

Exercises

1.1 The following measurements were recorded for the drying time, in hours, of a certain brand of latex paint.

3.4	2.5	4.8	2.9	3.6
2.8	3.3	5.6	3.7	2.8
4.4	4.0	5.2	3.0	4.8

Assume that the measurements are a simple random sample.

- What is the sample size for the above sample?
- Calculate the sample mean for this data. 3.787
- Calculate the sample median. 3.6.
- Plot the data by way of a dot plot.
- Compute the 20% trimmed mean for the above data set. 3.678

1.2 According to the journal *Chemical Engineering*, an important property of a fiber is its water absorbency. A random sample of 20 pieces of cotton fiber is taken and the absorbency on each piece was measured. The following are the absorbency values:

18.71	21.41	20.72	21.81	19.29	22.43	20.17
23.71	19.44	20.50	18.92	20.33	23.00	22.85
19.25	21.77	22.11	19.77	18.04	21.12.	

- Calculate the sample mean and median for the above sample values. Mean=20.768 and Median=20.610
- Compute the 10% trimmed mean. 20.743
- Do a dot plot of the absorbency data.

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1.3 A certain polymer is used for evacuation systems for aircraft. It is important that the polymer be resistant to the aging process. Twenty specimens of the polymer were used in an experiment. Ten were assigned randomly to be exposed to the accelerated batch aging process that involved exposure to high temperatures for 10 days. Measurements of tensile strength of

the specimens were made and the following data were recorded on tensile strength in psi.

No aging:	227	222	218	217	225
	218	216	229	228	221
Aging:	219	214	215	211	209
	218	203	204	201	205

- (a) Do a dot plot of the data.
- (b) From your plot, does it appear as if the aging process has had an effect on the tensile strength of this polymer? Explain.
- (c) Calculate the sample mean tensile strength of the two samples.
- (d) Calculate the median for both. Discuss the similarity or lack of similarity between the mean and median of each group.

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1.4 In a study conducted by the Department of Mechanical Engineering at Virginia Tech, the steel rods supplied by two different companies were compared. Ten sample springs were made out of the steel rods supplied by each company and a measure of flexibility was recorded for each. The data are as follows:

Company A:	9.3	8.8	6.8	8.7	8.5
	6.7	8.0	6.5	9.2	7.0
Company B:	11.0	9.8	9.9	10.2	10.1
	9.7	11.0	11.1	10.2	9.6

- (a) Calculate the sample mean and median for the data for the two companies. $\bar{X}_A = 7.950$ and $\bar{X}_A = 8.250$; $\bar{X}_B = 10.260$ and $\bar{X}_B = 10.150$.
- (b) Plot the data for the two companies on the **same** line and give your impression.

1.5 Twenty adult males between the ages of 30 and 40 were involved in a study to evaluate the effect of a specific health regimen involving diet and exercise on the blood cholesterol. Ten were randomly selected to be a control group and ten others were assigned to take

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part in the regimen as the treatment group for a period of 6 months. The following data show the reduction in cholesterol experienced for the time period for the 20 subjects:

Control group:	7	3	-4	14	2
	5	22	-7	9	5
Treatment group:	-6	5	9	4	4
	12	37	5	3	3

- Do a dot plot of the data for both groups on the same graph.
- Compute the mean, median, and 10% trimmed means for both groups.
- Explain why the difference in the mean suggests one conclusion about the effect of the regimen, while the difference in medians or trimmed means suggests a different conclusion.

Ex .1.6 The tensile strength of silicone rubber is thought to be a function of curing temperature. A study was carried out in which samples of 12 specimens of the rubber were prepared using curing temperatures of 20° C and 45° C. The data below show the tensile strength values in megapascals.

20° C:	2.07	2.14	2.22	2.03	2.21	2.03
	2.05	2.18	2.09	2.14	2.11	2.02
45° C:	2.52	2.15	2.49	2.03	2.37	2.05
	1.99	2.42	2.08	2.42	2.29	2.01

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- (a) Show a dot plot of the data with both low and high temperature tensile strength values.
- (b) Compute sample mean tensile strength for both samples.
- (c) Does it appear as if curing temperature has an influence on tensile strength based on the plot? Comment further.
- (d) Does anything else appear to be influenced by an increase in cure temperature? Explain.

