Alg 2

2 Linear Equations and Functions

Before

In Chapter 1, you learned the following skills, which you'll use in Chapter 2: evaluating algebraic expressions, solving linear equations, and rewriting equations.

Prerequisite Skills

VOCABULARY CHECK

Copy and complete the statement.

1. A **linear equation** in one variable is an equation that can be written in the form __?__ where a and b are constants and $a \neq 0$.
2. The **absolute value** of a real number is the distance the number is from __?__ on a number line.

SKILLS CHECK

Evaluate the expression for the given value of x. ***(Review p. 10 for 2.1.)***

3. $-2(x + 1)$ when $x = -5$
4. $11x - 14$ when $x = -3$
5. $x^2 + x + 1$ when $x = 4$
6. $-x^2 - 3x + 7$ when $x = 1$

Solve the equation. Check your solution. ***(Review p. 18 for 2.3.)***

7. $5x - 2 = 8$
8. $-6x - 10 = 20$
9. $-x + 9 = 2x - 27$

Solve the equation for y. ***(Review p. 26 for 2.4.)***

10. $2x + 3y = 6$
11. $-x - y = 10$
12. $x + 4y = -5$

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Now

In Chapter 2, you will apply the big ideas listed below and reviewed in the Chapter Summary on page 140. You will also use the key vocabulary listed below.

Big Ideas

1. **Representing relations and functions**
2. **Graphing linear equations and inequalities in two variables**
3. **Writing linear equations and inequalities in two variables**

KEY VOCABULARY

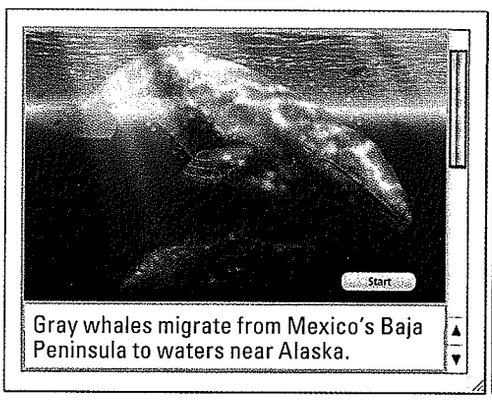
- domain, range, *p. 72*
- function, *p. 73*
- linear function, *p. 75*
- slope, *p. 82*
- rate of change, *p. 85*
- parent function, *p. 89*
- *y*-intercept, *p. 89*
- slope-intercept form, *p. 90*
- *x*-intercept, *p. 91*
- point-slope form, *p. 98*
- direct variation, *p. 107*
- correlation coefficient, *p. 114*
- best-fitting line, *p. 114*
- absolute value function, *p. 123*
- transformation, *p. 123*
- linear inequality in two variables, *p. 132*

Why?

You can use rates of change to find linear models. For example, you can use an average rate of change to model distance traveled as a function of time.

Animated Algebra

The animation illustrated below for Exercise 44 on page 111 helps you answer this question: If a whale migrates at a given rate, how far will it travel in different periods of time?

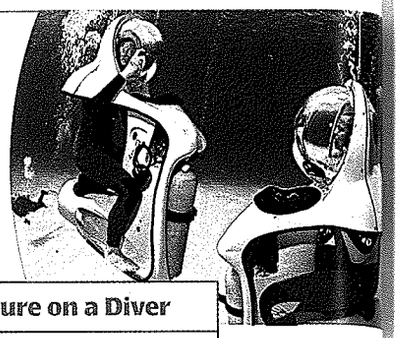


Animated Algebra at classzone.com

Other animations for Chapter 2: pages 73, 86, 90, 95, 98, 102, 107, 115, 133, and 140

DOMAINS IN REAL LIFE In Example 5, the domain of each function is all real numbers because there is an output for every real number x. In real life, you may need to restrict the domain so that it is reasonable in the given situation.

EXAMPLE 6 Use a function in real life



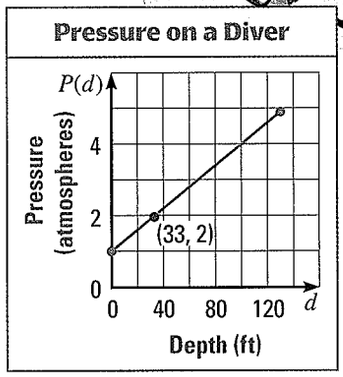
DIVING A diver using a Diver Propulsion Vehicle (DPV) descends to a depth of 130 feet. The pressure P (in atmospheres) on the diver is given by $P(d) = 1 + 0.03d$ where d is the depth (in feet). Graph the function, and determine a reasonable domain and range. What is the pressure on the diver at a depth of 33 feet?

Solution

The graph of $P(d)$ is shown. Because the depth varies from 0 feet to 130 feet, a reasonable domain is $0 \leq d \leq 130$.

The minimum value of $P(d)$ is $P(0) = 1$, and the maximum value of $P(d)$ is $P(130) = 4.9$. So, a reasonable range is $1 \leq P(d) \leq 4.9$.

▶ At a depth of 33 feet, the pressure on the diver is $P(33) = 1 + 0.03(33) \approx 2$ atmospheres, which you can verify from the graph.



✓ GUIDED PRACTICE for Example 6

7. **OCEAN EXPLORATION** In 1960, the deep-sea vessel *Trieste* descended to an estimated depth of 35,800 feet. Determine a reasonable domain and range of the function $P(d)$ in Example 6 for this trip.

2.1 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS2 for Exs. 7, 17, and 45

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 9, 20, 24, 40, 46, and 49

SKILL PRACTICE

1. **VOCABULARY** Copy and complete: In the equation $y = x + 5$, x is the _?_ variable and y is the _?_ variable.

2. ★ **WRITING** *Describe* how to find the domain and range of a relation given by a set of ordered pairs.

EXAMPLE 1 on p. 72 for Exs. 3–9

REPRESENTING RELATIONS **Identify the domain and range of the given relation. Then represent the relation using a graph and a mapping diagram.**

3. $(-2, 3), (1, 2), (3, -1), (-4, -3)$
4. $(5, -2), (-3, -2), (3, 3), (-1, -1)$
5. $(6, -1), (-2, -3), (1, 8), (-2, 5)$
6. $(-7, 4), (2, -5), (1, -2), (-3, 6)$
7. $(5, 20), (10, 20), (15, 30), (20, 30)$
8. $(4, -2), (4, 2), (16, -4), (16, 4)$

9. ★ **MULTIPLE CHOICE** What is the domain of the relation given by the ordered pairs (−4, 2), (−1, −3), (1, 4), (1, −3), and (2, 1)?

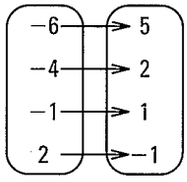
Ⓐ −3, 1, 2, and 4 Ⓑ −4, −1, 1, and 2

Ⓒ −4, −3, −1, and 2 Ⓓ −4, −3, −1, 1, 2, and 4

EXAMPLE 2 on p. 73 for Exs. 10–20

IDENTIFYING FUNCTIONS **Tell whether the relation is a function.** ***Explain.***

10.



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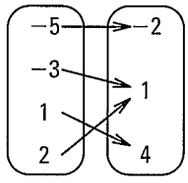

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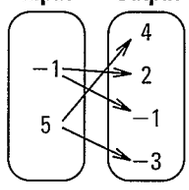

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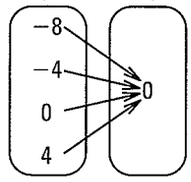


ERROR ANALYSIS ***Describe*** **and correct the error in the student's work.**

14.

The relation given by the ordered pairs (−4, 2), (−1, 5), (3, 6), and (7, 2) is not a function because the inputs −4 and 7 are both mapped to the output 2. ✗

15.

x	0	1	2	1	0
y	5	6	7	8	9

The relation given by the table is a function because there is only one value of x for each value of y. ✗

IDENTIFYING FUNCTIONS **Tell whether the relation is a function.** ***Explain.***

16. (3, −2), (0, 1), (1, 0), (−2, −1), (2, −1)

17. (2, −5), (−2, 5), (−1, 4), (−2, 0), (3, −4)

18. (0, 1), (1, 0), (2, 3), (3, 2), (4, 4)

19. (−1, −1), (2, 5), (4, 8), (−5, −9), (−1, −5)

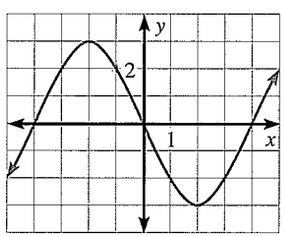
20. ★ **MULTIPLE CHOICE** The relation given by the ordered pairs (−6, 3), (−2, 4), (1, 5), and (4, 0) is a function. Which ordered pair can be included with this relation to form a new relation that is also a function?

Ⓐ (1, −5) Ⓑ (6, 3) Ⓒ (−2, 19) Ⓓ (4, 4)

EXAMPLE 3 on p. 74 for Exs. 21–23

VERTICAL LINE TEST **Use the vertical line test to tell whether the relation is a function.**

21.



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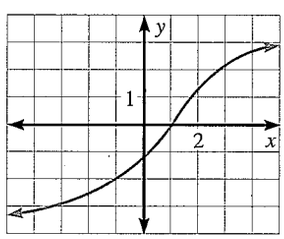

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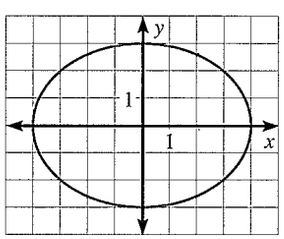


24. ★ **SHORT RESPONSE** *Explain* why a relation is not a function if a vertical line intersects the graph of the relation more than once.

EXAMPLE 4 on p. 75 for Exs. 25–33

GRAPHING EQUATIONS **Graph the equation.**

25. $y = x + 2$

26. $y = -x + 5$

27. $y = 3x + 1$

28. $y = 5x - 3$

29. $y = 2x - 7$

30. $y = -3x + 2$

31. $y = -2x$

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

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

EXAMPLE 5 on p. 75 for Exs. 34–39

EVALUATING FUNCTIONS **Tell whether the function is linear. Then evaluate the function for the given value of x.**

34. $f(x) = x + 15; f(8)$

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

36. $f(x) = |x| + 10; f(-4)$

37. $f(x) = 6; f(2)$

38. $g(x) = x^3 - 2x^2 + 5x - 8; g(-5)$

39. $h(x) = 7 - \frac{2}{3}x; h(15)$

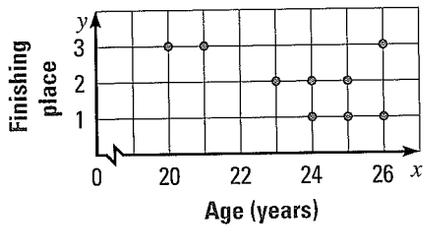
40. ★ **SHORT RESPONSE** Which, if any, of the relations described by the equations $y = |x|$, $x = |y|$, and $|y| = |x|$ represent functions? *Explain.*

41. **CHALLENGE** Let f be a function such that $f(a + b) = f(a) + f(b)$ for all real numbers a and b. Show that $f(2a) = 2 \cdot f(a)$ and that $f(0) = 0$.

PROBLEM SOLVING

EXAMPLE 3 on p. 74 for Exs. 42–43

42. **BICYCLING** The graph shows the ages of the top three finishers in the Mt. Washington Auto Road Bicycle Hillclimb each year from 2002 through 2004. Do the ordered pairs (age, finishing place) represent a function? *Explain.*



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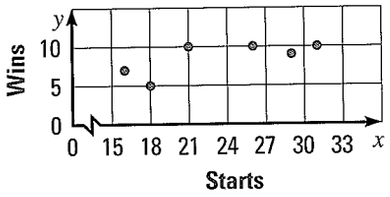
43. **BASEBALL** The graph shows the number of games started and the number of wins for each starting pitcher on a baseball team during a regular season. Do the ordered pairs (starts, wins) represent a function? *Explain.*



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44. **GEOMETRY** The volume V of a cube with edge length s is given by the function $V(s) = s^3$. Find $V(4)$. *Explain* what $V(4)$ represents.

45. **GEOMETRY** The volume V of a sphere with radius r is given by the function $V(r) = \frac{4}{3}\pi r^3$. Find $V(6)$. *Explain* what $V(6)$ represents.

EXAMPLE 6 on p. 76 for Exs. 46–48

46. ★ **SHORT RESPONSE** For the period 1999–2004, the average number of acres w (in thousands), used to grow watermelons in the United States can be modeled by the function $w(t) = -6.26t + 172$ where t is the number of years since 1999. Determine a reasonable domain and range for $w(t)$. *Explain* the meaning of the range.

47. **MULTI-STEP PROBLEM** Anthropologists can estimate a person's height from the length of certain bones. The height h (in inches) of an adult human female can be modeled by the function $h(\ell) = 1.95\ell + 28.7$ where ℓ is the length (in inches) of the femur, or thigh bone. The function is valid for femur lengths between 15 inches and 24 inches, inclusive.

a. Graph the function, and determine a reasonable domain and range.

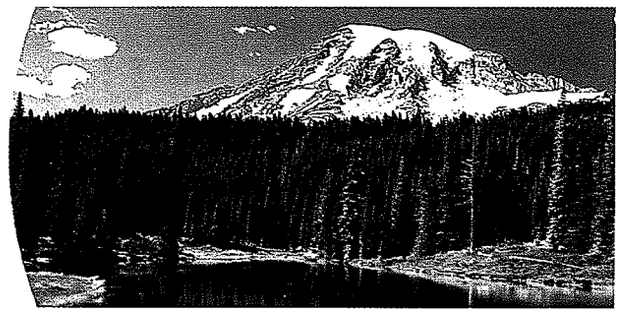
b. Suppose a female's femur is 15.5 inches long. About how tall was she?

c. If an anthropologist estimates a female's height as 5 feet 11 inches, about how long is her femur?

○ = **WORKED-OUT SOLUTIONS** on p. WS1

★ = **STANDARDIZED TEST PRACTICE**

48. MOUNTAIN CLIMBING A climber on Mount Rainier in Washington hikes from an elevation of 5400 feet above sea level to Camp Muir, which has an elevation of 10,100 feet. The elevation h (in feet) as the climber ascends can be modeled by $h(t) = 1000t + 5400$ where t is the time (in hours). Graph the function, and determine a reasonable domain and range. What is the climber's elevation after hiking 3.5 hours?



49. ★ EXTENDED RESPONSE The table shows the populations of several states and their electoral votes in the 2004 and 2008 U.S. presidential elections. The figures are based on U.S. census data for the year 2000.

a. Identify the domain and range of the relation given by the ordered pairs (p, v).

b. Is the relation from part (a) a function? *Explain.*

c. Is the relation given by the ordered pairs (v, p) a function? *Explain.*

State	Population (millions), p	Electoral votes, v
California	33.87	55
Florida	15.98	27
Illinois	12.42	21
New York	18.98	31
Ohio	11.35	20
Pennsylvania	12.28	21
Texas	20.85	34

50. CHALLENGE The table shows ground shipping charges for an online retail store.

a. Is the shipping cost a function of the merchandise cost? *Explain.*

b. Is the merchandise cost a function of the shipping cost? *Explain.*

Merchandise cost	Shipping cost
\$.01–\$30.00	\$4.50
\$30.01–\$60.00	\$7.25
\$60.01–\$100.00	\$9.50
Over \$100.00	\$12.50

MIXED REVIEW

PREVIEW
Prepare for Lesson 2.2 in Exs. 51–54.

Evaluate the expression for the given values of x and y. *(p. 10)*

51. $\frac{y-3}{x-4}$ when $x = 6$ and $y = 2$

52. $\frac{y-8}{x-2}$ when $x = 3$ and $y = 4$

53. $\frac{y-(-5)}{x-1}$ when $x = -3$ and $y = -3$

54. $\frac{24-y}{15-x}$ when $x = -17$ and $y = 8$

Solve the equation. Check your solution. *(p. 18)*

55. $3x + 16 = 31$

56. $-4x - 7 = 17$

57. $5x + 12 = -3x - 4$

58. $5 - 8z = 25 + 4z$

59. $\frac{5}{2}(3v - 4) = 30$

60. $6(4w + 1) = 1.5(8w + 18)$

Solve the inequality. Then graph the solution. *(p. 41)*

61. $2x - 6 > 8$

62. $\frac{1}{4}x + 7 > 0$

63. $15 - 2x \leq 7$

64. $4 - x < 3$

65. $-7 < 6x - 1 < 5$

66. $x - 2 \leq 1$ or $4x + 3 \geq 19$

Extension

Use after Lesson 2.1

Use Discrete and Continuous Functions

GOAL Graph and classify discrete and continuous functions.

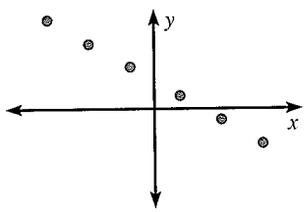
Key Vocabulary
- **discrete function**
- **continuous function**

The graph of a function may consist of *discrete*, or separate and unconnected, points in a plane. The graph of a function may also be a *continuous*, or unbroken, line or curve or part of a line or curve.

