

Box-and-Whisker Plots, IQR, and Outlier Detection

Statistics Worksheet · Grade 9-12

Name: _____

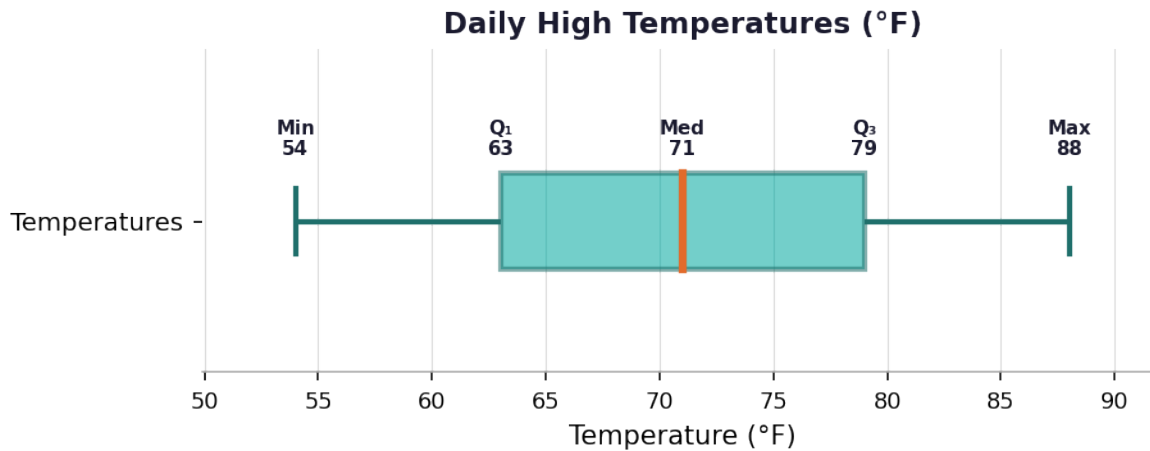
Date: _____

Learning Objectives

- Construct and interpret box-and-whisker plots using a five-number summary
- Calculate the interquartile range (IQR) and apply the $1.5 \times \text{IQR}$ rule to identify outliers
- Compare two data distributions using side-by-side box plots and summary statistics

Problems

1. The five-number summary for a dataset of daily high temperatures (°F) is shown in the box plot below. Identify the minimum, Q1, median, Q3, and maximum values.



2. A dataset of student quiz scores has the following values: 45, 50, 55, 60, 65, 70, 75. Calculate the IQR (interquartile range) for this dataset.

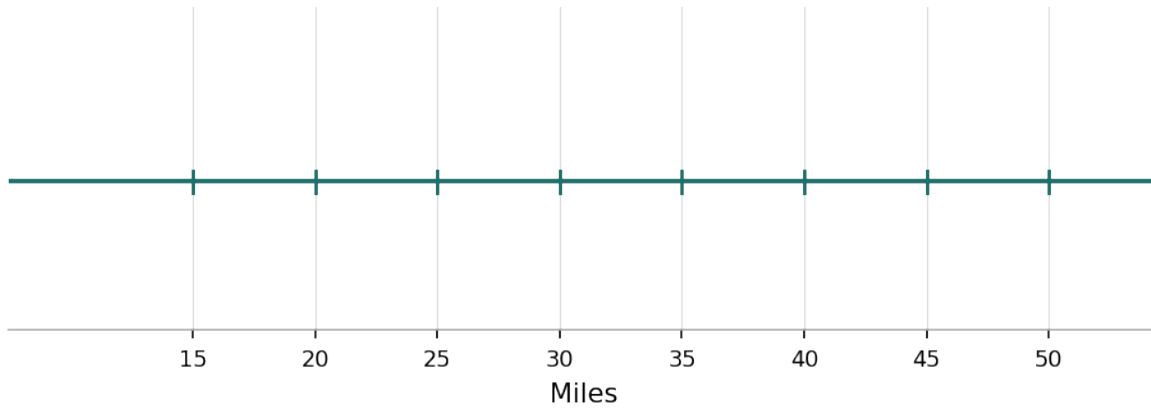
$$IQR = Q_3 - Q_1$$

3. Draw a box-and-whisker plot for the following data on the number of miles driven per day: 12, 18, 22, 25, 30, 35, 40, 45, 50. Use the five-number summary to construct the plot.

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Miles Driven Per Day



4. Using the 1.5 times IQR rule, determine the lower and upper outlier boundaries for a dataset with $Q_1 = 15$ and $Q_3 = 35$.

