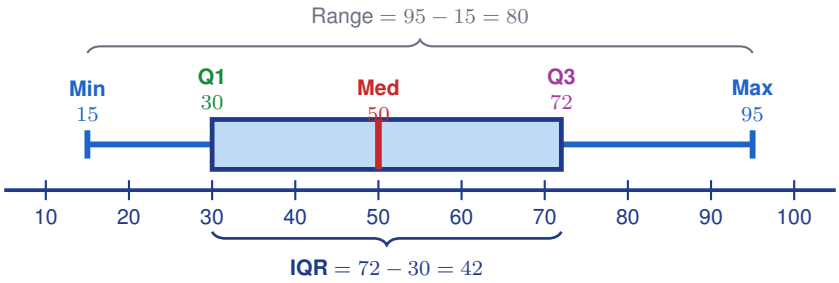
Box Plots and Measures of Spread

Name: _____	Date: _____	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 $Q1 - 1.5 \times$ IQR or above $Q3 + 1.5 \times$ 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: $Q3 + 1.5 \times$ IQR. With $Q3 = 23$ and 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

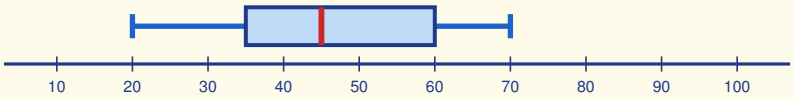
16. A class records how many books each student read over summer vacation: $0,\ 1,\ 2,\ 2,\ 3,\ 4,\ 5,\ 5,\ 6,\ 7,\ 8,\ 12$. Find the five-number summary, IQR, and range. Is 12 an outlier? Describe what the box plot would look like — would it be symmetric, left-skewed, or right-skewed?

_____

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 $1.5 \times$ IQR rule.



Answer Keys

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

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

17. Answer: Circle; radius at $10\ cm$ from apex: $r = \frac{10}{40} \times 15 = 3.75\ cm$; area $= \pi(3.75)^2 \approx 44.2\ cm^2$.
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 $10\ cm$ from the apex on a cone of height $40\ cm$, the scale factor is $\frac{10}{40} = \frac{1}{4}$. Apply that to the base radius: the cross-section radius is $\frac{1}{4} \times 15 = 3.75\ cm$. Then use the circle area formula, $A = \pi r^2$, to get about $44.2\ cm^2$.

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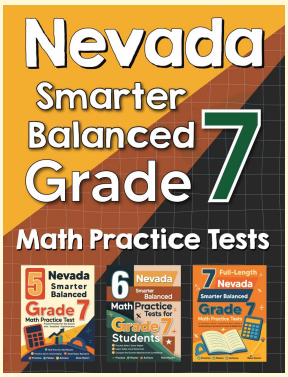

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