_2$; $m_1 m_2 = \frac{2}{3} \cdot \frac{3}{2} = 1 \neq -1$
neither

51. $m_1 = \sqrt{8} = 2\sqrt{2} = m_2$
parallel

52. $m_1 m_2 = 1(-1) = -1$
perpendicular

53. $m_1 m_2 = -\sqrt{2}\left(\frac{\sqrt{2}}{2}\right) = -1$
perpendicular

54. $m_2 = \sqrt{28} = 2\sqrt{7} = m_1$
parallel

55. $m_1 m_2 = -0.125(8) = -1$
perpendicular

56. $m_1 = 0.125 = \dfrac{1}{8} = m_2$
parallel

57. $m_1 m_2 = ab^{-1}\left(-a^{-1}b\right) = -a^0 b^0 = -1$
perpendicular

58. $m_1 = \left(\dfrac{a}{b}\right)^{-1} = \dfrac{b}{a} \neq -\dfrac{b}{a} = m_2$
$m_1 m_2 = \dfrac{b}{a}\left(-\dfrac{b}{a}\right) \neq -1 \Rightarrow$ neither

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EXERCISES 2.3

For Exercises 59-64 use the slope of line through R and S calculated below:

$m_{RS} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7-5}{2-(-3)} = \dfrac{2}{5}$

59. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6-4}{7-2} = \dfrac{2}{5} = m_{RS} \Rightarrow$ parallel

60. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-8}{-13-(-3)} = \dfrac{-4}{-10} = \dfrac{2}{5} = m_{RS} \Rightarrow$ parallel

61. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-6}{-2-(-4)} = \dfrac{-5}{2} = -\dfrac{5}{2} \Rightarrow$ perpendicular

62. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-9)}{4-0} = \dfrac{10}{4} = \dfrac{5}{2} \Rightarrow$ neither

63. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6a-a}{3a-a} = \dfrac{5a}{2a} = \dfrac{5}{2} \Rightarrow$ neither

64. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6b-b}{-b-b} = \dfrac{5b}{-2b} = -\dfrac{5}{2} \Rightarrow$ perpendicular

65. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{9-7}{2-(-3)} = \dfrac{2}{5}$; $m_{RS} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-6-(-4)}{x-10} = \dfrac{-2}{x-10}$

$\dfrac{2}{5} \cdot \dfrac{-1}{-1} = \dfrac{-2}{-5}$; $x - 10 = -5 \Rightarrow \boxed{x = 5}$

66. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7-(-3)}{5-2} = \dfrac{10}{3}$; $m_{RS} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{y-(-1)}{6-3} = \dfrac{y+1}{3}$

$10 = y + 1 \Rightarrow \boxed{y = 9}$

67. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-(-7)}{1-2} = \dfrac{7}{-1} = -7$; $m_{RS} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{y-5}{-2-(-9)} = \dfrac{y-5}{7}$

$-7 = \dfrac{-7}{1}$; Perp. slope $= \dfrac{1}{7}$; $y - 5 = 1 \Rightarrow \boxed{y = 6}$

68. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-(-2)}{3-1} = \dfrac{6}{2} = 3$; $m_{RS} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-6}{6-x} = \dfrac{-1}{6-x}$

$3 = \dfrac{3}{1}$; Perp. slope $= -\dfrac{1}{3} = \dfrac{-1}{3}$; $6 - x = 3 \Rightarrow \boxed{x = 3}$

69. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{9-8}{-6-(-2)} = \dfrac{1}{-4} = -\dfrac{1}{4}$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-8}{2-(-2)} = \dfrac{-3}{4} = -\dfrac{3}{4} \Rightarrow$ not on same line

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70. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-2-(-1)}{3-1} = \dfrac{-1}{2} = -\dfrac{1}{2}$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-(-1)}{-3-1} = \dfrac{1}{-4} = -\dfrac{1}{4} \Rightarrow$ not on same line

71. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-a}{0-(-a)} = \dfrac{-a}{a} = -1$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-a-a}{a-(-a)} = \dfrac{-2a}{2a} = -1 \Rightarrow$ on same line

72. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{b-(a+b)}{(a+b)-a} = \dfrac{-a}{b} = -\dfrac{a}{b}$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-(a+b)}{(a-b)-a} = \dfrac{-b}{-b} = 1 \Rightarrow$ not on same line

73. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-5-4}{2-5} = \dfrac{-9}{-3} = 3$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-3-4}{8-5} = \dfrac{-7}{3} = -\dfrac{7}{3}$

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-3-(-5)}{8-2} = \dfrac{2}{6} = \dfrac{1}{3} \Rightarrow$ None are perpendicular.

74. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6-(-2)}{4-8} = \dfrac{8}{-4} = -2$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7-(-2)}{6-8} = \dfrac{9}{-2} = -\dfrac{9}{2}$

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7-6}{6-4} = \dfrac{1}{2} \Rightarrow PQ$ and QR are perpendicular.

75. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{9-3}{1-1} = \dfrac{6}{0} \Rightarrow$ undefined $\Rightarrow$ vertical

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-3}{7-1} = \dfrac{0}{6} = 0 \Rightarrow$ horizontal

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-9}{7-1} = \dfrac{-6}{6} = -1 \Rightarrow PQ$ and PR are perpendicular.

76. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{2-(-3)}{-3-2} = \dfrac{5}{-5} = -1$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{8-(-3)}{3-2} = \dfrac{11}{1} = 11$

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{8-2}{3-(-3)} = \dfrac{6}{6} = 1 \Rightarrow PQ$ and QR are perpendicular.

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77. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{b-0}{a-0} = \dfrac{b}{a}$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-0}{-b-0} = \dfrac{a}{-b} = -\dfrac{a}{b}$

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-b}{-b-a} = \dfrac{a-b}{-b-a} \Rightarrow PQ$ and PR are perpendicular.

78. $m_{PQ} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{a-b}{-b-a} = \dfrac{a-b}{-(a+b)} = -\dfrac{a-b}{a+b}$

$m_{PR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{(a+b)-b}{(a-b)-a} = \dfrac{a}{-b} = -\dfrac{a}{b}$

$m_{QR} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{(a+b)-a}{(a-b)-(-b)} = \dfrac{b}{a} \Rightarrow PR$ and QR are perpendicular.

79. $m_{AB} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-(-1)}{-3-(-1)} = \dfrac{5}{-2} = -\dfrac{5}{2}$

$m_{AC} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-1)}{4-(-1)} = \dfrac{2}{5} \Rightarrow AB$ and AC are perpendicular. $\Rightarrow$ right triangle

80. $m_{DE} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-1}{-1-0} = \dfrac{2}{-1} = -2$

$m_{EF} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{5-3}{3-(-1)} = \dfrac{2}{4} = \dfrac{1}{2} \Rightarrow DE$ and EF are perpendicular. $\Rightarrow$ right triangle

81. $m_{AB} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-(-1)}{3-1} = \dfrac{1}{2}$; $\mathrm{d}(A, B) = \sqrt{(1-3)^2 + (-1-0)^2} = \sqrt{5}$

$m_{BC} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{2-0}{2-3} = \dfrac{2}{-1} = -2$; $\mathrm{d}(B, C) = \sqrt{(3-2)^2 + (0-2)^2} = \sqrt{5}$

$m_{CD} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-2}{0-2} = \dfrac{-1}{-2} = \dfrac{1}{2}$; $\mathrm{d}(C, D) = \sqrt{(2-0)^2 + (2-1)^2} = \sqrt{5}$

$m_{DA} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-1)}{0-1} = \dfrac{2}{-1} = -2$; $\mathrm{d}(D, A) = \sqrt{(1-0)^2 + (-1-1)^2} = \sqrt{5}$

Adjacent sides are perpendicular and congruent, so the figure is a square.

82. $m_{EF} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-(-1)}{3-(-1)} = \dfrac{1}{4}$; $\mathrm{d}(E, F) = \sqrt{(-1-3)^2 + (-1-0)^2} = \sqrt{17}$

$m_{FG} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-0}{2-3} = \dfrac{4}{-1} = -4$; $\mathrm{d}(F, G) = \sqrt{(3-2)^2 + (0-4)^2} = \sqrt{17}$

$m_{GH} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-4}{-2-2} = \dfrac{-1}{-4} = \dfrac{1}{4}$; $\mathrm{d}(G, H) = \sqrt{(2-(-2))^2 + (4-3)^2} = \sqrt{17}$

$m_{HE} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-(-1)}{-2-(-1)} = \dfrac{4}{-1} = -4$; $\mathrm{d}(H, E) = \sqrt{(-1-(-2))^2 + (-1-3)^2} = \sqrt{17}$

Adjacent sides are perpendicular and congruent, so the figure is a square.

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EXERCISES 2.3

83. $m_{AB} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{3-(-2)}{3-(-2)} = \dfrac{5}{5} = 1$

$m_{BC} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6-3}{2-3} = \dfrac{3}{-1} = -3$

$m_{CD} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-6}{-3-2} = \dfrac{-5}{-5} = 1$

$m_{DA} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-2)}{-3-(-2)} = \dfrac{3}{-1} = -3$

Opposite sides are parallel, so the figure is a parallelogram.

84. $m_{EF} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1-(-2)}{5-1} = \dfrac{3}{4}$

$m_{FG} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-1}{3-5} = \dfrac{3}{-2} = -\dfrac{3}{2}$

$m_{GH} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-4}{-3-3} = \dfrac{0}{-6} = 0$

$m_{HE} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-(-2)}{-3-1} = \dfrac{6}{-4} = -\dfrac{3}{2}$

Exactly one pair of sides is parallel, so the figure is a trapezoid.

85. $M\left(\dfrac{5+7}{2}, \dfrac{9+5}{2}\right) = M\left(\dfrac{12}{2}, \dfrac{14}{2}\right) = M(6, 7);\ N\left(\dfrac{1+7}{2}, \dfrac{3+5}{2}\right) = N\left(\dfrac{8}{2}, \dfrac{8}{2}\right) = N(4, 4)$

$m_{MN} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{4-7}{4-6} = \dfrac{-3}{-2} = \dfrac{3}{2}; m_{AC} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{9-3}{5-1} = \dfrac{6}{4} = \dfrac{3}{2} \Rightarrow MN \parallel AC$

86. $d(AB) = \sqrt{(0-a)^2 + (0-0)^2} = \sqrt{a^2 + 0^2} = \sqrt{a^2} = a$

$d(AC) = \sqrt{(0-b)^2 + (0-c)^2} = \sqrt{b^2 + c^2}$. From the given information, $a = \sqrt{b^2 + c^2}$.

$m_{AD} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{c-0}{(a+b)-0} = \dfrac{c}{a+b};\ \ m_{BC} = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{0-c}{a-b} = \dfrac{-c}{a-b}$

$m_{AD}m_{BC} = \dfrac{c}{a+b} \cdot \dfrac{-c}{a-b} = \dfrac{-c^2}{a^2 - b^2} = \dfrac{-c^2}{\left(\sqrt{b^2 + c^2}\right)^2 - b^2} = \dfrac{-c^2}{b^2 + c^2 - b^2} = \dfrac{-c^2}{c^2} = -1$

Thus, AD is perpendicular to BC.

87. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{42-14}{5-1} = \dfrac{28}{4} = 7$

The rate of growth was 7 students per year.

88. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{110{,}000 - 50{,}000}{3-1}$

$= \dfrac{60{,}000}{2} = 30{,}000$

The sales increased \$30,000 per year.

89. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{6700 - 2200}{10 - 3}$

$= \dfrac{4500}{7} \approx 642.86$

The cost decreased about \$642.86 per year.

90. The cost absorbed by the hospital was \$247 in 2000, \$375 in 2005 and \$505 in 2010.

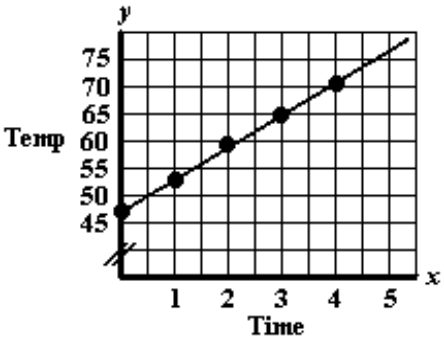
$m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{505 - 247}{2010 - 2000} = \dfrac{258}{10} = 25.8$

The cost absorbed by the hospital increased by \$25.80 per year.

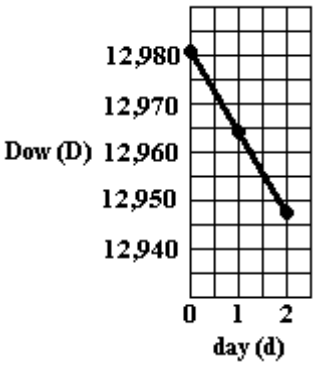
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EXERCISES 2.3

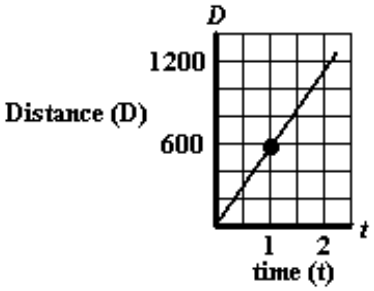
91. $\dfrac{\Delta T}{\Delta t}$ = the hourly rate of change of temperature.
(Let $t = x$ and $T = y$.)



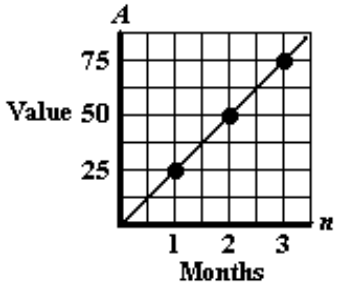
92. $\dfrac{\Delta D}{\Delta d}$ = the daily rate of change of the Dow Jones average.



93. $D = 590t$; The slope is the speed of the plane.



94. $A = 25n$; The slope is the monthly increase of the value of the account.



95-98. Answers may vary.

99. False. $m = \dfrac{y_2 - y_1}{x_2 - x_1}$.

100. True.

101. True. ($\Delta y = 0$.)

102. True. ($\Delta x = 0$.)

103. False. The line will be horizontal, so the slope is 0.

104. False. The line will be vertical, so the slope is undefined.

105. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{10.25 - 6.95}{2014 - 2008} = \dfrac{3.30}{6} = 0.55$. True.

106. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{9139 - 6015}{2014 - 2010} = \dfrac{3124}{4} = 781$. True.

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Exercises 2.4 (page 243)

1. slope-intercept

2. m

3. y-intercept

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

5. $Ax + By = C$

6. regression

7.
$$y = mx + b$$
$$y = 3x - 2$$

8.
$$y = mx + b$$
$$y = -\frac{1}{3}x + \frac{2}{3}$$

9.
$$y = mx + b$$
$$y = 5x - \frac{1}{5}$$

10.
$$y = mx + b$$
$$y = \sqrt{2}x + \sqrt{2}$$

11.
$$y = mx + b$$
$$y = ax + \frac{1}{a}$$

12.
$$y = mx + b$$
$$y = ax + 2a$$

13.
$$y = mx + b$$
$$y = ax + a$$

14.
$$y = mx + b$$
$$y = \frac{1}{a}x + a$$

15.
$$y = mx + b$$
$$0 = \frac{3}{2}(0) + b$$
$$0 = b$$

$$y = mx + b$$
$$y = \frac{3}{2}x + 0$$
$$2y = 3x$$
$$-3x + 2y = 0$$
$$3x - 2y = 0$$

16.
$$y = mx + b$$
$$-7 = -\frac{2}{3}(-3) + b$$
$$-7 = 2 + b$$
$$-9 = b$$

$$y = mx + b$$
$$y = -\frac{2}{3}x - 9$$
$$3y = -2x - 27$$
$$2x + 3y = -27$$

17.
$$y = mx + b$$
$$5 = -3(-3) + b$$
$$5 = 9 + b$$
$$-4 = b$$

$$y = mx + b$$
$$y = -3x - 4$$
$$3x + y = -4$$

18.
$$y = mx + b$$
$$1 = 1(-5) + b$$
$$1 = -5 + b$$
$$6 = b$$

$$y = mx + b$$
$$y = 1x + 6$$
$$-x + y = 6$$
$$x - y = -6$$

19.
$$y = mx + b$$
$$\sqrt{2} = \sqrt{2}(0) + b$$
$$\sqrt{2} = b$$

$$y = mx + b$$
$$y = \sqrt{2}x + \sqrt{2}$$
$$-\sqrt{2}x + y = \sqrt{2}$$
$$\sqrt{2}x - y = -\sqrt{2}$$

20.
$$y = mx + b$$
$$0 = 2\sqrt{3}\left(-\sqrt{3}\right) + b$$
$$0 = -6 + b$$
$$6 = b$$

$$y = mx + b$$
$$y = 2\sqrt{3}x + 6$$
$$-2\sqrt{3}x + y = 6$$
$$2\sqrt{3}x - y = -6$$

21.
$$3x - 2y = 8$$
$$-2y = -3x + 8$$
$$y = \frac{3}{2}x - 4$$
$$m = \frac{3}{2}, (0, -4)$$

22.
$$-2x + 4y = 12$$
$$4y = 2x + 12$$
$$y = \frac{1}{2}x + 3$$
$$m = \frac{1}{2}, (0, 3)$$

23.
$$-2(x + 3y) = 5$$
$$-2x - 6y = 5$$
$$-6y = 2x + 5$$
$$y = -\frac{1}{3}x - \frac{5}{6}$$
$$m = -\frac{1}{3}, \left(0, -\frac{5}{6}\right)$$

