

## EXERCISES 2.1

## 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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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.  $f(x) = 3x + 5 \Rightarrow \text{domain} = (-\infty, \infty)$
36.  $f(x) = -5x + 2 \Rightarrow \text{domain} = (-\infty, \infty)$
37.  $f(x) = x^2 - x + 1 \Rightarrow \text{domain} = (-\infty, \infty)$
38.  $f(x) = x^3 - 3x + 2 \Rightarrow \text{domain} = (-\infty, \infty)$
39.  $f(x) = \sqrt{x - 2} \Rightarrow x - 2 \geq 0$   
 $\text{domain} = [2, \infty)$
40.  $f(x) = \sqrt{2x + 3} \Rightarrow 2x + 3 \geq 0$   
 $\text{domain} = \left[-\frac{3}{2}, \infty\right)$
41.  $f(x) = \sqrt{4 - x} \Rightarrow 4 - x \geq 0$   
 $\text{domain} = (-\infty, 4]$
42.  $f(x) = 3\sqrt{2 - x} \Rightarrow 2 - x \geq 0$   
 $\text{domain} = (-\infty, 2]$
43.  $f(x) = \sqrt{x^2 - 1} \Rightarrow x^2 - 1 \geq 0$   
 $\text{domain} = (-\infty, -1] \cup [1, \infty)$
44.  $f(x) = \sqrt{x^2 - 2x - 3} \Rightarrow x^2 - 2x - 3 \geq 0$   
 $\text{domain} = (-\infty, -1] \cup [3, \infty)$

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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.  $f(x) = \frac{3}{x+1} \Rightarrow x \neq -1$   
 $\text{domain} = (-\infty, -1) \cup (-1, \infty)$       48.  $f(x) = \frac{-7}{x+3} \Rightarrow x \neq -3$   
 $\text{domain} = (-\infty, -3) \cup (-3, \infty)$

49.  $f(x) = \frac{x}{x-3} \Rightarrow x \neq 3$   
 $\text{domain} = (-\infty, 3) \cup (3, \infty)$       50.  $f(x) = \frac{x+2}{x-1} \Rightarrow x \neq 1$   
 $\text{domain} = (-\infty, 1) \cup (1, \infty)$

51.  $f(x) = \frac{x}{x^2-4} = \frac{x}{(x+2)(x-2)}$   
 $x \neq -2, x \neq 2$   
 $\text{domain} = (-\infty, -2) \cup (-2, 2) \cup (2, \infty)$       52.  $f(x) = \frac{2x}{x^2-9} = \frac{2x}{(x+3)(x-3)}$   
 $x \neq -3, x \neq 3$   
 $\text{domain} = (-\infty, -3) \cup (-3, 3) \cup (3, \infty)$

53.  $f(x) = \frac{1}{x^2-4x-5} = \frac{1}{(x+1)(x-5)}$   
 $x \neq -1, x \neq 5$   
 $\text{domain} = (-\infty, -1) \cup (-1, 5) \cup (5, \infty)$       54.  $f(x) = \frac{x}{2x^2-16x+30} = \frac{x}{2(x-3)(x-5)}$   
 $x \neq 3, x \neq 5$   
 $\text{domain} = (-\infty, 3) \cup (3, 5) \cup (5, \infty)$

55.  $f(x) = |x| + 3 \Rightarrow \text{domain} = (-\infty, \infty)$       56.  $f(x) = 2|x-1| \Rightarrow \text{domain} = (-\infty, \infty)$

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

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

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

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

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

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

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

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

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61.

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

|                       |                           |              |                                                                            |
|-----------------------|---------------------------|--------------|----------------------------------------------------------------------------|
| $f(2) = 2^2$<br>$= 4$ | $f(-3) = (-3)^2$<br>$= 9$ | $f(k) = k^2$ | $f(k^2 - 1) = (k^2 - 1)^2$<br>$= (k^2 - 1)(k^2 - 1)$<br>$= k^4 - 2k^2 + 1$ |
|-----------------------|---------------------------|--------------|----------------------------------------------------------------------------|

62.

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

|                                         |                                             |                  |                                                                                                                 |
|-----------------------------------------|---------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------|
| $f(2) = 3 - 2^2$<br>$= 3 - 4$<br>$= -1$ | $f(-3) = 3 - (-3)^2$<br>$= 3 - 9$<br>$= -6$ | $f(k) = 3 - k^2$ | $f(k^2 - 1) = 3 - (k^2 - 1)^2$<br>$= 3 - (k^2 - 1)(k^2 - 1)$<br>$= 3 - (k^4 - 2k^2 + 1)$<br>$= -k^4 + 2k^2 + 2$ |
|-----------------------------------------|---------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------|

63.

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

|                                                   |                                                         |                       |
|---------------------------------------------------|---------------------------------------------------------|-----------------------|
| $f(2) = 2^2 + 3(2) - 1$<br>$= 4 + 6 - 1$<br>$= 9$ | $f(-3) = (-3)^2 + 3(-3) - 1$<br>$= 9 - 9 - 1$<br>$= -1$ | $f(k) = k^2 + 3k - 1$ |
|---------------------------------------------------|---------------------------------------------------------|-----------------------|

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

64.

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

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

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

65.

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

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

# EXERCISES 2.1

66.

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

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

67.

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

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

68.

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

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

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

69.

$$f(x) = \frac{2}{x + 4}$$

|                                                           |                                                   |                          |                                                               |
|-----------------------------------------------------------|---------------------------------------------------|--------------------------|---------------------------------------------------------------|
| $f(2) = \frac{2}{2 + 4}$<br>$= \frac{2}{6} = \frac{1}{3}$ | $f(-3) = \frac{2}{-3 + 4}$<br>$= \frac{2}{1} = 2$ | $f(k) = \frac{2}{k + 4}$ | $f(k^2 - 1) = \frac{2}{k^2 - 1 + 4}$<br>$= \frac{2}{k^2 + 3}$ |
|-----------------------------------------------------------|---------------------------------------------------|--------------------------|---------------------------------------------------------------|

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70.

$$f(x) = \frac{3}{x-5}$$

|                                                 |                                                             |                        |                                                       |
|-------------------------------------------------|-------------------------------------------------------------|------------------------|-------------------------------------------------------|
| $f(2) = \frac{3}{2-5}$<br>$= \frac{3}{-3} = -1$ | $f(-3) = \frac{3}{-3-5}$<br>$= \frac{3}{-8} = -\frac{3}{8}$ | $f(k) = \frac{3}{k-5}$ | $f(k^2-1) = \frac{3}{k^2-1-5}$<br>$= \frac{3}{k^2-6}$ |
|-------------------------------------------------|-------------------------------------------------------------|------------------------|-------------------------------------------------------|

71.

$$f(x) = \frac{1}{x^2-1}$$

|                                                                  |                                                                      |                          |                                                                                            |
|------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------|
| $f(2) = \frac{1}{2^2-1}$<br>$= \frac{1}{4-1}$<br>$= \frac{1}{3}$ | $f(-3) = \frac{1}{(-3)^2-1}$<br>$= \frac{1}{9-1}$<br>$= \frac{1}{8}$ | $f(k) = \frac{1}{k^2-1}$ | $f(k^2-1) = \frac{1}{(k^2-1)^2-1}$<br>$= \frac{1}{k^4-2k^2+1-1}$<br>$= \frac{1}{k^4-2k^2}$ |
|------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------|

72.

$$f(x) = \frac{3}{x^2+3}$$

|                                                                  |                                                                                     |                          |                                                                                              |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------|
| $f(2) = \frac{3}{2^2+3}$<br>$= \frac{3}{4+3}$<br>$= \frac{3}{7}$ | $f(-3) = \frac{3}{(-3)^2+3}$<br>$= \frac{3}{9+3}$<br>$= \frac{3}{12} = \frac{1}{4}$ | $f(k) = \frac{3}{k^2+3}$ | $f(k^2-1) = \frac{3}{(k^2-1)^2+3}$<br>$= \frac{3}{k^4-2k^2+1+3}$<br>$= \frac{3}{k^4-2k^2+4}$ |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------|

73.

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

|                                                         |                                                              |                       |                                                                                     |
|---------------------------------------------------------|--------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------|
| $f(2) = \sqrt{2^2+1}$<br>$= \sqrt{4+1}$<br>$= \sqrt{5}$ | $f(-3) = \sqrt{(-3)^2+1}$<br>$= \sqrt{9+1}$<br>$= \sqrt{10}$ | $f(k) = \sqrt{k^2+1}$ | $f(k^2-1) = \sqrt{(k^2-1)^2+1}$<br>$= \sqrt{k^4-2k^2+1+1}$<br>$= \sqrt{k^4-2k^2+2}$ |
|---------------------------------------------------------|--------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------|

74.

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

|                                                         |                                                                         |                       |                                                                                                                                   |
|---------------------------------------------------------|-------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| $f(2) = \sqrt{2^2-1}$<br>$= \sqrt{4-1}$<br>$= \sqrt{3}$ | $f(-3) = \sqrt{(-3)^2-1}$<br>$= \sqrt{9-1}$<br>$= \sqrt{8} = 2\sqrt{2}$ | $f(k) = \sqrt{k^2-1}$ | $f(k^2-1) = \sqrt{(k^2-1)^2-1}$<br>$= \sqrt{k^4-2k^2+1-1}$<br>$= \sqrt{k^4-2k^2}$<br>$= \sqrt{k^2(k^2-2)}$<br>$=  k \sqrt{k^2-2}$ |
|---------------------------------------------------------|-------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------|

75.

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

|                        |                                                |                        |                                |
|------------------------|------------------------------------------------|------------------------|--------------------------------|
| $f(2) = \sqrt[3]{2}-1$ | $f(-3) = \sqrt[3]{-3}-1$<br>$= -\sqrt[3]{3}-1$ | $f(k) = \sqrt[3]{k}-1$ | $f(k^2-1) = \sqrt[3]{k^2-1}-1$ |
|------------------------|------------------------------------------------|------------------------|--------------------------------|

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76.  $f(x) = \sqrt[3]{x+1}$
- |                                           |                                                                  |                        |                                                     |
|-------------------------------------------|------------------------------------------------------------------|------------------------|-----------------------------------------------------|
| $f(2) = \sqrt[3]{2+1}$<br>$= \sqrt[3]{3}$ | $f(-3) = \sqrt[3]{-3+1}$<br>$= \sqrt[3]{-2}$<br>$= -\sqrt[3]{2}$ | $f(k) = \sqrt[3]{k+1}$ | $f(k^2-1) = \sqrt[3]{k^2-1+1}$<br>$= \sqrt[3]{k^2}$ |
|-------------------------------------------|------------------------------------------------------------------|------------------------|-----------------------------------------------------|
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.  $\frac{f(x+h) - f(x)}{h} = \frac{[(x+h)^2+1] - [x^2+1]}{h} = \frac{[x^2+2xh+h^2+1] - [x^2+1]}{h}$   
 $= \frac{x^2+2xh+h^2+1-x^2-1}{h}$   
 $= \frac{2xh+h^2}{h} = \frac{h(2x+h)}{h} = 2x+h$
82.  $\frac{f(x+h) - f(x)}{h} = \frac{[(x+h)^2-3] - [x^2-3]}{h} = \frac{[x^2+2xh+h^2-3] - [x^2-3]}{h}$   
 $= \frac{x^2+2xh+h^2-3-x^2+3}{h}$   
 $= \frac{2xh+h^2}{h} = \frac{h(2x+h)}{h} = 2x+h$
83.  $\frac{f(x+h) - f(x)}{h} = \frac{[4(x+h)^2-6] - [4x^2-6]}{h} = \frac{[4x^2+8xh+4h^2-6] - [4x^2-6]}{h}$   
 $= \frac{4x^2+8xh+4h^2-6-4x^2+6}{h}$   
 $= \frac{8xh+4h^2}{h} = \frac{h(8x+4h)}{h} = 8x+4h$

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$$\begin{aligned}
 84. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[5(x+h)^2 + 3] - [5x^2 + 3]}{h} = \frac{[5x^2 + 10xh + 5h^2 + 3] - [5x^2 + 3]}{h} \\
 &= \frac{5x^2 + 10xh + 5h^2 + 3 - 5x^2 - 3}{h} \\
 &= \frac{10xh + 5h^2}{h} = \frac{h(10x + 5h)}{h} = 10x + 5h
 \end{aligned}$$

$$\begin{aligned}
 85. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[(x+h)^2 + 3(x+h) - 7] - [x^2 + 3x - 7]}{h} \\
 &= \frac{[x^2 + 2xh + h^2 + 3x + 3h - 7] - [x^2 + 3x - 7]}{h} \\
 &= \frac{x^2 + 2xh + h^2 + 3x + 3h - 7 - x^2 - 3x + 7}{h} \\
 &= \frac{2xh + h^2 + 3h}{h} = \frac{h(2x + h + 3)}{h} = 2x + h + 3
 \end{aligned}$$

$$\begin{aligned}
 86. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[(x+h)^2 - 5(x+h) + 1] - [x^2 - 5x + 1]}{h} \\
 &= \frac{[x^2 + 2xh + h^2 - 5x - 5h + 1] - [x^2 - 5x + 1]}{h} \\
 &= \frac{x^2 + 2xh + h^2 - 5x - 5h + 1 - x^2 + 5x - 1}{h} \\
 &= \frac{2xh + h^2 - 5h}{h} = \frac{h(2x + h - 5)}{h} = 2x + h - 5
 \end{aligned}$$

$$\begin{aligned}
 87. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[2(x+h)^2 - 4(x+h) + 2] - [2x^2 - 4x + 2]}{h} \\
 &= \frac{[2x^2 + 4xh + 2h^2 - 4x - 4h + 2] - [2x^2 - 4x + 2]}{h} \\
 &= \frac{2x^2 + 4xh + 2h^2 - 4x - 4h + 2 - 2x^2 + 4x - 2}{h} \\
 &= \frac{4xh + 2h^2 - 4h}{h} = \frac{h(4x + 2h - 4)}{h} = 4x + 2h - 4
 \end{aligned}$$

$$\begin{aligned}
 88. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[3(x+h)^2 + 2(x+h) - 3] - [3x^2 + 2x - 3]}{h} \\
 &= \frac{[3x^2 + 6xh + 3h^2 + 2x + 2h - 3] - [3x^2 + 2x - 3]}{h} \\
 &= \frac{3x^2 + 6xh + 3h^2 + 2x + 2h - 3 - 3x^2 - 2x + 3}{h} \\
 &= \frac{6xh + 3h^2 + 2h}{h} = \frac{h(6x + 3h + 2)}{h} = 6x + 3h + 2
 \end{aligned}$$



# EXERCISES 2.1

$$\begin{aligned}
 89. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[-(x+h)^2 + (x+h) - 3] - [-x^2 + x - 3]}{h} \\
 &= \frac{[-x^2 - 2xh - h^2 + x + h - 3] - [-x^2 + x - 3]}{h} \\
 &= \frac{-x^2 - 2xh - h^2 + x + h - 3 + x^2 - x + 3}{h} \\
 &= \frac{-2xh - h^2 + h}{h} = \frac{h(-2x - h + 1)}{h} = -2x - h + 1
 \end{aligned}$$

$$\begin{aligned}
 90. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[-3(x+h)^2 + 5(x+h) - 1] - [-3x^2 + 5x - 1]}{h} \\
 &= \frac{[-3x^2 - 6xh - 3h^2 + 5x + 5h - 1] - [-3x^2 + 5x - 1]}{h} \\
 &= \frac{-3x^2 - 6xh - 3h^2 + 5x + 5h - 1 + 3x^2 - 5x + 1}{h} \\
 &= \frac{-6xh - 3h^2 + 5h}{h} = \frac{h(-6x - 3h + 5)}{h} = -6x - 3h + 5
 \end{aligned}$$

$$\begin{aligned}
 91. \quad \frac{f(x+h) - f(x)}{h} &= \frac{(x+h)^3 - x^3}{h} = \frac{[x^3 + 3x^2h + 3xh^2 + h^3] - [x^3]}{h} \\
 &= \frac{3x^2h + 3xh^2 + h^3}{h} \\
 &= \frac{h(3x^2 + 3xh + h^2)}{h} = 3x^2 + 3xh + h^2
 \end{aligned}$$

$$\begin{aligned}
 92. \quad \frac{f(x+h) - f(x)}{h} &= \frac{-(x+h)^3 - (-x^3)}{h} = \frac{[-x^3 - 3x^2h - 3xh^2 - h^3] + x^3}{h} \\
 &= \frac{-3x^2h - 3xh^2 - h^3}{h} \\
 &= \frac{h(-3x^2 - 3xh - h^2)}{h} = -3x^2 - 3xh - h^2
 \end{aligned}$$

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

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

$$\begin{aligned}
 95. \quad f(x) &= -0.6x + 132 \\
 f(25) &= -0.6(25) + 132 = 117
 \end{aligned}$$

$$\begin{aligned}
 96. \quad F(C) &= \frac{9}{5}C + 32 \\
 F(0) &= \frac{9}{5}(0) + 32 & F(-40) &= \frac{9}{5}(-40) + 32 & F(10) &= \frac{9}{5}(10) + 32 \\
 &= 32 & &= -40 & &= 50
 \end{aligned}$$

## EXERCISES 2.1

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<sup>3</sup>
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.  $\frac{f(x+h) - f(x)}{h} = \frac{5-5}{h} = \frac{0}{h} = 0.$
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.  $M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$
15.  $A(2, 3)$                       16.  $B(-3, 5)$                       17.  $C(-2, -3)$                       18.  $D(4, -5)$

## EXERCISES 2.2

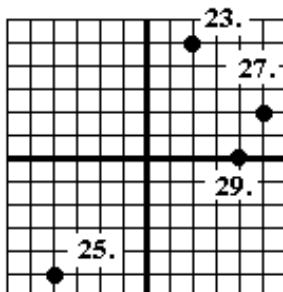
19.  $E(0, 0)$

20.  $F(-4, 0)$

21.  $G(-5, -5)$

22.  $H(2, -2)$

23, 25, 27, 29.



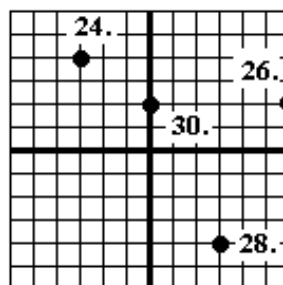
23. QI

25. QIII

27. QI

29.  $+x$ -axis

24, 26, 28, 30.



