## Essential Question How can you use a box-and-whisker plot to describe a data set?

**EXPLORATION 1** **Drawing a Box-and-Whisker Plot**

Work with a partner. The numbers of first cousins of the students in a ninth-grade class are shown. A *box-and-whisker plot* is one way to represent the data visually.

Numbers of First Cousins

3	10	18	8
9	3	0	32
23	19	13	8
6	3	3	10
12	45	1	5
13	24	16	14

a. Order the data on a strip of grid paper with 24 equally spaced boxes.

Fold the paper in half to find the median.
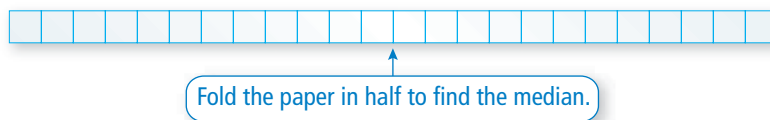
b. Fold the paper in half again to divide the data into four groups. Because there are 24 numbers in the data set, each group should have 6 numbers. Find the least value, the greatest value, the first quartile, and the third quartile.

least value   first quartile   median   third quartile   greatest value
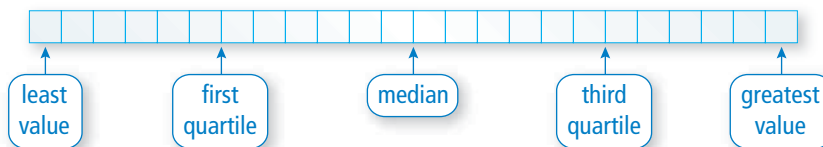
**c.** Explain how the box-and-whisker plot shown represents the data set.
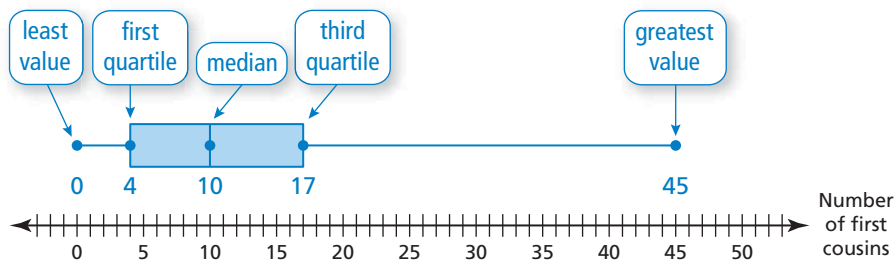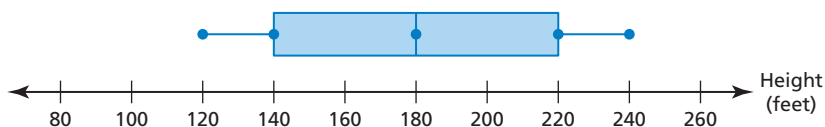
MODELING WITH MATHEMATICS

To be proficient in math, you need to identify important quantities in a practical situation.

Communicate Your Answer

2. How can you use a box-and-whisker plot to describe a data set?

3. Interpret each box-and-whisker plot.

a. body mass indices (BMI) of students in a ninth-grade class
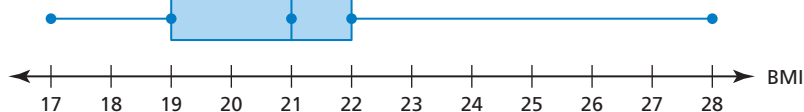
b. heights of roller coasters at an amusement park

What You Will Learn
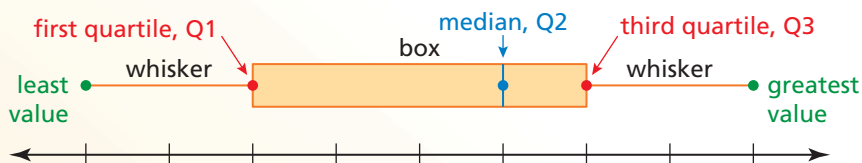
▶ Use box-and-whisker plots to represent data sets.
▶ Interpret box-and-whisker plots.
▶ Use box-and-whisker plots to compare data sets.

Using Box-and-Whisker Plots to Represent Data Sets

Core Concept

Box-and-Whisker Plot

A **box-and-whisker plot** shows the variability of a data set along a number line using the least value, the greatest value, and the *quartiles* of the data. **Quartiles** divide the data set into four equal parts. The median (second quartile, $Q2$) divides the data set into two halves. The median of the lower half is the first quartile, $Q1$. The median of the upper half is the third quartile, $Q3$.

The five numbers that make up a box-and-whisker plot are called the **five-number summary** of the data set.