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EXERCISES 2.4

24. $5(2x-3y)=4$

$10x-15y=4$

$-15y=-10x+4$

$y=\frac{2}{3}x-\frac{4}{15}$

$m=\frac{2}{3}, \left(0,-\frac{4}{15}\right)$

25. $x=\frac{2y-4}{7}$

$7x=2y-4$

$-2y=-7x-4$

$y=\frac{7}{2}x+2$

$m=\frac{7}{2}, (0,2)$

26. $3x+4=-\frac{2(y-3)}{5}$

$15x+20=-2(y-3)$

$15x+20=-2y+6$

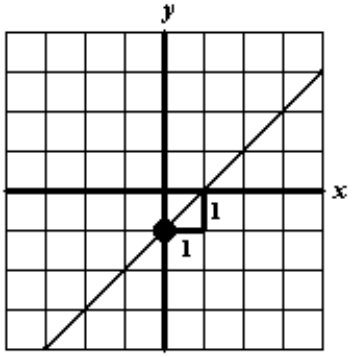
$2y=-15x-14$

$y=-\frac{15}{2}x-7$

$m=-\frac{15}{2}, (0,-7)$

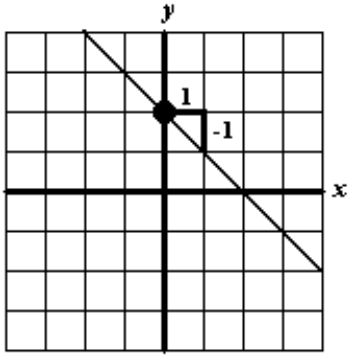
27. $x-y=1$

$y=x-1 \Rightarrow m=1, (0,-1)$



28. $x+y=2$

$y=-x+2 \Rightarrow m=-1, (0,2)$

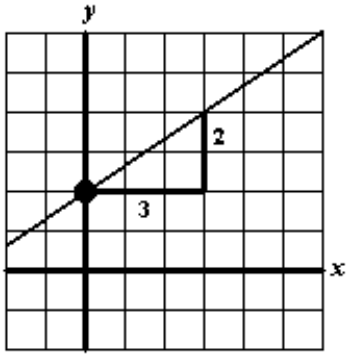


29. $x=\frac{3}{2}y-3$

$2x=3y-6$

$-3y=-2x-6$

$y=\frac{2}{3}x+2 \Rightarrow m=\frac{2}{3}, (0,2)$

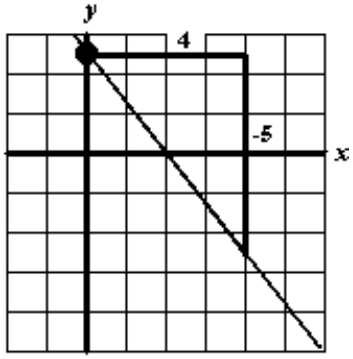


30. $x=-\frac{4}{5}y+2$

$5x=-4y+10$

$4y=-5x+10$

$y=-\frac{5}{4}x+\frac{5}{2} \Rightarrow m=-\frac{5}{4}, \left(0,\frac{5}{2}\right)$



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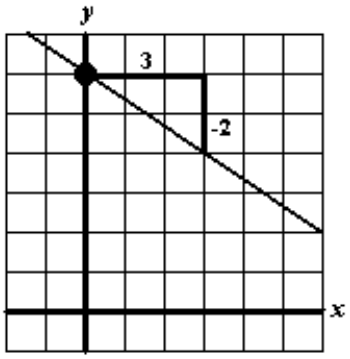
EXERCISES 2.4

31. $3(y-4) = -2(x-3)$

$3y - 12 = -2x + 6$

$3y = -2x + 18$

$y = -\frac{2}{3}x + 6 \Rightarrow m = -\frac{2}{3}, (0, 6)$

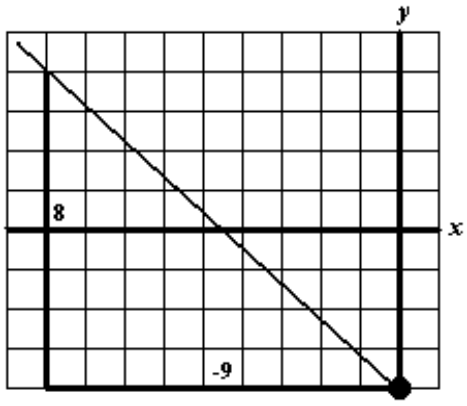


32. $-4(2x+3) = 3(3y+8)$

$-8x - 12 = 9y + 24$

$-9y = 8x + 36$

$y = -\frac{8}{9}x - 4$: $m = -\frac{8}{9}, (0, -4)$



33. $y = 3x + 4$ $\quad$ $y = 3x - 7$

$m = 3$ $\quad$ $m = 3$

The lines are parallel.

34. $y = 4x - 13$ $\quad$ $y = \frac{1}{4}x + 13$

$m = 4$ $\quad$ $m = \frac{1}{4}$

The lines are neither.

35. $x + y = 2$ $\quad$ $y = x + 5$

$y = -x + 2$ $\quad$ $m = 1$

$m = -1$

The lines are perpendicular.

36. $x = y + 2$ $\quad$ $y = x + 3$

$-y = -x + 2$ $\quad$ $m = 1$

$y = x - 2$

$m = 1$

The lines are parallel.

37. $y = 3x + 7$ $\quad$ $2y = 6x - 9$

$m = 3$ $\quad$ $y = 3x - \frac{9}{2}$

$m = 3$

The lines are parallel.

38. $2x + 3y = 9$ $\quad$ $3x - 2y = 5$

$3y = -2x + 9$ $\quad$ $-2y = -3x + 5$

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

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

The lines are perpendicular.

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EXERCISES 2.4

39. $3x + 6y = 1$
$6y = -3x + 1$
$y = -\frac{1}{2}x + \frac{1}{6}$
$m = -\frac{1}{2}$

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

The lines are neither.

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

$y = -3x + 7$
$m = -3$

The lines are perpendicular.

41. $y = 3$
horizontal

$x = 4$
vertical

The lines are perpendicular.

42. $y = -3$
horizontal

$y = -7$
horizontal

The lines are parallel.

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

$3(y-3) + x = 0$
$3y - 9 + x = 0$
$3y = -x + 9$
$y = -\frac{1}{3}x + 3$
$m = -\frac{1}{3}$

The lines are perpendicular.

44. $2y = 8$
$y = 4$
horizontal

$3(2 + x) = 3(y + 2)$ /
$6 + 3x = 3y + 6$
$-3y = -3x$
$y = x$
$m = 1$

neither

45. $y - y_1 = m(x - x_1)$
$y - 4 = 2(x - 2)$
$y - 4 = 2x - 4$
$-2x + y = 0$
$2x - y = 0$

46. $y - y_1 = m(x - x_1)$
$y - 5 = -3(x - 3)$
$y - 5 = -3x + 9$
$3x + y = 14$

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

48. $y - y_1 = m(x - x_1)$
$y + 2 = -6\left(x - \frac{1}{4}\right)$
$y + 2 = -6x + \frac{3}{2}$
$2y + 4 = -12x + 3$
$12x + 2y = -1$

49. $y - y_1 = m(x - x_1)$
$y - 1 = \frac{2}{5}(x + 1)$
$5(y - 1) = 2(x + 1)$
$5y - 5 = 2x + 2$
$-2x + 5y = 7$
$2x - 5y = -7$

50. $y - y_1 = m(x - x_1)$
$y + 3 = -\frac{1}{5}(x + 2)$
$5(y + 3) = -(x + 2)$
$5y + 15 = -x - 2$
$x + 5y = -17$

51. $y - y_1 = m(x - x_1)$
$y + 3 = 0(x + 6)$
$y + 3 = 0$
$y = -3$

52. $y - y_1 = m(x - x_1)$
$y - 5 = 0(x - 7)$
$y - 5 = 0$
$y = 5$

53. m is und $\Rightarrow$ vertical
$x =$ constant
$x = -6$

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54. m is und $\Rightarrow$ vertical
$x =$ constant
$x = 6$

55.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 0 &= \pi(x - \pi) \\ y &= \pi x - \pi^2 \\ -\pi x + y &= -\pi^2 \\ \pi x - y &= \pi^2 \end{aligned}$$

56.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - \pi &= \pi(x - 0) \\ y - \pi &= \pi x \\ -\pi x + y &= \pi \\ \pi x - y &= -\pi \end{aligned}$$

57. From the graph, $m = \frac{2}{3}$ and the line passes through $(2, 5)$.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 5 &= \frac{2}{3}(x - 2) \\ 3(y - 5) &= 3 \cdot \frac{2}{3}(x - 2) \\ 3y - 15 &= 2(x - 2) \\ 3y - 15 &= 2x - 4 \\ -2x + 3y &= 11 \\ 2x - 3y &= -11 \end{aligned}$$

58. From the graph, $m = -\frac{2}{3}$ and the line passes through $(-3, 2)$.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 2 &= -\frac{2}{3}(x + 3) \\ 3(y - 2) &= 3 \cdot \left(-\frac{2}{3}\right)(x + 3) \\ 3y - 6 &= -2(x + 3) \\ 3y - 6 &= -2x - 6 \\ 2x + 3y &= 0 \end{aligned}$$

59.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 0}{4 - 0} = \frac{4}{4} = 1$$
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 0 &= 1(x - 0) \\ y &= x \end{aligned}$$

60.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - (-5)}{0 - (-5)} = \frac{5}{5} = 1$$
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 0 &= 1(x - 0) \\ y &= x \end{aligned}$$

61.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3 - 4}{0 - 3} = \frac{-7}{-3} = \frac{7}{3}$$
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y + 3 &= \frac{7}{3}(x - 0) \\ y &= \frac{7}{3}x - 3 \end{aligned}$$

62.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-8 - 0}{6 - 4} = \frac{-8}{2} = -4$$
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 0 &= -4(x - 4) \\ y &= -4x + 16 \end{aligned}$$

63. From the graph, $m = -\frac{9}{5}$ and the line passes through $(-2, 4)$
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 4 &= -\frac{9}{5}(x + 2) \\ y - 4 &= -\frac{9}{5}x - \frac{18}{5} \\ y &= -\frac{9}{5}x - \frac{18}{5} + 4 \\ y &= -\frac{9}{5}x + \frac{2}{5} \end{aligned}$$

64. From the graph, $m = \frac{8}{5}$ and the line passes through $(2, 3)$.
$$\begin{aligned} y - y_1 &= m(x - x_1) \\ y - 3 &= \frac{8}{5}(x - 2) \\ y - 3 &= \frac{8}{5}x - \frac{16}{5} \\ y &= \frac{8}{5}x - \frac{16}{5} + 3 \\ y &= \frac{8}{5}x - \frac{1}{5} \end{aligned}$$

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EXERCISES 2.4

65. $y = 4x - 7$
$m = 4$
Use $m = 4$.

$y - y_1 = m(x - x_1)$
$y - 0 = 4(x - 0)$
$\boxed{y = 4x}$

66. $x = -3y - 12$
$3y = -x - 12$
$y = -\frac{1}{3}x - 4$
$m = -\frac{1}{3}$
Use $m = -\frac{1}{3}$.

$y - y_1 = m(x - x_1)$
$y - 0 = -\frac{1}{3}(x - 0)$
$\boxed{y = -\frac{1}{3}x}$

67. $4x - y = 7$
$-y = -4x + 7$
$y = 4x - 7$
$m = 4$
Use $m = 4$.

$y - y_1 = m(x - x_1)$
$y - 5 = 4(x - 2)$
$y - 5 = 4x - 8$
$\boxed{y = 4x - 3}$

68. $y + 3x = -12$
$y = -3x - 12$
$m = -3$
Use $m = -3$.

$y - y_1 = m(x - x_1)$
$y - 3 = -3(x + 6)$
$y - 3 = -3x - 18$
$\boxed{y = -3x - 15}$

69. $x = \frac{5}{4}y - 2$
$4x = 5y - 8$
$-5y = -4x - 8$
$y = \frac{4}{5}x + \frac{8}{5}$
$m = \frac{4}{5}$
Use $m = \frac{4}{5}$.

$y - y_1 = m(x - x_1)$
$y + 2 = \frac{4}{5}(x - 4)$
$y + 2 = \frac{4}{5}x - \frac{16}{5}$
$\boxed{y = \frac{4}{5}x - \frac{26}{5}}$

70. $x = -\frac{3}{4}y + 5$
$4x = -3y + 20$
$3y = -4x + 20$
$y = -\frac{4}{3}x + \frac{20}{3}$
$m = -\frac{4}{3}$
Use $m = -\frac{4}{3}$.

$y - y_1 = m(x - x_1)$
$y + 5 = -\frac{4}{3}(x - 1)$
$y + 5 = -\frac{4}{3}x + \frac{4}{3}$
$\boxed{y = -\frac{4}{3}x - \frac{11}{3}}$

71. $y = 4x - 7$
$m = 4$
Use $m = -\frac{1}{4}$.

$y - y_1 = m(x - x_1)$
$y - 0 = -\frac{1}{4}(x - 0)$
$\boxed{y = -\frac{1}{4}x}$

72. $x = -3y - 12$
$3y = -x - 12$
$y = -\frac{1}{3}x - 4$
$m = -\frac{1}{3}$
Use $m = 3$.

$y - y_1 = m(x - x_1)$
$y - 0 = 3(x - 0)$
$\boxed{y = 3x}$

73. $4x - y = 7$
$-y = -4x + 7$
$y = 4x - 7$
$m = 4$
Use $m = -\frac{1}{4}$.

$y - y_1 = m(x - x_1)$
$y - 5 = -\frac{1}{4}(x - 2)$
$y - 5 = -\frac{1}{4}x + \frac{1}{2}$
$\boxed{y = -\frac{1}{4}x + \frac{11}{2}}$

74. $y + 3x = -12$
$y = -3x - 12$
$m = -3$
Use $m = \frac{1}{3}$.

$y - y_1 = m(x - x_1)$
$y - 3 = \frac{1}{3}(x + 6)$
$y - 3 = \frac{1}{3}x + 2$
$\boxed{y = \frac{1}{3}x + 5}$

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

$4x = 5y - 8$

$-5y = -4x - 8$

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

$m = \frac{4}{5}$

Use $m = -\frac{5}{4}$.

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

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

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

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

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

$4x = -3y + 20$

$3y = -4x + 20$

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

$m = -\frac{4}{3}$

Use $m = \frac{3}{4}$.

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

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

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

$\boxed{y = \frac{3}{4}x - \frac{23}{4}}$

77. Since $y = 3$ is the equation of a horizontal line, any perpendicular line will be vertical. Find the midpoint:

$x = \frac{2 + (-6)}{2} = -2$; $y = \frac{4 + 10}{2} = 7$

The vertical line through $(-2, 7)$ is $x = -2$.

78. Since $y = -8$ is the equation of a horizontal line, any parallel line will be horizontal. Find the midpoint:

$x = \frac{-4 + (-2)}{2} = -3$; $y = \frac{2 + 8}{2} = 5$

The horizontal line through $(-3, 5)$ is $y = 5$.

79. Since $x = 3$ is the equation of a vertical line, any parallel line will be vertical. Find the midpoint:

$x = \frac{2 + 8}{2} = 5$; $y = \frac{-4 + 12}{2} = 4$

The vertical line through $(5, 4)$ is $x = 5$.

80. Since $x = 3$ is the equation of a vertical line, any perpendicular line will be horizontal. Find the midpoint:

$x = \frac{-2 + 4}{2} = 1$; $y = \frac{2 + (-8)}{2} = -3$

The horizontal line through $(1, -3)$: $y = -3$.

81. Let $x =$ the number of years the truck has been owned and let $y =$ the value of the truck. Then two points on the line are given: $(0, 24300)$ and $(7, 1900)$.

$m = \frac{24300 - 1900}{0 - 7} = \frac{22400}{-7} = -3200$

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

$y - 24300 = -3200(x - 0)$

$y - 24300 = -3200x$

$y = -3200x + 24300$

82. Let $x =$ the number of years the laptop has been owned and let $y =$ the value of the laptop. Then two points on the line are given: $(0, 2700)$ and $(4, 300)$.

$m = \frac{2700 - 300}{0 - 4} = \frac{2400}{-4} = -600$

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

$y - 2700 = -600(x - 0)$

$y - 2700 = -600x$

$y = -600x + 2700$

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83. Let $x =$ the number of years the building has been owned and let $y =$ the value of the building. Then two points on the line are given: $(0, 475000)$ and $(10, 950000)$.

$$m = \frac{950000 - 475000}{10 - 0} = \frac{475000}{10} = 47500$$

$$y - y_1 = m(x - x_1)$$
$$y - 475000 = 47500(x - 0)$$
$$y - 475000 = 47500x$$
$$y = 47500x + 475000$$

84. Let $x =$ the number of years the house has been owned and let $y =$ the value of the house. Then two points on the line are given: $(0, 112000)$ and $(12, 224000)$.

$$m = \frac{224000 - 112000}{12 - 0} = \frac{112000}{12} = \frac{28000}{3}$$

$$y - y_1 = m(x - x_1)$$
$$y - 112000 = \frac{28000}{3}(x - 0)$$
$$y - 112000 = \frac{28000}{3}x$$
$$y = \frac{28000}{3}x + 112000$$

85. Let $x =$ the number of years the TV has been owned and let $y =$ the value of the TV. Then two points on the line are given: $(0, 1900)$ and $(3, 1190)$.

$$m = \frac{1900 - 1190}{0 - 3} = \frac{710}{-3} = -\frac{710}{3}$$

$$y - y_1 = m(x - x_1)$$
$$y - 1900 = -\frac{710}{3}(x - 0)$$
$$y - 1900 = -\frac{710}{3}x$$
$$y = -\frac{710}{3}x + 1900$$

86. Let $x =$ the number of years the radio has been owned and let $y =$ the value of the radio. Then two points on the line are given: $(0, 555)$ and $(5, 80)$.

$$m = \frac{555 - 80}{0 - 5} = \frac{475}{-5} = -95$$

$$y - y_1 = m(x - x_1)$$
$$y - 555 = -95(x - 0)$$
$$y - 555 = -95x$$
$$y = -95x + 555$$

Let $x = 3$ and find the value of y:

$$y = -95x + 555$$
$$= -95(3) + 555 = 270$$

It will be worth \$270.