Lower Boundary = $Q_1 - 1.5 \times IQR$ Upper Boundary = $Q_3 + 1.5 \times IQR$

5. The table below shows a five-number summary for two fuel additives (Additive A and Additive B) measuring the change in gas mileage (mpg). Fill in the IQR for each additive.

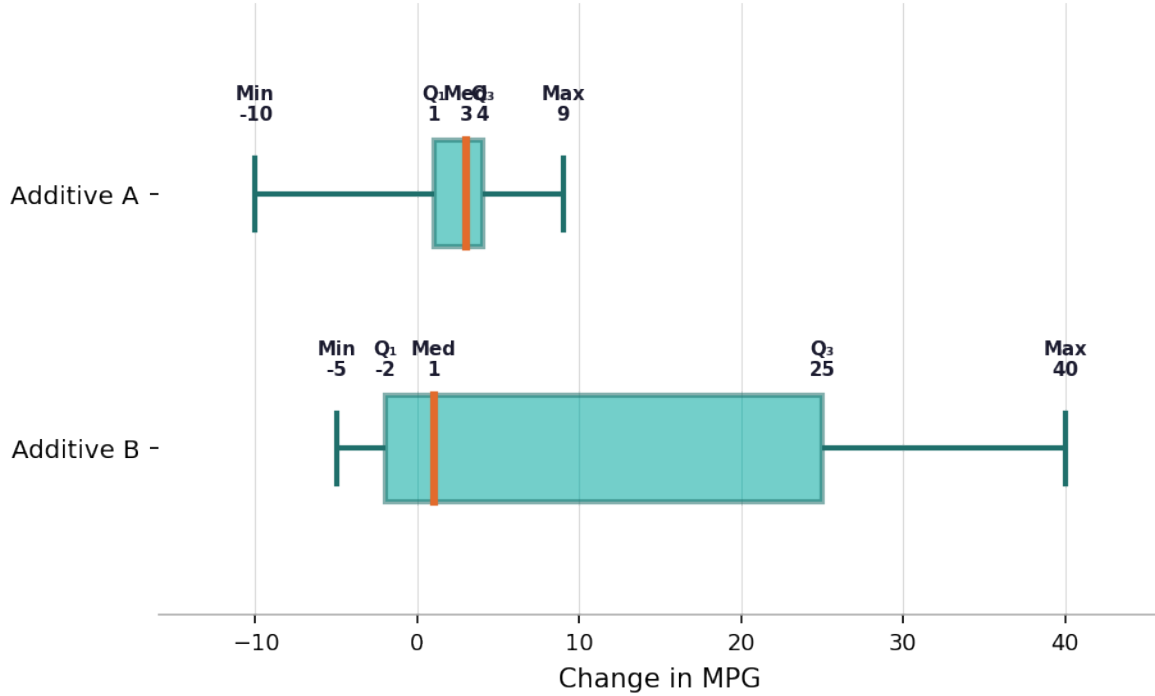
Additive	Min	Q1	Median	Q3	Max	IQR
A	-10	1	3	4	9	
B	-5	-2	1	25	40	

6. Compare the two box-and-whisker plots for Additive A and Additive B shown below. Which additive has a greater spread of data? Which has the higher median change in gas mileage?

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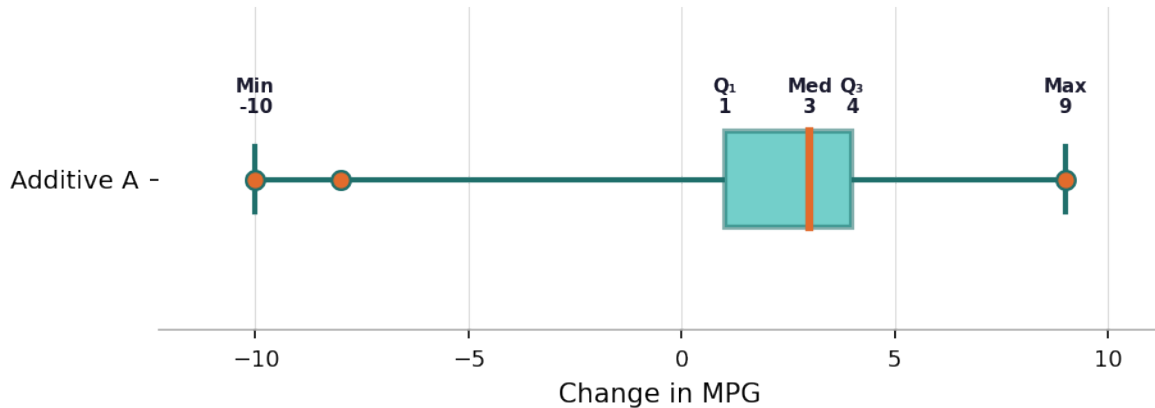


Gas Mileage Change (mpg): Additive A vs. Additive B



7. For Additive A with $Q_1 = 1$, $Q_3 = 4$, and $IQR = 3$, apply the 1.5 times IQR rule to determine which of the following data values are outliers: negative 10, negative 8, negative 2, 5, 7, 9.