24. QII

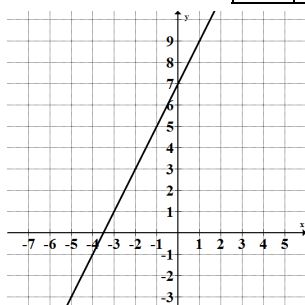
26. QI

28. QIV

30.  $+y$ -axis

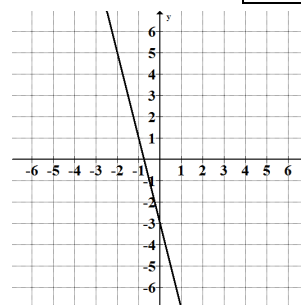
31.  $y - 2x = 7$   
 $y = 2x + 7$

| $x$ | $y$ |
|-----|-----|
| 0   | 7   |
| -2  | 3   |



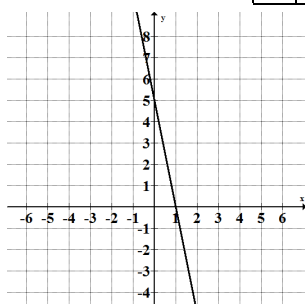
32.  $y + 3 = -4x$   
 $y = -4x - 3$

| $x$ | $y$ |
|-----|-----|
| 0   | -3  |
| -1  | 1   |



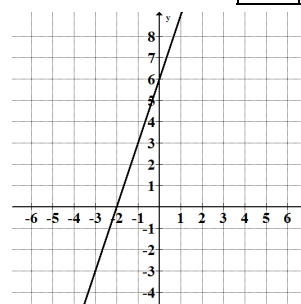
33.  $y + 5x = 5$   
 $y = -5x + 5$

| $x$ | $y$ |
|-----|-----|
| 0   | 5   |
| 1   | 0   |



34.  $y - 3x = 6$   
 $y = 3x + 6$

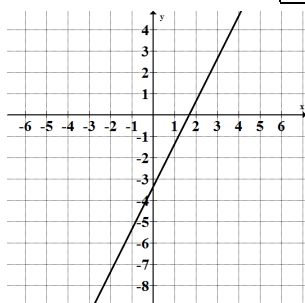
| $x$ | $y$ |
|-----|-----|
| 0   | 6   |
| -2  | 0   |



# EXERCISES 2.2

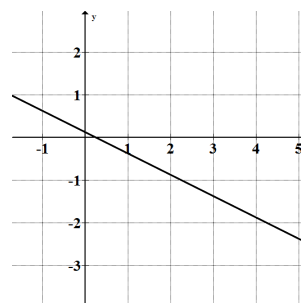
35.  $6x - 3y = 10$   
 $-3y = -6x + 10$   
 $y = 2x - \frac{10}{3}$

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



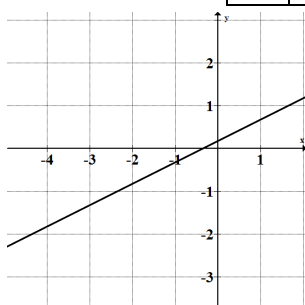
36.  $4x + 8y - 1 = 0$   
 $8y = -4x + 1$   
 $y = -\frac{1}{2}x + \frac{1}{8}$

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



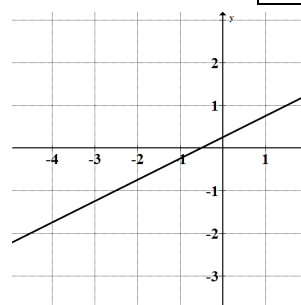
37.  $3x = 6y - 1$   
 $-6y = -3x - 1$   
 $y = \frac{1}{2}x + \frac{1}{6}$

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



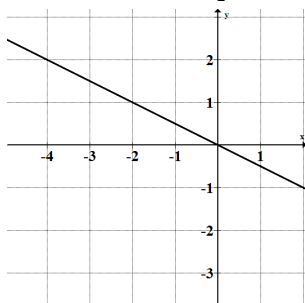
38.  $2x + 1 = 4y$   
 $-4y = -2x - 1$   
 $y = \frac{1}{2}x + \frac{1}{4}$

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



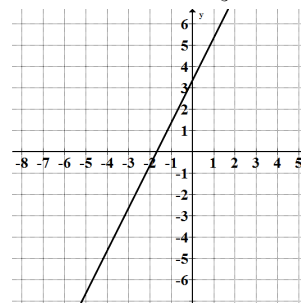
39.  $2(x + y + 1) = x + 2$   
 $2x + 2y + 2 = x + 2$   
 $2y = -x$   
 $y = -\frac{1}{2}x$

| $x$ | $y$ |
|-----|-----|
| 0   | 0   |
| -2  | 1   |



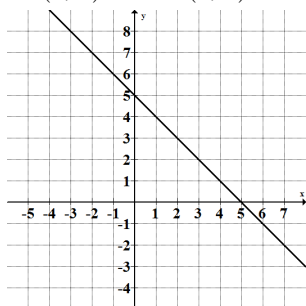
40.  $5(x + 2) = 3y - x$   
 $5x + 10 = 3y - x$   
 $-3y = -6x - 10$   
 $y = 2x + \frac{10}{3}$

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

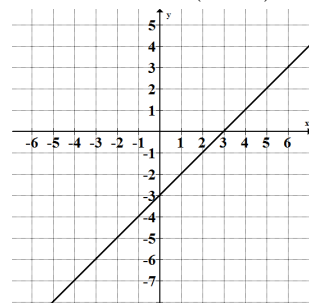


## EXERCISES 2.2

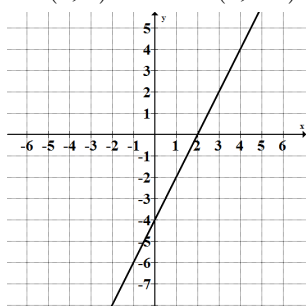
41.  $x + y = 5$      $x + y = 5$   
 $x + 0 = 5$      $0 + y = 5$   
 $x = 5$      $y = 5$   
 $(5, 0)$      $(0, 5)$



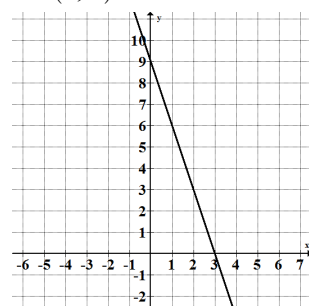
42.  $x - y = 3$      $x - y = 3$   
 $x - 0 = 3$      $0 - y = 3$   
 $x = 3$      $-y = 3$   
 $(3, 0)$      $y = -3$   
 $(0, -3)$



43.  $2x - y = 4$      $2x - y = 4$   
 $2x - 0 = 4$      $2(0) - y = 4$   
 $2x = 4$      $-y = 4$   
 $x = 2$      $y = -4$   
 $(2, 0)$      $(0, -4)$

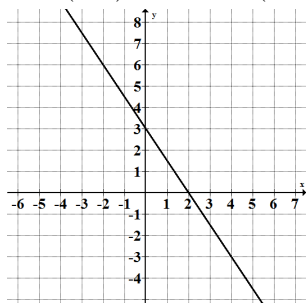


44.  $3x + y = 9$      $3x + y = 9$   
 $3x + 0 = 9$      $3(0) + y = 9$   
 $3x = 9$      $y = 9$   
 $x = 3$      $(0, 9)$   
 $(3, 0)$

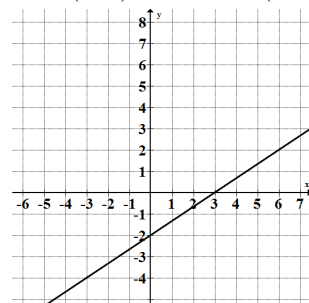


## EXERCISES 2.2

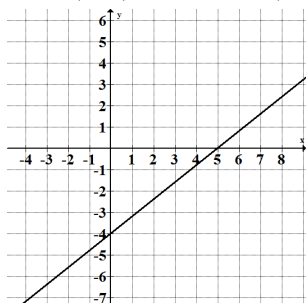
45.  $3x + 2y = 6$        $3x + 2y = 6$   
 $3x + 2(0) = 6$      $3(0) + 2y = 6$   
 $3x = 6$                  $2y = 6$   
 $x = 2$                  $y = 3$   
 $(2, 0)$                  $(0, 3)$



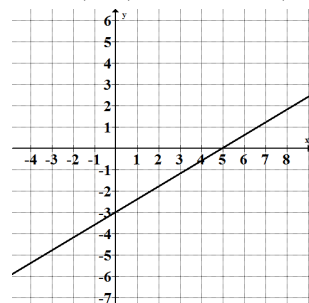
46.  $2x - 3y = 6$        $2x - 3y = 6$   
 $2x - 3(0) = 6$      $2(0) - 3y = 6$   
 $2x = 6$                  $-3y = 6$   
 $x = 3$                  $y = -2$   
 $(3, 0)$                  $(0, -2)$



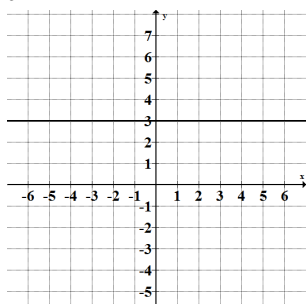
47.  $4x - 5y = 20$        $4x - 5y = 20$   
 $4x - 5(0) = 20$      $4(0) - 5y = 20$   
 $4x = 20$                  $-5y = 20$   
 $x = 5$                  $y = -4$   
 $(5, 0)$                  $(0, -4)$



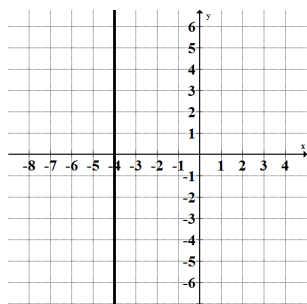
48.  $3x - 5y = 15$        $3x - 5y = 15$   
 $3x - 5(0) = 15$      $3(0) - 5y = 15$   
 $3x = 15$                  $-5y = 15$   
 $x = 5$                  $y = -3$   
 $(5, 0)$                  $(0, -3)$



49.  $y = 3$

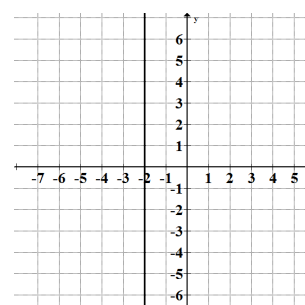


50.  $x = -4$



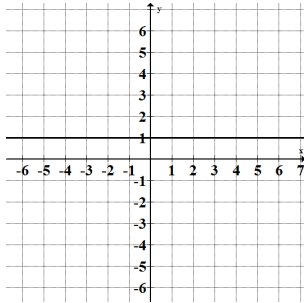
51.  $3x + 5 = -1$

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

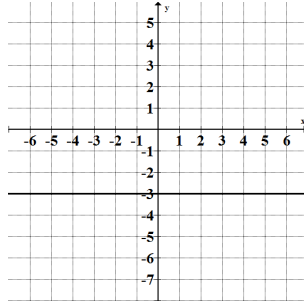


## EXERCISES 2.2

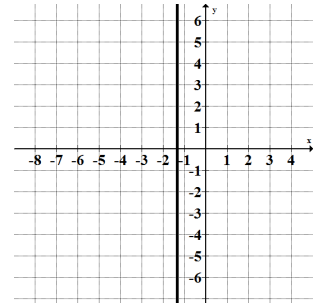
52.  $7y - 1 = 6$   
 $7y = 7 \Rightarrow y = 1$



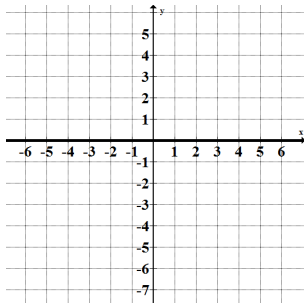
53.  $3(y + 2) = y$   
 $3y + 6 = y$   
 $2y = -6 \Rightarrow y = -3$



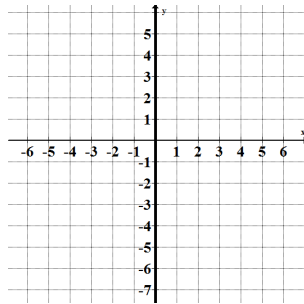
54.  $4 + 3y = 3(x + y)$   
 $4 + 3y = 3x + 3y$   
 $4 = 3x \Rightarrow x = \frac{4}{3}$



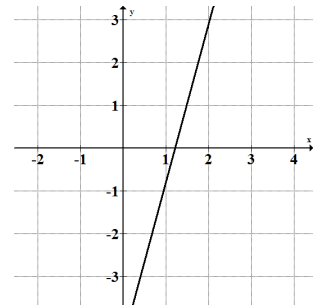
55.  $3(y + 2x) = 6x + y$   
 $3y + 6x = 6x + y$   
 $2y = 0 \Rightarrow y = 0$



56.  $5(y - x) = x + 5y$   
 $5y - 5x = x + 5y$   
 $0 = 6x \Rightarrow x = 0$

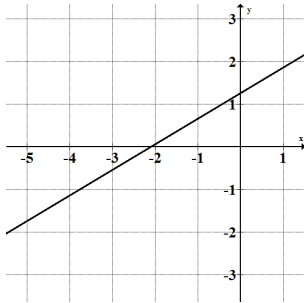


57.  $y = 3.7x - 4.5$



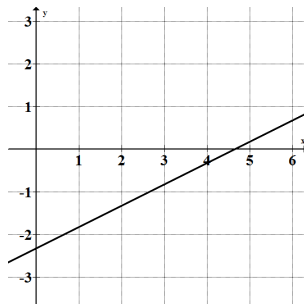
$x$ -int:  $x = 1.22$

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



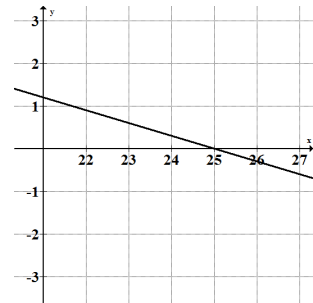
$x$ -int:  $x = -2.08$

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:  $x = 25.00$

## EXERCISES 2.2

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

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

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

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

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

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

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

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

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

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

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

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



## EXERCISES 2.2

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

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

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

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

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

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

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

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

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

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

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

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

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

## EXERCISES 2.2

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

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

$$\begin{aligned} M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) &= (3, 5) \\ \frac{x_1+x_2}{2} &= 3 & \frac{y_1+y_2}{2} &= 5 \\ \frac{1+x}{2} &= 3 & \frac{4+y}{2} &= 5 \\ 1+x &= 6 & 4+y &= 10 \\ x &= 5 & y &= 6 \\ Q(5, 6) \end{aligned}$$

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

$$\begin{aligned} M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) &= (-5, 6) \\ \frac{x_1+x_2}{2} &= -5 & \frac{y_1+y_2}{2} &= 6 \\ \frac{2+x}{2} &= -5 & \frac{-7+y}{2} &= 6 \\ 2+x &= -10 & -7+y &= 12 \\ x &= -12 & y &= 19 \\ Q(-12, 19) \end{aligned}$$

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

$$\begin{aligned} M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) &= (5, 5) \\ \frac{x_1+x_2}{2} &= 5 & \frac{y_1+y_2}{2} &= 5 \\ \frac{5+x}{2} &= 5 & \frac{-5+y}{2} &= 5 \\ 5+x &= 10 & -5+y &= 10 \\ x &= 5 & y &= 15 \\ Q(5, 15) \end{aligned}$$

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

$$\begin{aligned} M\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right) &= (0, 0) \\ \frac{x_1+x_2}{2} &= 0 & \frac{y_1+y_2}{2} &= 0 \\ \frac{-7+x}{2} &= 0 & \frac{3+y}{2} &= 0 \\ -7+x &= 0 & 3+y &= 0 \\ x &= 7 & y &= -3 \\ Q(7, -3) \end{aligned}$$

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.

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

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

## 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  $AOB = \frac{1}{2} \cdot \text{base} \cdot \text{height} = \frac{1}{2}(OA)(OB) = \frac{1}{2}(a)(b) = \frac{1}{2}ab$   
Area of  $OLMN = \text{length} \cdot \text{width} = (OL)(ON) = \frac{a}{2} \cdot \frac{b}{2} = \frac{1}{4}ab = \frac{1}{2}(\text{Area of } AOB)$
- 96.** Let  $x =$  the width (from  $A$  to  $D$ ). Then  
the length (from  $A$  to  $B$ )  $= 2x$ .  
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.**  $f(x) = 430 - 0.005x$   
 $350 = 430 - 0.005d$   
 $0.005d = 80$   
 $d = 16,000$   
\$16,000 would reduce the number to 350.

## EXERCISES 2.2

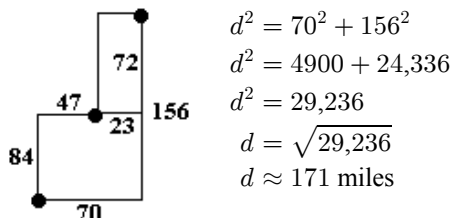
$$\begin{aligned}
 103. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\
 &= \sqrt{[0 - 30]^2 + [10 - 25]^2} \\
 &= \sqrt{(-30)^2 + (-15)^2} \\
 &= \sqrt{900 + 225} = \sqrt{1125} = 15\sqrt{5} \text{ yd}
 \end{aligned}$$

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

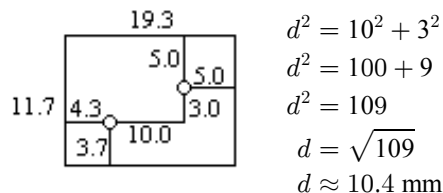
$$105. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{30 + 0}{2}, \frac{25 + 10}{2}\right) = M\left(\frac{30}{2}, \frac{35}{2}\right) = M(15, 17.5)$$

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

107.



108.