> **STUDY TIP**
>
> Sometimes, the first quartile is called the *lower quartile* and the third quartile is called the *upper quartile*.
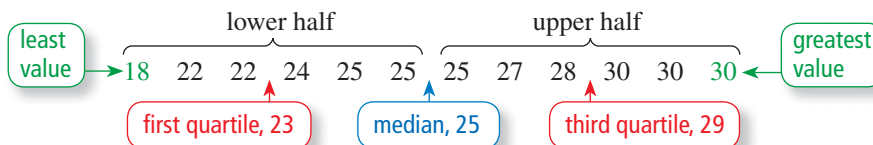
EXAMPLE 1 Making a Box-and-Whisker Plot

Make a box-and-whisker plot that represents the ages of the members of a backpacking expedition in the mountains.
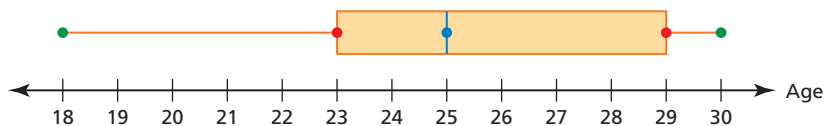
24, 30, 30, 22, 25, 22, 18, 25, 28, 30, 25, 27

SOLUTION

Step 1 Order the data. Find the median and the quartiles.

Step 2 Draw a number line that includes the least and greatest values. Graph points above the number line for the five-number summary.

Step 3 Draw a box using $Q1$ and $Q3$. Draw a line through the median. Draw whiskers from the box to the least and greatest values.

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1. A basketball player scores 14, 16, 20, 5, 22, 30, 16, and 28 points during a tournament. Make a box-and-whisker plot that represents the data.
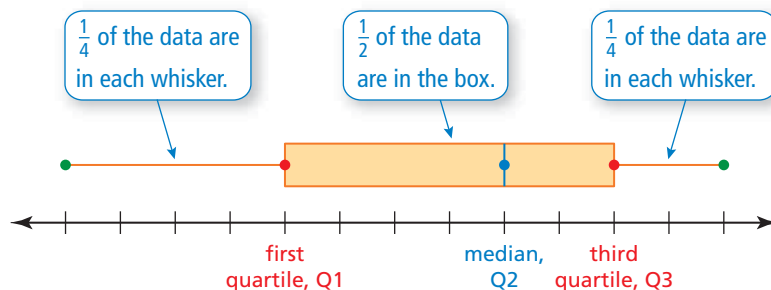
Interpreting Box-and-Whisker Plots

The figure shows how data are distributed in a box-and-whisker plot.

$\frac{1}{4}$ of the data are in each whisker.

$\frac{1}{2}$ of the data are in the box.

$\frac{1}{4}$ of the data are in each whisker.

first quartile, Q1   median, Q2   third quartile, Q3

Another measure of variation for a data set is the **interquartile range** (IQR), which is the difference of the third quartile, Q3, and the first quartile, Q1. It represents the range of the middle half of the data.

EXAMPLE 2   Interpreting a Box-and-Whisker Plot

The box-and-whisker plot represents the lengths (in seconds) of the songs played by a rock band at a concert.
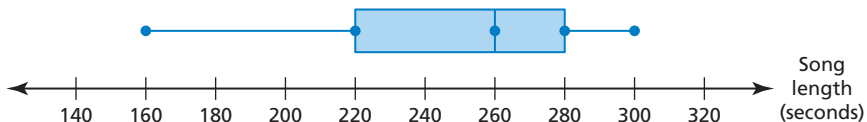
140 160 180 200 220 240 260 280 300 320   Song length (seconds)

a. Find and interpret the range of the data.

b. Describe the distribution of the data.

c. Find and interpret the interquartile range of the data.

d. Are the data more spread out below Q1 or above Q3? Explain.

SOLUTION

a. The least value is 160. The greatest value is 300.

▶ So, the range is $300 - 160 = 140$ seconds. This means that the song lengths vary by no more than 140 seconds.

b. Each whisker represents 25% of the data. The box represents 50% of the data. So,

- 25% of the song lengths are between 160 and 220 seconds.
- 50% of the song lengths are between 220 and 280 seconds.
- 25% of the song lengths are between 280 and 300 seconds.

c. $IQR = Q3 - Q1 = 280 - 220 = 60$

▶ So, the interquartile range is 60 seconds. This means that the middle half of the song lengths vary by no more than 60 seconds.

d. The left whisker is longer than the right whisker.

▶ So, the data below Q1 are more spread out than data above Q3.

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Use the box-and-whisker plot in Example 1.

2. Find and interpret the range and interquartile range of the data.

3. Describe the distribution of the data.

Using Box-and-Whisker Plots to Compare Data Sets

A box-and-whisker plot shows the shape of a distribution.

