

✓ CHECK Your Understanding

Examples 1–4 Write an inequality for each sentence.
(p. 243)

- Your speed must be 55 miles per hour or less.
- The game is recommended for ages greater than 6.

Examples 5 and 6 State whether each inequality is *true* or *false* for the given value.
(p. 244)

- $x - 11 < 9$, $x = 20$
- $42 \geq 6a$, $a = 8$
- $\frac{n}{3} + 1 \leq 6$, $n = 15$

Examples 7 and 8 Graph each inequality on a number line.
(p. 244)

- $n > 4$
- $p \leq 2$
- $x \geq 0$
- $a < 7$

Practice and Problem Solving

 = Step-by-Step Solutions begin on page R20.
Extra Practice is on page EP14.

Examples 1–4 Write an inequality for each sentence.
(p. 243)

- To be a U.S. senator, you must be 30 years of age or older.
- For a group of 10 or more, an 18% tip is already included.
- The maximum occupancy must be less than 512 people.
- The phone costs no more than \$25.
- You must spend more than \$50 to receive a discount.
- The heavyweight division is greater than 200 pounds.

Examples 5 and 6 State whether each inequality is *true* or *false* for the given value.
(p. 244)

- $12 + a < 20$, $a = 9$
- $15 - k > 6$, $k = 8$
- $-3y < 21$, $y = 8$
- $32 \leq 2x$, $x = 16$
- $\frac{n}{4} \geq 5$, $n = 12$
- $\frac{-18}{x} > 9$, $x = -2$

Examples 7 and 8 Graph each inequality on a number line.
(p. 244)

- $x > 6$
- $a > 0$
- $y < 8$
- $h < 2$
- $w \leq 3$
- $p \geq 7$
- $1 \leq n$
- $4 \geq d$

30. SPORTS The graph shows the number of children ages 5–14 recently treated in U.S. emergency rooms.

- In which sport(s) were more than 150,000 children injured?
- In which sport(s) were at least 75,000 children injured?
- Of the sports listed, which have fewer than 125,000 injuries?
- Write an inequality comparing the number treated for soccer-related injuries with those treated for football-related injuries.

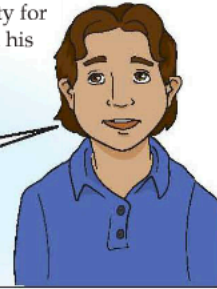




H.O.T. Problems

31. **FIND THE ERROR** Roberto is writing an inequality for the expression *at least 2 hours of homework*. Find his mistake and correct it.

$$h \leq 2$$



32. **CHALLENGE** If $x = 3$, is the following inequality *true* or *false*? Explain.

$$\frac{108}{12} + x \geq 15 - 4x + 9$$

33. **Write MATH** If $a < b$ and $b < c$, what is true about the relationship between a and c ? Explain your reasoning and give examples using both positive and negative values for a , b , and c .

NGSSS Practice

MA.8.A.4.2

34. Conner can spend no more than 4 hours at the swimming pool today. Which graph represents the time that Conner can spend at the pool?

$$t \leq 4$$



35. Which inequality matches the sentence below?

Members must be 18 years of age or older.

- E. $m > 18$
 G. $m \geq 18$
 H. $m < 18$
 I. $m \leq 18$

36. **SHORT RESPONSE** Graph the inequality $x < -8$ on a number line.

Spiral Review

37. **SHOPPING** Marisa bought 4 paperback books, each at the same price. The tax on her purchase was \$2.35, and the total was \$34.15. Write and solve an equation to find the price of each book. (Lesson 4-2C)

ALGEBRA Solve each equation. (Lesson 4-2B)

38. $9 + 5y = 19$

39. $-6 = 4 + 2x$


40. $8 - k = 17$

41. $2 = 18 - 4d$

**Main Idea**

Solve and graph one-step inequalities by using the Addition or Subtraction Properties of Inequality.

NGSSS

 **MA.8.A.4.2** Solve and graph one- and two-step inequalities in one variable.



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Solve Inequalities by Addition or Subtraction

WEATHER The temperature at 7 A.M. in three Florida cities is shown. The temperature in Miami is less than the temperature in Jacksonville.



Temperature (°F)	
Jacksonville	82°
Miami	78°
Tampa	76°

- If the temperature rises 5° in both cities, will this still be true?
- Would it be colder in Tampa or Jacksonville if the temperature in both cities dropped 10° ? Explain.

The examples above demonstrate properties of inequalities.