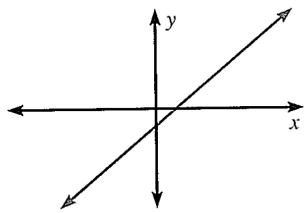
KEY CONCEPT *For Your Notebook*

Discrete and Continuous Functions

The graph of a **discrete function** consists of separate points.



The graph of a **continuous function** is unbroken.



EXAMPLE 1 Graph and classify functions

Graph the function $f(x) = 0.5x + 1$ for the given domain. Classify the function as *discrete* or *continuous* for the domain. Then identify the range.

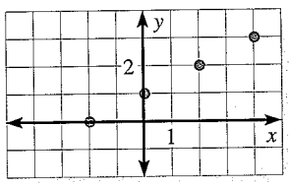
a. Domain: $x = -2, 0, 2, 4$

b. Domain: $x \geq -3$

Solution

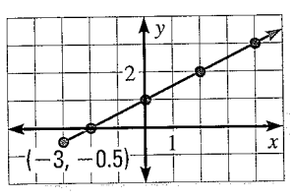
a. Make a table using the x-values in the domain.

x	−2	0	2	4
y	0	1	2	3



The graph consists of separate points, so the function is discrete. Its range is 0, 1, 2, 3.

b. Note that $f(x)$ is a linear function defined for $x \geq -3$, and that $f(-3) = -0.5$. So, the graph is the ray with endpoint $(-3, -0.5)$ that passes through all the points from the table in part (a).



The graph is unbroken, so the function is continuous. Its range is $y \geq -0.5$.

EXAMPLE 2 Graph and classify real-world functions

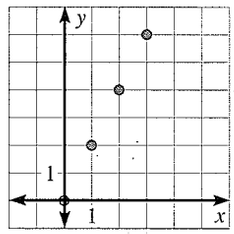
Write and graph the function described. Determine the domain and range. Then tell whether the function is *discrete* or *continuous*.

a. A student group is selling chocolate bars for \$2 each. The function $f(x)$ gives the amount of money collected after selling x chocolate bars.

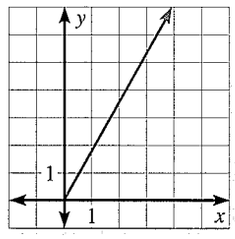
b. A low-flow shower head releases 1.8 gallons of water per minute. The function $V(x)$ gives the volume of water released after x minutes.

Solution

a. The function is $f(x) = 2x$. The first four points of the graph of $f(x)$ are shown. Only whole chocolate bars can be sold, so the domain is the set of whole numbers 0, 1, 2, 3, ... From the graph, you can see that the range is 0, 2, 4, 6, ... The graph consists of separate points, so the function is discrete.



b. The function is $V(x) = 1.8x$. You can run the shower any nonnegative amount of time, so the domain is $x \geq 0$. From the graph, you can see that the range is $y \geq 0$. The graph is unbroken, so the function is continuous.



PRACTICE

EXAMPLE 1 on p. 80 for Exs. 1–4

Graph the function for the given domain. Classify the function as *discrete* or *continuous*. Then identify the range of the function.

1. $y = 2x + 3$; domain: $-2, -1, 0, 1, 2$
2. $f(x) = 0.5x - 4$; domain: $-4, -2, 0, 2, 4$
3. $y = -3x + 9$; domain: $x < 5$
4. $f(x) = \frac{1}{3}x + 6$; domain: $x \geq -6$

EXAMPLE 2 on p. 81 for Exs. 5–8

Write and graph the function described. Determine the domain and range. Then tell whether the function is *discrete* or *continuous*.

5. Amanda walks at an average speed of 3.5 miles per hour. The function $d(x)$ gives the distance (in miles) Amanda walks in x hours.
6. A token to ride a subway costs \$1.25. The function $s(x)$ gives the cost of riding the subway x times.
7. A family has 3 gallons of milk delivered every Thursday. The function $m(x)$ gives the total amount of milk that is delivered to the family after x weeks.
8. Steel cable that is $\frac{3}{8}$ inch in diameter weighs 0.24 pound per foot. The function $w(x)$ gives the weight of x feet of steel cable.
9. On a number line, the *signed distance* from a number a to a number b is given by $b - a$. The function $d(x)$ gives the signed distance from 3 to any number x.

2.2 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS2 for Exs. 9, 19, and 45

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 17, 35, 36, 44, 45, and 48

SKILL PRACTICE

1. **VOCABULARY** Copy and complete: The _?_ of a nonvertical line is the ratio of vertical change to horizontal change.

2. ★ **WRITING** How can you use slope to decide whether two nonvertical lines are parallel? whether two nonvertical lines are perpendicular?

EXAMPLES 2 and 3 on pp. 82–83 for Exs. 3–17

FINDING SLOPE **Find the slope of the line passing through the given points. Then tell whether the line *rises, falls, is horizontal,* or *is vertical.***

3. (2, −4), (4, −1)
4. (8, 9), (−4, 3)
5. (5, 1), (8, −4)
6. (−3, −2), (3, −2)
7. (−1, 4), (1, −4)
8. (−6, 5), (−6, −5)
9. (−5, −4), (−1, 3)
10. (−3, 6), (−7, 3)
11. (4, 4), (4, 9)
12. (5, 5), (7, 3)
13. (0, −3), (4, −3)
14. (1, −1), (−1, −4)

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ERROR ANALYSIS ***Describe*** **and correct the error in finding the slope of the line passing through the given points.**

15. (−4, −3), (2, −1)

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

16. (−1, 4), (5, 1)

$$m = \frac{5-(-1)}{1-4} = -2$$ ✗

17. ★ **MULTIPLE CHOICE** What is true about the line through (2, −4) and (5, 1)?

Ⓐ It rises from left to right. Ⓑ It falls from left to right.

Ⓒ It is horizontal. Ⓓ It is vertical.

EXAMPLE 4 on p. 84 for Exs. 18–23

CLASSIFYING LINES **Tell whether the lines are *parallel, perpendicular,* or *neither.***

18. Line 1: through (3, −1) and (6, −4)
Line 2: through (−4, 5) and (−2, 7)

19. Line 1: through (1, 5) and (3, −2)
Line 2: through (−3, 2) and (4, 0)

20. Line 1: through (−1, 4) and (2, 5)
Line 2: through (−6, 2) and (0, 4)

21. Line 1: through (5, 8) and (7, 2)
Line 2: through (−7, −2) and (−4, −1)

22. Line 1: through (−3, 2) and (5, 0)
Line 2: through (−1, −4) and (3, −3)

23. Line 1: through (1, −4) and (4, −2)
Line 2: through (8, 1) and (14, 5)

EXAMPLE 5 on p. 85 for Exs. 24–27

AVERAGE RATE OF CHANGE **Find the average rate of change in y relative to x for the ordered pairs. Include units of measure in your answer.**

24. (2, 12), (5, 30) x is measured in hours and y is measured in dollars

25. (0, 11), (3, 50) x is measured in gallons and y is measured in miles

26. (3, 10), (5, 18) x is measured in seconds and y is measured in feet

27. (1, 8), (7, 20) x is measured in seconds and y is measured in meters

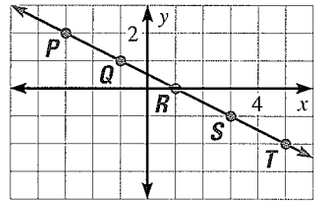
28. REASONING The Key Concept box on page 84 states that lines ℓ_1 and ℓ_2 must be nonvertical. *Explain* why this condition is necessary.

FINDING SLOPE Find the slope of the line passing through the given points.

29. $\left(-1, \frac{3}{2}\right), \left(0, \frac{7}{2}\right)$ **30.** $\left(-\frac{3}{4}, -2\right), \left(\frac{5}{4}, -3\right)$ **31.** $\left(-\frac{1}{2}, \frac{5}{2}\right), \left(\frac{5}{2}, 3\right)$

32. (−4.2, 0.1), (−3.2, 0.1) **33.** (−0.3, 2.2), (1.7, −0.8) **34.** (3.5, −2), (4.5, 0.5)

35. ★ SHORT RESPONSE Does it make a difference which two points on a line you choose when finding the slope? Does it make a difference which point is (x_1, y_1) and which point is (x_2, y_2) in the formula for slope? Support your answers using three different pairs of points on the line shown.



36. ★ OPEN-ENDED MATH Find two additional points on the line that passes through (0, 3) and has a slope of −4.

CHALLENGE Find the value of k so that the line through the given points has the given slope. Check your solution.

37. (2, −3) and (k, 7); $m = -2$ **38.** (0, k) and (3, 4); $m = 1$

39. (−4, 2k) and (k, −5); $m = -1$ **40.** (−2, k) and (2k, 2); $m = -0.25$

PROBLEM SOLVING

EXAMPLE 1 on p. 82 for Exs. 41–44

41. ESCALATORS An escalator in an airport rises 28 feet over a horizontal distance of 48 feet. What is the slope of the escalator?

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42. INCLINE RAILWAY The Duquesne Incline, a cable car railway, rises 400 feet over a horizontal distance of 685 feet on its ascent to an overlook of Pittsburgh, Pennsylvania. What is the slope of the incline?

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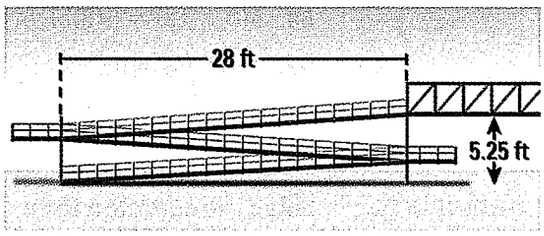
43. ROAD GRADE A road's *grade* is its slope expressed as a percent. A road rises 195 feet over a horizontal distance of 3000 feet. What is the grade of the road?

44. ★ SHORT RESPONSE The diagram shows a three-section ramp to a bridge. For a person walking up the ramp, each section has the same positive slope. *Compare* this slope with the slope that a single-section ramp would have if it rose directly to the bridge from the same starting point. *Explain* the benefits of a three-section ramp in this situation.



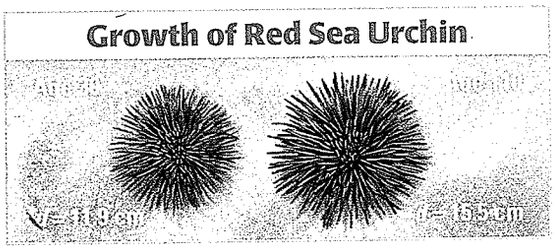
EXAMPLE 5 on p. 85 for Exs. 45–46

45. ★ MULTIPLE CHOICE Over a 30 day period, the amount of propane in a tank that stores propane for heating a home decreases from 400 gallons to 214 gallons. What is the average rate of change in the amount of propane?

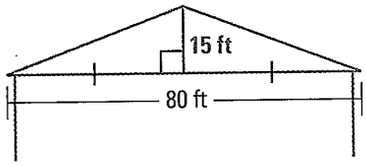
Ⓐ −6.2 gallons per day Ⓑ −6 gallons per day

Ⓒ −0.16 gallon per day Ⓓ 6 gallons per day

46. BIOLOGY A red sea urchin grows its entire life, which can last 200 years. The diagram gives information about the growth in the diameter d of one red sea urchin. What is the average growth rate of this urchin over the given period?



47. MULTI-STEP PROBLEM A building code requires the minimum slope, or *pitch*, of an asphalt-shingle roof to be a rise of 3 feet for each 12 feet of run. The asphalt-shingle roof of an apartment building has the dimensions shown.



a. Calculate What is the slope of the roof?

b. Interpret Does the roof satisfy the building code?

c. Reasoning If you answered "no" to part (b), by how much must the rise be increased to satisfy the code? If you answered "yes," by how much does the rise exceed the code minimum?

48. ★ EXTENDED RESPONSE Plans for a new water slide in an amusement park call for the slide to descend from a platform 80 feet tall. The slide will drop 1 foot for every 3 feet of horizontal distance.

a. What horizontal distance do you cover when descending the slide?

b. Use the Pythagorean theorem to find the length of the slide.

c. Engineers decide to shorten the slide horizontally by 5 feet to allow for a wider walkway at the slide's base. The plans for the platform remain unchanged. How will this affect the slope of the slide? *Explain.*

49. CHALLENGE A car travels 36 miles per gallon of gasoline in highway driving and 24 miles per gallon in city driving. If you drive the car equal distances on the highway and in the city, how many miles per gallon can you expect to average? (*Hint:* The average fuel efficiency for all the driving is the total distance traveled divided by the total amount of gasoline used.)

MIXED REVIEW

Identify the property that the statement illustrates. *(p. 2)*

50. $5(8 + 12) = 5(8) + 5(12)$

51. $(7 + 9) + 13 = 7 + (9 + 13)$

52. $4 + (-4) = 0$

53. $5 \cdot 10 = 10 \cdot 5$

54. $15 \cdot \frac{1}{15} = 1$

55. $\frac{2}{3} \cdot 1 = \frac{2}{3}$

PREVIEW
Prepare for Lesson 2.3 in Exs. 56–61.

Solve the equation for y. *(p. 26)*

56. $3x + y = 7$

57. $2x - y = 3$

58. $y - 4x = -6$

59. $2x + 3y = -12$

60. $7x - 4y = 10$

61. $-x + 2y = 9$

Solve the equation or inequality. *(p. 51)*

62. $|5 + 2x| = 7$

63. $|4x - 9| = 5$

64. $|6 - 5x| = 9$

65. $|3 - 7x| < 10$

66. $|3x + 1| > 25$

67. $|3 - 4x| \geq 7$

EXTRA PRACTICE for Lesson 2.2, p. 1011 **ONLINE QUIZ** at classzone.com

2.3 EXERCISES

HOMEWORK KEY

- ◯ = **WORKED-OUT SOLUTIONS** on p. WS3 for Exs. 15, 37, and 61
- ★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 23, 30, 55, 56, 63, and 68
- ◆ = **MULTIPLE REPRESENTATIONS** Ex. 67

SKILL PRACTICE

1. **VOCABULARY** Copy and complete: The linear equation $y = 2x + 5$ is written in ? form.

2. ★ **WRITING** *Describe* how to graph an equation of the form $Ax + By = C$.

EXAMPLE 1 on p. 89 for Exs. 3–8

GRAPHING LINEAR FUNCTIONS **Graph the equation. *Compare* the graph with the graph of $y = x$.**

3. $y = 3x$
4. $y = -x$
5. $y = x + 5$
6. $y = x - 2$
7. $y = 2x - 1$
8. $y = -3x + 2$

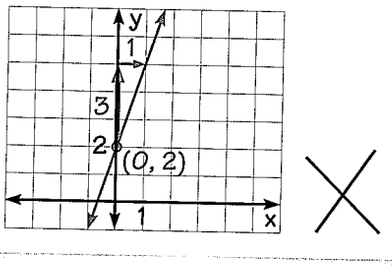
EXAMPLE 2 on p. 90 for Exs. 9–22

SLOPE-INTERCEPT FORM **Graph the equation.**

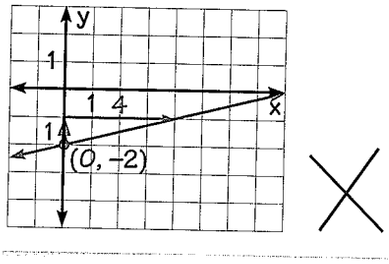
9. $y = -x - 3$
10. $y = x - 6$
11. $y = 2x + 6$
12. $y = 3x - 4$
13. $y = 4x - 1$
14. $y = \frac{2}{3}x - 2$
15. $f(x) = -\frac{1}{2}x - 1$
16. $f(x) = -\frac{5}{4}x + 1$
17. $f(x) = \frac{3}{2}x - 3$
18. $f(x) = \frac{5}{3}x + 4$
19. $f(x) = -1.5x + 2$
20. $f(x) = 3x - 1.5$

ERROR ANALYSIS ***Describe*** **and correct the error in graphing the equation.**

21. $y = 2x + 3$



22. $y = 4x - 2$



23. ★ **MULTIPLE CHOICE** What is the slope-intercept form of $4x - 3y = 18$?

Ⓐ $y = \frac{3}{4}x - 6$ Ⓑ $y = -\frac{3}{4}x - 6$ Ⓒ $y = \frac{4}{3}x - 6$ Ⓓ $y = -\frac{4}{3}x + 6$

EXAMPLES 4 and 5 on p. 92 for Exs. 24–42

FINDING INTERCEPTS **Find the x- and y-intercepts of the line with the given equation.**

24. $x - y = 4$
25. $x + 5y = -15$
26. $3x - 4y = -12$
27. $2x - y = 10$
28. $4x - 5y = 20$
29. $-6x + 8y = -36$

30. ★ **MULTIPLE CHOICE** What is the x-intercept of the graph of $5x - 6y = 30$?