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.  $-1$

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

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

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

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

# EXERCISES 2.3

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

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

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

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

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

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

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

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

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

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

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

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

$$27. \quad y = 3x + 2 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{5 - 2}{1 - 0} = \frac{3}{1} = 3$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | 2   |
| 1   | 5   |

$$28. \quad y = 5x - 8 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3 - (-8)}{1 - 0} = \frac{5}{1} = 5$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | -8  |
| 1   | -3  |

$$29. \quad y = 4x - 6 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - (-6)}{1 - 0} = \frac{4}{1} = 4$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | -6  |
| 1   | -2  |

$$30. \quad y = -\frac{1}{3}x + 5 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 5}{3 - 0} = \frac{-1}{3} = -\frac{1}{3}$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | 5   |
| 3   | 4   |

$$31. \quad 5x - 10y = 3 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{1}{5} - (-\frac{3}{10})}{1 - 0} = \frac{\frac{5}{10}}{1} = \frac{1}{2}$$

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

$$32. \quad 8y + 2x = 5 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{3}{8} - \frac{5}{8}}{1 - 0} = \frac{-\frac{2}{8}}{1} = -\frac{1}{4}$$

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

$$33. \quad 3(y + 2) = 2x - 3 \quad 3y - 2x = -9 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-1 - (-3)}{3 - 0} = \frac{2}{3}$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | -3  |
| 3   | -1  |

$$34. \quad 4(x - 2) = 3y + 2 \quad 4x - 3y = 10 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - (-\frac{10}{3})}{1 - 0} = \frac{\frac{4}{3}}{1} = \frac{4}{3}$$

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

# EXERCISES 2.3

35.  $3(y + x) = 3(x - 1)$   
 $3y = -3$   
 $y = -1$
- | $x$ | $y$ |
|-----|-----|
| 0   | -1  |
| 1   | -1  |
- $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-1 - (-1)}{1 - 0} = \frac{0}{1} = 0$$
36.  $2x + 5 = 2(y + x)$   
 $5 = 2y$   
 $\frac{5}{2} = y$
- | $x$ | $y$           |
|-----|---------------|
| 0   | $\frac{5}{2}$ |
| 1   | $\frac{5}{2}$ |
- $$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{5}{2} - \frac{5}{2}}{1 - 0} = \frac{0}{1} = 0$$
37. horizontal  $\Rightarrow m = 0$
38.  $2y = 5$   
 $y = \frac{5}{2}$   
horizontal  $\Rightarrow m = 0$
39.  $f(x) = \frac{1}{4} \Rightarrow y = \frac{1}{4}$   
horizontal  $\Rightarrow m = 0$
40.  $f(x) = \pi \Rightarrow y = \pi$   
horizontal  $\Rightarrow m = 0$
41.  $x = -\frac{1}{2}$   
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.  $m_1 m_2 = 3(-\frac{1}{3}) = -1$   
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.  $m_1 m_2 = -\sqrt{2}(\frac{\sqrt{2}}{2}) = -1$   
perpendicular
54.  $m_2 = \sqrt{28} = 2\sqrt{7} = m_1$   
parallel
55.  $m_1 m_2 = -0.125(8) = -1$   
perpendicular
56.  $m_1 = 0.125 = \frac{1}{8} = m_2$   
parallel
57.  $m_1 m_2 = ab^{-1}(-a^{-1}b) = -a^0 b^0 = -1$   
perpendicular
58.  $m_1 = (\frac{a}{b})^{-1} = \frac{b}{a} \neq -\frac{b}{a} = m_2$   
 $m_1 m_2 = \frac{b}{a}(-\frac{b}{a}) \neq -1 \Rightarrow$  neither

### EXERCISES 2.3

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### EXERCISES 2.3

- 70.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - (-1)}{3 - 1} = \frac{-1}{2} = -\frac{1}{2}$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - (-1)}{-3 - 1} = \frac{1}{-4} = -\frac{1}{4} \Rightarrow$  not on same line
- 71.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - a}{0 - (-a)} = \frac{-a}{a} = -1$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-a - a}{a - (-a)} = \frac{-2a}{2a} = -1 \Rightarrow$  on same line
- 72.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{b - (a + b)}{(a + b) - a} = \frac{-a}{b} = -\frac{a}{b}$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{a - (a + b)}{(a - b) - a} = \frac{-b}{-b} = 1 \Rightarrow$  not on same line
- 73.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-5 - 4}{2 - 5} = \frac{-9}{-3} = 3$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3 - 4}{8 - 5} = \frac{-7}{3} = -\frac{7}{3}$   
 $m_{QR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3 - (-5)}{8 - 2} = \frac{2}{6} = \frac{1}{3} \Rightarrow$  None are perpendicular.
- 74.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6 - (-2)}{4 - 8} = \frac{8}{-4} = -2$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{7 - (-2)}{6 - 8} = \frac{9}{-2} = -\frac{9}{2}$   
 $m_{QR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{7 - 6}{6 - 4} = \frac{1}{2} \Rightarrow PQ$  and  $QR$  are perpendicular.
- 75.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9 - 3}{1 - 1} = \frac{6}{0} \Rightarrow$  undefined  $\Rightarrow$  vertical  
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - 3}{7 - 1} = \frac{0}{6} = 0 \Rightarrow$  horizontal  
 $m_{QR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - 9}{7 - 1} = \frac{-6}{6} = -1 \Rightarrow PQ$  and  $PR$  are perpendicular.
- 76.**  $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{2 - (-3)}{-3 - 2} = \frac{5}{-5} = -1$   
 $m_{PR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8 - (-3)}{3 - 2} = \frac{11}{1} = 11$   
 $m_{QR} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8 - 2}{3 - (-3)} = \frac{6}{6} = 1 \Rightarrow PQ$  and  $QR$  are perpendicular.



### EXERCISES 2.3

$$\begin{aligned}
 77. \quad m_{PQ} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{b - 0}{a - 0} = \frac{b}{a} \\
 m_{PR} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{a - 0}{-b - 0} = \frac{a}{-b} = -\frac{a}{b} \\
 m_{QR} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{a - b}{-b - a} = \frac{a - b}{-b - a} \Rightarrow PQ \text{ and } PR \text{ are perpendicular.}
 \end{aligned}$$

$$\begin{aligned}
 78. \quad m_{PQ} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{a - b}{-b - a} = \frac{a - b}{-(a + b)} = -\frac{a - b}{a + b} \\
 m_{PR} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{(a + b) - b}{(a - b) - a} = \frac{a}{-b} = -\frac{a}{b} \\
 m_{QR} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{(a + b) - a}{(a - b) - (-b)} = \frac{b}{a} \Rightarrow PR \text{ and } QR \text{ are perpendicular.}
 \end{aligned}$$

$$\begin{aligned}
 79. \quad m_{AB} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - (-1)}{-3 - (-1)} = \frac{5}{-2} = -\frac{5}{2} \\
 m_{AC} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - (-1)}{4 - (-1)} = \frac{2}{5} \Rightarrow AB \text{ and } AC \text{ are perpendicular.} \Rightarrow \text{right triangle}
 \end{aligned}$$

$$\begin{aligned}
 80. \quad m_{DE} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - 1}{-1 - 0} = \frac{2}{-1} = -2 \\
 m_{EF} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{5 - 3}{3 - (-1)} = \frac{2}{4} = \frac{1}{2} \Rightarrow DE \text{ and } EF \text{ are perpendicular.} \Rightarrow \text{right triangle}
 \end{aligned}$$

$$\begin{aligned}
 81. \quad m_{AB} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - (-1)}{3 - 1} = \frac{1}{2}; \quad d(A, B) = \sqrt{(1 - 3)^2 + (-1 - 0)^2} = \sqrt{5} \\
 m_{BC} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{2 - 0}{2 - 3} = \frac{2}{-1} = -2; \quad d(B, C) = \sqrt{(3 - 2)^2 + (0 - 2)^2} = \sqrt{5} \\
 m_{CD} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - 2}{0 - 2} = \frac{-1}{-2} = \frac{1}{2}; \quad d(C, D) = \sqrt{(2 - 0)^2 + (2 - 1)^2} = \sqrt{5} \\
 m_{DA} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - (-1)}{0 - 1} = \frac{2}{-1} = -2; \quad d(D, A) = \sqrt{(1 - 0)^2 + (-1 - 1)^2} = \sqrt{5}
 \end{aligned}$$

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

$$\begin{aligned}
 82. \quad m_{EF} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - (-1)}{3 - (-1)} = \frac{1}{4}; \quad d(E, F) = \sqrt{(-1 - 3)^2 + (-1 - 0)^2} = \sqrt{17} \\
 m_{FG} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 0}{2 - 3} = \frac{4}{-1} = -4; \quad d(F, G) = \sqrt{(3 - 2)^2 + (0 - 4)^2} = \sqrt{17} \\
 m_{GH} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - 4}{-2 - 2} = \frac{-1}{-4} = \frac{1}{4}; \quad d(G, H) = \sqrt{(2 - (-2))^2 + (4 - 3)^2} = \sqrt{17} \\
 m_{HE} &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{3 - (-1)}{-2 - (-1)} = \frac{4}{-1} = -4; \quad d(H, E) = \sqrt{(-1 - (-2))^2 + (-1 - 3)^2} = \sqrt{17}
 \end{aligned}$$

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

### EXERCISES 2.3

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Thus,  $AD$  is perpendicular to  $BC$ .

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

The rate of growth was 7 students per year.

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

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

The sales increased \$30,000 per year.

$$89. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{6700 - 2200}{10 - 3} = \frac{4500}{7} \approx 642.86$$

The cost decreased about \$642.86 per year.

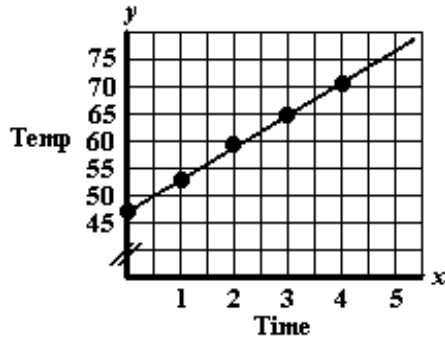
$$90. \quad \text{The cost absorbed by the hospital was \$247 in 2000, \$375 in 2005 and \$505 in 2010.}$$

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

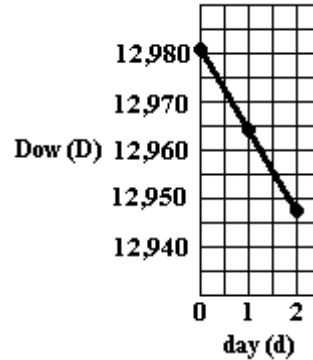
The cost absorbed by the hospital increased by \$25.80 per year.

# EXERCISES 2.3

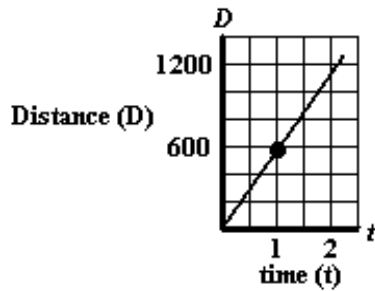
91.  $\frac{\Delta T}{\Delta t}$  = the hourly rate of change of temperature.  
(Let  $t = x$  and  $T = y$ .)



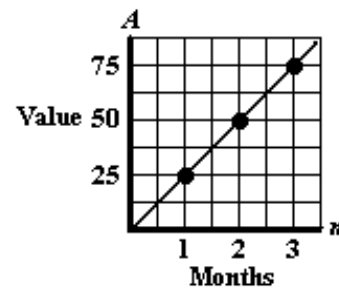
92.  $\frac{\Delta D}{\Delta d}$  = the daily rate of change of the Dow Jones average.



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.  $m = \frac{y_2 - y_1}{x_2 - x_1}$ .

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

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

## EXERCISES 2.4

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

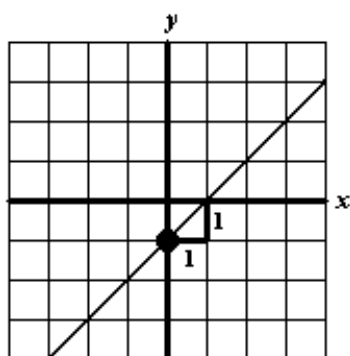
# EXERCISES 2.4

$$\begin{aligned}
 24. \quad & 5(2x - 3y) = 4 \\
 & 10x - 15y = 4 \\
 & -15y = -10x + 4 \\
 & y = \frac{2}{3}x - \frac{4}{15} \\
 & m = \frac{2}{3}, \left(0, -\frac{4}{15}\right)
 \end{aligned}$$

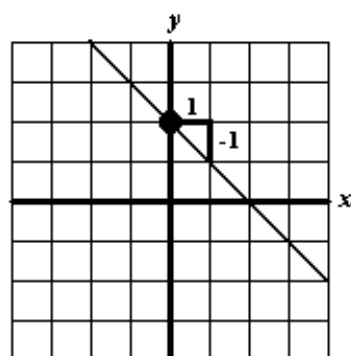
$$\begin{aligned}
 25. \quad & x = \frac{2y - 4}{7} \\
 & 7x = 2y - 4 \\
 & -2y = -7x - 4 \\
 & y = \frac{7}{2}x + 2 \\
 & m = \frac{7}{2}, (0, 2)
 \end{aligned}$$

$$\begin{aligned}
 26. \quad & 3x + 4 = -\frac{2(y - 3)}{5} \\
 & 15x + 20 = -2(y - 3) \\
 & 15x + 20 = -2y + 6 \\
 & 2y = -15x - 14 \\
 & y = -\frac{15}{2}x - 7 \\
 & m = -\frac{15}{2}, (0, -7)
 \end{aligned}$$

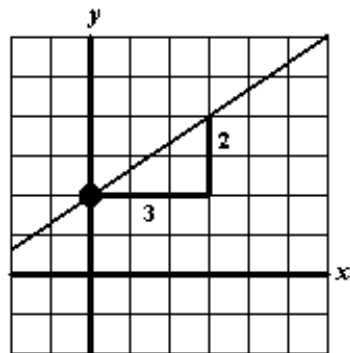
$$\begin{aligned}
 27. \quad & x - y = 1 \\
 & y = x - 1 \Rightarrow m = 1, (0, -1)
 \end{aligned}$$



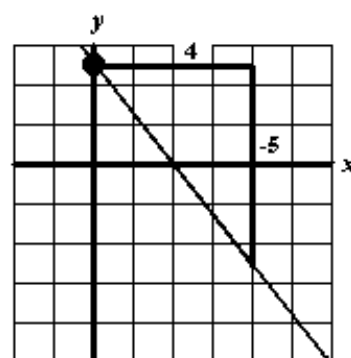
$$\begin{aligned}
 28. \quad & x + y = 2 \\
 & y = -x + 2 \Rightarrow m = -1, (0, 2)
 \end{aligned}$$



$$\begin{aligned}
 29. \quad & x = \frac{3}{2}y - 3 \\
 & 2x = 3y - 6 \\
 & -3y = -2x - 6 \\
 & y = \frac{2}{3}x + 2 \Rightarrow m = \frac{2}{3}, (0, 2)
 \end{aligned}$$

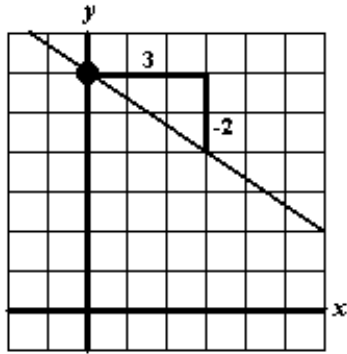


$$\begin{aligned}
 30. \quad & x = -\frac{4}{5}y + 2 \\
 & 5x = -4y + 10 \\
 & 4y = -5x + 10 \\
 & y = -\frac{5}{4}x + \frac{5}{2} \Rightarrow m = -\frac{5}{4}, \left(0, \frac{5}{2}\right)
 \end{aligned}$$

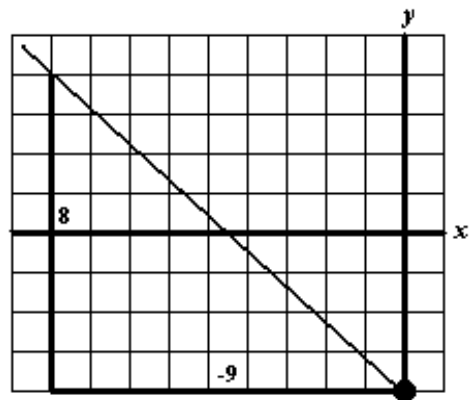


# EXERCISES 2.4

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.  $y = 3x + 4$      $y = 3x - 7$   
 $m = 3$      $m = 3$   
The lines are parallel.

34.  $y = 4x - 13$      $y = \frac{1}{4}x + 13$   
 $m = 4$      $m = \frac{1}{4}$   
The lines are neither.

35.  $x + y = 2$      $y = x + 5$   
 $y = -x + 2$      $m = 1$   
 $m = -1$   
The lines are perpendicular.

36.  $x = y + 2$      $y = x + 3$   
 $-y = -x + 2$      $m = 1$   
 $y = x - 2$   
 $m = 1$   
The lines are parallel.

37.  $y = 3x + 7$      $2y = 6x - 9$   
 $m = 3$      $y = 3x - \frac{9}{2}$   
 $m = 3$   
The lines are parallel.

38.  $2x + 3y = 9$      $3x - 2y = 5$   
 $3y = -2x + 9$      $-2y = -3x + 5$   
 $y = -\frac{2}{3}x + 3$      $y = \frac{3}{2}x - \frac{5}{2}$   
 $m = -\frac{2}{3}$      $m = \frac{3}{2}$   
The lines are perpendicular.

# EXERCISES 2.4

$$\begin{aligned} 39. \quad 3x + 6y &= 1 & y &= \frac{1}{2}x \\ 6y &= -3x + 1 & m &= \frac{1}{2} \\ y &= -\frac{1}{2}x + \frac{1}{6} \\ m &= -\frac{1}{2} \end{aligned}$$

The lines are neither.

$$\begin{aligned} 40. \quad x &= 3y + 4 & y &= -3x + 7 \\ -3y &= -x + 4 & m &= -3 \\ y &= \frac{1}{3}x - \frac{4}{3} \\ m &= \frac{1}{3} \end{aligned}$$

The lines are perpendicular.

$$\begin{aligned} 41. \quad y &= 3 & x &= 4 \\ \text{horizontal} & & \text{vertical} & \\ \text{The lines are perpendicular.} \end{aligned}$$

$$\begin{aligned} 42. \quad y &= -3 & y &= -7 \\ \text{horizontal} & & \text{horizontal} & \\ \text{The lines are parallel.} \end{aligned}$$

$$\begin{aligned} 43. \quad x &= \frac{y-2}{3} & 3(y-3) + x &= 0 \\ 3x &= y-2 & 3y-9+x &= 0 \\ -y &= -3x-2 & 3y &= -x+9 \\ y &= 3x+2 & y &= -\frac{1}{3}x+3 \\ m &= 3 & m &= -\frac{1}{3} \end{aligned}$$

The lines are perpendicular.

$$\begin{aligned} 44. \quad 2y &= 8 & 3(2+x) &= 3(y+2) / \\ y &= 4 & 6+3x &= 3y+6 \\ \text{horizontal} & & -3y &= -3x \\ & & y &= x \\ & & m &= 1 \\ \text{neither} \end{aligned}$$

$$\begin{aligned} 45. \quad y - y_1 &= m(x - x_1) \\ y - 4 &= 2(x - 2) \\ y - 4 &= 2x - 4 \\ -2x + y &= 0 \\ 2x - y &= 0 \end{aligned}$$

$$\begin{aligned} 46. \quad y - y_1 &= m(x - x_1) \\ y - 5 &= -3(x - 3) \\ y - 5 &= -3x + 9 \\ 3x + y &= 14 \end{aligned}$$

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

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

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

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

$$\begin{aligned} 51. \quad y - y_1 &= m(x - x_1) \\ y + 3 &= 0(x + 6) \\ y + 3 &= 0 \\ y &= -3 \end{aligned}$$

$$\begin{aligned} 52. \quad y - y_1 &= m(x - x_1) \\ y - 5 &= 0(x - 7) \\ y - 5 &= 0 \\ y &= 5 \end{aligned}$$

$$\begin{aligned} 53. \quad m &\text{ is und } \Rightarrow \text{ vertical} \\ x &= \text{ constant} \\ x &= -6 \end{aligned}$$

## EXERCISES 2.4

- 54.**  $m$  is und  $\Rightarrow$  vertical  
 $x = \text{constant}$   
 $x = 6$
- 55.**  $y - y_1 = m(x - x_1)$   
 $y - 0 = \pi(x - \pi)$   
 $y = \pi x - \pi^2$   
 $-\pi x + y = -\pi^2$   
 $\pi x - y = \pi^2$
- 56.**  $y - y_1 = m(x - x_1)$   
 $y - \pi = \pi(x - 0)$   
 $y - \pi = \pi x$   
 $-\pi x + y = \pi$   
 $\pi x - y = -\pi$
- 57.** From the graph,  $m = \frac{2}{3}$  and the line passes through  $(2, 5)$ .  
 $y - y_1 = m(x - x_1)$   
 $y - 5 = \frac{2}{3}(x - 2)$   
 $3(y - 5) = 3 \cdot \frac{2}{3}(x - 2)$   
 $3y - 15 = 2(x - 2)$   
 $3y - 15 = 2x - 4$   
 $-2x + 3y = 11$   
 $2x - 3y = -11$
- 58.** From the graph,  $m = -\frac{2}{3}$  and the line passes through  $(-3, 2)$ .  
 $y - y_1 = m(x - x_1)$   
 $y - 2 = -\frac{2}{3}(x + 3)$   
 $3(y - 2) = 3 \cdot \left(-\frac{2}{3}\right)(x + 3)$   
 $3y - 6 = -2(x + 3)$   
 $3y - 6 = -2x - 6$   
 $2x + 3y = 0$
- 59.**  $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 0}{4 - 0} = \frac{4}{4} = 1$   
 $y - y_1 = m(x - x_1)$   
 $y - 0 = 1(x - 0)$   
 $y = x$
- 60.**  $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - (-5)}{0 - (-5)} = \frac{5}{5} = 1$   
 $y - y_1 = m(x - x_1)$   
 $y - 0 = 1(x - 0)$   
 $y = x$
- 61.**  $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-3 - 4}{0 - 3} = \frac{-7}{-3} = \frac{7}{3}$   
 $y - y_1 = m(x - x_1)$   
 $y + 3 = \frac{7}{3}(x - 0)$   
 $y = \frac{7}{3}x - 3$
- 62.**  $m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-8 - 0}{6 - 4} = \frac{-8}{2} = -4$   
 $y - y_1 = m(x - x_1)$   
 $y - 0 = -4(x - 4)$   
 $y = -4x + 16$
- 63.** From the graph,  $m = -\frac{9}{5}$  and the line passes through  $(-2, 4)$ .  
 $y - y_1 = m(x - x_1)$   
 $y - 4 = -\frac{9}{5}(x + 2)$   
 $y - 4 = -\frac{9}{5}x - \frac{18}{5}$   
 $y = -\frac{9}{5}x - \frac{18}{5} + 4$   
 $y = -\frac{9}{5}x + \frac{2}{5}$
- 64.** From the graph,  $m = \frac{8}{5}$  and the line passes through  $(2, 3)$ .  
 $y - y_1 = m(x - x_1)$   
 $y - 3 = \frac{8}{5}(x - 2)$   
 $y - 3 = \frac{8}{5}x - \frac{16}{5}$   
 $y = \frac{8}{5}x - \frac{16}{5} + 3$   
 $y = \frac{8}{5}x - \frac{1}{5}$



# EXERCISES 2.4

65.  $y = 4x - 7$   $y - y_1 = m(x - x_1)$   
 $m = 4$   $y - 0 = 4(x - 0)$   
 Use  $m = 4$ .  $y = 4x$

66.  $x = -3y - 12$   $y - y_1 = m(x - x_1)$   
 $3y = -x - 12$   $y - 0 = -\frac{1}{3}(x - 0)$   
 $y = -\frac{1}{3}x - 4$   $y = -\frac{1}{3}x$   
 $m = -\frac{1}{3}$   
 Use  $m = -\frac{1}{3}$ .