Core Concept

Shapes of Box-and-Whisker Plots

| Skewed left | Symmetric | Skewed right |

- The left whisker is longer than the right whisker.

- Most of the data are on the right side of the plot.

- The whiskers are about the same length.
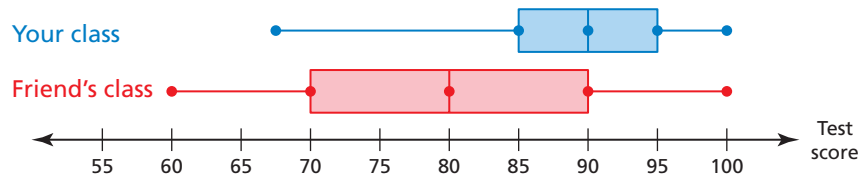
- The median is in the middle of the plot.

- The right whisker is longer than the left whisker.

- Most of the data are on the left side of the plot.

EXAMPLE 3 **Comparing Box-and-Whisker Plots**

The double box-and-whisker plot represents the test scores for your class and your friend's class.


a. Identify the shape of each distribution.

b. Which test scores are more spread out? Explain.

SOLUTION

a. For your class, the left whisker is longer than the right whisker, and most of the data are on the right side of the plot. For your friend's class, the whisker lengths are equal, and the median is in the middle of the plot.

▶ So, the distribution for your class is skewed left, and the distribution for your friend's class is symmetric.

b. The range and interquartile range of the test scores in your friend's class are greater than the range and interquartile range in your class.

▶ So, the test scores in your friend's class are more spread out.

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4. The double box-and-whisker plot represents the surfboard prices at Shop A and Shop B. Identify the shape of each distribution. Which shop's prices are more spread out? Explain.
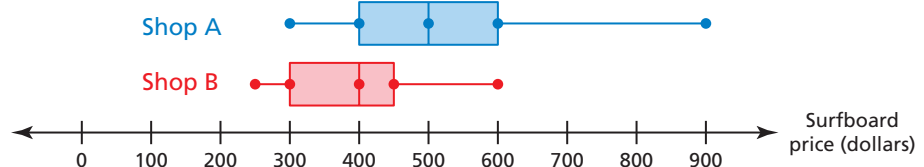
## Vocabulary and Core Concept Check

1. **WRITING** Describe how to find the first quartile of a data set.

2. **DIFFERENT WORDS, SAME QUESTION** Consider the box-and-whisker plot shown. Which is different? Find "both" answers.

   Find the interquartile range of the data.

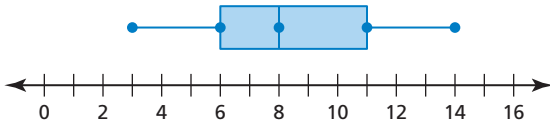   Find the range of the middle half of the data.

   Find the difference of the greatest value and the least value of the data set.

   Find the difference of the third quartile and the first quartile.
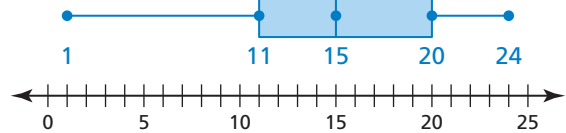
Monitoring Progress and Modeling with Mathematics

In Exercises 3–8, use the box-and-whisker plot to find the given measure.

3. least value
4. greatest value
5. third quartile
6. first quartile
7. median
8. range

In Exercises 9–12, make a box-and-whisker plot that represents the data. *(See Example 1.)*

9. Hours of television watched: 0, 3, 4, 5, 2, 4, 6, 5

10. Cat lengths (in inches): 16, 18, 20, 25, 17, 22, 23, 21

11. Elevations (in feet): $-2, 0, 5, -4, 1, -3, 2, 0, 2, -3, 6$

12. MP3 player prices (in dollars): 124, 95, 105, 110, 95, 124, 300, 190, 114

13. **ANALYZING DATA** The dot plot represents the numbers of hours students spent studying for an exam. Make a box-and-whisker plot that represents the data.
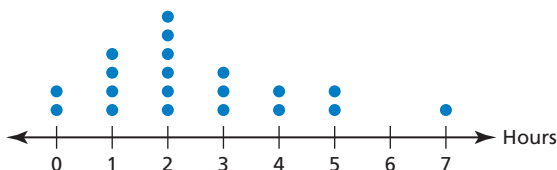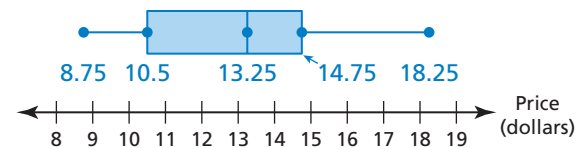
14. **ANALYZING DATA** The stem-and-leaf plot represents the lengths (in inches) of the fish caught on a fishing trip. Make a box-and-whisker plot that represents the data.

| Stem	Leaf
0	6 7 8 8 9
1	0 0 2 2 3 4 4 7
2	1 2

Key: 1|0 = 10 inches

15. **ANALYZING DATA** The box-and-whisker plot represents the prices (in dollars) of the entrées at a restaurant. *(See Example 2.)*

    a. Find and interpret the range of the data.

    b. Describe the distribution of the data.

    c. Find and interpret the interquartile range of the data.

   d. Are the data more spread out below Q1 or above Q3? Explain.

