1.2  EXERCISES

VOCABULARY: Fill in the blanks.
1. An ordered pair \((a, b)\) is a ______ of an equation in \(x\) and \(y\) if the equation is true when \(a\) is substituted for \(x\), and \(b\) is substituted for \(y\).
2. The set of all solution points of an equation is the ______ of the equation.
3. The points at which a graph intersects or touches an axis are called the ______ of the graph.
4. A graph is symmetric with respect to the ______ if, whenever \((x, y)\) is on the graph, \((-x, y)\) is also on the graph.
5. The equation \((x - h)^2 + (y - k)^2 = r^2\) is the standard form of the equation of a ______ with center ______ and radius ______.
6. When you construct and use a table to solve a problem, you are using a ______ approach.

SKILLS AND APPLICATIONS

In Exercises 7–14, determine whether each point lies on the graph of the equation.

\[
\begin{array}{c|c|c}
\text{Equation} & \text{Points} \\
7. y = \sqrt{x} + 4 & \text{(a) (0, 2) (b) (5, 3)} \\
8. y = \sqrt{5} - x & \text{(a) (1, 2) (b) (5, 0)} \\
9. y = x^2 - 3x + 2 & \text{(a) (2, 0) (b) (-2, 8)} \\
10. y = 4 - |x - 2| & \text{(a) (1, 5) (b) (6, 0)} \\
11. y = |x - 1| + 2 & \text{(a) (2, 3) (b) (-1, 0)} \\
12. 2x - y - 3 = 0 & \text{(a) (1, 2) (b) (1, -1)} \\
13. x^2 + y^2 = 20 & \text{(a) (3, -2) (b) (-4, 2)} \\
14. \frac{1}{3}x^3 - 2x^2 & \text{(a) (2, -\frac{16}{3}) (b) (-3, 9)} \\
\end{array}
\]

In Exercises 15–18, complete the table. Use the resulting solution points to sketch the graph of the equation.

15. \(y = -2x + 5\)

\[
\begin{array}{c|c|c|c|c|c}
x & -1 & 0 & 1 & 2 & \frac{5}{2} \\
\hline
y & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\hline
(x, y) & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\end{array}
\]

16. \(y = \frac{3}{4}x - 1\)

\[
\begin{array}{c|c|c|c|c|c}
x & -2 & 0 & 1 \frac{4}{3} & 2 \\
\hline
y & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\hline
(x, y) & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\end{array}
\]

17. \(y = x^2 - 3x\)

\[
\begin{array}{c|c|c|c|c|c}
x & -1 & 0 & 1 & 2 & 3 \\
\hline
y & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\hline
(x, y) & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\end{array}
\]

18. \(y = 5 - x^2\)

\[
\begin{array}{c|c|c|c|c|c}
x & -2 & -1 & 0 & 1 & 2 \\
\hline
y & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\hline
(x, y) & \text{ } & \text{ } & \text{ } & \text{ } & \text{ } \\
\end{array}
\]

In Exercises 19–22, graphically estimate the \(x\)- and \(y\)-intercepts of the graph. Verify your results algebraically.

19. \(y = (x - 3)^2\)

20. \(y = 16 - 4x^2\)

21. \(y = |x + 2|\)

22. \(y^2 = 4 - x\)

In Exercises 23–32, find the \(x\)- and \(y\)-intercepts of the graph of the equation.

23. \(y = 5x - 6\)

24. \(y = 8 - 3x\)

25. \(y = \sqrt{x} + 4\)

26. \(y = \sqrt{2x - 1}\)

27. \(y = |3x - 7|\)

28. \(y = -|x + 10|\)

29. \(y = 2x^3 - 4x^2\)

30. \(y = x^4 - 25\)

31. \(y^2 = 6 - x\)

32. \(y^2 = x + 1\)
In Exercises 33–40, use the algebraic tests to check for symmetry with respect to both axes and the origin.

