CHAPTER 4

Analyzing Linear Equations

BIG Ideas

- Find the slope of a line.
- Write linear equations in slope-intercept and point-slope forms.
- Write equations for parallel and perpendicular lines.
- Draw a scatter plot and write an equation for a line of fit.

Key Vocabulary

point-slope form (p. 220)
rate of change (p. 187)
slope (p. 189)
slope-intercept form (p. 204)

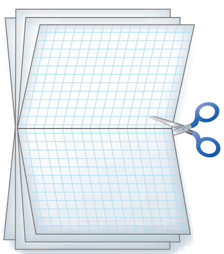
Real-World Link

Space Exploration Linear equations are used to model a variety of real-world situations, including the cost of the U.S. space program.

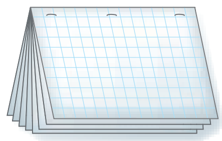
FOLDABLES™ Study Organizer

Analyzing Linear Equations Make this Foldable to help you organize information about writing linear equations. Begin with four sheets of grid paper.

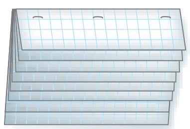
1. **Fold** each sheet of grid paper in half along the width. Then cut along the crease.



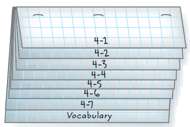
2. **Staple** the eight half-sheets together to form a booklet.

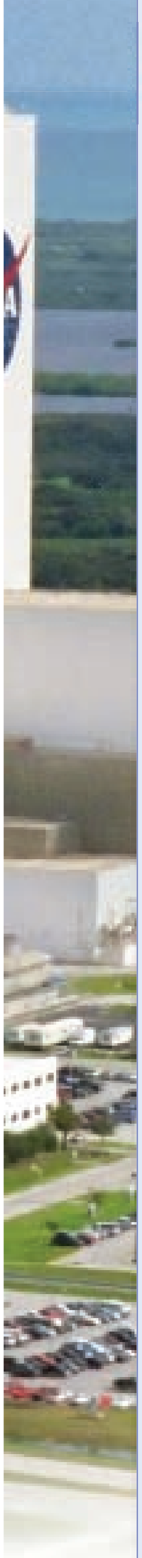


3. **Cut** seven lines from the bottom of the top sheet, six lines from the second sheet, and so on.



4. **Label** each of the tabs with a lesson number. The last tab is for the vocabulary.





GET READY for Chapter 4

Diagnose Readiness You have two options for checking Prerequisite Skills.

Option 2

Math Online Take the Online Readiness Quiz at algebra1.com.

Option 1

Take the Quick Check below. Refer to the Quick Review for help.

QUICKCheck

Simplify. (Prerequisite Skill)

1. $\frac{2}{10}$ **2.** $\frac{8}{12}$ **3.** $\frac{2}{-8}$

4. $\frac{-4}{8}$ **5.** $\frac{-5}{-15}$ **6.** $\frac{-7}{-28}$

7. $\frac{9}{3}$ **8.** $\frac{18}{12}$ **9.** $-\frac{26}{10}$

Evaluate $\frac{a-b}{c-d}$ for the values given. (Lesson 1-2)

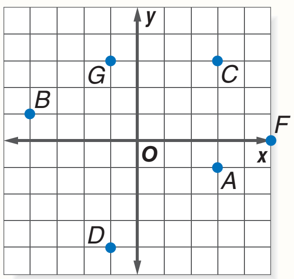
10. $a = 6, b = 5, c = 8, d = 4$

11. $a = -2, b = 1, c = 4, d = 0$

12. $a = -3, b = -3, c = 4, d = 7$

13. CELL PHONES The average cost per minute of using a cell phone decreased \$0.44 between 1996 and 2004. On average, how much did the cost decrease each year? (Lesson 1-2)

Write the ordered pair for each point. (Lesson 1-9)



14. A **15.** B

16. C **17.** D

18. F **19.** G

QUICKReview

EXAMPLE 1

Simplify $-\frac{4}{28}$.

$-\frac{4}{28} = \frac{-4 \div 4}{28 \div 4}$ Divide -4 and 28 by their GCF, 4.

$= \frac{-1}{7}$ or $-\frac{1}{7}$ Simplify. Since the signs are different, the quotient is negative.

EXAMPLE 2

Evaluate $\frac{a-b}{c-d}$ if $a = 2, b = 5, c = -3, d = -12$.

$\frac{a-b}{c-d}$ Original expression

$= \frac{2-5}{(-3)-(-12)}$ Substitute 2 for a, 5 for b, -3 for c, and -12 for d.

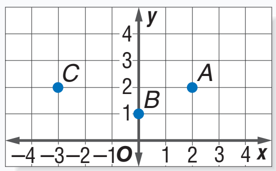
$= \frac{-3}{9}$ Simplify.

$= \frac{-3 \div 3}{9 \div 3}$ Divide -3 and 9 by their GCF, 3.

$= \frac{-1}{3}$ or $-\frac{1}{3}$ Simplify. The signs are different, so the quotient is negative.

EXAMPLE 3

Write the ordered pair for A.



Step 1 Begin at point A.

Step 2 Follow along a vertical line through the point to find the x-coordinate on the x-axis. The x-coordinate is 2.

Step 3 Follow along a horizontal line through the point to find the y-coordinate on the y-axis. The y-coordinate is 2.

The ordered pair for point A is (2, 2).

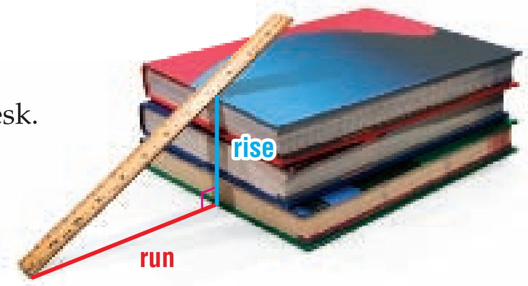
EXPLORE 4-1

Algebra Lab
Steepness of a Line

In mathematics, you can measure the steepness of a line using a ratio.

SET UP the Lab

- Stack three books on your desk.
- Lean a ruler on the books, creating a ramp.
- Tape the ruler to the desk.



ACTIVITY

Step 1 Measure and record the rise and the run of the ramp. Then calculate the ratio $\frac{\text{rise}}{\text{run}}$. Record the data in a table like the one at the right.

rise	run	$\frac{\text{rise}}{\text{run}}$

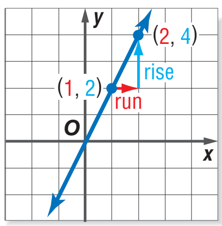
Step 2 Keeping the rise the same, move the books to make the ramp steeper. Measure the rise and run, and calculate the ratio $\frac{\text{rise}}{\text{run}}$. Repeat three times and record the data.

Step 3 Start with the last measurements from Step 2. Keeping the run the same, add a book to increase the rise of the ramp. Measure and record the rise and run, and calculate the ratio. Repeat one time, adding another book, and record the data.

ANALYZE THE RESULTS

1. Examine the ratios you recorded in Step 2. How do they change as the ramp becomes steeper?
2. Examine the ratios you recorded in Step 3. What happens to the ratio when the run stays the same and the rise increases?
3. **MAKE A PREDICTION** Suppose you want to construct a skateboard ramp that is not as steep as the one shown at the left. List three different sets of $\frac{\text{rise}}{\text{run}}$ measurements that will result in a less steep ramp. Verify your predictions by calculating the ratio $\frac{\text{rise}}{\text{run}}$ of each ramp.

4. Copy the coordinate graph and draw a line through the origin with a $\frac{\text{rise}}{\text{run}}$ ratio greater than the original line. Then draw a line through the origin with a ratio less than the original line. Explain your reasoning using the words *rise* and *run*.



4-1 Rate of Change and Slope

Main Ideas

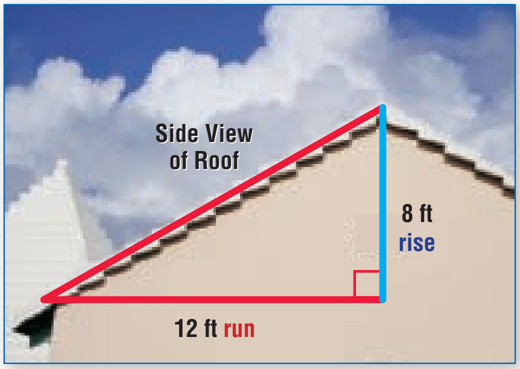
- Use rate of change to solve problems.
- Find the slope of a line.

New Vocabulary

rate of change
slope

GET READY for the Lesson

Houses in the north have steeper roofs so that snow does not pile up. A roof *pitch* describes how steep it is. It is the number of units the roof rises for each unit of run. In the photo, the roof rises 8 feet for each 12 feet of run.



$$\frac{\text{rise}}{\text{run}} = \frac{8}{12} \text{ or } \frac{2}{3}$$

Rate of Change **Rate of change** is a ratio that describes, on average, how much one quantity changes with respect to a change in another quantity. If x is the independent variable and y is the dependent variable, then

$$\text{rate of change} = \frac{\text{change in } y}{\text{change in } x}.$$

Study Tip

Independent Quantities

Rates of change often include *time* as the independent variable.

The table at the right shows the distance a person has walked for various amounts of time.

Time Walking (s)	Distance Walked (ft)
x	y
1	4
2	8
3	12

+1 +1 +4 +4

Each time x increases by 1 second, y increases by 4 feet.

$$\begin{aligned}\text{rate of change} &= \frac{\text{change in } y}{\text{change in } x}\\ &= \frac{\text{change in distance}}{\text{change in time}}\\ &= \frac{4}{1} \begin{array}{l}\leftarrow \text{feet}\\ \leftarrow \text{seconds}\end{array}\end{aligned}$$

The rate of change is $\frac{4}{1}$. This means that the person walked 4 feet per second.

Real-World EXAMPLE

1 **ENTERTAINMENT** **Use the table to find the rate of change. Explain the meaning of the rate of change.**

Number of Computer Games	Total Cost ($)
x	y
2	78
4	156
6	234

Each time x increases by 2 games, y increases by $78.

(continued on the next page)

$$\text{rate of change} = \frac{\text{change in } y}{\text{change in } x}$$

$$= \frac{\text{change in cost}}{\text{change in number of games}}$$

$$= \frac{156 - 78}{4 - 2}$$

$$= \frac{78}{2} \text{ or } \frac{39}{1} \quad \begin{array}{l} \leftarrow \text{dollars} \\ \leftarrow \text{games} \end{array}$$

The rate of change is $\frac{39}{1}$. This means that it costs \$39 per game.

CHECK Your Progress

REMODELING The table shows how the area changes with the number of floor tiles.

1A. Find the rate of change.

1B. Explain the meaning of the rate of change.

Floor Tiles	Area (in^2)
x	y
3	48
6	96
9	144

So far, you have seen rates of change that are *constant*. Many real-world situations involve rates of change that are not constant.

Real-World Link

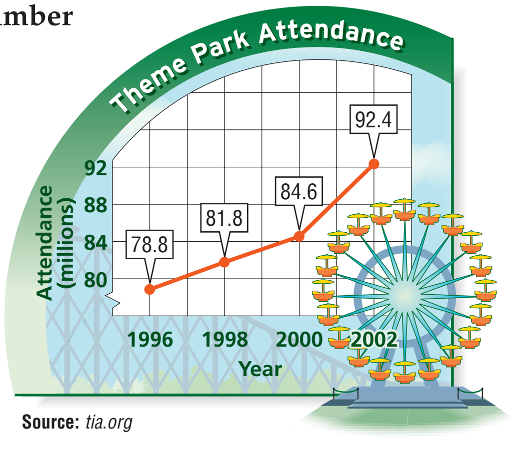
Walt Disney World's Magic Kingdom is the most visited theme park in the United States. An estimated 15 million people pass through its gates each year.

Source: *Amusement Business* Magazine

Real-World EXAMPLE

2 ENTERTAINMENT The graph shows the number of people who visited U.S. theme parks in recent years.

a. Find the rates of change for 1996–1998 and 2000–2002.



Source: *tia.org*

rate of change

$$= \frac{\text{change in attendance}}{\text{change in time}} \quad \begin{array}{l} \leftarrow \text{people} \\ \leftarrow \text{years} \end{array}$$

1996–1998:

$$\frac{\text{change in attendance}}{\text{change in time}} = \frac{81.8 - 78.8}{1998 - 1996} \quad \text{Substitute.}$$

$$= \frac{3}{2} \text{ or } 1.5 \quad \text{Simplify.}$$

Theme park attendance increased by 3 million in a 2-year period for a rate of change of 1.5 million per year.

2000–2002:

$$\frac{\text{change in attendance}}{\text{change in time}} = \frac{92.4 - 84.6}{2002 - 2000} \quad \text{Substitute.}$$

$$= \frac{7.8}{2} \text{ or } 3.9 \quad \text{Simplify.}$$

Over this 2-year period, attendance increased by 7.8 million, for a rate of change of 3.9 million per year.

b. Explain the meaning of the rate of change in each case.

For 1996–1998, on average, 1.5 million more people went to a theme park each year than the last.

For 2000–2002, on average, 3.9 million more people attended theme parks each year than the last.

c. How are the different rates of change shown on the graph?

There is a greater vertical change for 2000–2002 than for 1996–1998. Therefore, the section of the graph for 2000–2002 is steeper.

CHECK Your Progress

2. Refer to the graph. Without calculating, find the 2-year period that has the least rate of change. Then calculate to verify your answer.

Online **Personal Tutor at** algebra1.com

Vocabulary Link

Slope

Everyday Use A hill used for snow skiing is often called a slope.

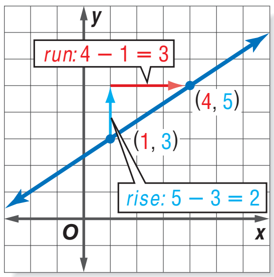
Math Use Slope is used to describe steepness.

Find Slope

The **slope** of a line is the ratio of the change in the y-coordinates (rise) to the change in the x-coordinates (run) as you move in the positive direction.

Slope can be used to describe a rate of change. This number describes how steep the line is. The greater the absolute value of the slope, the steeper the line.

The graph shows a line that passes through (1, 3) and (4, 5).



$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{\text{change in } y\text{-coordinates}}{\text{change in } x\text{-coordinates}}$$

$$= \frac{5-3}{4-1} \text{ or } \frac{2}{3}$$

So, the slope of the line is $\frac{2}{3}$.

Any two points on a line can be used to determine the slope.

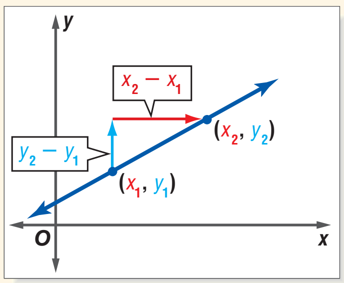
KEY CONCEPT — *Slope*

Words The slope of a line is the ratio of the rise to the run.

Symbols The slope m of a nonvertical line through any two points, (x_1, y_1) and (x_2, y_2), can be found as follows.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \begin{array}{l} \leftarrow \text{change in } y \\ \leftarrow \text{change in } x \end{array}$$

Graph



The slope of a line can be positive, negative, zero, or undefined.

Study Tip

Common Misconception

It may make your calculations easier to choose the point on the left as (x_1, y_1). However, either point may be chosen as (x_1, y_1).

EXAMPLE Positive Slope

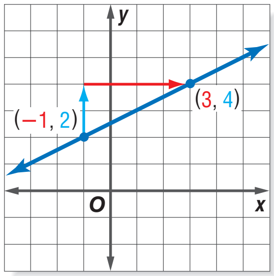
3 **Find the slope of the line that passes through (−1, 2) and (3, 4).**

Let $(-1, 2) = (x_1, y_1)$ and $(3, 4) = (x_2, y_2)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \qquad \frac{\text{rise}}{\text{run}}$$

$$= \frac{4 - 2}{3 - (-1)} \qquad \text{Substitute.}$$

$$= \frac{2}{4} \text{ or } \frac{1}{2} \qquad \text{Simplify.}$$



CHECK Your Progress

Find the slope of the line that passes through each set of points.

3A. (3, 6), (4, 8) **3B.** (−4, 2), (2, 10)

EXAMPLE Negative Slope

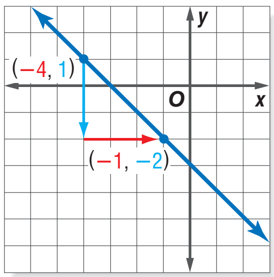
4 **Find the slope of the line that passes through (−1, −2)and (−4, 1).**

Let $(-1, -2) = (x_1, y_1)$ and $(-4, 1) = (x_2, y_2)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \qquad \frac{\text{rise}}{\text{run}}$$

$$= \frac{1 - (-2)}{-4 - (-1)} \qquad \text{Substitute.}$$

$$= \frac{3}{-3} \text{ or } -1 \qquad \text{Simplify.}$$



CHECK Your Progress

Find the slope of the line that passes though each set of points.

4A. (−2, 2), (−6, 4) **4B.** (4, 3), (−1, 11)

Real-World Link

A flat roof has a slope of zero.

EXAMPLE Zero Slope

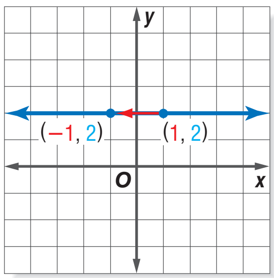
5 **Find the slope of the line that passes through (1, 2) and (−1, 2).**

Let $(1, 2) = (x_1, y_1)$ and $(-1, 2) = (x_2, y_2)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \qquad \frac{\text{rise}}{\text{run}}$$

$$= \frac{2 - 2}{-1 - 1} \qquad \text{Substitute.}$$

$$= \frac{0}{-2} \text{ or } 0 \qquad \text{Simplify.}$$



CHECK Your Progress

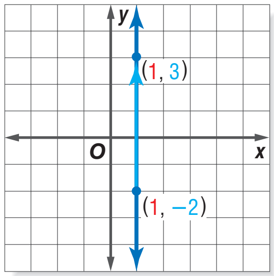
Find the slope of the line that passes through each set of points.

5A. (6, 7), (−2, 7) **5B.** (−4, −2), (0, −2)

EXAMPLE Undefined Slope

6 **Find the slope of the line that passes through (1, −2) and (1, 3).**

Let $(1, -2) = (x_1, y_1)$ and $(1, 3) = (x_2, y_2)$.



$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \frac{\text{rise}}{\text{run}}$$

$$= \frac{3 - (-2)}{1 - 1} \text{ or } \cancel{\frac{5}{0}}$$

Since division by zero is undefined, the slope is undefined.

CHECK Your Progress

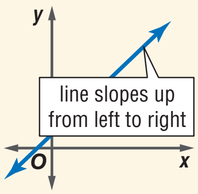
Find the slope of the line that passes through each set of points.

6A. (3, 2), (3, −1)

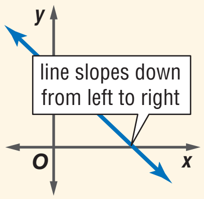
6B. (−2, −1), (−2, 5)

KEY CONCEPT — *Slope*

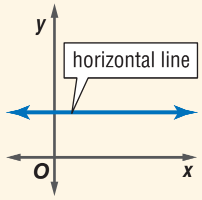
positive slope



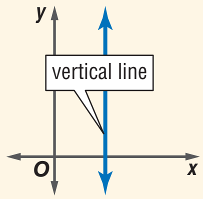
negative slope



slope of zero



undefined slope



Given the slope of a line and one point on the line, you can find other points on the line.

EXAMPLE Find Coordinates Given Slope

7 **Find the value of *r* so that the line through (*r*, 6) and (10, −3) has a slope of $-\frac{3}{2}$.**

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

$-\frac{3}{2} = \frac{-3 - 6}{10 - r}$ Let $(r, 6) = (x_1, y_1)$ and $(10, -3) = (x_2, y_2)$.

$-\frac{3}{2} = \frac{-9}{10 - r}$ Subtract.

$-3(10 - r) = 2(-9)$ Find the cross products.

$-30 + 3r = -18$ Simplify.

$3r = 12$ Add 30 to each side and simplify.

$r = 4$ Divide each side by 3 and simplify.

So, the line goes through (4, 6).

CHECK Your Progress

Find the value of *r* so the line that passes through each pair of points has the given slope.

7A. $(1, 4), (-1, r); m = 2$

7B. $(r, -6), (5, -8); m = -8$

CHECK Your Understanding

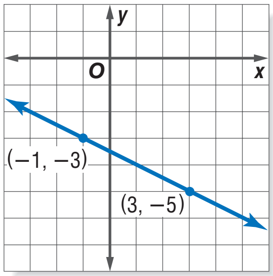
Example 1 (pp. 187–188)

Find the rate of change represented in each table or graph.

1.

x	y
3	−6
5	2
7	10
9	18
11	26

2.



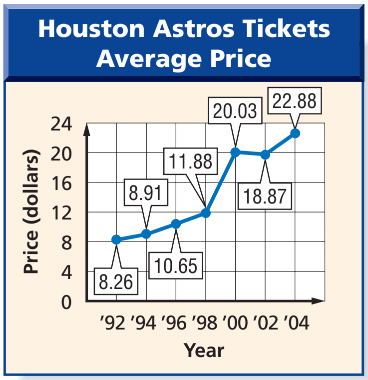
Example 2 (pp. 188–189)

SPORTS For Exercises 3–5, use the graph at the right.

3. Find the rate of change for prices from 2002 to 2004. Explain the meaning of the rate of change.

4. Without calculating, find a 2-year period that had a greater rate of change than 2002 to 2004. Explain.

5. Between which years might a new stadium have been built? Explain your reasoning.



Source: *Team Marketing Report*

Examples 3–6 (pp. 190–191)

Find the slope of the line that passes through each pair of points.