16. ANALYZING DATA A baseball player scores 101 runs in a season. The box-and-whisker plot represents the numbers of runs the player scores against different opposing teams.
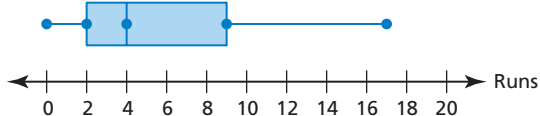
  a. Find and interpret the range and interquartile range of the data.

  b. Describe the distribution of the data.

  c. Are the data more spread out between Q1 and Q2 or between Q2 and Q3? Explain.

17. ANALYZING DATA The double box-and-whisker plot represents the monthly car sales for a year for two sales representatives. *(See Example 3.)*
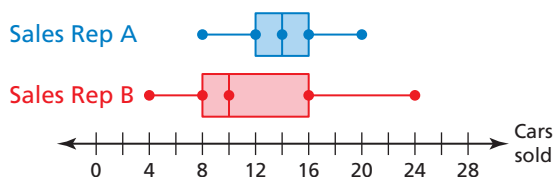

  a. Identify the shape of each distribution.

  b. Which representative's sales are more spread out? Explain.

  c. Which representative had the single worst sales month during the year? Explain.

**18. ERROR ANALYSIS** Describe and correct the error in describing the box-and-whisker plot.
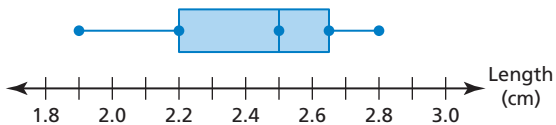
  ✗ The distribution is skewed left. So, most of the data are on the left side of the plot.

19. WRITING Given the numbers 36 and 12, identify which number is the range and which number is the interquartile range of a data set. Explain.

20. HOW DO YOU SEE IT? The box-and-whisker plot represents a data set. Determine whether each statement is always true. Explain your reasoning.
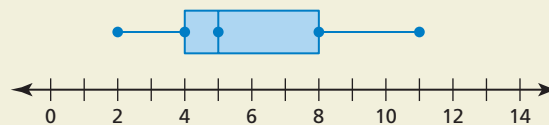

  a. The data set contains the value 11.

  b. The data set contains the value 6.

  c. The distribution is skewed right.

  d. The mean of the data is 5.

21. ANALYZING DATA The double box-and-whisker plot represents the battery lives (in hours) of two brands of cell phones.
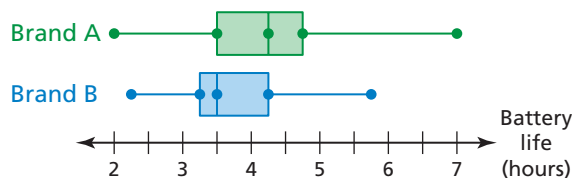
  a. Identify the shape of each distribution.

  b. What is the range of the upper 75% of each brand?

  c. Compare the interquartile ranges of the two data sets.

  d. Which brand do you think has a greater standard deviation? Explain.

  e. You need a cell phone that has a battery life of more than 3.5 hours most of the time. Which brand should you buy? Explain.

22. THOUGHT PROVOKING Create a data set that can be represented by the box-and-whisker plot shown. Justify your answer.
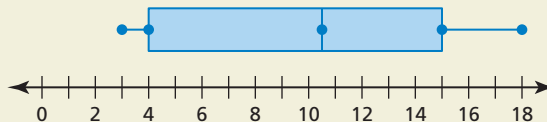
23. CRITICAL THINKING Two data sets have the same median, the same interquartile range, and the same range. Is it possible for the box-and-whisker plots of the data sets to be different? Justify your answer.

Maintaining Mathematical Proficiency
Reviewing what you learned in previous grades and lessons

Use zeros to graph the function. *(Section 8.5)*

24. $f(x) = -2(x + 9)(x - 3)$

25. $y = 3(x - 5)(x + 5)$

26. $y = 4x^2 - 16x - 48$

27. $h(x) = -x^2 + 5x + 14$