33. \( x^2 - y = 0 \)  
34. \( x - y^2 = 0 \)  
35. \( y = x^3 \)  
36. \( y = x^4 - x^2 + 3 \)  
37. \( y = \frac{x}{x^2 + 1} \)  
38. \( y = \frac{1}{x^2 + 1} \)  
39. \( xy^2 + 10 = 0 \)  
40. \( xy = 4 \)

In Exercises 41–44, assume that the graph has the indicated type of symmetry. Sketch the complete graph of the equation. To print an enlarged copy of the graph, go to the website www.mathgraphs.com.

41.  
42.  

43.  
44.  

45. \( y = -3x + 1 \)  
46. \( y = 2x - 3 \)  
47. \( y = x^2 - 2x \)  
48. \( y = -x^2 - 2x \)  
49. \( y = x^3 + 3 \)  
50. \( y = x^3 - 1 \)  
51. \( y = \sqrt{x - 3} \)  
52. \( y = \sqrt{1 - x} \)  
53. \( y = |x - 6| \)  
54. \( y = 1 - |x| \)  
55. \( x = y^2 - 1 \)  
56. \( x = y^2 - 5 \)

In Exercises 45–56, identify any intercepts and test for symmetry. Then sketch the graph of the equation.

57. \( y = 3 - \frac{1}{2}x \)  
58. \( y = \frac{7}{3}x - 1 \)  
59. \( y = x^2 - 4x + 3 \)  
60. \( y = x^2 + x - 2 \)  
61. \( y = \frac{2x}{x - 1} \)  
62. \( y = \frac{4}{x^2 + 1} \)  
63. \( y = \sqrt{x} + 2 \)  
64. \( y = \sqrt[3]{x} + 1 \)

The symbol \( \Rightarrow \) indicates an exercise or a part of an exercise in which you are instructed to use a graphing utility.

In Exercises 65–68, use the graphing utility to graph the equation. Use a standard setting. Approximate any intercepts.

65. \( y = x\sqrt{x} + 6 \)  
66. \( y = (6 - x)\sqrt{x} \)  
67. \( y = |x + 3| \)  
68. \( y = 2 - |x| \)

In Exercises 69–76, write the standard form of the equation of the circle with the given characteristics.

69. Center: \((0, 0)\); Radius: 4  
70. Center: \((0, 0)\); Radius: 5  
71. Center: \((2, -1)\); Radius: 4  
72. Center: \((-7, -4)\); Radius: 7  
73. Center: \((-1, 2)\); Solution point: \((0, 0)\)  
74. Center: \((3, -2)\); Solution point: \((1, 1)\)  
75. Endpoints of a diameter: \((0, 0), (6, 8)\)  
76. Endpoints of a diameter: \((-4, -1), (4, 1)\)

In Exercises 77–82, find the center and radius of the circle, and sketch its graph.

77. \( x^2 + y^2 = 25 \)  
78. \( x^2 + y^2 = 16 \)  
79. \( (x - 1)^2 + (y + 3)^2 = 9 \)  
80. \( x^2 + (y - 1)^2 = 1 \)  
81. \( (x - \frac{1}{2})^2 + (y - \frac{3}{2})^2 = \frac{9}{4} \)  
82. \( (x - 2)^2 + (y + 3)^2 = \frac{16}{9} \)

83. DEPRECIATION A hospital purchases a new magnetic resonance imaging (MRI) machine for $500,000. The depreciated value \( y \) (reduced value) after \( t \) years is given by \( y = 500,000 - 40,000t, \) \( 0 \leq t \leq 8. \) Sketch the graph of the equation.

84. CONSUMERISM You purchase an all-terrain vehicle (ATV) for $8000. The depreciated value \( y \) after \( t \) years is given by \( y = 8000 - 900t, \) \( 0 \leq t \leq 6. \) Sketch the graph of the equation.

85. GEOMETRY A regulation NFL playing field (including the end zones) of length \( x \) and width \( y \) has a perimeter of \( 346 \) or \( 1080 \) yards.

