

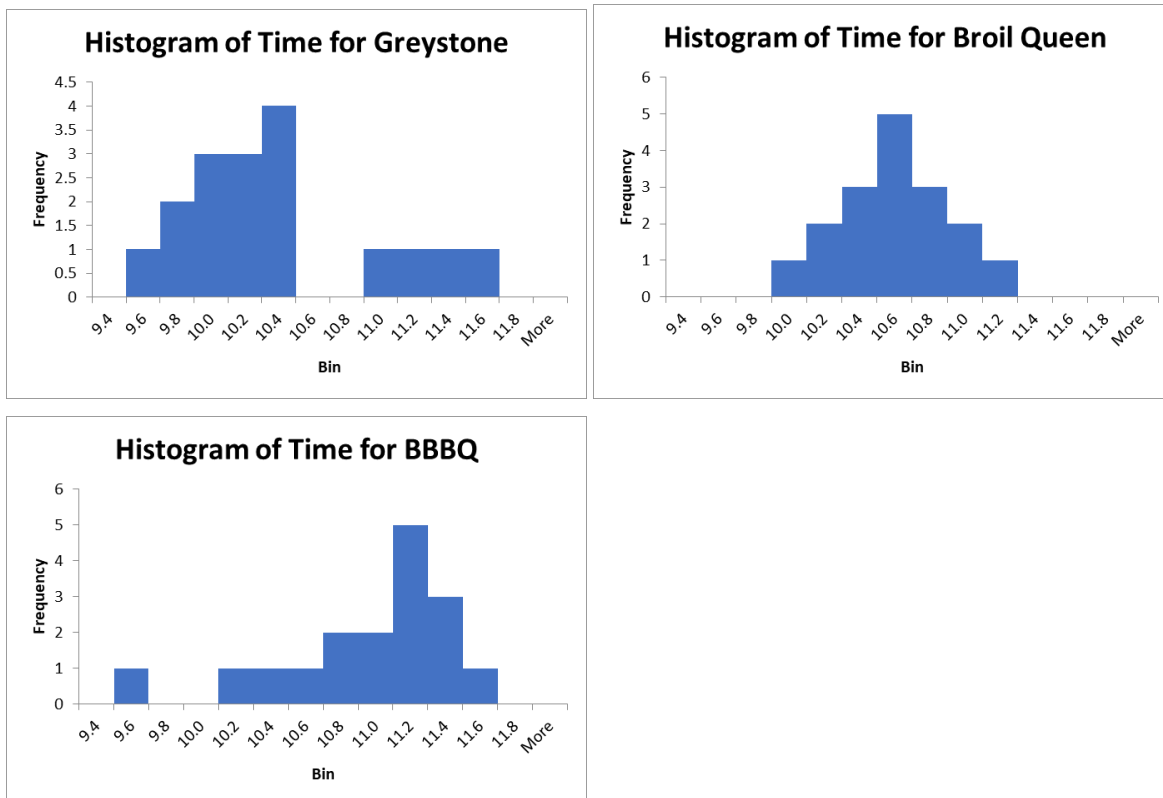
LAB 1 ASSIGNMENT SOLUTIONS

Question 1

As different treatments are applied, this design would indicate an experiment. Since random sampling is not directly present within each brand, population inferences cannot be applied to the population of interest (each brand). The population of interest could be described as all barbecues within each brand. With random assignment not mentioned, causal inferences cannot apply for mass directly changing time. Thus, it is uncertain whether brand causes change in time and, more directly, it is not possible to show that mass causes changes in time.

Question 2

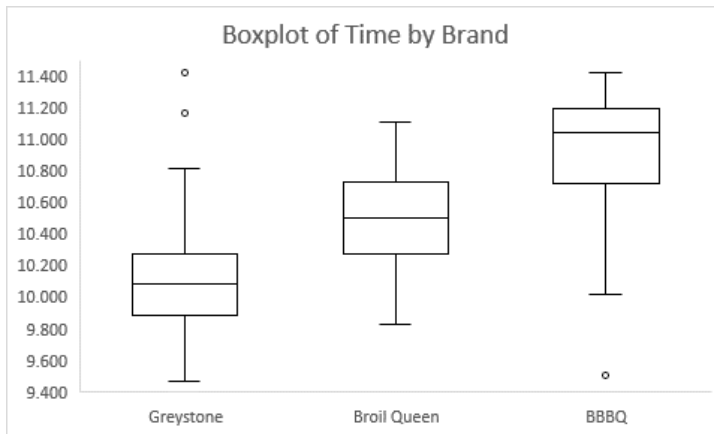
(a) The histograms of time for the three brands (Greystone, Broil Queen, and BBQ) are displayed below.



