

# Box Plots and Measures of Spread

Name: \_\_\_\_\_

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Score: \_\_\_\_\_ / 18

A **box plot** gives you a quick snapshot of how data is distributed—all in one compact picture! It uses the **five-number summary**: minimum, first quartile, median, third quartile, and maximum. The box shows the middle half of the data, and the whiskers show how far the values stretch. This makes box plots perfect for spotting spread, center, and possible outliers at a glance!



## Key Concepts & Quick Review

**Five-number summary:** Min, Q1, Median (Q2), Q3, Max.

**Finding quartiles:** Q1 = median of lower half; Q3 = median of upper half (do not include the overall median in either half).

**IQR =  $Q3 - Q1$ :** measures spread of the middle 50%. Resistant to outliers.

**Outlier rule:** a value is an outlier if it is below  $Q1 - 1.5 \times \text{IQR}$  or above  $Q3 + 1.5 \times \text{IQR}$ .

## Examples

① Find the five-number summary and IQR for: 4, 8, 15, 16, 23, 42.

**Think It Through:** The data are already sorted, which makes the quartiles easier to find. The minimum is 4 and the maximum is 42. Because there are 6 values, the median is the average of the two middle numbers:  $(15 + 16) \div 2 = 15.5$ . The lower half is 4, 8, 15, so its median is 8, which is Q1. The upper half is 16, 23, 42, so its median is 23, which is Q3. Then the interquartile range is  $23 - 8 = 15$ .

**Answer:** Min 4; Q1 8; Med 15.5; Q3 23; Max 42; IQR = 15

② For the data in Example ①, check whether 42 is an outlier.

**Think It Through:** Use the upper outlier fence:  $Q3 + 1.5 \times \text{IQR}$ . With  $Q3 = 23$  and  $\text{IQR} = 15$ , the upper fence is  $23 + 1.5(15) = 45.5$ . A value must be greater than 45.5 to count as an upper outlier. Since 42 is below that cutoff, it is not an outlier.

**Answer:** 42 is not an outlier ( $42 < 45.5$ )



**Practice Problems**

Find the five-number summary and IQR, or answer the question about the box plot.

1. For the data set 2, 5, 7, 8, 10, 11, find the five-number summary and the IQR. \_\_\_\_\_
2. For the data set 10, 20, 30, 40, 50, find the five-number summary and the IQR. \_\_\_\_\_
3. For the data set 3, 4, 5, 6, 7, 8, 9, find the five-number summary and the IQR. \_\_\_\_\_
4. For the data set 15, 18, 20, 22, 25, 30, find the five-number summary and the IQR. \_\_\_\_\_
5. For the data set 1, 3, 5, 7, 9, 11, 13, find the five-number summary and the IQR. \_\_\_\_\_
6. For the data set 60, 65, 70, 75, 80, 85, 90, find the five-number summary and the IQR. \_\_\_\_\_
7. For the data set 4, 4, 6, 8, 10, 12, 12, find the five-number summary and the IQR. \_\_\_\_\_
8. For the data set 0, 5, 10, 15, 20, 25, 30, find the five-number summary and the IQR. \_\_\_\_\_
9. A box plot has  $Q1 = 10$  and  $Q3 = 22$ . Find the IQR. \_\_\_\_\_
10. A box plot has IQR 18 and  $Q1 = 7$ . Find  $Q3$ . \_\_\_\_\_
11. Use the outlier rule with  $Q1 = 15$  and  $Q3 = 33$ . Is  $x = 50$  an outlier? \_\_\_\_\_
12. Use the outlier rule with  $Q1 = 20$  and  $Q3 = 44$ . Is  $x = 10$  an outlier? \_\_\_\_\_
13. For the data set 12, 15, 17, 19, 20, 24, 28, find the five-number summary and the IQR. \_\_\_\_\_
14. For the data set 100, 110, 120, 130, 140, 200, find the five-number summary and the IQR. \_\_\_\_\_
15. A box plot has minimum 5,  $Q1 = 15$ , median 25,  $Q3 = 40$ , and maximum 60. Find the IQR. \_\_\_\_\_

**Study Tips**

-  **Always sort the data first.** Finding  $Q1$  and  $Q3$  from unsorted data is a guaranteed mistake.
-  The box always contains **exactly 50%** of the data. Each whisker and each half of the box contains about 25%.
-  A **long whisker or lopsided box** indicates skewness. When the median is closer to  $Q1$ , data is right-skewed (long right whisker).