(a) Draw a rectangle that gives a visual representation of the problem. Use the specified variables to label the sides of the rectangle.

(b) Show that the width of the rectangle is \( y = \frac{520}{3} - x \) and its area is \( A = x\left(\frac{520}{3} - x\right). \)

(c) Use a graphing utility to graph the area equation. Be sure to adjust your window settings.

(d) From the graph in part (c), estimate the dimensions of the rectangle that yield a maximum area.

(e) Use your school's library, the Internet, or some other reference source to find the actual dimensions and area of a regulation NFL playing field and compare your findings with the results of part (d).
86. **GEOMETRY**  A soccer playing field of length $x$ and width $y$ has a perimeter of 360 meters.

(a) Draw a rectangle that gives a visual representation of the problem. Use the specified variables to label the sides of the rectangle.

(b) Show that the width of the rectangle is $y = 180 - x$ and its area is $A = x(180 - x)$.

(c) Use a graphing utility to graph the area equation. Be sure to adjust your window settings.

(d) From the graph in part (c), estimate the dimensions of the rectangle that yield a maximum area.

(e) Use your school’s library, the Internet, or some other reference source to find the actual dimensions and area of a regulation Major League Soccer field and compare your findings with the results of part (d).

87. **POPULATION STATISTICS**  The table shows the life expectancies of a child (at birth) in the United States for selected years from 1920 to 2000.  *(Source: U.S. National Center for Health Statistics)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Life Expectancy, $y$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.3 EXERCISES

VOCABULARY

In Exercises 1–7, fill in the blanks.

1. The simplest mathematical model for relating two variables is the _linear_ equation in two variables \( y = mx + b \).
2. For a line, the ratio of the change in \( y \) to the change in \( x \) is called the **slope** of the line.
3. Two lines are **parallel** if and only if their slopes are equal.
4. Two lines are ______ if and only if their slopes are negative reciprocals of each other. **perpendicular**
5. When the \( x \)-axis and \( y \)-axis have different units of measure, the slope can be interpreted as a **rate or rate of change**
6. The prediction method _______ _______ is the method used to estimate a point on a line when the point does not lie between the given points. **linear extrapolation**
7. Every line has an equation that can be written in ______ form. **general**

SKILLS AND APPLICATIONS

In Exercises 9 and 10, identify the line that has each slope.

9. (a) \( m = \frac{4}{3} \) \( L_2 \)
   (b) \( m \) is undefined. \( L_3 \)
   (c) \( m = -2 \) \( L_1 \)
10. (a) \( m = 0 \) \( L_2 \)
    (b) \( m = -\frac{3}{2} \) \( L_1 \)
    (c) \( m = 1 \) \( L_3 \)

In Exercises 11 and 12, sketch the lines through the point with the indicated slopes on the same set of coordinate axes.

<table>
<thead>
<tr>
<th>Point</th>
<th>Slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2, 3)</td>
<td>(a) 0</td>
</tr>
<tr>
<td>(-4, 1)</td>
<td>(a) 3</td>
</tr>
</tbody>
</table>

11–12. See margin.

In Exercises 13–16, estimate the slope of the line.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| \( y = \frac{1}{2} \) | \( y = \frac{5}{2} \)

In Exercises 17–28, find the slope and \( y \)-intercept (if possible) of the equation of the line. Sketch the line. 17–28. See margin.

17. \( y = 5x + 3 \)  
18. \( y = x - 10 \)
19. \( y = -\frac{1}{2}x + 4 \)  
20. \( y = -\frac{3}{2}x + 6 \)
21. \( 5x - 2 = 0 \)  
22. \( 3y + 5 = 0 \)
23. \( 7x + 6y = 30 \)  
24. \( 2x + 3y = 9 \)
25. \( y - 3 = 0 \)  
26. \( y + 4 = 0 \)
27. \( x + 5 = 0 \)  
28. \( x - 2 = 0 \)

In Exercises 29–40, plot the points and find the slope of the line passing through the pair of points. 29–40. See margin.