Additive A – Identifying Outliers

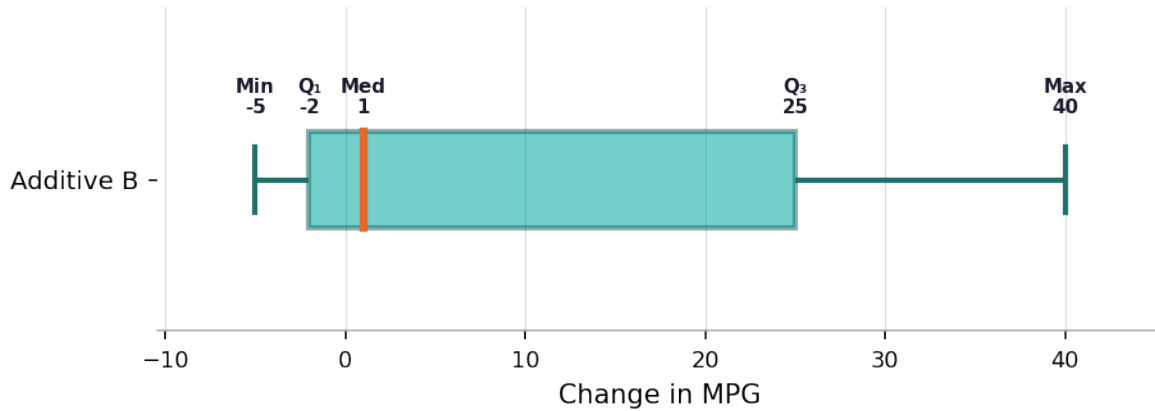


8. For Additive B with $Q_1 = \text{negative } 2$, $Q_3 = 25$, and $IQR = 27$, apply the 1.5 times IQR rule. The full dataset values include: negative 5, negative 2, 0, 1, 10, 20, 25, 40. Identify all outliers.

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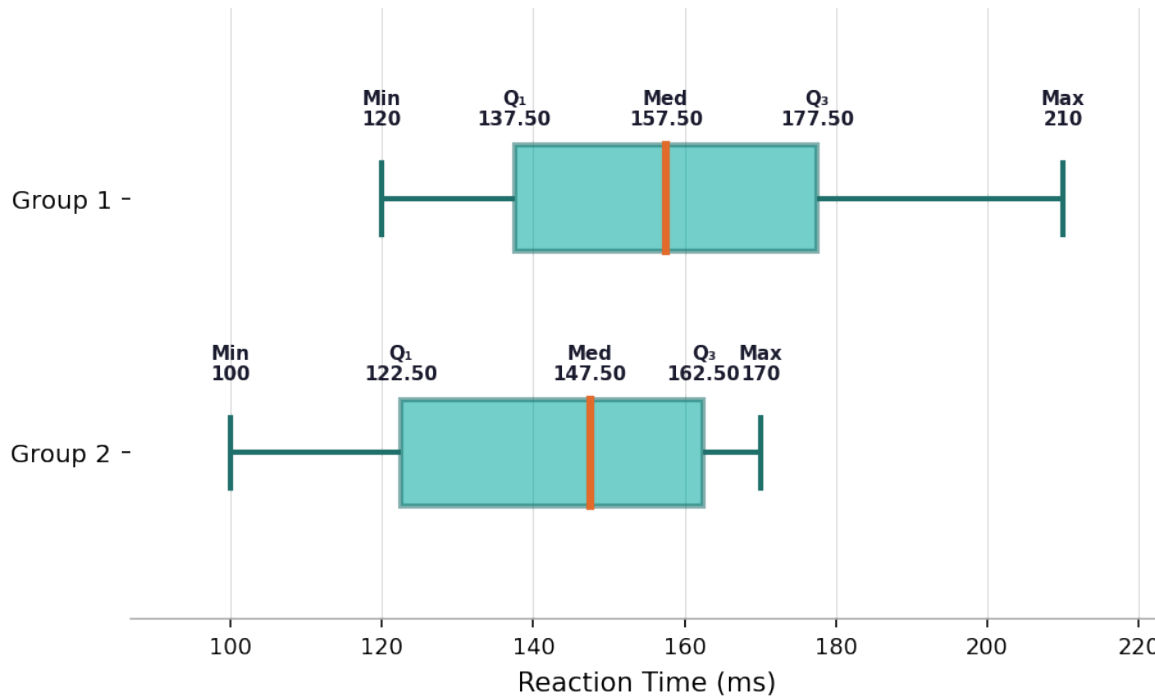