Ⓐ -5 Ⓑ $\frac{5}{6}$ Ⓒ 6 Ⓓ 30

STANDARD FORM **Graph the equation. Label any intercepts.**

31. $x + 4y = 8$ **32.** $2x - 6y = -12$ **33.** $x = 4$

34. $y = -2$ **35.** $5x - y = 3$ **36.** $3x + 4y = 12$

37. $-5x + 10y = 20$ **38.** $-x - y = 6$ **39.** $y = 1.5$

40. $2.5x - 5y = -15$ **41.** $x = -\frac{5}{2}$ **42.** $\frac{1}{2}x + 2y = -2$

CHOOSING A METHOD **Graph the equation using any method.**

43. $6y = 3x + 6$ **44.** $-3 + x = 0$ **45.** $y + 7 = -2x$

46. $4y = 16$ **47.** $8y = -2x + 20$ **48.** $4x = -\frac{1}{2}y - 1$

49. $-4x = 8y + 12$ **50.** $3.5x = 10.5$ **51.** $y - 5.5x = 6$

52. $14 - 3x = 7y$ **53.** $2y - 5 = 0$ **54.** $5y = 7.5 - 2.5x$

55. ★ **OPEN-ENDED MATH** Write equations of two lines, one with an x-intercept but no y-intercept and one with a y-intercept but no x-intercept.

56. ★ **SHORT RESPONSE** Sketch $y = mx$ for several values of m, both positive and negative. *Describe* the relationship between m and the steepness of the line.

57. **REASONING** Consider the graph of $Ax + By = C$ where $B \neq 0$. What are the slope and y-intercept in terms of A, B, and C?

58. **CHALLENGE** Prove that the slope of the line $y = mx + b$ is m. (*Hint:* First find two points on the line by choosing convenient values of x.)

PROBLEM SOLVING

EXAMPLE 3 on p. 91 for Exs. 59–62

59. **FITNESS** The total cost y (in dollars) of a gym membership after x months is given by $y = 45x + 75$. Graph the equation. What is the total cost of the membership after 9 months?

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60. **CAMPING** Your annual membership fee to a nature society lets you camp at several campgrounds. Your total annual cost y (in dollars) to use the campgrounds is given by $y = 5x + 35$ where x is the number of nights you camp. Graph the equation. What do the slope and y-intercept represent?

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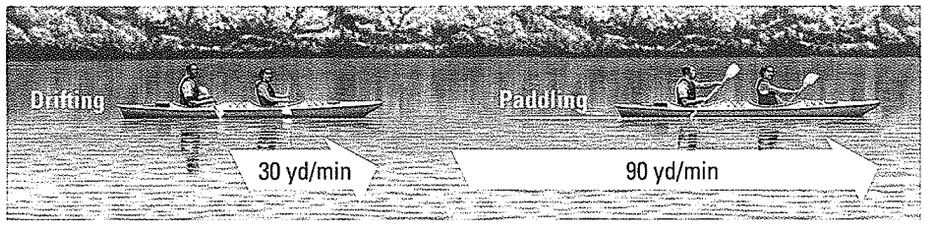
61. **SPORTS** Bowling alleys often charge a fixed fee to rent shoes and then charge for each game you bowl. The function $C(g) = 3g + 1.5$ gives the total cost C (in dollars) to bowl g games. Graph the function. What is the cost to rent shoes? What is the cost per game?

62. **PHONE CARDS** You purchase a 300 minute phone card. The function $M(w) = -30w + 300$ models the number M of minutes that remain on the card after w weeks. *Describe* how to determine a reasonable domain and range. Graph the function. How many minutes per week do you use the card?

○ = **WORKED-OUT SOLUTIONS** on p. WS1 ★ = **STANDARDIZED TEST PRACTICE** ◆ = **MULTIPLE REPRESENTATIONS**

63. ★ **SHORT RESPONSE** You receive a $30 gift card to a shop that sells fruit smoothies for $3. If you graph an equation of the line that represents the money y remaining on the card after you buy x smoothies, what will the y-intercept be? Will the line rise or fall from left to right? *Explain.*

64. **MULTI-STEP PROBLEM** You and a friend kayak 1800 yards down a river. You drift with the current partway at 30 yards per minute and paddle partway at 90 yards per minute. The trip is modeled by $30x + 90y = 1800$ where x is the drifting time and y is the paddling time (both in minutes).



a. Graph the equation, and determine a reasonable domain and range. What do the x- and y-intercepts represent?

b. If you paddle for 5 minutes, what is the total trip time?

c. If you paddle and drift equal amounts of time, what is the total trip time?

65. **VOLUNTEERING** You participate in a 14 mile run/walk for charity. You run partway at 6 miles per hour and walk partway at 3.5 miles per hour. A model for this situation is $6r + 3.5w = 14$ where r is the time you run and w is the time you walk (both in hours). Graph the equation. Give three possible combinations of running and walking times.

66. **TICKETS** An honor society has $150 to buy science museum and art museum tickets for student awards. The numbers of tickets that can be bought are given by $5s + 7a = 150$ where s is the number of science museum tickets (at $5 each) and a is the number of art museum tickets (at $7 each). Graph the equation. Give two possible combinations of tickets that use all $150.

67. **MULTIPLE REPRESENTATIONS** A hot air balloon is initially 200 feet above the ground. The burners are then turned on, causing the balloon to ascend at a rate of 150 feet per minute.

a. **Making a Table** Make a table showing the height h (in feet) of the balloon t minutes after the burners are turned on where $0 \leq t \leq 5$.

b. **Drawing a Graph** Plot the points from the table in part (a). Draw a line through the points for the domain $0 \leq t \leq 5$.

c. **Writing an Equation** The balloon's height is its initial height plus the product of the ascent rate and time. Write an equation representing this.

Animated Algebra at classzone.com

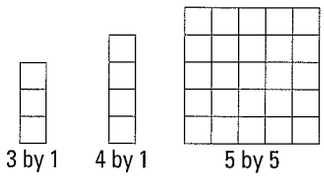
68. ★ **EXTENDED RESPONSE** You and a friend are each typing your research papers on computers. The function $y = 1400 - 50x$ models the number y of words you have left to type after x minutes. For your friend, $y = 1200 - 50x$ models the number y of words left to type after x minutes.

a. Graph the two equations in the same coordinate plane. *Describe* how the graphs are related geometrically.

b. What do the x-intercepts, y-intercepts, and slopes represent?

c. Who will finish first? *Explain.*

69. CHALLENGE You want to cover a five-by-five grid completely with x three-by-one rectangles and y four-by-one rectangles that do not overlap or extend beyond the grid.



a. *Explain* why x and y must be whole numbers that satisfy the equation $3x + 4y = 25$.

b. Find all solutions (x, y) of the equation in part (a) such that x and y are whole numbers.

c. Do all the solutions from part (b) represent combinations of rectangles that can actually cover the grid? Use diagrams to support your answer.

MIXED REVIEW

Evaluate the expression for the given value of the variable. *(p. 10)*

70. $3n - 10$ when $n = 5$ **71.** $-4x + 16$ when $x = -2$ **72.** $2(11 - 5p)$ when $p = 4$

73. $(4q + 5)(2q)$ when $q = -1$ **74.** $m^2 - 4m$ when $m = -3$ **75.** $(d + 1)^2 - d$ when $d = 6$

Tell whether the relation is a function. ***Explain.*** *(p. 72)*

76. $(-2, -7), (0, 3), (1, -2), (-2, 13), (3, -12)$ **77.** $(1, 3), (0, 0), (2, -2), (-3, 6), (-2, -2)$

PREVIEW
Prepare for Lesson 2.4 in Exs. 78–83.

Find the slope of the line passing through the given points. *(p. 82)*

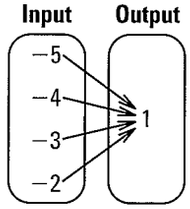
78. $(1, -3), (5, 0)$ **79.** $(-2, 1), (6, -7)$ **80.** $(4, 4), (8, 4)$

81. $(2, 5), (-5, 8)$ **82.** $(6, -3), (1, -13)$ **83.** $(2.5, 0), (-3.5, -4)$

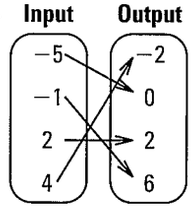
QUIZ *for Lessons 2.1–2.3*

Tell whether the relation is a function. ***Explain.*** *(p. 72)*

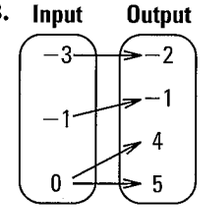
1.



2.



3.



Tell whether the lines are *parallel*, *perpendicular*, or *neither*. *(p. 82)*

4. Line 1: through $(-3, -7)$ and $(1, 9)$
Line 2: through $(-1, -4)$ and $(0, -2)$

5. Line 1: through $(2, 7)$ and $(-1, -2)$
Line 2: through $(3, -6)$ and $(-6, -3)$

Graph the equation. *(p. 89)*

6. $y = -5x + 3$ **7.** $x = 10$ **8.** $4x + 3y = -24$

9. ROWING SPEED In 1999, Tori Murden became the first woman to row across the Atlantic Ocean. She rowed a total of 3333 miles during her crossing. The distance d rowed (in miles) can be modeled by $d = 41t$ where t represents the time rowed (in days) at an average rate of 41 miles per day. Graph the function, and determine a reasonable domain and range. Then estimate how long it took Tori Murden to row 1000 miles. *(p. 72)*

EXTRA PRACTICE for Lesson 2.3, p. 1011 **ONLINE QUIZ** at classzone.com

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Keystrokes

2.3 Graph Equations

QUESTION **How can you use a graphing calculator to graph an equation?**

You can use a graphing calculator to graph equations in two variables. On most calculators, you must first write the equation in the form $y = f(x)$.

EXAMPLE **Graph a linear equation**

Graph the equation $x + 4y = 8$.

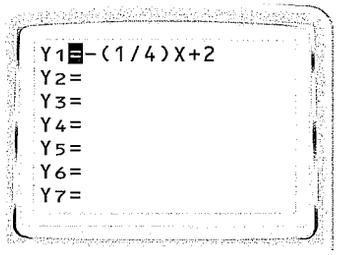
STEP 1 ***Solve for y***

First, solve the equation for y so that it can be entered into the calculator.

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

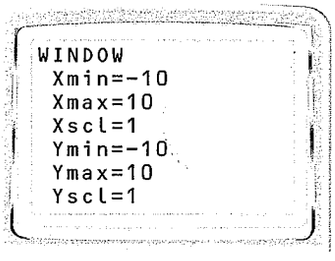
STEP 2 ***Enter equation***

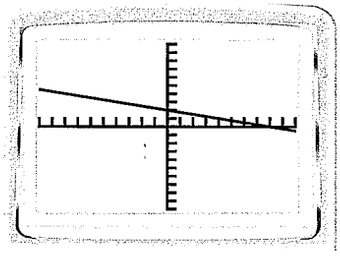
For fractional coefficients, use parentheses. So, enter the equation as $y = -(1/4)x + 2$.



STEP 3 ***Set viewing window and graph***

Enter minimum and maximum x- and y-values and x- and y-scales. The viewing window should show the intercepts. The *standard viewing window* settings and the corresponding graph are shown below.





PRACTICE

Graph the equation in a graphing calculator's standard viewing window.

1. $y + 14 = 17 - 2x$ **2.** $3x - y = 4$ **3.** $3x - 6y = -18$

Graph the equation using a graphing calculator. Use a viewing window that shows the x- and y-intercepts.

4. $8x = 5y + 16$ **5.** $4x = 25y - 240$ **6.** $1.25x + 4.2y = 28.7$

EXAMPLE 6 Write a model using standard form

ONLINE MUSIC You have \$30 to spend on downloading songs for your digital music player. Company A charges \$.79 per song, and company B charges \$.99 per song. Write an equation that models this situation.

Solution

Write a verbal model. Then write an equation.

Company A song price (dollars/song)	·	Songs from company A (songs)	+	Company B song price (dollars/song)	·	Songs from company B (songs)	=	Your budget (dollars)
⩔		⩔		⩔		⩔		⩔
0.79	·	x	+	**0.99**	·	y	=	**30**

▶ An equation for this situation is $0.79x + 0.99y = 30$.

✓ GUIDED PRACTICE for Example 6

10. WHAT IF? In Example 6, suppose that company A charges \$.69 per song and company B charges \$.89 per song. Write an equation that models this situation.

2.4 EXERCISES

HOMEWORK KEY

- ◯ = **WORKED-OUT SOLUTIONS** on p. WS3 for Exs. 15, 35, and 53
- ★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 26, 39, 47, and 53
- ◆ = **MULTIPLE REPRESENTATIONS** Ex. 57

SKILL PRACTICE

1. VOCABULARY Copy and complete: The linear equation $6x + 8y = 72$ is written in _?_ form.

2. ★ WRITING Given two points on a line, explain how you can use point-slope form to write an equation of the line.

EXAMPLE 1 on p. 98 for Exs. 3–8

SLOPE-INTERCEPT FORM **Write an equation of the line that has the given slope and y-intercept.**

3. $m = 0, b = 2$ **4.** $m = 3, b = -4$ **5.** $m = 6, b = 0$

6. $m = \frac{2}{3}, b = 4$ **7.** $m = -\frac{5}{4}, b = 7$ **8.** $m = -5, b = -1$

EXAMPLE 2 on p. 99 for Exs. 9–19

POINT-SLOPE FORM **Write an equation of the line that passes through the given point and has the given slope.**

9. $(0, -2), m = 4$ **10.** $(3, -1), m = -3$ **11.** $(-4, 3), m = 2$

12. $(-5, -6), m = 0$ **13.** $(8, 13), m = -9$ **14.** $(12, 0), m = \frac{3}{4}$

15. $(7, -3), m = -\frac{4}{7}$ **16.** $(-4, 2), m = \frac{3}{2}$ **17.** $(9, -5), m = -\frac{1}{3}$

ERROR ANALYSIS *Describe* **and correct the error in writing an equation of the line that passes through the given point and has the given slope.**

18. $(-4, 2)$, $m = 3$

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

19. $(5, 1)$, $m = -2$

$$y - y_1 = m(x - x_1)$$
$$y - 5 = -2(x - 1)$$
$$y - 5 = -2x + 2$$
$$y = -2x + 7$$

EXAMPLE 3 on p. 99 for Exs. 20–26

PARALLEL AND PERPENDICULAR LINES **Write an equation of the line that passes through the given point and satisfies the given condition.**

20. $(-3, -5)$; parallel to $y = -4x + 1$

21. $(7, 1)$; parallel to $y = -x + 3$

22. $(2, 8)$; parallel to $y = 3x - 2$

23. $(4, 1)$; perpendicular to $y = \frac{1}{3}x + 3$

24. $(-6, 2)$; perpendicular to $y = -2$

25. $(3, -1)$; perpendicular to $y = 4x + 1$

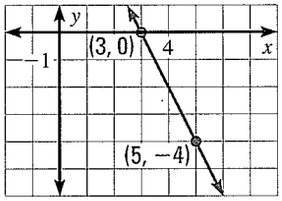
26. ★ **MULTIPLE CHOICE** What is an equation of the line that passes through $(1, 4)$ and is perpendicular to the line $y = 2x - 3$?

Ⓐ $y = 2x + 2$ Ⓑ $y = \frac{1}{2}x + \frac{7}{2}$ Ⓒ $y = -\frac{1}{2}x + \frac{9}{2}$ Ⓓ $y = -\frac{1}{2}x + 4$

EXAMPLE 4 on p. 100 for Exs. 27–38

VISUAL THINKING **Write an equation of the line.**

27.



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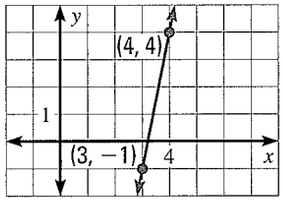

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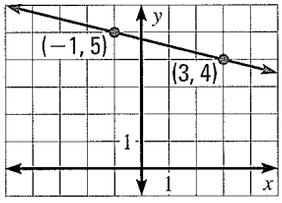

WRITING EQUATIONS **Write an equation of the line that passes through the given points.**

30. $(-1, 3)$, $(2, 9)$

31. $(4, -1)$, $(6, -7)$

32. $(-2, -3)$, $(2, -1)$

33. $(0, 7)$, $(3, 5)$

34. $(-1, 2)$, $(3, -4)$

35. $(-5, -2)$, $(-3, 8)$

36. $(15, 20)$, $(-12, 29)$

37. $(3.5, 7)$, $(-1, 20.5)$

38. $(0.6, 0.9)$, $(3.4, -2.6)$

39. ★ **MULTIPLE CHOICE** Which point lies on the line that passes through the point $(9, -5)$ and has a slope of -6?

Ⓐ $(6, 10)$ Ⓑ $(6, 6)$ Ⓒ $(7, 7)$ Ⓓ $(6, -4)$

STANDARD FORM **Write an equation in standard form $Ax + By = C$ of the line that satisfies the given conditions. Use integer values for A, B, and C.**

40. $m = -3$, $b = 5$

41. $m = 4$, $b = -3$

42. $m = -\frac{3}{2}$, passes through $(4, -7)$

43. $m = \frac{4}{5}$, passes through $(2, 3)$

44. passes through $(-1, 3)$ and $(-6, -7)$

45. passes through $(2, 8)$ and $(-4, 16)$

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○ = **WORKED-OUT SOLUTIONS** on p. WS1

★ = **STANDARDIZED TEST PRACTICE**

46. REASONING Write an equation of the line that passes through (3, 4) and satisfies the given condition.

a. Parallel to $y = -2$

b. Perpendicular to $y = -2$

c. Parallel to $x = -2$

d. Perpendicular to $x = -2$

47. ★ OPEN-ENDED MATH Write an equation of a line ℓ such that ℓ and the lines $y = -3x + 5$ and $y = 2x + 1$ form a right triangle.