67.  $4x - y = 7$   $y - y_1 = m(x - x_1)$   
 $-y = -4x + 7$   $y - 5 = 4(x - 2)$   
 $y = 4x - 7$   $y - 5 = 4x - 8$   
 $m = 4$   $y = 4x - 3$   
 Use  $m = 4$ .

68.  $y + 3x = -12$   $y - y_1 = m(x - x_1)$   
 $y = -3x - 12$   $y - 3 = -3(x + 6)$   
 $m = -3$   $y - 3 = -3x - 18$   
 Use  $m = -3$ .  $y = -3x - 15$

69.  $x = \frac{5}{4}y - 2$   $y - y_1 = m(x - x_1)$   
 $4x = 5y - 8$   $y + 2 = \frac{4}{5}(x - 4)$   
 $-5y = -4x - 8$   $y + 2 = \frac{4}{5}x - \frac{16}{5}$   
 $y = \frac{4}{5}x + \frac{8}{5}$   $y = \frac{4}{5}x - \frac{26}{5}$   
 $m = \frac{4}{5}$   
 Use  $m = \frac{4}{5}$ .

70.  $x = -\frac{3}{4}y + 5$   $y - y_1 = m(x - x_1)$   
 $4x = -3y + 20$   $y + 5 = -\frac{4}{3}(x - 1)$   
 $3y = -4x + 20$   $y + 5 = -\frac{4}{3}x + \frac{4}{3}$   
 $y = -\frac{4}{3}x + \frac{20}{3}$   $y = -\frac{4}{3}x - \frac{11}{3}$   
 $m = -\frac{4}{3}$   
 Use  $m = -\frac{4}{3}$ .

71.  $y = 4x - 7$   $y - y_1 = m(x - x_1)$   
 $m = 4$   $y - 0 = -\frac{1}{4}(x - 0)$   
 Use  $m = -\frac{1}{4}$ .  $y = -\frac{1}{4}x$

72.  $x = -3y - 12$   $y - y_1 = m(x - x_1)$   
 $3y = -x - 12$   $y - 0 = 3(x - 0)$   
 $y = -\frac{1}{3}x - 4$   $y = 3x$   
 $m = -\frac{1}{3}$   
 Use  $m = 3$ .

73.  $4x - y = 7$   $y - y_1 = m(x - x_1)$   
 $-y = -4x + 7$   $y - 5 = -\frac{1}{4}(x - 2)$   
 $y = 4x - 7$   $y - 5 = -\frac{1}{4}x + \frac{1}{2}$   
 $m = 4$   $y = -\frac{1}{4}x + \frac{11}{2}$   
 Use  $m = -\frac{1}{4}$ .

74.  $y + 3x = -12$   $y - y_1 = m(x - x_1)$   
 $y = -3x - 12$   $y - 3 = \frac{1}{3}(x + 6)$   
 $m = -3$   $y - 3 = \frac{1}{3}x + 2$   
 Use  $m = \frac{1}{3}$ .  $y = \frac{1}{3}x + 5$

## EXERCISES 2.4

- 75.**  $x = \frac{5}{4}y - 2$   $y - y_1 = m(x - x_1)$   
 $4x = 5y - 8$   $y + 2 = -\frac{5}{4}(x - 4)$   
 $-5y = -4x - 8$   $y + 2 = -\frac{5}{4}x + 5$   
 $y = \frac{4}{5}x + \frac{8}{5}$   $y = -\frac{5}{4}x + 3$   
 $m = \frac{4}{5}$   
 Use  $m = -\frac{5}{4}$ .
- 76.**  $x = -\frac{3}{4}y + 5$   $y - y_1 = m(x - x_1)$   
 $4x = -3y + 20$   $y + 5 = \frac{3}{4}(x - 1)$   
 $3y = -4x + 20$   $y + 5 = \frac{3}{4}x - \frac{3}{4}$   
 $y = -\frac{4}{3}x + \frac{20}{3}$   $y = \frac{3}{4}x - \frac{23}{4}$   
 $m = -\frac{4}{3}$   
 Use  $m = \frac{3}{4}$ .
- 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  $(1, -3)$  is  $y = -3$ .
- 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  $(4, 300)$ .  
 $m = \frac{2700 - 300}{0 - 4} = \frac{2400}{-4} = -600$   
 $y - y_1 = m(x - x_1)$   
 $y - 2700 = -600(x - 0)$   
 $y - 2700 = -600x$   
 $y = -600x + 2700$

## EXERCISES 2.4

- 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  $(10, 950000)$ .

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

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

$$y - 475000 = 47500(x - 0)$$

$$y - 475000 = 47500x$$

$$y = 47500x + 475000$$

- 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  $(3, 1190)$ .

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

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

$$y - 1900 = -\frac{710}{3}(x - 0)$$

$$y - 1900 = -\frac{710}{3}x$$

$$y = -\frac{710}{3}x + 1900$$

- 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.

- 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  $(12, 224000)$ .

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

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

$$y - 112000 = \frac{28000}{3}(x - 0)$$

$$y - 112000 = \frac{28000}{3}x$$

$$y = \frac{28000}{3}x + 112000$$

- 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.

- 88.** Let  $x$  = the number of years the jet ski has been owned and let  $y$  = its value. Then 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.

## 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.
- 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.
- 93.** Let  $x$  = the hours of labor and let  $y$  = the labor charge. Then  $m$  = the hourly charge.
- $$y = mx \quad y = 46x$$
- $$69 = m(1.5) \quad y = 46(5) = 230$$
- $$46 = m \quad \text{The charge will be \$230.}$$
- 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.
- 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.
- 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.
- $$y = mx + b \quad y = x + 45$$
- $$y = 1x + b \quad y = 10 + 45 = 55$$
- $$52 = 1(7) + b \quad \text{The charge will be \$55.}$$
- $$45 = b$$

## EXERCISES 2.4

- 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  $x$ :
- $$y = 80x + 33000$$
- $$100000 = 80x + 33000$$
- $$67000 = 80x$$
- $$837.5 = x \Rightarrow \text{There will be about 838 fires when the population is 100,000.}$$
- 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  $(20, 29)$ .
- $$m = \frac{29 - 47}{20 - 0} = \frac{-18}{20} = -\frac{9}{10}$$
- $$y - y_1 = m(x - x_1)$$
- $$y - 47 = -\frac{9}{10}(x - 0)$$
- $$y = -\frac{9}{10}x + 47$$
- 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  $(40.2, 150)$ .
- $$m = \frac{150 - 200}{40.2 - 62.5} = \frac{-50}{-22.3} \approx 2.242$$
- $$h - h_1 = m(f - f_1)$$
- $$h - 200 = 2.242(f - 62.5)$$
- $$h - 200 = 2.242f - 140.125$$
- $$h = 2.242f + 59.875$$
- Let  $f = 50$ :
- $$h = 2.242(50) + 59.875 \approx 172$$
- He would be about 172 cm tall.

## 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.

- 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.

- 102.** Let January be represented by  $x = 0$ , and later months by  $x = 1, 2, 3, \dots$ . 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.

- 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).

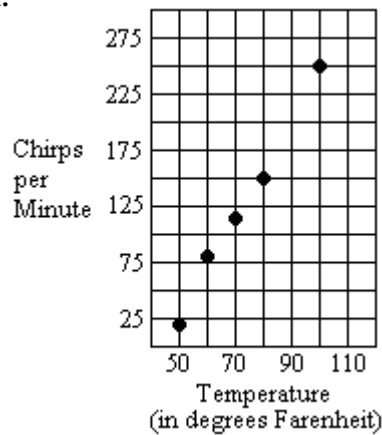
$$m = \frac{-33000 - 137000}{12 - 0} = -\frac{42500}{3}$$

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

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

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

- 105. a.**



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

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

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

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

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

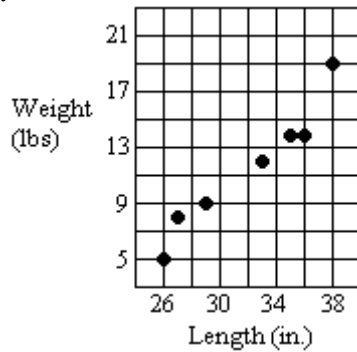
$$y = \frac{23}{5}x - 210$$

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

The rate will be about 204 chirps per minute.

## 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.  $Ax + By = C$   
 $By = -Ax + C$   
 $y = -\frac{A}{B}x + \frac{C}{B}$   
 False.  $m = -\frac{A}{B}$

120.  $Ax + By = C$   
 $By = -Ax + C$   
 $y = -\frac{A}{B}x + \frac{C}{B}$   
 $y$ -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.  $\frac{\sqrt{5}x + \sqrt{10}y}{\sqrt{5}} = \frac{\sqrt{15}}{\sqrt{5}}$   
 $x + \sqrt{2}y = \sqrt{3}$ ; True.

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

## EXERCISES 2.5

### 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. $y = x^2 - 4$<br>$0 = (x + 2)(x - 2)$<br>$x = -2, x = 2$<br>$x$ -int: $(-2, 0), (2, 0)$                                                              | $y = x^2 - 4$<br>$y = 0^2 - 4$<br>$y = -4$<br>$y$ -int: $(0, -4)$             | 12. $y = x^2 - 9$<br>$0 = x^2 - 9$<br>$0 = (x + 3)(x - 3)$<br>$x = -3, x = 3$<br>$x$ -int: $(-3, 0), (3, 0)$                             | $y = x^2 - 9$<br>$y = 0^2 - 9$<br>$y = -9$<br>$y$ -int: $(0, -9)$                 |
| 13. $y = 4x^2 - 2x$<br>$0 = 2x(2x - 1)$<br>$x = 0, x = \frac{1}{2}$<br>$x$ -int: $(0, 0), (\frac{1}{2}, 0)$                                              | $y = 4x^2 - 2x$<br>$y = 4(0)^2 - 2(0)$<br>$y = 0$<br>$y$ -int: $(0, 0)$       | 14. $y = 2x - 4x^2$<br>$0 = 2x(1 - 2x)$<br>$x = 0, x = \frac{1}{2}$<br>$x$ -int: $(0, 0), (\frac{1}{2}, 0)$                              | $y = 2x - 4x^2$<br>$y = 2(0) - 4(0)^2$<br>$y = 0$<br>$y$ -int: $(0, 0)$           |
| 15. $y = x^2 - 4x - 5$<br>$0 = (x + 1)(x - 5)$<br>$x = -1, x = 5$<br>$x$ -int: $(-1, 0), (5, 0)$                                                         | $y = x^2 - 4x - 5$<br>$y = 0^2 - 4(0) - 5$<br>$y = -5$<br>$y$ -int: $(0, -5)$ | 16. $y = x^2 - 10x + 21$<br>$0 = (x - 3)(x - 7)$<br>$x = 3, x = 7$<br>$x$ -int: $(3, 0), (7, 0)$                                         | $y = x^2 - 10x + 21$<br>$y = 0^2 - 10(0) + 21$<br>$y = 21$<br>$y$ -int: $(0, 21)$ |
| 17. $y = x^2 + x - 2$<br>$0 = (x + 2)(x - 1)$<br>$x = -2, x = 1$<br>$x$ -int: $(-2, 0), (1, 0)$                                                          | $y = x^2 + x - 2$<br>$y = 0^2 + 0 - 2$<br>$y = -2$<br>$y$ -int: $(0, -2)$     | 18. $y = x^2 + 2x - 3$<br>$0 = (x + 3)(x - 1)$<br>$x = -3, x = 1$<br>$x$ -int: $(-3, 0), (1, 0)$                                         | $y = x^2 + 2x - 3$<br>$y = 0^2 + 2(0) - 3$<br>$y = -3$<br>$y$ -int: $(0, -3)$     |
| 19. $y = x^3 - 9x$<br>$0 = x(x^2 - 9)$<br>$0 = x(x + 3)(x - 3)$<br>$x = 0, x = -3, x = 3$<br>$x$ -int: $(0, 0), (-3, 0), (3, 0)$                         | $y = x^3 - 9x$<br>$y = 0^3 - 9(0)$<br>$y = 0$<br>$y$ -int: $(0, 0)$           | 20. $y = x^3 + x$<br>$0 = x(x^2 + 1)$<br>$x = 0, \{x^2 + 1 \neq 0\}$<br>$x$ -int: $(0, 0)$                                               | $y = x^3 + x$<br>$y = 0^3 + 0$<br>$y = 0$<br>$y$ -int: $(0, 0)$                   |
| 21. $y = x^4 - 1$<br>$0 = (x^2 + 1)(x^2 - 1)$<br>$0 = (x^2 + 1)(x + 1)(x - 1)$<br>$\{x^2 + 1 \neq 0\}$<br>$x = -1, x = 1$<br>$x$ -int: $(-1, 0), (1, 0)$ | $y = x^4 - 1$<br>$y = 0^4 - 1$<br>$y = -1$<br>$y$ -int: $(0, -1)$             | 22. $y = x^4 - 25x^2$<br>$0 = x^2(x^2 - 25)$<br>$0 = x^2(x + 5)(x - 5)$<br>$x = 0, x = -5, x = 5$<br>$x$ -int: $(0, 0), (-5, 0), (5, 0)$ | $y = x^4 - 25x^2$<br>$y = 0^4 - 25(0)^2$<br>$y = 0$<br>$y$ -int: $(0, 0)$         |

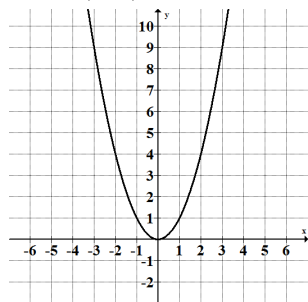


# EXERCISES 2.5

23.  $y = x^2$

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

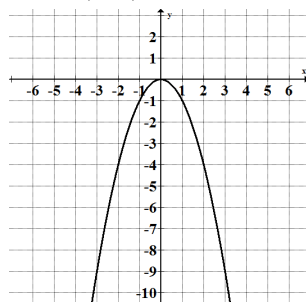
$y$ -int:  $(0, 0)$



24.  $y = -x^2$

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

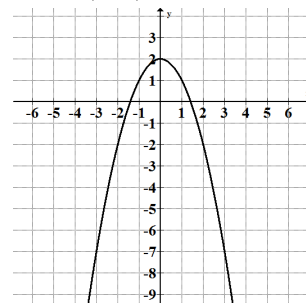
$y$ -int:  $(0, 0)$



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

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

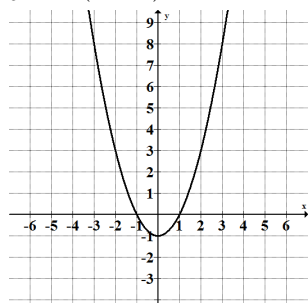
$y$ -int:  $(0, 2)$



26.  $y = x^2 - 1$

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

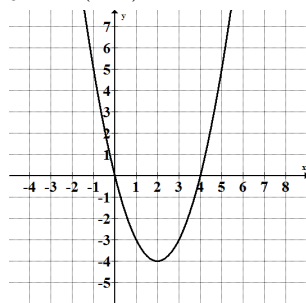
$y$ -int:  $(0, -1)$



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

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

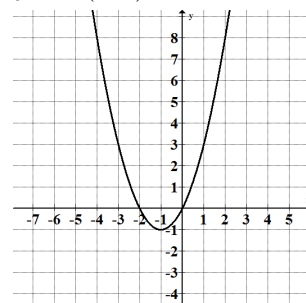
$y$ -int:  $(0, 0)$



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

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

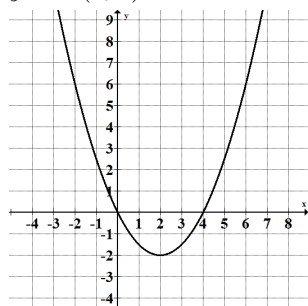
$y$ -int:  $(0, 0)$



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

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

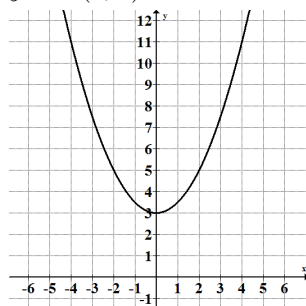
$y$ -int:  $(0, 0)$



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

$x$ -int: none

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



# EXERCISES 2.5

31.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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 |

# EXERCISES 2.5

37.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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.

| $x$ -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 |

# EXERCISES 2.5

43.

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

44.

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

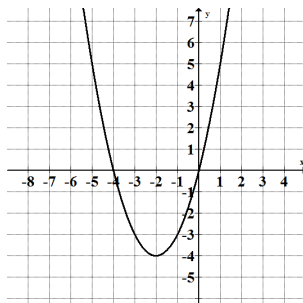
45.