- (b) Notice that the three histograms have notably dissimilar overall shapes, yet the sample size (17) can be sufficient to visualize modality. Since the observations that appear separate from the rest due to gaps in the data may not constitute a large enough group (1 – 4 observations), each graph can be considered to be unimodal. The histogram for Greystone is unimodal and right-skewed with 4 outliers on the right (some students might state this graph is bimodal). The histogram for Broil Queen is unimodal and perfectly symmetric. The histogram for BBQ is unimodal and left-skewed with 1 outlier on the far left.
- (c) The center (identified by the mode, or highest bar) is different for all three brands, the Greystone brand having the lowest mode at 10.400 minutes while the BBQ brand has the highest mode at 11.200 minutes. The Broil Queen brand is unimodal with a mode of 10.600 minutes. The spread (identified by the range) is approximately the same for the Greystone and BBQ brands (about 2) while the range for the Broil Queen brand is smaller (1.200).
- (d) As the distribution for the Greystone is right-skewed, the mean should be higher than the median. The perfectly symmetric distribution for the Broil Queen brand should indicate at least approximate equality between the mean and median. As the distribution for the BBQ brand is left-skewed, the mean should be lower than the median.

Question 3

- (a) The side-by-side boxplots of time vs. brand is displayed below. Note the need to change the settings on the boxplots so that quartile calculation will include the median.



- (b) The boxplot for the Greystone brand is right-skewed overall (yet symmetric inside the box) with 3 outliers at the top, using the $1.5 \times \text{IQR}$ Rule. The boxplot for the Broil Queen brand is perfectly symmetric. The boxplot for the BBBQ brand is left-skewed (both inside and outside the box) with 1 outlier at the bottom.
- (c) The medians for the three brands are all different in where they relate to the y-axis, the Greystone brand having the lowest while the BBBQ brand has the highest. The IQRs for the three brands are not exactly the same (the BBBQ brand has the largest visually), yet they are approximately similar in size.
- (d) The shapes are consistent with those identified in Question 2, but the numbers of outliers are different. This difference can happen when using different criteria to indicate outliers. The medians are not quite the same in value as the modes, but there is consistency in indicating differences between the centers. The analysis of spreads is different in that the Broil Queen and BBBQ brands now have more similar spreads while the Greystone brand is relatively separate. Still, there can be consistency in indicating approximate similarity.

Question 4

- (a) The summary statistics (to three significant decimal places) are shown in the table below.

BRAND	Greystone	Broil Queen	BBBQ
MEAN	10.263	10.494	10.868
STD. DEV.	0.564	0.337	0.519
MODE(S)	10.080, 10.272	10.272, 10.432, 10.592	10.912
RANGE	1.960	1.288	1.920

The means for the three brands are all different, the Greystone brand having the lowest while the BBBQ brand has the highest. The standard deviations for the three brands are not exactly the same (the Broil Queen brand has the smallest), yet they are reasonably similar in size, though the other two brands are closer together.

The (mathematical) modes for the three brands are all different, the Greystone brand having the lowest while the BBBQ brand has the highest. The ranges for the Greystone and BBBQ brands are similar in value while the Broil Queen brand has a notably smaller range.

The mathematical mode and graphical mode are reasonably the same for the Broil Queen brand, yet very different for the other two brands. Thus, the consistency varies. Since ranges are similar from the histograms and exact calculations, they have consistent analysis in that the Broil Queen brand is noticeably smaller.

Note: The comparison of means is consistent with the comparison of graphical modes in indicating differences. Simultaneously, the Greystone brand has a smaller standard deviation and range than the other two brands which have similar measures of spread in terms of standard deviation and range.

- (b) The summaries (to three significant decimal places) are displayed below.