29. \((0, 9), (6, 0)\)  
30. \((12, 0), (0, -8)\)
31. \((-3, -2), (1, 6)\)  
32. \((-2, 4), (4, -4)\)
33. \((5, -7), (8, -7)\)  
34. \((-2, 1), (-4, -5)\)
35. \((-6, -1), (-6, 4)\)  
36. \((0, -10), (-4, 0)\)
37. \(\left(\frac{11}{2}, -\frac{4}{3}\right), \left(-\frac{3}{2}, -\frac{1}{3}\right)\)  
38. \(\left(-\frac{3}{2}, -\frac{1}{3}\right), \left(-\frac{1}{2}, -\frac{4}{3}\right)\)
39. \((4.8, 3.1), (-5.2, 1.6)\)  
40. \((-1.75, -8.3), (2.25, -2.6)\)
In Exercises 51–64, find the slope-intercept form of the equation of the line that passes through the given point and has the indicated slope $m$. Sketch the line. 51–64. See margin.

51. $(0, -2), \ m = 3$  
52. $(0, 10), \ m = -1$
53. $(-3, 6), \ m = -2$  
54. $(0, 4), \ m = 4$
55. $(4, 0), \ m = -\frac{1}{3}$  
56. $(8, 2), \ m = \frac{1}{4}$
57. $(2, -3), \ m = -\frac{1}{2}$  
58. $(2, -6), \ m = -\frac{3}{4}$
59. $(6, -1), \ m = \text{undefined}$
60. $(-10, 4), \ m = \text{undefined}$
61. $(4, \frac{3}{5}), \ m = 0$  
62. $(-\frac{1}{3}, \frac{3}{5}), \ m = 0$
63. $(-5.1, 1.8), \ m = 5$  
64. $(2.3, -8.5), \ m = -2.5$

In Exercises 65–78, find the slope-intercept form of the equation of the line passing through the points. Sketch the line. 65–78. See margin.

65. $(-5, -1), (-5, 5)$  
66. $(4, 3), (-4, -4)$
67. $(-8, 1), (-8, 7)$  
68. $(-1, 4), (6, 4)$
69. $(2, \frac{1}{3}), (\frac{1}{2}, \frac{5}{3})$  
70. $(1, 1), (6, -\frac{3}{2})$
71. $(-\frac{1}{3}, -\frac{3}{5}), (\frac{1}{5}, \frac{9}{5})$  
72. $(\frac{3}{4}, -\frac{1}{3}), (\frac{3}{4}, \frac{1}{3})$
73. $(1, 0.6), (-2, -0.6)$  
74. $(-8, 0.6), (2, -2.4)$
75. $(2, -1), (\frac{1}{3}, -1)$  
76. $(\frac{1}{3}, -2), (-6, -2)$
77. $(\frac{3}{2}, -8), (\frac{2}{3}, 1)$  
78. $(1.5, -2), (1.5, 0.2)$

In Exercises 79–82, determine whether the lines are parallel, perpendicular, or neither.

79. $L_1$: $y = \frac{1}{3}x - 2$  
80. $L_1$: $y = 4x - 1$  

81. $L_1$: $y = \frac{1}{3}x + 3$  
82. $L_2$: $y = 4x + 7$  

83. $L_1$: $y = \frac{1}{3}x - 3$  
84. $L_2$: $y = -\frac{1}{3}x + 1$  

85. $L_1$: $(3, 6), (-6, 0)$  
86. $L_2$: $(0, -1), (5, \frac{2}{3})$  

In Exercises 87–96, write the slope-intercept forms of equations of the lines through the given point (a) parallel to the given line and (b) perpendicular to the given line.