6. (1, 1), (3, 4)
7. (0, 0), (5, 4)
8. (−2, 2), (−1, −2)
9. (9, −4), (7, −1)
10. (3, 5), (−2, 5)
11. (−1, 3), (−1, 0)

Example 7 (p. 191)

Find the value of r so the line that passes through each pair of points has the given slope.

12. $(6, -2), (r, -6), m = 4$
13. $(9, r), (6, 3), m = -\frac{1}{3}$

Exercises

HOMEWORK HELP

For Exercises	See Examples
14–17	1
18–19	2
20–31	3–6
32–35	7

Find the rate of change represented in each table or graph.

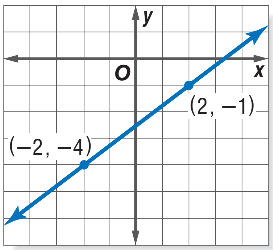
14.

x	y
5	2
10	3
15	4
20	5

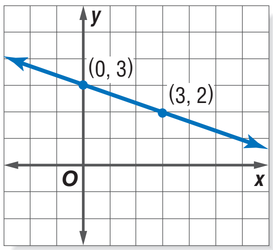
15.

x	y
1	15
2	9
3	3
4	−3

16.



17.



18. SPORTS What was the annual rate of change from 1995 to 2003? Explain the meaning of the rate of change.

Women Competing in Triathlons	
Year	**Number of Women**
1995	4600
2003	19,100

19. CELL PHONES In 2000, 5% of 13- to 17-year-olds had cell phones. By 2004, 56% of teens had cell phones. Find the annual rate of change in the percent of teens with cell phones from 2000 to 2004. Describe what the rate of change means.

Find the slope of the line that passes through each pair of points.

20. $(2, 3), (9, 7)$ **21.** $(-3, 6), (2, 4)$ **22.** $(2, 6), (-1, 3)$

23. $(-3, 3), (1, 3)$ **24.** $(-2, 1), (-2, 3)$ **25.** $(-3, 9), (-7, 6)$

26. $(5, 7), (-2, -3)$ **27.** $(2, -1), (5, -3)$ **28.** $(-4, -1), (-3, -3)$

29. $(-3, -4), (5, -1)$ **30.** $(-2, 3), (8, 3)$ **31.** $(-5, 4), (-5, -1)$

Find the value of r so the line that passes through each pair of points has the given slope.

32. $(6, 2), (9, r), m = -1$ **33.** $(r, -5), (3, 13), m = 8$

34. $(5, r), (2, -3), m = \frac{4}{3}$ **35.** $(-2, 8), (r, 4), m = -\frac{1}{2}$

Find the slope of the line that passes through each pair of points.

36.

x	y
4.5	-1
5.3	2

37.

x	y
0.75	1
0.75	-1

38.

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

Real-World Link

Tony Hawk made skateboarding history by landing a 900 at the 1999 X Games. That's two and a half rotations in mid-air!

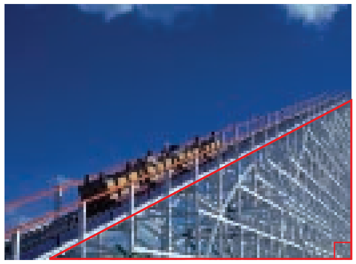
Source: espn.go.com

39. DRIVING When driving up a certain hill, you rise 15 feet for every 1000 feet you drive forward. What is the slope of the road?

CONSTRUCTION **Use a ruler to estimate the slope of each object.**

40.

41.



42. Find the slope of the line that passes through the origin and (r, s).

43. What is the slope of the line that passes through (a, b) and $(a, -b)$?

Find the value of r so the line that passes through each pair of points has the given slope.

44. $\left(\frac{1}{2}, -\frac{1}{4}\right), \left(r, -\frac{5}{4}\right), m = 4$ **45.** $\left(\frac{2}{3}, r\right), \left(1, \frac{1}{2}\right), m = \frac{1}{2}$

46. $(4, r), (r, 2), m = -\frac{5}{4}$ **47.** $(r, 5), (-2, r), m = -\frac{2}{9}$

ANALYZE TABLES **For Exercises 48–50, use the table that shows Karen's height at various ages.**

Age (years)	12	14	16	18	20
Height (inches)	60	64	66	67	67

48. Make a broken-line graph of the data.

49. Use the graph to determine in which two-year period Karen grew the fastest. Explain your reasoning.

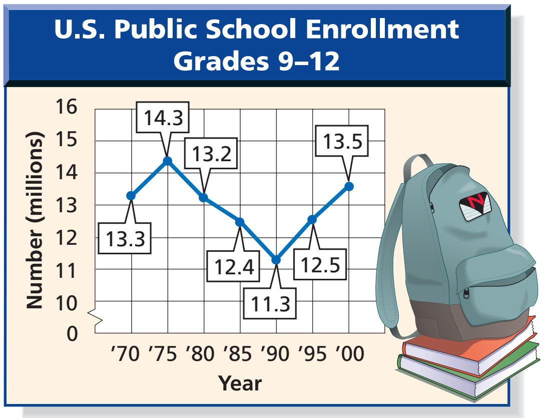
50. Discuss the rate of change associated with the horizontal section of the graph.

ANALYZE GRAPHS **For Exercises 51–53, use the graph that shows public school enrollment.**

51. For which 5-year period was the rate of change the greatest? the least?

52. Find the rate of change from 1985 to 1990.

53. Explain the meaning of the part of the graph with a negative slope.



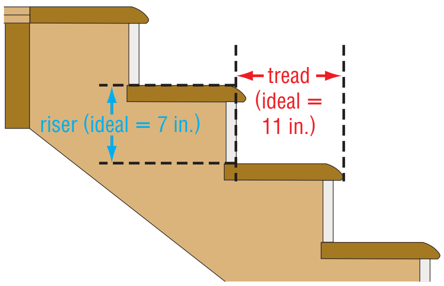
GROWTH RATE **For Exercises 54–56, use the following information.**
After her last haircut, May's hair was 8 inches long. In three months, it grew another inch. Assume that the hair growth continues at the same rate.

54. Make a table that shows May's hair length for each of the three months and for the next three months.

55. Draw a graph showing the relationship between May's hair length and time in months.

56. What is the slope of the graph? What does it represent?

57. **CONSTRUCTION** The slope of a stairway determines how easy it is to climb the stairs. Suppose the vertical distance between two floors is 8 feet 9 inches. Find the total run of the ideal stairway in feet and inches. (*Hint:* Do not include any part of the top or bottom floor in the run.)



EXTRA PRACTICE
See pages 724, 747.
Math Online
Self-Check Quiz at
algebra1.com

58. **RESEARCH** Use the Internet or another reference to find the population of your city or town in 1930, 1940, ..., 2000. Between which two decades was the rate of change the greatest? Explain.

H.O.T. Problems

59. **CHALLENGE** Develop a strategy for determining whether the slope of the line through $(-4, -5)$ and $(4, 5)$ is positive or negative without calculating.

60. **OPEN ENDED** Integrate what you know about rate of change to describe the function at the right.

Time (wk)	Height of Plant (in.)
4	9.0
6	13.5
8	18.0

61. CHALLENGE Determine whether $Q(2, 3)$, $R(-1, -1)$, and $S(-4, -2)$ lie on the same line that passes through $(-2, -2)$ and $(4, 0)$. Explain your reasoning.

62. FIND THE ERROR Carlos and Allison are finding the slope of the line that passes through (2, 6) and (5, 3). Who is correct? Explain your reasoning.

Carlos
$\frac{3-6}{5-2} = \frac{-3}{3}$ or -1

Allison
$\frac{6-3}{5-2} = \frac{3}{3}$ or 1

63. *Writing in Math* Discuss how to find the slope of a roof and compare the appearance of roofs with different slopes.

STANDARDIZED TEST PRACTICE

64. A music store has x CDs in stock. If 350 are sold and $3y$ are added to stock, which expression represents the number of CDs in stock?

A $350 + 3y - x$

B $x - 350 + 3y$

C $x + 350 + 3y$

D $3y - 350 - x$

65. REVIEW A recipe for fruit punch calls for 2 ounces of orange juice for every 8 ounces of lemonade. If Jennifer uses 64 ounces of lemonade, which proportion can she use to find x, the number of ounces of orange juice she should add to make the fruit punch?

F $\frac{2}{x} = \frac{64}{6}$

G $\frac{8}{x} = \frac{64}{2}$

H $\frac{2}{8} = \frac{x}{64}$

J $\frac{6}{2} = \frac{x}{64}$

Spiral Review

Write an equation in function notation for each relation. (Lesson 3-5)

66.

Number of Lunches	1	2	3	4	5
Total Cost ($)	5	10	15	20	25

67.

Time (s)	7	9	11	14	16
Altitude (ft)	4	2	0	−3	−5

Find the next three terms of each arithmetic sequence. (Lesson 3-4)

68. 8, 20, 32, 44, ...

69. −9, −6, −3, 0, ...

70. 35, 31, 27, 23, ...

71. −56, −47, −38, −29, ...

72. FOOD Garrett is making $\frac{1}{3}$-pound hamburgers. One pound of hamburger costs $3.19. How much will it cost to make 18 hamburgers? (Lesson 2-3)

GET READY for the Next Lesson

PREREQUISITE SKILL Find each quotient. (Pages 690–691)

73. $6 \div \frac{2}{3}$

74. $\frac{3}{4} \div \frac{1}{6}$

75. $\frac{3}{4} \div 6$

76. $18 \div \frac{7}{8}$

4-2 Slope and Direct Variation

Main Ideas

- Write and graph direct variation equations.
- Solve problems involving direct variation.

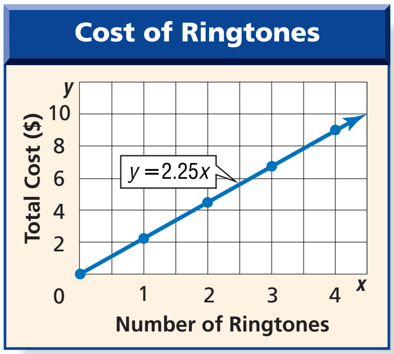
New Vocabulary

direct variation
constant of variation
family of graphs
parent graph

GET READY for the Lesson

It costs $2.25 per ringtone that you download for your cell phone. If you graph the ordered pairs, the slope of the line is 2.25.

Number of Ringtones	Total Cost ($)
x	y
0	0
1	2.25
2	4.50
3	6.75
4	9.00



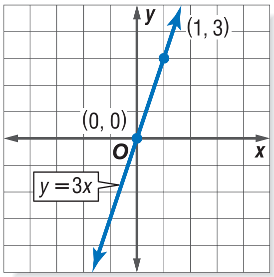
The total cost y depends *directly* on the number of ringtones that you download x. The rate of change is constant.

Direct Variation A **direct variation** is described by an equation of the form $y = kx$, where $k \neq 0$. The equation $y = kx$ represents a constant rate of change and k is the **constant of variation**.

EXAMPLE Slope and Constant of Variation

1 **Name the constant of variation for each equation. Then find the slope of the line that passes through each pair of points.**

a.



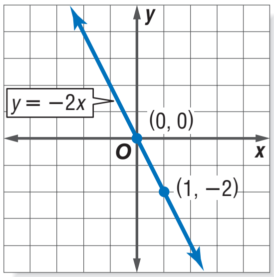
The constant of variation is 3.

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

$= \frac{3 - 0}{1 - 0}$ $(x_1, y_1) = (0, 0)$ $(x_2, y_2) = (1, 3)$

$= 3$ The slope is 3.

b.



The constant of variation is -2.

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

$= \frac{-2 - 0}{1 - 0}$ $(x_1, y_1) = (0, 0)$ $(x_2, y_2) = (1, -2)$

$= -2$ The slope is -2.

Study Tip

Constant of Variation

Compare the constants of variation with the slopes of the graphs. What is the slope of the graph of $y = kx$?

CHECK Your Progress

1. Name the constant of variation for $y = \frac{1}{4}x$. Then find the slope of the line that passes through (0, 0) and (4, 1).

Since (0, 0) is a solution of $y = kx$, the graph of $y = kx$ always passes through the origin.

EXAMPLE **Graph a Direct Variation**

2 Graph each equation.

a. $y = 4x$

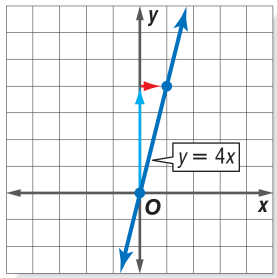
Step 1 Write the slope as a ratio.

$4 = \frac{4}{1}$ $\frac{\text{rise}}{\text{run}}$

Step 2 Graph (0, 0).

Step 3 From the point (0, 0), move up 4 units and right 1 unit. Draw a dot.

Step 4 Draw a line containing the points.



Study Tip

Direct Proportions

In direct variation equations, the variables are directly proportional to each other. That is, the ratio $x : y$ is a constant.

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

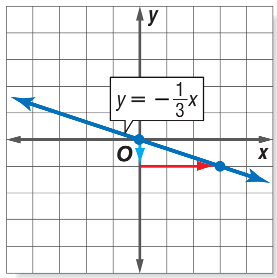
Step 1 Write the slope as a ratio.

$-\frac{1}{3} = \frac{-1}{3}$ $\frac{\text{rise}}{\text{run}}$

Step 2 Graph (0, 0).

Step 3 From the point (0, 0), move down 1 unit and right 3 units. Draw a dot.

Step 4 Draw a line containing the points.



CHECK Your Progress

Graph each equation.

2A. $y = 6x$ **2B.** $y = \frac{2}{3}x$ **2C.** $y = -5x$ **2D.** $y = -\frac{3}{4}x$

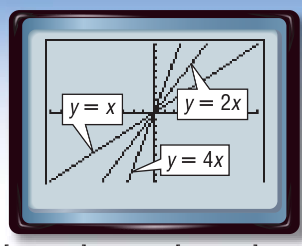
A **family of graphs** includes graphs and equations of graphs that have at least one characteristic in common. The **parent graph** is the simplest graph in a family.

GRAPHING CALCULATOR LAB

Graphs of $y = mx$

The calculator screen shows the graphs of $y = x$, $y = 2x$, and $y = 4x$.

THINK AND DISCUSS



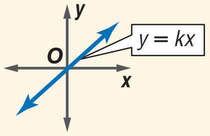
[−10, 10] scl: 1 by [−10, 10] scl: 1

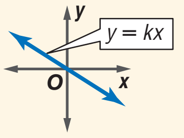
1. Describe any similarities and differences among the graphs.
2. Write an equation with a graph that has a steeper slope than $y = 4x$. Check your answer by graphing $y = 4x$ and your equation.
3. Write an equation with a graph that lies between the graphs of $y = x$ and $y = 2x$. Check your answer by graphing the equations.
4. What characteristics do the graphs have in common? How are they different?
5. These equations are all of the form $y = mx$. How does the graph change as the absolute value of m increases?

The results of the Graphing Calculator Lab lead to some general observations about the graphs of direct variation equations.

CONCEPT SUMMARY ***Direct Variation Graphs***

- Direct variation equations are of the form $y = kx$, where $k \neq 0$.
- The graph of $y = kx$ always passes through the origin.
- The slope is positive if $k > 0$.
- The slope is negative if $k < 0$.





If you know that y varies directly as x, you can write a direct variation equation that relates the two quantities.

EXAMPLE Write and Solve a Direct Variation Equation

3 **Suppose y varies directly as x, and $y = 28$ when $x = 7$.**

a. Write a direct variation equation that relates x and y.

Find the value of k.

$y = kx$	Direct variation formula
$28 = k(7)$	Replace y with 28 and x with 7.
$\frac{28}{7} = \frac{k(7)}{7}$	Divide each side by 7.
$4 = k$	Simplify.

Therefore, the direct variation equation is $y = 4x$.

b. Use the direct variation equation to find x when $y = 52$.

$y = 4x$	Direct variation equation
$52 = 4x$	Replace y with 52.
$\frac{52}{4} = \frac{4x}{4}$	Divide each side by 4.
$13 = x$	Simplify.

Therefore, $x = 13$ when $y = 52$.

Study Tip

Direct Variation

Once you have the value of k, you can use it to find the value of x or y when given the value of the other variable.

CHECK Your Progress

Suppose y varies directly as x, and $y = 6$ when $x = -18$.

3A. Write a direct variation equation that relates x and y.

3B. Find y when $x = -2$.

Solve Problems One of the most common applications of direct variation is the formula $d = rt$. Distance d varies directly as time t, and the rate r is the constant of variation.

Real-World EXAMPLE

4 **BIOLOGY** **The migration of snow geese varies directly as the number of hours. A flock of snow geese migrated 375 miles in 7.5 hours.**

a. Write a direct variation equation for the distance *d* flown in time *t*.

Words	Distance	equals	rate	times	time.
Variable	Let r = rate.				
Equation	375 mi	$=$	r	$\times$	7.5 h

Solve for the rate.

$375 = r(7.5)$ Original equation

$\frac{375}{7.5} = \frac{r(7.5)}{7.5}$ Divide each side by 7.5.

$50 = r$ Simplify.

Therefore, the direct variation equation is $d = 50t$. What does the 50 represent?

Real-World Link

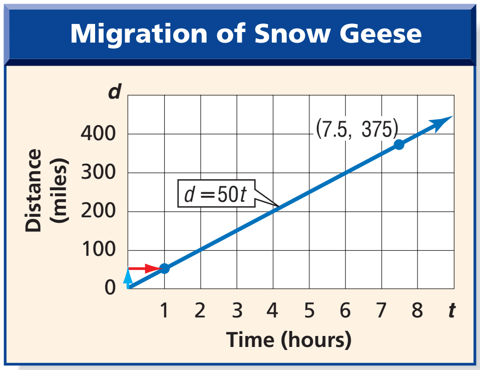
Snow geese migrate more than 3000 miles from their winter home in the southwest United States to their summer home in the Canadian arctic.

Souce: Audubon Society

b. Graph the equation.

The graph of $d = 50t$ passes through the origin with slope 50.

$m = \frac{50}{1}$ $\frac{\text{rise}}{\text{run}}$



c. Estimate how many hours of flying time it would take the geese to migrate 3000 miles.

$d = 50t$ Original equation

$3000 = 50t$ Replace d with 3000.

$\frac{3000}{50} = \frac{50t}{50}$ Divide each side by 50.

$t = 60$ Simplify.

At this rate, it would take 60 hours of flying time to migrate 3000 miles.

CHECK Your Progress

HOT AIR BALLOONS **A hot air balloon's ascent varies directly as the number of minutes. A hot air balloon ascended 350 feet in 5 minutes.**

4A. Write a direct variation for the distance d ascended in time t.

4B. Graph the equation.

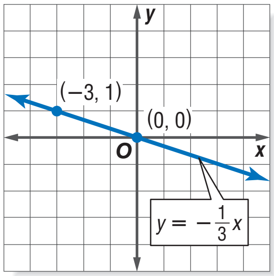
4C. Estimate how many minutes it would take the hot air balloon to ascend 2100 feet.

Online **Personal Tutor at** algebra1.com

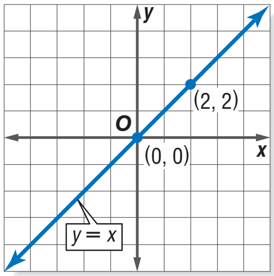
CHECK Your Understanding

Example 1 (p. 196) **Name the constant of variation for each equation. Then find the slope of the line that passes through each pair of points.**

1.



2.



Example 2 (p. 197) **Graph each equation.**

3. $y = 2x$ **4.** $y = \frac{1}{2}x$ **5.** $y = -3x$ **6.** $y = -\frac{5}{3}x$

Example 3 (p. 198) **Suppose *y* varies directly as *x*. Write a direct variation equation that relates *x* and *y*. Then solve.**

7. If $y = 27$ when $x = 6$, find x when $y = 45$.

8. If $y = -7$ when $x = 14$, find y when $x = -16$.

Example 4 (pp. 198–199) **JOBS For Exercises 9–11, use the following information.**
Suppose your pay varies directly as the number of hours you work. Your pay for 7.5 hours is $45.

9. Write a direct variation equation relating your pay to the hours worked.

10. Graph the equation.

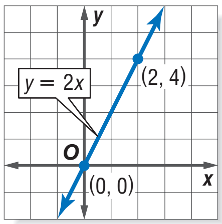
11. Find your pay if you work 30 hours.

Exercises

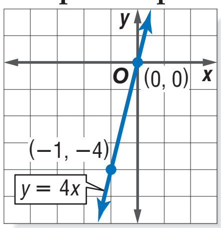
HOMEWORK HELP	
For Exercises	See Examples
12–17	1
18–25	2
26–29	3
30, 31	4

Name the constant of variation for each equation. Then find the slope of the line that passes through each pair of points.

12.



13.



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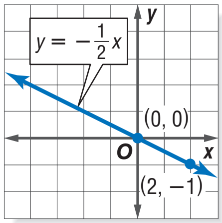

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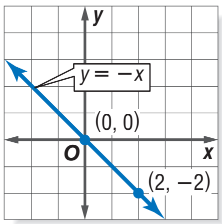

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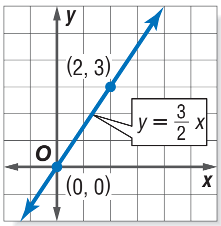

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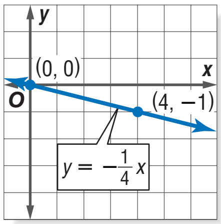


Graph each equation.