1.7 Consider the drying time data for Exercise 1.1 on page 13. Compute the sample variance and sample standard deviation, $s^2 = 0.94284$, $s = 0.971$.

1.8 Compute the sample variance and standard deviation for the water absorbency data of Exercise 1.2 on page 13. 1.592

1.9 Exercise 1.3 on page 13 showed samples of tensile strength data, one for specimens that were exposed to an aging process and one in which there was no aging of the specimens. Calculate the sample variance as well as standard deviation in tensile strength for both samples. $s^2_{\text{No Aging}} = 42.12$, $s_{\text{No Aging}} = 6.49$, $s^2_{\text{Aging}} = 23.62$, $s_{\text{Aging}} = 4.86$.

1.10 For the data of Exercise 1.4 on page 13, compute both the mean and variance in "flexibility" for berth company A and company B. $s^2_A = 1.2078$, $s_A = 1.099$, $s^2_B = 0.3249$, $s_B = 0.570$

1.11 Consider the data in Exercise 1.5 on page 13. Compute the sample variance and the sample standard deviation for both the control and treatment groups. $s^2_{\text{Control}} = 69.39$, $s_{\text{Control}} = 8.33$, $s^2_{\text{Treatment}} = 128.14$, $s_{\text{Treatment}} = 11.32$

1.12 For Exercise 1.6 on page 14, compute the sample standard deviation in tensile strength for the samples separately for the two temperatures. Does it appear as if an increase in temperature influences the variability in tensile strength? Explain. $s^2_{20^\circ\text{C}} = 0.005$, $s_{20^\circ\text{C}} = 0.071$, $s^2_{45^\circ\text{C}} = 0.0413$, $s_{45^\circ\text{C}} = 0.2032$

The variation of the tensile strength is influenced by the increase of cure temperature.

1.13 A manufacturer of electronic components is interested in determining the lifetime of a certain type of battery. A sample, in hour's of life, is as follows:

123, 116, 122, 110, 175, 126, 125, 111, 118, 117.

- (a) Find the sample mean and median. Mean = 124.3, median = 120
- (b) What feature in this data set is responsible for the substantial difference between the two? 175

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1.14 A tire manufacturer wants to determine the inner diameter of a certain grade of tire. Ideally, the diameter would be 570 mm. The data are as follows:

572, 572, 573, 568, 569, 575, 565, 570.

- (a) Find the sample mean and median. Mean = 570.5, median = 571
- (b) Find the sample variance, standard deviation, and range. Variance= 10, standard deviation= 3.162, range=10
- (c) Using the calculated statistics in parts (a) and (b), can you comment on the quality of the tires?

Variation of the diameters seems too big.

1.15 Five independent coin tosses result in *HHHHH*. It turns out that if the coin is fair the probability of this outcome is $(1/2)^5 = 0.03125$. Does this produce strong evidence that the coin is not fair? Comment and use the concept of P-value discussed in Section 1.2.

1.16 Show that the n pieces of information in $\sum_{i=1}^n (x_i - \bar{x})^2$ are not independent; that is, show that,

$$\sum_{i=1}^n (x_i - \bar{x}) = 0.$$

1.17 A study of the effects of smoking on sleep patterns is conducted. The measure observed is the time, in minutes, that it takes to fall asleep. These data are obtained:

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Smokers:	69.3	56.0	22.1	47.6
	53.2	48.1	52.7	34.4
	60.2	43.8	23.2	13.8
Nonsmokers:	28.6	25.1	26.4	34.9
	29.8	28.4	38.5	30.2
	30.6	31.8	41.6	21.1
	36.0	37.9	13.9	

$\bar{x}_{\text{smokers}} = 43.70$, $\bar{x}_{\text{nonsmokers}} = 30.32$;

- Find the sample mean for each group.
- Find the sample standard deviation for each group.
 $s_{\text{smokers}} = 16.93$ and $s_{\text{nonsmokers}} = 7.13$
- Make a dot plot of the data sets A and B on the same line.
- Comment on what kind of impact smoking appears to have on the time required to fall asleep.

1.18 The following scores represent the final examination grade for an elementary statistics course:

23	60	79	32	57	74	52	70	82
36	80	77	81	95	41	65	92	85
55	76	52	10	64	75	78	25	80
98	81	67	41	71	83	54	64	72
88	62	74	43	60	78	89	76	84
48	84	90	15	79	34	67	17	82
69	74	63	80	85	61			

- Construct a stem-and-leaf plot for the examination grades in which the stems are 1, 2, 3, ..., 9.
- Set up a relative frequency distribution.
- Construct a relative frequency histogram, draw an estimate of the graph of the distribution and discuss the skewness of the distribution.
- Compute the sample mean, sample median, and sample standard deviation.