87. Let $x =$ the number of years the copier has been owned and let $y =$ the value of the copier. Then one point on the line is given: $(0, 1050)$. Since the copier depreciates by \$120 per year, $m = -120$.

$$y - y_1 = m(x - x_1)$$
$$y - 1050 = -120(x - 0)$$
$$y - 1050 = -120x$$
$$y = -120x + 1050$$

Let $x = 8$ and find the value of y:

$$y = -120x + 1050$$
$$= -120(8) + 1050 = 90$$

The salvage value will be \$90.

88. Let $x =$ the number of years the jet ski has been owned and let $y =$ its value. Then two two points on the line are given: $(0, 13800)$ and $(6, 0)$.

$$m = \frac{13800 - 0}{0 - 6} = \frac{13800}{-6} = -2300$$

The jet ski depreciates at a rate of \$2300 per year.

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EXERCISES 2.4

89. Let $x =$ the number of years the table has been owned and let $y =$ the value of the table. Then one point on the line is given: $(2, 450)$. Since the table appreciates by \$40 per year, $m = 40$.

$$y - y_1 = m(x - x_1)$$
$$y - 450 = 40(x - 2)$$
$$y - 450 = 40x - 80$$
$$y = 40x + 370$$

Let $x = 13$ and find the value of y:

$$y = 40x + 370$$
$$= 40(13) + 370 = 890$$

The value will be \$890.

90. Let $x =$ the number of years the clock has been owned and let $y =$ the value of the clock. Then two points on the line are given: $(2, 350)$ and $(5, 530)$.

$$m = \frac{530 - 350}{5 - 2} = \frac{180}{3} = 60$$
$$y - y_1 = m(x - x_1)$$
$$y - 350 = 60(x - 2)$$
$$y - 350 = 60x - 120$$
$$y = 60x + 230$$

Let $x = 7$ and find the value of y:

$$y = 60x + 230$$
$$= 60(7) + 230 = 650$$

It will be worth \$650.

91. Let $x =$ the number of years the cottage has been owned and let $y =$ the value of the cottage. Then one point on the line is given: $(3, 47700)$. Since the cottage appreciates by \$3500 per year, $m = 3500$.

$$y - y_1 = m(x - x_1)$$
$$y - 47700 = 3500(x - 3)$$
$$y - 47700 = 3500x - 10500$$
$$y = 3500x + 37200$$

Let $x = 0$ and find the value of y:

$$y = 3500x + 37200$$
$$= 3500(0) + 37200 = 37200$$

The purchase price was \$37,200.

92. Let $x =$ the number of hours of service needed and let $y =$ the total charge. Then two points on the line are given: $(2, 70)$ and $(4, 105)$

$$m = \frac{105 - 70}{4 - 2} = \frac{35}{2} = 17.50$$
$$y - y_1 = m(x - x_1)$$
$$y - 70 = 17.50(x - 2)$$
$$y - 70 = 17.50x - 35$$
$$y = 17.50x + 35$$

The hourly charge is \$17.50.

93. Let $x =$ the hours of labor and let $y =$ the labor charge. Then $m =$ the hourly charge.

$y = mx$ $\qquad$ $y = 46x$
$69 = m(1.5)$ $\qquad$ $y = 46(5) = 230$
$46 = m$ $\qquad$ The charge will be \$230.

94. Let $x =$ the number of hundreds of copies and let $y =$ the total charge. Then $m =$ the charge per copy and $b =$ the fixed charge.

$y = mx + b$ $\qquad$ $y = x + 45$
$y = 1x + b$ $\qquad$ $y = 10 + 45 = 55$
$52 = 1(7) + b$ $\qquad$ The charge will be \$55.
$45 = b$

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95. Let $x =$ the number of fires and let $y =$ the population. Then two points on the line are given: (300, 57000) and (325, 59000).

$$m = \frac{59000 - 57000}{325 - 300} = \frac{2000}{25} = 80$$

$$y - y_1 = m(x - x_1)$$
$$y - 57000 = 80(x - 300)$$
$$y - 57000 = 80x - 24000$$
$$y = 80x + 33000$$

Let $y = 100000$ and find the value of x:

$$y = 80x + 33000$$
$$100000 = 80x + 33000$$
$$67000 = 80x$$
$$837.5 = x \Rightarrow$$

There will be about 838 fires when the population is 100,000.

96. Let $x =$ the number of feet of gutter and let $y =$ the total charge. Then $m =$ the charge per foot. One point on the line is given: (250, 435)

$$y = mx + b$$
$$435 = m(250) + 60$$
$$375 = 250m$$
$$1.5 = m$$

Let $x = 300$ and find the value of y:

$$y = 1.5x + 60$$
$$= 1.5(300) + 60 = 510$$

It will cost \$510.

97. Let F replace x and C replace y. Then two points on the line are given: (32, 0) and (212, 100).

$$m = \frac{100 - 0}{212 - 32} = \frac{100}{180} = \frac{5}{9}$$
$$C - C_1 = m(F - F_1)$$
$$C - 0 = \frac{5}{9}(F - 32)$$
$$C = \frac{5}{9}(F - 32)$$

98. Two points on the line are given: (1, 88) and (0, 0).

$$m = \frac{88 - 0}{1 - 0} = \frac{88}{1} = 88$$
$$y - y_1 = m(x - x_1)$$
$$y - 0 = 88(x - 0)$$
$$y = 88x$$

99. Let $y =$ the percent who smoke and let $x =$ the # of years since 1974. Two points are given: (0, 47) and (20, 29).

$$m = \frac{29 - 47}{20 - 0} = \frac{-18}{20} = -\frac{9}{10}$$
$$y - y_1 = m(x - x_1)$$
$$y - 47 = -\frac{9}{10}(x - 0)$$
$$\boxed{y = -\frac{9}{10}x + 47}$$

Let $x = 50$:

$$y = -\frac{9}{10}(50) + 47 = -45 + 47 = 2$$

2% will smoke in 2024.

100. Let f replace x and h replace y. Then two points on the line are given: (62.5, 200) and (40.2, 150).

$$m = \frac{150 - 200}{40.2 - 62.5} = \frac{-50}{-22.3} \approx 2.242$$
$$h - h_1 = m(f - f_1)$$
$$h - 200 = 2.242(f - 62.5)$$
$$h - 200 = 2.242f - 140.125$$
$$\boxed{h = 2.242f + 59.875}$$

Let $f = 50$:

$$h = 2.242(50) + 59.875 \approx 172$$

He would be about 172 cm tall.

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EXERCISES 2.4

101. Two points on the line are given: $(0, 37.5)$ and $(2, 45)$.

$$m = \frac{45 - 37.5}{2 - 0} = \frac{7.5}{2} = 3.75$$

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

$$y - 37.5 = 3.75(x - 0)$$

$$y = 3.75x + 37.5$$

Let $x = 10$ and find the value of y:

$$y = 3.75x + 37.5$$

$$= 3.75(10) + 37.5$$

$$= 37.5 + 37.5 = 75$$

The price will be \$75 in the year 2020.

102. Let January be represented by $x = 0$, and later months by $x = 1, 2, 3, \ldots$ Let y represent the inventory. Then two points on the line are given: $(0, 375)$ and $(3, 264)$.

$$m = \frac{375 - 264}{0 - 3} = \frac{111}{-3} = -37$$

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

$$y - 375 = -37(x - 0)$$

$$y = -37x + 375$$

Let $x = 2$ and find the value of y:

$$y = -37x + 375$$

$$= -37(2) + 375 = 301$$

The March inventory will be about 301.

103. The equation describing the production is $y = -70x + 1900$, where x represents the number of years and y is the level of production. Let $x = 3\frac{1}{2} = \frac{7}{2}$.

$$y = -70x + 1900$$

$$= -70\left(\frac{7}{2}\right) + 1900 = 1655$$

The production will be 1655 barrels per day.

104. Let $x =$ the number of years the piping has been owned and let $y =$ the value of the piping. Then two points on the line are given: $(0, 137000)$ and $(12, -33000)$.

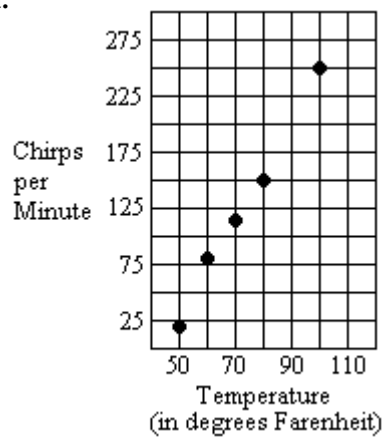
$$m = \frac{-33000 - 137000}{12 - 0} = -\frac{42500}{3}$$

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

$$y - 137000 = -\frac{42500}{3}(x - 0)$$

$$y = -\frac{42500}{3}x + 137000$$

105. a.



b. Use $(50, 20)$ and $(100, 250)$ for the regression line.

$$m = \frac{250 - 20}{100 - 50} = \frac{230}{50} = \frac{23}{5}$$

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

$$y - 20 = \frac{23}{5}(x - 50)$$

$$y - 20 = \frac{23}{5}x - 230$$

$$y = \frac{23}{5}x - 210$$

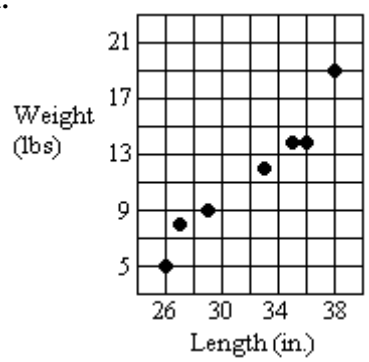
c. $y = \frac{23}{5}(90) - 210 = 204$

The rate will be about 204 chirps per minute.

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EXERCISES 2.4

106. a.



b. Use $(26, 5)$ and $(38, 19)$ for the regression line.

$$m = \frac{19-5}{38-26} = \frac{14}{12} = \frac{7}{6}$$
$$y - y_1 = m(x - x_1)$$
$$y - 5 = \frac{7}{6}(x - 26)$$
$$y - 5 = \frac{7}{6}x - \frac{91}{3}$$
$$y = \frac{7}{6}x - \frac{76}{3}$$

c. $y = \frac{7}{6}(32) - \frac{76}{3} = 12$

The weight will be about 12 pounds.

107. $y = 4.44x - 196.62$

108. $y = 0.96x - 19.22$

109-112. Answers may vary.

113.
$$m = \frac{b-0}{0-a} = -\frac{b}{a}$$
$$y - y_1 = m(x - x_1)$$
$$y - b = -\frac{b}{a}(x - 0)$$
$$y - b = -\frac{b}{a}x$$
$$ay - ab = -bx$$
$$bx + ay = ab$$
$$\frac{bx + ay}{ab} = \frac{ab}{ab}$$
$$\frac{x}{a} + \frac{y}{b} = 1$$

114.

x-intercept	y-intercept
$bx + ay = ab$	$bx + ay = ab$
$bx + a(0) = ab$	$b(0) + ay = ab$
$bx = ab$	$ay = ab$
$x = a$	$y = b$
$(a, 0)$	$(0, b)$

115-118. Answers may vary.

119.
$$Ax + By = C$$
$$By = -Ax + C$$
$$y = -\tfrac{A}{B}x + \tfrac{C}{B}$$

False. $m = -\frac{A}{B}$

120.
$$Ax + By = C$$
$$By = -Ax + C$$
$$y = -\tfrac{A}{B}x + \tfrac{C}{B}$$

y-intercept: $\frac{C}{B}$

121. Both are horizontal. True.

122. $\frac{\sqrt{11}}{11} \cdot \left(-\sqrt{11}\right) = \frac{-11}{11} = -1$; True.

123. $x = 99$ is vertical, so the parallel line must be vertical too $(x = -99)$. False.

124. $y = 99$ is horizontal, so the perpendicular line must be vertical too $(x = 99)$. True.

125.
$$\sqrt{5}x + \sqrt{10y} = \sqrt{15}$$
$$\frac{\sqrt{5}x + \sqrt{10y}}{\sqrt{5}} = \frac{\sqrt{15}}{\sqrt{5}}$$
$$x + \sqrt{2}y = \sqrt{3}; \text{ True.}$$

126. False. You can tell by calculating the slopes.

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Exercises 2.5 (page 265)

1. x-intercept **2.** y-axis **3.** axis of symmetry **4.** y-axis

5. x-axis **6.** origin **7.** circle, center **8.** radius

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

10. $(x-h)^2 + (y-k)^2 = r^2$

11.
$y = x^2 - 4$
$0 = (x+2)(x-2)$
$x = -2, x = 2$
x-int: $(-2, 0), (2, 0)$

$y = x^2 - 4$
$y = 0^2 - 4$
$y = -4$
y-int: $(0, -4)$

12.
$y = x^2 - 9$
$0 = x^2 - 9$
$0 = (x+3)(x-3)$
$x = -3, x = 3$
x-int: $(-3, 0), (3, 0)$

$y = x^2 - 9$
$y = 0^2 - 9$
$y = -9$
y-int: $(0, -9)$

13.
$y = 4x^2 - 2x$
$0 = 2x(2x-1)$
$x = 0, x = \frac{1}{2}$
x-int: $(0, 0), \left(\frac{1}{2}, 0\right)$

$y = 4x^2 - 2x$
$y = 4(0)^2 - 2(0)$
$y = 0$
y-int: $(0, 0)$

14.
$y = 2x - 4x^2$
$0 = 2x(1-2x)$
$x = 0, x = \frac{1}{2}$
x-int: $(0, 0), \left(\frac{1}{2}, 0\right)$

$y = 2x - 4x^2$
$y = 2(0) - 4(0)^2$
$y = 0$
y-int: $(0, 0)$

15.
$y = x^2 - 4x - 5$
$0 = (x+1)(x-5)$
$x = -1, x = 5$
x-int: $(-1, 0), (5, 0)$

$y = x^2 - 4x - 5$
$y = 0^2 - 4(0) - 5$
$y = -5$
y-int: $(0, -5)$

16.
$y = x^2 - 10x + 21$
$0 = (x-3)(x-7)$
$x = 3, x = 7$
x-int: $(3, 0), (7, 0)$

$y = x^2 - 10x + 21$
$y = 0^2 - 10(0) + 21$
$y = 21$
y-int: $(0, 21)$

17.
$y = x^2 + x - 2$
$0 = (x+2)(x-1)$
$x = -2, x = 1$
x-int: $(-2, 0), (1, 0)$

$y = x^2 + x - 2$
$y = 0^2 + 0 - 2$
$y = -2$
y-int: $(0, -2)$

18.
$y = x^2 + 2x - 3$
$0 = (x+3)(x-1)$
$x = -3, x = 1$
x-int: $(-3, 0), (1, 0)$

$y = x^2 + 2x - 3$
$y = 0^2 + 2(0) - 3$
$y = -3$
y-int: $(0, -3)$

19.
$y = x^3 - 9x$
$0 = x\left(x^2 - 9\right)$
$0 = x(x+3)(x-3)$
$x = 0, x = -3, x = 3$
x-int: $(0, 0), (-3, 0), (3, 0)$

$y = x^3 - 9x$
$y = 0^3 - 9(0)$
$y = 0$
y-int: $(0, 0)$

20.
$y = x^3 + x$
$0 = x\left(x^2 + 1\right)$
$x = 0, \left\{x^2 + 1 \neq 0\right\}$
x-int: $(0, 0)$

$y = x^3 + x$
$y = 0^3 + 0$
$y = 0$
y-int: $(0, 0)$

21.
$y = x^4 - 1$
$0 = \left(x^2 + 1\right)\left(x^2 - 1\right)$
$0 = \left(x^2 + 1\right)(x+1)(x-1)$
$\left\{x^2 + 1 \neq 0\right\}$
$x = -1, x = 1$
x-int: $(-1, 0), (1, 0)$

$y = x^4 - 1$
$y = 0^4 - 1$
$y = -1$
y-int: $(0, -1)$

22.
$y = x^4 - 25x^2$
$0 = x^2\left(x^2 - 25\right)$
$0 = x^2(x+5)(x-5)$
$x = 0, x = -5, x = 5$
x-int: $(0, 0), (-5, 0), (5, 0)$

$y = x^4 - 25x^2$
$y = 0^4 - 25(0)^2$
$y = 0$
y-int: $(0, 0)$

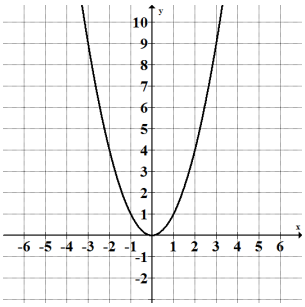
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EXERCISES 2.5

23. $y = x^2$

x-int: $(0, 0)$

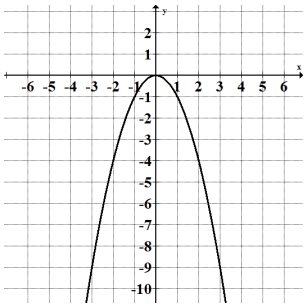
y-int: $(0, 0)$



24. $y = -x^2$

x-int: $(0, 0)$

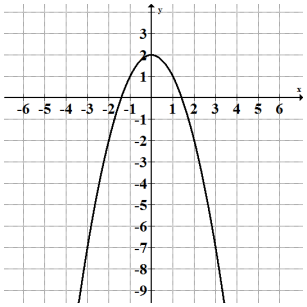
y-int: $(0, 0)$



25. $y = -x^2 + 2$

x-int: $\left(\sqrt{2}, 0\right), \left(-\sqrt{2}, 0\right)$

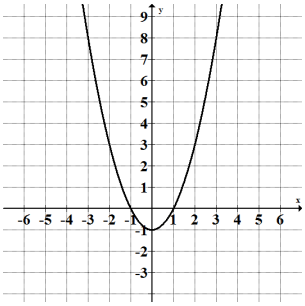
y-int: $(0, 2)$



26. $y = x^2 - 1$

x-int: $(1, 0), (-1, 0)$

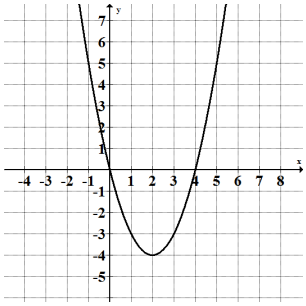
y-int: $(0, -1)$



27. $y = x^2 - 4x$

x-int: $(0, 0), (4, 0)$

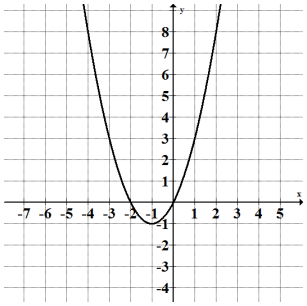
y-int: $(0, 0)$



28. $y = x^2 + 2x$

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

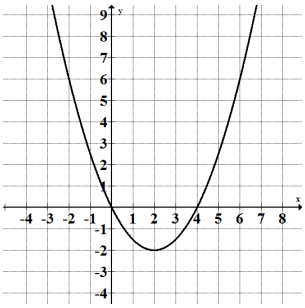
y-int: $(0, 0)$



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

x-int: $(0, 0), (4, 0)$

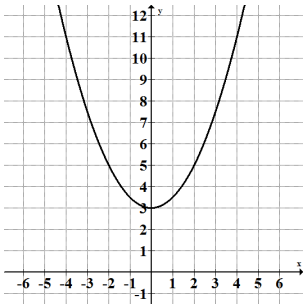
y-int: $(0, 0)$



30. $y = \frac{1}{2}x^2 + 3$

x-int: none

y-int: $(0, 3)$



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EXERCISES 2.5

31.