**Key Concept****Properties of Inequality**

Words When you add or subtract the same number from each side of an inequality, the inequality remains true.

Symbols For all numbers, a , b , and c ,

- if $a > b$, then $a + c > b + c$ and $a - c > b - c$.
- if $a < b$, then $a + c < b + c$ and $a - c < b - c$.

Examples

$2 > -3$	$3 < 8$
$2 + 5 > -3 + 5$	$3 - 4 < 8 - 4$
$7 > 2$ ✓	$-1 < 4$ ✓

These properties are also true for $a \geq b$ and $a \leq b$.

Solving an inequality means finding values that make the inequality true.

EXAMPLES Solve Inequalities

- Solve $n - 8 < 15$. Graph the solution set on a number line.

$$n - 8 < 15 \quad \text{Write the inequality.}$$

$$\underline{+ 8} \quad \underline{+ 8} \quad \text{Addition Property of Inequality}$$

$$n < 23 \quad \text{Simplify.}$$

Graph the solution set.

**Study Tip**

Checking Solutions To check the solution of an inequality, replace the variable with a value that satisfies the solution. In Example 1, replace n with 22.
 $n - 8 < 15$
 $22 - 8 < 15$
 $14 < 15$
 Since $14 < 15$, the statement is true.



Study Tip

Equivalent Inequalities If -11 is greater than or equal to a , then a is less than or equal to -11 .

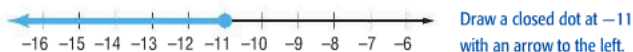


Real-World Link . . .
The Airbus A380 is one of the largest airplanes in the world.

2 Solve $-4 \geq a + 7$. Graph the solution set on a number line.

$$\begin{array}{rcl} -4 \geq a + 7 & & \text{Write the inequality.} \\ \underline{-7 \quad -7} & & \text{Subtraction Property of Inequality} \\ -11 \geq a \text{ or } a \leq -11 & & \text{Simplify.} \end{array}$$

The solution is $a \leq -11$.



CHECK Your Progress

Solve each inequality. Graph the solution set on a number line.

- a. $t + 3 > 12$ b. $n + \frac{1}{2} \geq 4$ c. $y - 1.5 < 2$

Real-World EXAMPLE



3 PLANES The Airbus A380 can seat up to 853 passengers. Suppose there are currently 632 passengers boarded on the airplane. Write and solve an inequality to determine how many more people are able to board.

The phrase *up to* means *less than or equal to*. Let p = the number of passengers left to board.

Estimate $850 - 650 = 200$

Current passengers	plus	passengers left to board	is less than or equal to	853 total passengers.
↓	↓	↓	↓	↓
632	+	p	\leq	853
$632 + p \leq 853$ Write the inequality.				
$\underline{-632 \quad -632}$ Subtraction Property of Inequality				
$p \leq 221$ Simplify.				

Check for Reasonableness $200 \approx 221$ ✓

At most, 221 people are able to board.

CHECK Your Progress

d. **WEATHER** An F1 tornado has wind speeds that are at least 73 miles per hour. An F2 tornado has wind speeds that are at least 113 miles per hour. Write and solve an inequality to determine how much the winds of an F1 tornado need to increase to become at least an F2 tornado.



CHECK Your Understanding

Examples 1 and 2
(pp. 247–248)

Solve each inequality. Graph the solution set on a number line.

1. $b + 5 > 9$ 2. $12 + n \leq 4$ 3. $x - 4 < 10$

Example 3
(p. 248)

4. **WEATHER** Concord, New Hampshire, receives an average of 37 inches of precipitation per year, and there has been 13 inches so far this year. Write and solve an inequality to determine how much more precipitation Concord can get and stay at or below the average.

Practice and Problem Solving

= Step-by-Step Solutions begin on page R20.
Extra Practice is on page EP14.

Examples 1 and 2
(pp. 247–248)

Solve each inequality. Graph the solution set on a number line.

5. $5 + x \leq 18$ 6. $10 + n \geq -2$ 7. $-4 < k + 6$
8. $3 < y + 8$ 9. $c + 10 < 9$ 10. $g - 4 \geq 13$
11. $2 + m \geq 3.5$ 12. $q + 0.8 \leq -0.5$ 13. $v - 6 > 2.7$
14. $p - 4.8 > -6$ 15. $d + 1\frac{2}{3} \leq \frac{1}{2}$ 16. $5 > f + 1\frac{1}{4}$

Example 3
(p. 248)

17. **BASKETBALL** Amos, who is 15 years old, is thinking about joining the City Basketball League. Write and solve an inequality to determine how many years until he is able to join.