48. REASONING Consider two distinct nonvertical lines $A_1x + B_1y = C_1$ and $A_2x + B_2y = C_2$. Show that the following statements are true.

a. If the lines are parallel, then $A_1B_2 = A_2B_1$.

b. If the lines are perpendicular, then $A_1A_2 + B_1B_2 = 0$.

49. CHALLENGE Show that an equation of the line with x-intercept a and y-intercept b is $\frac{x}{a} + \frac{y}{b} = 1$. This is the *intercept form* of a linear equation.

PROBLEM SOLVING

EXAMPLE 5
on p. 100
for Exs. 50–51

50. CAR EXPENSES You buy a used car for $6500. The monthly cost of owning the car (including insurance, fuel, maintenance, and taxes) averages $350. Write an equation that models the total cost of buying and owning the car.

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51. HOUSING Since its founding, a volunteer group has restored 50 houses. It plans to restore 15 houses per year in the future. Write an equation that models the total number n of restored houses t years from now.

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EXAMPLE 6
on p. 101
for Exs. 52–54

52. GARDENING You have a rectangular plot measuring 16 feet by 25 feet in a community garden. You want to grow tomato plants that each need 8 square feet of space and pepper plants that each need 5 square feet. Write an equation that models how many tomato plants and how many pepper plants you can grow. How many pepper plants can you grow if you grow 15 tomato plants?

53. ★ SHORT RESPONSE Concert tickets cost $15 for general admission, but only $9 with a student ID. Ticket sales total $4500. Write and graph an equation that models this situation. *Explain* how to use your graph to find how many student tickets were sold if 200 general admission tickets were sold.

54. MULTI-STEP PROBLEM A company will lease office space in two buildings. The annual cost is $21.75 per square foot in the first building and $17 per square foot in the second. The company has $86,000 budgeted for rent.

a. Write an equation that models the possible amounts of space rented in the buildings.

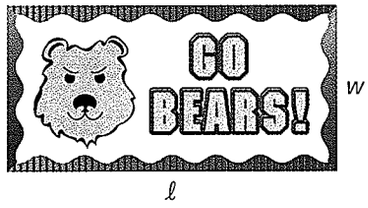
b. How many square feet of space can be rented in the first building if 2500 square feet are rented in the second?

c. If the company wants to rent equal amounts of space in the buildings, what is the total number of square feet that can be rented?

55. CABLE TELEVISION In 1994, the average monthly cost for expanded basic cable television service was $21.62. In 2004, this cost had increased to $38.23. Write a linear equation that models the monthly cost as a function of the number of years since 1994. Predict the average monthly cost of expanded basic cable television service in 2010.

56. TIRE PRESSURE Automobile tire pressure increases about 1 psi (pound per square inch) for each 10°F increase in air temperature. At an air temperature of 55°F, a tire's pressure is 30 psi. Write an equation that models the tire's pressure as a function of air temperature.

57. MULTIPLE REPRESENTATIONS Your class wants to make a rectangular spirit display, and has 24 feet of decorative border to enclose the display



a. **Writing an Equation** Write an equation in standard form relating the possible lengths ℓ and widths w of the display.

b. **Drawing a Graph** Graph the equation from part (a).

c. **Making a Table** Make a table of at least five possible pairs of dimensions for the display.

58. CHALLENGE You are participating in a dance-a-thon to raise money for a class trip. Donors can pledge an amount of money for each hour you dance, a fixed amount of money that does not depend on how long you dance, or both. The table shows the amounts pledged by four donors. Write an equation that models the total amount y of money you will raise from the donors if you dance for x hours.

Donor	Hourly amount	Fixed amount
Clare	$4	$15
Emilia	$8	None
Julio	None	$35
Max	$3	$20

MIXED REVIEW

PREVIEW
Prepare for Lesson 2.5 in Exs. 59–64.

Solve the equation. Check your solution. *(p. 18)*

59. $9x = 27$ **60.** $5x = 20$ **61.** $-3x = 21$

62. $8x = 6$ **63.** $4x = -14$ **64.** $10x = 8$

Solve the inequality. Then graph the solution. *(p. 41)*

65. $3x + 5 < 17$ **66.** $2x - 4 > -10$ **67.** $6x + 4 \geq 22$

68. $5x + 3 \leq 2x - 12$ **69.** $4x + 5 \geq 2x + 3$ **70.** $-3 \leq 2x - 7 \leq 13$

71. $14 < 5 - x < 9$ **72.** $3x - 5 \geq 7$ or $-x - 4 > 3$ **73.** $2x < 6$ or $5x - 9 \geq 16$

Graph the equation. *(p. 72)*

74. $y = x - 8$ **75.** $y = -2x + 1$ **76.** $y = 3x - 2$

77. $y = 4x + 2$ **78.** $y = -\frac{1}{3}x + 4$ **79.** $y = \frac{5}{2}x - 6$

80. RESERVOIRS The surface elevation of a reservoir is 940 feet above sea level. Water is released over a period of 15 days, lowering the surface elevation to 934 feet above sea level. What is the average rate of change in the reservoir's surface elevation over the period? *(p. 82)*

PROBLEM SOLVING WORKSHOP
LESSON 2.4

Using ALTERNATIVE METHODS

Another Way to Solve Example 4, page 100

MULTIPLE REPRESENTATIONS In Example 4 on page 100, you wrote an equation of a line through two given points by first writing the equation in point-slope form and then rewriting it in slope-intercept form. You can also write an equation of a line through two points by using the slope-intercept form to solve for the y-intercept.

PROBLEM

Write an equation of the line that passes through (5, −2) and (2, 10).

METHOD

Solving for the y-Intercept To write an equation of a line through two points, you can substitute the slope and the coordinates of one of the points into $y = mx + b$ and solve for the y-intercept b.

STEP 1 **Find** the slope of the line.	$m = \frac{10 - (-2)}{2 - 5} = \frac{12}{-3} = -4$
STEP 2 **Substitute** the slope and the coordinates of one point into the slope-intercept form. Use the point (**5**, **−2**).	$y = mx + b$ $\mathbf{-2} = -4(\mathbf{5}) + b$
STEP 3 **Solve** for b.	$-2 = -20 + b$ $18 = b$
STEP 4 **Substitute** m and b into the slope-intercept form.	$y = -4x + 18$

PRACTICE

1. **WRITE AN EQUATION** Use the method above to write an equation of the line that passes through (2, 15) and (7, 35).

2. **FITNESS** At a speed of 45 yards per minute, a 120 pound swimmer burns 420 calories per hour and a 172 pound swimmer burns 600 calories per hour. Use two different methods to write a linear equation that models the number of calories burned per hour as a function of a swimmer's weight.

3. **SAFETY** A motorist lights an emergency flare after having a flat tire. After burning for 6 minutes, the flare is 13 inches long. After burning for 20 minutes, it is 6 inches long. Use two different methods to write a linear equation that models the flare's length as a function of time.

4. **SNOWFALL** After 4 hours of snowfall, the snow depth is 8 inches. After 6 hours of snowfall, the snow depth is 9.5 inches. Use two different methods to write a linear equation that models the snow depth as a function of time.

5. **ARCHAEOLOGY** Ancient cities often rose in elevation through time as citizens built on top of accumulating rubble and debris. An archaeologist at a site dates artifacts from a depth of 54 feet as 3500 years old and artifacts from a depth of 26 feet as 2600 years old. Use two different methods to write a linear equation that models an artifact's age as a function of depth.

6. **REASONING** Suppose a line has slope m and passes through (x_1, y_1). Write an expression for the y-intercept b in terms of m, x_1, and y_1.

MIXED REVIEW of Problem Solving

STATE TEST PRACTICE
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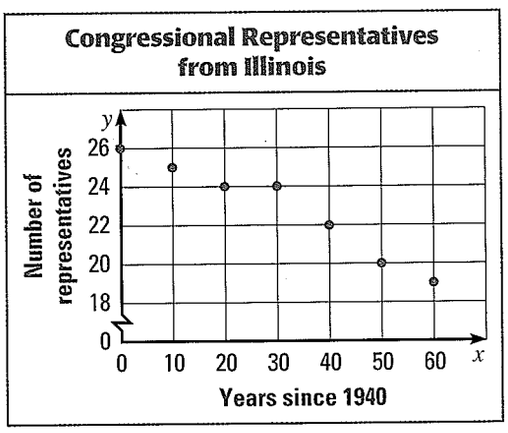
Lessons 2.1–2.4

1. **MULTI-STEP PROBLEM** From January to June, the number of visitors to a news website increased by an average of 1200 per month. In January, there were 50,000 visitors to the website.
   a. Write an equation that gives the number v of visitors to the website as a function of the number t of months since January.
   b. Graph the equation from part (a).
   c. Use the equation from part (a) to predict the number of website visitors in October.

2. **MULTI-STEP PROBLEM** The official population of Baton Rouge, Louisiana, was 219,531 in 1990 and 227,818 in 2000.
   a. What was the average rate of change in the population from 1990 to 2000?
   b. Write a linear equation that models the population P of Baton Rouge from 1990 to 2000. Let t represent the number of years since 1990.
   c. Use your equation from part (b) to predict the population of Baton Rouge in 2010.

3. **SHORT RESPONSE** The graph shows the number of representatives in the U.S. Congress given to Illinois by each national census from 1940 to 2000. Does the graph represent a function? *Explain.*



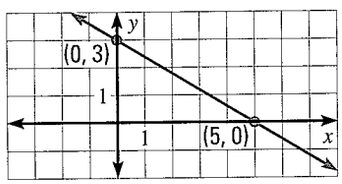
4. **OPEN-ENDED** Write an equation of a line that is parallel to the line $x + 3y = 12$ and that contains no points in Quadrant I.

5. **EXTENDED RESPONSE** General admission tickets to a high school football game cost $7, while student tickets cost $4. Ticket sales for a game totaled $11,200.

   a. Write an equation for the possible numbers of general admission and student tickets that could have been sold for the game.
   b. Graph the equation from part (a).
   c. Is it possible that 950 general admission tickets were sold? *Explain.*
   d. Find three possible combinations of general admission and student tickets that could have been sold. *Explain* how you found your answers.

6. **GRIDDED ANSWER** What is the slope of a line parallel to $\frac{1}{4}y - 3x = 5$?

7. **GRIDDED ANSWER** What is the slope of a line perpendicular to the line shown?



8. **SHORT RESPONSE** Your digital camera has a 512 megabyte memory card. You take low resolution pictures requiring 4 megabytes of memory each and high resolution pictures requiring 8 megabytes of memory each.
   a. Write and graph an equation for the possible numbers of low and high resolution pictures you can take.
   b. *Describe* the meaning of the slope and intercepts in the context of the problem.

✓ GUIDED PRACTICE for Examples 2 and 3

5. **WHAT IF?** In Example 2, suppose that a hailstone forming in a cloud has a radius of 0.6 inch. Predict how long it has been forming.

6. **SHARKS** In Example 3, the respective body masses m (in kilograms) of the great white sharks are 80, 220, 375, 730, 1690, and 3195. Tell whether tooth length and body mass show direct variation. If so, write an equation that relates the quantities.

2.5 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS3 for Exs. 5, 15, and 41

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 17, 30, 40, and 44

SKILL PRACTICE

1. **VOCABULARY** Define the constant of variation for two variables x and y that vary directly.

2. ★ **WRITING** Given a table of ordered pairs (x, y), describe how to determine whether x and y show direct variation.

EXAMPLE 1 on p. 107 for Exs. 3–10

WRITING AND GRAPHING **Write and graph a direct variation equation that has the given ordered pair as a solution.**

3. (2, 6)
4. (−3, 12)
5. (6, −21)
6. (4, 10)
7. (−5, −1)
8. (24, −8)
9. $\left(\frac{4}{3}, -4\right)$
10. (12.5, 5)

EXAMPLE 2 on p. 108 for Exs. 11–17

WRITING AND EVALUATING **The variables x and y vary directly. Write an equation that relates x and y. Then find y when $x = 12$.**

11. $x = 4, y = 8$
12. $x = -3, y = -5$
13. $x = 35, y = -7$
14. $x = -18, y = 4$
15. $x = -4.8, y = -1.6$
16. $x = \frac{2}{3}, y = -10$

17. ★ **MULTIPLE CHOICE** Which equation is a direct variation equation that has (3, 18) as a solution?

Ⓐ $y = 2x^2$ Ⓑ $y = \frac{1}{6}x$ Ⓒ $y = 6x$ Ⓓ $y = 4x + 6$

IDENTIFYING DIRECT VARIATION **Tell whether the equation represents direct variation. If so, give the constant of variation.**

18. $y = -8x$
19. $y - 4 = 3x$
20. $3y - 7 = 10x$
21. $2y - 5x = 0$
22. $5y = -4x$
23. $6y = x$

WRITING AND SOLVING **The variables x and y vary directly. Write an equation that relates x and y. Then find x when $y = -4$.**

24. $x = 5, y = -15$
25. $x = -6, y = 8$
26. $x = -18, y = -2$
27. $x = -12, y = 84$
28. $x = -\frac{20}{3}, y = -\frac{15}{8}$
29. $x = -0.5, y = 3.6$

30. ★ OPEN-ENDED MATH Give an example of two real-life quantities that show direct variation. *Explain* your reasoning.

EXAMPLE 3 on p. 108 for Exs. 31–34

IDENTIFYING DIRECT VARIATION **Tell whether the data in the table show direct variation. If so, write an equation relating x and y.**

31.

x	3	6	9	12	15
y	−1	−2	−3	−4	−5

32.

x	1	2	3	4	5
y	7	9	11	13	15

33.

x	−5	−4	−3	−2	−1
y	20	16	12	8	4

34.

x	−8	−4	4	8	12
y	8	4	−4	−8	−12

35. ERROR ANALYSIS A student tried to determine whether the data pairs (1, 24), (2, 12), (3, 8), and (4, 6) show direct variation. *Describe* and correct the error in the student's work.

$1 \cdot 24 = 24$ $2 \cdot 12 = 24$
$3 \cdot 8 = 24$ $4 \cdot 6 = 24$

Because the products xy are constant, y varies directly with x.

36. REASONING Let (x_1, y_1) be a solution, other than (0, 0), of a direct variation equation. Write a second direct variation equation whose graph is perpendicular to the graph of the first equation.

37. CHALLENGE Let (x_1, y_1) and (x_2, y_2) be any two distinct solutions of a direct variation equation. Show that $\frac{x_2}{x_1} = \frac{y_2}{y_1}$.

PROBLEM SOLVING

EXAMPLE 2 on p. 108 for Exs. 38–40

38. SCUBA DIVING The time t it takes a diver to ascend safely to the surface varies directly with the depth d. It takes a minimum of 0.75 minute for a safe ascent from a depth of 45 feet. Write an equation that relates d and t. Then predict the minimum time for a safe ascent from a depth of 100 feet.

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39. WEATHER Hail 0.5 inch deep and weighing 1800 pounds covers a roof. The hail's weight w varies directly with its depth d. Write an equation that relates d and w. Then predict the weight on the roof of hail that is 1.75 inches deep.

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40. ★ MULTIPLE CHOICE Your weight M on Mars varies directly with your weight E on Earth. If you weigh 116 pounds on Earth, you would weigh 44 pounds on Mars. Which equation relates E and M?

Ⓐ $M = E - 72$ Ⓑ $44M = 116E$ Ⓒ $M = \frac{29}{11}E$ Ⓓ $M = \frac{11}{29}E$

EXAMPLE 3 on p. 108 for Exs. 41–43

41. INTERNET DOWNLOADS The ordered pairs (4.5, 23), (7.8, 40), and (16.0, 82) are in the form (s, t) where t represents the time (in seconds) needed to download an Internet file of size s (in megabytes). Tell whether the data show direct variation. If so, write an equation that relates s and t.

○ = WORKED-OUT SOLUTIONS on p. WS1

★ = STANDARDIZED TEST PRACTICE

GEOMETRY In Exercises 42 and 43, consider squares with side lengths of 1, 2, 3, and 4 centimeters.

42. Copy and complete the table.

Side length, s (cm)	1	2	3	4
Perimeter, P (cm)	?	?	?	?
Area, A (cm^2)	?	?	?	?

43. Tell whether the given variables show direct variation. If so, write an equation relating the variables. If not, explain why not.

a. s and P **b.** s and A **c.** P and A

44. ★ **EXTENDED RESPONSE** Each year, gray whales migrate from Mexico's Baja Peninsula to feeding grounds near Alaska. A whale may travel 6000 miles at an average rate of 75 miles per day.

a. Write an equation that gives the distance d_1 traveled in t days of migration.

b. Write an equation that gives the distance d_2 that remains to be traveled after t days of migration.

c. Tell whether the equations from parts (a) and (b) represent direct variation. *Explain* your answers.

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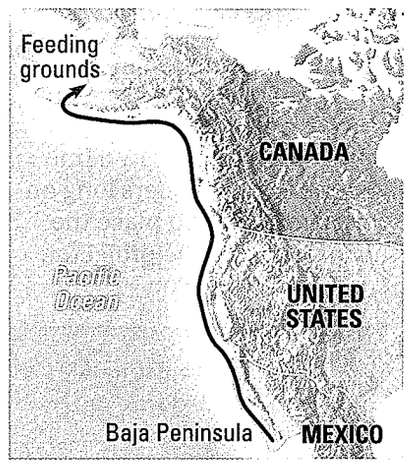


45. **CHALLENGE** At a jewelry store, the price p of a gold necklace varies directly with its length ℓ. Also, the weight w of a necklace varies directly with its length. Show that the price of a necklace varies directly with its weight.