**Word Problems**

16. A class records how many books each student read over summer vacation: 0, 1, 2, 2, 3, 4, 5, 5, 6, 7, 8, 12. Find the five-number summary, IQR, and range. Is 12 an outlier? Describe what the box plot would look like — would it be symmetric, left-skewed, or right-skewed?  
\_\_\_\_\_

17. A sports journalist compares ticket prices (\$) for two stadiums. Stadium A: \$25, \$35, \$40, \$45, \$55, \$60, \$80. Stadium B: \$30, \$32, \$35, \$38, \$40, \$42, \$45. Find the five-



number summary and IQR for each. Which stadium has more variable prices? How can you tell from the IQR? \_\_\_\_\_

**18.** Use this box plot to read the five-number summary, compute the IQR and the range, and decide whether 80 would be an outlier under the  $1.5 \times \text{IQR}$  rule.



## Answer Keys

- |   |  |
|---|--|
| <p>1) min 2, Q1 5, med <math>\frac{15}{2}</math>, Q3 10, max 11, IQR 5</p> <p>2) min 10, Q1 15, med 30, Q3 45, max 50, IQR 30</p> <p>3) min 3, Q1 4, med 6, Q3 8, max 9, IQR 4</p> <p>4) min 15, Q1 18, med 21, Q3 25, max 30, IQR 7</p> <p>5) min 1, Q1 3, med 7, Q3 11, max 13, IQR 8</p> <p>6) min 60, Q1 65, med 75, Q3 85, max 90, IQR 20</p> <p>7) min 4, Q1 4, med 8, Q3 12, max 12, IQR 8</p> <p>8) min 0, Q1 5, med 15, Q3 25, max 30, IQR 20</p> <p>9) 12</p> <p>10) 25</p> <p>11) no</p> | <p>12) no</p> <p>13) min 12, Q1 15, med 19, Q3 24, max 28, IQR 9</p> <p>14) min 100, Q1 110, med 125, Q3 140, max 200, IQR 30</p> <p>15) 25</p> <p>16) Min 0; Q1 2; median 4.5; Q3 6.5; max 12; IQR 4.5; range 12; no outlier; right-skewed</p> <p>17) A: min 25, Q1 35, med 45, Q3 60, max 80, IQR 25; B: min 30, Q1 32, med 38, Q3 42, max 45, IQR 10; A more variable</p> <p>18) Min 20; Q1 35; med 45; Q3 60; max 70; IQR 25; range 50; 80 is not an outlier</p> |
|---|--|

### Step-by-Step Explanations

**Strategy:** For Cross Sections of 3-D Figures, picture the slicing plane and name the flat shape made where the cut passes through the solid. Once the slice direction is clear, the name of the cross section is much easier to see.

**Practice 1:** A cube is sliced by a horizontal plane parallel to its base. What is the cross-section shape?

**Answer:** square

At the beginning of the practice, picture the slicing plane and name the two-dimensional shape it reveals.

**Practice 15:** A cylinder has radius 5. A horizontal cut is parallel to its base. Find the cross-section area.

**Answer:** 78.5

For the second model problem, picture the slicing plane and name the two-dimensional shape it reveals.

**Word-problem notes:**

**16. Answer:** (a)  $\text{rect. } 24 \times 12 = 288 \text{ cm}^2$ ; (b)  $\text{rect. } 24 \times 8 = 192 \text{ cm}^2$ ; (c) rectangle (a slanted cut on a box still gives a rectangle)  $24 \times \sqrt{8^2 + 12^2} = 24 \times 14.4 = 345.6 \text{ cm}^2$ .

For the horizontal cut, the slice is parallel to the base, so it is a rectangle  $24 \times 12$  with area  $288 \text{ cm}^2$ . For the vertical cut along the length, the cross section is a rectangle  $24 \times 8$  with area  $192 \text{ cm}^2$ . For the diagonal cut, the length stays  $24 \text{ cm}$ , but the other side becomes the diagonal across the  $12$  by  $8$  face. Use Pythagoras:  $\sqrt{12^2 + 8^2} = \sqrt{208} \approx 14.4 \text{ cm}$ . So the slanted rectangle has area about  $24 \times 14.4 = 345.6 \text{ cm}^2$ .

**17. Answer:** Circle; radius at  $10 \text{ cm}$  from apex:  $r = \frac{10}{40} \times 15 = 3.75 \text{ cm}$ ; area =  $\pi(3.75)^2 \approx 44.2 \text{ cm}^2$ .

A horizontal cut through a cone makes a circular cross section. The small cone above the cut is similar to the full cone, so the radii scale in the same ratio as the heights. Since the cut is  $10 \text{ cm}$  from the apex on a cone of height  $40 \text{ cm}$ , the scale factor is  $\frac{10}{40} = \frac{1}{4}$ . Apply that to the base radius: the cross-section radius is  $\frac{1}{4} \times 15 = 3.75 \text{ cm}$ . Then use the circle area formula,  $A = \pi r^2$ , to get about  $44.2 \text{ cm}^2$ .



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