18. **ANIMALS** Hippos weigh up to 5,300 pounds. Write and solve an inequality that describes how much weight a young hippo could gain if its current weight is 2,200 pounds.

19. **MULTIPLE REPRESENTATIONS** The inequality $y < x + 1$ is a linear inequality.
- WORDS** Use the definition of a linear function to make a conjecture about the definition of a linear inequality.
 - GRAPHS** Graph the function $y = x + 1$. This is the line that determines the inequality. Similar to the open/closed dot, the line will be dashed or solid. Should the graph of this inequality be a dashed or solid line?
 - NUMBERS** Choose a point not on the line and substitute the x - and y -values into the inequality. If the resulting inequality is true, shade the area containing the point. If it is false, shade the area that does not contain the point.
20. **FIND THE DATA** Refer to the Data File on pages 2–5. Choose some data and write a real-world problem in which you would need to solve an inequality using addition or subtraction.

Join the City Basketball League



Division A (ages 18–23)
Division B (ages 24–29)
Division C (ages 30 and up)



H.O.T. Problems

CHALLENGE Determine whether each equation or inequality has no solution, one solution, or more than one solution.

21. $y - y = 0$ 22. $x + 4 = 9$ 23. $x + 4 > 9$ 24. $y > y + 1$

25. **OPEN ENDED** Write two different inequalities that each have the solution $x < 9$. One inequality should be solved using addition properties, and the other should be solved using subtraction properties.

26. **Write MATH** Write a word problem that has the solution $w \leq 200$.



Practice

MA.6.A.3.2, MA.8.A.4.2

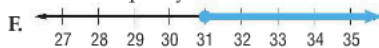
27. **SHORT RESPONSE** Kali has \$80 to go clothes shopping. She spends \$25 on a new shirt. Write an inequality that represents how much money she has left to spend on clothes.

28. The solution set of which inequality is represented in the number line below?



- A. $x + 6 \leq 14$ C. $x + 6 < 14$
B. $x + 6 \geq 14$ D. $x + 6 > 14$

29. Which of the following shows the solution set of the inequality $w + 4 < 35$?



Spiral Review

State whether each inequality is *true* or *false* for the given value. (Lesson 4-3A)

30. $18 - n > 4, n = 11$ 31. $13 + x < 21, x = 8$ 32. $34 \leq 5p, p = 7$

33. **FOOTBALL** In football, a touchdown with an extra point is worth 7 points and a field goal is worth 3 points. The winning team scored 27 points. The score consisted of two field goals, and the rest were touchdowns with extra points. Write and solve an equation to determine how many touchdowns the winning team scored. (Lesson 4-2C)

State the slope and y -intercept for the graph of each equation. (Lesson 3-2A)

34. $y = 3x + 2$ 35. $y = -\frac{x}{2} - 1$ 36. $y = -2x + 4$


37. **MONEY** The table at the right shows how much Julianne earned per paycheck. If she saved 28% of her earnings, how much money did she save? (Lesson 1-2C)

Paycheck	Total Earnings (\$)
1	272
2	298
3	304

**Main Idea**

Solve and graph one-step inequalities by using the Multiplication or Division Properties of Inequality.

NGSSS

 **MA.8.A.4.2** Solve and graph one- and two-step inequalities in one variable.



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Solving Inequalities by Multiplication or Division

COINS Lamar, Oscar, and Nick put the money from their pockets on the table. Lamar has more money than Nick. Will this still be true if each boy spends half of his money?

Name	Money	Amount
Lamar	1 dollar bill, 2 quarters, 2 dimes	\$1.70
Oscar	1 dollar bill, 3 quarters, 1 dime, 1 nickel	\$1.90
Nick	5 quarters, 1 dime, 1 nickel	\$1.40

1. Divide each side of the inequality $1.70 > 1.40$ by 2. Is the resulting inequality *true* or *false*?
2. Oscar and Lamar each tripled their money by doing lawn work. Who has more now?

The example above demonstrates additional properties of inequality.

**Key Concept****Properties of Inequality**

Words When you multiply or divide each side of an inequality by a positive number, the inequality remains true.

Symbols For all numbers a , b , and c , where $c > 0$,

1. if $a > b$, then $ac > bc$ and $\frac{a}{c} > \frac{b}{c}$.
2. if $a < b$, then $ac < bc$ and $\frac{a}{c} < \frac{b}{c}$.