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1.19 The following data represent the length of life in years, measured to the nearest tenth, of 39 similar fuel pumps:

2.0	3.0	0.3	3.3	1.3	0.4
0.2	6.0	5.5	6.5	0.2	2.3
1.5	4.0	5.9	1.8	4.7	0.7
4.5	0.3	1.5	0.5	2.5	5.0
1.0	6.0	5.6	6.0	1.2	0.2

- (a) Construct a stem-and-leaf plot for the life in years of the fuel pump using the digit to the left of the decimal point as the stem for each observation.
- (b) Set up a relative frequency distribution.
- (c) Compute the sample mean, sample range, and sample standard deviation.

1.20 The following data represent the length of life, in seconds, of 50 fruit flies subject to a new spray in a controlled laboratory experiment:

17	20	10	9	23	13	12	19	18	24
12	14	6	9	13	6	7	10	13	7
16	18	8	13	3	32	9	7	10	11
13	7	18	7	10	4	27	19	16	8
7	10	5	14	15	10	9	6	7	15

- (a) Construct a double-stem-and-leaf plot for the life span of the fruit flies using the stems 0*, 0•, 1*, 1•, 2*, 2•, and 3* such that stems coded by the symbols * and • are associated, respectively, with leaves 0 through 4 and 5 through 9.
- (b) Set up a relative frequency distribution.
- (c) Construct a relative frequency histogram.
- (d) Find the median.

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1.21 The nicotine contents, in milligrams, for 40 cigarettes of a certain brand were recorded as follows:

1.09	1.92	2.31	1.79	2.28
1.74	1.47	1.97	0.85	1.24
1.58	2.03	1.70	2.17	2.55
2.11	1.86	1.90	1.68	1.51
1.64	0.72	1.69	1.85	1.82
1.79	2.46	1.88	2.08	1.67
1.37	1.93	1.40	1.64	2.09
1.75	1.63	2.37	1.75	1.69

$$\bar{x} = 1.7743 \text{ and } s = 0.3905$$

(a) Find the sample mean and sample median.

(b) Find the sample standard deviation. $s = 0.3905$.

1.22 The following data are the measures of the diameters of 36 rivet heads in 1/100 of an inch.

6.72	6.77	6.82	6.70	6.78	6.70	6.62	6.75
6.66	6.66	6.64	6.76	6.73	6.80	6.72	6.76
6.76	6.68	6.66	6.62	6.72	6.76	6.70	6.78
6.76	6.67	6.70	6.72	6.74	6.81	6.79	6.78
6.66	6.76	6.76	6.72				

(a) Compute the sample mean and sample standard deviation. $\bar{x} = 6.7261, 0.0536$.

(b) Construct a relative frequency histogram of the data.

(c) Comment on whether there is any clear indication or not that the sample came from a population that depicts a bell-shaped distribution.

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1.23 The hydrocarbon emissions at idling speed in parts per million (ppm) for automobiles of 1980 and 1990 are given for 20 randomly selected cars.

1980 models:

141	359	247	940	882	494	306	210	105	880
200	223	188	940	241	190	300	435	241	380

1990 models:

140	160	20	20	223	60	20	95	360	70
220	400	217	58	235	380	200	175	85	65

- (a) Construct a dot plot as in Figure 1.1.
- (b) Compute the sample means for the two years and superimpose the two means on the plots.
- (c) Comment on what the dot plot indicates regarding whether or not the population emissions changed from 1980 to 1990. Use the concept of variability in your comments.

1.24 The following are historical **data** on staff salaries (dollars per pupil on 30 schools sampled in the eastern part of the United States in the early 1970s).

3.79	2.99	2.77	2.91	3.10	1.84	2.52	3.22
2.45	2.14	2.67	2.52	2.71	2.75	3.57	3.85
3.36	2.05	2.89	2.83	3.13	2.44	2.10	3.71
3.14	3.54	2.37	2.68	3.51	3.37		

- (a) Compute the sample mean and sample standard deviation.
- (b) Construct a relative frequency histogram of the data.
- (c) Construct a stem-and-leaf display of the data.