Additive B — Identifying Outliers



9. A researcher records the following reaction times (in milliseconds) for two groups. Group 1: 120, 135, 140, 155, 160, 175, 180, 210. Group 2: 100, 115, 130, 145, 150, 160, 165, 170. Compute the five-number summary for each group, then determine which group has a higher median reaction time and which has greater variability based on IQR.

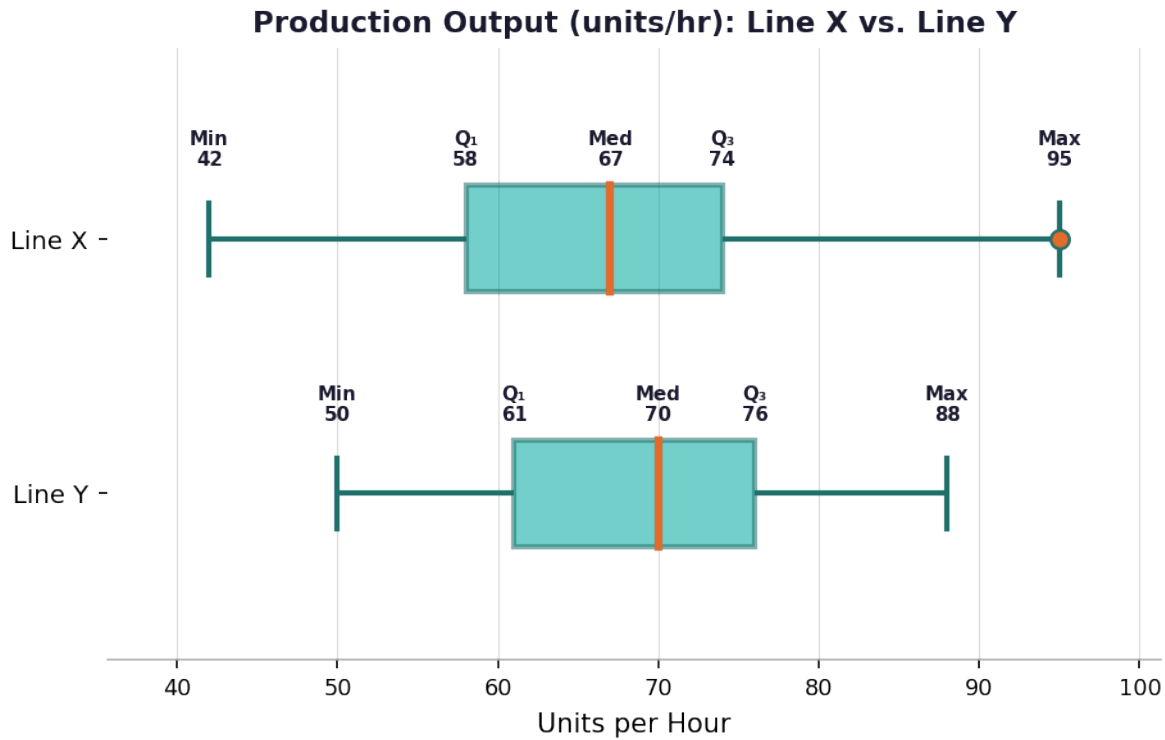
Reaction Times (ms): Group 1 vs. Group 2



10. A quality control analyst measures the output (units per hour) of two production lines over several shifts. The five-number summaries are: Line X — Min = 42, Q₁ = 58, Median = 67, Q₃ = 80, Max = 95. Line Y — Min = 30, Q₁ = 40, Median = 50, Q₃ = 60, Max = 70.



= 74, Max = 95. Line Y — Min = 50, Q1 = 61, Median = 70, Q3 = 76, Max = 88. (a) Calculate the IQR for each line. (b) Apply the 1.5 times IQR rule to find outlier boundaries for each line. (c) Determine whether the maximum value of each line is an outlier. (d) Describe the skewness of each distribution based on the box plots.