Examples

$5 < 8$	$2 > -10$
$4(5) < 4(8)$	$\frac{2}{2} > \frac{-10}{2}$
$20 < 32$	$1 > -5$

These properties are also true for $a \geq b$ and $a \leq b$.

Study Tip

Checking Solutions You can check the solution in Example 1 by substituting numbers greater than -6 into the inequality and testing it to verify that it holds true.

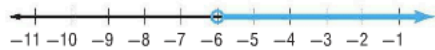
EXAMPLES Solve Inequalities

1. Solve $7y > -42$. Graph the solution set on a number line.

$$7y > -42 \quad \text{Write the inequality.}$$

$$\frac{7y}{7} > \frac{-42}{7} \quad \text{Division Property of Inequality}$$

$$y > -6 \quad \text{Simplify.}$$



Draw an open dot at -6 with an arrow to the right.



2 Solve $\frac{1}{3}x \leq 8$. Graph the solution set on a number line.

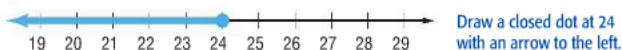
$\frac{1}{3}x \leq 8$ Write the inequality.

$3\left(\frac{1}{3}x\right) \leq 3(8)$ Multiplication Property of Inequality

$x \leq 24$ Simplify.

The solution is $x \leq 24$.

Graph the solution set.



CHECK Your Progress

Solve each inequality. Graph the solution set on a number line.

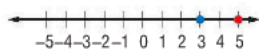
a. $3a \geq 45$

b. $\frac{n}{4} < -16$

c. $81 \leq 9p$

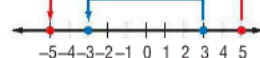
What happens when each side of an inequality is multiplied or divided by a negative number?

Graph 3 and 5 on a number line.



Since 3 is to the left of 5, $3 < 5$.

Multiply each number by -1 .



Since -3 is to the right of -5 , $-3 > -5$.

The numbers being compared switched positions as a result of being multiplied by a negative number. In other words, their order reversed.

Study Tip

Common Error Do not reverse the inequality symbol just because there is a negative sign in the inequality, as in $7y < -42$. Only reverse the inequality symbol when you multiply or divide each side by a negative number.

Key Concept Properties of Inequality

Words When you multiply or divide each side of an inequality by a negative number, the direction of the inequality symbol must be reversed for the inequality to remain true.

Symbols For all numbers a , b , and c , where $c < 0$,

1. if $a > b$, then $ac < bc$ and $\frac{a}{c} < \frac{b}{c}$.

2. if $a < b$, then $ac > bc$ and $\frac{a}{c} > \frac{b}{c}$.

Examples

$8 > 5$		$-3 < 9$
$-1(8) < -1(5)$	Reverse the inequality symbols.	$\frac{-3}{-3} > \frac{9}{-3}$
$-8 < -5$		$1 > -3$

These properties are also true for $a \geq b$ and $a \leq b$.



EXAMPLES Multiply or Divide by a Negative Number

Solve each inequality. Graph the solution set on a number line.

3 $\frac{a}{-2} \geq 8$

$\frac{a}{-2} \geq 8$ Write the inequality.

$-2\left(\frac{a}{-2}\right) \leq -2(8)$ Multiplication Property of Inequality; reverse inequality symbol.

$a \leq -16$ Simplify.



4 $-24 > -6n$

$-24 > -6n$ Write the inequality.

$\frac{-24}{-6} < \frac{-6n}{-6}$ Division Property of Inequality; reverse inequality symbol.

$4 < n$ or $n > 4$ Simplify.



CHECK Your Progress

d. $\frac{c}{-7} < -14$

e. $-5d \geq 30$

f. $-3 \leq \frac{w}{-8}$



Real-World Link

More than 400,000 people participate each year in marathons. The most popular marathon is the New York Marathon.

Real-World EXAMPLE

- 5 **MARATHONS** Dyani is training for a marathon by running no less than 45 kilometers per week. She runs at an average rate of 12 kilometers per hour. Write and solve an inequality to find the minimum number of hours she should run. Interpret the solution.

The phrase *no less than* means *greater than or equal to*. Let h = the number of hours she runs in one week.

$12h \geq 45$ Write the inequality.

$\frac{12h}{12} \geq \frac{45}{12}$ Division Property of Inequality

$h \geq 3.75$ Simplify.