18. $y = 3x$ **19.** $y = -x$ **20.** $y = -4x$ **21.** $y = \frac{5}{2}x$

22. $y = \frac{1}{5}x$ **23.** $y = -\frac{2}{3}x$ **24.** $y = -\frac{4}{3}x$ **25.** $y = -\frac{9}{2}x$

Suppose y varies directly as x. Write a direct variation equation that relates x and y. Then solve.

26. If $y = 8$ when $x = 4$, find y when $x = 5$.

27. If $y = -16$ when $x = 4$, find x when $y = 20$.

28. If $y = 4$ when $x = 12$, find y when $x = -24$.

29. If $y = 12$ when $x = 15$, find x when $y = 21$.

SPORTS **For Exercises 30 and 31, use the following information.**
The distance a golf ball travels at an altitude of 7000 feet varies directly with the distance the ball travels at sea level, as shown in the table.

Hitting a Golf Ball

Altitude (ft)	0 (sea level)	7000
Distance (yd)	200	210

30. Write and graph an equation that relates the distance a golf ball travels at an altitude of 7000 feet y with the distance at sea level x.

31. What would be a person's average driving distance at 7000 feet if his average driving distance at sea level is 180 yards?

Real-World Career
Veterinarian
A veterinarian uses math to compare the age of an animal to the age of a human on the basis of bone and tooth growth and to determine the amount of medicine to prescribe based on the weight of the animal.

Math Online
For more information, go to algebra1.com.

ANALYZE TABLES **For Exercises 32 and 33, use the following information.**
Most animals age more rapidly than humans do. The chart shows equivalent ages for horses and humans.

Horse age (x)	0	1	2	3	4	5
Human age (y)	0	3	6	9	12	15

32. Write an equation that relates human age to horse age.

33. Find the equivalent horse age for a human who is 16 years old.

Suppose y varies directly as x. Write a direct variation equation that relates x and y. Then solve.

34. If $y = 2.5$ when $x = 0.5$, find y when $x = 20$.

35. If $y = -6.6$ when $x = 9.9$, find y when $x = 6.6$.

36. If $y = 2\frac{2}{3}$ when $x = \frac{1}{4}$, find y when $x = 1\frac{1}{8}$.

37. If $y = 6$ when $x = \frac{2}{3}$, find x when $y = 12$.

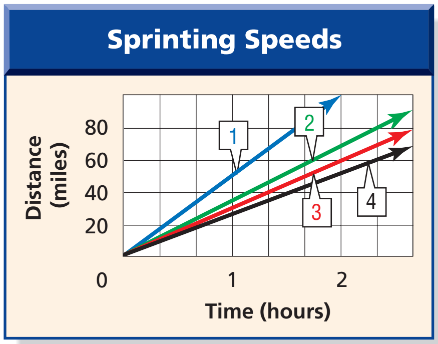
ANALYZE GRAPHS **Which line in the graph represents the sprinting speed of each animal?**

38. elephant, 25 mph

39. reindeer, 32 mph

40. lion, 50 mph

41. grizzly bear, 30 mph



Write a direct variation equation that relates the variables. Then graph the equation.

42. **GEOMETRY** The circumference C of a circle is about 3.14 times the diameter d.

43. **GEOMETRY** The perimeter P of a square is 4 times the length of a side s.

44. **RETAIL** The total cost is C for n yards of ribbon priced at \$0.99 per yard.

45. **RETAIL** Kona coffee beans are \$14.49 per pound. The cost of p pounds is C.

GRAPHING CALCULATOR **Consider the graphs of $y = -1x$, $y = -2x$, and $y = -4x$.**

46. Graph these three equations on the same screen.

47. Describe the similarities and differences between these graphs and the graphs in the Graphing Calculator Lab on page 195.

48. Write an equation whose graph is steeper than the graph of $y = -4x$.

49. Make a conjecture about how you can determine without graphing which of two direct variation equations has the graph with a steeper slope.

EXTRA PRACTICE
See pages 725, 747.

Math Online
Self-Check Quiz at algebra1.com

H.O.T. Problems

50. **Which One Doesn't Belong?** Identify the equation that does not belong with the other three. Explain your reasoning.

$9 = rs$	$9a = 0$	$z = \frac{1}{9}x$	$s = \frac{9}{t}$

51. **OPEN ENDED** Model a real-world situation using a direct variation equation. Graph the equation and describe the rate of change.

52. **CHALLENGE** Suppose y varies directly as x. If the value of x is doubled, what can you conclude about the value of y? Explain your reasoning.

53. ***Writing in Math*** Write an equation that relates the total cost y to the number of ringtones x for ringtones that cost \$1.50 each. Compare the steepness of the graph of this equation to the graph at the top of page 196.

STANDARDIZED TEST PRACTICE

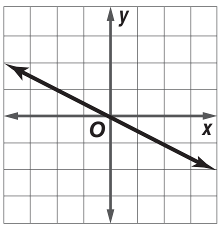
54. Which equation *best* represents the graph?

A $y = 2x$

B $y = -2x$

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

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



55. **REVIEW** Roberto receives an employee discount of 12%. If he spent \$355 at the store, how much was his discount to the nearest dollar?

F \$3

G \$4

H \$30

J \$43

Spiral Review

56. Find the value of r so that the line that passes through (1, 7) and (r, 3) has a slope of 2. (Lesson 4-1)

Write an equation in function notation for the relation shown in each table. (Lesson 3-5)

57.

x	0	1	2	3	4	5
y	1	5	9	13	17	21

58.

x	2	4	6	8	10	12
y	8	6	4	2	0	−2

59. **BASKETBALL** A school purchased five new basketballs for \$149.95. At that rate, how much more money will it cost the school to have 12 new basketballs in all? (Lesson 2-6)

GET READY for the Next Lesson

PREREQUISITE SKILL **Solve each equation for y.** (Lesson 2-8)

60. $4x = y + 3$

61. $2y = 4x + 10$

62. $9x + 3y = 12$

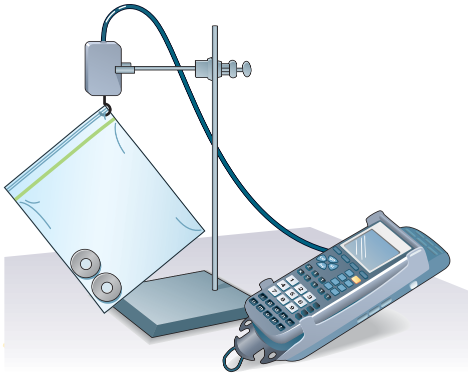
EXPLORE
4-3

Graphing Calculator Lab

Investigating Slope-Intercept Form

SET UP the Lab

- Cut a small hole in a top corner of a plastic sandwich bag. Hang the bag from the end of the force sensor.
- Connect the force sensor to your data collection device.



ACTIVITY

Step 1 Use the sensor to collect the weight with 0 washers in the bag. Record the data pair in the calculator.

Step 2 Place one washer in the plastic bag. Wait for the bag to stop swinging, then measure and record the weight.

Step 3 Repeat the experiment, adding different numbers of washers to the bag. Each time, record the data.

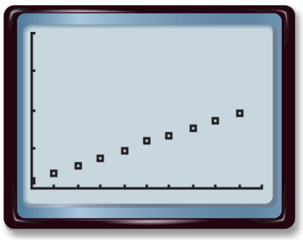
Analyze the Results

1. The domain contains values represented by the independent variable, washers. The range contains values represented by the dependent variable, weight. Use the graphing calculator to create a scatterplot using the ordered pairs (washers, weight).
2. Write a sentence that describes the points on the graph.
3. Describe the position of the point on the graph that represents the trial with no washers in the bag.
4. The rate of change can be found by using the formula for slope.

   $$\frac{\text{rise}}{\text{run}} = \frac{\text{change in weight}}{\text{change in number of washers}}$$

   Find the rate of change in the weight as more washers are added.
5. Explain how the rate of change is shown on the graph.

The graph shows sample data from a washer experiment. Describe the graph for each situation.



[0, 20] scl: 2 by [0, 1] scl: 0.25

6. A bag that hangs weighs 0.8 N when empty and increases in weight at the rate of the sample.
7. A bag that has the same weight when empty as the sample and increases in weight at a faster rate.
8. A bag that has the same weight when empty as the sample and increases in weight at a slower rate.

4-3 Graphing Equations in Slope-Intercept Form

Main Ideas

- Write and graph linear equations in slope-intercept form.
- Model real-world data with an equation in slope-intercept form.

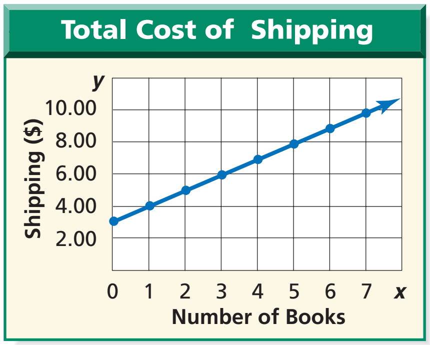
New Vocabulary

slope-intercept form

GET READY for the Lesson

An online store charges $3 per order plus $0.99 per book for shipping.

Number of Books	Shipping Cost
1	3.99
2	4.98
3	5.97
4	6.96
5	7.95
6	8.94
7	9.93



The slope of the line is 0.99. It crosses the y-axis at (0, 3).

The equation of the line is $y = 0.99x + 3$.

$$y = \underbrace{0.99}_{\text{charge per book, \$0.99}}x + \underbrace{3}_{\text{flat fee, \$3.00}}$$

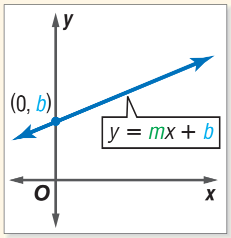
Slope-Intercept Form An equation of the form $y = mx + b$, where m is the slope and b is the y-intercept, is in **slope-intercept form**.

KEY CONCEPT — *Slope-Intercept Form*

Words The linear equation $y = mx + b$ is written in slope-intercept form, where m is the slope and b is the y-intercept.

Symbols $y = \underbrace{m}_{\text{slope}}x + \underbrace{b}_{y\text{-intercept}}$

Graph



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EXAMPLE 1 Write an Equation Given Slope and y-Intercept

Write an equation in slope-intercept form of the line with a slope of 3 and a y-intercept of -5.

$y = mx + b$ — Slope-intercept form

$y = 3x + (-5)$ — Replace m with 3 and b with -5.

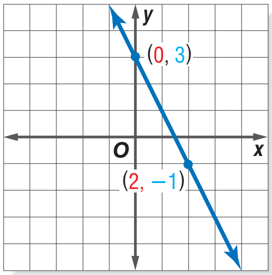
$y = 3x - 5$ — Rewrite.

CHECK Your Progress

1. Write an equation of the line with a slope of $-\frac{1}{2}$ and a y-intercept of 3.

EXAMPLE 2 Write an Equation From a Graph

Write an equation in slope-intercept form of the line shown in the graph.



Step 1 Find the slope using two points on the line. Let $(x_1, y_1) = (0, 3)$ and $(x_2, y_2) = (2, -1)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \frac{\text{rise}}{\text{run}}$$

$$= \frac{-1 - 3}{2 - 0} \quad x_1 = 0, x_2 = 2;\ y_1 = 3, y_2 = -1$$

$$= \frac{-4}{2} \text{ or } -2 \quad \text{Simplify.}$$

The slope is -2.

Step 2 The line crosses the y-axis at $(0, 3)$. So, the y-intercept is 3.

Step 3 Finally, write the equation.

$y = mx + b$ Slope-intercept form

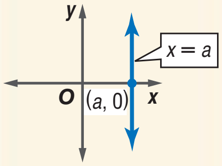
$y = -2x + 3$ Replace m with -2 and b with 3.

The equation of the line is $y = -2x + 3$.

Study Tip

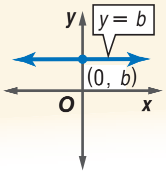
Vertical Lines

The equation of a vertical line *cannot* be written in slope-intercept form. *Why?*



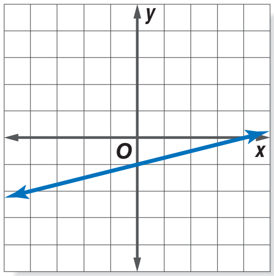
Horizontal Lines

The equation of a horizontal line *can* be written in slope-intercept form as $y = 0x + b$ or $y = b$.



CHECK Your Progress

2. Write an equation in slope-intercept form of the line shown at the right.



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EXAMPLE 3 Graph Equations

Graph each equation.

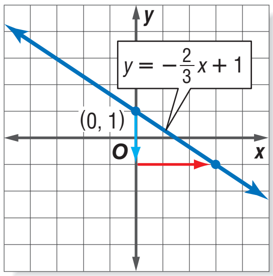
a. $y = -\frac{2}{3}x + 1$

Step 1 The y-intercept is 1. So, graph $(0, 1)$.

Step 2 The slope is $-\frac{2}{3}$ or $\frac{-2}{3}$. $\frac{\text{rise}}{\text{run}}$

From $(0, 1)$, move down 2 units and right 3 units. Draw a dot.

Step 3 Draw a line through the points.



b. $5x - 3y = 6$

Step 1 Solve for y to write the equation in slope-intercept form.

$5x - 3y = 6$ Original equation

$5x - 3y - 5x = 6 - 5x$ Subtract $5x$ from each side.

$-3y = 6 - 5x$ Simplify.

$-3y = -5x + 6$ $6 - 5x = 6 + (-5x)$ or $-5x + 6$

$\frac{-3y}{-3} = \frac{-5x + 6}{-3}$ Divide each side by -3.

$\frac{-3y}{-3} = \frac{-5x}{-3} + \frac{6}{-3}$ Divide each term in the numerator by -3.

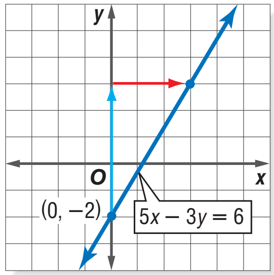
$y = \frac{5}{3}x - 2$ Simplify.

(continued on the next page)

Step 2 The y-intercept of $y = \frac{5}{3}x - 2$ is -2. So, graph $(0, -2)$.

Step 3 The slope is $\frac{5}{3}$. From $(0, -2)$, move up 5 units and right 3 units. Draw a dot.

Step 4 Draw a line containing the points.



CHECK Your Progress

Graph each equation.

3A. $y = 2x - 3$ **3B.** $y = \frac{1}{4}x + 5$ **3C.** $4x + 3y = -12$ **3D.** $2x - 3y = 6$

Model Real-World Data If a quantity changes at a constant rate over time, it can be modeled by a linear equation. The y-intercept represents a starting point, and the slope represents the rate of change.

Real-World Link

In 1997, 2.6 million girls competed in high school sports.

Source: www.nfhs.org

Real-World EXAMPLE

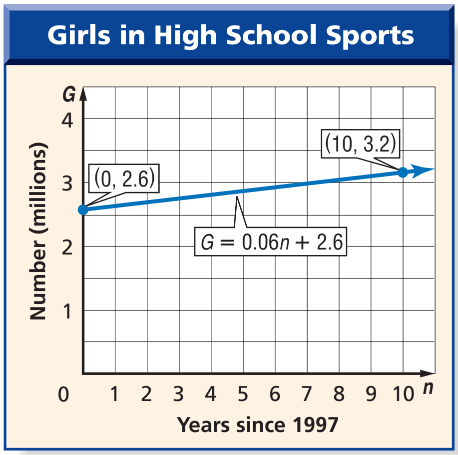
4 **SPORTS** **Use the information at the left about high school sports.**

a. The number of girls competing in high school sports has increased by an average of 0.06 million per year since 1997. Write a linear equation to find the number of girls in high school sports in any year after 1997.

Words	Number of girls competing	equals	rate of change	times	number of years after 1997	plus	amount at start.
Variables	Let G = number of girls competing.				Let n = number of years after 1997.		
Equation	G	$=$	0.06	$\cdot$	n	$+$	2.6

b. Graph the equation.

The graph passes through (0, 2.6) with slope 0.06.



c. Find the number of girls competing in 2007.

The year 2007 is 10 years after 1997.

$G = 0.06n + 2.6$ Write the equation.

$= 0.06(10) + 2.6$ Replace n with 10.

$= 3.2$ Simplify.

So, 3.2 million girls competed in high school sports in 2007.

CHECK Your Progress

FUND-RAISERS **The band boosters are selling submarine sandwiches for \$5 each. The cost of the ingredients to make the sandwiches was \$1160.**

4A. Write an equation for the profit P made on s sandwiches.

4B. Graph the equation.

4C. Find the total profit if 1400 sandwiches are sold.

CHECK Your Understanding

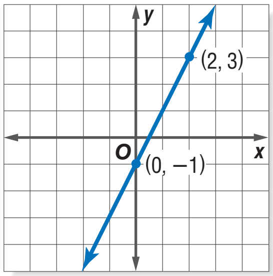
Example 1 (p. 204) **Write an equation in slope-intercept form of the line with the given slope and y-intercept.**

1. slope: -3, y-intercept: 1

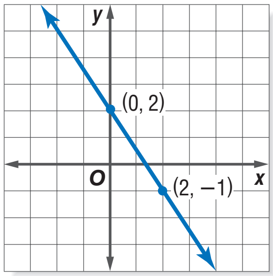
2. slope: 4, y-intercept: -2

Example 2 (p. 205) **Write an equation in slope-intercept form of the line shown in each graph.**

3.



4.



Example 3 (p. 205) **Graph each equation.**

5. $y = 2x - 3$

6. $y = -3x + 1$

7. $2x + y = 5$

8. $3x - 2y = 2$

Example 4 (p. 206) **MONEY For Exercises 9–11, use the following information.**
Suppose you have already saved \$50 toward the cost of a new television. You plan to save \$5 more each week for the next several weeks.

9. Write an equation for the total amount T that you will have w weeks from now.

10. Graph the equation.

11. Find the total amount saved after 7 weeks.

Exercises

HOMEWORK HELP

For Exercises	See Examples
12–17	1
18–23	2
24–32	3
33–38	4

Write an equation in slope-intercept form of the line with the given slope and y-intercept.

12. slope: -2, y-intercept: 6

13. slope: 3, y-intercept: -5

14. slope: $\frac{1}{2}$, y-intercept: 3

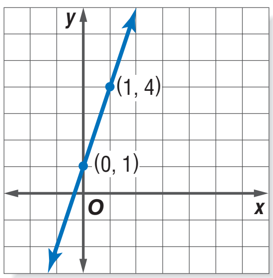
15. slope: $-\frac{3}{5}$, y-intercept: 12

16. slope: 0, y-intercept: 3

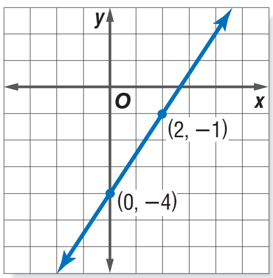
17. slope: -1, y-intercept: 0

Write an equation in slope-intercept form of the line shown in each graph.

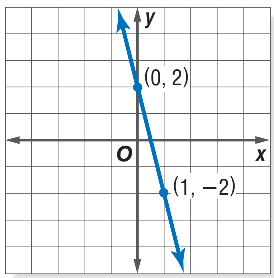
18.



19.

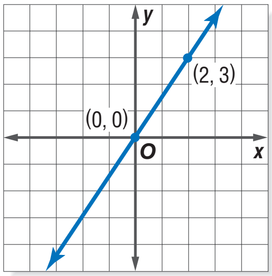


20.

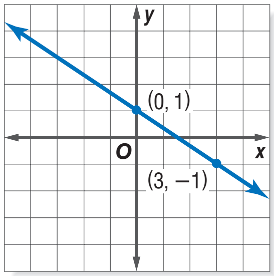


Write an equation in slope-intercept form of the line shown in each graph.

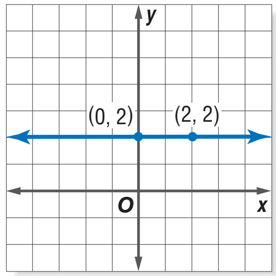
21.



22.



23.



Graph each equation.

24. $y = x - 2$
25. $y = 3x + 1$
26. $y = -4x + 1$
27. $y = \frac{1}{2}x + 4$
28. $y = -\frac{1}{3}x - 3$
29. $3x + y = -2$
30. $2x - y = -3$
31. $3y = 2x + 3$
32. $2x + 3y = 6$

BICYCLES For Exercises 33 and 34, use the following information.
A rental company on Padre Island charges $8 per hour for a mountain bicycle plus a $5 fee for a helmet.

33. Write a linear equation in slope-intercept form for the total rental cost for a helmet and bicycle for t hours. Then graph the equation.

34. Find the cost of a 2-hour rental.

Real-World Link

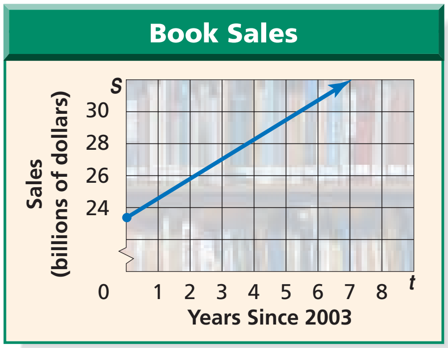
More than 3 million teens participate in mountain bicycling each year.

Source: *Statistical Abstract of the United States*

ANALYZE GRAPHS For Exercises 35 and 36, use the following information.
In 2003, book sales in the United States totaled $23.4 billion. Suppose sales continue to increase by about $1.2 billion each year.

35. Write an equation in slope-intercept form to find the total sales S for the number of years t since 2003.

36. If the trend continues, what will sales be in 2007?



Source: Association of American Publishers

COLLEGE For Exercises 37 and 38, use the following information
For Kentucky residents, the average tuition per year at the University of Kentucky is $258.15 per credit hour for part-time students. Housing costs $2125 per year.