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

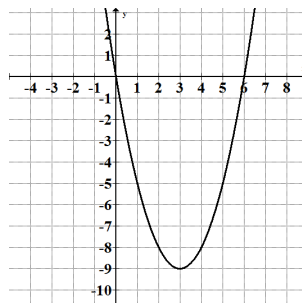
46.

| $x$ -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 |

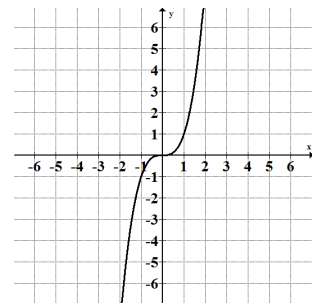
47.  $y = x^2 + 4x$   
 $x$ -int:  $(0, 0), (-4, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry: none



48.  $y = x^2 - 6x$   
 $x$ -int:  $(0, 0), (6, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry: none

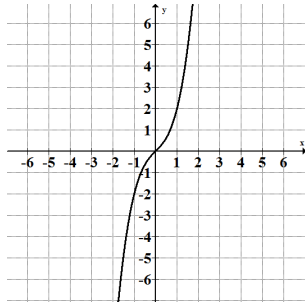


49.  $y = x^3$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry: origin

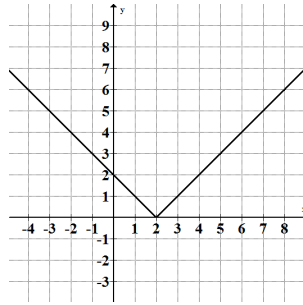


# EXERCISES 2.5

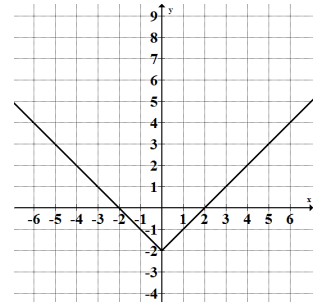
50.  $y = x^3 + x$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry: origin



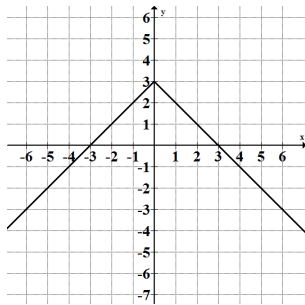
51.  $y = |x - 2|$   
 $x$ -int:  $(2, 0)$   
 $y$ -int:  $(0, 2)$   
symmetry: none



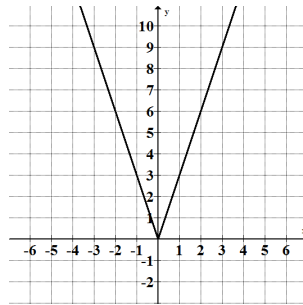
52.  $y = |x| - 2$   
 $x$ -int:  $(-2, 0), (2, 0)$   
 $y$ -int:  $(0, -2)$   
symmetry:  $y$ -axis



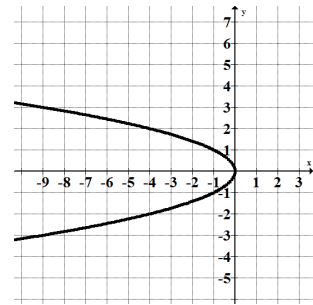
53.  $y = -|x| + 3$   
 $x$ -int:  $(-3, 0), (3, 0)$   
 $y$ -int:  $(0, 3)$   
symmetry:  $y$ -axis



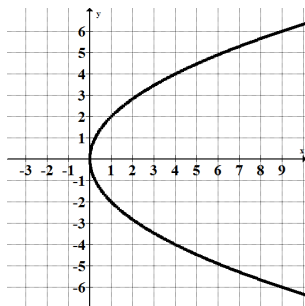
54.  $y = 3|x|$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry:  $y$ -axis



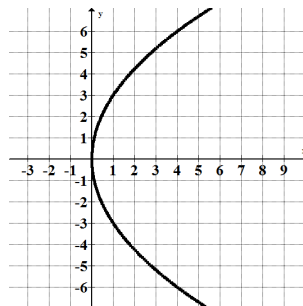
55.  $y^2 = -x$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry:  $x$ -axis



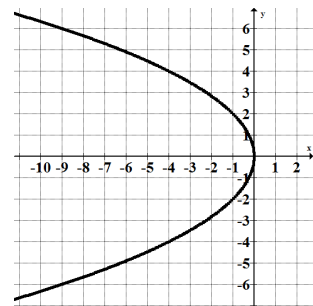
56.  $y^2 = 4x$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry:  $x$ -axis



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

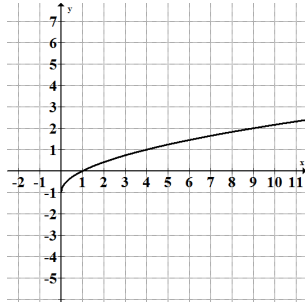


58.  $y^2 = -4x$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry:  $x$ -axis

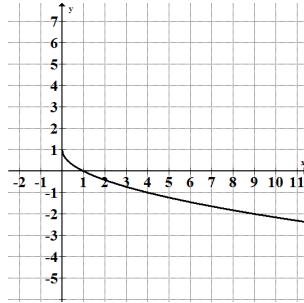


# EXERCISES 2.5

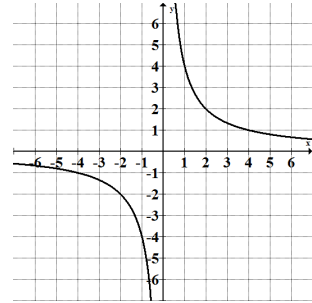
59.  $y = \sqrt{x} - 1$   
 $x$ -int: (1, 0)  
 $y$ -int: (0, -1)  
 symmetry: none



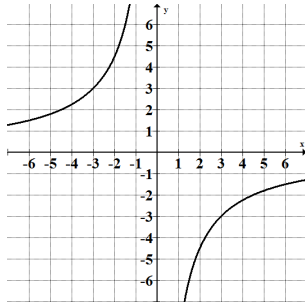
60.  $y = 1 - \sqrt{x}$   
 $x$ -int: (1, 0)  
 $y$ -int: (0, 1)  
 symmetry: none



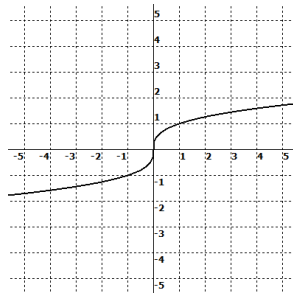
61.  $xy = 4$   
 $x$ -int: none  
 $y$ -int: none  
 symmetry: origin



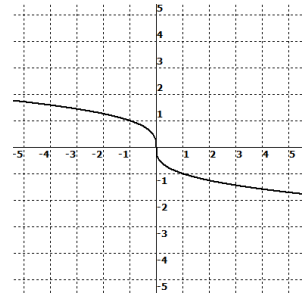
62.  $xy = -9$   
 $x$ -int: none  
 $y$ -int: none  
 symmetry: origin



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

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

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

## EXERCISES 2.5

$$\begin{aligned} 71. \quad (x-4)^2 + (y-1)^2 &= 9 \\ (x-4)^2 + (y-1)^2 &= 3^2 \\ \text{C: } (4, 1); r &= 3 \end{aligned}$$

$$\begin{aligned} 72. \quad (x+11)^2 + (y+7)^2 &= 121 \\ (x-(-11))^2 + (y-(-7))^2 &= 11^2 \\ \text{C: } (-11, -7); r &= 11 \end{aligned}$$

$$\begin{aligned} 73. \quad (x-\frac{1}{4})^2 + (y+2)^2 &= 45 \\ (x-\frac{1}{4})^2 + (y-(-2))^2 &= (\sqrt{45})^2 \\ (x-\frac{1}{4})^2 + (y-(-2))^2 &= (3\sqrt{5})^2 \\ \text{C: } (\frac{1}{4}, -2); r &= 3\sqrt{5} \end{aligned}$$

$$\begin{aligned} 74. \quad (x+\sqrt{5})^2 + (y-3)^2 &= 1 \\ (x-(-\sqrt{5}))^2 + (y-3)^2 &= (1)^2 \\ \text{C: } (-\sqrt{5}, 3); r &= 1 \end{aligned}$$

$$\begin{aligned} 75. \quad (x-0)^2 + (y-0)^2 &= 5^2 \\ x^2 + y^2 &= 25 \end{aligned}$$

$$\begin{aligned} 76. \quad (x-0)^2 + (y-0)^2 &= (\sqrt{3})^2 \\ x^2 + y^2 &= 3 \end{aligned}$$

$$\begin{aligned} 77. \quad (x-0)^2 + (y-(-6))^2 &= 6^2 \\ x^2 + (y+6)^2 &= 36 \end{aligned}$$

$$\begin{aligned} 78. \quad (x-0)^2 + (y-7)^2 &= 9^2 \\ x^2 + (y-7)^2 &= 81 \end{aligned}$$

$$\begin{aligned} 79. \quad (x-8)^2 + (y-0)^2 &= (\frac{1}{5})^2 \\ (x-8)^2 + y^2 &= \frac{1}{25} \end{aligned}$$

$$\begin{aligned} 80. \quad (x-(-10))^2 + (y-0)^2 &= (\sqrt{11})^2 \\ (x+10)^2 + y^2 &= 11 \end{aligned}$$

$$\begin{aligned} 81. \quad (x-(-2))^2 + (y-12)^2 &= 13^2 \\ (x+2)^2 + (y-12)^2 &= 169 \end{aligned}$$

$$\begin{aligned} 82. \quad (x-\frac{2}{7})^2 + (y-(-5))^2 &= 7^2 \\ (x-\frac{2}{7})^2 + (y+5)^2 &= 49 \end{aligned}$$

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

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

$$\begin{aligned} 85. \quad (x-6)^2 + (y-8)^2 &= 4^2 \\ x^2 - 12x + 36 + y^2 - 16y + 64 &= 16 \\ x^2 + y^2 - 12x - 16y + 84 &= 0 \end{aligned}$$

$$\begin{aligned} 86. \quad (x-5)^2 + (y-3)^2 &= 2^2 \\ x^2 - 10x + 25 + y^2 - 6y + 9 &= 4 \\ x^2 + y^2 - 10x - 6y + 30 &= 0 \end{aligned}$$

$$\begin{aligned} 87. \quad (x-3)^2 + (y+4)^2 &= (\sqrt{2})^2 \\ x^2 - 6x + 9 + y^2 + 8y + 16 &= 2 \\ x^2 + y^2 - 6x + 8y + 23 &= 0 \end{aligned}$$

$$\begin{aligned} 88. \quad (x+9)^2 + (y-8)^2 &= (2\sqrt{3})^2 \\ x^2 + 18x + 81 + y^2 - 16y + 64 &= 12 \\ x^2 + y^2 + 18x - 16y + 133 &= 0 \end{aligned}$$

## EXERCISES 2.5

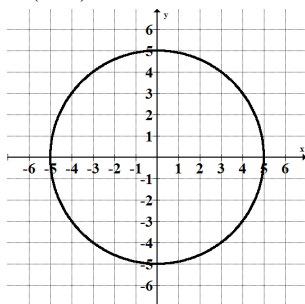
- 89.** Center:  $x = \frac{3+3}{2} = 3, y = \frac{-2+8}{2} = 3$   
 $r = \text{distance from center to endpoint}$   
 $= \sqrt{(3-3)^2 + (3-8)^2} = 5$   
 $(x-3)^2 + (y-3)^2 = 5^2$   
 $x^2 - 6x + 9 + y^2 - 6y + 9 = 25$   
 $x^2 + y^2 - 6x - 6y - 7 = 0$
- 90.** Center:  $x = \frac{-5+5}{2} = 0, y = \frac{-9+9}{2} = 0$   
 $r = \text{distance from center to endpoint}$   
 $= \sqrt{(0-5)^2 + (0-9)^2} = \sqrt{106}$   
 $(x-0)^2 + (y-0)^2 = (\sqrt{106})^2$   
 $x^2 + y^2 = 106$   
 $x^2 + y^2 - 106 = 0$
- 91.**  $r = \text{distance from center to origin}$   
 $= \sqrt{(0-(-3))^2 + (0-4)^2} = 5$   
 $(x+3)^2 + (y-4)^2 = 5^2$   
 $x^2 + 6x + 9 + y^2 - 8y + 16 = 25$   
 $x^2 + y^2 + 6x - 8y = 0$
- 92.**  $r = \text{distance from center to origin}$   
 $= \sqrt{(0-(-2))^2 + (0-6)^2} = \sqrt{40}$   
 $(x+2)^2 + (y-6)^2 = (\sqrt{40})^2$   
 $x^2 + 4x + 4 + y^2 - 12y + 36 = 40$   
 $x^2 + y^2 + 4x - 12y = 0$
- 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.**  $2x^2 + 2y^2 - 8x - 16y + 22 = 0$   
 $x^2 + y^2 - 4x - 8y + 11 = 0$   
 $x^2 - 4x + y^2 - 8y = -11$   
 $x^2 - 4x + 4 + y^2 - 8y + 16 = -11 + 4 + 16$   
 $(x-2)^2 + (y-4)^2 = 9$



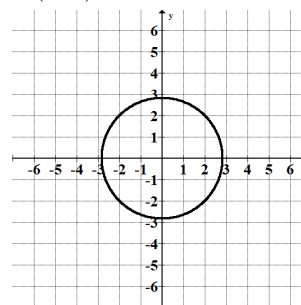
# EXERCISES 2.5

98.  $3x^2 + 3y^2 + 6x - 30y + 3 = 0$   
 $x^2 + y^2 + 2x - 10y + 1 = 0$   
 $x^2 + 2x + y^2 - 10y = -1$   
 $x^2 + 2x + 1 + y^2 - 10y + 25 = -1 + 1 + 25$   
 $(x + 1)^2 + (y - 5)^2 = 25$

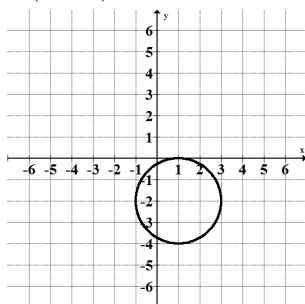
99.  $x^2 + y^2 - 25 = 0$   
 $x^2 + y^2 = 25$   
 $C(0, 0), r = 5$



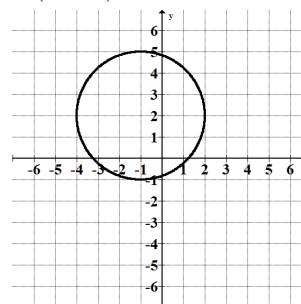
100.  $x^2 + y^2 - 8 = 0$   
 $x^2 + y^2 = 8$   
 $C(0, 0), r = \sqrt{8} = 2\sqrt{2}$



101.  $(x - 1)^2 + (y + 2)^2 = 4$   
 $C(1, -2), r = 2$

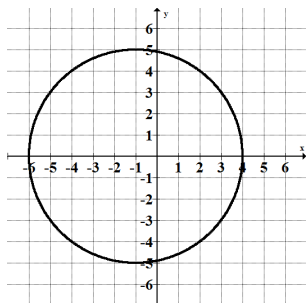


102.  $(x + 1)^2 + (y - 2)^2 = 9$   
 $C(-1, 2), r = 3$

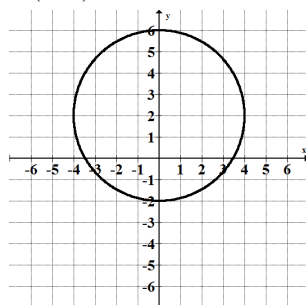


# EXERCISES 2.5

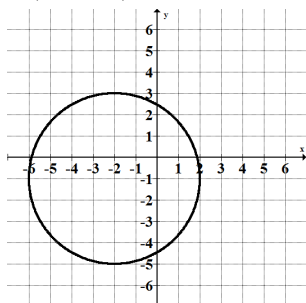
103.  $x^2 + y^2 + 2x - 24 = 0$   
 $x^2 + 2x + y^2 = 24$   
 $x^2 + 2x + 1 + y^2 = 24 + 1$   
 $(x + 1)^2 + y^2 = 25$   
 $C(-1, 0), r = 5$



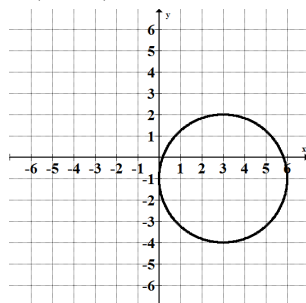
104.  $x^2 + y^2 - 4y = 12$   
 $x^2 + y^2 - 4y + 4 = 12 + 4$   
 $x^2 + (y - 2)^2 = 16$   
 $C(0, 2), r = 4$



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.  $x^2 + y^2 - 6x + 2y + 1 = 0$   
 $x^2 - 6x + y^2 + 2y = -1$   
 $x^2 - 6x + 9 + y^2 + 2y + 1 = -1 + 9 + 1$   
 $(x - 3)^2 + (y + 1)^2 = 9$   
 $C(3, -1), r = 3$



# EXERCISES 2.5

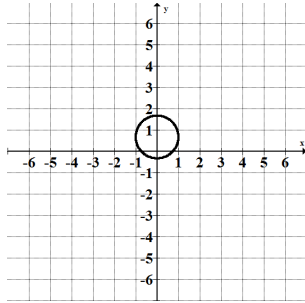
107.  $9x^2 + 9y^2 - 12y = 5$

$$x^2 + y^2 - \frac{4}{3}y = \frac{5}{9}$$

$$x^2 + y^2 - \frac{4}{3}y + \frac{4}{9} = \frac{5}{9} + \frac{4}{9}$$

$$x^2 + \left(y - \frac{2}{3}\right)^2 = 1$$

$$C\left(0, \frac{2}{3}\right), r = 1$$



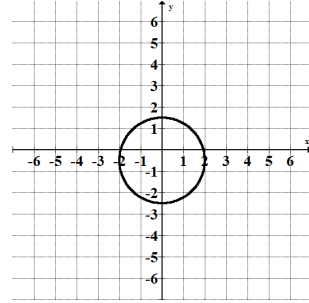
108.  $4x^2 + 4y^2 + 4y = 15$

$$x^2 + y^2 + y = \frac{15}{4}$$

$$x^2 + y^2 + y + \frac{1}{4} = \frac{15}{4} + \frac{1}{4}$$

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

$$C\left(0, -\frac{1}{2}\right), r = 2$$



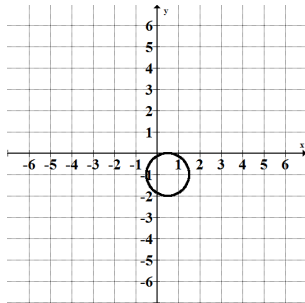
109.  $4x^2 + 4y^2 - 4x + 8y + 1 = 0$

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

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

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

$$C\left(\frac{1}{2}, -1\right), r = 1$$



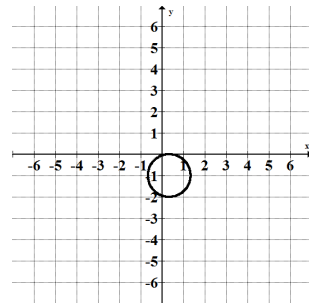
110.  $9x^2 + 9y^2 - 6x + 18y + 1 = 0$

$$x^2 + y^2 - \frac{2}{3}x + 2y = -\frac{1}{9}$$

$$x^2 - \frac{2}{3}x + \frac{1}{9} + y^2 + 2y + 1 = -\frac{1}{9} + \frac{1}{9} + 1$$