Dyani should run for at least 3.75 hours, or 3 hours 45 minutes, per week.

CHECK Your Progress

- g. **GRADES** Each of the 20 questions on a math test is worth 3 points. Write and solve an inequality to find how many questions you must answer correctly to earn a score of at least 45 points. Interpret the solution.



CHECK Your Understanding

Examples 1–4
(pp. 251–253)

Solve each inequality. Graph the solution set on a number line.

1. $3x > 12$ 2. $\frac{1}{2} > \frac{1}{3}y$ 3. $8x \leq -72$ 4. $\frac{h}{4} \geq -6$
 5. $-4y > 32$ 6. $-56 \leq -7p$ 7. $\frac{g}{-2} < -7$ 8. $\frac{d}{-3} \geq -3$

Example 5
(p. 253)

9. **MUSIC** Monique wants to practice the piano at least 6 hours each week. If she averages 1.5 hours per day, write and solve an inequality to find how many days she will have to practice to have at least 6 hours of practice per week. Interpret the solution.

Practice and Problem Solving

= Step-by-Step Solutions begin on page R21.
Extra Practice is on page EP14.

Examples 1–4
(pp. 251–253)

Solve each inequality. Graph the solution set on a number line.

10. $5x < 15$ 11. $9n \leq 45$ 12. $14k \geq -84$
 13. $-12 > 3g$ 14. $-100 \leq 50p$ 15. $2y < -22$
 16. $\frac{x}{9} \leq -3$ 17. $\frac{n}{7} < -14$ 18. $\frac{m}{-2} < -7$
 19. $\frac{t}{-5} \leq -2$ 20. $-8 \leq \frac{y}{0.2}$ 21. $\frac{-1}{2}k > -10$

Example 5
(p. 253)

22. **GYM MEMBERSHIP** A gym charges \$5 each time you go, or you can buy a yearly membership for \$190. Write and solve an inequality to find how many times a person should use the gym so that a yearly membership is less expensive than paying each time. Interpret the solution.
23. **WORK** Max charges \$6 an hour to rake leaves. He is saving money for shoes that cost \$89. Write and solve an inequality to find how many whole hours Max must work to buy the shoes. Interpret the solution.
24. **GRAPHIC NOVEL** Refer to the graphic novel frame below for Exercises a–b.



- a. In order to win the game, a player must earn 50 points. How many more points does each player need to earn 50 points?
 b. Write and solve an inequality to determine how many questions each player needs to answer correctly to earn a total of 50 points.



H.O.T. Problems

25. **OPEN ENDED** Write an inequality for the following sentence and then solve. Then name three numbers that are possible solutions. Explain.
The quotient of a number and -6 increased by 5 is at most 9 .
26. **CHALLENGE** The product of an integer and -12 is less than -132 . What is the least integer that meets this condition?
27. **Which One Doesn't Belong?** Identify the inequality that does not belong with the other three. Explain your reasoning.
- $-2m < 6$

$-10 > -5x$

$4a < -16$

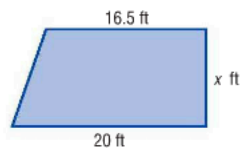
$-b > 12$
28. **Write MATH** Explain when you should reverse the inequality symbol when solving an inequality.



Practice

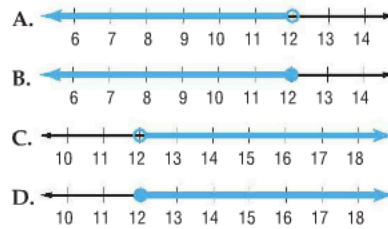
MA.8.A.4.2

29. Which is a possible value of x if the area of the trapezoid is less than 256 square feet?



- A. 14 C. 16
B. 15 D. 17
30. If $3n > 18$, then n could be which of the following values?
E. 2 H. 6
G. 4 I. 8

31. Which of the following shows the solution set of $\frac{x}{-4} \geq -3$?



32. **SHORT RESPONSE** Solve the inequality $\frac{-x}{5} \leq -6$.

Spiral Review

Solve each inequality. Graph the solution set on a number line. (Lesson 4-3B)

33. $y + 7 < 9$

34. $a - 5 < 2$

35. $j - 9 \geq -12$

36. $-14 > 8 + n$

Write an inequality for each sentence. (Lesson 4-3A)

37. A minimum speed on a certain highway is 45 miles per hour.

38. A hummingbird's wings can beat up to 200 times per second.