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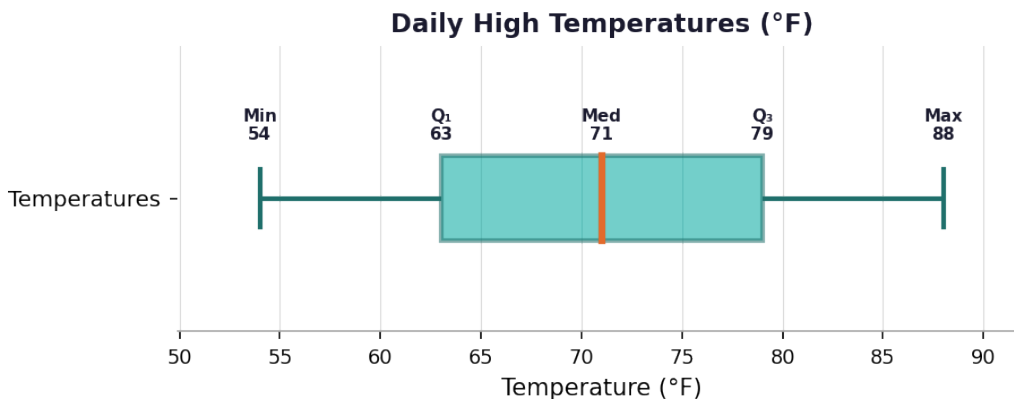


Box-and-Whisker Plots, IQR, and Outlier Detection – Answer Key

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Answer Key

1. Answer: Min = 54, Q1 = 63, Median = 71, Q3 = 79, Max = 88



- The left whisker end gives the minimum: 54°F.
- The left edge of the box is Q1: 63°F.
- The line inside the box is the median: 71°F.
- The right edge of the box is Q3: 79°F.
- The right whisker end gives the maximum: 88°F.

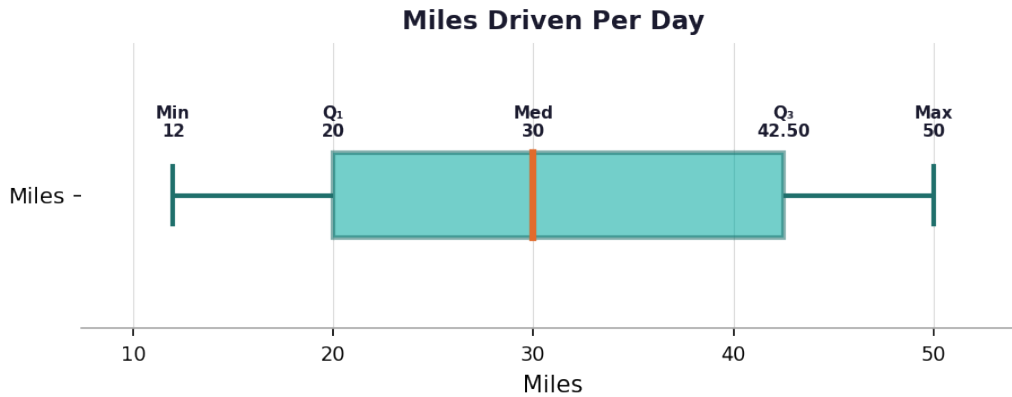
2. Answer: IQR = 20

- Order the data: 45, 50, 55, 60, 65, 70, 75 (already ordered).
- Median = 60 (4th value).
- Lower half: 45, 50, 55 → Q1 = 50.
- Upper half: 65, 70, 75 → Q3 = 70.
- IQR = Q3 – Q1 = 70 – 50 = 20.

3. Answer: Min = 12, Q1 = 20, Median = 30, Q3 = 42.5, Max = 50

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- Order the data: 12, 18, 22, 25, 30, 35, 40, 45, 50.
- Minimum = 12, Maximum = 50.
- Median = 30 (5th value out of 9).
- Lower half: 12, 18, 22, 25 → $Q_1 = (18+22)/2 = 20$.
- Upper half: 35, 40, 45, 50 → $Q_3 = (40+45)/2 = 42.5$.
- Draw a number line, mark Min, Q₁, Median, Q₃, Max, and construct the box and whiskers.

4. Answer: Lower Boundary = -15, Upper Boundary = 65

- $IQR = Q_3 - Q_1 = 35 - 15 = 20$.
- $1.5 \times IQR = 1.5 \times 20 = 30$.
- Lower Boundary = $Q_1 - 30 = 15 - 30 = -15$.
- Upper Boundary = $Q_3 + 30 = 35 + 30 = 65$.
- Any data value below -15 or above 65 is an outlier.