37. Write an equation in slope-intercept form for the tuition T for c credit hours.

38. Find the cost of tuition in a year for a student taking 32 credit hours.

EXTRA PRACTICE
See pages 715, 737.

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Write an equation of the line with the given slope and y-intercept.

39. slope: -1, y-intercept: 0
40. slope: 0.5; y-intercept: 7.5
41. slope: 0, y-intercept: 7
42. slope: -1.5, y-intercept: -0.25

43. Write an equation of a horizontal line that crosses the y-axis at $(0, -5)$.

44. Write an equation of a line that passes through the origin with slope 3.

H.O.T. Problems

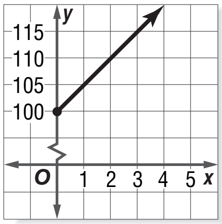
45. CHALLENGE Summarize the characteristic that the graphs of $y = 2x + 3$, $y = 4x + 3$, $y = -x + 3$, and $y = -10x + 3$ have in common.

46. OPEN ENDED Draw a graph representing a real-world linear function and write an equation for the graph. Describe verbally what the graph represents, including the slope and y-intercept.

47. *Writing in Math* Use the data about online shipping costs on page 204 to explain how y-intercepts can be used to describe real-world costs. Write a description of a situation in which the y-intercept of its graph is \$25.

STANDARDIZED TEST PRACTICE

48. Which statement is *most* strongly supported by the graph?



A You have \$100 and plan to spend \$5 each week.

B You have \$100 and plan to save \$5 each week.

C You need \$100 for a new CD player and plan to save \$5 each week.

D You need \$100 for a new CD player and plan to spend \$5 each week.

49. REVIEW Sam is going to put a border around a poster he is making for a class project. x represents the poster's width, and y represents the poster's length. Which equation represents how much border Sam will use if he doubles both the length and the width of the poster?

F $4xy$

G $4(x + y)$

H $(x + y)^4$

J $16(x + y)$

Spiral Review

Suppose y varies directly as x. Write a direct variation equation that relates x and y. Then solve. (Lesson 4-2)

50. If $y = -54$ when $x = 9$, find x when $y = -42$.

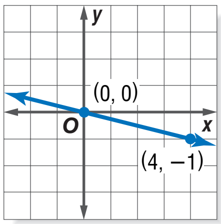
51. If $y = 45$ when $x = 60$, find x when $y = 8$.

Find the rate of change represented in each table or graph. (Lesson 4-1)

52.

x	y
1	4
2	7
3	10
4	13
5	16

53.



54.

x	y
8	50
13	40
18	30
23	20
28	10

55. LIFE SCIENCE A *Laysan albatross* tracked by biologists flew more than 24,843 miles in just 90 days in flights across the North Pacific to find food for its chick. At this rate, how far could the bird fly in a week? (Lesson 2-6)

GET READY for the Next Lesson

PREREQUISITE SKILL Find the slope of the line that passes through each pair of points. (Lesson 4-1)

56. $(-1, 2), (1, -2)$

57. $(-3, -1), (2, 3)$

58. $(5, 8), (-2, 8)$

EXTEND 4-3

Graphing Calculator Lab
The Family of Linear Graphs

A family of people is a group related by birth, marriage, or adoption. Recall that a *family of graphs* includes graphs with at least one characteristic in common.

You can use a graphing calculator to investigate how changing the parameters m and b in $y = mx + b$ affects the graphs in the family of linear functions.

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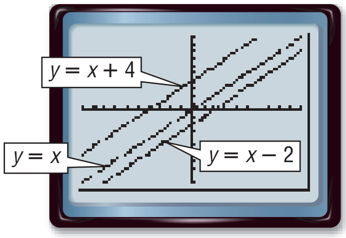
ACTIVITY 1 Changing b in $y = mx + b$

Graph $y = x$, $y = x + 4$, and $y = x - 2$ in the standard viewing window.

Enter the equations in the Y= list as Y1, Y2, and Y3. Then graph the equations.



KEYSTROKES: *Review graphing on pages 162 and 163.*

1A. How do the slopes of the graphs compare?

1B. Compare the graph of $y = x + 4$ and the graph of $y = x$. How would you obtain the graph of $y = x + 4$ from the graph of $y = x$?

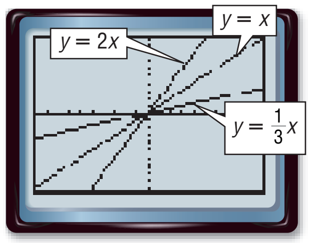
1C. How would you obtain the graph of $y = x - 2$ from the graph of $y = x$?

Changing m in $y = mx + b$ affects the graphs in a different way than changing b. First, investigate positive values of m.

ACTIVITY 2 Changing m in $y = mx + b$, Positive Values

Graph $y = x$, $y = 2x$, and $y = \frac{1}{3}x$ in the standard viewing window.

Enter the equations in the Y= list and graph.



2A. How do the y-intercepts of the graphs compare?

2B. Compare the graphs of $y = 2x$ and $y = x$.

2C. Which is steeper, the graph of $y = \frac{1}{3}x$ or the graph of $y = x$?

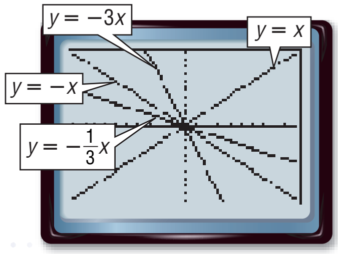
Does changing m to a negative value affect the graph differently than changing it to a positive value?

Math Online Other Calculator Keystrokes at algebra1.com

ACTIVITY 3 Changing m in $y = mx + b$, Negative Values

Graph $y = x$, $y = -x$, $y = -3x$, and $y = -\frac{1}{2}x$ in the standard viewing window.

Enter the equations in the Y= list and graph.



3A. How are the graphs with negative values of m different than graphs with a positive m?

3B. Compare the graphs of $y = -x$, $y = -3x$, and $y = -\frac{1}{2}x$. Which is steepest?

Analyze the Results

Graph each set of equations on the same screen. Describe the similarities or differences among the graphs.

1. $y = 2x$
$y = 2x + 3$
$y = 2x - 7$

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

3. $y = x + 4$
$y = 2x + 4$
$y = 0.75x + 4$

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

5. $y = -2x - 2$
$y = -4x - 2$
$y = -\frac{1}{3}x - 2$

6. $y = 3x$
$y = 3x + 6$
$y = 3x - 7$

7. Families of graphs have common characteristics. What do the graphs of all equations of the form $y = mx + b$ have in common?

8. How does the value of b affect the graph of $y = mx + b$?

9. What is the result of changing the value of m on the graph of $y = mx + b$ if m is positive? if m is negative?

10. How can you determine which graph is steepest by examining the following equations?

$y = 3x$, $y = -4x - 7$, $y = \frac{1}{2}x + 4$

11. Explain how knowing about the effects of m and b can help you sketch the graph of an equation.

Nonlinear functions can also be defined in terms of a family of graphs. Graph each set of equations on the same screen. Describe the similarities or differences among the graphs.

12. $y = x^2$
$y = -3x^2$
$y = (-3x)^2$

13. $y = x^2$
$y = x^2 + 3$
$y = (x - 2)^2$

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

15. Describe the similarities and differences in the classes of functions $f(x) = x^2 + c$ and $f(x) = (x + c)^2$, where c is any real number.

Chapter 4 Mid-Chapter Quiz

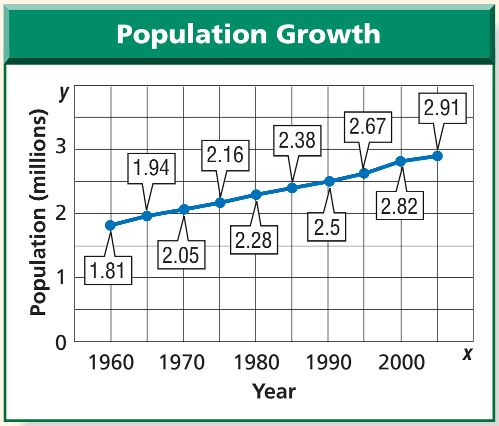
Lessons 4–1 through 4–3

Find the slope of the line that passes through each pair of points. (Lesson 4-1)

1. $(-4, 6), (-3, 8)$ **2.** $(8, 3), (-11, 3)$

POPULATION GROWTH **For Exercises 3–5, use the following information.**

The graph shows the population growth in the USA for 1960 through 2003. (Lesson 4-1)



Source: U.S. Census Bureau

3. For which 5-year time period was the rate of change the greatest? the least?

4. Find the rate of change from 1980 to 1990.

5. Explain the meaning of the slope from 1960 to 2003.

6. What is the slope of the *line* containing the points shown in the table? (Lesson 4-1)

x	y
-4	-3
2	6
6	12

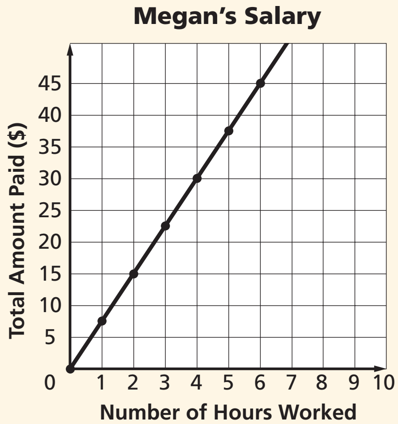
7. Find the value of r so the line that passes through $(5, -3)$ and $(r, -5)$ has slope 2. (Lesson 4-1)

8. Suppose that y varies directly as x, and $y = 24$ when $x = 8$. Write a direct variation equation that relates x and y. Use the equation to find y when $x = -3$. (Lesson 4-2)

Graph each equation. (Lessons 4–2 and 4–3)

9. $y = -7x$ **10.** $y = \frac{3}{4}x + 2$ **11.** $x - y = 5$

12. **MULTIPLE CHOICE** Megan works at a sporting goods store, and her salary is shown in the graph. Which is a valid conclusion that can be made from the graph? (Lesson 4-2)



A Megan earns about $7 per hour.

B Megan earns about $30 for every 2 hours that she works.

C Megan earns about $52 per week.

D Megan earns about $60 for each shift that she works.

For Exercises 13–15, use the following information.

Suppose you have already saved $75 toward the cost of a new television. You plan to save $5 more each week for the next several weeks. (Lesson 4-3)

13. Write an equation for the total amount T you will have w weeks from now.

14. Graph the equation.

15. Find the total amount saved after 10 weeks.

16. **MULTIPLE CHOICE** Which equation describes a line that has a y-intercept of 3 and a slope of 2? (Lesson 4-3)

F $y = 3 + 2x$

G $y = (3 + x)2$

H $y = 3x + 2$

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

4-4 Writing Equations in Slope-Intercept Form

Main Ideas

- Write an equation of a line given the slope and one point on a line.
- Write an equation of a line given two points on the line.

New Vocabulary

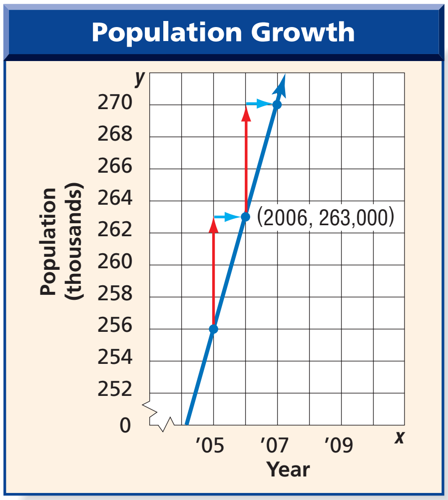
linear extrapolation

GET READY for the Lesson

In 2006, the population of a city was about 263 thousand. At that time, the population was growing at a rate of about 7 thousand per year.

Year	Population (thousands)
2005	256
2006	263
2007	270

If you could write an equation based on the slope, 7 (thousand), and the point (2006, 263), you could predict the population for another year.



Write an Equation Given the Slope and One Point You have learned how to write an equation of a line when you know the slope and a specific point, the y-intercept. The following example shows how to write an equation when you know the slope and any point on the line.

EXAMPLE Write an Equation Given Slope and One Point

1 **Write an equation of a line that passes through (1, 5) with slope 2.**

Step 1 Find the y-intercept by replacing m with 2 and (x, y) with (1, 5) in the slope-intercept form and solving for b.

$y = mx + b$	Slope-intercept form
$5 = 2(1) + b$	Replace m with 2, y with 5, and x with 1.
$5 = 2 + b$	Multiply.
$5 - 2 = 2 + b - 2$	Subtract 2 from each side.
$3 = b$	Simplify.

Step 2 Write the slope-intercept form using $m = 2$ and $b = 3$.

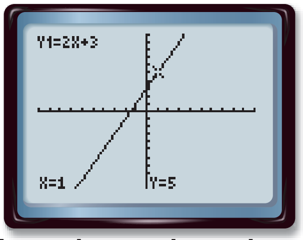
$y = mx + b$	Slope-intercept form
$y = 2x + 3$	Replace m with 2 and b with 3.

Therefore, an equation of the line is $y = 2x + 3$.

(continued on the next page)

CHECK You can check your result by graphing $y = 2x + 3$ on a graphing calculator.

Use the CALC menu to verify.



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CHECK Your Progress

1. Write an equation of the line that passes through (−4, 7) with slope −1.

Write an Equation Given Two Points If you know two points on a line, first find the slope. Then follow the steps in Example 1.

STANDARDIZED TEST EXAMPLE — Write an Equation Given Two Points

2 The table shows the coordinates of two points on the graph of a linear function. Which equation describes the function?

x	y
−3	−1
6	−4

A $y = -\frac{1}{3}x - 2$ **C** $y = -\frac{1}{3}x + 2$

B $y = 3x - 2$ **D** $y = \frac{1}{3}x - 2$

Read the Test Item

The table represents the ordered pairs (−3, −1) and (6, −4).

Solve the Test Item

Step 1 Find the slope of the line containing the points.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \text{Slope formula}$$

$$= \frac{-4 - (-1)}{6 - (-3)} \quad (x_1, y_1) = (-3, -1) \text{ and } (x_2, y_2) = (6, -4)$$

$$= \frac{-3}{9} \text{ or } -\frac{1}{3} \quad \text{Simplify.}$$

Step 2 Use the slope and one of the two points to find the y-intercept.

$$y = mx + b \quad \text{Slope-intercept form}$$

$$-4 = -\frac{1}{3}(6) + b \quad \text{Replace } m \text{ with } -\tfrac{1}{3}, x \text{ with 6, and } y \text{ with } -4.$$

$$-4 = -2 + b \quad \text{Multiply.}$$

$$-2 = b \quad \text{Add 2 to each side.}$$

Step 3 Write the slope-intercept form using $m = -\frac{1}{3}$ and $b = -2$.

$$y = mx + b \quad \text{Slope-intercept form}$$

$$y = -\frac{1}{3}x - 2 \quad \text{Replace } m \text{ with } -\tfrac{1}{3}, \text{ and } b \text{ with } -2.$$

The answer is A.

Test-Taking Tip

Check Results You can check your result by graphing. The line should pass through (−3, −1) and (6, −4).

CHECK Your Progress

2. The graph of an equation contains the points at (−1, 12) and (4, −8). Which equation describes this function?

F $y = -\frac{1}{4}x - 8$ **H** $y = \frac{1}{4}x - 8$

G $y = 4x + 8$ **J** $y = -4x + 8$

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Real-World Link

In 2005, J. D. Drew played a total of 72 games.

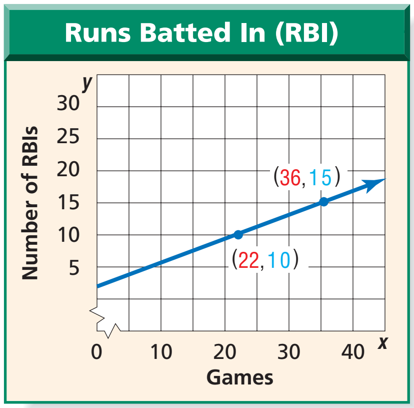
Source: MLB.com

Real-World EXAMPLE

3 **BASEBALL** **After 22 games in 2005, J. D. Drew of the Los Angeles Dodgers had 10 runs batted in. After 36 games, he had 15 runs batted in. Write a linear equation to estimate the number of runs batted in for any number of games that season.**

Explore You know the number of runs batted in after 22 and 36 games.

Plan Let x represent the number of games. Let y represent the number of runs batted in. Write an equation of the line that passes through (22, 10) and (36, 15).



Solve Find the slope.

$m = \dfrac{y_2 - y_1}{x_2 - x_1}$ Slope formula

$= \dfrac{15 - 10}{36 - 22}$ Let $(x_1, y_1) = (22, 10)$ and $(x_2, y_2) = (36, 15)$.

$= \dfrac{5}{14}$ or about 0.357 Simplify.

Choose (36, 15) and find the y-intercept of the line.

$y = mx + b$ Slope-intercept form

$15 = 0.357(36) + b$ Replace m with 0.357, x with 36, and y with 15.

$15 = 12.852 + b$ Multiply.

$2.148 = b$ Subtract 12.852 from each side and simplify.

Write the slope-intercept form using $m = 0.357$, and $b = 2.148$.

$y = mx + b$ Slope-intercept form

$y = 0.357x + 2.148$ Replace m with 0.357 and b with 2.148.

Therefore, the equation is $y = 0.357x + 2.148$.

Check Check your result by substituting the coordinates of the point not chosen, (22, 10), into the equation.

$y = 0.357x + 2.148$ Original equation

$10 \stackrel{?}{=} 0.357(22) + 2.148$ Replace y with 10 and x with 22.

$10 \approx 10.0$ Simplify.

The slope was rounded, so the answers vary slightly. The answer checks.

CHECK Your Progress

3. **MONEY** As a part-time job, Ethan makes deliveries for a caterer. In addition to his weekly salary, he is also paid \$16 per delivery. Last week, he made 5 deliveries and his total salary was \$215. Write a linear equation to find Ethan's total weekly salary S if he makes d deliveries.

When you use a linear equation to predict values that are beyond the range of the data, you are using **linear extrapolation**.

Vocabulary Link

Extra

Everyday Use beyond or outside, as in extracurricular activities

Math Use beyond the range of data

Real-World EXAMPLE

4 **SPORTS** **Use the equation in Example 3 and the information in the margin to estimate Drew's runs batted in during the 2005 season.**

$y = 0.357x + 2.148$	Original equation
$= 0.357(72) + 2.148$	Replace x with 72.
≈ 28	Simplify.

Using the equation, an estimate for the number of RBIs is 28.

CHECK Your Progress

4. **MONEY** Use the equation that you wrote in Check Your Progress 3 to predict how much money Ethan will earn in a week if he makes 8 deliveries.

Be cautious when making a prediction or an estimate using just two given points. The model may be *approximately* correct, but still give inaccurate predictions. For example, in 2005, J. D. Drew had 36 runs batted in, which was 8 more than the estimate.

CHECK Your Understanding

Example 1 (p. 213)

Write an equation of the line that passes through each point with the given slope.

1. $(4, -2)$, $m = 2$ **2.** $(3, 7)$, $m = -3$ **3.** $(-3, 5)$, $m = -1$

Example 2 (p. 214)

Write an equation of the line that passes through each pair of points.

4. $(5, 1)$, $(8, -2)$ **5.** $(6, 0)$, $(0, 4)$ **6.** $(5, 2)$, $(-7, -4)$

7. **STANDARDIZED TEST PRACTICE** The table of ordered pairs shows the coordinates of the two points on the graph of a line. Which equation describes the line?

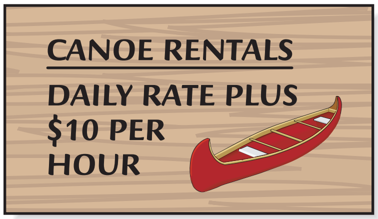
x	y
-5	2
0	7

A $y = x + 7$ C $y = -5x + 2$

B $y = x - 7$ D $y = 5x + 2$

Examples 3 and 4 (pp. 215–216)

CANOE RENTAL **For Exercises 8 and 9, use the information at the right and below.** Ilia and her friends rented a canoe for 3 hours and paid a total of \$45.



8. Write a linear equation to find the total cost C of renting the canoe for h hours.

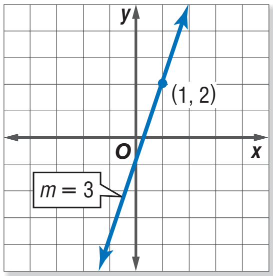
9. How much would it cost to rent the canoe for 8 hours?

Exercises

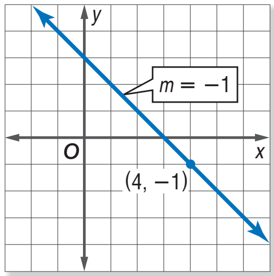
HOMEWORK HELP	
For Exercises	See Examples
10–17	1
18–25	2
26–29	3, 4

Write an equation of the line that passes through each point with the given slope.

10.



11.



12. $(5, -2)$, $m = 3$ **13.** $(5, 4)$, $m = -5$ **14.** $(3, 0)$, $m = -2$

15. $(5, 3)$, $m = \frac{1}{2}$ **16.** $(-3, -1)$, $m = -\frac{2}{3}$ **17.** $(-3, -5)$, $m = -\frac{5}{3}$

Write an equation of the line that passes through each pair of points.

18. $(4, 2)$, $(-2, -4)$ **19.** $(3, -2)$, $(6, 4)$

20. $(-1, 3)$, $(2, -3)$ **21.** $(2, -2)$, $(3, 2)$

22. $(7, -2)$, $(-4, -2)$ **23.** $(0, 5)$, $(-3, 5)$

24. $(1, 1)$, $(7, 4)$ **25.** $(5, 7)$, $(0, 6)$

POPULATION **For Exercises 26 and 27, use the data at the top of page 213.**

26. Write a linear equation to find the city's population P for any year t.

27. Predict what the city's population will be in 2010.

DOGS **For Exercises 28 and 29, refer to the information below.**
In 2001, there were about 62.5 thousand golden retrievers registered in the United States. In 2002, the number was 56.1 thousand.