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1.25 The following data set is related to that in Exercise 1.24. It gives the percent of the families that are in the upper income level at the same individual schools in the same order as in Exercise 1.24.

72.2	31.9	26.5	29.1	27.3	8.6	22.3	26.5
20.4	12.8	25.1	19.2	24.1	58.2	68.1	89.2
55.1	9.4	14.5	13.9	20.7	17.9	8.5	55.4
38.1	54.2	21.5	26.2	59.1	43.3		

- (a) Calculate the sample mean. = 33.31
- (b) Calculate the sample median. 26.35
- (c) Construct a relative frequency histogram of the data.
- (d) Compute the 10% trimmed mean. Compare with the results in (a) and (b) and comment.

1.26 Suppose it is of interest to use the data sets in Exercises 1.24 and 1.25 to derive a model that would predict staff salaries as a function of percent of families in a high income level for current school systems. Comment on any disadvantage in carrying out this type of analysis.

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1.27 A study is done to determine the influence of the wear, y , of a bearing as a function of the load, x , on the bearing. A designed experiment is used for this study. Three levels of load were used, 700 lb, 1000 lb, and 1300 lb. Four specimens were used at each level and the sample means were, respectively, 210, 325, and 375.

- (a) Plot average of wear against load.
- (b) From the plot in (a), does it appear as if a relationship exists between wear and load?
- (c) Suppose we look at the individual wear values for each of the four specimens at each load level.

	x		
	700	1000	1300
y_1	145	250	150
y_2	105	195	180
y_3	260	375	420
y_4	330	480	750
<hr/>			
	$\bar{y}_1 = 210$	$\bar{y}_2 = 325$	$\bar{y}_3 = 375$

Plot the wear results for all specimens against the three load values.

- (d) From your plot in (c), does it appear as if a clear relationship exists? If your answer is different from that in (b), explain why.

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1.28 Many manufacturing companies in the United States and abroad use molded parts as components of a process. Shrinkage is often a major problem. Thus a molded die for a part is built larger than nominal to allow for part shrinkage. In an injection molding study it is known that the shrinkage is influenced by many factors, among which are the injection velocity in **ft/sec** and mold temperature in **°C**. The following two data sets show the results of a designed experiment in which injection velocity held at two levels (say "low" and "high") and mold temperature was held constant at a "low" level. The shrinkage is measured in **cm X 10⁴**.

Shrinkage values at low injection velocity:

72.68	72.62	72.58	72.48	73.07
72.55	72.42	72.84	72.58	72.92

Shrinkage values at high injection velocity:

71.62	71.68	71.74	71.48	71.55
71.52	71.71	71.56	71.70	71.50

- (a) Construct a dot plot of both data sets on the same graph. Indicate on the plot both shrinkage means, that for low injection velocity and high injection velocity.
- (b) Based on the graphical results in (a), using the location of the two means and your sense of variability, what is your conclusion regarding the effect of injection velocity on shrinkage at "low" mold temperature?

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1.29 Consider the situation of Exercise 1.28. But now use the following data set in which shrinkage is measured once again at low injection velocity and high injection velocity. However, this time the mold temperature is raised to a "high" level and held constant.

Shrinkage values at low injection velocity:

76.20	76.09	75.98	76.15	76.17
75.94	76.12	76.18	76.25	75.82

Shrinkage values at high injection velocity:

93.25	93.19	92.87	93.29	93.37
92.98	93.47	93.75	93.89	91.62

- (a) As in Exercise 1.28, construct a dot plot with both data sets on the same graph and identify both means (i.e., mean shrinkage for low injection velocity and for high injection velocity).
- (b) As in Exercise 1.28, comment on the influence of injection velocity on shrinkage for high mold temperature. Take into account the position of the two means and the variability around each mean.
- (c) Compare your conclusion in (b) with that in (b) of Exercise 1.28 in which mold temperature was held at a low level. Would you say that there is an interaction between injection velocity and mold temperature? Explain.

1.30 Use the results of Exercises 1.28 and 1.29 to create a plot that illustrates the interaction evident from the data. Use the plot in Figure 1.3 in Example 1.3 as a guide. Could the type of information found in Exercises 1.28, 1.29, and 1.30 have been found in an observational study in which there was no control on injection velocity and mold temperature by the analyst? Explain why or why not.