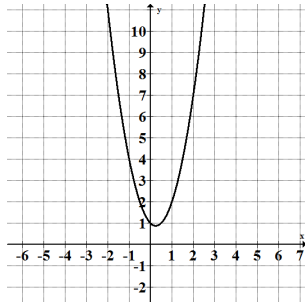
$$\left(x - \frac{1}{3}\right)^2 + (y + 1)^2 = 1$$

$$C\left(\frac{1}{3}, -1\right), r = 1$$

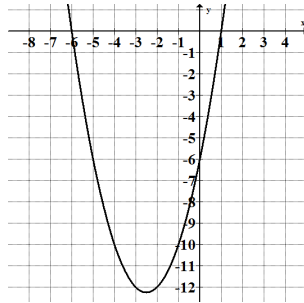


## EXERCISES 2.5

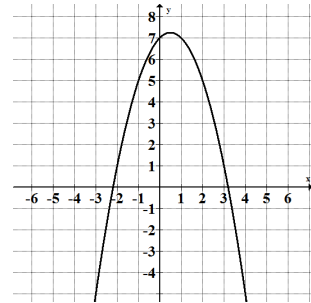
111.  $y = 2x^2 - x + 1$   
Vertex: (0.25, 0.88)



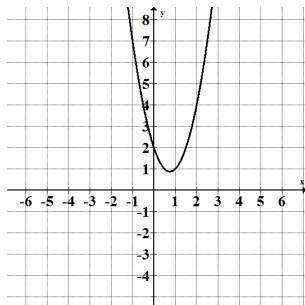
112.  $y = x^2 + 5x - 6$   
Vertex: (-2.50, -12.25)



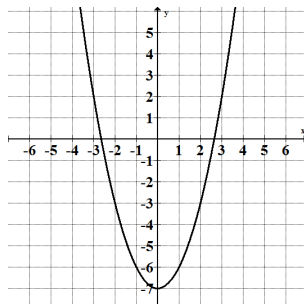
113.  $y = 7 + x - x^2$   
Vertex: (0.50, 7.25)



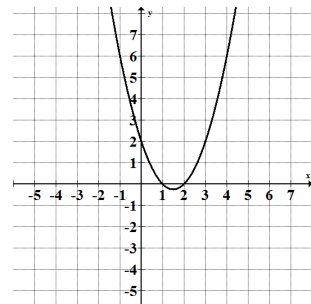
114.  $y = 2x^2 - 3x + 2$   
Vertex: (0.75, 0.88)



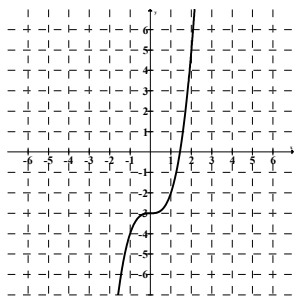
115. Graph  $y = x^2 - 7$ .  
Find the  $x$ -intercepts.  
 $x = -2.65, x = 2.65$



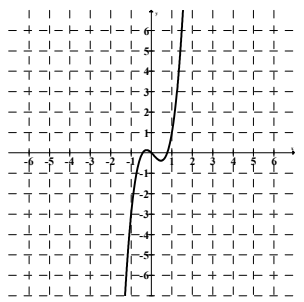
116. Graph  $y = x^2 - 3x + 2$ .  
Find the  $x$ -intercepts.  
 $x = 1.00, x = 2.00$



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.  
 $x = -0.43, x = 0, x = 0.77$

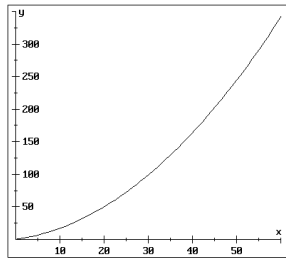


119. Let  $y = 0$ :  
 $y = 64t - 16t^2$   
 $0 = 16t(4 - t)$   
 $t = 0$  or  $t = 4$   
It strikes the ground after 4 seconds.

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.

## 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

$$C(12, 12), r = 12$$

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

$$x^2 - 24x + 144 + y^2 - 24y + 144 = 144$$

$$x^2 + y^2 - 24x - 24y + 144 = 0$$

Second tire

$$C(36, 12), r = 12$$

$$(x - 36)^2 + (y - 12)^2 = 12^2$$

$$x^2 - 72x + 1296 + y^2 - 24y + 144 = 144$$

$$x^2 + y^2 - 72x - 24y + 1296 = 0$$

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.

## EXERCISES 2.5

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

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.  $x^2, z$

$$\begin{aligned} 11. \quad \frac{4}{x} &= \frac{2}{7} \\ 4 \cdot 7 &= 2 \cdot x \\ 28 &= 2x \\ 14 &= x \end{aligned}$$

$$\begin{aligned} 12. \quad \frac{5}{2} &= \frac{x}{6} \\ 5 \cdot 6 &= x \cdot 2 \\ 30 &= 2x \\ 15 &= x \end{aligned}$$

$$\begin{aligned} 13. \quad \frac{x}{2} &= \frac{3}{x+1} \\ x(x+1) &= 3 \cdot 2 \\ x^2 + x &= 6 \\ x^2 + x - 6 &= 0 \\ (x+3)(x-2) &= 0 \\ x &= -3 \text{ or } x = 2 \end{aligned}$$

$$\begin{aligned} 14. \quad \frac{x+5}{6} &= \frac{7}{8-x} \\ (x+5)(8-x) &= 7 \cdot 6 \\ -x^2 + 3x + 40 &= 42 \\ 0 &= x^2 - 3x + 2 \\ 0 &= (x-2)(x-1) \\ x &= 1 \text{ or } x = 2 \end{aligned}$$

15. Let  $x$  = the number of women.

$$\begin{aligned} \frac{3}{5} &= \frac{x}{30} \\ 3 \cdot 30 &= 5 \cdot x \\ 90 &= 5x \\ 18 = x &\Rightarrow \text{There are 18 women.} \end{aligned}$$

16. Let  $x$  = the number of bags of lime.

$$\begin{aligned} \frac{3}{7} &= \frac{x}{21} \\ 3 \cdot 21 &= x \cdot 7 \\ 63 &= 7x \\ 9 = x &\Rightarrow 9 \text{ bags of lime should be used.} \end{aligned}$$

17.  $y = kx$

$$15 = k(30)$$

$$\frac{1}{2} = k$$

18.  $z = kt$

$$21 = k(7)$$

$$3 = k$$

$$\begin{aligned} 19. \quad I &= \frac{k}{R} \\ 50 &= \frac{k}{20} \\ 1000 &= k \end{aligned}$$

## EXERCISES 2.6

$$\begin{aligned} 20. \quad R &= \frac{k}{I^2} \\ 100 &= \frac{k}{25^2} \\ 100 &= \frac{k}{625} \\ 62500 &= k \end{aligned}$$

$$\begin{aligned} 21. \quad E &= kIR \\ 125 &= k(5)(25) \\ 125 &= 125k \\ 1 &= k \end{aligned}$$

$$\begin{aligned} 22. \quad z &= k(x + y) \\ 28 &= k(2 + 5) \\ 28 &= 7k \\ 4 &= k \end{aligned}$$

$$\begin{aligned} 23. \quad y &= kx & y &= \frac{15}{4}x \\ 15 &= k(4) & y &= \frac{15}{4} \cdot \frac{7}{5} \\ \frac{15}{4} &= k & y &= \frac{21}{4} \end{aligned}$$

$$\begin{aligned} 24. \quad w &= kz & w &= -3z \\ -6 &= k(2) & w &= -3(-3) \\ -3 &= k & w &= 9 \end{aligned}$$

$$\begin{aligned} 25. \quad w &= \frac{k}{z} & w &= \frac{30}{z} \\ 10 &= \frac{k}{3} & w &= \frac{30}{5} \\ 30 &= k & w &= 6 \end{aligned}$$

$$\begin{aligned} 26. \quad y &= \frac{k}{x} & y &= \frac{200}{x} \\ 100 &= \frac{k}{2} & y &= \frac{200}{50} \\ 200 &= k & y &= 4 \end{aligned}$$

$$\begin{aligned} 27. \quad P &= krs & P &= -\frac{2}{5}rs \\ 16 &= k(5)(-8) & P &= -\frac{2}{5}(2)(10) \\ 16 &= -40k & P &= -8 \\ -\frac{16}{40} &= k \\ -\frac{2}{5} &= k \end{aligned}$$

$$\begin{aligned} 28. \quad m &= kn^2\sqrt{q} & m &= 3n^2\sqrt{q} \\ 24 &= k(2)^2\sqrt{4} & m &= 3(5)^2\sqrt{9} \\ 24 &= k(4)(2) & m &= 3(25)(3) \\ 24 &= 8k & m &= 225 \\ 3 &= k \end{aligned}$$

29. direct

30. neither

31. neither

32. inverse

33. Let  $x$  = the amount of caffeine.

$$\begin{aligned} \frac{55}{12} &= \frac{x}{44} & \frac{47}{12} &= \frac{x}{44} & \frac{37}{12} &= \frac{x}{44} \\ 55 \cdot 44 &= 12 \cdot x & 47 \cdot 44 &= 12 \cdot x & 37 \cdot 44 &= 12 \cdot x \\ 2420 &= 12x & 2068 &= 12x & 1628 &= 12x \\ 202 \text{ mg} &\approx x & 172 \text{ mg} &\approx x & 136 \text{ mg} &\approx x \end{aligned}$$

34. Let  $x$  = the number of phones.

$$\begin{aligned} \frac{221}{250} &= \frac{x}{280000} \\ 221 \cdot 280000 &= 250 \cdot x \\ 61880000 &= 250x \\ 247,520 &= x \\ 247,520 &\text{ have cellular phones.} \end{aligned}$$

35. Let  $x$  = the amount of adhesive needed.

$$\begin{aligned} \frac{\frac{1}{2}}{140} &= \frac{x}{500} \\ \frac{1}{2} \cdot 500 &= 140 \cdot x \\ 250 &= 140x \\ 1.79 &\approx x \end{aligned}$$

About 2 gallons of adhesive will be needed.

## 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.  $V = \frac{kT}{P}$        $V = \frac{\frac{80}{33}T}{P}$

$$20 = \frac{k(330)}{40}$$

$$800 = 330k$$

$$\frac{800}{330} = k$$

$$\frac{80}{33} = k$$

$$V = \frac{\frac{80}{33}(300)}{50}$$

$$V = \frac{\frac{8000}{11}}{50}$$

$$V = \frac{160}{11} = 14\frac{6}{11} \text{ ft}^3$$

38.  $f = kd$        $f = 25d$

$$5 = k(0.2)$$

$$25 = k$$

$$f = 25(0.35)$$

$$f = 8.75 \text{ Newtons}$$

39.  $d = kt^2$        $d = 16t^2$

$$16 = k(1)^2$$

$$16 = k$$

$$144 = 16t^2$$

$$9 = t^2$$

$$3 = t \Rightarrow 3 \text{ seconds}$$

40.  $P = \frac{kV^2}{R}$        $P = \frac{V^2}{R}$

$$20 = \frac{k(20)^2}{20}$$

$$400 = 400k$$

$$1 = k$$

$$40 = \frac{V^2}{10}$$

$$400 = V^2$$

$$20 = V \Rightarrow 20 \text{ volts}$$

41.  $t = kl^2$        $t = l^2$

$$1 = k(1)^2$$

$$1 = k$$

$$2 = l^2$$

$$\sqrt{2} = l \Rightarrow \sqrt{2} \text{ meters}$$

42.  $f = k\sqrt{T}$        $f = \frac{144}{\sqrt{2}}\sqrt{T}$

$$144 = k\sqrt{2}$$

$$\frac{144}{\sqrt{2}} = k$$

$$f = \frac{144}{\sqrt{2}}\sqrt{18}$$

$$f = 144\sqrt{9}$$

$$f = 144(3) = 432 \text{ hertz}$$

43.  $I = \frac{k}{d^2}$        $I = \frac{6000}{d^2}$

$$60 = \frac{k}{10^2}$$

$$60 = \frac{k}{100}$$

$$6000 = k$$

$$I = \frac{6000}{d^2}$$

$$I = \frac{6000}{20^2}$$

$$I = \frac{6000}{400}$$

$$I = 15 \Rightarrow 15 \text{ lumens}$$

44.  $I = \frac{k}{d^2}$        $I = \frac{22500}{d^2}$

$$100 = \frac{k}{15^2}$$

$$100 = \frac{k}{225}$$

$$22500 = k$$

$$I = \frac{22500}{25^2}$$

$$I = \frac{22500}{625}$$

$$I = 36 \Rightarrow 36 \text{ lumens}$$

45.  $E = kmv^2 = k(2m)(3v)^2$

$$= k(2m)(9v^2)$$

$$= 18 \cdot kmv^2$$

The energy is multiplied by 18.

46.  $P = kRC^2$        $P = RC^2$

$$10 = k(10)(1)^2$$

$$10 = 10k$$

$$1 = k$$

$$P = 5(3)^2$$

$$P = 5(9)$$

$$P = 45 \text{ watts}$$



## EXERCISES 2.6

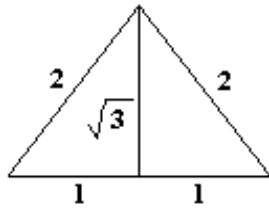
$$\begin{aligned}
 47. \quad G &= \frac{km_1m_2}{d^2} = \frac{k(3m_1)(3m_2)}{(2d)^2} \\
 &= \frac{k \cdot 9m_1m_2}{4d^2} \\
 &= \frac{9}{4} \cdot \frac{km_1m_2}{d^2}
 \end{aligned}$$

The force is multiplied by  $\frac{9}{4}$ .

$$\begin{aligned}
 48. \quad G &= \frac{km_1m_2}{d^2} = \frac{k(2m_1)(3m_2)}{\left(\frac{d}{2}\right)^2} \\
 &= \frac{k \cdot 6m_1m_2}{\frac{d^2}{4}} \\
 &= 24 \cdot \frac{km_1m_2}{d^2}
 \end{aligned}$$

The force is multiplied by 24.

49. Consider this figure:



$h = \sqrt{3}$  can be computed using the Pythagorean Theorem.

$$A = \frac{1}{2}bh = \frac{1}{2}(2)\sqrt{3} = \sqrt{3}$$

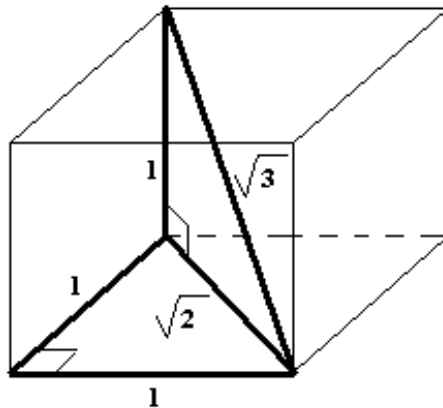
$$A = ks^2$$

$$\sqrt{3} = k(2)^2$$

$$\sqrt{3} = 4k$$

$$\frac{\sqrt{3}}{4} = k$$

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.

## CHAPTER 2 REVIEW

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.  $f(x) = y = \frac{3x}{x - 5}$   
domain =  $(-\infty, 5) \cup (5, \infty)$
9.  $f(x) = \frac{3x}{4x^2 - 16} = \frac{3x}{4(x + 2)(x - 2)}$   
 $x \neq -2, x \neq 2$   
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.  $f(x) = \frac{6}{x - 5}$   
 $f(2) = \frac{6}{2 - 5} = \frac{6}{-3} = -2$   
 $f(-3) = \frac{6}{-3 - 5} = \frac{6}{-8} = -\frac{3}{4}$   
 $f(k) = \frac{6}{k - 5}$
15.  $f(x) = |x - 2|$   
 $f(2) = |2 - 2| = |0| = 0$   
 $f(-3) = |-3 - 2| = |-5| = 5$   
 $f(k) = |k - 2|$
16.  $f(x) = \frac{x^2 - 3}{x^2 + 3}$   
 $f(2) = \frac{2^2 - 3}{2^2 + 3} = \frac{1}{7}$   
 $f(-3) = \frac{(-3)^2 - 3}{(-3)^2 + 3} = \frac{6}{12} = \frac{1}{2}$   
 $f(k) = \frac{k^2 - 3}{k^2 + 3}$
17.  $\frac{f(x + h) - f(x)}{h} = \frac{[5(x + h) - 6] - [5x - 6]}{h} = \frac{[5x + 5h - 6] - [5x - 6]}{h}$   
 $= \frac{5x + 5h - 6 - 5x + 6}{h} = \frac{5h}{h} = 5$

# CHAPTER 2 REVIEW

$$\begin{aligned}
 18. \quad \frac{f(x+h) - f(x)}{h} &= \frac{[2(x+h)^2 - 7(x+h) + 3] - [2x^2 - 7x + 3]}{h} \\
 &= \frac{[2x^2 + 4xh + 2h^2 - 7x - 7h + 3] - [2x^2 - 7x + 3]}{h} \\
 &= \frac{2x^2 + 4xh + 2h^2 - 7x - 7h + 3 - 2x^2 + 7x - 3}{h} \\
 &= \frac{4xh + 2h^2 - 7h}{h} = \frac{h(4x + 2h - 7)}{h} = 4x + 2h - 7
 \end{aligned}$$

$$\begin{aligned}
 19. \quad f(x) &= -0.6x + 132 \\
 f(45) &= -0.6(45) + 132 = 105
 \end{aligned}$$

$$\begin{aligned}
 20. \quad \text{a. } I(h) &= 3.5h - 50 \\
 \text{b. } I(200) &= 3.5(200) - 50 = \$650
 \end{aligned}$$

$$21. \quad A(2, 0)$$

$$22. \quad B(-2, 1)$$

$$23. \quad C(0, -1)$$

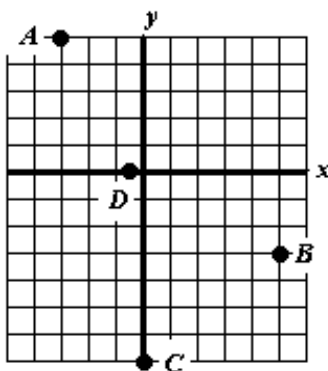
$$24. \quad D(3, -1)$$

$$25. \quad A(-3, 5): \text{QII}$$

$$26. \quad B(5, -3): \text{QIV}$$

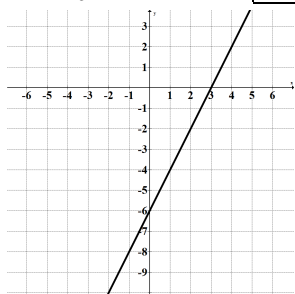
$$27. \quad C(0, -7): \text{negative } y\text{-axis}$$

$$28. \quad D\left(-\frac{1}{2}, 0\right): \text{negative } x\text{-axis}$$



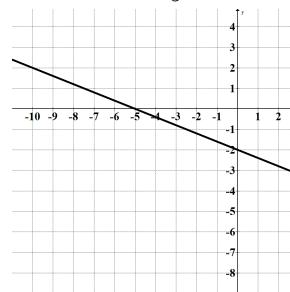
$$\begin{aligned}
 29. \quad 2x - y &= 6 \\
 -y &= -2x + 6 \\
 y &= 2x - 6
 \end{aligned}$$

| $x$ | $y$ |
|-----|-----|
| 0   | -6  |
| 2   | -2  |



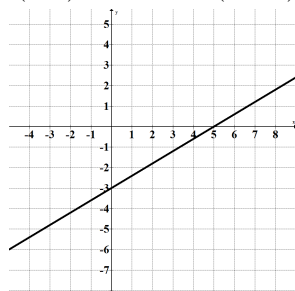
$$\begin{aligned}
 30. \quad 2x + 5y &= -10 \\
 5y &= -2x - 10 \\
 y &= -\frac{2}{5}x - 2
 \end{aligned}$$

| $x$ | $y$ |
|-----|-----|
| 0   | -2  |
| -5  | 0   |

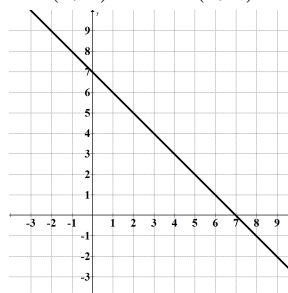


## CHAPTER 2 REVIEW

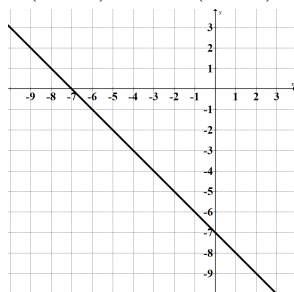
31.  $3x - 5y = 15$        $3x - 5y = 15$   
 $3x - 5(0) = 15$      $3(0) - 5y = 15$   
 $3x = 15$                $-5y = 15$   
 $x = 5$                  $y = -3$   
 $(5, 0)$                $(0, -3)$