$y = x^2 + 2$

x-axis	y-axis	origin
$-y = x^2 + 2$	$y = (-x)^2 + 2$	$-y = (-x)^2 + 2$
not equivalent: no symmetry	$y = x^2 + 2$	$-y = x^2 + 2$
	equivalent: symmetry	not equivalent: no symmetry

32.

$y = 3x + 2$

x-axis	y-axis	origin
$-y = 3x + 2$	$y = 3(-x) + 2$	$-y = 3(-x) + 2$
not equivalent: no symmetry	$y = -3x + 2$	$-y = -3x + 2$
	not equivalent: no symmetry	$y = 3x - 2$
		not equivalent: no symmetry

33.

$y^2 + 1 = x$

x-axis	y-axis	origin
$(-y)^2 + 1 = x$	$y^2 + 1 = -x$	$(-y)^2 + 1 = -x$
$y^2 + 1 = x$	not equivalent: no symmetry	$y^2 + 1 = -x$
equivalent: symmetry		not equivalent: no symmetry

34.

$y^2 + y = x$

x-axis	y-axis	origin
$(-y)^2 + (-y) = x$	$y^2 + y = -x$	$(-y)^2 + (-y) = -x$
$y^2 - y = x$	not equivalent: no symmetry	$y^2 - y = -x$
not equivalent: no symmetry		$-y^2 + y = x$
		not equivalent: no symmetry

35.

$y^2 = x^2$

x-axis	y-axis	origin
$(-y)^2 = x^2$	$y^2 = (-x)^2$	$(-y)^2 = (-x)^2$
$y^2 = x^2$	$y^2 = x^2$	$y^2 = x^2$
equivalent: symmetry	equivalent: symmetry	equivalent: symmetry

36.

$y = 3x + 7$

x-axis	y-axis	origin
$-y = 3x + 7$	$y = 3(-x) + 7$	$-y = 3(-x) + 7$
not equivalent: no symmetry	$y = -3x + 7$	$-y = -3x + 7$
	not equivalent: no symmetry	$y = 3x - 7$
		not equivalent: no symmetry

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37.

$y = 3x^2 + 7$

x-axis	y-axis	origin
$-y = 3x^2 + 7$	$y = 3(-x)^2 + 7$	$-y = 3(-x)^2 + 7$
not equivalent: no symmetry	$y = 3x^2 + 7$	$-y = 3x^2 + 7$
	equivalent: symmetry	not equivalent: no symmetry

38.

$x^2 + y^2 = 1$

x-axis	y-axis	origin
$x^2 + (-y)^2 = 1$	$(-x)^2 + y^2 = 1$	$(-x)^2 + (-y)^2 = 1$
$x^2 + y^2 = 1$	$x^2 + y^2 = 1$	$x^2 + y^2 = 1$
equivalent: symmetry	equivalent: symmetry	equivalent: symmetry

39.

$y = 3x^3 + 7$

x-axis	y-axis	origin
$-y = 3x^3 + 7$	$y = 3(-x)^3 + 7$	$-y = 3(-x)^3 + 7$
not equivalent: no symmetry	$y = -3x^3 + 7$	$-y = -3x^3 + 7$
	not equivalent: no symmetry	$y = 3x^3 - 7$
		not equivalent: no symmetry

40.

$y = 3x^3 + 7x$

x-axis	y-axis	origin
$-y = 3x^3 + 7x$	$y = 3(-x)^3 + 7x$	$-y = 3(-x)^3 + 7(-x)$
not equivalent: no symmetry	$y = -3x^3 + 7x$	$-y = -3x - 7x$
	not equivalent: no symmetry	$y = 3x^3 + 7x$
		equivalent: symmetry

41.

$y^2 = 3x$

x-axis	y-axis	origin
$(-y)^2 = 3x$	$y^2 = 3(-x)$	$(-y)^2 = 3(-x)$
$y^2 = 3x$	$y^2 = -3x$	$y^2 = -3x$
equivalent: symmetry	not equivalent: no symmetry	not equivalent: no symmetry

42.

$y = 3x^4 + 7$

x-axis	y-axis	origin
$-y = 3x^4 + 7$	$y = 3(-x)^4 + 7$	$-y = 3(-x)^4 + 7$
not equivalent: no symmetry	$y = 3x^4 + 7$	$-y = 3x^4 + 7$
	equivalent: symmetry	not equivalent: no symmetry

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43.

$y = |x|$

x-axis	y-axis	origin
$-y = \|x\|$	$y = \|-x\|$	$-y = \|-x\|$
not equivalent: no symmetry	$y = \|-1\|\|x\|$	$-y = \|-1\|\|x\|$
	$y = \|x\|$	$-y = \|x\|$
	equivalent: symmetry	not equivalent: no symmetry

44.

$y = |x + 1|$

x-axis	y-axis	origin
$-y = \|x + 1\|$	$y = \|-x + 1\|$	$-y = \|-x + 1\|$
not equivalent: no symmetry	not equivalent: no symmetry	not equivalent: no symmetry

45.

$|y| = x$

x-axis	y-axis	origin
$\|-y\| = x$	$\|y\| = -x$	$\|-y\| = -x$
$\|-1\|\|y\| = x$	not equivalent: no symmetry	$\|-1\|\|y\| = -x$
$\|y\| = x$		$\|y\| = -x$
equivalent: symmetry		not equivalent: no symmetry

46.

$|y| = |x|$

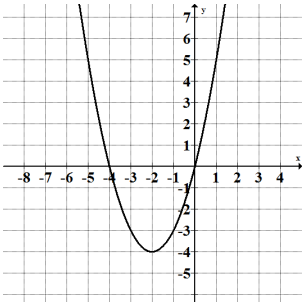
x-axis	y-axis	origin
$\|-y\| = \|x\|$	$\|y\| = \|-x\|$	$\|-y\| = \|-x\|$
$\|-1\|\|y\| = \|x\|$	$\|y\| = \|-1\|\|x\|$	$\|-1\|\|y\| = \|-1\|\|x\|$
$\|y\| = \|x\|$	$\|y\| = \|x\|$	$\|y\| = \|x\|$
equivalent: symmetry	equivalent: symmetry	equivalent: symmetry

47. $y = x^2 + 4x$

x-int: $(0, 0), (-4, 0)$

y-int: $(0, 0)$

symmetry: none

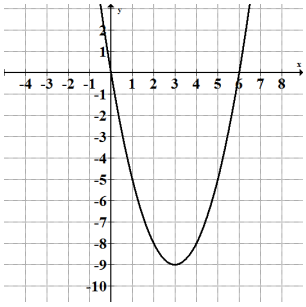


48. $y = x^2 - 6x$

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

y-int: $(0, 0)$

symmetry: none

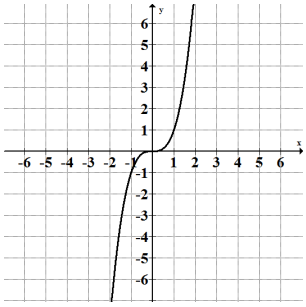


49. $y = x^3$

x-int: $(0, 0)$

y-int: $(0, 0)$

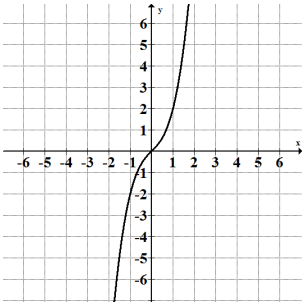
symmetry: origin



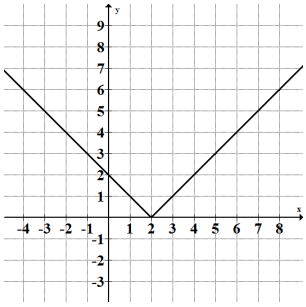
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EXERCISES 2.5

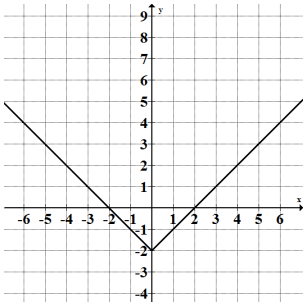
50. $y = x^3 + x$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: origin



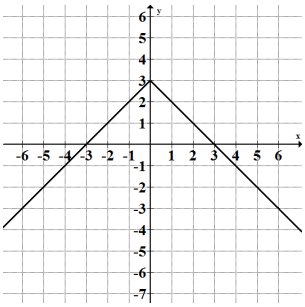
51. $y = |x - 2|$
x-int: $(2, 0)$
y-int: $(0, 2)$
symmetry: none



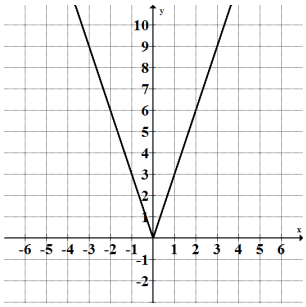
52. $y = |x| - 2$
x-int: $(-2, 0), (2, 0)$
y-int: $(0, -2)$
symmetry: y-axis



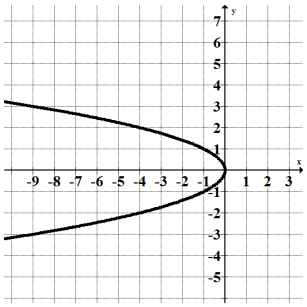
53. $y = -|x| + 3$
x-int: $(-3, 0), (3, 0)$
y-int: $(0, 3)$
symmetry: y-axis



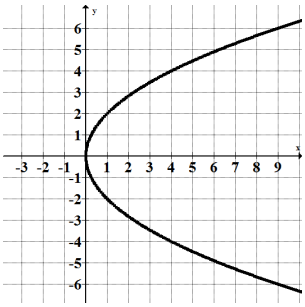
54. $y = 3|x|$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: y-axis



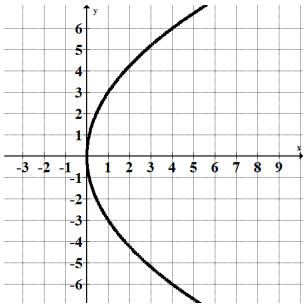
55. $y^2 = -x$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: x-axis



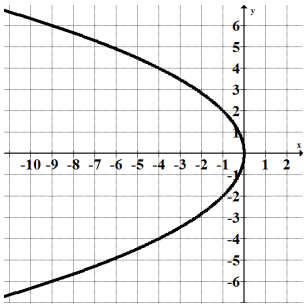
56. $y^2 = 4x$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: x-axis



57. $y^2 = 9x$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: x-axis



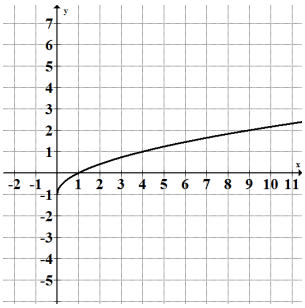
58. $y^2 = -4x$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: x-axis



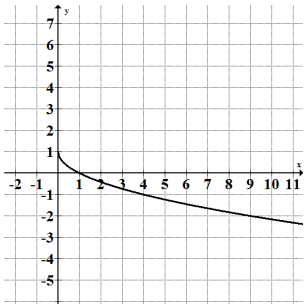
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EXERCISES 2.5

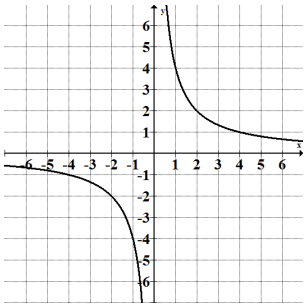
59. $y = \sqrt{x} - 1$
x-int: $(1, 0)$
y-int: $(0, -1)$
symmetry: none



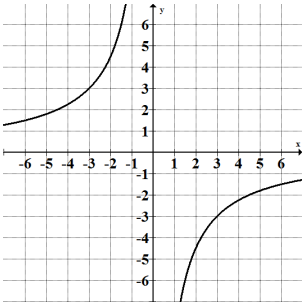
60. $y = 1 - \sqrt{x}$
x-int: $(1, 0)$
y-int: $(0, 1)$
symmetry: none



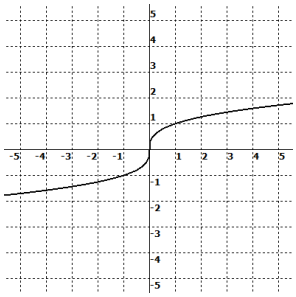
61. $xy = 4$
x-int: none
y-int: none
symmetry: origin



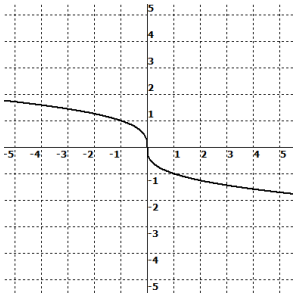
62. $xy = -9$
x-int: none
y-int: none
symmetry: origin



63. $y = \sqrt[3]{x}$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: origin



64. $y = -\sqrt[3]{x}$
x-int: $(0, 0)$
y-int: $(0, 0)$
symmetry: origin



65. $x^2 + y^2 = 100$
$(x-0)^2 + (y-0)^2 = 10^2$
C: $(0, 0)$; $r = 10$

66. $x^2 + y^2 = 81$
$(x-0)^2 + (y-0)^2 = 9^2$
C: $(0, 0)$; $r = 9$

67. $x^2 + (y-5)^2 = 49$
$(x-0)^2 + (y-5)^2 = 7^2$
C: $(0, 5)$; $r = 7$

68. $x^2 + (y+3)^2 = 8$
$(x-0)^2 + (y-(-3))^2 = \left(\sqrt{8}\right)^2$
$(x-0)^2 + (y-(-3))^2 = \left(2\sqrt{2}\right)^2$
C: $(0, -3)$; $r = 2\sqrt{2}$

69. $(x+6)^2 + y^2 = \frac{1}{4}$
$(x-(-6))^2 + (y-0)^2 = \left(\frac{1}{2}\right)^2$
C: $(-6, 0)$; $r = \frac{1}{2}$

70. $(x-5)^2 + y^2 = \frac{16}{25}$
$(x-5)^2 + (y-0)^2 = \left(\frac{4}{5}\right)^2$
C: $(5, 0)$; $r = \frac{4}{5}$

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EXERCISES 2.5

71. $(x-4)^2+(y-1)^2=9$
$(x-4)^2+(y-1)^2=3^2$
C: $(4,1)$; $r=3$

72. $(x+11)^2+(y+7)^2=121$
$(x-(-11))^2+(y-(-7))^2=11^2$
C: $(-11,-7)$; $r=11$

73. $\left(x-\frac{1}{4}\right)^2+(y+2)^2=45$
$\left(x-\frac{1}{4}\right)^2+(y-(-2))^2=\left(\sqrt{45}\right)^2$
$\left(x-\frac{1}{4}\right)^2+(y-(-2))^2=\left(3\sqrt{5}\right)^2$
C: $\left(\frac{1}{4},-2\right)$; $r=3\sqrt{5}$

74. $\left(x+\sqrt{5}\right)^2+(y-3)^2=1$
$\left(x-\left(-\sqrt{5}\right)\right)^2+(y-3)^2=(1)^2$
C: $\left(-\sqrt{5},3\right)$; $r=1$

75. $(x-0)^2+(y-0)^2=5^2$
$x^2+y^2=25$

76. $(x-0)^2+(y-0)^2=\left(\sqrt{3}\right)^2$
$x^2+y^2=3$

77. $(x-0)^2+(y-(-6))^2=6^2$
$x^2+(y+6)^2=36$

78. $(x-0)^2+(y-7)^2=9^2$
$x^2+(y-7)^2=81$

79. $(x-8)^2+(y-0)^2=\left(\frac{1}{5}\right)^2$
$(x-8)^2+y^2=\frac{1}{25}$

80. $(x-(-10))^2+(y-0)^2=\left(\sqrt{11}\right)^2$
$(x+10)^2+y^2=11$

81. $(x-(-2))^2+(y-12)^2=13^2$
$(x+2)^2+(y-12)^2=169$

82. $\left(x-\frac{2}{7}\right)^2+(y-(-5))^2=7^2$
$\left(x-\frac{2}{7}\right)^2+(y+5)^2=49$