5. Answer: IQR for A = 3; IQR for B = 27

Additive	Min	Q1	Median	Q3	Max	IQR
A	-10	1	3	4	9	3
B	-5	-2	1	25	40	27

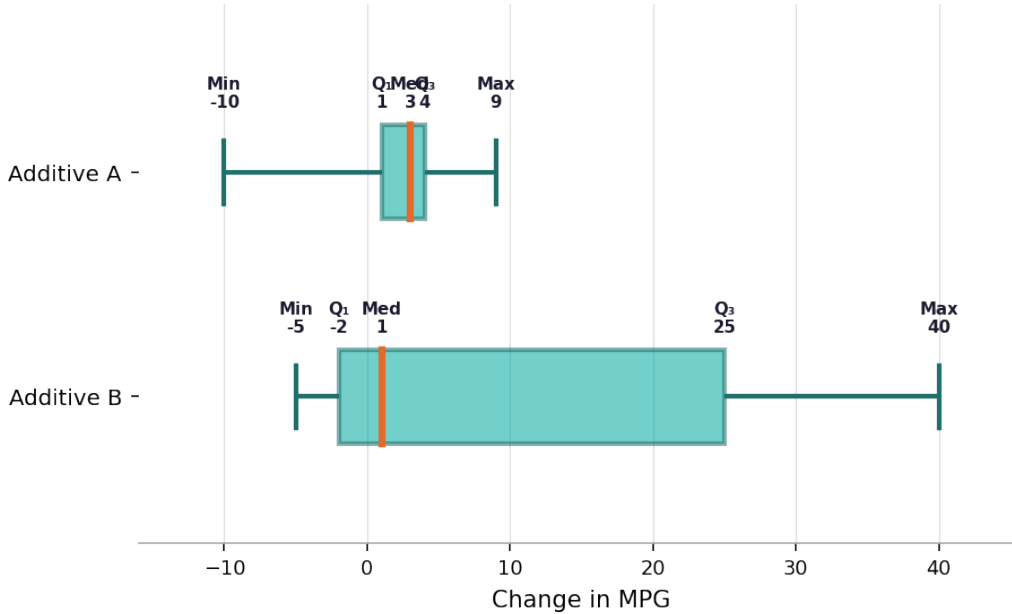
- For Additive A: $IQR = Q_3 - Q_1 = 4 - 1 = 3$.
- For Additive B: $IQR = Q_3 - Q_1 = 25 - (-2) = 27$.

6. Answer: Additive B has greater spread (IQR = 27 vs. 3); Additive A has higher median (3 vs. 1)

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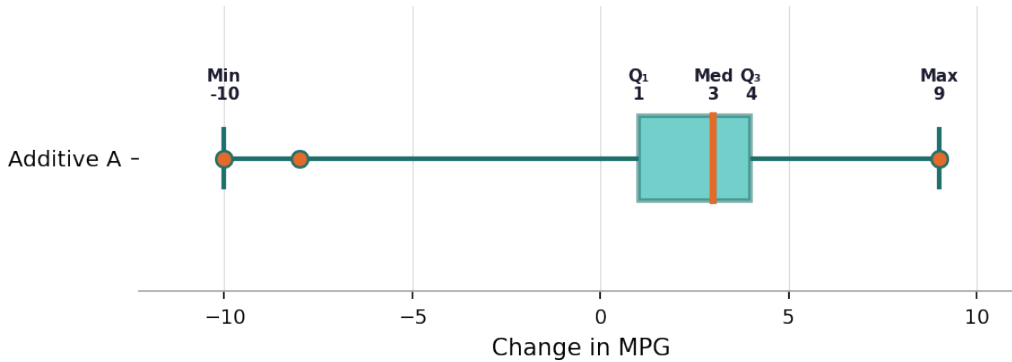
Gas Mileage Change (mpg): Additive A vs. Additive B



- Additive A: IQR = 3, Median = 3.
- Additive B: IQR = 27, Median = 1.
- Additive B has a much larger IQR ($27 > 3$), so its data is more spread out.
- Additive A has a higher median ($3 > 1$), meaning it more consistently improved mileage.
- Additive B has a wider range (45 vs. 19) but less consistent results.