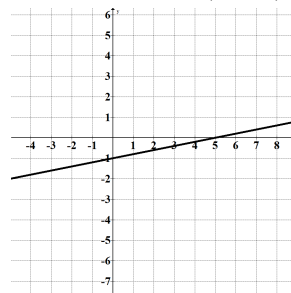
32.  $x + y = 7$        $x + y = 7$   
 $x + 0 = 7$        $0 + y = 7$   
 $x = 7$                $y = 7$   
 $(7, 0)$                $(0, 7)$



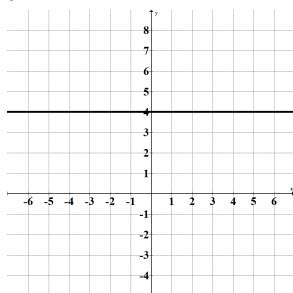
33.  $x + y = -7$        $x + y = -7$   
 $x + 0 = -7$        $0 + y = -7$   
 $x = -7$                $y = -7$   
 $(-7, 0)$                $(0, -7)$



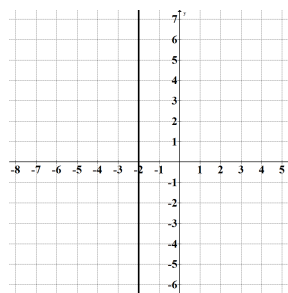
34.  $x - 5y = 5$        $x - 5y = 5$   
 $x - 5(0) = 5$        $0 - 5y = 5$   
 $x = 5$                $-5y = 5$   
 $(5, 0)$                $y = -1$   
 $(0, -1)$



35.  $y = 4 \Rightarrow$  horizontal



36.  $x = -2 \Rightarrow$  vertical



37. Let  $x = 3$ :  $y = -2200x + 18,750 = -2200(3) + 18,750 = -6600 + 18,750 = \$12,150$

38. Let  $x = 5$ :  $y = 16,500x + 250,000 = 16,500(5) + 250,000 = 82,500 + 250,000 = \$332,500$

## CHAPTER 2 REVIEW

$$\begin{aligned} 39. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(-3 - 3)^2 + (7 - (-1))^2} \\ &= \sqrt{(-6)^2 + (8)^2} \\ &= \sqrt{36 + 64} = \sqrt{100} = 10 \end{aligned}$$

$$\begin{aligned} 40. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(-12 - (-8))^2 + (10 - 6)^2} \\ &= \sqrt{(-4)^2 + 4^2} \\ &= \sqrt{16 + 16} = \sqrt{32} = 4\sqrt{2} \end{aligned}$$

$$\begin{aligned} 41. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(\sqrt{3} - \sqrt{3})^2 + (9 - 7)^2} \\ &= \sqrt{0^2 + (2)^2} \\ &= \sqrt{0 + 4} = \sqrt{4} = 2 \end{aligned}$$

$$\begin{aligned} 42. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(a - (-a))^2 + (-a - a)^2} \\ &= \sqrt{(2a)^2 + (-2a)^2} \\ &= \sqrt{4a^2 + 4a^2} = \sqrt{8a^2} = 2\sqrt{2}|a| \end{aligned}$$

$$43. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{-3 + 3}{2}, \frac{7 + (-1)}{2}\right) = M\left(\frac{0}{2}, \frac{6}{2}\right) = M(0, 3)$$

$$44. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{0 + (-12)}{2}, \frac{5 + 10}{2}\right) = M\left(\frac{-12}{2}, \frac{15}{2}\right) = M\left(-6, \frac{15}{2}\right)$$

$$45. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{\sqrt{3} + \sqrt{3}}{2}, \frac{9 + 7}{2}\right) = M\left(\frac{2\sqrt{3}}{2}, \frac{16}{2}\right) = M(\sqrt{3}, 8)$$

$$46. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{a + (-a)}{2}, \frac{-a + a}{2}\right) = M\left(\frac{0}{2}, \frac{0}{2}\right) = M(0, 0)$$

$$47. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{7 - (-5)}{1 - 3} = \frac{12}{-2} = -6$$

$$48. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7 - 7}{-5 - 2} = \frac{-14}{-7} = 2$$

$$49. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{1}{2} - (-8)}{5 - 5} = \frac{8\frac{1}{2}}{0}: \text{und.}$$

$$50. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-8 - (-8)}{-1 - \frac{2}{3}} = \frac{0}{-1\frac{2}{3}} = 0$$

$$51. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{b - a}{a - b} = -1$$

$$52. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{(b - a) - b}{b - (a + b)} = \frac{-a}{-a} = 1$$

$$53. \quad y = 3x + 6 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{9 - 6}{1 - 0} = \frac{3}{1} = 3$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | 6   |
| 1   | 9   |

$$54. \quad y = -\frac{1}{5}x - 6 \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-7 - (-6)}{5 - 0} = \frac{-1}{5} = -\frac{1}{5}$$

|     |     |
|-----|-----|
| $x$ | $y$ |
| 0   | -6  |
| 5   | -7  |

55. The slope is zero.

56. The slope is undefined.

57. The slope is negative.

58. The slope is positive.

## CHAPTER 2 REVIEW

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.  $m = \frac{\Delta y}{\Delta x} = \frac{3000}{15} = 200$  ft per minute

64.  $m = \frac{\Delta y}{\Delta x} = \frac{147,500 - 50,000}{3 - 1} = \frac{97,500}{2} = \$48,750$  per year

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

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

67.  $3x - 2y = 10$   
 $-2y = -3x + 10$   
 $y = \frac{3}{2}x - 5$   
 $m = \frac{3}{2}, (0, -5)$

68.  $2x + 4y = -8$   
 $4y = -2x - 8$   
 $y = -\frac{1}{2}x - 2$   
 $m = -\frac{1}{2}, (0, -2)$

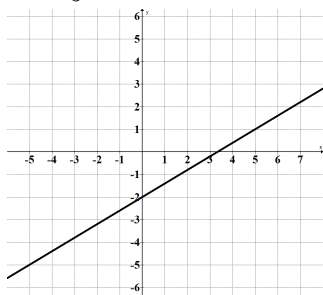
69.  $-2y = -3x + 10$   
 $y = \frac{3}{2}x - 5$   
 $m = \frac{3}{2}, (0, -5)$

70.  $2x = -4y - 8$   
 $4y = -2x - 8$   
 $y = -\frac{1}{2}x - 2$   
 $m = -\frac{1}{2}, (0, -2)$

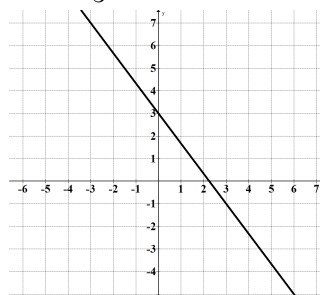
71.  $5x + 2y = 7$   
 $2y = -5x + 7$   
 $y = -\frac{5}{2}x + \frac{7}{2}$   
 $m = -\frac{5}{2}, (0, \frac{7}{2})$

72.  $3x - 4y = 14$   
 $-4y = -3x + 14$   
 $y = \frac{3}{4}x - \frac{7}{2}$   
 $m = \frac{3}{4}, (0, -\frac{7}{2})$

73.  $y = \frac{3}{5}x - 2$   
 $m = \frac{3}{5}, b = -2$



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



## CHAPTER 2 REVIEW

$$\begin{aligned} 75. \quad y &= 3x + 8 & 2y &= 6x - 19 \\ m &= 3 & y &= 3x - \frac{19}{2} \\ m &= 3 \end{aligned}$$

The lines are parallel.

$$\begin{aligned} 76. \quad 2x + 3y &= 6 & 3x - 2y &= 15 \\ 3y &= -2x + 6 & -2y &= -3x + 15 \\ y &= -\frac{2}{3}x + 2 & y &= \frac{3}{2}x - \frac{15}{2} \\ m &= -\frac{2}{3} & m &= \frac{3}{2} \end{aligned}$$

The lines are perpendicular.

$$\begin{aligned} 77. \quad m &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{7 - 0}{-5 - 0} = -\frac{7}{5} \\ y - y_1 &= m(x - x_1) \\ y - 0 &= -\frac{7}{5}(x - 0) \\ y &= -\frac{7}{5}x \\ 5y &= 5\left(-\frac{7}{5}x\right) \\ 5y &= -7x \\ 7x + 5y &= 0 \end{aligned}$$

$$\begin{aligned} 78. \quad y - y_1 &= m(x - x_1) \\ y - 1 &= -4(x + 2) \\ y - 1 &= -4x - 8 \\ 4x + y &= -7 \end{aligned}$$

$$\begin{aligned} 79. \quad y - y_1 &= m(x - x_1) \\ y + 1 &= -\frac{1}{5}(x - 2) \\ 5(y + 1) &= 5 \cdot \left[-\frac{1}{5}(x - 2)\right] \\ 5y + 5 &= -(x - 2) \\ 5y + 5 &= -x + 2 \\ x + 5y &= -3 \end{aligned}$$

$$\begin{aligned} 80. \quad m &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - (-5)}{4 - 7} = \frac{6}{-3} = -2 \\ y - y_1 &= m(x - x_1) \\ y + 5 &= -2(x - 7) \\ y + 5 &= -2x + 14 \\ 2x + y &= 9 \end{aligned}$$

$$\begin{aligned} 81. \quad m &= 0 \Rightarrow \text{horizontal} \\ y &= 17 \end{aligned}$$

$$\begin{aligned} 82. \quad m &\text{ is undefined } \Rightarrow \text{vertical} \\ x &= -5 \end{aligned}$$

$$\begin{aligned} 83. \quad 3x - 4y &= 7 \\ -4y &= -3x + 7 \\ y &= \frac{3}{4}x - \frac{7}{4} \\ m &= \frac{3}{4} \\ \text{Use } m &= \frac{3}{4}. \\ y - y_1 &= m(x - x_1) \\ y - 0 &= \frac{3}{4}(x - 2) \\ y &= \frac{3}{4}x - \frac{3}{2} \end{aligned}$$

$$\begin{aligned} 84. \quad m &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{-10 - 4}{4 - 2} = -7 \\ y - y_1 &= m(x - x_1) \\ y + 2 &= -7(x - 7) \\ y + 2 &= -7x + 49 \\ y &= -7x + 47 \end{aligned}$$

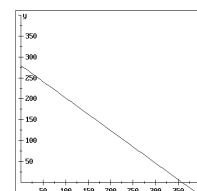
## CHAPTER 2 REVIEW

**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.**  $y = 4x - 8x^2$        $y = 4x - 8x^2$       **90.**  $y = x^2 - 10x - 24$        $y = x^2 - 10x - 24$   
 $0 = 4x(1 - 2x)$        $y = 4(0) - 8(0)^2$        $0 = (x - 12)(x + 2)$        $y = 0^2 - 10(0) - 24$   
 $x = 0, x = \frac{1}{2}$        $y = 0$        $x = 12, x = -2$        $y = -24$   
 $x$ -int:  $(0, 0), (\frac{1}{2}, 0)$        $y$ -int:  $(0, 0)$        $x$ -int:  $(12, 0), (-2, 0)$        $y$ -int:  $(0, -24)$

**91.**

| $x$ -axis                                                                        | $y^2 = 8x$<br>$y$ -axis     | origin                      |
|----------------------------------------------------------------------------------|-----------------------------|-----------------------------|
| $(-y)^2 = 8x$                                                                    | $y^2 = 8(-x)$               | $(-y)^2 = 8(-x)$            |
| $y^2 = 8x$                                                                       | $y^2 = -8x$                 | $y^2 = -8x$                 |
| equivalent: <span style="border: 1px solid black; padding: 2px;">symmetry</span> | not equivalent: no symmetry | not equivalent: no symmetry |

**92.**

| $x$ -axis                   | $y = 3x^4 + 6$<br>$y$ -axis                                                      | origin                      |
|-----------------------------|----------------------------------------------------------------------------------|-----------------------------|
| $-y = 3x^4 + 6$             | $y = 3(-x)^4 + 6$                                                                | $-y = 3(-x)^4 + 6$          |
| $-y = 3x^4 + 6$             | $y = 3x^4 + 6$                                                                   | $-y = 3x^4 + 6$             |
| not equivalent: no symmetry | equivalent: <span style="border: 1px solid black; padding: 2px;">symmetry</span> | not equivalent: no symmetry |



# CHAPTER 2 REVIEW

93.

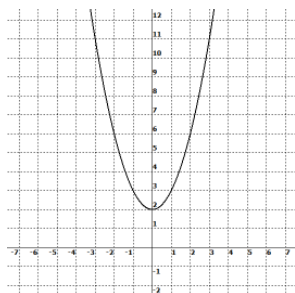
| $x$ -axis                   | $y$ -axis                                                                        | origin                      |
|-----------------------------|----------------------------------------------------------------------------------|-----------------------------|
| $-y = -2 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: <span style="border: 1px solid black; padding: 2px;">symmetry</span> | $y = 2 x $                  |
|                             |                                                                                  | not equivalent: no symmetry |

94.

| $x$ -axis                   | $y$ -axis      | origin                      |
|-----------------------------|----------------|-----------------------------|
| $-y =  x + 2 $              | $y =  x + 2 $  | $-y =  -x + 2 $             |
| not equivalent: no symmetry | $y =  -x + 2 $ | not equivalent: no symmetry |

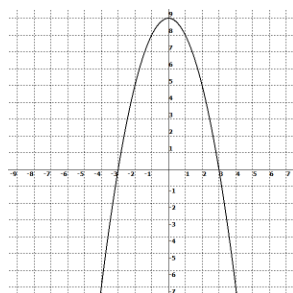
95.

$y = x^2 + 2$   
 $x$ -int: none,  $y$ -int:  $(0, 2)$   
 symmetry:  $y$ -axis



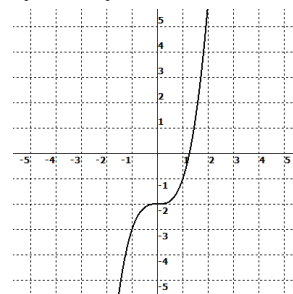
96.

$y = -x^2 + 9$   
 $x$ -int:  $(\pm 3, 0)$ ,  $y$ -int:  $(0, 9)$   
 symmetry:  $y$ -axis



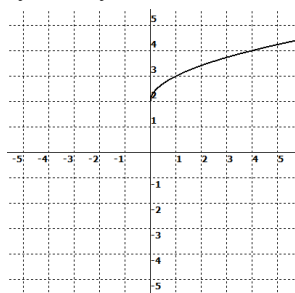
97.

$y = x^3 - 2$   
 $x$ -int:  $(\sqrt[3]{2}, 0)$ ,  
 $y$ -int:  $(0, -2)$   
 symmetry: none



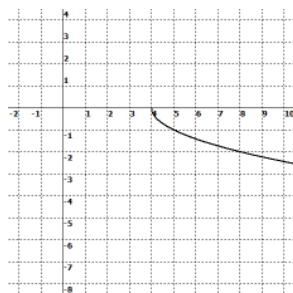
98.

$y = \sqrt{x} + 2$   
 $x$ -int: none,  $y$ -int:  $(0, 2)$   
 symmetry: none



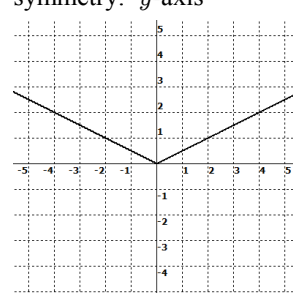
99.