28. Write a linear equation to predict the number of golden retrievers G that will be registered in year t.

29. Predict the number of golden retrievers that will be registered in 2007.

Write an equation of the line that passes through each pair of points.

30. $(5, -2)$, $(7, 1)$ **31.** $\left(-\frac{5}{4}, 1\right), \left(-\frac{1}{4}, \frac{3}{4}\right)$ **32.** $\left(\frac{5}{12}, -1\right), \left(-\frac{3}{4}, \frac{1}{6}\right)$

EXTRA PRACTICE
See pages 725, 747.
Math Online
Self-Check Quiz at
algebra1.com

33. Write an equation of the line that has an x-intercept -3 and a y-intercept 5.

For Exercises 34 and 35, consider line ℓ that passes through (14, 2) and (28, 6).

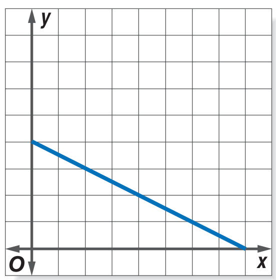
34. Write an equation for line ℓ and describe the slope.

35. Where does line ℓ intersect the x-axis? the y-axis?

H.O.T. Problems

36. CHALLENGE The x-intercept of a line is p, and the y-intercept is q. Use symbols to describe an equation of the line.

37. OPEN ENDED Create a real-world situation that fits the graph at the right. Then draw and label the graph to represent this situation. Define the two quantities and describe the functional relationship between them. Write an equation to represent this relationship and describe what the slope and y-intercept mean.



H.O.T. Problems

38. **REASONING** Tell whether the statement is *sometimes*, *always*, or *never* true. Explain your reasoning.

You can write the equation of a line given its x- and y-intercepts.

39. ***Writing in Math*** Use the information about population on page 213 to explain how the slope-intercept form can be used to make predictions. Discuss how slope-intercept form is used in linear extrapolation.

STANDARDIZED TEST PRACTICE

40. Which equation *best* describes the relationship between the values of x and y shown in the table?

A $y = x - 5$

B $y = 2x - 5$

C $y = 3x - 7$

D $y = x^2 - 7$

x	y
−1	−7
0	−5
2	−1
4	3

41. **REVIEW** Mrs. Aguilar's bedroom is shaped like a rectangle that measures 13 feet by 11 feet. She wants to purchase carpet for the bedroom that costs \$2.95 per square foot, including tax. How much will it cost to carpet her bedroom?

F \$70.80

G \$141.60

H \$145.95

J \$421.85

Spiral Review

Graph each equation. (Lesson 4-3)

42. $y = 3x - 2$

43. $x + y = 6$

44. $x + 2y = 8$

45. **HEALTH** Each time your heart beats, it pumps 2.5 ounces of blood. Write a direct variation equation that relates the total volume of blood V with the number of times your heart beats b. (Lesson 4-2)

Determine the x-intercept and y-intercept of each linear function and describe what the intercepts mean. (Lesson 3-3)

46.

Kwame's Bike Ride	
Time, x (min)	Distance, y (mi)
0	0
5	1
10	2
15	3

47.

Tara's Walk Home	
Time, x (min)	Distance, y (mi)
0	3
15	2
30	1
45	0

Determine the domain and range of each relation. (Lesson 3-1)

48. $\{(0, 8), (9, -2), (4, 2)\}$

49. $\{(-2, 1), (5, 1), (-2, 7), (0, -3)\}$

GET READY for the Next Lesson

PREREQUISITE SKILL **Find each difference.** (Pages 688–689)

50. $4 - 7$

51. $5 - 12$

52. $2 - (-3)$

53. $-1 - 4$

EXTEND 4-4

Graphing Calculator Lab
Step Functions

The graph of a step function is a series of line segments. One step function is called the *greatest integer function.* The greatest integer function is written as $f(x) = [\![x]\!]$, where $f(x)$ is the greatest integer less than or equal to x.

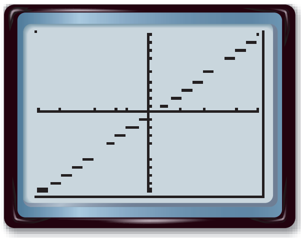
ACTIVITY 1

Graph $f(x) = [\![x]\!]$ in the standard viewing window.

The calculator may need to be changed to dot mode for the function to graph correctly. Press MODE then use the arrow and ENTER keys to select DOT.

Enter the equation in the Y= list. Then graph the equation.

KEYSTROKES: Y= MATH ▶ 5 X,T,θ,n) Zoom 6



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1a. How does the graph of $f(x) = [\![x]\!]$ compare to the graph of $f(x) = x$?

1b. What are the domain and range of the function $f(x) = [\![x]\!]$? Explain.

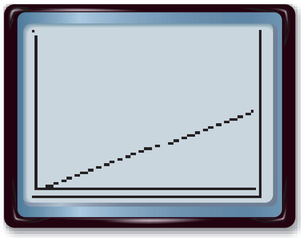
Step functions are often used in real-world situations involving time or money.

ACTIVITY 2

TAXES A city collects $0.02 in income tax for every $1 of income. Write and graph a function for the taxes y of an income of x dollars.

Because the city does not collect taxes for fractions of a dollar, the situation can be described by the step function $y = 0.02[\![x]\!]$.

KEYSTROKES: Y= 0.02 MATH ▶ 5 X,T,θ,n) GRAPH



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2a. Explain why the situation is correctly modeled by a step function instead of the linear function $y = 0.02x$.

2b. Use the CALC function to find the income tax on $458.67.

Analyze the Results

1. A parking garage charges $4 for every hour or fraction of an hour. Is this situation modeled by a linear function or a step function? Explain your reasoning.

2. **MAKE A CONJECTURE** Explain why the greatest integer function is sometimes called the *floor function.*

Math Online Other Calculator Keystrokes at algebra1.com

4-5 Writing Equations in Point-Slope Form

Main Ideas

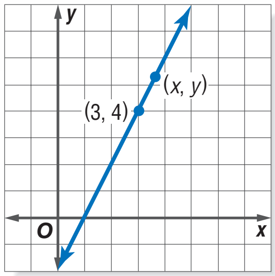
- Write the equation of a line in point-slope form.
- Write linear equations in different forms.

New Vocabulary

point-slope form

GET READY for the Lesson

The graph shows a line with slope 2. Another point on the line is (x, y).



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

$$2 = \frac{y - 4}{x - 3}$$ $(x_2, y_2) = (x, y)$, $(x_1, y_1) = (3, 4)$

$$2(x - 3) = \frac{y - 4}{x - 3}(x - 3)$$ Multiply each side by $(x - 3)$.

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

$$y - 4 = 2(x - 3)$$ Symmetric Property of Equality

y-coordinate (4), slope (2), x-coordinate (3)

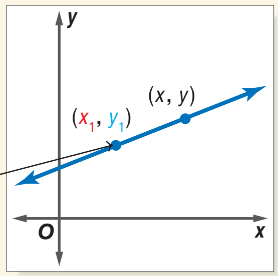
Point-Slope Form The equation above was generated using the coordinates of a known point and the slope of the line. It is written in **point-slope form**.

KEY CONCEPT — Point-Slope Form

Words The linear equation $y - y_1 = m(x - x_1)$ is written in point-slope form, where (x_1, y_1) is a given point on a nonvertical line and m is the slope of the line.

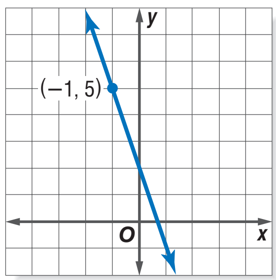
Symbols $y - y_1 = m(x - x_1)$ given point

Model



EXAMPLE Write an Equation Given Slope and a Point

1 **Write the point-slope form of an equation for the line that passes through (−1, 5) with slope −3.**



$y - y_1 = m(x - x_1)$ Point-slope form

$y - 5 = -3[x - (-1)]$ $(x_1, y_1) = (-1, 5)$

$y - 5 = -3(x + 1)$ Simplify.

CHECK Your Progress

1. Write the point-slope form of an equation for the line that passes through $(1, -4)$ with slope $-\frac{8}{3}$.

EXAMPLE Write an Equation of a Horizontal Line

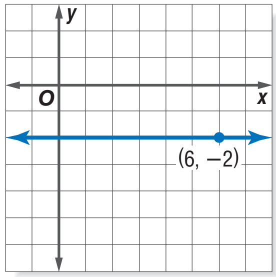
Study Tip

Vertical and Horizontal Lines

Vertical lines cannot be written in point-slope form because the slope is undefined. Horizontal lines can be written in point-slope form because their slope is 0.

2 **Write the point-slope form of an equation for the horizontal line that passes through (6, –2).**

$y - y_1 = m(x - x_1)$	Point-slope form
$y - (-2) = 0(x - 6)$	$(x_1, y_1) = (6, -2)$
$y + 2 = 0$	Simplify.



CHECK Your Progress

2. Write the point-slope form of an equation for the horizontal line that passes through (–4, 4).

Forms of Linear Equations You have learned how to write linear equations given the slope and one point or two points.

CONCEPT SUMMARY *Writing Equations*

Given the Slope and One Point

Step 1 Substitute the values of *m*, *x*, and *y* into the slope-intercept form and solve for *b*. Or use the point-slope form. Substitute the value of *m* and let *x* and *y* be (x_1, y_1).

Step 2 Write the slope-intercept form using the values of *m* and *b*.

Given Two Points

Step 1 Find the slope.

Step 2 Choose one of the two points to use.

Step 3 Follow the steps for writing an equation given the slope and one point.

Study Tip

Look Back

To review **standard form**, see Lesson 3–5.

Linear equations in point-slope form can be written in slope-intercept or standard form.

EXAMPLE Write an Equation in Standard Form

3 **Write $y + 5 = -\frac{5}{4}(x - 2)$ in standard form.**

In standard form, the variables are on the left side of the equation. *A*, *B*, and *C* are all integers.

$y + 5 = -\frac{5}{4}(x - 2)$	Original equation
$4(y + 5) = 4\left(-\frac{5}{4}\right)(x - 2)$	Multiply each side by 4 to eliminate the fraction.
$4y + 20 = -5(x - 2)$	Distributive Property
$4y + 20 = -5x + 10$	Distributive Property
$4y + 20 - 20 = -5x + 10 - 20$	Subtract 20 from each side.
$4y = -5x - 10$	Simplify.
$4y + 5x = -5x - 10 + 5x$	Add $5x$ to each side.
$5x + 4y = -10$	Simplify.

The standard form of the equation is $5x + 4y = -10$.

CHECK Your Progress

3. Write $y - 1 = 7(x + 5)$ in standard form.

EXAMPLE Write an Equation in Slope-Intercept Form

4 **Write $y - 2 = \frac{1}{2}(x + 5)$ in slope-intercept form.**

$y - 2 = \frac{1}{2}(x + 5)$ Original equation

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

$y - 2 + 2 = \frac{1}{2}x + \frac{5}{2} + 2$ Add 2 to each side.

$y = \frac{1}{2}x + \frac{9}{2}$ $2 = \frac{4}{2}$ and $\frac{4}{2} + \frac{5}{2} = \frac{9}{2}$

The slope-intercept form of the equation is $y = \frac{1}{2}x + \frac{9}{2}$.

CHECK Your Progress

4. Write $y + 6 = -3(x - 4)$ in slope-intercept form.

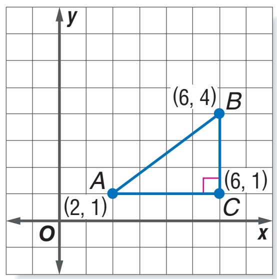
EXAMPLE Write an Equation in Point-Slope Form

Study Tip

Hypotenuse

The *hypotenuse* is the side of a right triangle opposite the right angle.

5 **GEOMETRY** **The figure shows right triangle ABC.**



a. Write the point-slope form of the line containing hypotenuse $\overline{AB}$.

Step 1 First, find the slope of $\overline{AB}$.

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

$= \frac{4 - 1}{6 - 2}$ or $\frac{3}{4}$ $(x_1, y_1) = (2, 1)$ and $(x_2, y_2) = (6, 4)$

Step 2 You can use either point for (x_1, y_1) in the point-slope form.

Method 1 Use (6, 4).	**Method 2** Use (2, 1).
$y - y_1 = m(x - x_1)$	$y - y_1 = m(x - x_1)$
$y - 4 = \frac{3}{4}(x - 6)$	$y - 1 = \frac{3}{4}(x - 2)$

Study Tip

Standard Form

Regardless of which point is used to find the point-slope form, the standard form results in the same equation.

b. Write each equation in standard form.

$y - 4 = \frac{3}{4}(x - 6)$	Original equation	$y - 1 = \frac{3}{4}(x - 2)$
$4(y - 4) = 4\left(\frac{3}{4}\right)(x - 6)$	Multiply each side by 4.	$4(y - 1) = 4\left(\frac{3}{4}\right)(x - 2)$
$4y - 16 = 3(x - 6)$	Multiply.	$4y - 4 = 3(x - 2)$
$4y - 16 = 3x - 18$	Distributive Property	$4y - 4 = 3x - 6$
$4y = 3x - 2$	Add to each side.	$4y = 3x - 2$
$-3x + 4y = -2$	Subtract 3x from each side.	$-3x + 4y = -2$
$3x - 4y = 2$	Multiply each side by −1.	$3x - 4y = 2$

CHECK Your Progress

GEOMETRY **Triangle JKL has vertices $J(1, 2,)$ $K(0, -3)$, and $L(-4, 1)$.**

5A. Write the point-slope form of the line containing side $\overline{JK}$.

5B. Write the standard form of the line containing $\overline{JK}$.

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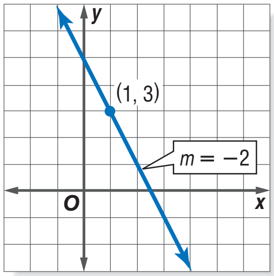
CHECK Your Understanding

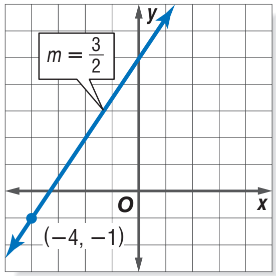
Examples 1, 2 (pp. 220–221)

Write the point-slope form of an equation for the line that passes through each point with the given slope.

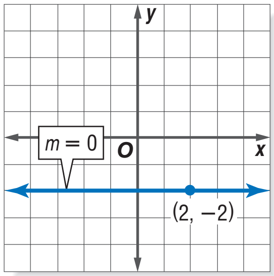
1.



2.



3.



Example 3 (p. 221)

Write each equation in standard form.

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

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

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

Example 4 (p. 222)

Write each equation in slope-intercept form.

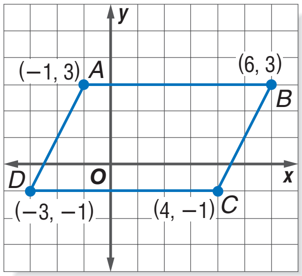
7. $y + 6 = 2(x - 2)$

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

9. $y - 9 = x + 4$

Example 5 (p. 222)

GEOMETRY **For Exercises 10 and 11, use parallelogram *ABCD*.**



10. Write the point-slope form of the line containing $\overline{AD}$.

11. Write the standard form of the line containing $\overline{AD}$.

Exercises

HOMEWORK HELP	
For Exercises	See Examples
12–19	1, 2
20–27	3
28–35	4
36–41	5

Write the point-slope form of an equation for the line that passes through each point with the given slope.

12. $(6, 1), m = -4$

13. $(-4, -3), m = 1$

14. $(9, -5), m = 0$

15. $(-7, 6), m = 0$

16. $(-4, 8), m = \frac{7}{2}$

17. $(1, -3), m = -\frac{5}{8}$

18. Write the point-slope form of an equation for the horizontal line that passes through $(5, -9)$.

19. A horizontal line passes through $(0, 7)$. Write the point-slope form of its equation.

Write each equation in standard form.

20. $y - 13 = 4(x - 2)$

21. $y - 5 = -2(x + 6)$

22. $y + 3 = -5(x + 1)$

23. $y + 7 = \frac{1}{2}(x + 2)$

24. $y - 1 = \frac{5}{6}(x - 4)$

25. $y - 2 = -\frac{2}{5}(x - 8)$

26. $2y + 3 = -\frac{1}{3}(x - 2)$

27. $4y - 5x = 3(4x - 2y + 1)$

Write each equation in slope-intercept form.

28. $y - 2 = 3(x - 1)$

29. $y - 5 = 6(x + 1)$

30. $y + 2 = -2(x - 5)$

31. $y + 3 = \frac{1}{2}(x + 4)$

32. $y - 1 = \frac{2}{3}(x + 9)$

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

34. $y + 3 = -\frac{1}{3}(2x + 6)$

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

BUSINESS **For Exercises 36–38, use the following information.**
A home security company provides security systems for \$5 per week, plus an installation fee. The total cost for installation and 12 weeks of service is \$210.

36. Write the point-slope form of an equation to find the total fee y for any number of weeks x. (*Hint:* The point (12, 210) is a solution to the equation.)

37. Write the equation in slope-intercept form.

38. What is the flat fee for installation?

Real-World Link

In 1907, movie theaters were called nickelodeons. There were about 5000 movie screens, and the average movie ticket cost 5 cents.

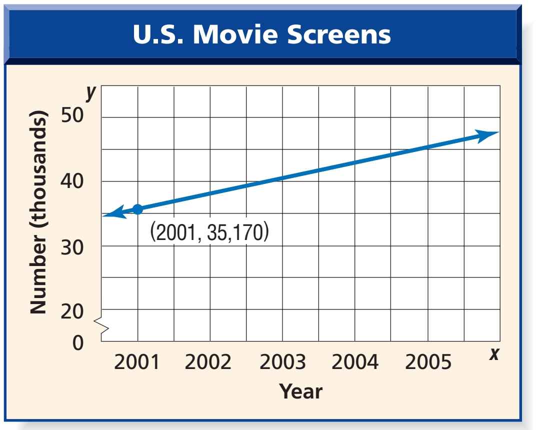
Source: National Association of Theatre Owners

MOVIES **For Exercises 39–41, use the following information.**
Between 2001 and 2003, the number of movie screens in the United States increased an average of 410 each year. In 2001, there were about 35,170 movie screens.

39. Write the point-slope form of an equation to find the total number of screens y for any year x.

40. Write the equation in slope-intercept form.

41. Predict the number of movie screens in the United States in 2007.



Source: National Association of Theatre Owners

Write each equation in standard form.

42. $y + 4 = -\frac{1}{3}(x - 12)$

43. $y - 3 = 2.5(x + 1)$

44. $y - 6 = 1.7(x + 7)$

Write each equation in slope-intercept form.

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

46. $y - \frac{7}{2} = \frac{1}{2}(x - 4)$

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

EXTRA PRACTICE
See pages 726, 747.

Math Online
Self-Check Quiz at algebra1.com

48. Write the point-slope form, slope-intercept form, and standard form of an equation for a line that passes through (5, −3) with slope 10.

49. Line ℓ passes through (1, −6) with slope $\frac{3}{2}$. Write the point-slope form, slope-intercept form, and standard form of an equation for line ℓ.

H.O.T. Problems

50. **FIND THE ERROR** Tanya and Akira wrote the point-slope form of an equation for a line that passes through (−2, −6) and (1, 6). Tanya says that Akira's equation is wrong. Tanya says they are both correct. Who is correct? Explain.

Tanya	Akira
$y + 6 = 4(x + 2)$	$y - 6 = 4(x - 1)$

51. OPEN ENDED Compose a real-life scenario that has a constant rate of change and whose value at a particular time is (x, y). Represent this situation using an equation in slope-intercept form and an equation in point-slope form.

52. REASONING Find an equation for the line that passes through $(-4, 8)$ and $(3, -7)$. What is the slope? Where does the line intersect the x-axis? the y-axis?

53. REASONING Barometric pressure is a linear function of altitude. At an altitude of 2 kilometers, the barometric pressure is 600 mmHg, At 7 kilometers, the barometric pressure is 300 mmHg. Find a formula for the barometric pressure as a function of altitude.

54. CHALLENGE A line contains the points $(9, 1)$ and $(5, 5)$. Make a convincing argument that the same line intersects the x-axis at $(10, 0)$.

55. *Writing in Math* Demonstrate how you can use the slope formula to write the point-slope form of an equation of a line.

STANDARDIZED TEST PRACTICE

56. What is the equation of the line that passes through $(0, 1)$, and that has a slope of 3?

A $y = 3x - 1$

B $y = 3x - 2$

C $y = 3x + 4$

D $y = 3x + 1$

57. REVIEW What is the slope of the equation of the line that passes through $(1, 3)$ and $(-3, 1)$?

F -2

G $-\frac{1}{2}$

H $\frac{1}{2}$

J 2

Spiral Review

Write the slope-intercept form of an equation of the line that satisfies each condition. (Lessons 4-3 and 4-4)

58. passes through $(2, -4)$ and $(0, 6)$

59. a horizontal line through $(1, -1)$

60. slope -2 and y-intercept -5

61. passes through $(-2, 4)$ with slope 3

62. WATER The table shows the number of gallons of water that a standard showerhead uses. Write an equation in function notation to describe the relation. (Lesson 3-5)

Number of Minutes	1	2	3	4
Number of Gallons	6	12	18	24

Solve each equation. (Lesson 2-3)

63. $4a - 5 = 15$

64. $7 + 3c = -11$

65. $\frac{2}{9}v - 6 = 14$

66. Evaluate $(25 - 4) \div (2^2 - 1^3)$. (Lesson 1-3)

GET READY for the Next Lesson

PREREQUISITE SKILL Write the slope-intercept form of an equation for the line that passes through each pair of points. (Lesson 4-3)

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

68. $(0, 2), (8, 0)$

69. $(2, 1), (3, -4)$

READING MATH

Understanding the Questions

Describe what canyon hiking is.