87. $4x - 2y = 3, (-2, 1)$  
88. $x + y = 7, (-3, -1)$
89. $3x + 4y = 7, (-\frac{2}{3}, \frac{7}{3})$  
90. $5x + 3y = 10, (1, -3)$
91. $y + 3 = 0, (-1, 0)$  
92. $y - 2 = 0, (2, 3)$
93. $x - 4 = 0, (3, -2)$  
94. $x + 2 = 0, (5, 1)$
95. $x - y = 4, (2.5, 6.8)$  
96. $6x + 2y = 9, (-3.9, -1.4)$

(a) $y = -3x - 13.1$  
(b) $y = \frac{1}{3}x - 0.1$

In Exercises 97–102, use the intercept form to find an equation of the line with the given intercepts. The intercept form of the equation of a line with intercepts $(a, 0)$ and $(b, 0)$ is

$$\frac{x}{a} + \frac{y}{b} = 1, a \neq 0, b \neq 0.$$  

97. $x$-intercept: $(2, 0)$  
98. $y$-intercept: $(0, 3)$
99. $x$-intercept: $(-\frac{1}{3}, 0)$  
100. $y$-intercept: $(-1, 0)$

101. Point on line: $(1, 2)$  
102. Point on line: $(-3, 4)$

101. $x$-intercept: $(c, 0)$  
102. $y$-intercept: $(0, c), \ c \neq 0$

GRAPHICAL ANALYSIS In Exercises 103–106, identify any relationships that exist among the lines, and then use a graphing utility to graph the three equations in the same viewing window. Adjust the viewing window so that the graph appears visually correct—that is, so that parallel lines appear parallel and perpendicular lines appear to intersect at right angles. 103–106. See margin.

103. $(a) y = 2x$  
104. $(a) y = \frac{5}{2}x$  
105. $(a) y = -\frac{1}{3}x$  
106. $(a) y = x - 8$

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

(c) $y = x + 1$  
(c) $y = x + 3$

In Exercises 107–110, find a relationship between $x$ and $y$ such that $(x, y)$ is equidistant (the same distance) from the two points.

107. $3x - 2y - 1 = 0$  
108. $5x + 13y + 2 = 0$
109. $5x - 13y + 2 = 0$  
110. $10x + 13y + 2 = 0$

108. $(4, -1), (-2, 3)$  
109. $(3, \frac{5}{2}), (-7, 1)$
110. $(\frac{3}{2}, -4), (-\frac{3}{2}, 0)$

80x + 12y + 139 = 0  
128x + 168y + 320 = 0
11. **SALES** The following are the slopes of lines representing annual sales $y$ in terms of time $x$ in years. Use the slopes to interpret any change in annual sales for a one-year increase in time. See margin.

(a) The line has a slope of $m = 135$.
(b) The line has a slope of $m = 0$.
(c) The line has a slope of $m = -40$.

12. **REVENUE** The following are the slopes of lines representing daily revenues $y$ in terms of time $x$ in days. Use the slopes to interpret any change in daily revenues for a one-day increase in time. See margin.

(a) The line has a slope of $m = 400$.
(b) The line has a slope of $m = 100$.
(c) The line has a slope of $m = 0$.


(a) Use the slopes of the line segments to determine the time periods in which the average salary increased the greatest and the least.
(b) Find the slope of the line segment connecting the points for the years 1996 and 2008.
(c) Interpret the meaning of the slope in part (b) in the context of the problem.

114. **SALES** The graph shows the sales (in billions of dollars) for Apple Inc. for the years 2001 through 2007. (Source: Apple Inc.) See margin.

(a) Use the slopes of the line segments to determine the years in which the sales showed the greatest increase and the least increase.
(b) Find the slope of the line segment connecting the points for the years 2001 and 2007.
(c) Interpret the meaning of the slope in part (b) in the context of the problem.

115. **ROAD GRADE** You are driving on a road that has a 6% uphill grade (see figure). This means that the slope of the road is $\frac{6}{100}$. Approximate the amount of vertical change in your position if you drive 200 feet.