$y = -\sqrt{x - 4}$   
 $x$ -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

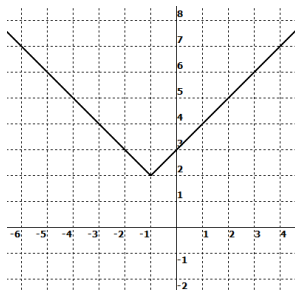


## CHAPTER 2 REVIEW

**101.**  $y = |x + 1| + 2$

$x$ -int: none,  $y$ -int:  $(0, 3)$

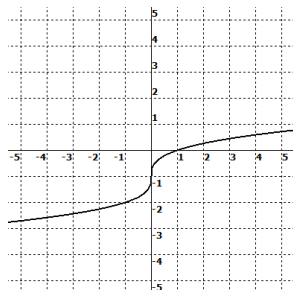
symmetry: none



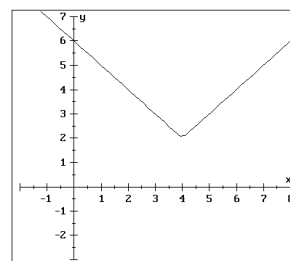
**102.**  $y = \sqrt[3]{x} - 1$

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

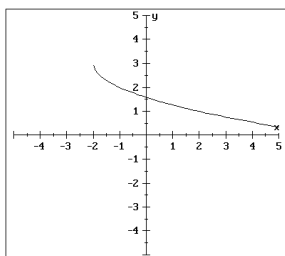
symmetry: none



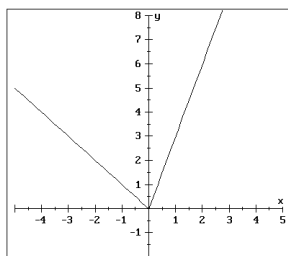
**103.**  $y = |x - 4| + 2$



**104.**  $y = -\sqrt{x + 2} + 3$

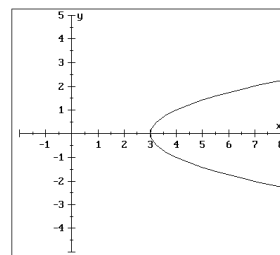


**105.**  $y = x + 2|x|$



**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.**  $\left(x - \frac{2}{7}\right)^2 + (y - 5)^2 = 9^2$   
 $\left(x - \frac{2}{7}\right)^2 + (y - 5)^2 = 81$

## CHAPTER 2 REVIEW

115.  $C(-3, 4); r = 12$

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

$$(x + 3)^2 + (y - 4)^2 = 144$$

$$\text{or } x^2 + y^2 + 6x - 8y - 119 = 0$$

116. Center:  $x = \frac{-6 + 5}{2} = -\frac{1}{2}$

$$y = \frac{-3 + 8}{2} = \frac{5}{2}$$

$$r = \text{distance from center to endpoint}$$

$$= \sqrt{\left(-\frac{1}{2} - 5\right)^2 + \left(\frac{5}{2} - 8\right)^2} = \sqrt{\frac{121}{2}}$$

$$\left(x + \frac{1}{2}\right)^2 + \left(y - \frac{5}{2}\right)^2 = \frac{121}{2}, \text{ or}$$

$$x^2 + y^2 + x - 5y - 54 = 0$$

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.  $2x^2 + 2y^2 - 8x - 16y - 10 = 0$

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

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

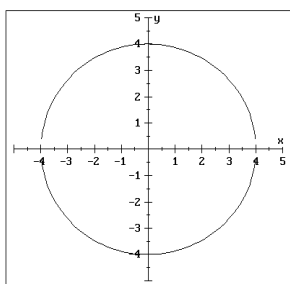
$$x^2 - 4x + 4 + y^2 - 8y + 16 = 5 + 4 + 16$$

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

119.  $x^2 + y^2 - 16 = 0$

$$(x - 0)^2 + (y - 0)^2 = 16$$

$$C(0, 0), r = 4$$



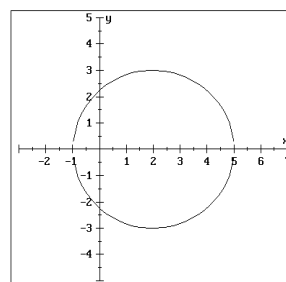
120.  $x^2 + y^2 - 4x = 5$

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

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

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

$$C(2, 0), r = 3$$

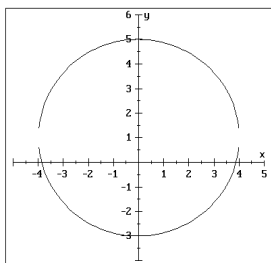


121.  $x^2 + y^2 - 2y = 15$

$$x^2 + y^2 - 2y + 1 = 15 + 1$$

$$x^2 + (y - 1)^2 = 16$$

$$C(0, 1), r = 4$$

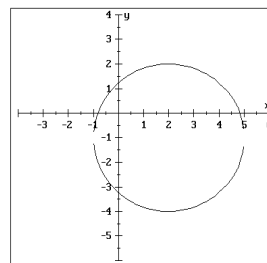


122.  $x^2 + y^2 - 4x + 2y = 4$

$$x^2 - 4x + 4 + y^2 + 2y + 1 = 4 + 4 + 1$$

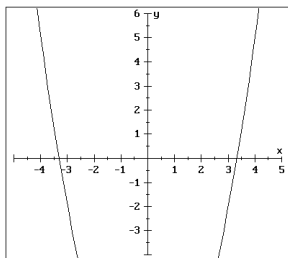
$$(x - 2)^2 + (y + 1)^2 = 9$$

$$C(2, -1), r = 3$$

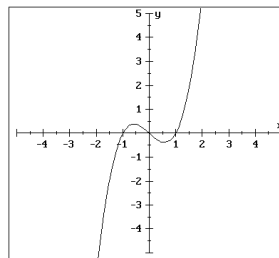


## CHAPTER 2 REVIEW

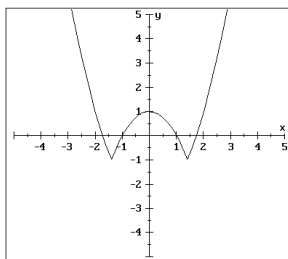
- 123.** Graph  $y = x^2 - 11$ .  
Find the  $x$ -intercepts.  
 $x = -3.32, x = 3.32$



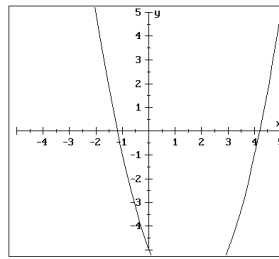
- 124.** Graph  $y = x^3 - x$ .  
Find the  $x$ -intercepts.  
 $x = -1, x = 0, x = 1$



- 125.** Graph  $y = |x^2 - 2| - 1$ .  
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.**

$$f = ks \quad f = \frac{3}{5}s$$

$$3 = k(5) \quad f = \frac{3}{5}(3)$$

$$\frac{3}{5} = k \quad f = \frac{9}{5} \text{ pounds}$$

## CHAPTER 2 REVIEW

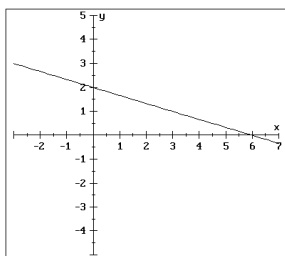
- 131.**  $E = kv^2$   
 30 mph      50 mph  
 $E = k(30)^2$      $E = k(50)^2$   
 $E = 900k$        $E = 2500k$   
 Factor of increase =  $\frac{2500k}{900k} = \frac{25}{9}$
- 132.**  $V = \frac{kT}{P}$        $V = \frac{\frac{100}{3}T}{P}$   
 $400 = \frac{k(300)}{25}$        $V = \frac{\frac{100}{3}(200)}{20}$   
 $10000 = 300k$        $V = \frac{1000}{3}$   
 $\frac{100}{3} = k$        $V = 333\frac{1}{3} \text{ cm}^3$
- 133.**  $A = klw$   
 $A = 1lw \Rightarrow k = 1$
- 134.**  $R = \frac{kL}{D^2}$        $R = \frac{0.0005L}{D^2}$   
 $200 = \frac{k(1000)}{(.05)^2}$        $V = \frac{0.0005(1500)}{(0.08)^2}$   
 $200 = \frac{1000k}{.0025}$        $V \approx 117 \text{ ohms}$   
 $0.0005 = k$

## Chapter 2 Test (page 291)

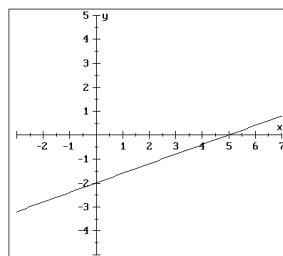
- 1.**  $f(x) = \frac{3}{2x-5}$   
 domain =  $\left(-\infty, \frac{5}{2}\right) \cup \left(\frac{5}{2}, \infty\right)$
- 2.**  $f(x) = \sqrt{x+3}$ : domain =  $[-3, \infty)$
- 3.**  $f(-1) = \frac{-1}{-1-1} = \frac{-1}{-2} = \frac{1}{2}$   
 $f(2) = \frac{2}{2-1} = \frac{2}{1} = 2$
- 4.**  $f(-1) = \sqrt{-1+7} = \sqrt{6}$   
 $f(2) = \sqrt{2+7} = \sqrt{9} = 3$
- 5.** 
$$\begin{aligned} \frac{f(x+h) - f(x)}{h} &= \frac{[(x+h)^2 - (x+h) + 5] - [x^2 - x + 5]}{h} \\ &= \frac{[x^2 + 2xh + h^2 - x - h + 5] - [x^2 - x + 5]}{h} \\ &= \frac{x^2 + 2xh + h^2 - x - h + 5 - x^2 + x - 5}{h} \\ &= \frac{2xh + h^2 - h}{h} = \frac{h(2x + h - 1)}{h} = 2x + h - 1 \end{aligned}$$
- 6.**  $(-3, \pi) \Rightarrow \text{QII}$
- 7.**  $(0, -8) \Rightarrow \text{negative } y\text{-axis}$

# CHAPTER 2 TEST

8.  $x + 3y = 6$   $x + 3y = 6$   
 $x + 3(0) = 6$   $0 + 3y = 6$   
 $x = 6$   $y = 2$   
 $(6, 0)$   $(0, 2)$

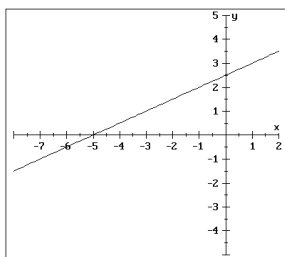


9.  $2x - 5y = 10$   $2x - 5y = 10$   
 $2x - 5(0) = 10$   $2(0) - 5y = 10$   
 $x = 5$   $y = -2$   
 $(5, 0)$   $(0, -2)$



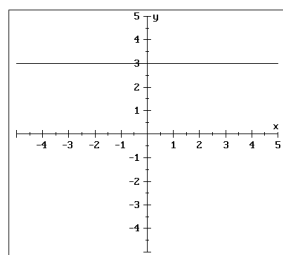
10.  $2(x + y) = 3x + 5$   
 $2x + 2y = 3x + 5$   
 $2y = x + 5$   
 $y = \frac{1}{2}x + \frac{5}{2}$

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



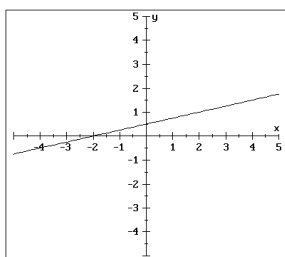
11.  $3x - 5y = 3(x - 5)$   
 $3x - 5y = 3x - 15$   
 $-5y = -15$   
 $y = 3$

| x  | y |
|----|---|
| 0  | 3 |
| -2 | 3 |



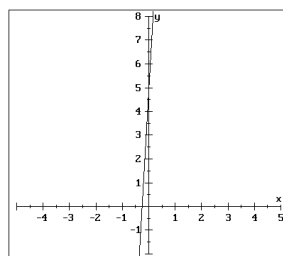
12.  $\frac{1}{2}(x - 2y) = y - 1$   
 $\frac{1}{2}x - y = y - 1$   
 $x - 2y = 2y - 2$   
 $-4y = -x - 2$   
 $y = \frac{1}{4}x + \frac{1}{2}$

| x | y             |
|---|---------------|
| 0 | $\frac{1}{2}$ |
| 2 | 1             |



13.  $\frac{x + y - 5}{7} = 3x$   
 $x + y - 5 = 21x$   
 $y = 20x + 5$

| x              | y |
|----------------|---|
| 0              | 5 |
| $-\frac{1}{4}$ | 0 |



# CHAPTER 2 TEST

$$\begin{aligned} 14. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(1 - (-3))^2 + (-1 - 4)^2} \\ &= \sqrt{(4)^2 + (-5)^2} \\ &= \sqrt{16 + 25} = \sqrt{41} \end{aligned}$$

$$\begin{aligned} 15. \quad d &= \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \\ &= \sqrt{(0 - (-\pi))^2 + (\pi - 0)^2} \\ &= \sqrt{\pi^2 + \pi^2} \\ &= \sqrt{2\pi^2} = \pi\sqrt{2} \approx 4.44 \end{aligned}$$

$$16. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{3 + (-3)}{2}, \frac{-7 + 7}{2}\right) = M\left(\frac{0}{2}, \frac{0}{2}\right) = M(0, 0)$$

$$17. \quad M\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right) = M\left(\frac{0 + \sqrt{8}}{2}, \frac{\sqrt{2} + \sqrt{18}}{2}\right) = M\left(\frac{2\sqrt{2}}{2}, \frac{4\sqrt{2}}{2}\right) = M(\sqrt{2}, 2\sqrt{2})$$

$$18. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1 - (-9)}{-5 - 3} = \frac{10}{-8} = -\frac{5}{4}$$

$$19. \quad m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0 - 3}{-\sqrt{12} - \sqrt{3}} = \frac{-3}{-3\sqrt{3}} = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$$

$$\begin{array}{ll} 20. \quad y = 3x - 2 & y = 2x - 3 \\ m = 3 & m = 2 \\ & \text{neither} \end{array}$$

$$\begin{array}{ll} 21. \quad 2x - 3y = 5 & 3x + 2y = 7 \\ -3y = -2x + 5 & 2y = -3x + 7 \\ y = \frac{2}{3}x - \frac{5}{3} & y = -\frac{3}{2}x + \frac{7}{2} \\ m = \frac{2}{3} & m = -\frac{3}{2} \\ & \text{perpendicular} \end{array}$$

$$\begin{aligned} 22. \quad y - y_1 &= m(x - x_1) \\ y + 5 &= 2(x - 3) \\ y + 5 &= 2x - 6 \\ y &= 2x - 11 \end{aligned}$$

$$\begin{aligned} 23. \quad y &= mx + b \\ y &= 3x + \frac{1}{2} \end{aligned}$$

$$\begin{aligned} 24. \quad 2x - y &= 3 \\ -y &= -2x + 3 \\ y &= 2x - 3 \\ m &= 2 & y &= 2x + 5 \end{aligned}$$

$$\begin{aligned} 25. \quad 2x - y &= 3 \\ -y &= -2x + 3 \\ y &= 2x - 3 \\ m &= 2 & y &= -\frac{1}{2}x + 5 \end{aligned}$$

$$\begin{aligned} 26. \quad m &= \frac{y_2 - y_1}{x_2 - x_1} = \frac{\frac{1}{2} - (-\frac{3}{2})}{3 - 2} = \frac{\frac{4}{2}}{1} = 2 \\ y - y_1 &= m(x - x_1) \\ y - \frac{1}{2} &= 2(x - 3) \\ y - \frac{1}{2} &= 2x - 6 \\ y &= 2x - \frac{11}{2} \end{aligned}$$

$$27. \quad \text{If the line is parallel to the } y\text{-axis, then it is a vertical line: } x = 3$$

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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:  $(0, 4)$

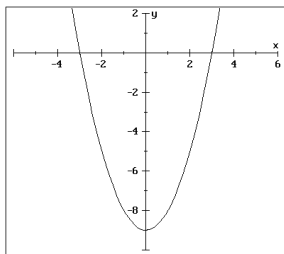
30.

|                                                                                  |                             |                             |                             |
|----------------------------------------------------------------------------------|-----------------------------|-----------------------------|-----------------------------|
| $x$ -axis                                                                        | $y^2 = x - 1$               | $y^2 = x - 1$               | origin                      |
| $(-y)^2 = x - 1$                                                                 | $y^2 = -x - 1$              | $(-y)^2 = -x - 1$           | $(-y)^2 = -x - 1$           |
| $y^2 = x - 1$                                                                    | not equivalent: no symmetry | $y^2 = -x - 1$              | $y^2 = -x - 1$              |
| equivalent: <span style="border: 1px solid black; padding: 2px;">symmetry</span> |                             | not equivalent: no symmetry | not equivalent: no symmetry |

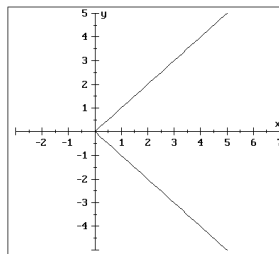
31.

|                             |                                                                                  |                             |                             |
|-----------------------------|----------------------------------------------------------------------------------|-----------------------------|-----------------------------|
| $x$ -axis                   | $y = x^4 + 1$                                                                    | $y = x^4 + 1$               | origin                      |
| $-y = x^4 + 1$              | $y = (-x)^4 + 1$                                                                 | $-y = (-x)^4 + 1$           | $-y = (-x)^4 + 1$           |
| not equivalent: no symmetry | $y = x^4 + 1$                                                                    | $-y = x^4 + 1$              | $-y = x^4 + 1$              |
|                             | equivalent: <span style="border: 1px solid black; padding: 2px;">symmetry</span> | not equivalent: no symmetry | not equivalent: no symmetry |

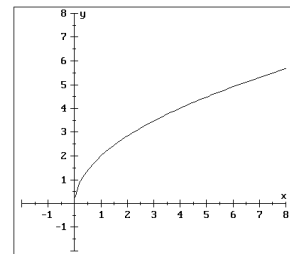
32.  $y = x^2 - 9$   
 $x$ -int:  $(3, 0), (-3, 0)$   
 $y$ -int:  $(0, -9)$   
symmetry:  $y$ -axis



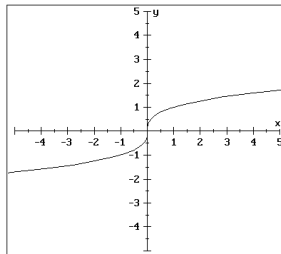
33.  $x = |y|$   
 $x$ -int:  $(0, 0)$   
 $y$ -int:  $(0, 0)$   
symmetry:  $x$ -axis



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

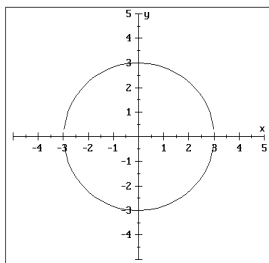




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36.  $C(5, 7); r = 8$   
 $(x - h)^2 + (y - k)^2 = r^2$   
 $(x - 5)^2 + (y - 7)^2 = 64$

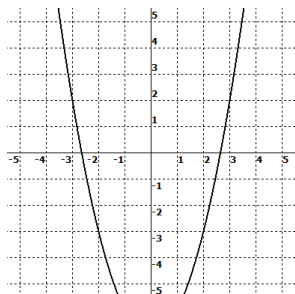
38.  $x^2 + y^2 = 9$   
 $C(0, 0), r = 3$



40.  $y = kz^2$

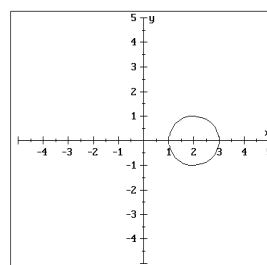
42.  $P = kQ$      $P = \frac{7}{2}Q$   
 $7 = k(2)$   
 $\frac{7}{2} = k$      $P = \frac{7}{2}(5)$   
 $P = \frac{35}{2}$

44. Graph  $y = x^2 - 7$ .  
 Find any positive  $x$ -intercept.  
 $x = 2.65$



37.  $r = \sqrt{(2 - 6)^2 + (4 - 8)^2}$   
 $= \sqrt{32}$   
 $(x - h)^2 + (y - k)^2 = r^2$   
 $(x - 2)^2 + (y - 4)^2 = 32$

39.  $x^2 - 4x + y^2 + 3 = 0$   
 $x^2 - 4x + y^2 = -3$   
 $x^2 - 4x + 4 + y^2 = -3 + 4$   
 $(x - 2)^2 + y^2 = 1$   
 $C(2, 0), r = 1$



41.  $w = krs^2$

43.  $y = \frac{kx}{z^2}$      $y = \frac{\frac{64}{3}x}{z^2}$   
 $16 = \frac{k(3)}{2^2}$      $2 = \frac{\frac{64}{3}x}{3^2}$   
 $16 = \frac{3k}{4}$      $18 = \frac{\frac{64}{3}x}{3}$   
 $\frac{64}{3} = k$      $\frac{3}{64} \cdot 18 = \frac{3}{64} \cdot \frac{64}{3}x$   
 $\frac{27}{32} = x$

45. Graph  $y = x^2 - 5x - 5$ .  
 Find any positive  $x$ -intercept.  
 $x = 5.85$