MIXED REVIEW

Solve the inequality. Then graph the solution. *(p. 51)*

46. $|x - 5| \geq 10$ **47.** $|8 - 3x| < 13$ **48.** $|-x - 4| \leq 5$

49. $|4x - 3| > 3$ **50.** $\left|6 - \frac{3}{2}x\right| < 9$ **51.** $\left|\frac{1}{3}x + 2\right| \geq 3$

PREVIEW
Prepare for Lesson 2.6 in Exs. 52–57.

Find the slope of the line passing through the given points. *(p. 82)*

52. (2, −5), (−1, 4) **53.** (−1, −5), (−3, −2) **54.** (3, 11), (−2, −4)

55. (−2, −10), (−2, 8) **56.** (−4, 9), (6, −9) **57.** (−15, 1), (−6, 13)

Graph the equation. *(p. 89)*

58. $y = 1 + 2x$ **59.** $f(x) = \frac{3}{4}x - 5$ **60.** $f(x) = -4x - 3$

61. $5x + 8y = 40$ **62.** $y = -5$ **63.** $6x - 10y = 15$

64. **UTILITIES** Your June electric bill is \$78 for 720 kilowatt-hours of electricity. Your July bill is \$120 for 1140 kilowatt-hours. Write a linear equation that models cost as a function of electricity use. *(p. 98)*

2.6 Fitting a Line to Data

MATERIALS • overhead projector • overhead transparency • metric ruler • meter stick • graph paper

QUESTION **How can you approximate the *best-fitting line* for a set of data?**

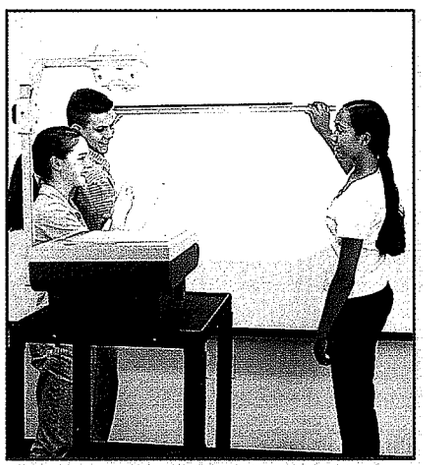
EXPLORE **Collect and record data**

STEP 1 ***Set up***

Position an overhead projector a convenient distance from a projection screen. Draw a line segment 15 centimeters long on a transparency, and place the transparency on the projector.

STEP 2 ***Collect data***

Measure the distance, in centimeters, from the projector to the screen and the length of the line segment as it appears on the screen. Reposition the projector several times, each time taking these measurements.



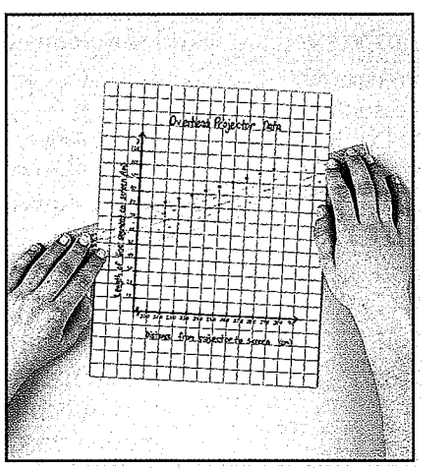
STEP 3 ***Record data***

Record your measurements from Step 2 in a table like the one shown below.

Distance from projector to screen (cm), x	Length of line segment on screen (cm), y
200	?
210	?
220	?
230	?
240	?
250	?
260	?
270	?
280	?
290	?

DRAW CONCLUSIONS **Use your observations to complete these exercises**

1. Graph the data pairs (x, y). What pattern do you observe?
2. Use a ruler to draw a line that lies as close as possible to all of the points on the graph, as shown at the right. The line does not have to pass through any of the points. There should be about as many points above the line as below it.
3. Estimate the coordinates of two points on your line. Use your points to write an equation of the line.
4. Using your equation from Exercise 3, predict the length of the line segment on the screen for a particular projector-to-screen distance less than those in your table and for a particular projector-to-screen distance greater than those in your table.
5. Test your predictions from Exercise 4. How accurate were they?



✓ GUIDED PRACTICE for Examples 3, 4, and 5

4. **OIL PRODUCTION** The table shows the U.S. daily oil production y (in thousands of barrels) x years after 1994.

x	0	1	2	3	4	5	6	7	8
y	6660	6560	6470	6450	6250	5880	5820	5800	5750

a. Approximate the best-fitting line for the data.

b. Use your equation from part (a) to predict the daily oil production in 2009.

c. Use a graphing calculator to find and graph an equation of the best-fitting line. Repeat the prediction from part (b) using this equation.

2.6 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS3 for Exs. 9, 11, and 25

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 16, 18, 21, and 28

◆ = **MULTIPLE REPRESENTATIONS** Ex. 27

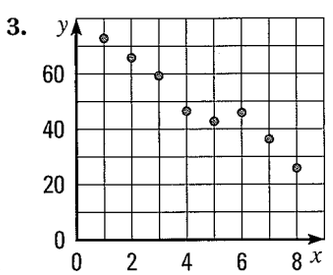
SKILL PRACTICE

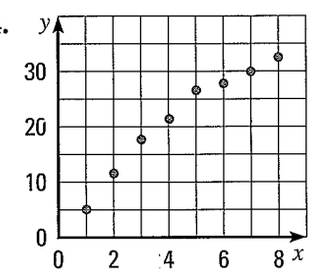
1. **VOCABULARY** Copy and complete: A line that lies as close as possible to a set of data points (x, y) is called the ? for the data points.

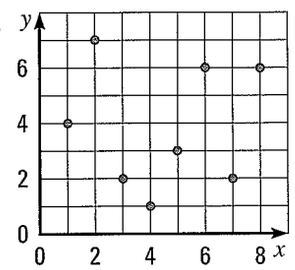
2. ★ **WRITING** *Describe* how to tell whether a set of data points shows a positive correlation, a negative correlation, or approximately no correlation.

EXAMPLE 1 on p. 113 for Exs. 3–5

DESCRIBING CORRELATIONS **Tell whether the data have a *positive correlation*, a *negative correlation*, or *approximately no correlation*.**

3. 

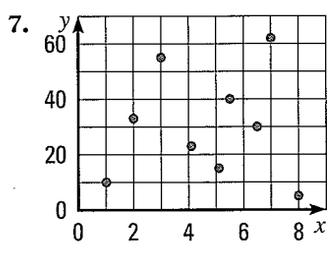
4. 

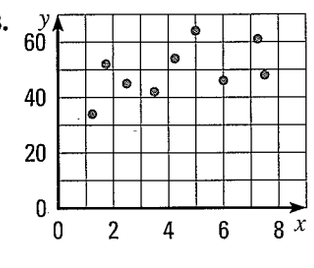
5. 

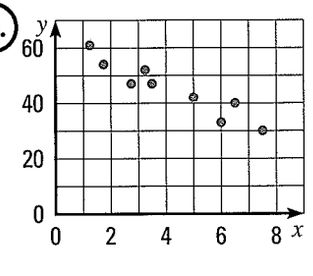
6. **REASONING** *Explain* how you can determine the type of correlation for a set of data pairs by examining the data in a table without drawing a scatter plot.

EXAMPLE 2 on p. 114 for Exs. 7–9

CORRELATION COEFFICIENTS **Tell whether the correlation coefficient for the data is closest to −1, −0.5, 0, 0.5, or 1.**

7. 

8. 

9. 

EXAMPLES 3 and 4
on pp. 115–116
for Exs. 10–15

BEST-FITTING LINES **In Exercises 10–15, (a) draw a scatter plot of the data, (b) approximate the best-fitting line, and (c) estimate y when $x = 20$.**

10.

x	1	2	3	4	5
y	10	22	35	49	62

11.

x	1	2	3	4	5
y	120	101	87	57	42

12.

x	12	25	36	50	64
y	100	75	52	26	9

13.

x	3	7	10	15	18
y	16	45	82	102	116

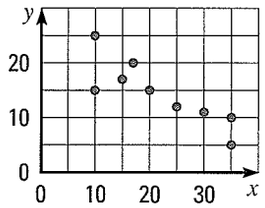
14.

x	5.6	6.2	7	7.3	8.4
y	120	130	141	156	167

15.

x	16	24	39	55	68
y	3.9	3.7	3.4	2.9	2.6

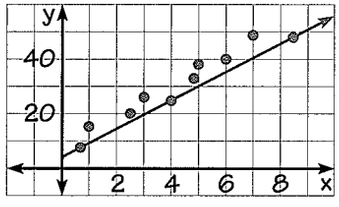
16. ★ **MULTIPLE CHOICE** Which equation best models the data in the scatter plot?



Ⓐ $y = 15$ Ⓑ $y = -\frac{1}{2}x + 26$

Ⓒ $y = -\frac{2}{5}x + 19$ Ⓓ $y = -\frac{4}{5}x + 33$

17. **ERROR ANALYSIS** The graph shows one student's approximation of the best-fitting line for the data in the scatter plot. *Describe* and correct the error in the student's work.



18. ★ **MULTIPLE CHOICE** A set of data has correlation coefficient r. For which value of r would the data points lie closest to a line?

Ⓐ $r = -0.96$ Ⓑ $r = 0$ Ⓒ $r = 0.38$ Ⓓ $r = 0.5$

EXAMPLE 5
on p. 116
for Exs. 19–20

GRAPHING CALCULATOR **In Exercises 19 and 20, use a graphing calculator to find and graph an equation of the best-fitting line.**

19.

x	78	74	68	76	80	84	50	76	55	93
y	5.1	5.0	4.6	4.9	5.3	5.5	3.7	5.0	3.9	5.8

20.

x	7000	7400	7800	8100	8500	8800	9200	9500	9800
y	56.0	54.5	51.9	50.0	47.3	45.6	43.1	41.6	39.9

21. ★ **OPEN-ENDED MATH** Give two real-life quantities that have **(a)** a positive correlation, **(b)** a negative correlation, and **(c)** approximately no correlation.

22. **REASONING** A set of data pairs has correlation coefficient $r = 0.1$. Is it logical to use the best-fitting line to make predictions from the data? *Explain.*

23. **CHALLENGE** If x and y have a positive correlation and y and z have a negative correlation, what can you say about the correlation between x and z? *Explain.*

PROBLEM SOLVING

EXAMPLES 3, 4, and 5 on pp. 115–116 for Exs. 24–28

GRAPHING CALCULATOR **You may wish to use a graphing calculator to complete the following Problem Solving exercises.**

24. POPULATION The data pairs (x, y) give the population y (in millions) of Texas x years after 1997. Approximate the best-fitting line for the data.

(0, 19.7), (1, 20.2), (2, 20.6), (3, 20.9), (4, 21.3), (5, 21.7), (6, 22.1), (7, 22.5)

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25. TUITION The data pairs (x, y) give U.S. average annual public college tuition y (in dollars) x years after 1997. Approximate the best-fitting line for the data.

(0, 2271), (1, 2360), (2, 2430), (3, 2506), (4, 2562), (5, 2727), (6, 2928)

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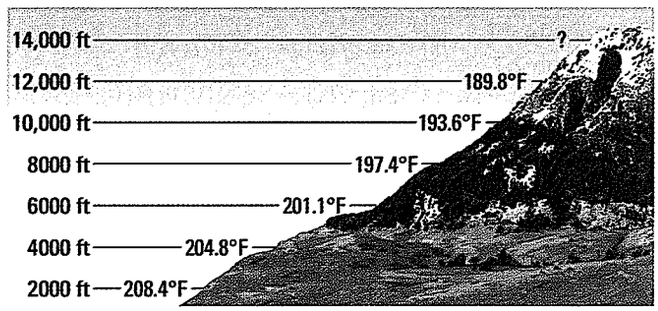
26. PHYSICAL SCIENCE The diagram shows the boiling point of water at various elevations. Approximate the best-fitting line for the data pairs (x, y) where x represents the elevation (in feet) and y represents the boiling point (in degrees Fahrenheit). Then use this line to estimate the boiling point at an elevation of 14,000 feet.



27. MULTIPLE REPRESENTATIONS The table shows the numbers of countries that participated in the Winter Olympics from 1980 to 2002.

Year	1980	1984	1988	1992	1994	1998	2002
Countries	37	49	57	64	67	72	77

a. Making a List Use the table to make a list of data pairs (x, y) where x represents years since 1980 and y represents the number of countries.

b. Drawing a Graph Draw a scatter plot of the data pairs from part (a).

c. Writing an Equation Write an equation that approximates the best-fitting line, and use it to predict the number of participating countries in 2014.

28. ★ EXTENDED RESPONSE The table shows manufacturers' shipments (in millions) of cassettes and CDs in the United States from 1988 to 2002.

Year	1988	1990	1992	1994	1996	1998	2000	2002
Cassettes	450.1	442.2	336.4	345.4	225.3	158.5	76.0	31.1
CDs	149.7	286.5	407.5	662.1	778.9	847.0	942.5	803.3

a. Draw a scatter plot of the data pairs (year, shipments of cassettes). *Describe* the correlation shown by the scatter plot.

b. Draw a scatter plot of the data pairs (year, shipments of CDs). *Describe* the correlation shown by the scatter plot.

c. *Describe* the correlation between cassette shipments and CD shipments. What real-world factors might account for this?

TATIONS

29. CHALLENGE Data from some countries in North America show a positive correlation between the average life expectancy in a country and the number of personal computers per capita in that country.

a. Make a conjecture about the reason for the positive correlation between life expectancy and number of personal computers per capita.

b. Is it reasonable to conclude from the data that giving residents of a country more personal computers will lengthen their lives? *Explain.*

MIXED REVIEW

Solve the equation for y. Then find the value of y for the given value of x. *(p. 26)*

30. $2x - y = 10; x = 8$ **31.** $6y + x = -5; x = 1$ **32.** $x - 4y = 3; x = -3$

33. $-3x + 4y + 5 = 0; x = -2$ **34.** $-0.5y + 0.25x = 2; x = 4$ **35.** $xy - 4x = 9; x = 6$

PREVIEW
Prepare for Lesson 2.7 in Exs. 36–41.

Evaluate the function for the given value of x. *(p. 72)*

36. $f(x) = -x + 7; f(9)$ **37.** $f(x) = -4x - 11; f(-5)$ **38.** $f(x) = 14 - |x|; f(-2)$

39. $f(x) = |x - 10|; f(10)$ **40.** $f(x) = |-6 - x|; f(4)$ **41.** $f(x) = |2x + 8| - 1; f(-3)$

Graph the equation. *(p. 89)*

42. $y = x + 8$ **43.** $y = -x - 14$ **44.** $y = 5x + 9$

45. $2x + y = 1$ **46.** $3x - 2y = -4$ **47.** $x + 3y = 15$

QUIZ for Lessons 2.4–2.6

Write an equation of the line that satisfies the given conditions. *(p. 98)*

1. $m = -5, b = 3$ **2.** $m = 2, b = 12$

3. $m = 4$, passes through $(-3, 6)$ **4.** $m = -7$, passes through $(1, -4)$

5. passes through $(0, 7)$ and $(-3, -2)$ **6.** passes through $(-9, 9)$ and $(-9, 0)$

Write and graph a direct variation equation that has the given ordered pair as a solution. *(p. 107)*

7. $(1, 2)$ **8.** $(-2, 8)$ **9.** $(5, -16)$ **10.** $(12, 4)$

The variables x and y vary directly. Write an equation that relates x and y. Then find y when $x = 8$. *(p. 107)*

11. $x = 4, y = 12$ **12.** $x = -3, y = -8$ **13.** $x = 40, y = -5$ **14.** $x = 12, y = 2$

15. CONCERT TICKETS The table shows the average price of a concert ticket to one of the top 50 musical touring acts for the years 1999–2004. Write an equation that approximates the best-fitting line for the data pairs (x, y). Use the equation to predict the average price of a ticket in 2010. *(p. 113)*

Years since 1999, x	0	1	2	3	4	5
Ticket price (dollars), y	38.56	44.80	46.69	50.81	51.81	58.71

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Keystrokes

2.7 Exploring Transformations

MATERIALS • graphing calculator

QUESTION **How are the equation and the graph of an absolute value function related?**

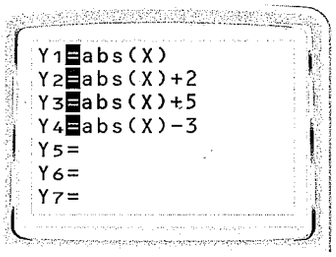
You can investigate families of *absolute value functions* with equations of the form $y = a|x - h| + k$ by varying the values of a, h, and k and then graphing. The resulting graphs are *transformations* of the graph of the parent function $y = |x|$.

EXAMPLE 1 Graph $y = |x| + k$

Graph and describe the family of absolute value functions of the form $y = |x| + k$.

