In Lesson 1-6, you used measures of central tendency to describe data sets. In this lesson, you will use **quartiles** to separate data in four equal parts. The median separates the data into upper and lower halves. The **first quartile** ($Q_1$) is the median of the lower half of the data. The **third quartile** ($Q_3$) is the median of the upper half of the data.

### Finding Median, First, and Third Quartiles

**Example** Finding Median, First, and Third Quartiles

For the data below, find the median ($Q_2$), first quartile ($Q_1$), and third quartile ($Q_3$).

$$39 \ 27.5 \ 26 \ 31 \ 42 \ 26 \ 37 \ 30 \ 22$$

**Step 1** Arrange the data in order from least to greatest. Find the median.

$$22 \ 26 \ 26 \ 27.5 \ 30 \ 31 \ 37 \ 39 \ 42$$

**The median ($Q_2$) is the middle value 30.**

**Step 2** Find the first quartile and third quartile, which are the medians of the lower and upper halves.

$$22 \ 26 | 26 \ 27.5 \ 30 \ 31 \ 37 | 39 \ 42$$

First quartile ($Q_1$) = \( \frac{26 + 26}{2} = 26 \)  
Third quartile ($Q_3$) = \( \frac{37 + 39}{2} = 38 \)

**Quick Check** 1 For the following data, find the median, the first quartile, and the third quartile.

$$480 \ 500 \ 600 \ 250 \ 660 \ 570 \ 490 \ 610 \ 530$$
The **five number summary** of a set of data includes the minimum, the first quartile, the median, the third quartile, and the maximum. The **minimum** of a data set is the least value. The **maximum** is the greatest value.

### Finding the Five Number Summary

Find the five number summary for the data below.

125 80 140 135 126 140 350

**Step 1** Arrange the data in order from least to greatest.

80 125 126 135 140 140 350

**Step 2** Find the minimum, maximum, and median.

80 125 126 135 140 140 350

The minimum is 80. The maximum is 350. The median is 135.

**Step 3** Find the first quartile and third quartile.

First quartile \((Q_1) = \frac{125 + 126}{2} = 125.5\)

Third quartile \((Q_3) = \frac{140 + 140}{2} = 140\)

The five number summary is minimum = 80, \(Q_1 = 125.5\), median = 135, \(Q_3 = 140\), and maximum = 350.

### Finding a Percentile Rank

Of 25 test scores, eight are less than or equal to 75. What is the percentile rank of a test score of 75?

Write a ratio of the number of scores less than or equal to 75 compared to the total number of test scores.

\[
\frac{8}{25} \quad \text{Number of test scores less than or equal to 75}
\]

\[
\frac{8}{25} = 0.32 \quad \text{Total number of test scores}
\]

\[
0.32 = 32\% \quad \text{Rewrite} \quad \frac{8}{25} \quad \text{as a percent.}
\]

The percentile rank of 75 is 32.

### Quick Check

2. **Find the five number summary for each set of data.**

   a. 95 85 75 85 65 60 100 105 75 85 75
   b. 11 19 7 5 21 53

   Data sets can be separated into smaller equal parts. **Percentiles** separate data sets into 100 equal parts. The **percentile rank** of a score is the percentage of scores that are less than or equal to that score.

   a. **Critical Thinking** Is it possible to have a percentile rank of 0? Explain.
A **box-and-whisker plot** is a graph that summarizes a data set along a number line. The box represents the first quartile, the median, and the third quartile of the data. The whiskers on the left and right sides represent the minimum and maximum values. Use the five number summary to construct a box-and-whisker plot.

**Box-and-Whisker Plot**

![Box-and-Whisker Plot Diagram]

**Example**

**Real-World Problem Solving**

**Agriculture** The table below shows United States crops harvested from 1992 to 2004. Find the five number summary and construct a box-and-whisker plot of the data.

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres (millions)</th>
<th>Year</th>
<th>Acres (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>317</td>
<td>1999</td>
<td>327</td>
</tr>
<tr>
<td>1993</td>
<td>308</td>
<td>2000</td>
<td>325</td>
</tr>
<tr>
<td>1994</td>
<td>321</td>
<td>2001</td>
<td>321</td>
</tr>
<tr>
<td>1995</td>
<td>314</td>
<td>2002</td>
<td>316</td>
</tr>
<tr>
<td>1996</td>
<td>326</td>
<td>2003</td>
<td>324</td>
</tr>
<tr>
<td>1997</td>
<td>332</td>
<td>2004</td>
<td>321</td>
</tr>
</tbody>
</table>

**Step 1** Arrange the data in order from least to greatest. Find the minimum, maximum, and the median.

308, 314, 316, 317, 321, 321, 321, 324, 325, 326, 326, 327, 332

**Step 2** Find the first quartile and third quartile.

First quartile = \(\frac{316 + 317}{2} = \frac{633}{2} = 316.5\)

Third quartile = \(\frac{326 + 326}{2} = \frac{652}{2} = 326\)

**Step 3** Draw a number line. Construct the box-and-whisker plot. Mark the values of the minimum, first quartile, median, third quartile, and maximum.