- hiking in a deep narrow valley that has steep sides

Explain what canyon hiking involves.

- Depending on the canyon, the hike may require a rope and training in basic rope work, or advanced training in rope work, rappelling, setting up anchors, and so on to descend canyon walls safely.

Notice that both responses above give information about canyon hiking. However, the second response provides more in-depth information than the first. Often in mathematics you are asked to *describe, explain, compare and contrast*, or *justify* statements. As in the situation above, these terms require different levels of response.

Question	What Your Answer Should Show
Describe	**KNOWLEDGE:** recalling information
Explain	**COMPREHENSION:** understanding information
Compare and Contrast	**ANALYSIS:** taking apart information
Justify	**EVALUATION:** making choices based on information

Reading to Learn

1. Describe the information that is needed to write an equation of a line. Explain the steps that you can take to write an equation of a line.

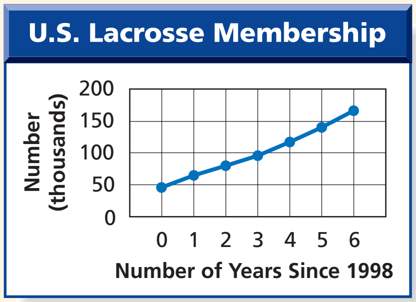
2. Compare and contrast equations that are written in slope-intercept form, point-slope form, and standard form.

3. The graph shows the number of members in U.S. Lacrosse.

a. Describe the trend.

b. Explain possible reasons for the trend.

c. Use the graph to justify a city's decision to have a lacrosse field included in a new sports complex.



Source: U.S. Lacrosse Participation Survey, 2004

4. *Distinguish, summarize, define, predict,* and *demonstrate* are other terms used in mathematics. Write a brief definition of each term as it applies to mathematics and determine whether it requires an answer that shows knowledge, comprehension, analysis, or evaluation.

4-6 Statistics: Scatter Plots and Lines of Fit

Main Ideas

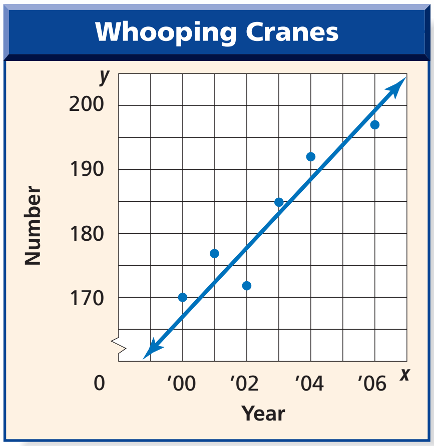
- Interpret points on a scatter plot.
- Use lines of fit to make and evaluate predictions.

New Vocabulary

scatter plot
line of fit
best-fit line
linear interpolation

GET READY for the Lesson

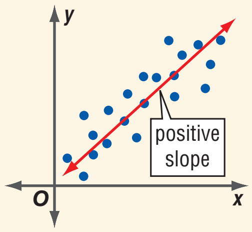
The points of a set of real-world data do not always lie on one line. But, you may be able to draw a line that seems to be close to all the points. The line in the graph shows a linear relationship between the year x and the number of whooping cranes sighted in January of each year, y. Generally, as the years increase, the number of whooping cranes also increases.



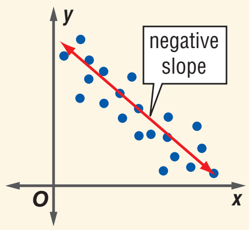
Interpret Points On a Scatter Plot A **scatter plot** is a graph in which two sets of data are plotted as ordered pairs in a coordinate plane. Scatter plots are used to investigate a relationship between two quantities. If the pattern in a scatter plot is linear, you can draw a line to summarize the data. This can help identify trends in the data and the type of correlation.

KEY CONCEPT — Scatter Plots

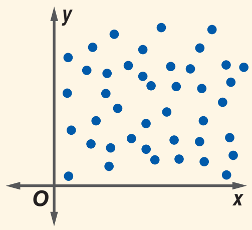
Positive Correlation



Negative Correlation

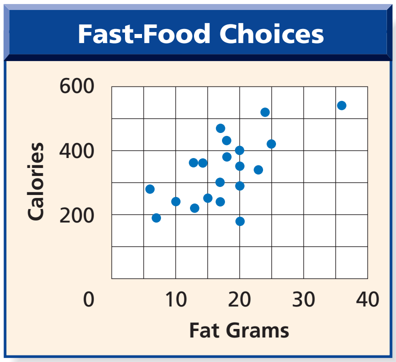


No Correlation



Real-World EXAMPLE

1 **NUTRITION Determine whether the graph shows a *positive correlation*, a *negative correlation*, or *no correlation*. If there is a positive or negative correlation, describe its meaning in the situation.**



Source: Olen Publishing Co.

The graph shows a positive correlation. As the number of fat grams increases, the number of Calories increases.

Study Tip

Correlations

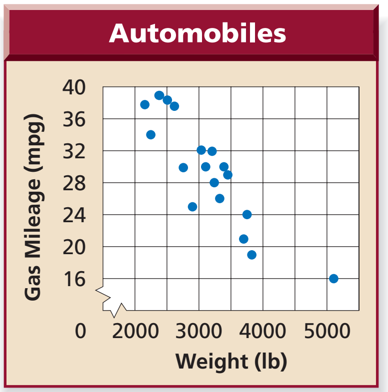
positive: as x increases, y increases

negative: as x increases, y decreases

no correlation: no relationship between x and y

CHECK Your Progress

1. **CARS** The graph shows the weight and the highway gas mileage of selected cars. Determine whether the graph shows a *positive correlation*, a *negative correlation*, or *no correlation*. If there is a positive or negative correlation, describe its meaning in the situation.



Source: Yahoo!

Is there a relationship between the length of a person's foot and his or her height? Make a scatter plot and then look for a pattern.

ALGEBRA LAB

Making Predictions

COLLECT AND ORGANIZE THE DATA

- Measure your partner's foot and height in centimeters. Then trade places.
- Add the points (foot length, height) to a class scatter plot.

ANALYZE THE DATA

1. Is there a correlation between foot length and height for the members of your class? If so, describe it.
2. Draw a line that summarizes the data and shows how the height changes as the foot length changes.

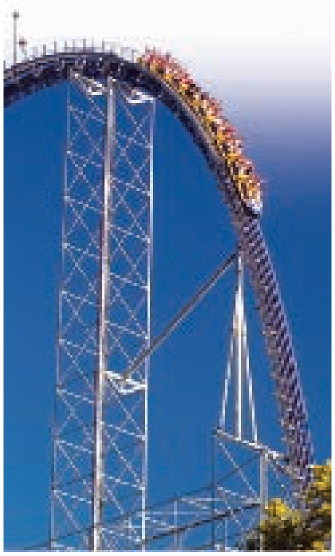
MAKE A CONJECTURE

3. Use the line to predict the height of a person whose foot length is 25 centimeters. Explain your method.

Make and Evaluate Predictions If the data points do not all lie on a line, but are close to a line, you can draw a **line of fit.** This line describes the trend of the data. Once you have a line of fit, you can find an equation of the line.

In this lesson, you will use a graphical method to find a line of fit. In Extend Lesson 4-6, you will use a graphing calculator to find a line of fit. The calculator uses a statistical method to find the line that most closely approximates the data. This line is called the **best-fit line.**

Math Online Extra Examples at algebra1.com



Real-World EXAMPLE

2 **ROLLER COASTERS** **The table shows the largest vertical drops of nine roller coasters in the United States and the number of years after 1988 that they were opened.**

Years since 1988	1	3	5	8	12	12	12	13	15
Vertical Drop (ft)	151	155	225	230	306	300	255	255	400

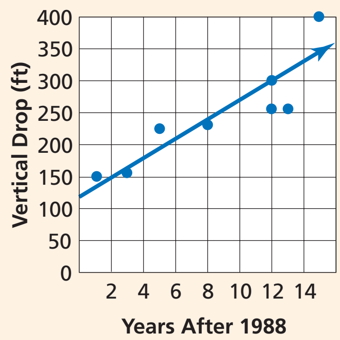
Source: ultimaterollercoaster.com

a. Draw a scatter plot and determine what relationship exists, if any, in the data.

As the number of years increases, the vertical drop of roller coasters increases. There is a positive correlation between the variables.

b. Draw a line of fit.

No one line will pass through all of the data points. Draw a line that passes close to the points. One line of fit is shown in the scatter plot.



c. Write the slope-intercept form of an equation for the line of fit.

The line of fit shown above passes through (2, 150) and (12, 300).

Step 1 Find the slope.

$$m = \frac{y_2 - y_1}{x_2 - x_1} \quad \text{Slope formula}$$

$$= \frac{300 - 150}{12 - 2} \quad (x_1, y_1) = (2, 150), (x_2, y_2) = (12, 300)$$

$$= \frac{150}{10} \text{ or } 15 \quad \text{Simplify.}$$

Step 2 Use $m = 15$ and either the point-slope form or the slope-intercept form to write the equation of the line of fit.

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

$$y - 150 = 15(x - 2)$$

$$y - 150 = 15x - 30$$

$$y = 15x + 120$$

A slope of 15 means that the vertical drops increased an average of 15 feet per year. A y-intercept of 120 means that a roller coaster that opened in 1988 has a vertical drop of approximately 120 feet.

Real-World Link

The difference in height between the top of the hill and the bottom is the vertical drop.

Source: ultimaterollercoaster.com

Study Tip

Lines of Fit

When you use the graphical method, the line of fit is an approximation. So, you may draw another line of fit using other points that is equally valid. Some valid lines of fit may not contain any of the data points.

CHECK Your Progress

EAGLES **The table shows an estimate for the number of bald eagle pairs in the United States for certain years since 1985.**

Year since 1985	3	5	7	9	11	14	15
Bald Eagle Pairs	2500	3000	3700	4500	5000	5800	6500

Source: U.S. Fish and Wildlife Service

2A. Draw a scatter plot and determine what relationship exists, if any, in the data.

2B. Draw a line of fit for the scatter plot.

2C. Write the slope-intercept form of an equation for the line of fit.

Concepts in Motion
Interactive Lab
algebra1.com

Online Personal Tutor at algebra1.com

Linear extrapolation is used to predict values that are *outside* the range of the data. You can also use a linear equation to predict values that are *inside* the range of the data. This is called **linear interpolation**.

Study Tip

Limits of the Model

Notice that the equation cannot be used in extreme cases. For example, it is not reasonable that a roller coaster be 1000 feet tall.

Real-World EXAMPLE

3 ROLLER COASTERS Use the equation for the line of fit in Example 2. Estimate the largest vertical drop of a roller coaster that is opened in 2007.

$y = 15x + 120$ Original equation

$= 15(19) + 120$ Replace x with 2007 − 1988 or 19.

$= 405$ Simplify.

In 2007, the largest vertical drop is estimated to be 405 feet.

CHECK Your Progress

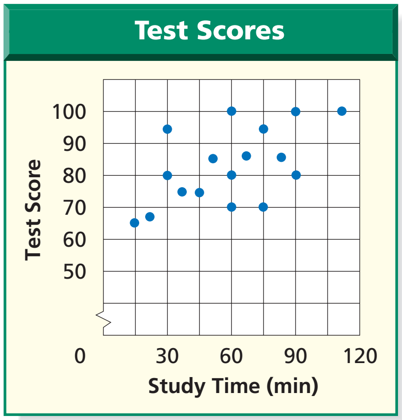
3. EAGLES Use the equation for the line of fit in Check Your Progress 2B on page 229 to estimate the number of bald eagle pairs in 2008.

CHECK Your Understanding

Example 1 (p. 228)

Determine whether each graph shows a *positive correlation*, a *negative correlation*, or *no correlation*. If there is a positive or negative correlation, describe its meaning in the situation.

1.



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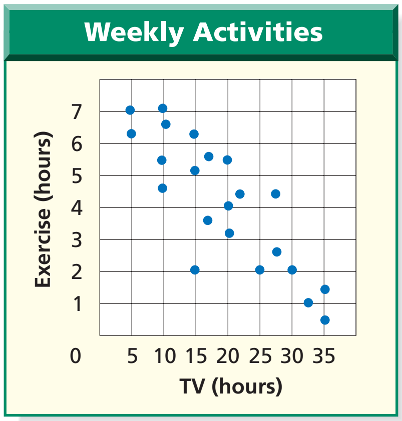


BIOLOGY For Exercises 3–7, use the table that shows the average body temperature in degrees Celsius of nine insects at a given air temperature.

	Temperature (°C)								
Air	25.7	30.4	28.7	31.2	31.5	26.2	30.1	31.5	18.2
Body	27.0	31.5	28.9	31.0	31.5	25.6	28.4	31.7	18.7

Example 2 (p. 229)

3. Draw a scatter plot and determine what relationship exists, if any, in the data.

4. Draw a line of fit for the scatter plot.

5. Write the slope-intercept form of an equation for the line of fit.

Example 3 (p. 230)

6. Predict the body temperature of an insect if the air temperature is 40.2°C.

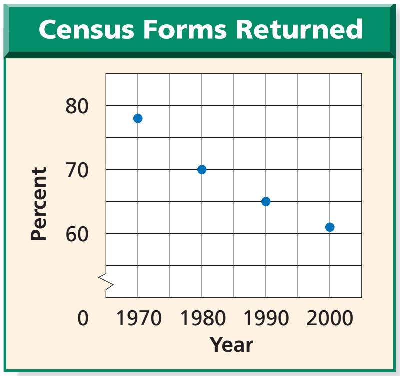
7. Suppose the air temperature is −50°C. According to your judgment, do you think the equation can give a reasonable estimate for the body temperature of an insect? Explain.

Exercises

HOMEWORK HELP	
For Exercises	See Examples
8–11	1
12–27	2, 3

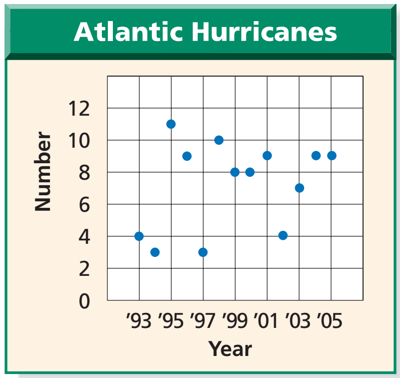
Determine whether each graph shows a *positive correlation*, a *negative correlation*, or *no correlation*. If there is a positive or negative correlation, describe its meaning in the situation.

8.



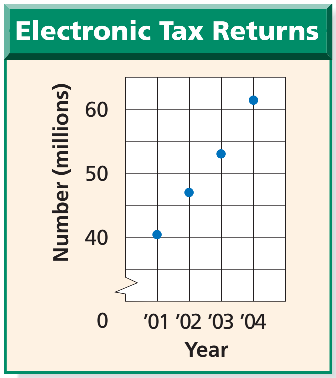
Source: U.S. Census Bureau

9.



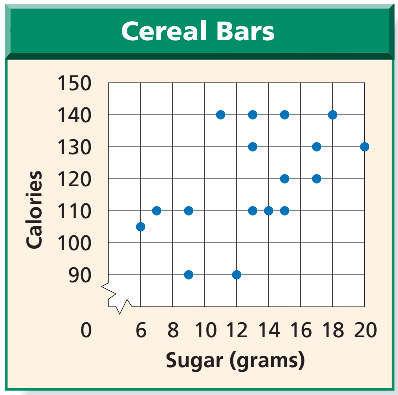
Source: *USA TODAY*

10.



Source: IRS

11.



Source: *Vitality*

BIRDS **For Exercises 12–14, refer to the graph at the top of page 227 about whooping cranes.**

12. Use the points (2000, 170) and (2003, 185) to write an equation for a line of fit.

13. Predict the number of whooping cranes in 2008.

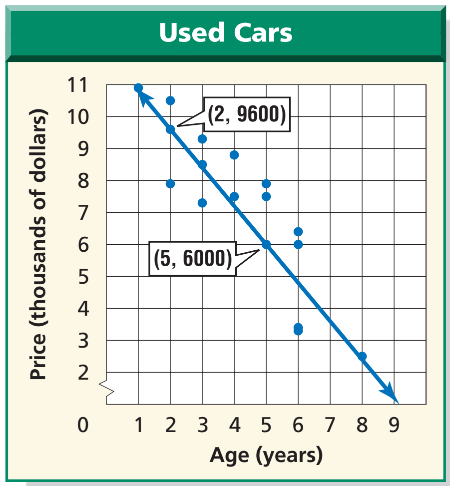
14. Is it reasonable to use the equation to estimate the number of whooping cranes in any year, such as in 1900? Explain.

USED CARS **For Exercises 15–17, use the scatter plot that shows the ages and prices of used cars from classified ads.**

15. Use the points (2, 9600) and (5, 6000) to write the slope-intercept form of an equation for the line of fit shown in the scatter plot.

16. Predict the price of a car that is 7 years old.

17. Can you use the equation to make a decision about buying a used car that is 50 years old? Explain.



Source: *Columbus Dispatch*

Cross-Curricular Project

Math Online You can use a line of fit to describe the trend in winning Olympic times. Visit algebra1.com to continue work on your project.

PHYSICAL SCIENCE For Exercises 18–22, use the following information.
Hydrocarbons are composed of only carbon and hydrogen atoms. The table gives the number of carbon atoms and the boiling points for several hydrocarbons.

Hydrocarbons			
Name	Formula	Number of Carbon Atoms	Boiling Point (°C)
Ethane	C_2H_6	2	−89
Propane	C_3H_8	3	−42
Butane	C_4H_{10}	4	−1
Hexane	C_6H_{12}	6	69
Octane	C_8H_{18}	8	126

18. Draw a scatter plot comparing the numbers of carbon atoms to the boiling points.
19. Draw a line of fit for the data.
20. Write the slope-intercept form of an equation for the line of fit.
21. Predict the boiling point for pentane (C_5H_{12}), which has 5 carbon atoms.
22. The boiling point of heptane is 98.4°C. Use the equation of the line of fit to predict the number of carbon atoms in heptane.

Real-World Career
Aereospace Engineers
Aerospace engineers specialize in a type of aircraft such as commercial airplanes, military aircraft, and spacecraft.

Math Online
For more information, go to algebra1.com.

SPACE For Exercises 23–27, use the table that shows the amount the United States government has spent on space and other technologies in selected years.

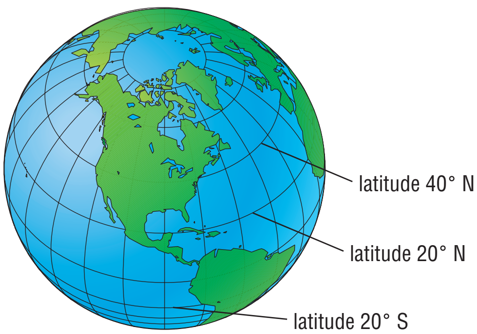
Federal Spending on Space and Other Technologies									
Year	1980	1985	1990	1995	1996	1997	1998	1999	2004
Spending (billions of dollars)	4.5	6.6	11.6	12.6	12.7	13.1	12.9	12.4	15.4

Source: U.S. Office of Management and Budget

23. Draw a scatter plot and determine what relationship, if any, exists in the data.
24. Draw a line of fit for the scatter plot.
25. Let x represent the number of years since 1980. Let y represent spending in billions of dollars. Write the slope-intercept form of the equation for the line of fit.
26. Predict the amount that will be spent on space and other technologies in 2007.
27. Make a critical judgment about the amount that will be spent on space and other technologies in the next century. Would the equation that you wrote be a useful model?

GEOGRAPHY For Exercises 28–31, use the following information.
The *latitude* of a place on Earth is the measure of its distance from the equator.

28. **MAKE A CONJECTURE** What do you think is the relationship between a city's latitude and its January temperature?
29. **RESEARCH** Use the Internet or other reference to find the latitude of 15 cities in the northern hemisphere and the corresponding January mean temperatures.
30. Make a scatter plot and draw a line of fit for the data.
31. Write an equation for the line of fit.



EXTRA PRACTICE
See pages 726, 747.
Math Online
Self-Check Quiz at algebra1.com

H.O.T. Problems

32. **OPEN ENDED** Sketch scatter plots that have each type of correlation: positive, negative, and none. Associate each graph with a real-life situation.

33. **REASONING** Compare and contrast interpolation and extrapolation.

34. **CHALLENGE** A test contains 20 true-false questions. Draw a scatter plot that shows the relationship between the number of correct answers x and the number of incorrect answers y.

35. ***Writing in Math*** Draw a scatter plot that shows a person's height and his or her age, with a description of any trends. Explain how you could use the scatter plot to predict a person's age given his or her height. How can the information from a scatter plot be used to identify trends and make decisions?

STANDARDIZED TEST PRACTICE

36. **REVIEW** Mr. Hernandez collected data on the heights and average stride lengths of a random sample of students in grades 8, 9, and 10. He then graphed the data on a scatter plot. What correlation did he most likely see?