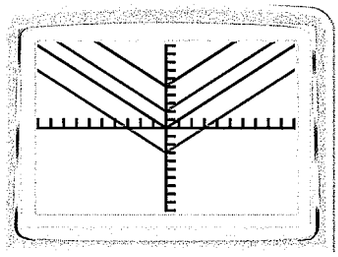
STEP 1 ***Vary the value of k***

Enter $y = |x|$, $y = |x| + 2$, $y = |x| + 5$, and $y = |x| - 3$.



STEP 2 ***Display graphs***

Graph the equations in the standard viewing window by pressing ZOOM 6.



STEP 3 ***Compare graphs***

Describe how the family of graphs of $y = |x| + k$ is related to the graph of $y = |x|$.

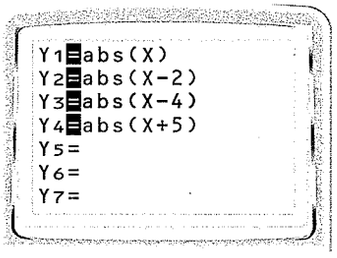
The graphs of absolute value functions of the form $y = |x| + k$ have the same shape as the graph of $y = |x|$, but are shifted k units vertically.

EXAMPLE 2 Graph $y = |x - h|$

Graph and describe the family of absolute value functions of the form $y = |x - h|$.

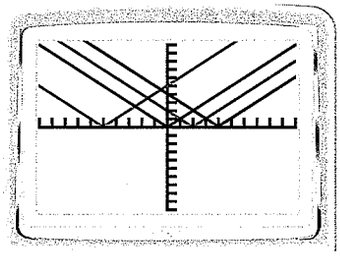
STEP 1 ***Vary the value of h***

Enter $y = |x|$, $y = |x - 2|$, $y = |x - 4|$, and $y = |x + 5|$.



STEP 2 ***Display graphs***

Graph the equations in the standard viewing window by pressing ZOOM 6.



STEP 3 ***Compare graphs***

Describe how the family of graphs of $y = |x - h|$ is related to the graph of $y = |x|$.

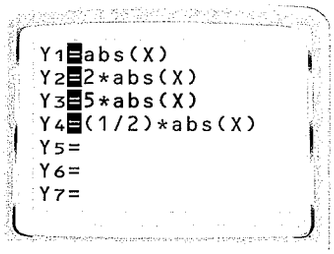
The graphs of absolute value functions of the form $y = |x - h|$ have the same shape as the graph of $y = |x|$, but are shifted h units horizontally.

EXAMPLE 3 Graph $y = a|x|$ where a is a positive number

Graph and describe the family of absolute value functions of the form $y = a|x|$ where $a > 0$.

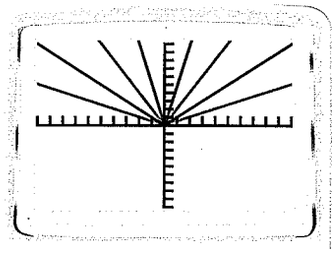
STEP 1 Vary the value of a

Enter $y = |x|$, $y = 2|x|$, $y = 5|x|$, and $y = \frac{1}{2}|x|$.



STEP 2 Display graphs

Graph the equations in the standard viewing window by pressing ZOOM 6.



STEP 3 Compare graphs

Describe how the family of graphs of $y = a|x|$ where $a > 0$ is related to the graph of $y = |x|$.

As with $y = |x|$, the graph of $y = a|x|$ $(a > 0)$ has its lowest point at the origin. If $a > 1$, the graph is narrower than that of $y = |x|$. If $0 < a < 1$, the graph is wider than that of $y = |x|$.

PRACTICE

1. Graph and describe the family of absolute value functions of the form $y = a|x|$ where $a < 0$. Follow these steps:

   STEP 1 Enter $y = |x|$, $y = -|x|$, $y = -3|x|$, and $y = -\frac{1}{2}|x|$.

   STEP 2 Graph the equations in the standard viewing window by pressing ZOOM 6.

   STEP 3 Describe how the family of graphs of $y = a|x|$ where $a < 0$ is related to the graph of $y = |x|$.

***Describe* how the graph of the given equation is related to the graph of $y = |x|$. Then graph the given equation along with $y = |x|$ to confirm your answer.**

2. $y = |x| + 6$
3. $y = |x| - 4$
4. $y = |x - 3|$
5. $y = |x + 2|$
6. $y = \frac{2}{3}|x|$
7. $y = -6|x|$
8. $y = |x - 1| + 2$
9. $y = 3|x + 2|$
10. $y = -0.5|x + 1| + 7$

DRAW CONCLUSIONS

Answer the following questions about the graph of $y = a|x - h| + k$.

11. How does the value of k affect the graph?
12. How does the value of h affect the graph?
13. How do the sign and absolute value of a affect the graph?
14. What are the coordinates of the lowest or highest point on the graph? How can you tell whether this point is the lowest point or the highest point?

2.7 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS4 for Exs. 13, 19, and 39

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 27, 28, 31, 32, 33, 38, and 40

◆ = **MULTIPLE REPRESENTATIONS** Ex. 41

SKILL PRACTICE

1. **VOCABULARY** The point (h, k) is the __?__ of the graph of $y = a|x - h| + k$.

2. ★ **WRITING** *Describe* three different types of transformations.

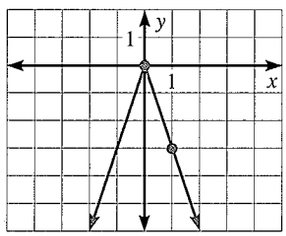
EXAMPLES 1, 2, and 3 on pp. 124–125 for Exs. 3–14

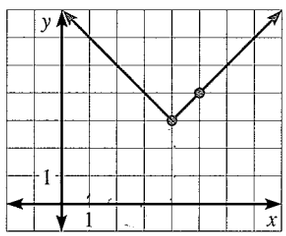
GRAPHING FUNCTIONS **Graph the function. *Compare* the graph with the graph of $y = |x|$.**

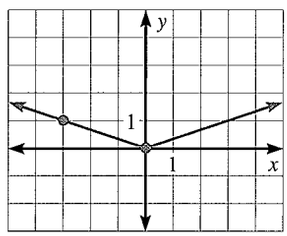
3. $y = |x| - 7$
4. $y = |x + 2|$
5. $y = |x + 4| - 2$
6. $f(x) = |x - 1| + 4$
7. $f(x) = 2|x|$
8. $f(x) = -3|x|$
9. $y = -\frac{1}{3}|x|$
10. $y = \frac{3}{4}|x|$
11. $y = 2|x + 1| - 6$
12. $f(x) = -4|x + 2| - 3$
13. $f(x) = -\frac{1}{2}|x - 1| + 5$
14. $f(x) = \frac{1}{4}|x - 4| + 3$

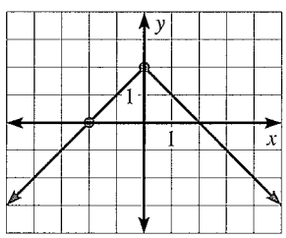
EXAMPLE 4 on p. 125 for Exs. 15–20

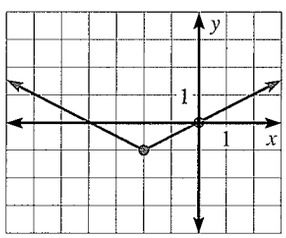
WRITING EQUATIONS **Write an equation of the graph.**

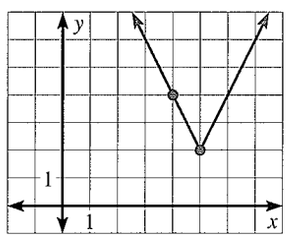
15. 

16. 

17. 

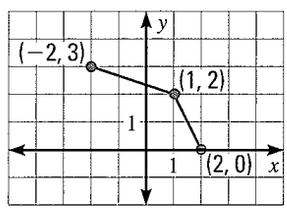
18. 

19. 

20. 

EXAMPLE 5 on p. 126 for Exs. 21–28

TRANSFORMATIONS **Use the graph of $y = f(x)$ shown to sketch the graph of the given function.**



21. $y = f(x + 2) - 3$
22. $y = f(x - 4) + 1$
23. $y = \frac{1}{2} \cdot f(x)$
24. $y = -3 \cdot f(x)$
25. $y = -f(x - 1) + 4$
26. $y = 2 \cdot f(x + 3) - 1$

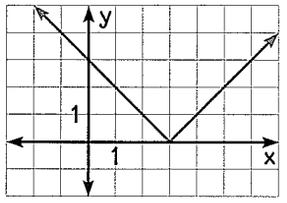
27. ★ **OPEN-ENDED MATH** Create a graph of a function $y = f(x)$. Then sketch the graphs of **(a)** $y = f(x + 3) - 4$, **(b)** $y = 2 \cdot f(x)$, and **(c)** $y = -f(x)$.

28. ★ **MULTIPLE CHOICE** The highest point on the graph of $y = f(x)$ is $(-1, 6)$. What is the highest point on the graph of $y = 4 \cdot f(x - 3) + 5$?

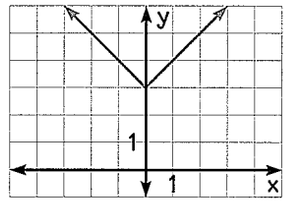
Ⓐ $(-11, 6)$ Ⓑ $(8, 11)$ Ⓒ $(-4, 29)$ Ⓓ $(2, 29)$

ERROR ANALYSIS *Describe* **and correct the error in graphing** $y = |x + 3|$.

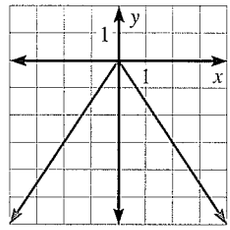
29.



30.



31. ★ **MULTIPLE CHOICE** Which equation has the graph shown?

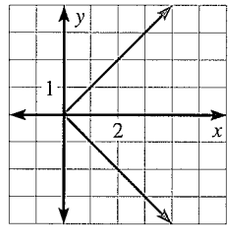


Ⓐ $y = \frac{3}{2}|x|$ Ⓑ $y = \frac{2}{3}|x|$

Ⓒ $y = -\frac{2}{3}|x|$ Ⓓ $y = -\frac{3}{2}|x|$

32. ★ **WRITING** *Describe* how the signs of h and k affect how to obtain the graph of $y = f(x - h) + k$ from the graph of $y = f(x)$.

33. ★ **SHORT RESPONSE** The graph of the relation $x = |y|$ is shown at the right. Is the relation a function? *Explain*.



34. **REASONING** Is it true in general that $|x + h| = |x| + |h|$? *Justify* your answer by considering how the graphs of $y = |x + h|$ and $y = |x| + |h|$ are related to the graph of $y = |x|$.

35. **CHALLENGE** The graph of $y = a|x - h| + k$ passes through $(-2, 4)$ and $(4, 4)$. *Describe* the possible values of h and k.

PROBLEM SOLVING

EXAMPLE 1 on p. 124 for Ex. 36

36. **SPEEDOMETER** A car's speedometer reads 60 miles per hour. The error E in this measurement is $E = |a - 60|$ where a is the actual speed. Graph the function. For what value(s) of a will E be 2.5 miles per hour?

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EXAMPLE 3 on p. 125 for Ex. 37

37. **SALES** Weekly sales s (in thousands) of a new basketball shoe increase steadily for a while and then decrease as described by the function $s = -2|t - 15| + 50$ where t is the time (in weeks). Graph the function. What is the greatest number of pairs of shoes sold in one week?

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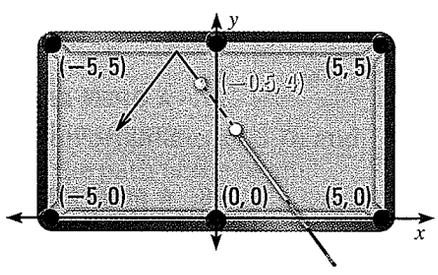
EXAMPLE 4 on p. 125 for Exs. 38–39

38. ★ **SHORT RESPONSE** On the pool table shown, you bank the five ball off the side at $(-1.25, 5)$. You want the ball to go in the pocket at $(-5, 0)$.

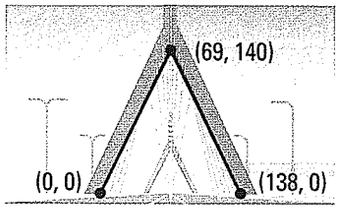


a. Write an equation for the path of the ball.

b. Do you make the shot? *Explain* how you found your answer.

○ = **WORKED-OUT SOLUTIONS** on p. WS1 ★ = **STANDARDIZED TEST PRACTICE** ◈ = **MULTIPLE REPRESENTATIONS**

39. ENGINEERING The Leonard P. Zakim Bunker Hill Bridge spans the Charles River in Boston. The bridge is suspended from two towers. Each tower has the dimensions shown. Write an absolute value function that represents the inverted V-shaped portion of a tower.



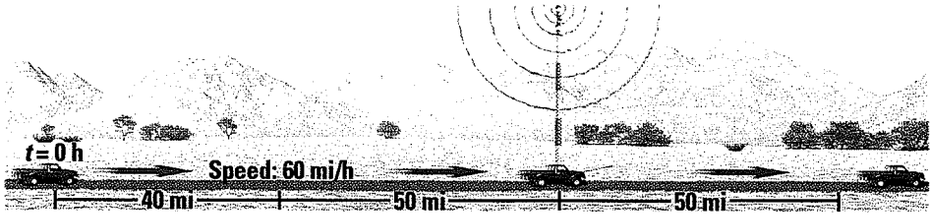
40. ★ EXTENDED RESPONSE A snowstorm begins with light snow that increases to very heavy snow before decreasing again. The snowfall rate r (in inches per hour) is given by $r(t) = -0.5|t - 4| + 2$ where t is the time (in hours).

a. Graph Graph the function.

b. Interpret When is the snowfall heaviest? What is the maximum snowfall rate? How are your answers related to the function's graph?

c. Extend The total snowfall is given by the area of the triangle formed by the graph of $r(t)$ and the t-axis. What is the total snowfall?

41. MULTIPLE REPRESENTATIONS The diagram shows a truck driving toward a radio station transmitter that has a broadcasting range of 50 miles.



a. Making a Table Make a table that shows the truck's distance d (in miles) from the transmitter after $t = 0$, 0.5, 1, 1.5, 2, 2.5, and 3 hours.

b. Drawing a Graph Use your table from part (a) to draw a graph that shows d as a function of t.

c. Writing an Equation Write an equation that gives d as a function of t. During what driving times is the truck within range of the transmitter?

42. CHALLENGE A hiker walks up and down a hill. The hill has a cross section that can be modeled by $y = -\frac{4}{3}|x - 300| + 400$ where x and y are measured in feet and $0 \le x \le 600$. How far does the hiker walk?

MIXED REVIEW

PREVIEW
Prepare for Lesson 2.8 in Exs. 43–48.

Solve the inequality. Then graph the solution. *(p. 41)*

43. $5x - 17 \ge 13$ **44.** $8 - 3x > -13$ **45.** $2x - 5 < 6x + 9$

46. $4x + 6 \le x - 18$ **47.** $11 \le 2x - 5 \le 25$ **48.** $x + 5 \le -1$ or $x - 3 > 4$

Graph the equation. *(p. 89)*

49. $y = -x + 6$ **50.** $y = -4x + 3$ **51.** $y = 2x - 5$

52. $y = -3$ **53.** $y = 1.5x + 2$ **54.** $y = 3x - 1$

55. DONATIONS The number d of donations a charity receives varies directly with the number r of requests it mails. The charity sends out 9500 requests and receives 420 donations. Write an equation that relates r and d. *(p. 107)*

Extension

Use after Lesson 2.7

Use Piecewise Functions

GOAL Evaluate, graph, and write piecewise functions.

Key Vocabulary
- **piecewise function**
- **step function**

A **piecewise function** is defined by at least two equations, each of which applies to a different part of the function's domain. One example of a piecewise function is the absolute value function $f(x) = |x|$, which can be defined by the equations $y = -x$ for $x < 0$ and $y = x$ for $x \geq 0$. Another example is given below.

$$g(x) = \begin{cases} 2x - 1, & \text{if } x \leq 1 \\ 3x + 1, & \text{if } x > 1 \end{cases}$$

The equation $y = 2x - 1$ gives the value of $g(x)$ when x is less than or equal to 1, and the equation $y = 3x + 1$ gives the value of $g(x)$ when x is greater than 1.

EXAMPLE 1 Evaluate a piecewise function

Evaluate the function $g(x)$ above when (a) $x = 1$ and (b) $x = 5$.

Solution

a. $g(x) = 2x - 1$ — **Because $1 \leq 1$, use first equation.**

$g(\mathbf{1}) = 2(\mathbf{1}) - 1 = 1$ — **Substitute 1 for x and simplify.**

b. $g(x) = 3x + 1$ — **Because $5 > 1$, use second equation.**

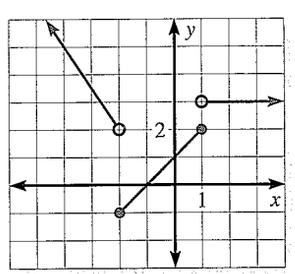
$g(\mathbf{5}) = 3(\mathbf{5}) + 1 = 16$ — **Substitute 5 for x and simplify.**

EXAMPLE 2 Graph a piecewise function

Graph the function $f(x) = \begin{cases} -\frac{3}{2}x - 1, & \text{if } x < -2 \\ x + 1, & \text{if } -2 \leq x \leq 1 \\ 3, & \text{if } x > 1 \end{cases}$

Solution

STEP 1 To the left of $x = -2$, graph $y = -\frac{3}{2}x - 1$. Use an open dot at $(-2, 2)$ because the equation $y = -\frac{3}{2}x - 1$ does not apply when $x = -2$.