**Quick Check**

Construct a box-and-whisker plot for the following distances of bird migrations in thousands of miles.

5, 2.5, 6, 8, 9, 2, 1, 4, 6.2, 18
Using a Graphing Calculator

Use a graphing calculator to make a box-and-whisker plot of the data below. Find the five number summary.

10 26 18 35 14 11 17 29 31 25 27 20 19 12 13 26

The five number summary is minimum = 10, Q1 = 13.5, median = 19.5, Q3 = 26.5, maximum = 35.

Use a graphing calculator to find the five number summary for the following set of student test grades shown below.

98 92 76 84 93 82 74 68 85 91 77 83 94 97 72 88 70 84 87 82

The interquartile range is the difference between the first and third quartiles. In a box-and-whisker plot, this is the width of the box. You can use a parallel box-and-whisker plot to compare two sets of data.

Comparing Data Sets

The box-and-whisker plot below shows average monthly rainfall for Miami and New Orleans. Which city shows the greater range in average monthly rainfall?

Miami has the longer box-and-whisker plot, so it has the greater range.

What do the interquartile ranges tell you about the average monthly rainfall for Miami and New Orleans?
Find the median, the first quartile, and the third quartile.

1. 12 10 11 7 9 10 5
2. 4.5 3.2 6.3 5.2 5 4.8 6 3.9 12
3. 55 53 67 52 50 49 51 52 52
4. 101 100 100 105 101 102 104
5. Find the five number summary for the set of data.
   1 1 3 3 4 5 7 7 8 9 9 32 31 29 35 30 32 11
6. Of 20 scores, 19 are less than or equal to 10. Find the percentile rank of 10.
7. Gerry ranks 48th in a class of 120 students. What is his percentile rank?
8. Construct a box-and-whisker plot for the ages of the members of the art club.
   13 18 16 14 15 17 15 16 15 16 14 14 17 19
9. Use a graphing calculator to draw a box-and-whisker plot for the data below. Then find the interquartile range.
   16 18 59 75 30 34 25 49 27 16 21 58 71 19 50
10. Compare the box-and-whisker plots below. What can you conclude?

Ages of U.S. Olympic Soccer Team Players

| Ages | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 |
|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Men  |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Women|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

For Exercises 11–16, use the data below. Find each measure.

1.8 2.5 3.9 4.6 4.7 4.8 4.8 4.9

11. median 12. first quartile 13. minimum
14. maximum 15. third quartile 16. percentile rank of 4.6

17. Use the box-and-whisker plot below. What can you conclude about the areas of state parks?

Areas of State Parks (acres)

For Exercises 18–21, use the graph below showing box-and-whisker plots for two sets of data, A and B.

Data Set A
Data Set B

18. Which set of data has the greater range?
19. Which set of data has the lesser median?
20. Which set of data has the greater interquartile range?

21. Which set of data has the lesser minimum?

For Exercises 22–24, use the five number summary given below.
Minimum = 10  
Q₁ = 20  
Median = 30  
Q₃ = 42  
Maximum = 75

22. Find the interquartile range.

23. Find the range of the data.

24. Use the data to construct a box-and-whisker plot.

25. Social Studies  The plots below compare the percents of the voting-age population who said they registered to vote in U.S. elections to the percents who said they voted. Which conclusion best reflects the data collected?


A. The percent who voted was about 15% less than the percent who registered.
B. The percent who voted was about half the percent who registered.
C. The percent who voted was equal to the percent who registered.
D. The percent who voted was about 15% more than the percent who registered.

26. Error Analysis  In a class of 250 students, Emily had the tenth highest grade average. She computed her percentile rank as 4. What was her error?

27. Reasoning  Can you find the mean, median, and mode of a set of data by looking at a box-and-whisker plot? Explain.

28. Find the first quartile and third quartile in the following data set.
   17  20  30  19  20  18  25  28  31  23  17  29  31  33  28
   A. 19 and 30  
   B. 17 and 25  
   C. 19.5 and 30.5  
   D. 17 and 33

29. Of 20 test scores, sixteen are less than or equal to 80. What is the percentile rank of a test score of 80?
   F. 16th  
   G. 85th  
   H. 25th  
   J. 80th

30. Describe how you could find the 75th percentile score in a set of 20 scores.

31. The total cost of the number of CDs times $5.00.

32. The perimeter of a square equals 4 times the length of the side.

Define variables and write an equation to model each situation.

33. All whole numbers are rational numbers.

34. The square root of a number is always smaller than the number.