83. $x^2+y^2=1^2 \Rightarrow x^2+y^2-1=0$

84. $x^2+y^2=4^2 \Rightarrow x^2+y^2-16=0$

85. $(x-6)^2+(y-8)^2=4^2$
$x^2-12x+36+y^2-16y+64=16$
$x^2+y^2-12x-16y+84=0$

86. $(x-5)^2+(y-3)^2=2^2$
$x^2-10x+25+y^2-6y+9=4$
$x^2+y^2-10x-6y+30=0$

87. $(x-3)^2+(y+4)^2=\left(\sqrt{2}\right)^2$
$x^2-6x+9+y^2+8y+16=2$
$x^2+y^2-6x+8y+23=0$

88. $(x+9)^2+(y-8)^2=\left(2\sqrt{3}\right)^2$
$x^2+18x+81+y^2-16y+64=12$
$x^2+y^2+18x-16y+133=0$

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EXERCISES 2.5

89. Center: $x = \dfrac{3+3}{2} = 3,\ y = \dfrac{-2+8}{2} = 3$

r = distance from center to endpoint

$$= \sqrt{(3-3)^2 + (3-8)^2} = 5$$

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

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

$$x^2 + y^2 - 6x - 6y - 7 = 0$$

90. Center: $x = \dfrac{-5+5}{2} = 0,\ y = \dfrac{-9+9}{2} = 0$

r = distance from center to endpoint

$$= \sqrt{(0-5)^2 + (0-9)^2} = \sqrt{106}$$

$$(x-0)^2 + (y-0)^2 = \left(\sqrt{106}\right)^2$$

$$x^2 + y^2 = 106$$

$$x^2 + y^2 - 106 = 0$$

91. r = distance from center to origin

$$= \sqrt{(0-(-3))^2 + (0-4)^2} = 5$$

$$(x+3)^2 + (y-4)^2 = 5^2$$

$$x^2 + 6x + 9 + y^2 - 8y + 16 = 25$$

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

92. r = distance from center to origin

$$= \sqrt{(0-(-2))^2 + (0-6)^2} = \sqrt{40}$$

$$(x+2)^2 + (y-6)^2 = \left(\sqrt{40}\right)^2$$

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

$$x^2 + y^2 + 4x - 12y = 0$$

93. $$x^2 + y^2 - 6x + 4y + 4 = 0$$

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

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

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

94. $$x^2 + y^2 + 4x - 8y - 5 = 0$$

$$x^2 + 4x + y^2 - 8y = 5$$

$$x^2 + 4x + 4 + y^2 - 8y + 16 = 5 + 4 + 16$$

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

95. $$x^2 + y^2 - 10x - 12y + 57 = 0$$

$$x^2 - 10x + y^2 - 12y = -57$$

$$x^2 - 10x + 25 + y^2 - 12y + 36 = -57 + 25 + 36$$

$$(x-5)^2 + (y-6)^2 = 4$$

96. $$x^2 + y^2 + 2x + 18y + 57 = 0$$

$$x^2 + 2x + y^2 + 18y = -57$$

$$x^2 + 2x + 1 + y^2 + 18y + 81 = -57 + 1 + 81$$

$$(x+1)^2 + (y+9)^2 = 25$$

97. $$2x^2 + 2y^2 - 8x - 16y + 22 = 0$$

$$x^2 + y^2 - 4x - 8y + 11 = 0$$

$$x^2 - 4x + y^2 - 8y = -11$$

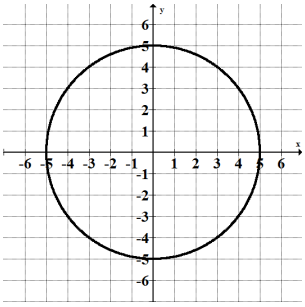
$$x^2 - 4x + 4 + y^2 - 8y + 16 = -11 + 4 + 16$$

$$(x-2)^2 + (y-4)^2 = 9$$

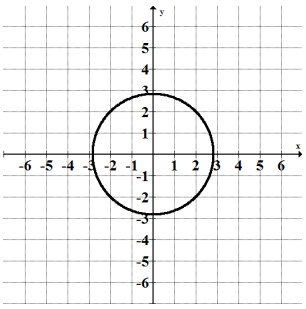
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98.
$$3x^2 + 3y^2 + 6x - 30y + 3 = 0$$
$$x^2 + y^2 + 2x - 10y + 1 = 0$$
$$x^2 + 2x + y^2 - 10y = -1$$
$$x^2 + 2x + 1 + y^2 - 10y + 25 = -1 + 1 + 25$$
$$(x+1)^2 + (y-5)^2 = 25$$

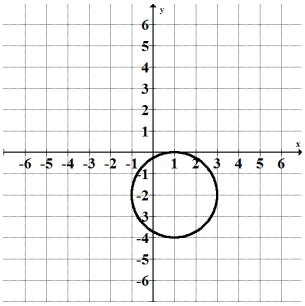
99. $x^2 + y^2 - 25 = 0$
$x^2 + y^2 = 25$
$C(0, 0), r = 5$



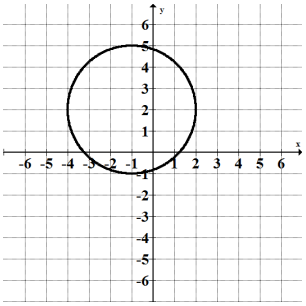
100. $x^2 + y^2 - 8 = 0$
$x^2 + y^2 = 8$
$C(0, 0), r = \sqrt{8} = 2\sqrt{2}$



101. $(x-1)^2 + (y+2)^2 = 4$
$C(1, -2), r = 2$



102. $(x+1)^2 + (y-2)^2 = 9$
$C(-1, 2), r = 3$



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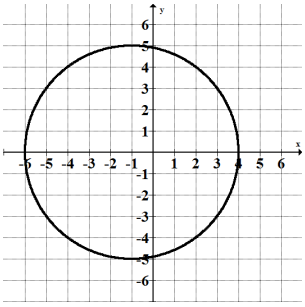
103. $x^2 + y^2 + 2x - 24 = 0$

$x^2 + 2x + y^2 = 24$

$x^2 + 2x + 1 + y^2 = 24 + 1$

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

$C(-1, 0), r = 5$

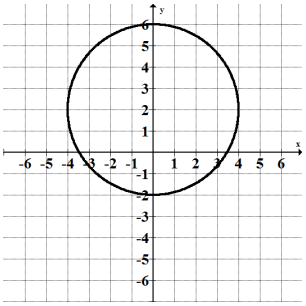


104. $x^2 + y^2 - 4y = 12$

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

$x^2 + (y - 2)^2 = 16$

$C(0, 2), r = 4$



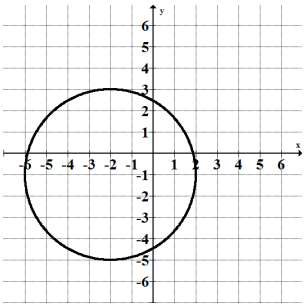
105. $x^2 + y^2 + 4x + 2y - 11 = 0$

$x^2 + 4x + y^2 + 2y = 11$

$x^2 + 4x + 4 + y^2 + 2y + 1 = 11 + 4 + 1$

$(x + 2)^2 + (y + 1)^2 = 16$

$C(-2, -1), r = 4$



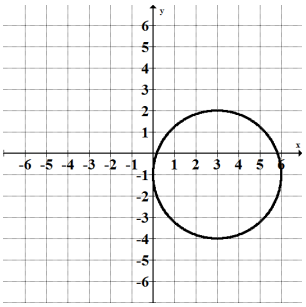
106. $x^2 + y^2 - 6x + 2y + 1 = 0$

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

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

$(x - 3)^2 + (y + 1)^2 = 9$

$C(3, -1), r = 3$



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EXERCISES 2.5

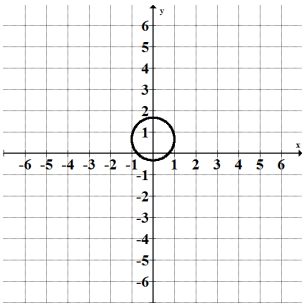
107. $9x^2 + 9y^2 - 12y = 5$

$$x^2 + y^2 - \frac{4}{3}y = \frac{5}{9}$$

$$x^2 + y^2 - \frac{4}{3}y + \frac{4}{9} = \frac{5}{9} + \frac{4}{9}$$

$$x^2 + \left(y - \frac{2}{3}\right)^2 = 1$$

$C\left(0, \frac{2}{3}\right), r = 1$



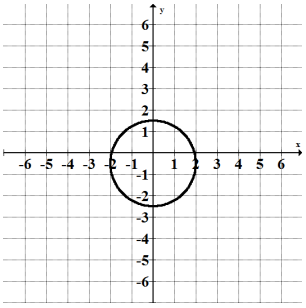
108. $4x^2 + 4y^2 + 4y = 15$

$$x^2 + y^2 + y = \frac{15}{4}$$

$$x^2 + y^2 + y + \frac{1}{4} = \frac{15}{4} + \frac{1}{4}$$

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

$C\left(0, -\frac{1}{2}\right), r = 2$



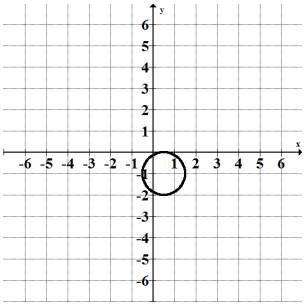
109. $4x^2 + 4y^2 - 4x + 8y + 1 = 0$

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

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

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

$C\left(\frac{1}{2}, -1\right), r = 1$



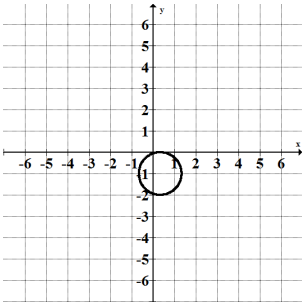
110. $9x^2 + 9y^2 - 6x + 18y + 1 = 0$

$$x^2 + y^2 - \frac{2}{3}x + 2y = -\frac{1}{9}$$

$$x^2 - \frac{2}{3}x + \frac{1}{9} + y^2 + 2y + 1 = -\frac{1}{9} + \frac{1}{9} + 1$$

$$\left(x - \frac{1}{3}\right)^2 + (y+1)^2 = 1$$

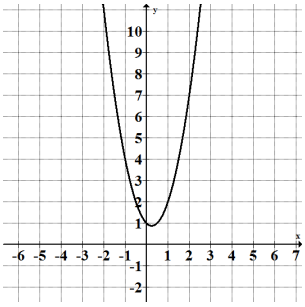
$C\left(\frac{1}{3}, -1\right), r = 1$



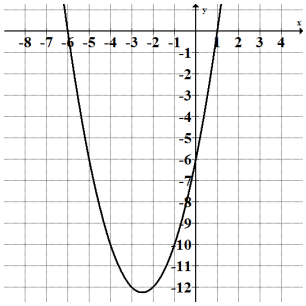
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EXERCISES 2.5

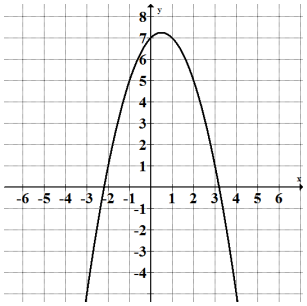
111. $y = 2x^2 - x + 1$
Vertex: $(0.25, 0.88)$



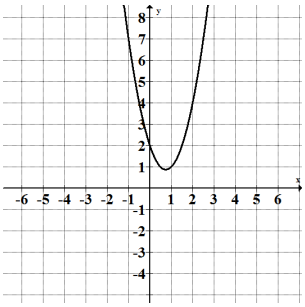
112. $y = x^2 + 5x - 6$
Vertex: $(-2.50, -12.25)$



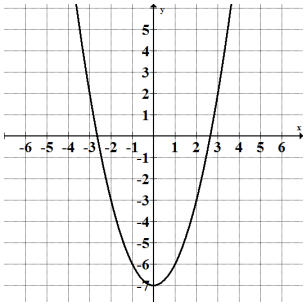
113. $y = 7 + x - x^2$
Vertex: $(0.50, 7.25)$



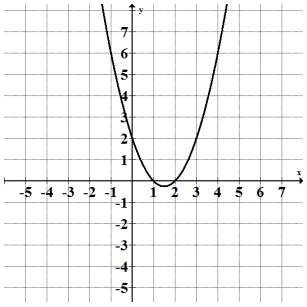
114. $y = 2x^2 - 3x + 2$
Vertex: $(0.75, 0.88)$



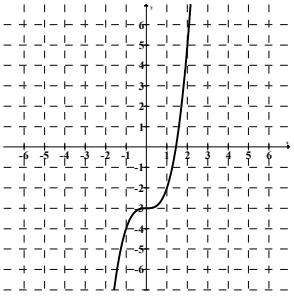
115. Graph $y = x^2 - 7$.
Find the x-intercepts.
$x = -2.65,\ x = 2.65$



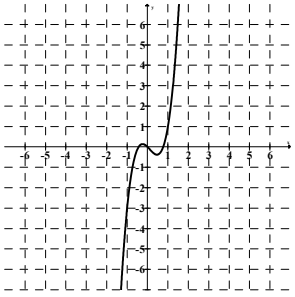
116. Graph $y = x^2 - 3x + 2$.
Find the x-intercepts.
$x = 1.00,\ x = 2.00$



117. Graph $y = x^3 - 3$.
Find the x-intercepts.
$x = 1.44$



118. Graph $y = 3x^3 - x^2 - x$.
Find the x-intercepts.
$x = -0.43,\ x = 0,$
$x = 0.77$



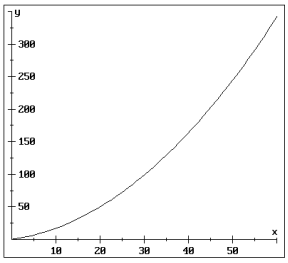
119. Let $y = 0$:
$y = 64t - 16t^2$
$0 = 16t(4 - t)$
$t = 0$ or $t = 4$
It strikes the ground after 4 seconds.

120. From **#119**, the flight lasts 4 seconds. Thus, half the flight is 2 seconds. Let $t = 2$:
$y = 64t - 16t^2$
$y = 64(2) - 16(2)^2 = 128 - 64 = 64$; The highest point is 64 feet above ground.

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EXERCISES 2.5

121. $D = 0.08V^2 + 0.9V$;



122. Refer to the graph for **#121**.
The y-coordinate for $x = 30$ is $y = 99$.
The y-coordinate for $x = 60$ is $y = 342$.
$342 - 99 = 243$
At 60 mph, 243 more feet is required to stop than at 30 mph.

123. $r = \frac{12}{2} = 6$

$$(x-0)^2 + (y-0)^2 = 6^2$$
$$x^2 + y^2 = 36$$

124. $r = 10(2 \text{ in.}) = 20 \text{ in.}$

$$(x-0)^2 + (y-0)^2 = 20^2$$
$$x^2 + y^2 = 400$$

125. $r = \frac{60}{2} = 30$

$$(x-0)^2 + (y-35)^2 = 30^2$$
$$x^2 + (y-35)^2 = 900$$

126. $r = \frac{30}{2} = 15$

$$(x-5)^2 + (y-10)^2 = 15^2$$
$$(x-5)^2 + (y-10)^2 = 225$$

127. $r = \sqrt{(10-7)^2 + (0-4)^2} = 5$

$$(x-7)^2 + (y-4)^2 = 5^2$$
$$x^2 - 14x + 49 + y^2 - 8y + 16 = 25$$
$$x^2 + y^2 - 14x - 8y + 40 = 0$$

128.

First tire	Second tire
$C(12, 12), r = 12$	$C(36, 12), r = 12$
$(x-12)^2 + (y-12)^2 = 12^2$	$(x-36)^2 + (y-12)^2 = 12^2$
$x^2 - 24x + 144 + y^2 - 24y + 144 = 144$	$x^2 - 72x + 1296 + y^2 - 24y + 144 = 144$
$x^2 + y^2 - 24x - 24y + 144 = 0$	$x^2 + y^2 - 72x - 24y + 1296 = 0$

129-132. Answers may vary.

133. $x^2 - 4x + y^2 - 6y + 13 = 0$

$$x^2 - 4x + 4 + y^2 - 6y + 9 = -13 + 4 + 9$$
$$(x+2)^2 + (y-3)^2 = 0 \Rightarrow \text{a single point}$$

134. $x^2 - 12x + y^2 + 4y + 43 = 0$

$$x^2 - 12x + 36 + y^2 + 4y + 4 = -43 + 36 + 4$$
$$(x-6)^2 + (y+2)^2 = -3 \Rightarrow \text{nonexistent}$$

135. False. The graphs are symmetric with respect to the y-axis.

136. False. The graphs are symmetric with respect to the origin.

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137. True.

138. False. The line $y = x$ has symmetry with respect to the origin, but not with respect to either the x- or y-axis.

139. True.

140. True.

141. False. The graph is the single point $\left(4, -\frac{1}{7}\right)$.

142. True.

Exercises 2.6 (page 276)

1. quotient

2. ratios

3. means

4. extremes

5. extremes, means

6. $y = kx$

7. inverse

8. constant

9. joint

10. x^2, z

11.
$$\frac{4}{x} = \frac{2}{7}$$
$$4 \cdot 7 = 2 \cdot x$$
$$28 = 2x$$
$$14 = x$$

12.
$$\frac{5}{2} = \frac{x}{6}$$
$$5 \cdot 6 = x \cdot 2$$
$$30 = 2x$$
$$15 = x$$

13.
$$\frac{x}{2} = \frac{3}{x+1}$$
$$x(x+1) = 3 \cdot 2$$
$$x^2 + x = 6$$
$$x^2 + x - 6 = 0$$
$$(x+3)(x-2) = 0$$
$x = -3$ or $x = 2$

14.
$$\frac{x+5}{6} = \frac{7}{8-x}$$
$$(x+5)(8-x) = 7 \cdot 6$$
$$-x^2 + 3x + 40 = 42$$
$$0 = x^2 - 3x + 2$$
$$0 = (x-2)(x-1)$$
$x = 1$ or $x = 2$

15. Let $x =$ the number of women.
$$\tfrac{3}{5} = \tfrac{x}{30}$$
$$3 \cdot 30 = 5 \cdot x$$
$$90 = 5x$$
$18 = x \Rightarrow$ There are 18 women.