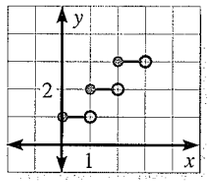


STEP 2 From $x = -2$ to $x = 1$, inclusive, graph $y = x + 1$. Use solid dots at $(-2, -1)$ and $(1, 2)$ because the equation $y = x + 1$ applies to both $x = -2$ and $x = 1$.

STEP 3 To the right of $x = 1$, graph $y = 3$. Use an open dot at $(1, 3)$ because the equation $y = 3$ does not apply when $x = 1$.

EXAMPLE 3 Write a piecewise function

Write a piecewise function for the graph shown.



Solution

For x between 0 and 1, including $x = 0$, the graph is the line segment given by $y = 1$.

For x between 1 and 2, including $x = 1$, the graph is the line segment given by $y = 2$.

For x between 2 and 3, including $x = 2$, the graph is the line segment given by $y = 3$. So, a piecewise function for the graph is as follows:

$$f(x) = \begin{cases} 1, & \text{if } 0 \le x < 1 \\ 2, & \text{if } 1 \le x < 2 \\ 3, & \text{if } 2 \le x < 3 \end{cases}$$

STEP FUNCTIONS The piecewise function in Example 3 is called a **step function** because its graph resembles a set of stairs. A step function is defined by a constant value over each part of its domain. The constant values can increase with each "step" as in Example 3, or they can decrease with each step.

PRACTICE

EXAMPLE 1 on p. 130 for Exs. 1–4

EVALUATING FUNCTIONS **Evaluate the function below for the given value of x.**

$$f(x) = \begin{cases} 9x - 4, & \text{if } x > 3 \\ \frac{1}{2}x + 1, & \text{if } x \le 3 \end{cases}$$

1. $f(-4)$ 2. $f(2)$ 3. $f(3)$ 4. $f(5)$

EXAMPLE 2 on p. 130 for Exs. 5–8

GRAPHING FUNCTIONS **Graph the function.**

5. $f(x) = \begin{cases} 2x + 1, & \text{if } x \ge 0 \\ -x + 1, & \text{if } x < 0 \end{cases}$

6. $g(x) = \begin{cases} -\frac{1}{2}x - 1, & \text{if } x < 2 \\ 3x - 7, & \text{if } x \ge 2 \end{cases}$

7. $h(x) = \begin{cases} 3, & \text{if } 0 < x \le 2 \\ 1, & \text{if } 2 < x \le 4 \\ 5, & \text{if } 4 < x \le 6 \end{cases}$

8. **POSTAL RATES** In 2005, the cost C (in dollars) to send U.S. Postal Service Express Mail up to 5 pounds depended on the weight w (in ounces) according to the function at the right.

$$C(w) = \begin{cases} 13.65, & \text{if } 0 < w \le 8 \\ 17.85, & \text{if } 8 < w \le 32 \\ 21.05, & \text{if } 32 < w \le 48 \\ 24.20, & \text{if } 48 < w \le 64 \\ 27.30, & \text{if } 64 < w \le 80 \end{cases}$$

   a. Graph the function.

   b. What is the cost to send a parcel weighing 2 pounds 9 ounces?

EXAMPLE 3 on p. 131 for Exs. 9–10

SPECIAL STEP FUNCTIONS **Write and graph the piecewise function described using the domain $-3 \le x \le 3$.**

9. **Rounding Function** The output $f(x)$ is the input x rounded to the nearest integer. (If the decimal part of x is 0.5, then x is rounded up when x is positive and x is rounded down when x is negative.)

10. **Greatest Integer Function** The output $f(x)$ is the greatest integer less than or equal to the input x.

ABSOLUTE VALUE INEQUALITIES Graphing an absolute value inequality is similar to graphing a linear inequality, but the boundary is an absolute value graph.

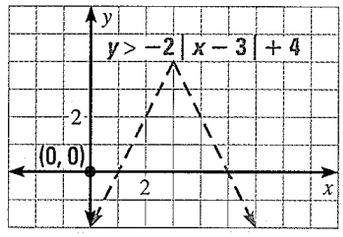
EXAMPLE 5 Graph an absolute value inequality

Graph $y > -2|x - 3| + 4$ in a coordinate plane.

Solution

STEP 1 **Graph** the equation of the boundary, $y = -2|x - 3| + 4$. Use a dashed line because the inequality symbol is >.

STEP 2 **Test** the point (0, 0). Because (0, 0) *is* a solution of the inequality, shade the portion of the coordinate plane outside the absolute value graph.



✓ GUIDED PRACTICE for Examples 4 and 5

11. WHAT IF? Repeat the steps of Example 4 if each student group is allotted up to 420 MB of video space.

Graph the inequality in a coordinate plane.

12. $y \leq |x - 2| + 1$ **13.** $y \geq -|x + 3| - 2$ **14.** $y < 3|x - 1| - 3$

2.8 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS4 for Exs. 15, 25, and 45

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 21, 28, 39, 40, 41, 46, and 48

SKILL PRACTICE

1. VOCABULARY Copy and complete: The graph of a linear inequality in two variables is a(n) ___?___.

2. ★ WRITING *Compare* the graph of a linear inequality in two variables with the graph of a linear equation in two variables.

EXAMPLE 1 on p. 132 for Exs. 3–6

CHECKING SOLUTIONS Tell whether the given ordered pairs are solutions of the inequality.

3. $x > -7$; (0, 10), (−8, −5)

4. $y \leq -5x$; (3, 2), (−2, 1)

5. $y \geq -2x + 4$; (0, 4), (−1, 8)

6. $2x - y < 3$; (0, 0), (2, −2)

EXAMPLES 2 and 3 on p. 133 for Exs. 7–20

GRAPHING INEQUALITIES Graph the inequality in a coordinate plane.

7. $x < 3$ **8.** $x \geq 6$ **9.** $y > -2$

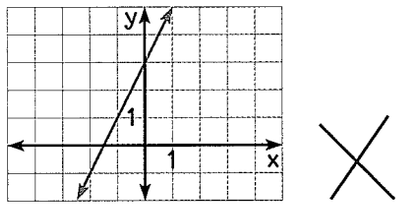
10. $-2y \leq 8$ **11.** $y \leq -2x - 1$ **12.** $y < 3x + 3$

13. $y > \frac{3}{4}x + 1$ **14.** $y \geq -\frac{2}{3}x - 2$ **15.** $2x + y < 6$

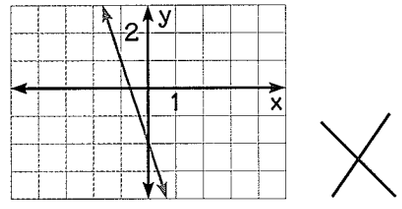
16. $x + 4y > -12$ **17.** $3x - y \geq 1$ **18.** $2x + 5y \leq -10$

ERROR ANALYSIS *Describe* **and correct the error in graphing the inequality.**

19. $y < 2x + 3$



20. $y \geq -3x - 2$



21. ★ **MULTIPLE CHOICE** Which ordered pair is *not* a solution of $3x - 5y < 30$?

Ⓐ $(0, 0)$ Ⓑ $(-1, 7)$ Ⓒ $(1, -7)$ Ⓓ $(-5, -5)$

EXAMPLE 5 on p. 135 for Exs. 22–28

ABSOLUTE VALUE INEQUALITIES **Graph the inequality in a coordinate plane.**

22. $y > |x - 1|$

23. $y < |x| + 5$

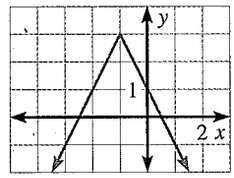
24. $y > |x + 4| - 3$

25. $y \leq -\frac{1}{2}|x - 2| + 1$

26. $y < 3|x| + 2$

27. $y \geq 2|x - 1| - 4$

28. ★ **MULTIPLE CHOICE** The graph of which inequality is shown?



Ⓐ $y \leq -2|x + 1| + 3$ Ⓑ $y \geq -2|x - 1| + 3$

Ⓒ $y > -2|x + 1| + 3$ Ⓓ $y \geq -2|x + 1| + 3$

CHECKING SOLUTIONS **Tell whether the given ordered pairs are solutions of the inequality.**

29. $y \geq -\frac{2}{3}x + \frac{1}{2}$; $(-6, 8)$, $(-3, -3)$

30. $4.5 + y < 1.6x$; $(0.5, 1)$, $(3.8, 0)$

31. $0.2x + 0.7y > -1$; $(0.5, -1)$, $(-3, -1.5)$

32. $\frac{1}{4}x - y > 1$; $\left(\frac{4}{3}, 0\right)$, $\left(\frac{2}{3}, -4\right)$

GRAPHING INEQUALITIES **Graph the inequality in a coordinate plane.**

33. $3y < 4.5x + 15$

34. $-1.5y - 2x > 3$

35. $-y - 0.2 > -0.6x$

36. $\frac{2}{3}x + \frac{1}{2}y > 2$

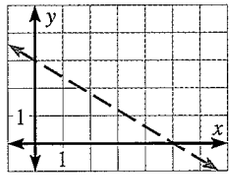
37. $y \geq -\frac{5}{2}|x - 3| - \frac{3}{2}$

38. $2y - 4 \leq -3|x + 2|$

39. ★ **OPEN-ENDED MATH** Write a linear inequality in two variables that has $(-1, 3)$ and $(1, 6)$ as solutions, but does not have $(4, 0)$ as a solution.

40. ★ **WRITING** *Explain* why it is not helpful when graphing a linear inequality in two variables to choose a test point that lies on the boundary line.

41. ★ **SHORT RESPONSE** Write an inequality for the graph shown. *Explain* how you came up with the inequality. Then describe a real-life situation that the first-quadrant portion of the graph could represent.



42. **CHALLENGE** Write an absolute value inequality that has exactly one solution in common with $y \geq 2|x - 3| + 5$. The common solution should not be the vertex $(3, 5)$ of the boundary. *Explain* how you found your inequality.

PROBLEM SOLVING

EXAMPLE 4 on p. 134 for Exs. 43–48

43. CALLING CARDS You have a $20 phone card. Calls made using the card cost $.03 per minute to destinations within the United States and $.06 per minute to destinations in Brazil. Write an inequality describing the numbers of minutes you can use for calls to U.S. destinations and to Brazil.

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44. RESTAURANT MANAGEMENT A pizza shop has 300 pounds (4800 ounces) of dough. A small pizza uses 12 ounces of dough and a large pizza uses 18 ounces of dough. Write and graph an inequality describing the possible numbers of small and large pizzas that can be made. Then give three possible solutions.

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45. CRAFTS Cotton lace costs $1.50 per yard and linen lace costs $2.50 per yard. You plan to order at most $75 of lace for crafts. Write and graph an inequality describing how much of each type of lace you can order. If you buy 24 yards of cotton lace, what are the amounts of linen lace you can buy?

46. ★ SHORT RESPONSE You sell T-shirts for $15 each and caps for $10 each. Write and graph an inequality describing how many shirts and caps you must sell to exceed $1800 in sales. *Explain* how you can modify this inequality to describe how many shirts and caps you must sell to exceed $600 in *profit* if you make a 40% profit on shirts and a 30% profit on caps.

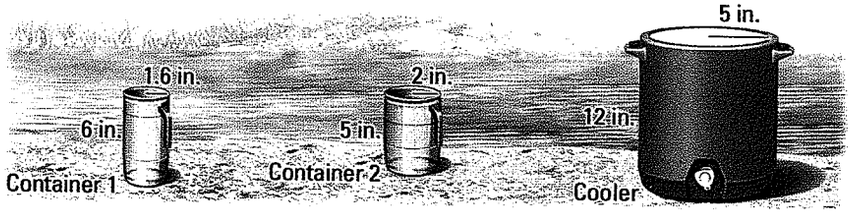
47. MULTI-STEP PROBLEM On a two week vacation, you and your brother can rent one canoe for $11 per day or rent two mountain bikes for $13 each per day. Together, you have $120 to spend.

a. Write and graph an inequality describing the possible numbers of days you and your brother can canoe or bicycle together.

b. Give three possible solutions of the inequality from part (a).

c. You decide that on one day you will canoe alone and your brother will bicycle alone. Repeat parts (a) and (b) using this new condition.

48. ★ EXTENDED RESPONSE While camping, you and a friend filter river water into two cylindrical containers with the radii and heights shown. You then use these containers to fill the water cooler shown.



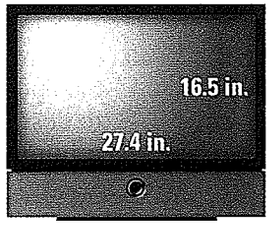
a. Find the volumes of the containers and the cooler in cubic inches.

b. Using your results from part (a), write and graph an inequality describing how many times the containers can be filled and emptied into the water cooler without the cooler overflowing.

c. Convert the volumes from part (a) to gallons (1 in.^{3} $\approx$ 0.00433 gal). Then rewrite the inequality from part (b) in terms of these converted volumes.

d. Graph the inequality from part (c). *Compare* the graph with your graph from part (b), and explain why the results make sense.

49. CHALLENGE A widescreen television image has a width w and a height h that satisfy the inequality $\frac{w}{h} > \frac{4}{3}$.



a. Does the television screen shown at the right meet the requirements of a widescreen image?

b. Let d be the length of a diagonal of a television image. Write an inequality describing the possible values of d and h for a widescreen image.

MIXED REVIEW

Look for a pattern in the table. Then write an equation that represents the table. *(p. 34)*

50.

x	0	1	2	3
y	11	15	19	23

51.

x	0	1	2	3
y	60	45	30	15

PREVIEW
Prepare for Lesson 3.1 in Exs. 52–57.

Graph the equation. *(p. 89)*

52. $x + 3y = -6$ **53.** $4x - 3y = 15$ **54.** $8x - 6y = 18$

55. $6x + 9y = 18$ **56.** $-2x - 5y = 20$ **57.** $-10x + 4y = 20$

Write an equation of the line that satisfies the given conditions. *(p. 98)*

58. $m = \frac{4}{5}$, passes through $(10, -2)$ **59.** $m = -3$, passes through $(3, 7)$

60. passes through $(0, 2)$ and $(5, 8)$ **61.** passes through $(4, -1)$ and $(7, -6)$

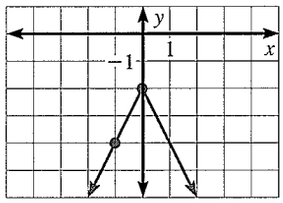
QUIZ for Lessons 2.7–2.8

Graph the function. *Compare* the graph with the graph of $y = |x|$. *(p. 123)*

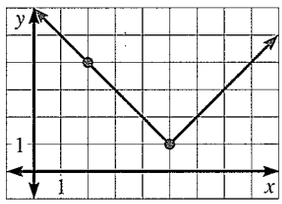
1. $y = |x + 7| + 4$ **2.** $y = -2|x + 10| - 1$ **3.** $f(x) = \frac{1}{2}|x - 1| - 5$

Write an equation of the graph. *(p. 123)*

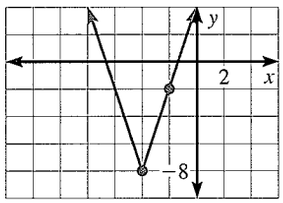
4.



5.



6.



Graph the inequality in a coordinate plane. *(p. 132)*

7. $y > -2$ **8.** $y \leq 3x + 1$ **9.** $2x - 5y \geq 10$

10. MINI-CARS You have a 20 credit gift pass to a mini-car raceway. It takes 2 credits to drive the cars on the Rally track and 3 credits to drive the cars on the Grand Prix track. Write and graph an inequality describing how many times you can race on the two tracks using your gift pass. Then give three possible solutions. *(p. 132)*

MIXED REVIEW of Problem Solving

STATE TEST PRACTICE
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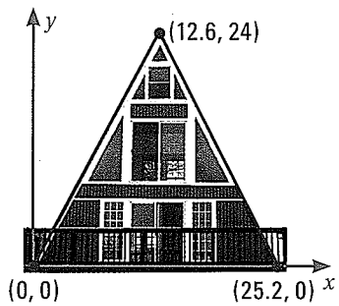
Lessons 2.5–2.8

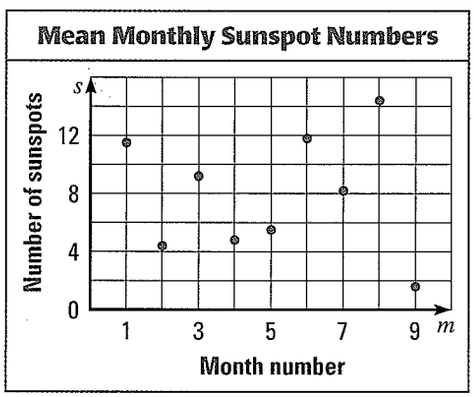
1. **MULTI-STEP PROBLEM** A greenhouse sells marigolds for $2 each and dahlias for $3 each. You have a total of $30 to spend.
   a. Write an inequality describing the numbers of marigolds and dahlias you can buy.
   b. Graph the inequality from part (a).
   c. What is the greatest number of marigolds you can buy if you buy 5 dahlias?