7. Answer: Outliers: -10, -8, and 9

Additive A – Identifying Outliers



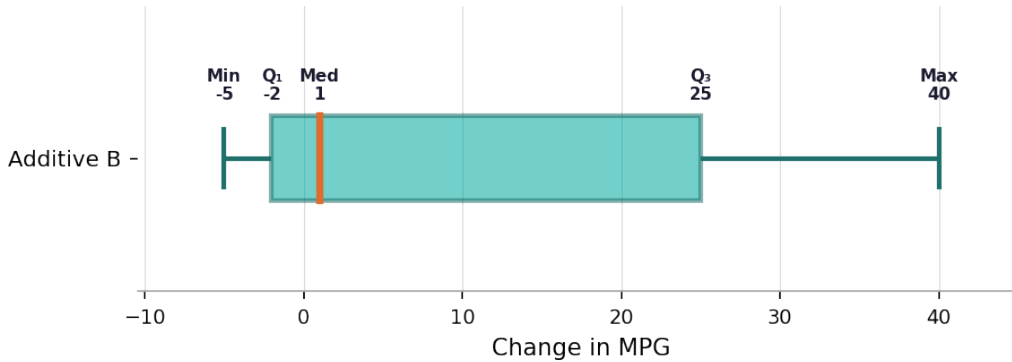
- $1.5 \times \text{IQR} = 1.5 \times 3 = 4.5$.
- Lower boundary = $Q1 - 4.5 = 1 - 4.5 = -3.5$.
- Upper boundary = $Q3 + 4.5 = 4 + 4.5 = 8.5$.
- Values below -3.5 : -10 and -8 are outliers.
- Values above 8.5 : 9 is an outlier.
- Values -2 , 5 , and 7 are within the range, so they are NOT outliers.

8. Answer: No outliers for Additive B

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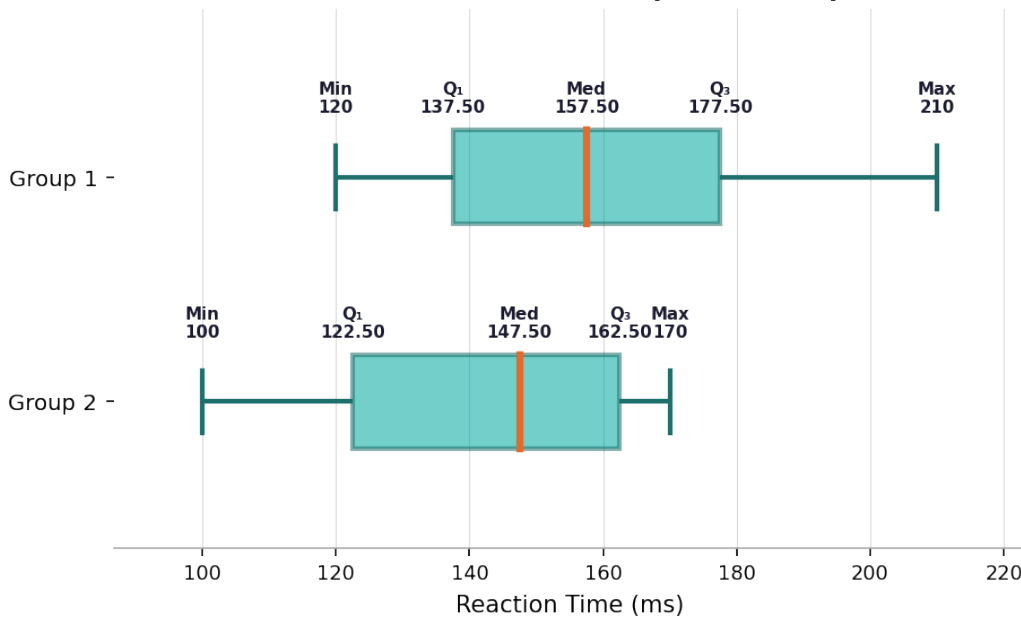
Additive B – Identifying Outliers



- $1.5 \times IQR = 1.5 \times 27 = 40.5$.
- Lower boundary = $Q1 - 40.5 = -2 - 40.5 = -42.5$.
- Upper boundary = $Q3 + 40.5 = 25 + 40.5 = 65.5$.
- Minimum value is -5 , which is greater than $-42.5 \rightarrow$ no lower outliers.
- Maximum value is 40 , which is less than $65.5 \rightarrow$ no upper outliers.
- Conclusion: Additive B has no outliers.