12 ft

116. **ROAD GRADE** From the top of a mountain road, a surveyor takes several horizontal measurements $x$ and several vertical measurements $y$, as shown in the table. (Source: Apple Inc.) See margin.

<table>
<thead>
<tr>
<th>$x$</th>
<th>300</th>
<th>600</th>
<th>900</th>
<th>1200</th>
<th>1500</th>
<th>1800</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y$</td>
<td>-25</td>
<td>-50</td>
<td>-75</td>
<td>-100</td>
<td>-125</td>
<td>-150</td>
<td>-175</td>
</tr>
</tbody>
</table>

(a) Sketch a scatter plot of the data.
(b) Use a straightedge to sketch the line that you think best fits the data.
(c) Find an equation for the line you sketched in part (b).
(d) Interpret the meaning of the slope of the line in part (c) in the context of the problem.
(e) The surveyor needs to put up a road sign that indicates the steepness of the road. For instance, a surveyor would put up a sign that states "8% grade" on a road with a downhill grade that has a slope of $-\frac{8}{100}$. What should the sign state for the road in this problem?

**RATE OF CHANGE** In Exercises 117 and 118, you are given the dollar value of a product in 2010 and the rate at which the value of the product is expected to change during the next 5 years. Use this information to write a linear equation that gives the dollar value $V$ of the product in terms of the year $t$. (Let $t = 10$ represent 2010.)

<table>
<thead>
<tr>
<th>2010 Value</th>
<th>Rate</th>
<th>$V(t)$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$117. $2540$</td>
<td>$125$ decrease per year</td>
<td>$V(t) = 3790 - 125t$</td>
</tr>
<tr>
<td>$118. $156$</td>
<td>$4.50$ increase per year</td>
<td>$V(t) = 4.5t + 111$</td>
</tr>
</tbody>
</table>
122. DEPRECIATION A school district purchases a high-volume printer, copier, and scanner for $25,000. After 10 years, the equipment will have to be replaced. Write a linear equation giving the value \( V \) of the equipment during the 10 years it will be in use. \( V = 25,000 - \frac{2304}{10}t \)

123. SALES A discount outlet is offering a 20% discount on all items. Write a linear equation giving the sale price \( S \) for an item with a list price \( L \). \( S = 0.8L \)

124. HOURLY WAGE A microchip manufacturer pays its assembly line workers $12.25 per hour. In addition, workers receive a piecework rate of $0.75 per unit produced. Write a linear equation for the hourly wage \( W \) in terms of the number of units \( x \) produced per hour.

125. MONTHLY SALARY A pharmaceutical salesperson receives a monthly salary of $2500 plus a commission of 7% of sales. Write a linear equation for the salesperson’s monthly wage \( W \) in terms of monthly sales \( S \).

126. BUSINESS COSTS A sales representative of a company using a personal car receives $120 per day for lodging and meals plus $0.55 per mile driven. Write a linear equation giving the daily cost \( C \) to the company in terms of \( x \), the number of miles driven.

127. CASH FLOW PER SHARE The cash flow per share for the Timberland Co. was $1.21 in 1999 and $1.46 in 2007. Write a linear equation that gives the cash flow per share in terms of the year. Let \( t = 9 \) represent 1999. Then predict the cash flows for the years 2012 and 2014. (Source: The Timberland Co.) \( y = -2.75t + 1086.25; y(12) = 1053.25; y(14) = 1047.75; \) Answers will vary.

128. NUMBER OF STORES In 2003 there were 1078 J.C. Penney stores and in 2007 there were 1067 stores. Write a linear equation that gives the number of stores in terms of the year. Let \( t = 3 \) represent 2003. Then predict the numbers of stores for the years 2012 and 2014. Are your answers reasonable? Explain. (Source: J.C. Penney Co.) \( y = -2.75t + 1086.25; y(12) = 1053.25; y(14) = 1047.75; \) Answers will vary.