    A positive
    B negative
    C constant
    D no correlation

37. Which equation *best* fits the data in the table?

x	y
1	5
2	7
3	7
4	11

   F $y = x + 4$
   G $y = 2x + 3$
   H $y = 7$
   J $y = 4x - 5$

Spiral Review

Write the point-slope form of an equation for the line that passes through each point with the given slope. (Lesson 4-5)

38. $(1, -2)$; $m = 3$

39. $(-2, 3)$; $m = -2$

40. $(-3, -3)$; $m = 1$

41. **COMMUNICATION** A calling plan charges a rate per minute plus a flat fee. A 10-minute call to the Czech Republic costs \$3.19. A 15-minute call costs \$4.29. Write a linear equation in slope-intercept form to represent the total cost C of an m-minute call. Then find the cost of a 12-minute call. (Lesson 4-4)

42. **EXERCISE** The statement below was found in *Healthy Fun* magazine.

    A typical 100-pound kid can burn more than 350 calories per hour riding a bike.

    At this rate, about how many Calories would be burned riding a bike 25 minutes? (Lesson 2-6)

GET READY for the Next Lesson

PREREQUISITE SKILL **Write the multiplicative inverse of each number.** (Pages 698–699)

43. 10

44. -1

45. $\frac{2}{3}$

46. $-\frac{1}{9}$

47. $\frac{3}{4}$

EXTEND 4-6

Graphing Calculator Lab
Regression and Median-Fit Lines

One type of equation of best-fit you can find is a linear **regression equation.**

ACTIVITY 1

MUSIC **The table shows the percent of music sales that were made on the Internet in the United States for the period 1997–2004.**

Year	1997	1998	1999	2000	2001	2002	2003	2004
Sales	0.3	1.1	2.4	3.2	2.9	3.4	5.0	5.9

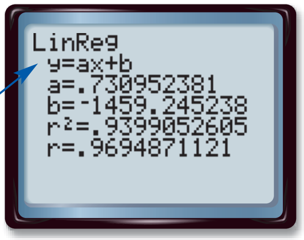
Source: Recording Industry Association of America

Find and graph a linear regression equation. Then predict the percent of music sales that will be made on the Internet in 2010.

Step 1 Find a regression equation.

Enter the years in L1 and the earnings in L2. Find the regression equation.

KEYSTROKES: STAT ENTER 1997 ENTER … ▶ 0.3 ENTER … STAT ▶ 4 ENTER



The equation is in the form $y = ax + b$.

The equation is about $y = 0.73x - 1459.25$.

r is the **linear correlation coefficient.** The closer the absolute value of r is to 1, the better the equation models the data.

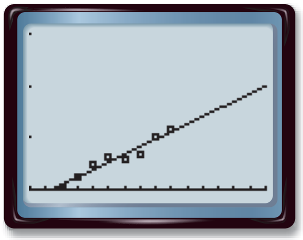
Step 2 Graph the regression equation.

Use STAT PLOT to graph the scatter plot.

KEYSTROKES: 2nd [STAT] ENTER ENTER

Copy the equation to the Y= list and graph.

KEYSTROKES: Y= VARS 5 ▶ ▶ 1 GRAPH



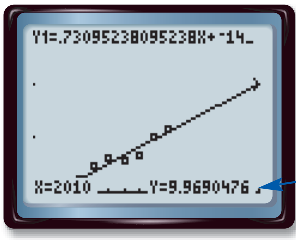
[1995, 2010] scl: 1 by [0, 15] scl: 5

Step 3 Predict using the regression equation.

Find y when $x = 2010$.

KEYSTROKES: 2nd [CALC] 1 2010 ENTER

According to the regression equation, in 2010 about 9.97% of music sales will be made on the Internet.



The graph and the coordinates of the point are shown.

Math Online Other Calculator Keystrokes at algebra1.com

A second type of best-fit line that can be found using a graphing calculator is a **median-fit line.** The equation of a median-fit line is calculated using the medians of the coordinates of the data points.

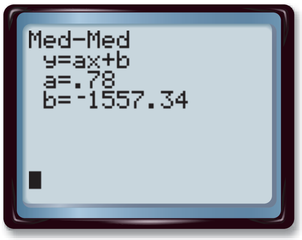
ACTIVITY 2

Find and graph a median-fit equation for the data on music sales. Then predict the percent of sales that will be made on the Internet in 2010. Compare this prediction to the one made using the regression equation.

Step 1 **Find a median-fit equation.**

The data are already in Lists 1 and 2. Find the median-fit equation by using *Med-Med* on the STAT CALC menu.

KEYSTROKES: [STAT] [▶] 3 [ENTER]

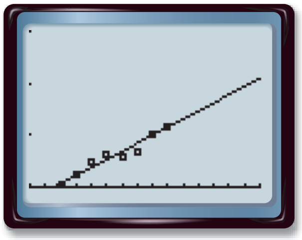


The median-fit equation is $y = 0.78x - 1557.34$.

Step 2 **Graph the median-fit equation.**

Copy the equation to the Y= list and graph.

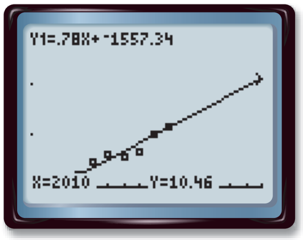
KEYSTROKES: [Y=] [CLEAR] [VARS] 5 [▶] [▶] 1 [GRAPH]



[1995, 2010] scl: 1 by [0, 15] scl: 5

Step 3 **Predict using the median-fit equation.**

KEYSTROKES: [2nd] [CALC] 1 2010 [ENTER]



According to the median-fit equation, about 10.46% of music sales will be made on the Internet in 2010. This is slightly more than the predicted value found using the regression equation.

ANALYZE THE RESULTS

Refer to the data on roller coasters in Example 2 on page 229.

1. Find regression and median-fit equations for the data.

2. What is the correlation coefficient of the regression equation? What does it tell you about the data?

3. Use the regression and median-fit equations to predict the largest vertical drop for a roller coaster in 2007. Compare these to the number found in Example 3 on page 230.

4-7 Geometry: Parallel and Perpendicular Lines

Main Ideas

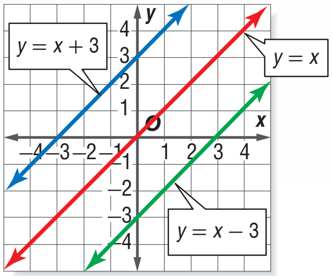
- Write an equation of the line that passes through a given point, parallel to a given line.
- Write an equation of the line that passes through a given point, perpendicular to a given line.

New Vocabulary

parallel lines
perpendicular lines

GET READY for the Lesson

The graph shows a family of linear graphs whose slope is 1. Note that the lines do not appear to intersect.

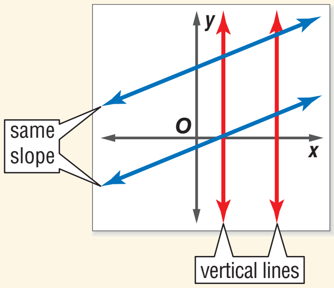


Parallel Lines Lines in the same plane that do not intersect are called **parallel lines.** Parallel lines have the same slope.

KEY CONCEPT — Parallel Lines in a Coordinate Plane

Words If two nonvertical lines have the same slope, then they are parallel. All vertical lines are parallel.

Model



You can write the equation of a line parallel to a given line if you know a point on the line and an equation of the given line.

EXAMPLE Parallel Line Through a Given Point

1 **Write the slope-intercept form of an equation for the line that passes through (−1, −2) and is parallel to the graph of $y = -3x - 2$.**

The line parallel to $y = -3x - 2$ has the same slope, −3. Replace m with −3, and (x_1, y_1) with (−1, −2) in the point-slope form.

$y - y_1 = m(x - x_1)$	Point-slope form
$y - (-2) = -3[x - (-1)]$	Replace m with −3, y_1 with −2, and x_1 with −1.
$y + 2 = -3(x + 1)$	Simplify.
$y + 2 = -3x - 3$	Distributive Property
$y + 2 - 2 = -3x - 3 - 2$	Subtract 2 from each side.
$y = -3x - 5$	Write the equation in slope-intercept form.

CHECK Your Progress

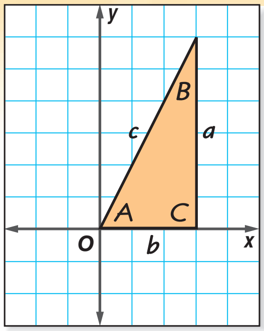
1. Write the point-slope form of an equation for the line that passes through (4, −1) and is parallel to the graph of $y = \frac{1}{4}x + 7$.

Perpendicular Lines Lines that intersect at right angles are called **perpendicular lines.** There is a relationship between the slopes of perpendicular lines.

ALGEBRA LAB

Perpendicular Lines

- A scalene triangle is one in which no two sides are equal in length. Cut out a scalene right triangle *ABC* so that $\angle C$ is a right angle. Label the vertices and the sides as shown.
- Draw a coordinate plane on grid paper. Place $\triangle ABC$ on the coordinate plane so that *A* is at the origin and side *b* lies along the positive *x*-axis.



ANALYZE THE RESULTS

1. Name the coordinates of *B*.
2. What is the slope of side *c*?
3. Rotate the triangle 90° counterclockwise so that *A* is still at the origin and side *b* is along the positive *y*-axis. Name the coordinates of *B*.
4. What is the slope of side *c*?
5. Repeat the activity for two other scalene right triangles.
6. For each triangle and its rotation, what is the relationship between the first position of side *c* and the second?
7. For each triangle and its rotation, describe the relationship between the coordinates of *B* in the first and second positions.
8. Describe the relationship between the slopes of *c* in each position.

MAKE A CONJECTURE

9. Describe the relationship between the slopes of any two perpendicular lines.

Study Tip

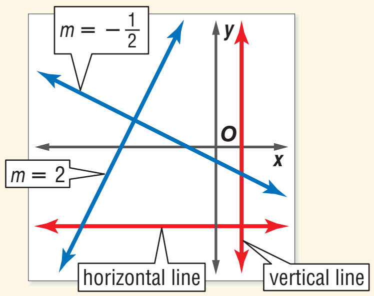
Look Back
To review **rotations on the coordinate plane,** see Lesson 3-2.

The results of the Algebra Lab suggests an important property of perpendicular lines.

KEY CONCEPT *Perpendicular Lines in a Coordinate Plane*

Words If the product of the slopes of two nonvertical lines is −1, then the lines are perpendicular. In this case, the slopes are *opposite reciprocals* of each other. Vertical lines and horizontal lines are also perpendicular.

Model

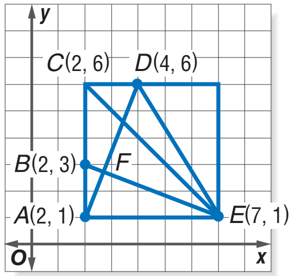


Review Vocabulary

Reciprocals $\frac{1}{4}$ and 4 are reciprocals because their product is 1. (Lesson 1-4)

Real-World EXAMPLE — Determine Whether Lines are Perpendicular

2 **DESIGN The outline of a new company logo is shown on a coordinate plane. Is $\angle DFE$ a right angle?**



If $\overline{BE}$ and $\overline{AD}$ are perpendicular, then $\angle DEF$ is a right angle. Find the slopes of $\overline{BE}$ and $\overline{AD}$.

slope of $\overline{BE}$: $m = \frac{1 - 3}{7 - 2}$ or $-\frac{2}{5}$

slope of $\overline{AD}$: $m = \frac{6 - 1}{4 - 2}$ or $\frac{5}{2}$

The line segments are perpendicular because $-\frac{2}{5} \cdot \frac{5}{2} = -1$. Therefore, $\angle DEF$ is a right angle.

CHECK Your Progress

2. **CONSTRUCTION** On the plans for a tree house, a beam represented by $\overline{QR}$ has endpoints $Q(-6, 2)$ and $R(-1, 8)$. A beam represented by $\overline{ST}$ has endpoints $S(-3, 6)$ and $T(-8, 5)$. Are the beams perpendicular? Explain.

You can write the equation of a line perpendicular to a given line if you know a point on the line and the equation of the given line.

EXAMPLE — Perpendicular Line Through a Given Point

3 **Write the slope-intercept form of an equation for the line that passes through $(-3, -2)$ and is perpendicular to the graph of $x + 4y = 12$.**

Step 1 Find the slope of the given line.

$x + 4y = 12$	Original equation
$x + 4y - x = 12 - x$	Subtract $1x$ from each side.
$4y = -1x + 12$	Simplify.
$\frac{4y}{4} = \frac{-1x + 12}{4}$	Divide each side by 4.
$y = -\frac{1}{4}x + 3$	Simplify.

Step 2 The slope of the given line is $-\frac{1}{4}$. So, the slope of the line perpendicular to this line is the opposite reciprocal of $-\frac{1}{4}$, or 4.

Step 3 Use the point-slope form to find the equation.

$y - y_1 = m(x - x_1)$	Point-slope form
$y - (-2) = 4[x - (-3)]$	$(x_1, y_1) = (-3, -2)$ and $m = 4$
$y + 2 = 4(x + 3)$	Simplify.
$y + 2 = 4x + 12$	Distributive Property
$y + 2 - 2 = 4x + 12 - 2$	Subtract 2 from each side.
$y = 4x + 10$	Simplify.

Study Tip

Graphing Calculator

If you graph perpendicular lines on a graphing calculator, the lines will not appear to be perpendicular if the scales on the axes are not set correctly. After graphing, press ZOOM 5 to set the axes for a correct representation.

CHECK Your Progress

3. Write the slope-intercept form of an equation for the line that passes through $(4, 7)$ and is perpendicular to the graph of $y = \frac{2}{3}x - 1$.

Online Personal Tutor at algebra1.com

EXAMPLE Perpendicular Line Through a Given Point

4 **Write an equation in slope-intercept form for a line perpendicular to the graph of $y = -\frac{1}{3}x + 2$ that passes through the x-intercept of that line.**

Step 1 Find the slope of the perpendicular line. The slope of the given line is $-\frac{1}{3}$, therefore a perpendicular line has slope 3.

Step 2 Find the x-intercept of the given line.

$y = -\frac{1}{3}x + 2$ Original equation

$0 = -\frac{1}{3}x + 2$ Replace y with 0.

$-2 = -\frac{1}{3}x$ Subtract 2 from each side.

$6 = x$ Multiply each side by -3.

The x-intercept is at (6, 0).

Step 3 Substitute the slope and the given point into the point-slope form of a linear equation. Then write in slope-intercept form.

$y - y_1 = m(x - x_1)$ Point-slope form

$y - 0 = 3(x - 6)$ Replace x_1 with 6, y_1 with 0, and m with 3.

$y = 3x - 18$ Distributive Property

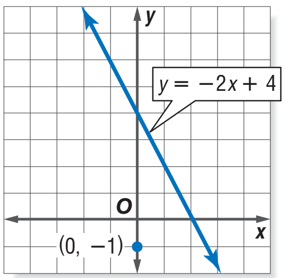
CHECK Your Progress

4. Write an equation in slope-intercept form for a line perpendicular to the graph of $3x + 2y = 8$ that passes through the y-intercept of that line.

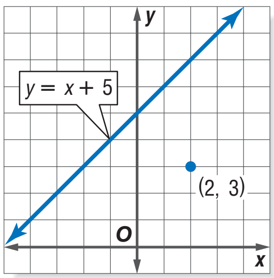
CHECK Your Understanding

Example 1 (pp. 236–237) **Write the slope-intercept form of an equation for the line that passes through the given point and is parallel to the graph of each equation.**

1.



2.



3. $(1, -3)$, $y = 2x - 1$

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

Example 2 (p. 238)

5. GARDENS A garden is in the shape of a quadrilateral with vertices $A(-2, 1)$, $B(3, -3)$, $C(5, 7)$, and $D(-3, 4)$. Two paths represented by $\overline{AC}$ and $\overline{BD}$ cut across the garden. Are the paths perpendicular? Explain.

Example 3 (p. 238) **Write the slope-intercept form of an equation for the line that passes through the given point and is perpendicular to the graph of the equation.**

6. $(-3, 1)$, $y = \frac{1}{3}x + 2$

7. $(6, -2)$, $y = \frac{3}{5}x - 4$

8. $(2, -2)$, $2x + y = 5$

Example 4 (p. 239)

9. Write the slope-intercept form for an equation of a line that is perpendicular to the graph of $y = 6x - 6$ and passes through the x-intercept of that line.

Exercises

HOMEWORK HELP	
For Exercises	See Examples
10–16	1
18, 19	2
17, 20–25	3
26, 27	4

Write the slope-intercept form of an equation for the line that passes through the given point and is parallel to the graph of each equation.

10. $(-3, 2), y = x - 6$

11. $(2, -1), y = 2x + 2$

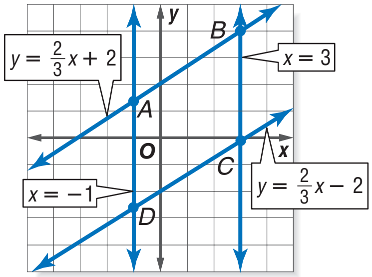
12. $(-5, -4), y = \frac{1}{2}x + 1$

13. $(3, 3), y = \frac{2}{3}x - 1$

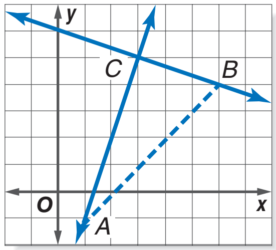
14. $(-4, -3), y = -\frac{1}{3}x + 3$

15. $(-1, 2), y = -\frac{1}{2}x - 4$

16. **GEOMETRY** A *parallelogram* is a quadrilateral in which opposite sides are parallel. Determine whether $ABCD$ is a parallelogram. Explain your reasoning.



17. **GEOMETRY** The line with equation $y = 3x - 4$ contains side $\overline{AC}$ of right triangle ABC. If the vertex of the right angle C is at $(3, 5)$, what is an equation of the line that contains side $\overline{BC}$?



18. Determine whether $y = -6x + 4$ and $y = \frac{1}{6}x$ are perpendicular. Explain.

19. **MAPS** On a map, Elmwood Drive passes through $R(4, -11)$ and $S(0, -9)$ and Taylor Road passes through $J(6, -2)$ and $K(4, -5)$. If they are straight lines, are the two streets perpendicular? Explain.

Write the slope-intercept form of an equation for the line that passes through the given point and is perpendicular to the graph of the equation.

20. $(-2, 0), y = x - 6$

21. $(1, 1), y = 4x + 6$

22. $(-3, 1), y = -3x + 7$

23. $(1, -3), y = \frac{1}{2}x + 4$

24. $(-2, 7), 2x - 5y = 3$

25. $(4, 7), 3y - 2x = -3$

26. Find an equation for the line that has a y-intercept of -2 and is perpendicular to the graph of $3x + 6y = 2$.

27. Write an equation of the line that is perpendicular to the line through $(9, 10)$ and $(3, -2)$ and passes through the x-intercept of that line.

Determine whether the graphs of each pair of equations are *parallel, perpendicular,* or *neither.*

28. $y = -2x + 11$
$y + 2x = 23$

29. $3y = 2x + 14$
$2x - 3y = 2$

30. $y = -5x$
$y = 5x - 18$

EXTRA PRACTICE
See pages 726, 747.
Math Online
Self-Check Quiz at algebra1.com

31. **GEOMETRY** Determine the relationship between the diagonals $\overline{AC}$ and $\overline{BD}$ of square $ABCD$ with $A(1, 3)$, $B(3, -1)$, $C(-1, -3)$ and $D(-3, 1)$.

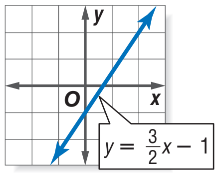
32. Write an equation of the line that is parallel to the graph of $y = 7x - 3$ and passes through the origin.

H.O.T. Problems

33. **CHALLENGE** The line that passes through the points $(3a, 4)$ and $(-1, 2)$ is parallel to the graph of $-4x + 2y = 6$. Find the value of a.

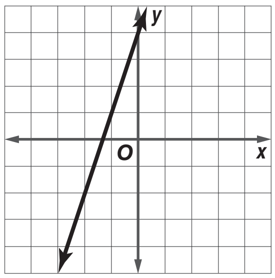
34. **OPEN ENDED** Draw two segments on the coordinate plane that appear to be perpendicular. Describe how you could check your accuracy without measuring.

35. ***Writing in Math*** Illustrate how you can determine whether two lines are parallel or perpendicular. Write an equation for a graph parallel to the line graphed at the right, and an equation with a graph perpendicular to the line graphed. Explain.



STANDARDIZED TEST PRACTICE

36. Which equation represents a line that is perpendicular to the graph and passes through the point at (2, 0)?



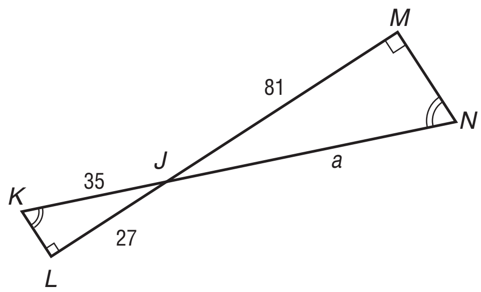
A $y = 3x - 6$

B $y = -3x + 6$

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

D $y = \frac{1}{3}x - \frac{2}{3}$

37. **REVIEW** If $\triangle JKL$ is similar to $\triangle JNM$ what is the length of side a?



F 62.5 units

G 105 units

H 125 units

J 155.5 units

Spiral Review

38. **TECHNOLOGY** Would a scatter plot showing the relationship between the year and the amount of memory available on a personal computer show a *positive*, *negative*, or *no* correlation? (Lesson 4-6)

Write the point-slope form of an equation for the line that passes through each point with the given slope. (Lesson 4-5)

39. $(3, 5)$, $m = -2$

40. $(-4, 7)$, $m = 5$

41. $(-1, -3)$, $m = -\frac{1}{2}$

42. **ARCHITECTURE** An architect is building a scale model of a sports complex. If the tallest building of the complex is 160 feet and the scale is 1 inch = 8 feet, how tall is the highest point of the scale model? (Lesson 2-6)

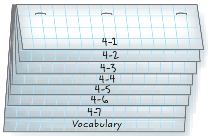
43. Solve $\frac{6c - t}{7} = b$ for c. (Lesson 2-8)

CHAPTER 4 Study Guide and Review

STUDY TO GO Download Vocabulary Review from algebra1.com

FOLDABLES Study Organizer — GET READY to Study

Be sure the following Key Concepts are noted in your Foldable.