9. Answer: Group 1: Min=120, Q1=137.5, Med=157.5, Q3=177.5, Max=210, IQR=40. Group 2: Min=100, Q1=122.5, Med=147.5, Q3=162.5, Max=170, IQR=40. Group 1 has higher median; both groups have equal IQR.

Reaction Times (ms): Group 1 vs. Group 2



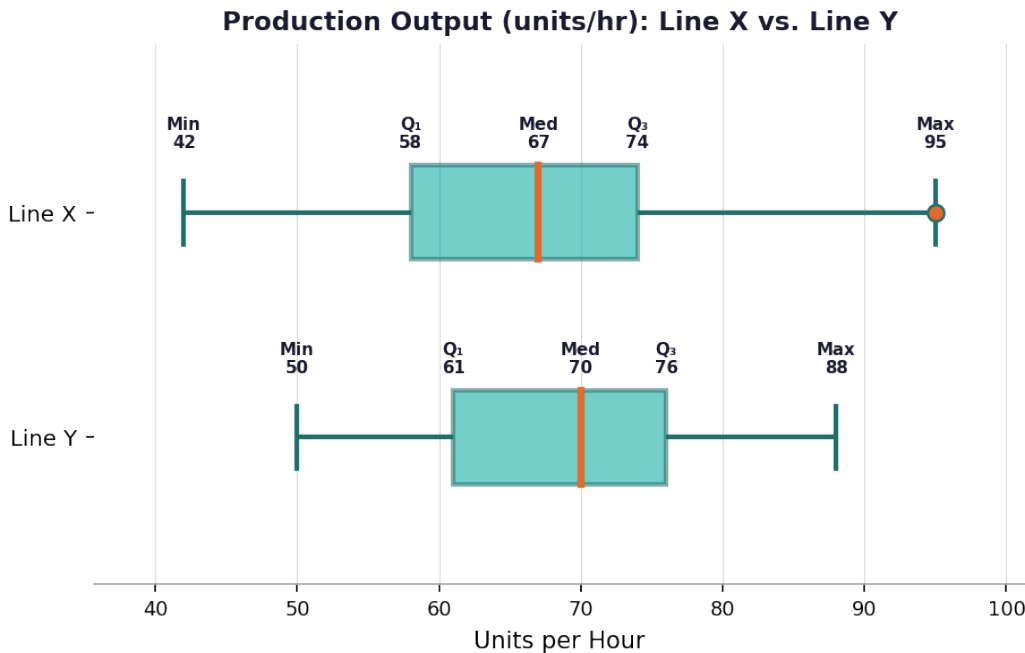
- Group 1 ordered: 120, 135, 140, 155, 160, 175, 180, 210.
- Group 1 Median = $(155+160)/2 = 157.5$. $Q1 = (135+140)/2 = 137.5$. $Q3 = (175+180)/2 = 177.5$. $IQR = 177.5 - 137.5 = 40$.
- Group 2 ordered: 100, 115, 130, 145, 150, 160, 165, 170.

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- Group 2 Median = $(145+150)/2 = 147.5$. $Q_1 = (115+130)/2 = 122.5$. $Q_3 = (160+165)/2 = 162.5$. $IQR = 162.5 - 122.5 = 40$.
- Group 1 has a higher median ($157.5 > 147.5$), indicating slower average reaction times.
- Both groups have the same $IQR = 40$, so variability is equal.

10. Answer: Line X: $IQR=16$, boundaries= $[34, 98]$, $max=95$ is NOT an outlier. Line Y: $IQR=15$, boundaries= $[38.5, 98.5]$, $max=88$ is NOT an outlier. Line X is right-skewed; Line Y is approximately symmetric.



- (a) Line X $IQR = Q_3 - Q_1 = 74 - 58 = 16$. Line Y $IQR = 76 - 61 = 15$.
- (b) Line X: $1.5 \times 16 = 24$. Lower = $58 - 24 = 34$. Upper = $74 + 24 = 98$. Line Y: $1.5 \times 15 = 22.5$. Lower = $61 - 22.5 = 38.5$. Upper = $76 + 22.5 = 98.5$.
- (c) Line X $max = 95 < 98 \rightarrow$ NOT an outlier. Line Y $max = 88 < 98.5 \rightarrow$ NOT an outlier.
- (d) Line X: Median (67) is closer to Q₁ (58) than Q₃ (74), and the upper whisker ($95-74=21$) is longer than the lower ($58-42=16$) \rightarrow right-skewed (positively skewed).
- Line Y: Median (70) is roughly centered between Q₁ (61) and Q₃ (76), and both whiskers are similar in length \rightarrow approximately symmetric.

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