BRAND	Greystone	Broil Queen	BBBQ
MIN	9.464	9.824	9.504
Q1	9.888	10.272	10.720
MEDIAN	10.084	10.504	11.040
Q3	10.272	10.728	11.200
MAX	11.424	11.112	11.424
IQR	0.384	0.456	0.480

For the Greystone brand, the minimum is closer to the median than the maximum while Q_3 and Q_1 are similar in distance to the median. These traits are consistent with an overall right-skewed distribution. For the Broil Queen brand, the distance between the median and the Q_3 is quite similar to the distance between the median and the Q_1 while the minimum and maximum are somewhat similar distances away from their respective quartiles. These traits are consistent with an approximately symmetric distribution. For the BBBQ brand, the maximum and Q_3 are closer to the median than the minimum and Q_1 . These traits are consistent with a left-skewed distribution. Therefore, conclusions are consistent for all 3 brands in relation to the boxplots seen in Question 3 and, to a lesser extent since there are no quartiles, the histograms seen in Question 2.

- (c) The mean and standard deviation for time at each of the 17 mass values are given below (to three significant decimal places). The leftmost column provides the mean change in time for each mass increase of 0.125 lbs.

MASS	MEAN	STD. DEV.	MEAN CHANGE
2.000	9.597	0.197	
2.125	9.909	0.185	0.312
2.250	10.197	0.379	0.288
2.375	10.197	0.333	0.000
2.500	10.309	0.441	0.112
2.625	10.584	0.644	0.275
2.750	10.444	0.572	-0.140
2.875	10.509	0.372	0.0653
3.000	10.464	0.508	-0.0453
3.125	10.709	0.569	0.245
3.250	10.800	0.500	0.0907
3.375	10.592	0.320	-0.208
3.500	10.599	0.320	0.00667
3.625	10.923	0.185	0.324
3.750	11.149	0.0323	0.227
3.875	11.137	0.325	-0.0120
4.000	11.083	0.564	-0.0547
AVERAGE			0.09283

The general trend is that, as mass increases, time increases, yet the change in mean time is not constant. In some cases, the additional mass of 0.125 lbs. decreases time slightly instead of increasing it or showing no change. The highest value in mean time change (0.324 minutes) is obtained at 3.625 lbs. while the lowest value in mean time change (-0.208 minutes) is obtained at 3.375 lbs. Nevertheless, on average, time changes by 0.09283 minutes with each additional 0.125 lbs. in mass.

Question 5

The graphs obtained in Questions 2 and 3 as well as the descriptive statistics obtained in Question 4 demonstrate that the best brand in terms of variation is the Broil Queen brand since it displays the smallest variation. In terms of the fastest time, the Greystone brand has the lowest mean, mode, and median, though it was not always higher than the other brands (note that it has the same maximum as BBBQ). These observations could be due to other factors (even potential measurement error), so the Greystone brand should still be the best brand for fastest time.

The decreasing trend identified in Question 4, part (c) should not impact either choice of best brand since the general trend is present for all three brands.

LAB 1 ASSIGNMENT MARKING SCHEMA
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Question 1 (6)

Type of study: 2 points

Population inferences: 2 points

Causal inferences: 2 points

Question 2 (28)

- (a) Correctly formatted histogram: 4 points each (12 points total)
- (b) Analysis of the shape of each histogram: 3 points each (9 points total)
- (c) Comparing the centers and spreads: 2 points each (4 points total)
- (d) Relationship between the mean and the median: 1 point each (3 points total)

Question 3 (16)

- (a) Correctly formatted side-by-side boxplots of time versus brand: 4 points
- (b) Analysis of the shape of each boxplot: 2 points each (6 points total)
- (c) Comparing the centers and spreads: 2 points each (4 points total)
- (d) Consistency: 2 points

Question 4 (51)

- (a) Summaries (mean, std. dev., mode, range) for each of the three brands: 2 points each (6 total)
Comparing the means and standard deviations: 2 points each (4 points total)
Comparing the modes and ranges: 2 points each (4 points total)
Consistency: 2 points each (4 points total)
- (b) Summaries (5-number summary and IQR) for each of the three brands: 3 points each (9 total)
5-number summaries relating to shapes: 3 points
- (c) Table of means, standard deviations, and changes in mean time: 3 points per column (9 total)
Effect of higher mass on mean time: 4 points
Highest and lowest changes: 2 points each (4 points total)
Average change in time as mass increases by 0.125: 4 points

Question 5 (6)

Best brand (variation, fastest): 2 points each (4 total)

Impact of trend: 2 points

TOTAL = 107