Key Concepts

Rate of Change and Slope (Lesson 4-1)

- If x is the independent variable and y is the dependent variable, then rate of change equals $\frac{\text{change in } y}{\text{change in } x}$.
- The slope of a line is the ratio of the rise to the run; $m = \frac{y_2 - y_1}{x_2 - x_1}$.

Slope and Direct Variation (Lesson 4-2)

- A direct variation is described by an equation of the form $y = kx$, where $k \neq 0$.

Linear Equations in Slope-Intercept and Point-Slope Form (Lessons 4-3, 4-4, 4-5)

- The linear equation $y = mx + b$ is in slope-intercept form, where m = slope and b = y-intercept.
- The linear equation $y - y_1 = m(x - x_1)$ is in point-slope form, where (x_1, y_1) is a point on a nonvertical line and m is the slope.

Scatter Plots and Lines of Fit (Lesson 4-6)

- A line of fit describes the trend of the data, and its equation can be used to make predictions.
- The correlation between x and y is positive if as x increases, y increases, and negative if as x increases, y decreases. There is no correlation between x and y if no relationship exists between x and y.

Parallel and Perpendicular Lines (Lesson 4-7)

- Two nonvertical lines are parallel if they have the same slope. Two nonvertical lines are perpendicular if the product of their slopes is -1.

Key Vocabulary

best-fit line (p. 229)
constant of variation (p. 196)
direct variation (p. 196)
family of graphs (p. 197)
linear extrapolation (p. 216)
linear interpolation (p. 230)
line of fit (p. 229)
parallel lines (p. 236)
parent graph (p. 197)
perpendicular lines (p. 227)
point-slope form (p. 220)
rate of change (p. 187)
scatter plot (p. 227)
slope (p. 189)
slope-intercept form (p. 204)

Vocabulary Check

State whether each sentence is *true* or *false*. If *false*, replace the underlined word or number to make a true sentence.

1. Any two points on a line can be used to determine the slope.
2. The equation $y - 2 = -3(x - 1)$ is written in point-slope form.
3. The equation of a vertical line can be written in slope-intercept form.
4. When you use a linear equation to predict values that are beyond the range of the data, you are using linear interpolation.
5. The lines with equations $y = -5x + 7$ and $y = -5x - 6$ are perpendicular.
6. The lines with the equations $4x - y = 8$ and $y = -\frac{1}{4}x$ are parallel.
7. The slope of the line $y = 5$ is 5.
8. The line that most closely approximates a set of data is called a best-fit line.
9. An equation of the form $y = kx$, where $k \neq 0$, describes a linear extrapolation.
10. The y-intercept of the equation $3x - 2y = 24$ is $\frac{3}{2}$.

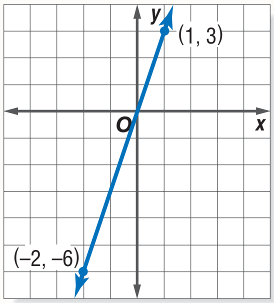
Math Online Vocabulary Review at algebra1.com

Lesson-by-Lesson Review

4–1 Rate of Change and Slope (pp. 187–195)

Find the rate of change represented in each table or graph.

11.



12.

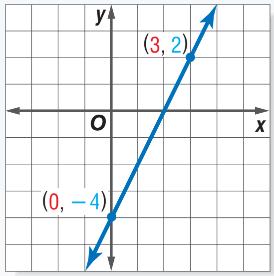
x	y
–2	–3
4	–3

Find the slope of the line that passes through each pair of points.

13. (0, 5), (6, 2) **14.** (–6, 4), (–6, –2)

15. DIGITAL CAMERAS The average cost of using an online photo finisher decreased from \$0.50 per print to \$0.27 per print between 2002 and 2005. Find the average rate of change in the cost. Explain what the rate of change means.

Example 1 **Find the slope of the line that passes through (0, –4) and (3, 2).**



Let $(0, -4) = (x_1, y_1)$ and $(3, 2) = (x_2, y_2)$.

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

$= \frac{2 - (-4)}{3 - 0}$ $x_1 = 0, x_2 = 3, y_1 = -4, y_2 = 2$

$= \frac{6}{3}$ or 2 Simplify.

4–2 Slope and Direct Variation (pp. 196–202)

Graph each equation.

16. $y = x$ **17.** $y = \frac{4}{3}x$ **18.** $y = -2x$

Suppose y varies directly as x. Write a direct variation equation that relates x and y. Then solve.

19. If $y = 15$ when $x = 2$, find y when $x = 8$.

20. $y = -6$ when $x = 9$, find x when $y = -3$.

21. $y = 4$ when $x = -4$, find y when $x = 7$.

22. JOBS Suppose you earn \$127 for working 20 hours. Write a direct variation equation relating your earnings to the number of hours worked.

Example 2 **Suppose y varies directly as x, and $y = -24$ when $x = 8$. Write a direct variation equation that relates x and y.**

Find the constant of variation.

$y = kx$ Direct variation equation

$-24 = k(8)$ Replace y with –24 and x with 8.

$\frac{-24}{8} = \frac{k(8)}{8}$ Divide each side by 8.

$-3 = k$ Simplify.

So, the direct variation equation is $y = -3x$.

CHAPTER 4 Study Guide and Review

4–3 Slope-Intercept Form (pp. 204–209)

Write an equation in slope-intercept form of the line with the given slope and *y*-intercept.

23. slope: 3, y-intercept: 2

24. slope: 1, y-intercept: -3

25. slope: 0, y-intercept: 4

26. slope: $\frac{1}{3}$, y-intercept: 2

Graph each equation.

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

28. $6x + 2y = -8$

29. $y = -x - 5$

30. $5x - 3y = -3$

31. WIRELESS PHONES A wireless phone-service provider charges a \$0.35 daily fee plus \$0.10 per minute. Write a linear equation to find the daily cost y for any number of minutes x.

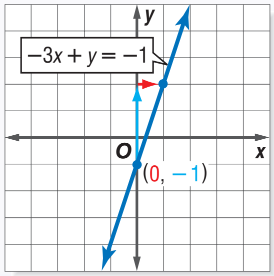
Example 3 **Graph $-3x + y = -1$.**

Write in slope-intercept form.

$-3x + y = -1$	Original equation
$-3x + y + 3x = -1 + 3x$	Add $3x$ to each side.
$y = 3x - 1$	Simplify.

Step 1 The y-intercept is -1. So, graph $(0, -1)$.

Step 2 The slope is 3 or $\frac{3}{1}$. From $(0, -1)$, move up 3 units and right 1 unit. Then draw a line.



4–4 Writing Equations in Slope-Intercept Form (pp. 213–218)

Write an equation of the line that passes through each point with the given slope.

32. $(-3, 3)$, $m = 1$

33. $(4, -3)$, $m = -\frac{3}{5}$

34. $(8, -1)$, $m = 0$

35. $(0, 6)$, $m = -2$

Write an equation of the line that passes through each pair of points.

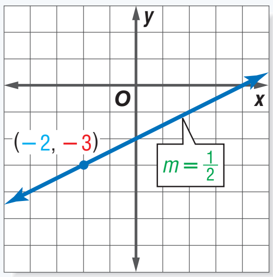
36. $(-4, 2)$, $(1, 12)$

37. $(5, 0)$, $(4, 5)$

38. MUSIC The table shows the average time Americans spent annually listening to recorded music. Write an equation to predict the number of hours h for any year y.

Year	Amount of Time (h)
1999	290
2006	195

Example 4 **Write an equation of the line that passes through $(-2, -3)$ with slope $\frac{1}{2}$.**



$y = mx + b$	Slope-intercept form
$-3 = \frac{1}{2}(-2) + b$	Replace m with $\frac{1}{2}$, y with -3, and x with -2.
$-3 = -1 + b$	Multiply.
$-3 + 1 = -1 + b + 1$	Add 1 to each side.
$-2 = b$	Simplify.

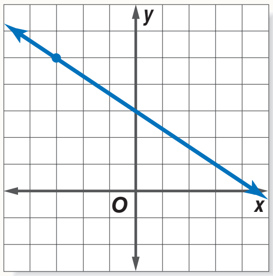
Therefore, the equation is $y = \frac{1}{2}x - 2$.

Mixed Problem Solving
For mixed problem-solving practice, see page 747.

4–5 Writing Equations in Point-Slope Form (pp. 220–225)

Write the point-slope form of an equation for the line that passes through each point with the given slope.

39.



40. $(4, 6)$, $m = 5$

41. $(5, -3)$, $m = \frac{1}{2}$

42. $\left(\frac{1}{4}, -2\right)$, $m = 0$

Write each equation in standard form.

43. $y + 4 = 1.5(x - 4)$

44. $y - 6 = \frac{2}{3}(x + 9)$

Write each equation in slope-intercept form.

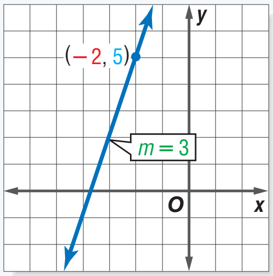
45. $y - 1 = 2(x + 1)$

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

47. LAWN CARE A lawn care company charges $25 per month for lawn maintenance, plus an initial service fee. The total cost for service fee and 8 months of maintenance is $165. Write the point-slope form of an equation to find the total cost y for any number of months x. (*Hint:* (8, 165) is a solution of the equation.)

Example 5 **Write the point-slope form of an equation for a line that passes through (–2, 5) with slope 3.**

$y - y_1 = m(x - x_1)$	Point-slope form
$y - 5 = 3[x - (-2)]$	$(x_1, y_1) = (-2, 5)$
$y - 5 = 3(x + 2)$	Subtract.



Example 6 **Write $y + 4 = \frac{1}{2}(x - 6)$ in slope-intercept form and in standard form.**

$y + 4 = \frac{1}{2}(x - 6)$	Original equation
$2(y + 4) = 2\left(\frac{1}{2}\right)(x - 6)$	Multiply each side by 2 to eliminate the fraction.
$2y + 8 = x - 6$	Distributive Property
$2y = x - 14$	Subtract 8 from each side.
$\frac{2y}{2} = \frac{x - 14}{2}$	Divide each side by 2.
$y = \frac{1}{2}x - 7$	Simplify.

The slope-intercept form is $y = \frac{1}{2}x - 7$.

$2y = x - 14$	Return to equation.
$2y - x = x - 14 - x$	Subtract x from each side.
$-x + 2y = -14$	Simplify.
$\frac{-x + 2y}{-1} = \frac{-14}{-1}$	Divide each side by –1.
$x - 2y = 14$	Simplify.

The standard form is $x - 2y = 14$.

CHAPTER 4

Study Guide and Review

4–6 Statistics: Scatter Plots and Lines of Fit (pp. 227–233)

USE TABLES For Exercises 48–52, use the table that shows the length and weight of several humpback whales.

Length (ft)	40	42	45	46	50	52	55
Weight (long tons)	25	29	34	35	43	45	51

48. Draw a scatter plot with length on the x-axis and weight on the y-axis.

49. Draw a line of fit for the data.

50. Write the slope-intercept form of an equation for the line of fit.

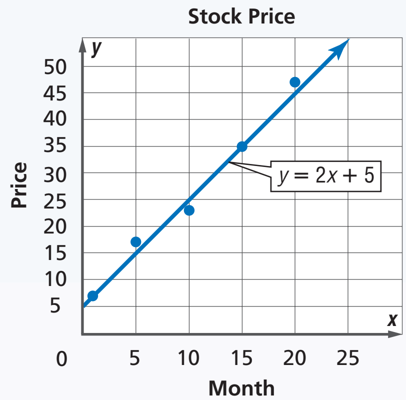
51. Predict the weight of a 48-foot humpback whale.

52. Most newborn humpback whales are about 12 feet in length. Use the equation of the line of fit to predict the weight of a newborn humpback whale. Do you think your prediction is accurate? Explain.

Example 7 Use the table shown to draw a scatter plot and predict the future stock price.

Month	1	5	10	15	20	48
Price	\$7	\$17	\$23	\$35	\$47	?

Step 1 Draw the scatter plot and find the line of fit.



Step 2 Use line of fit to make predictions.

$y = 2x + 5$ Line of fit equation

$= 2(48) + 5$ Substitute 48 for x.

$= 96 + 5$ or 101 Simplify.

If the trend continues, the price will be \$101.

4–7 Geometry: Parallel and Perpendicular Lines (pp. 236–241)

Write the slope-intercept form of an equation for the line that passes through the given point and satisfies each condition.

53. (4, 6); parallel to $y = 3x - 2$

54. (3, 0); parallel to $3x + 9y = 1$

55. (2, –5); perpendicular to $5y = -x + 1$

56. (0, –3); perpendicular to $y = -2x - 7$

57. **GEOMETRY** Determine if triangle ABC with vertices $A(-2, 0)$, $B(3, 3)$, and $C(-5, 5)$ is a right triangle. Explain.

Example 8 Write the slope-intercept form of an equation for a line that passes through (5, –2) and is parallel to $y = 2x + 7$.

The line parallel to $y = 2x + 7$ has the same slope, 2.

$y - y_1 = m(x - x_1)$ Point-slope form

$y - (-2) = 2(x - 5)$ Replace m with 2, y_1 with –2, and x_1 with 5.

$y + 2 = 2x - 10$ Simplify.

$y = 2x - 12$ Subtract 2 from each side.

CHAPTER 4

Practice Test

Find the slope of the line that passes through each pair of points.

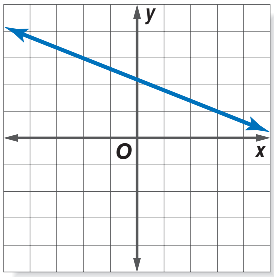
1. (5, 8), (−3, 7)

2. (5, −2), (3, −2)

3. (−4, 7), (8, −1)

4. (6, −3), (6, 4)

5. **MULTIPLE CHOICE** Which is the slope of the linear function shown in the graph?



A $-\frac{5}{2}$

B $-\frac{2}{5}$

C $\frac{5}{2}$

D $\frac{2}{5}$

6. **BUSINESS** A Web design company advertises that it will design and maintain a Website for your business for $9.95 per month. Write a direct variation equation to find the total cost *C* for any number of months *m*.

Graph each equation.

7. $y = 3x - 1$

8. $y = 2x + 3$

9. $2x + 3y = 9$

10. $4y - 2x = 12$

Suppose *y* varies directly as *x*. Write a direct variation equation that relates *x* and *y*.

11. $y = 6$ when $x = 9$

12. $y = -8$ when $x = 8$

13. $y = -5$ when $x = -2$

14. $y = 2$ when $x = -12$

15. Write the point-slope form of an equation for a line that passes through (−4, 3) with slope −2.

16. **MULTIPLE CHOICE** The temperature is 80°F at noon and is expected to rise 4° each hour during the afternoon. Which equation could be used to determine *h*, the number of hours it will take to reach a temperature of 96°?

F $96 = 4 + 80h$

G $96 = 4(h + 80)$

H $96 = 80 + 4h$

J $96 = (4 + 80)h$

Write the slope-intercept form of an equation of the line that satisfies each condition.

17. has slope −4 and *y*-intercept 3

18. passes through (−2, −5) and (8, −3)

19. parallel to $3x + 7y = 4$ and passes through (5, −2)

20. perpendicular to the graph of $5x - 3y = 9$ and passes through the origin

ANALYZE TABLES **For Exercises 21–25, use the table that shows the relationship between dog years and human years.**

Dog Years	1	2	3	4	5	6	7
Human Years	15	24	28	32	37	42	47

21. Draw a scatter plot and determine what relationship, if any, exists in the data.

22. Draw a line of fit for the scatter plot.

23. Write the slope-intercept form of an equation for the line of fit.

24. Determine how many human years are comparable to 13 dog years.

25. Is it reasonable to use the equation for the line of fit to estimate the age in human years of a dog 20 years old? Explain.

CHAPTER 4

Standardized Test Practice

Cumulative, Chapters 1-4

Read each question. Then fill in the correct answer on the answer document provided by your teacher or on a sheet of paper.

1. Which of the equations below represents the third step of the solution process?

Step 1 $-2(3a - 1) + 2 = 16$

Step 2 $-6a + 2 + 2 = 16$

Step 3 $\boxed{}$

Step 4 $-6a = 12$

Step 5 $a = -2$

A $-2(3a - 1) = 16$ **C** $-2(3a + 1) = 16$
B $-6a + 4 = 16$ **D** $-6a - 1 + 4 = 16$

2. Corey collected data on the number of hours that his class spent studying per day and the number of hours they spent watching TV. If he posts the data on a scatterplot, what correlation will he mostly likely see between the number of hours spent studying and the number of hours spent watching TV?

F Negative **H** Positive
G No correlation **J** Constant

3. Petra is starting a jewelry business. She has \$200 to make jewelry for her business. If each bead costs \$12, which table best describes a, the amount of money remaining after she buys n beads?

A

n	a
0	\$200.00
1	\$188.00
2	\$176.00
3	\$164.00
4	\$152.00

C

n	a
0	\$200.00
1	\$176.00
4	\$140.00
6	\$116.00
8	\$92.00

B

n	a
0	\$200.00
2	\$188.00
4	\$176.00
6	\$164.00
8	\$152.00

D

n	a
0	\$188.00
1	\$176.00
2	\$164.00
3	\$140.00
4	\$128.00

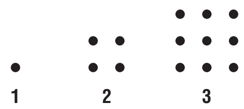
4. Which is always a correct conclusion about the quantities in the function $y = 2x$?

F The value of y will always be positive.
G The value of y will always be greater than the value of x.
H The variable y is always twice x.
J As the value of x increases the value of y decreases.

TEST-TAKING TIP

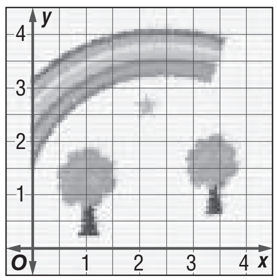
Read each question carefully. Be sure you understand what the question asks. Look for words such as not, estimate, always and approximately.

5. GRIDDABLE The figure shows a pattern of squares made of dots.



How many dots will be in the sixth square?

6. Vera is drawing a mural on her wall. She placed a grid over the mural.

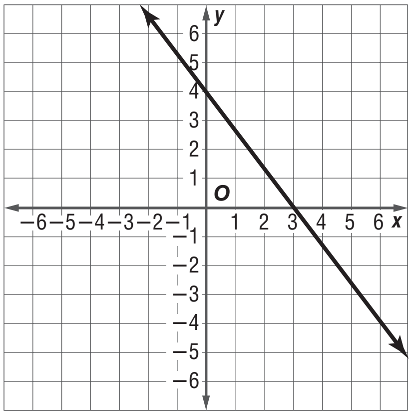


Which coordinate point best describes the star on the mural?

A (4, 5)
B (5, 4)
C (2, 2.5)
D (2.5, 2)

For test-taking strategies and more practice, see pages 756–773.

7. What is the equation of the line shown below?



F $y = -\frac{4}{3}x + 4$ **H** $y = -\frac{4}{3}x + 3$

G $y = -\frac{3}{4}x + 4$ **J** $y = -\frac{3}{4}x + 3$

8. GRIDDABLE Meagan makes and sells jewelry at the local farmer's market. At last year's farmer's market, Meagan sold 75% of her jewelry. If she sold the same percentage this year and had 1,000 pieces of jewelry, how many pieces of jewelry did she sell?

9. The data in the table show the cost of renting a boat by the hour, including a deposit.

Renting a Boat

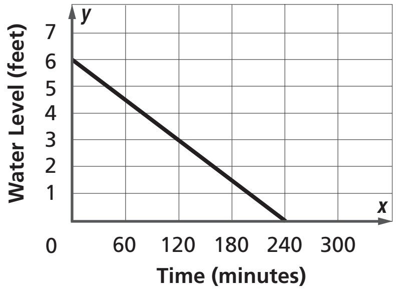
Hours (h)	1	3	5
Cost in dollars (c)	30	60	90

If hours h were graphed on the horizontal axis and cost c were graphed on the vertical axis, what would be the equation of the line that fits the data?

A $c = 15h$ **C** $c = 15h - 15$

B $c = \frac{1}{15}h + 15$ **D** $c = 15h + 15$

10. The graph shows the levels of the water in a pool from the time it begins to drain to the time it is empty. Which of the following best describes the slope of the line segment?



F The water drains about 1 foot per 40 minutes.

G The water drains about 40 feet per minute.

H The water drains about 1 foot per 2 minutes.

J The water drains about 2 feet per minute.

Pre-AP

Record your answers on a sheet of paper. Show your work.

11. A friend wants to enroll for cellular phone service. Three different plans are available.

Plan 1 charges \$0.59 per minute.

Plan 2 charges a monthly fee of \$10, plus \$0.39 per minute.

Plan 3 charges a monthly fee of \$59.95.

a. For each plan, write an equation that represents the monthly cost C for m number of minutes per month.

b. Graph each of the three equations.

c. Your friend expects to use 100 minutes per month. In which plan do you think that your friend should enroll? Explain.

NEED EXTRA HELP?											
If You Missed Question...	1	2	3	4	5	6	7	8	9	10	11
Go to Lesson or Page...	2–4	4–7	3–1	4–1	3–5	1-9	4-3	694	4-6	4–3	4–3