16. Let $x =$ the number of bags of lime.
$$\tfrac{3}{7} = \tfrac{x}{21}$$
$$3 \cdot 21 = x \cdot 7$$
$$63 = 7x$$
$9 = x \Rightarrow$ 9 bags of lime should be used.

17.
$$y = kx$$
$$15 = k(30)$$
$$\tfrac{1}{2} = k$$

18.
$$z = kt$$
$$21 = k(7)$$
$$3 = k$$

19.
$$I = \frac{k}{R}$$
$$50 = \frac{k}{20}$$
$$1000 = k$$

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EXERCISES 2.6

20.
$$R = \frac{k}{I^2}$$
$$100 = \frac{k}{25^2}$$
$$100 = \frac{k}{625}$$
$$62500 = k$$

21.
$$E = kIR$$
$$125 = k(5)(25)$$
$$125 = 125k$$
$$1 = k$$

22.
$$z = k(x+y)$$
$$28 = k(2+5)$$
$$28 = 7k$$
$$4 = k$$

23.
$$y = kx$$
$$15 = k(4)$$
$$\tfrac{15}{4} = k$$

$$y = \tfrac{15}{4}x$$
$$y = \tfrac{15}{4} \cdot \tfrac{7}{5}$$
$$y = \tfrac{21}{4}$$

24.
$$w = kz$$
$$-6 = k(2)$$
$$-3 = k$$

$$w = -3z$$
$$w = -3(-3)$$
$$w = 9$$

25.
$$w = \frac{k}{z}$$
$$10 = \frac{k}{3}$$
$$30 = k$$

$$w = \frac{30}{z}$$
$$w = \frac{30}{5}$$
$$w = 6$$

26.
$$y = \frac{k}{x}$$
$$100 = \frac{k}{2}$$
$$200 = k$$

$$y = \frac{200}{x}$$
$$y = \frac{200}{50}$$
$$y = 4$$

27.
$$P = krs$$
$$16 = k(5)(-8)$$
$$16 = -40k$$
$$-\tfrac{16}{40} = k$$
$$-\tfrac{2}{5} = k$$

$$P = -\tfrac{2}{5}rs$$
$$P = -\tfrac{2}{5}(2)(10)$$
$$P = -8$$

28.
$$m = kn^2\sqrt{q}$$
$$24 = k(2)^2\sqrt{4}$$
$$24 = k(4)(2)$$
$$24 = 8k$$
$$3 = k$$

$$m = 3n^2\sqrt{q}$$
$$m = 3(5)^2\sqrt{9}$$
$$m = 3(25)(3)$$
$$m = 225$$

29. direct

30. neither

31. neither

32. inverse

33. Let $x =$ the amount of caffeine.

$$\tfrac{55}{12} = \tfrac{x}{44}$$
$$55 \cdot 44 = 12 \cdot x$$
$$2420 = 12x$$
$$202 \text{ mg} \approx x$$

$$\tfrac{47}{12} = \tfrac{x}{44}$$
$$47 \cdot 44 = 12 \cdot x$$
$$2068 = 12x$$
$$172 \text{ mg} \approx x$$

$$\tfrac{37}{12} = \tfrac{x}{44}$$
$$37 \cdot 44 = 12 \cdot x$$
$$1628 = 12x$$
$$136 \text{ mg} \approx x$$

34. Let $x =$ the number of phones.

$$\tfrac{221}{250} = \tfrac{x}{280000}$$
$$221 \cdot 280000 = 250 \cdot x$$
$$61880000 = 250x$$
$$247{,}520 = x$$

247,520 have cellular phones.

35. Let $x =$ the amount of adhesive needed.

$$\tfrac{\frac{1}{2}}{140} = \tfrac{x}{500}$$
$$\frac{1}{2} \cdot 500 = 140 \cdot x$$
$$250 = 140x$$
$$1.79 \approx x$$

About 2 gallons of adhesive will be needed.

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EXERCISES 2.6

36. Let $x =$ the dosage.

$$\frac{0.006}{1} = \frac{x}{30}$$
$$0.006 \cdot 30 = 1 \cdot x$$
$$0.18 = x$$

The dosage should be 0.18 g, or 180 mg.

37.
$$V = \frac{kT}{P} \qquad V = \frac{\frac{80}{33}T}{P}$$
$$20 = \frac{k(330)}{40} \qquad V = \frac{\frac{80}{33}(300)}{50}$$
$$800 = 330k \qquad V = \frac{\frac{8000}{11}}{50}$$
$$\frac{800}{330} = k \qquad V = \frac{160}{11} = 14\frac{6}{11} \text{ ft}^3$$
$$\frac{80}{33} = k$$

38.
$$f = kd \qquad f = 25d$$
$$5 = k(0.2) \qquad f = 25(0.35)$$
$$25 = k \qquad f = 8.75 \text{ Newtons}$$

39.
$$d = kt^2 \qquad d = 16t^2$$
$$16 = k(1)^2 \qquad 144 = 16t^2$$
$$16 = k \qquad 9 = t^2$$
$$3 = t \Rightarrow 3 \text{ seconds}$$

40.
$$P = \frac{kV^2}{R} \qquad P = \frac{V^2}{R}$$
$$20 = \frac{k(20)^2}{20} \qquad 40 = \frac{V^2}{10}$$
$$400 = 400k \qquad 400 = V^2$$
$$1 = k \qquad 20 = V \Rightarrow 20 \text{ volts}$$

41.
$$t = kl^2 \qquad t = l^2$$
$$1 = k(1)^2 \qquad 2 = l^2$$
$$1 = k \qquad \sqrt{2} = l \Rightarrow \sqrt{2} \text{ meters}$$

42.
$$f = k\sqrt{T} \qquad f = \frac{144}{\sqrt{2}}\sqrt{T}$$
$$144 = k\sqrt{2} \qquad f = \frac{144}{\sqrt{2}}\sqrt{18}$$
$$\frac{144}{\sqrt{2}} = k \qquad f = 144\sqrt{9}$$
$$f = 144(3) = 432 \text{ hertz}$$

43.
$$I = \frac{k}{d^2} \qquad I = \frac{6000}{d^2}$$
$$60 = \frac{k}{10^2} \qquad I = \frac{6000}{20^2}$$
$$60 = \frac{k}{100} \qquad I = \frac{6000}{400}$$
$$6000 = k \qquad I = 15 \Rightarrow 15 \text{ lumens}$$

44.
$$I = \frac{k}{d^2} \qquad I = \frac{22500}{d^2}$$
$$100 = \frac{k}{15^2} \qquad I = \frac{22500}{25^2}$$
$$100 = \frac{k}{225} \qquad I = \frac{22500}{625}$$
$$22500 = k \qquad I = 36 \Rightarrow 36 \text{ lumens}$$

45.
$$E = kmv^2 = k(2m)(3v)^2$$
$$= k(2m)\left(9v^2\right)$$
$$= 18 \cdot kmv^2$$

The energy is multiplied by 18.

46.
$$P = kRC^2 \qquad P = RC^2$$
$$10 = k(10)(1)^2 \qquad P = 5(3)^2$$
$$10 = 10k \qquad P = 5(9)$$
$$1 = k \qquad P = 45 \text{ watts}$$

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EXERCISES 2.6

47. $G = \dfrac{km_1m_2}{d^2} = \dfrac{k(3m_1)(3m_2)}{(2d)^2}$

$= \dfrac{k \cdot 9m_1m_2}{4d^2}$

$= \dfrac{9}{4} \cdot \dfrac{km_1m_2}{d^2}$

The force is multiplied by $\dfrac{9}{4}$.

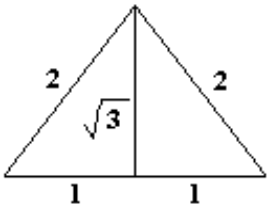
48. $G = \dfrac{km_1m_2}{d^2} = \dfrac{k(2m_1)(3m_2)}{\left(\frac{d}{2}\right)^2}$

$= \dfrac{k \cdot 6m_1m_2}{\frac{d^2}{4}}$

$= 24 \cdot \dfrac{km_1m_2}{d^2}$

The force is multiplied by 24.

49. Consider this figure:



$h = \sqrt{3}$ can be computed using the Pythagorean Theorem.

$A = \dfrac{1}{2}bh = \dfrac{1}{2}(2)\sqrt{3} = \sqrt{3}$

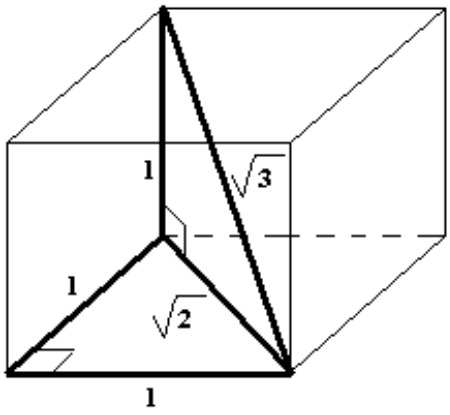
$A = ks^2$

$\sqrt{3} = k(2)^2$

$\sqrt{3} = 4k$

$\dfrac{\sqrt{3}}{4} = k$

50. Consider this figure:



The diagonal is obtained by repeatedly using the Pythagorean Theorem.

$d = ks$

$\sqrt{3} = k(1)$

$\sqrt{3} = k$

51-58. Answers may vary.

59. d **60.** c **61.** b **62.** a

63. c **64.** d **65.** a **66.** b

Chapter 2 Review (page 279)

1. D $= \{3, 4, 5, 6\}$; R $= \{4, 5, 6, 7\}$
Each element of the domain is paired with only one element of the range. Function.

2. D $= \{2, 3, -4\}$; R $= \{4, 5, 6, 3\}$
2 is both paired with 4 and 5. Not a function.

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3. $y = 3$
Each value of x is paired with only one value of y.
function

4. $y + 5x^2 = 2$
$y = -5x^2 + 2$
Each value of x is paired with only one value of y.
function

5. $y^2 - x = 5$
$y^2 = x + 5$
$y = \pm\sqrt{x+5}$
Each value of x is paired with more than one value of y. **not a function**

6. $y = |x| + x$
Each value of x is paired with only one value of y.
function

7. $f(x) = y = 3x^2 - 5$
domain $= (-\infty, \infty)$

8. $f(x) = y = \dfrac{3x}{x-5}$
domain $= (-\infty, 5) \cup (5, \infty)$

9. $f(x) = \dfrac{3x}{4x^2 - 16} = \dfrac{3x}{4(x+2)(x-2)}$
$x \neq -2, x \neq 2$
domain $= (-\infty, -2) \cup (-2, 2) \cup (2, \infty)$

10. $f(x) = y = \sqrt{x-1}$
domain $= [1, \infty)$

11. $f(x) = y = \sqrt{5-x}$
domain $= (-\infty, 5]$

12. $f(x) = y = \sqrt{x^2+1}$
$x^2 + 1 \geq 0 \Rightarrow$ domain $= (-\infty, \infty)$

13. $f(x) = 5x - 2$
$f(2) = 5(2) - 2 = 8$
$f(-3) = 5(-3) - 2 = -17$
$f(k) = 5k - 2$

14. $f(x) = \dfrac{6}{x-5}$
$f(2) = \dfrac{6}{2-5} = \dfrac{6}{-3} = -2$
$f(-3) = \dfrac{6}{-3-5} = \dfrac{6}{-8} = -\dfrac{3}{4}$
$f(k) = \dfrac{6}{k-5}$

15. $f(x) = |x - 2|$
$f(2) = |2 - 2| = |0| = 0$
$f(-3) = |-3 - 2| = |-5| = 5$
$f(k) = |k - 2|$

16. $f(x) = \dfrac{x^2 - 3}{x^2 + 3}$
$f(2) = \dfrac{2^2 - 3}{2^2 + 3} = \dfrac{1}{7}$
$f(-3) = \dfrac{(-3)^2 - 3}{(-3)^2 + 3} = \dfrac{6}{12} = \dfrac{1}{2}$
$f(k) = \dfrac{k^2 - 3}{k^2 + 3}$

17. $\dfrac{f(x+h) - f(x)}{h} = \dfrac{[5(x+h) - 6] - [5x - 6]}{h} = \dfrac{[5x + 5h - 6] - [5x - 6]}{h}$
$= \dfrac{5x + 5h - 6 - 5x + 6}{h} = \dfrac{5h}{h} = 5$

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18. $$\frac{f(x+h)-f(x)}{h} = \frac{\left[2(x+h)^2-7(x+h)+3\right]-\left[2x^2-7x+3\right]}{h}$$
$$= \frac{[2x^2+4xh+2h^2-7x-7h+3]-[2x^2-7x+3]}{h}$$
$$= \frac{2x^2+4xh+2h^2-7x-7h+3-2x^2+7x-3}{h}$$
$$= \frac{4xh+2h^2-7h}{h} = \frac{h(4x+2h-7)}{h} = 4x+2h-7$$

19. $f(x) = -0.6x + 132$
$f(45) = -0.6(45) + 132 = 105$

20. **a.** $I(h) = 3.5h - 50$
b. $I(200) = 3.5(200) - 50 = \$650$

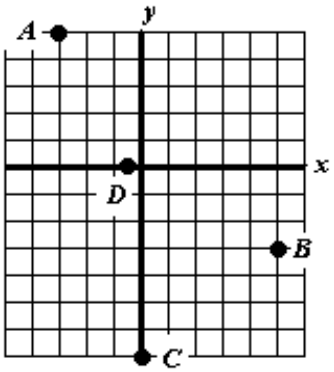
21. $A(2, 0)$ **22.** $B(-2, 1)$ **23.** $C(0, -1)$ **24.** $D(3, -1)$

25. $A(-3, 5)$: QII

26. $B(5, -3)$: QIV

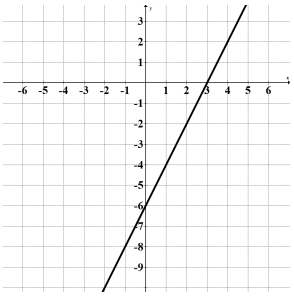
27. $C(0, -7)$: negative y-axis

28. $D\left(-\frac{1}{2}, 0\right)$: negative x-axis



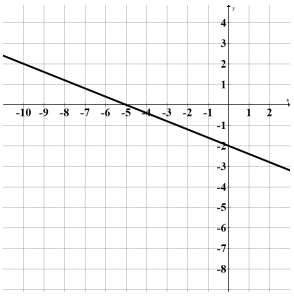
29. $2x - y = 6$
$-y = -2x + 6$
$y = 2x - 6$

x	y
0	-6
2	-2



30. $2x + 5y = -10$
$5y = -2x - 10$
$y = -\frac{2}{5}x - 2$

x	y
0	-2
-5	0



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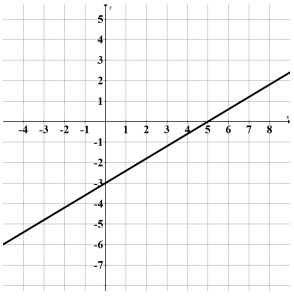
31. $3x - 5y = 15$ $\quad$ $3x - 5y = 15$

$3x - 5(0) = 15$ $\quad$ $3(0) - 5y = 15$

$3x = 15$ $\quad$ $-5y = 15$

$x = 5$ $\quad$ $y = -3$

$(5, 0)$ $\quad$ $(0, -3)$

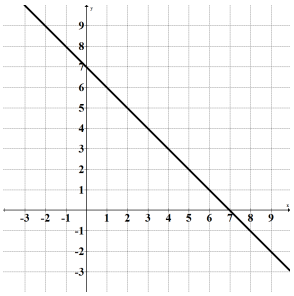


32. $x + y = 7$ $\quad$ $x + y = 7$

$x + 0 = 7$ $\quad$ $0 + y = 7$

$x = 7$ $\quad$ $y = 7$

$(7, 0)$ $\quad$ $(0, 7)$

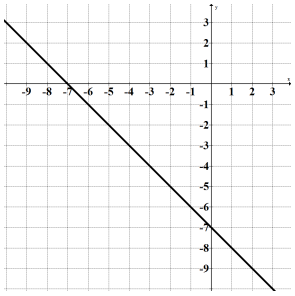


33. $x + y = -7$ $\quad$ $x + y = -7$

$x + 0 = -7$ $\quad$ $0 + y = -7$

$x = -7$ $\quad$ $y = -7$

$(-7, 0)$ $\quad$ $(0, -7)$



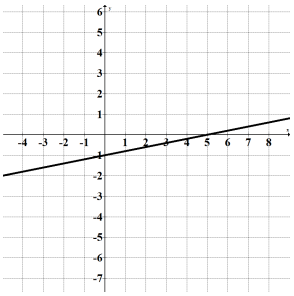
34. $x - 5y = 5$ $\quad$ $x - 5y = 5$

$x - 5(0) = 5$ $\quad$ $0 - 5y = 5$

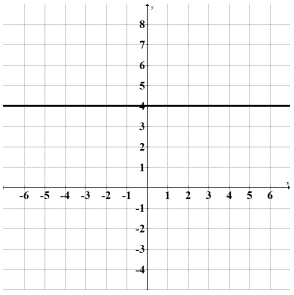
$x = 5$ $\quad$ $-5y = 5$

$(5, 0)$ $\quad$ $y = -1$

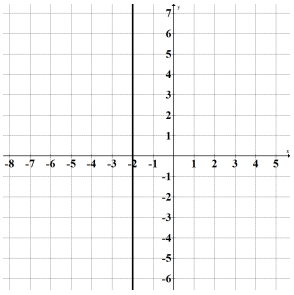
$(0, -1)$



35. $y = 4 \Rightarrow$ horizontal



36. $x = -2 \Rightarrow$ vertical



37. Let $x = 3$: $\quad y = -2200x + 18{,}750 = -2200(3) + 18{,}750 = -6600 + 18{,}750 = \$12{,}150$

38. Let $x = 5$: $\quad y = 16{,}500x + 250{,}000 = 16{,}500(5) + 250{,}000 = 82{,}500 + 250{,}000 = \$332{,}500$

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39. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{(-3 - 3)^2 + (7 - (-1))^2}$
$= \sqrt{(-6)^2 + (8)^2}$
$= \sqrt{36 + 64} = \sqrt{100} = 10$

40. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{(-12 - (-8))^2 + (10 - 6)^2}$
$= \sqrt{(-4)^2 + 4^2}$
$= \sqrt{16 + 16} = \sqrt{32} = 4\sqrt{2}$

41. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{\left(\sqrt{3} - \sqrt{3}\right)^2 + (9 - 7)^2}$
$= \sqrt{0^2 + (2)^2}$
$= \sqrt{0 + 4} = \sqrt{4} = 2$

42. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{(a - (-a))^2 + (-a - a)^2}$
$= \sqrt{(2a)^2 + (-2a)^2}$
$= \sqrt{4a^2 + 4a^2} = \sqrt{8a^2} = 2\sqrt{2}|a|$

43. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{-3 + 3}{2}, \frac{7 + (-1)}{2}\right) = M\left(\frac{0}{2}, \frac{6}{2}\right) = M(0, 3)$

44. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{0 + (-12)}{2}, \frac{5 + 10}{2}\right) = M\left(\frac{-12}{2}, \frac{15}{2}\right) = M\left(-6, \frac{15}{2}\right)$

45. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{\sqrt{3} + \sqrt{3}}{2}, \frac{9 + 7}{2}\right) = M\left(\frac{2\sqrt{3}}{2}, \frac{16}{2}\right) = M\left(\sqrt{3}, 8\right)$

46. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{a + (-a)}{2}, \frac{-a + a}{2}\right) = M\left(\frac{0}{2}, \frac{0}{2}\right) = M(0, 0)$

47. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{7 - (-5)}{1 - 3} = \frac{12}{-2} = -6$

48. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7 - 7}{-5 - 2} = \frac{-14}{-7} = 2$

49. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{1}{2} - (-8)}{5 - 5} = \frac{8\frac{1}{2}}{0}$: und.

50. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-8 - (-8)}{-1 - \frac{2}{3}} = \frac{0}{-1\frac{2}{3}} = 0$

51. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{b - a}{a - b} = -1$

52. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(b - a) - b}{b - (a + b)} = \frac{-a}{-a} = 1$

53. $y = 3x + 6$ $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9 - 6}{1 - 0} = \frac{3}{1} = 3$

x	y
0	6
1	9

54. $y = -\frac{1}{5}x - 6$ $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7 - (-6)}{5 - 0} = \frac{-1}{5} = -\frac{1}{5}$

x	y
0	-6
5	-7

55. The slope is zero.

56. The slope is undefined.

57. The slope is negative.

58. The slope is positive.

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59. $m_1 m_2 = 5\left(-\frac{1}{5}\right) = -1$
perpendicular

60. $m_1 \neq m_2;\ m_1 m_2 = \frac{2}{7} \cdot \frac{7}{2} = 1 \neq -1$
neither

61.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{10-5}{6-(-2)} = \frac{5}{8}$$
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{y-2}{10-2} = \frac{5}{8}$$
$$8(y-2) = 5(8)$$
$$8y - 16 = 40$$
$$8y = 56$$
$$y = 7$$

62.
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{10-5}{6-(-2)} = \frac{5}{8}$$
$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3-5}{x-(-2)} = \frac{-8}{5}$$
$$5(-8) = -8(x+2)$$
$$-40 = -8x - 16$$
$$8x = 24$$
$$x = 3$$

63. $m = \dfrac{\Delta y}{\Delta x} = \dfrac{3000}{15} = 200$ ft per minute

64. $m = \dfrac{\Delta y}{\Delta x} = \dfrac{147{,}500 - 50{,}000}{3-1} = \dfrac{97{,}500}{2} = \$48{,}750$ per year

65.
$$y = mx + b$$
$$y = \frac{2}{3}x + 3$$

66.
$$y = mx + b$$
$$y = -\frac{3}{2}x - 5$$

67.
$$3x - 2y = 10$$
$$-2y = -3x + 10$$
$$y = \tfrac{3}{2}x - 5$$
$m = \frac{3}{2}$, $(0, -5)$

68.
$$2x + 4y = -8$$
$$4y = -2x - 8$$
$$y = -\tfrac{1}{2}x - 2$$
$m = -\frac{1}{2}$, $(0, -2)$

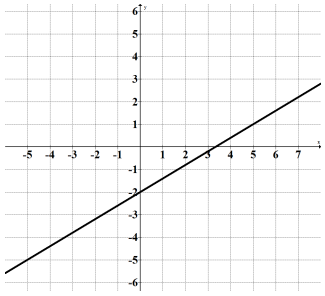
69.
$$-2y = -3x + 10$$
$$y = \tfrac{3}{2}x - 5$$
$m = \frac{3}{2}$, $(0, -5)$

70.
$$2x = -4y - 8$$
$$4y = -2x - 8$$
$$y = -\tfrac{1}{2}x - 2$$
$m = -\frac{1}{2}$, $(0, -2)$

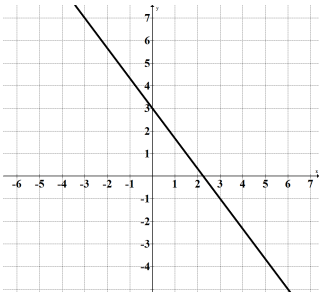
71.
$$5x + 2y = 7$$
$$2y = -5x + 7$$
$$y = -\tfrac{5}{2}x + \tfrac{7}{2}$$
$m = -\frac{5}{2}$, $\left(0, \frac{7}{2}\right)$

72.
$$3x - 4y = 14$$
$$-4y = -3x + 14$$
$$y = \tfrac{3}{4}x - \tfrac{7}{2}$$
$m = \frac{3}{4}$, $\left(0, -\frac{7}{2}\right)$

73.
$$y = \frac{3}{5}x - 2$$
$$m = \frac{3}{5},\ b = -2$$



74.
$$y = -\frac{4}{3}x + 3$$
$$m = -\frac{4}{3},\ b = 3$$



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75. $y = 3x + 8$ $\quad m = 3$

$2y = 6x - 19$

$y = 3x - \frac{19}{2}$

$m = 3$

The lines are parallel.

76. $2x + 3y = 6$

$3y = -2x + 6$

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

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

$3x - 2y = 15$

$-2y = -3x + 15$

$y = \frac{3}{2}x - \frac{15}{2}$

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

The lines are perpendicular.

77. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{7 - 0}{-5 - 0} = -\dfrac{7}{5}$

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

$y - 0 = -\dfrac{7}{5}(x - 0)$

$y = -\dfrac{7}{5}x$

$5y = 5\left(-\dfrac{7}{5}x\right)$

$5y = -7x$

$7x + 5y = 0$

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

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

$y - 1 = -4x - 8$

$4x + y = -7$

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

$y + 1 = -\dfrac{1}{5}(x - 2)$

$5(y + 1) = 5 \cdot \left[-\dfrac{1}{5}(x - 2)\right]$

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

$5y + 5 = -x + 2$

$x + 5y = -3$

80. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{1 - (-5)}{4 - 7} = \dfrac{6}{-3} = -2$

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

$y + 5 = -2(x - 7)$

$y + 5 = -2x + 14$

$2x + y = 9$

81. $m = 0 \Rightarrow$ horizontal

$y = 17$

82. m is undefined $\Rightarrow$ vertical

$x = -5$

83. $3x - 4y = 7$

$-4y = -3x + 7$

$y = \dfrac{3}{4}x - \dfrac{7}{4}$

$m = \dfrac{3}{4}$

Use $m = \dfrac{3}{4}$.

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

$y - 0 = \dfrac{3}{4}(x - 2)$

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

84. $m = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{-10 - 4}{4 - 2} = -7$

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

$y + 2 = -7(x - 7)$

$y + 2 = -7x + 49$

$y = -7x + 47$

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85. $x + 3y = 4$

$3y = -x + 4$

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

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

Use $m = 3$.

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

$y - 5 = 3(x - 0)$

$y - 5 = 3x$

$y = 3x + 5$

86. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-10 - 4}{4 - 2} = -7$

Use $m = \frac{1}{7}$.

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

$y + 2 = \frac{1}{7}(x - 7)$

$y + 2 = \frac{1}{7}x - 1$

$y = \frac{1}{7}x - 3$

87. Let $x =$ the number of rolls hung and let $y =$ the total charge. Then two points on the line are given: $(11, 177)$ and $(20, 294)$

$m = \frac{294 - 177}{20 - 11} = \frac{117}{9} = 13$

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

$y - 177 = 13(x - 11)$

$y - 177 = 13x - 143$

$y = 13x + 34$

Let $x = 27$:

$y = 13(27) + 34 = 385$. The charge is \$385.

88. $14x + 18y = 5040$

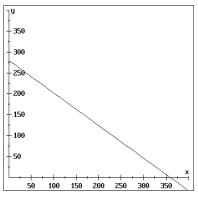
Let $x = 180$:

$14(180) + 18y = 5040$

$2520 + 18y = 5040$

$18y = 2520$

$y = 140$



140 hours of tutoring Spanish

89. $y = 4x - 8x^2$

$0 = 4x(1 - 2x)$

$x = 0, x = \frac{1}{2}$

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

$y = 4x - 8x^2$

$y = 4(0) - 8(0)^2$

$y = 0$

y-int: $(0, 0)$

90. $y = x^2 - 10x - 24$

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

$x = 12, x = -2$

x-int: $(12, 0), (-2, 0)$

$y = x^2 - 10x - 24$

$y = 0^2 - 10(0) - 24$

$y = -24$

y-int: $(0, -24)$

91. $y^2 = 8x$

x-axis	y-axis	origin
$(-y)^2 = 8x$	$y^2 = 8(-x)$	$(-y)^2 = 8(-x)$
$y^2 = 8x$	$y^2 = -8x$	$y^2 = -8x$
equivalent: symmetry	not equivalent: no symmetry	not equivalent: no symmetry

92. $y = 3x^4 + 6$

x-axis	y-axis	origin
$-y = 3x^4 + 6$	$y = 3(-x)^4 + 6$	$-y = 3(-x)^4 + 6$
not equivalent: no symmetry	$y = 3x^4 + 6$	$-y = 3x^4 + 6$
	equivalent: symmetry	not equivalent: no symmetry

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93.

$y = -2|x|$

x-axis	y-axis	origin
$-y = -2\|x\|$	$y = -2\|-x\|$	$-y = -2\|-x\|$
$y = 2\|x\|$	$y = -2\|-1\|\|x\|$	$y = 2\|-x\|$
not equivalent: no symmetry	$y = -2\|x\|$	$y = 2\|-1\|\|x\|$
	equivalent: symmetry	$y = 2\|x\|$
		not equivalent: no symmetry

94.

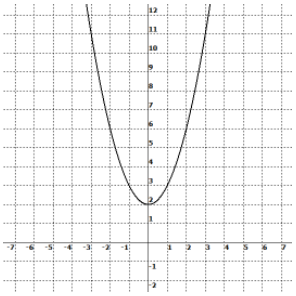
$y = |x + 2|$

x-axis	y-axis	origin
$-y = \|x + 2\|$	$y = \|-x + 2\|$	$-y = \|-x + 2\|$
not equivalent: no symmetry	not equivalent: no symmetry	not equivalent: no symmetry

95. $y = x^2 + 2$

x-int: none, y-int: $(0, 2)$

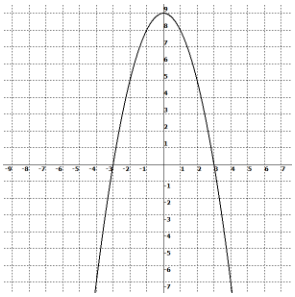
symmetry: y-axis



96. $y = -x^2 + 9$

x-int: $(\pm 3, 0)$, y-int: $(0, 9)$

symmetry: y-axis

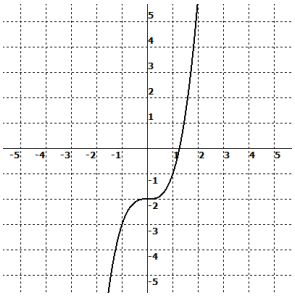


97. $y = x^3 - 2$

x-int: $\left(\sqrt[3]{2}, 0\right)$,

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

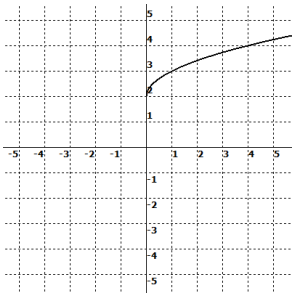
symmetry: none



98. $y = \sqrt{x} + 2$

x-int: none, y-int: $(0, 2)$

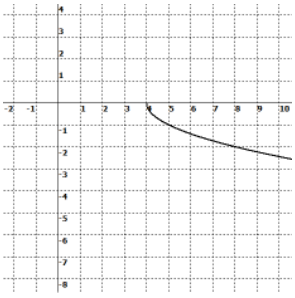
symmetry: none



99. $y = -\sqrt{x - 4}$

x-int: $(4, 0)$, y-int: none

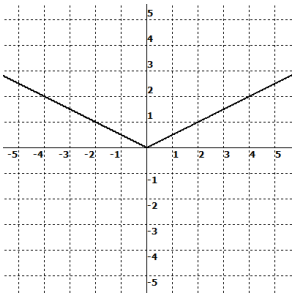
symmetry: none



100. $y = \frac{1}{2}|x|$

x-int: $(0, 0)$, y-int: $(0, 0)$

symmetry: y-axis



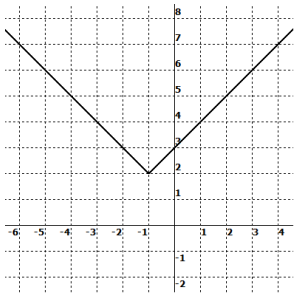
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CHAPTER 2 REVIEW

101. $y = |x+1| + 2$

x-int: none, y-int: $(0, 3)$

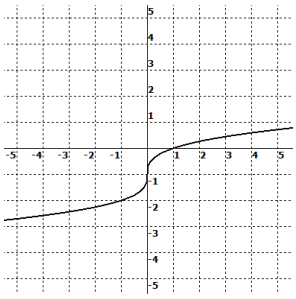
symmetry: none



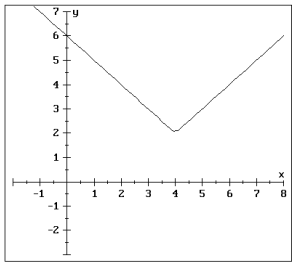
102. $y = \sqrt[3]{x} - 1$

x-int: $(1, 0)$, y-int: $(0, -1)$

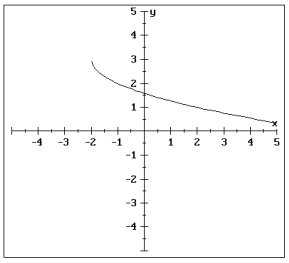
symmetry: none



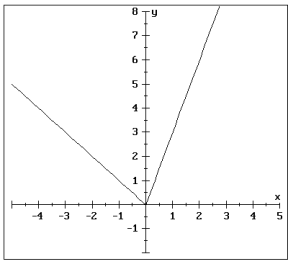
103. $y = |x-4| + 2$



104. $y = -\sqrt{x+2} + 3$

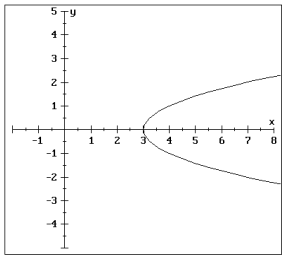


105. $y = x + 2|x|$



106. $y^2 = x - 3$

Graph $y = \pm\sqrt{x-3}$.