2. **MULTI-STEP PROBLEM** An "A-frame" house is shown below. The coordinates x and y are both measured in feet.



   a. Write an absolute value function that models the front of the house.
   b. Rewrite your function from part (a) with the origin at the midpoint of the house's base.

3. **SHORT RESPONSE** Tell whether the data points show a positive correlation, a negative correlation, or approximately no correlation. *Explain* your reasoning.



4. **OPEN-ENDED** Use the symbol < or > to write a linear inequality in two variables that has (1, −5) and (7, −8) as solutions.

5. **SHORT RESPONSE** Tell whether the data show direct variation. *Explain.*

Monthly Internet Service	
Subscription time, x (months)	Total cost, y (dollars)
1	10.95
2	21.90
3	32.85
4	43.80
5	54.75

6. **EXTENDED RESPONSE** The table shows the number of daily newspapers printed in the United States and their daily circulation at 20 year intervals from 1900 to 2000.

Year	Newspapers	Circulation (millions)
1900	2226	15.1
1920	2042	27.8
1940	1878	41.1
1960	1763	58.9
1980	1745	62.2
2000	1480	55.8

   a. Draw a scatter plot of the data pairs (years since 1900, newspapers).
   b. Approximate the best-fitting line for the scatter plot from part (a).
   c. Use your model from part (b) to predict the number of daily newspapers in 2020.
   d. Draw a scatter plot of the data pairs (years since 1900, circulation). Is it reasonable to use a linear model to predict the circulation in 2020? *Explain.*

7. **GRIDDED ANSWER** You are selling sandwiches to raise money for a class trip. Your daily sales s (in dollars) increase steadily for the first few days and then decrease as given by the function $s(t) = -15|t - 5| + 180$ where t is the time (in days). What was the maximum amount of money you raised in one day?

2 CHAPTER SUMMARY

Animated Algebra
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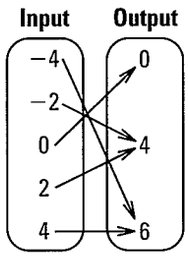
Electronic Function Library

BIG IDEAS — For Your Notebook

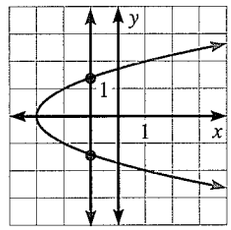
Big Idea 1

Representing Relations and Functions

A relation pairs input values with output values. A relation is a function if each input value is paired with exactly one output value.



This relation is a function because each input has exactly one output.

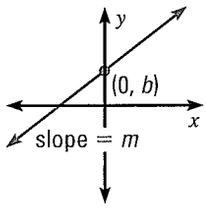


This relation is not a function because a vertical line intersects the graph at more than one point.

Big Idea 2

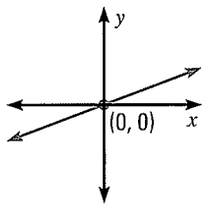
Graphing Linear Equations and Inequalities in Two Variables

Linear Function



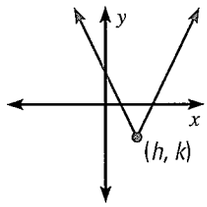
$y = mx + b$

Direct Variation Equation



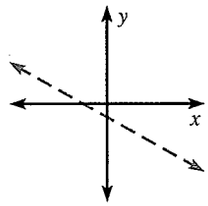
$y = ax$

Absolute Value Function



$y = a|x - h| + k$

Linear Inequality



$Ax + By > C$

Big Idea 3

Writing Linear Equations and Inequalities in Two Variables

Form	Equation	Key Facts
Slope-intercept form	$y = mx + b$	The graph is a line with slope m and y-intercept b.
Standard form	$Ax + By = C$	The graph is a line with intercepts $x = \frac{C}{A}$ and $y = \frac{C}{B}$.
Point-slope form	$y - y_1 = m(x - x_1)$	The graph is a line that has slope m and passes through (x_1, y_1).
Direct variation	$y = ax, a \neq 0$	The graph is a line that passes through the origin and has slope a (the constant of variation).
Linear inequality	$Ax + By > C$	The graph is a half-plane with boundary line $Ax + By = C$.

2 CHAPTER REVIEW

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- Multi-Language Glossary
- Vocabulary practice

REVIEW KEY VOCABULARY

- relation, *p. 72*
- domain, range, *p. 72*
- function, *p. 73*
- equation in two variables, *p. 74*
- solution, graph of an equation in two variables, *p. 74*
- independent variable, *p. 74*
- dependent variable, *p. 74*
- linear function, *p. 75*
- function notation, *p. 75*
- slope, *p. 82*
- parallel, perpendicular, *p. 84*
- rate of change, *p. 85*
- parent function, *p. 89*
- *y*-intercept, *p. 89*
- slope-intercept form, *p. 90*
- *x*-intercept, *p. 91*
- standard form of a linear equation, *p. 91*
- point-slope form, *p. 98*
- direct variation, *p. 107*
- constant of variation, *p. 107*
- scatter plot, *p. 113*
- positive correlation, *p. 113*
- negative correlation, *p. 113*
- correlation coefficient, *p. 114*
- best-fitting line, *p. 114*
- absolute value function, *p. 123*
- vertex of an absolute value graph, *p. 123*
- transformation, *p. 123*
- translation, *p. 123*
- reflection, *p. 124*
- linear inequality in two variables, *p. 132*
- solution, graph of a linear inequality in two variables, *p. 132*
- half-plane, *p. 132*

VOCABULARY EXERCISES

1. Copy and complete: The linear equation $5x - 4y = 16$ is written in __?__ form.
2. Copy and complete: A set of data pairs (x, y) shows a __?__ correlation if y tends to decrease as x increases.
3. Copy and complete: Two variables x and y show __?__ if $y = ax$ and $a \neq 0$.
4. **WRITING** *Explain* what distinguishes a function from a relation.

REVIEW EXAMPLES AND EXERCISES

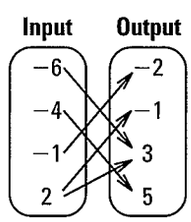
Use the review examples and exercises below to check your understanding of the concepts you have learned in each lesson of Chapter 2.

2.1 Represent Relations and Functions *pp. 72–79*

EXAMPLE

Tell whether the relation given by the ordered pairs (−6, 3), (−4, 5), (−1, −2), (2, −1), and (2, 3) is a function.

The relation is *not* a function because the input 2 is mapped onto both −1 and 3, as shown in the mapping diagram.



EXERCISES

EXAMPLES 1, 2, and 5 on pp. 72–75 for Exs. 5–7

Consider the relation given by the ordered pairs. Identify the domain and range. Then tell whether the relation is a function.

5. (−2, −2), (−1, 0), (2, 6), (3, 8)
6. (−1, −5), (1, 2), (3, 4), (1, −7)
7. Tell whether $f(x) = 16 - 7x$ is a linear function. Then find $f(-5)$.

2 CHAPTER REVIEW

2.2 Find Slope and Rate of Change

pp. 82–88

EXAMPLE

Find the slope m of the line passing through the points $(-4, 12)$ and $(3, -2)$.

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{-2 - 12}{3 - (-4)} = \frac{-14}{7} = -2$$

EXERCISES

EXAMPLE 2 on p. 82 for Exs. 8–11

Find the slope of the line passing through the given points.

8. $(-2, -1), (4, 3)$ **9.** $(1, -5), (1, 2)$ **10.** $(5, -3), (1, 7)$ **11.** $(6, 2), (-8, 2)$

2.3 Graph Equations of Lines

pp. 89–96

EXAMPLE

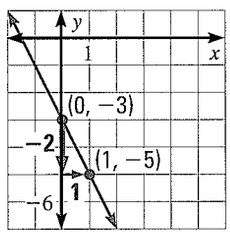
Graph $3 + y = -2x$.

STEP 1 Write the equation in slope-intercept form, $y = -2x - 3$.

STEP 2 The y-intercept is -3. So, plot the point $(0, -3)$.

STEP 3 The slope is -2. Plot a second point by starting at $(0, -3)$ and then moving down 2 units and right 1 unit.

STEP 4 Draw a line through the two points.



EXERCISES

EXAMPLES 1, 2, and 4 on pp. 89–92 for Exs. 12–15

Graph the equation.

12. $y = 5 - x$ **13.** $y - 5x = -4$ **14.** $x = 4$ **15.** $6x - 4y = 12$

2.4 Write Equations of Lines

pp. 98–104

EXAMPLE

Write an equation of the line that passes through $(-2, 5)$ and $(-4, -1)$.

The slope is $m = \frac{-1 - 5}{-4 - (-2)} = 3$. Use the point-slope form with $(x_1, y_1) = (-2, 5)$.

$y - y_1 = m(x - x_1)$ **Use point-slope form.**

$y - 5 = 3(x - (-2))$ **Substitute for m, x_1, and y_1.**

$y = 3x + 11$ **Write in slope-intercept form.**

EXERCISES

EXAMPLE 4 on p. 100 for Exs. 16–18

Write an equation of the line that passes through the given points.

16. $(-3, 4), (2, -6)$ **17.** $(-4, 5), (12, -7)$ **18.** $(-4, 1), (3, -6)$

2.5 Model Direct Variation

pp. 107–111

EXAMPLE

The variables x and y vary directly, and $y = 76$ when $x = -8$. Write an equation that relates x and y. Then find y when $x = -6$.

$y = ax$ **Write direct variation equation.**

$76 = a(-8)$ **Substitute 76 for y and -8 for x.**

$-9.5 = a$ **Solve for a.**

An equation that relates x and y is $y = -9.5x$. When $x = -6$, $y = -9.5(-6) = 57$.

EXERCISES

EXAMPLE 2 on p. 108 for Exs. 19–22

The variables x and y vary directly. Write an equation that relates x and y. Then find y when $x = 3$.

19. $x = 6, y = -48$ **20.** $x = -9, y = 15$ **21.** $x = -3, y = 2.4$

22. PHYSICS Charles's Law states that when pressure is constant, the volume V of a gas varies directly with its temperature T (in kelvins). A gas occupies 4.8 liters at a temperature of 300 kelvins. Write an equation that gives V as a function of T. What is the volume of the gas when the temperature is 420 kelvins?

2.6 Draw Scatter Plots and Best-Fitting Lines

pp. 113–120

EXAMPLE

The table shows the shoe size x and height y (in inches) for 7 men. Approximate the best-fitting line for the data.

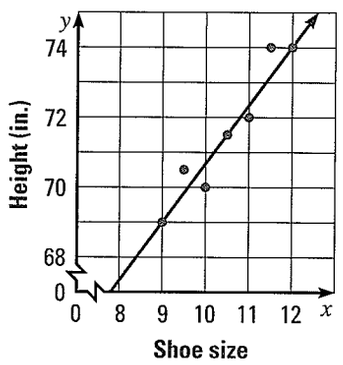
x	9	9.5	10	10.5	11	11.5	12
y	69	70.5	70	71.5	72	74	74

Draw a scatter plot and sketch the line that appears to best fit the data points.

Choose two points on the line, such as (9, 69) and (12, 74). Use the points to find an equation of the line.

The slope is $m = \frac{74 - 69}{12 - 9} = \frac{5}{3} \approx 1.67$.

An equation is $y - 69 = 1.67(x - 9)$, or $y = 1.67x + 54$.



EXERCISES

EXAMPLE 3 on p. 115 for Ex. 23

Approximate the best-fitting line for the data.

23.

x	−2	−1	0	1	2	3	4	5
y	4	3	2.5	2	0.5	−1	−2	−3

2 CHAPTER REVIEW

2.7 Use Absolute Value Functions and Transformations

pp. 123–129

EXAMPLE

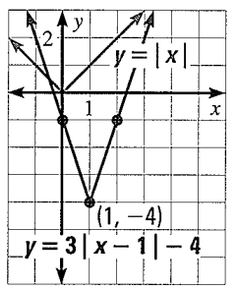
Graph $y = 3|x - 1| - 4$. Compare the graph with the graph of $y = |x|$.

STEP 1 **Identify** and plot the vertex, $(h, k) = (1, -4)$.

STEP 2 **Plot** another point on the graph, such as $(0, -1)$. Use symmetry to plot a third point, $(2, -1)$.

STEP 3 **Connect** the points with a V-shaped graph.

STEP 4 **Compare** with $y = |x|$. The graph of $y = 3|x - 1| - 4$ is the graph of $y = |x|$ stretched vertically by a factor of 3, then translated right 1 unit and down 4 units.



EXERCISES

EXAMPLES 1, 2, 3, and 4 on pp. 123–125 for Exs. 24–27

Graph the function. *Compare* the graph to the graph of $y = |x|$.

24. $y = |x - 3| + 2$ **25.** $y = \frac{3}{4}|x|$ **26.** $f(x) = -4|x + 2| + 3$

27. FINANCE Analysts predict that a company will report earnings of \$1.50 per share in the next quarter. The function $d = |a - 1.50|$ gives the absolute difference d between the actual earnings a and the predicted earnings. Graph the function. For what value(s) of a will d be \$.25?

2.8 Graph Linear Inequalities in Two Variables

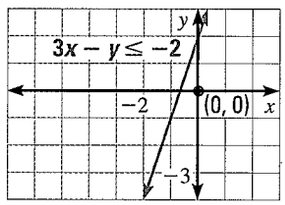
pp. 132–138

EXAMPLE

Graph $3x - y \leq -2$ in a coordinate plane.

STEP 1 **Graph** the boundary line $3x - y = -2$. Use a solid line because the inequality symbol is $\leq$.

STEP 2 **Test** the point $(0, 0)$. Because $(0, 0)$ is *not* a solution of the inequality, shade the half-plane that does not contain $(0, 0)$.



EXERCISES

EXAMPLES 2, 3, and 4 on pp. 132–134 for Exs. 28–34

Tell whether the given ordered pair is a solution of the inequality.

28. $-y \leq 5x$; $(0, 1)$ **29.** $y > -3x - 7$; $(-4, 6)$ **30.** $3x - 4y < -8$; $(-2, 0)$

Graph the inequality in a coordinate plane.

31. $-4y < 16$ **32.** $y - 2x > 8$ **33.** $12x - 8y \leq 24$

34. WIND ENERGY An electric company buys energy from "windmill farms" that have windmills of two sizes, one producing 1.5 megawatts of power and one producing 2.5 megawatts of power. The company wants a total power supply of at least 180 megawatts. Write and graph an inequality describing how many of each size of windmill it takes to supply the electric company.

2 CHAPTER TEST

In Exercises 1 and 2, tell whether the relation is a function. *Explain.*

1. $(1, -5), (0, 4), (2, 3), (-1, 2), (2, 7), (1, 2)$

2. $(-3, 4), (2, 5), (1, 0), (0, 4), (-2, -3), (3, 6)$

3. Evaluate $f(x) = 3x^2 - 2x + 11$ when $x = -6$.

Find the slope of the line passing through the given points. Then tell whether the line *rises*, *falls*, *is horizontal*, or *is vertical*.

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

5. $(6, -7), (13, -7)$

6. $(-2, 1), (1, -4)$

7. $(-4, 9), (-4, 8)$

Graph the equation.

8. $x = 4$

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

10. $x + 2y = 6$

11. $3y = 2x - 12$

Write an equation of the line that passes through the given point and satisfies the given condition.

12. $(9, -1)$; parallel to $y = -\frac{1}{3}x - 8$

13. $(10, 2)$; perpendicular to $y = -5x + 7$

The variables x and y vary directly. Write an equation that relates x and y. Then find x when $y = 6$.

14. $x = 4, y = -8$

15. $x = -2, y = -1$

16. $x = 8, y = 18$

17. $x = 16, y = -6$

In Exercises 18 and 19, (a) draw a scatter plot of the data, (b) approximate the best-fitting line for the data, and (c) estimate the value of y when $x = 10$.

18.

x	1	2	3	4	5
y	18	40	55	73	91

19.

x	1	2	3	4	5
y	97	91	87	81	75

20. Graph $y = -3|x + 1| + 3$. *Compare* the graph with the graph of $y = |x|$.

Graph the inequality in a coordinate plane.

21. $y \geq -2x + 4$

22. $2x - 4y \leq 16$

23. $y < |x - 3| + 1$

24. $y > -2|x| - 3$

25. TIRE WEAR A new set of car tires has a tread depth of 8 millimeters. The tread depth decreases 0.12 millimeter per thousand miles driven. Write an equation that gives the tread depth as a function of the distance driven. Then predict at what distance the tread depth will be 2 millimeters.

26. PAINTING The amount of paint an electric paint sprayer applies varies directly with time. A sprayer is set to apply 0.5 gallon in 2.5 minutes. Write an equation that gives the amount p of paint as a function of the time t. How much paint is applied if the sprayer is operated for 20 minutes?

27. COMPUTER CHIPS The table shows the number x of transistors (in millions) and the speed y (in gigahertz) for several computer processors. Approximate the best-fitting line for the data.

x	3.1	9.5	28	37	42	55	106	125
y	0.06	0.45	0.5	1.5	1.5	2	2.4	3.6