107. $x^2 + y^2 = 64$

$(x-0)^2 + (y-0)^2 = 8^2$

C: $(0, 0)$; $r = 8$

108. $x^2 + (y-6)^2 = 100$

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

C: $(0, 6)$; $r = 10$

109. $(x+7)^2 + y^2 = \frac{1}{4}$

$(x-(-7))^2 + (y-0)^2 = \left(\frac{1}{2}\right)^2$

C: $(-7, 0)$; $r = \frac{1}{2}$

110. $(x-5)^2 + (y+1)^2 = 9$

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

C: $(5, -1)$; $r = 3$

111. $(x-0)^2 + (y-0)^2 = 7^2$

$x^2 + y^2 = 49$

112. $(x-3)^2 + (y-0)^2 = \left(\frac{1}{5}\right)^2$

$(x-3)^2 + y^2 = \frac{1}{25}$

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

$(x+2)^2 + (y-12)^2 = 25$

114. $\left(x-\frac{2}{7}\right)^2 + (y-5)^2 = 9^2$

$\left(x-\frac{2}{7}\right)^2 + (y-5)^2 = 81$

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115. $C(-3, 4); r = 12$

$(x-h)^2 + (y-k)^2 = r^2$

$(x+3)^2 + (y-4)^2 = 144$

or $x^2 + y^2 + 6x - 8y - 119 = 0$

116. Center: $x = \dfrac{-6+5}{2} = -\dfrac{1}{2}$

$y = \dfrac{-3+8}{2} = \dfrac{5}{2}$

r = distance from center to endpoint

$= \sqrt{\left(-\frac{1}{2} - 5\right)^2 + \left(\frac{5}{2} - 8\right)^2} = \sqrt{\frac{121}{2}}$

$\left(x + \frac{1}{2}\right)^2 + \left(y - \frac{5}{2}\right)^2 = \frac{121}{2}$, or

$x^2 + y^2 + x - 5y - 54 = 0$

117. $x^2 + y^2 + 6x - 4y + 4 = 0$

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

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

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

118. $2x^2 + 2y^2 - 8x - 16y - 10 = 0$

$x^2 + y^2 - 4x - 8y - 5 = 0$

$x^2 - 4x + y^2 - 8y = 5$

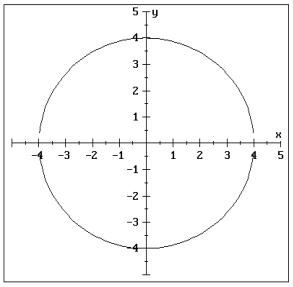
$x^2 - 4x + 4 + y^2 - 8y + 16 = 5 + 4 + 16$

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

119. $x^2 + y^2 - 16 = 0$

$(x-0)^2 + (y-0)^2 = 16$

$C(0, 0), r = 4$



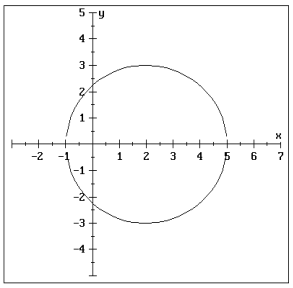
120. $x^2 + y^2 - 4x = 5$

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

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

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

$C(2, 0), r = 3$

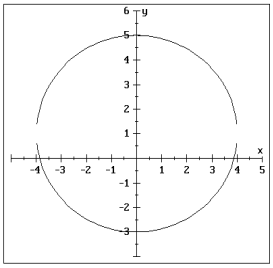


121. $x^2 + y^2 - 2y = 15$

$x^2 + y^2 - 2y + 1 = 15 + 1$

$x^2 + (y-1)^2 = 16$

$C(0, 1), r = 4$

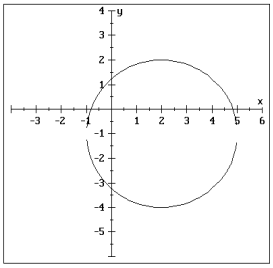


122. $x^2 + y^2 - 4x + 2y = 4$

$x^2 - 4x + 4 + y^2 + 2y + 1 = 4 + 4 + 1$

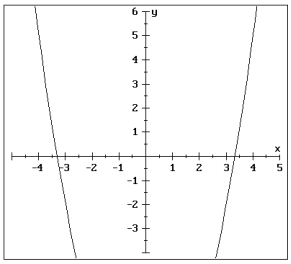
$(x-2)^2 + (y+1)^2 = 9$

$C(2, -1), r = 3$

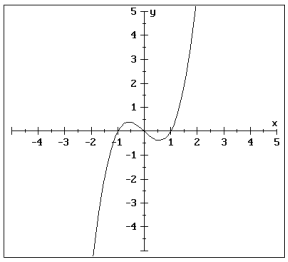


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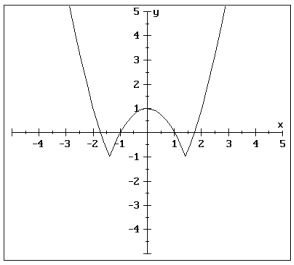
123. Graph $y = x^2 - 11$.
Find the x-intercepts.
$x = -3.32,\ x = 3.32$



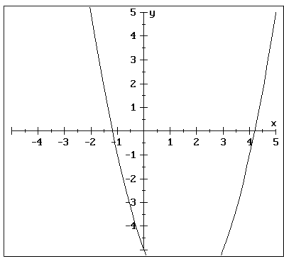
124. Graph $y = x^3 - x$.
Find the x-intercepts.
$x = -1,\ x = 0, x = 1$



125. Graph $y = \left|x^2 - 2\right| - 1$.
Find the x-intercepts.
$x = -1.73,\ x = -1, x = 1, x = 1.73$



126. Graph $y = x^2 - 3x - 5$.
Find the x-intercepts.
$x = -1.19,\ x = 4.19$



127.
$$\frac{x+3}{10} = \frac{x-1}{x}$$
$$x(x+3) = 10(x-1)$$
$$x^2 + 3x = 10x - 10$$
$$x^2 - 7x + 10 = 0$$
$$(x-5)(x-2) = 0$$
$$x = 5 \text{ or } x = 2$$

128.
$$\frac{x-1}{2} = \frac{12}{x+1}$$
$$(x+1)(x-1) = 2(12)$$
$$x^2 - 1 = 24$$
$$x^2 = 25$$
$$x = \pm 5$$

129. Let $x =$ the dosage needed.
$$\frac{250}{110} = \frac{x}{176}$$
$$250 \cdot 176 = 110 \cdot x$$
$$44000 = 110x$$
$$400 = x$$
The dosage is 400 mg.

130.
$$f = ks$$
$$3 = k(5)$$
$$\frac{3}{5} = k$$
$$f = \frac{3}{5}s$$
$$f = \frac{3}{5}(3)$$
$$f = \frac{9}{5}\text{pounds}$$

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131. $E = kv^2$

30 mph: $E = k(30)^2$, $E = 900k$

50 mph: $E = k(50)^2$, $E = 2500k$

Factor of increase $= \dfrac{2500k}{900k} = \dfrac{25}{9}$

132. $V = \dfrac{kT}{P}$

$400 = \dfrac{k(300)}{25}$

$10000 = 300k$

$\frac{100}{3} = k$

$V = \dfrac{\frac{100}{3}T}{P}$

$V = \dfrac{\frac{100}{3}(200)}{20}$

$V = \frac{1000}{3}$

$V = 333\frac{1}{3}$ cm^3

133. $A = klw$

$A = 1lw \Rightarrow k = 1$

134. $R = \dfrac{kL}{D^2}$

$200 = \dfrac{k(1000)}{(.05)^2}$

$200 = \dfrac{1000k}{.0025}$

$0.0005 = k$

$R = \dfrac{0.0005L}{D^2}$

$V = \dfrac{0.0005(1500)}{(0.08)^2}$

$V \approx 117$ ohms

Chapter 2 Test (page 291)

1. $f(x) = \dfrac{3}{2x-5}$

domain $= \left(-\infty, \dfrac{5}{2}\right) \cup \left(\dfrac{5}{2}, \infty\right)$

2. $f(x) = \sqrt{x+3}$: domain $= [-3, \infty)$

3. $f(-1) = \dfrac{-1}{-1-1} = \dfrac{-1}{-2} = \dfrac{1}{2}$

$f(2) = \dfrac{2}{2-1} = \dfrac{2}{1} = 2$

4. $f(-1) = \sqrt{-1+7} = \sqrt{6}$

$f(2) = \sqrt{2+7} = \sqrt{9} = 3$

5.
$$\frac{f(x+h)-f(x)}{h} = \frac{\left[(x+h)^2-(x+h)+5\right]-\left[x^2-x+5\right]}{h}$$
$$= \frac{[x^2+2xh+h^2-x-h+5]-[x^2-x+5]}{h}$$
$$= \frac{x^2+2xh+h^2-x-h+5-x^2+x-5}{h}$$
$$= \frac{2xh+h^2-h}{h} = \frac{h(2x+h-1)}{h} = 2x+h-1$$

6. $(-3, \pi) \Rightarrow$ QII

7. $(0, -8) \Rightarrow$ negative y-axis

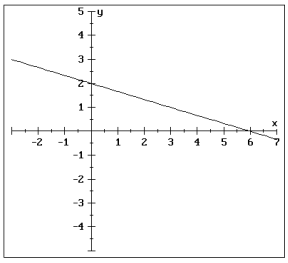
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8. $x + 3y = 6$ $\quad x + 3y = 6$

$x + 3(0) = 6 \quad 0 + 3y = 6$

$x = 6 \quad y = 2$

$(6, 0) \quad (0, 2)$

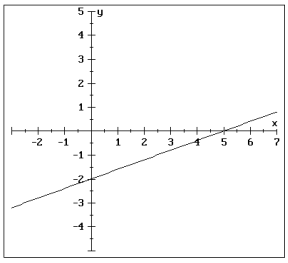


9. $2x - 5y = 10 \quad 2x - 5y = 10$

$2x - 5(0) = 10 \quad 2(0) - 5y = 10$

$x = 5 \quad y = -2$

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



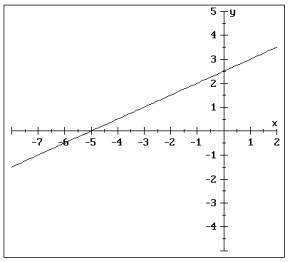
10. $2(x + y) = 3x + 5$

$2x + 2y = 3x + 5$

$2y = x + 5$

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

x	y
0	$\frac{5}{2}$
1	3



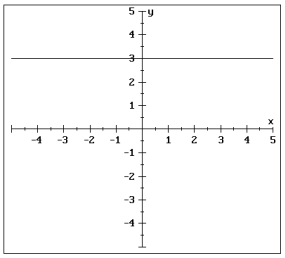
11. $3x - 5y = 3(x - 5)$

$3x - 5y = 3x - 15$

$-5y = -15$

$y = 3$

x	y
0	3
-2	3



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

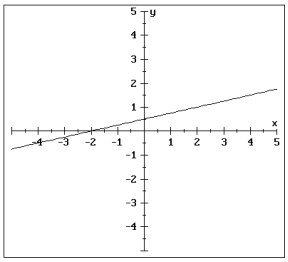
$\frac{1}{2}x - y = y - 1$

$x - 2y = 2y - 2$

$-4y = -x - 2$

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

x	y
0	$\frac{1}{2}$
2	1

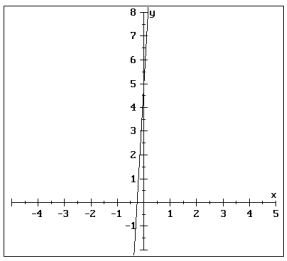


13. $\dfrac{x + y - 5}{7} = 3x$

$x + y - 5 = 21x$

$y = 20x + 5$

x	y
0	5
$-\frac{1}{4}$	0



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14. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{(1 - (-3))^2 + (-1 - 4)^2}$
$= \sqrt{(4)^2 + (-5)^2}$
$= \sqrt{16 + 25} = \sqrt{41}$

15. $d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
$= \sqrt{(0 - (-\pi))^2 + (\pi - 0)^2}$
$= \sqrt{\pi^2 + \pi^2}$
$= \sqrt{2\pi^2} = \pi\sqrt{2} \approx 4.44$

16. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{3 + (-3)}{2}, \frac{-7 + 7}{2}\right) = M\left(\frac{0}{2}, \frac{0}{2}\right) = M(0, 0)$

17. $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{0 + \sqrt{8}}{2}, \frac{\sqrt{2} + \sqrt{18}}{2}\right) = M\left(\frac{2\sqrt{2}}{2}, \frac{4\sqrt{2}}{2}\right) = M\left(\sqrt{2}, 2\sqrt{2}\right)$

18. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - (-9)}{-5 - 3} = \frac{10}{-8} = -\frac{5}{4}$

19. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 3}{-\sqrt{12} - \sqrt{3}} = \frac{-3}{-3\sqrt{3}} = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$

20. $y = 3x - 2$ $\quad$ $y = 2x - 3$
$m = 3$ $\quad$ $m = 2$
neither

21. $2x - 3y = 5$ $\quad$ $3x + 2y = 7$
$-3y = -2x + 5$ $\quad$ $2y = -3x + 7$
$y = \frac{2}{3}x - \frac{5}{3}$ $\quad$ $y = -\frac{3}{2}x + \frac{7}{2}$
$m = \frac{2}{3}$ $\quad$ $m = -\frac{3}{2}$
perpendicular

22. $y - y_1 = m(x - x_1)$
$y + 5 = 2(x - 3)$
$y + 5 = 2x - 6$
$y = 2x - 11$

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

24. $2x - y = 3$
$-y = -2x + 3$
$y = 2x - 3$
$m = 2$ $\quad$ $y = 2x + 5$

25. $2x - y = 3$
$-y = -2x + 3$
$y = 2x - 3$
$m = 2$ $\quad$ $y = -\frac{1}{2}x + 5$

26. $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{1}{2} - \left(-\frac{3}{2}\right)}{3 - 2} = \frac{\frac{4}{2}}{1} = 2$
$y - y_1 = m(x - x_1)$
$y - \frac{1}{2} = 2(x - 3)$
$y - \frac{1}{2} = 2x - 6$
$y = 2x - \frac{11}{2}$

27. If the line is parallel to the y-axis, then it is a vertical line: $x = 3$

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28. $y = x^3 - 16x$

$0 = x(x^2 - 16)$

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

$x = 0, x = -4, x = 4$

x-int: $(0, 0), (-4, 0), (4, 0)$

$y = x^3 - 16x$

$y = 0^3 - 16(0)$

$y = 0$

y-int: $(0, 0)$

29. $y = |x - 4|$

$0 = |x - 4|$

$0 = x - 4$

$4 = x$

x-int: $(4, 0)$

$y = |x - 4|$

$y = |0 - 4|$

$y = |-4|$

$y = 4$

y-int: $(0, 4)$

30. $y^2 = x - 1$

x-axis	y-axis	origin
$(-y)^2 = x - 1$	$y^2 = -x - 1$	$(-y)^2 = -x - 1$
$y^2 = x - 1$	not equivalent: no symmetry	$y^2 = -x - 1$
equivalent: symmetry		not equivalent: no symmetry

31. $y = x^4 + 1$

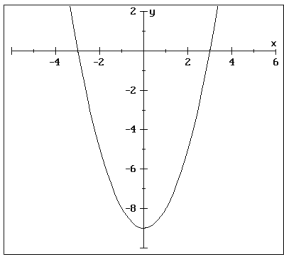
x-axis	y-axis	origin
$-y = x^4 + 1$	$y = (-x)^4 + 1$	$-y = (-x)^4 + 1$
not equivalent: no symmetry	$y = x^4 + 1$	$-y = x^4 + 1$
	equivalent: symmetry	not equivalent: no symmetry

32. $y = x^2 - 9$

x-int: $(3, 0), (-3, 0)$

y-int: $(0, -9)$

symmetry: y-axis

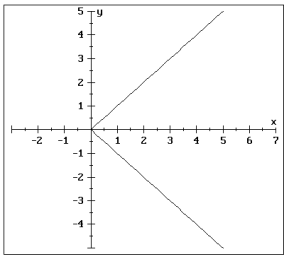


33. $x = |y|$

x-int: $(0, 0)$

y-int: $(0, 0)$

symmetry: x-axis

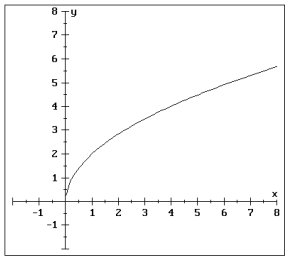


34. $y = 2\sqrt{x}$

x-int: $(0, 0)$

y-int: $(0, 0)$

symmetry: none

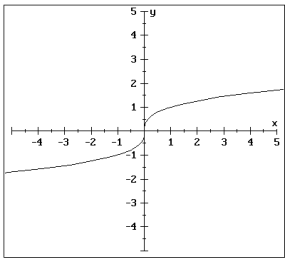


35. $x = y^3$

x-int: $(0, 0)$

y-int: $(0, 0)$

symmetry: origin



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36. $C(5, 7); r = 8$

$(x-h)^2 + (y-k)^2 = r^2$

$(x-5)^2 + (y-7)^2 = 64$

37. $r = \sqrt{(2-6)^2 + (4-8)^2}$

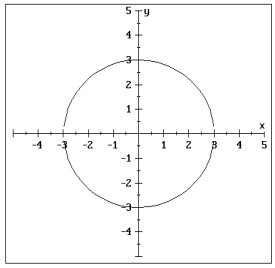
$= \sqrt{32}$

$(x-h)^2 + (y-k)^2 = r^2$

$(x-2)^2 + (y-4)^2 = 32$

38. $x^2 + y^2 = 9$

$C(0, 0), r = 3$



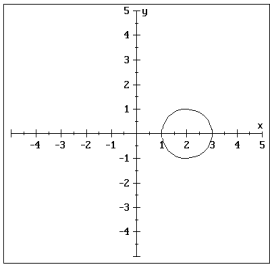
39. $x^2 - 4x + y^2 + 3 = 0$

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

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

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

$C(2, 0), r = 1$



40. $y = kz^2$

41. $w = krs^2$

42. $P = kQ$

$7 = k(2)$

$\frac{7}{2} = k$

$P = \frac{7}{2}Q$

$P = \frac{7}{2}(5)$

$P = \frac{35}{2}$

43. $y = \frac{kx}{z^2}$

$16 = \frac{k(3)}{2^2}$

$16 = \frac{3k}{4}$

$\frac{64}{3} = k$

$y = \frac{\frac{64}{3}x}{z^2}$

$2 = \frac{\frac{64}{3}x}{3^2}$

$18 = \frac{64}{3}x$

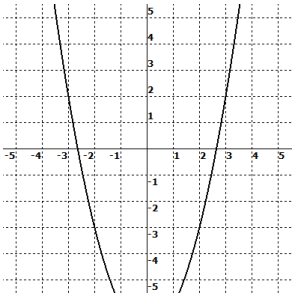
$\frac{3}{64} \cdot 18 = \frac{3}{64} \cdot \frac{64}{3}x$

$\frac{27}{32} = x$

44. Graph $y = x^2 - 7$.

Find any positive x-intercept.

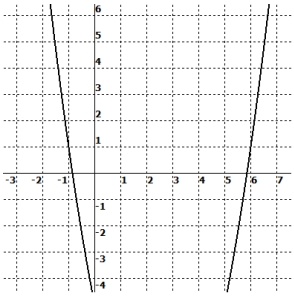
$x = 2.65$



45. Graph $y = x^2 - 5x - 5$.

Find any plosive x-intercept.

$x = 5.85$



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