4-3

Speed data collected on an urban roadway yielded a standard deviation in speeds of ±4.8 mi/hr.

(a) If an engineer wishes to estimate the average speed on the roadway at a 95% confidence level so that the estimate is within ±2 mi/hr of the true average, how many spot speeds should be collected?

(b) If the estimate of the average must be within ±1 mi/hr, what should the sample size be?

(a) Using Equation 4.5,
\[ N = \left[ \frac{z \sigma}{d} \right]^2 \]
\[ N = \left[ \frac{1.96(4.8)}{2} \right]^2 \]
\[ N = 22.1 \Rightarrow 23 \text{ spot speed observations} \]

Note: \( z = 1.96 \text{ for 95% confidence interval} \)

(b)
For speeds within ±1 mi/h:
\[ N = \left[ \frac{1.96(4.8)}{1} \right]^2 \]
\[ N = 88.5 \Rightarrow 89 \text{ spot speed observations} \]

4-5

An engineer wishing to determine whether there is a statistically significant difference between the average speed of passenger cars and that of large trucks on a section of highway, collected the data shown below. Determine whether the engineer can conclude that the average speed of large trucks is the same as for passenger cars.

<table>
<thead>
<tr>
<th></th>
<th>Trucks</th>
<th>Passenger Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Speed (mi/hr)</td>
<td>62</td>
<td>59</td>
</tr>
<tr>
<td>Standard deviation of speed ± mi/hr</td>
<td>5.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Sample size</td>
<td>275</td>
<td>175</td>
</tr>
</tbody>
</table>

To determine whether the difference in mean speeds was statistically significant, first, the pooled standard deviation must be determined, using Equation 4.6.

\[ s_p = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}} = \sqrt{\frac{(5.5)^2}{275} + \frac{(6.3)^2}{175}} = 0.58 \]

Then, compare the absolute value of the difference of the sample means with the product of the appropriate z-statistic and the pooled standard deviation.

Absolute difference in means = 62 - 59 = 3.
\[ ZS_d = (1.96)(0.58) \]
\[ 3 > 1.13 \]

Therefore, a statistically significant difference exists between the two data sets, and it cannot be concluded that the average speed of large trucks is the same as that of passenger cars.
4.7

First calculate average and standard deviation for both sets of data.

\[ u_b = 35.1 \text{ mi/h} \quad s_b^2 = 3.209^2 \]
\[ u_a = 27.5 \text{ mi/h} \quad s_a^2 = 5.444^2 \]

Next, calculate the pooled standard deviation for both sets of data.

\[ s_d = \left[ \frac{(s_b^2 / n_b) + (s_a^2 / n_a)}{2} \right]^{1/2} \]
\[ = \left[ \frac{(3.209^2 / 30) + (5.444^2 / 30)}{2} \right]^{1/2} \]
\[ = 1.154 \]

Then compare the difference in average speed with the product of the z-statistic and standard deviation.

\[ |u_b - u_a| = 7.6 \]
\[ Z_{sd} = 1.96(1.154) \]
\[ = 2.262 \]

Since 7.6 > 2.262 therefore the speeds are significantly different.

4-8

Using the data furnished in Problem 4-7, draw the histogram frequency distribution and cumulative percentage distribution for each set of data and determine (a) average speed, (b) 85th-percentile speed, (c) 15th-percentile speed, (d) mode, (e) median, and (f) pace.

(a) average speed = \( \Sigma u_i / \Sigma f_i \)

"before" average = 1053/30 = 35.1 mi/h
"after" average = 824/30 = 27.5 mi/h

(b) 85%-ile speeds from cumulative distribution plots

before = 38.4 mi/h
after = 33.6 mi/h

(c) 15%-ile speeds from cumulative distribution plots

before = 30.8 mi/h
after = 20.5 mi/h

(d) mode from histograms

before = 35 mi/h
after = 21 mi/h

(e) median from cumulative distribution plots

before = 34.5 mi/h
after = 31 mi/h

(f) pace from histograms

before = 30 – 40 mi/h
after = 21 – 31 mi/h
Define the following terms and cite examples of how they are used.

**Average annual daily traffic (AADT)**

**Average daily traffic (ADT)**

**Vehicle-miles of travel (VMT)**

**Peak hour volume (PHV)**

- **Average annual daily traffic (AADT)** is the average of 24-hour traffic counts collected every day in the year. These counts are used to estimate highway user revenues, compute accident rates, and establish traffic volume trends.

- **Average daily traffic (ADT)** is the average of 24-hour traffic counts collected over a number of days greater than one but less than a year. These counts are used for planning of highway activities, measuring current traffic demand, and evaluating existing traffic flow.

- **Vehicle miles of travel (VMT)** is a measure of travel usage along a section of road. It is the product of the volume (ADT) and the length of roadway in miles to which the volume is applicable. This measure is used mainly as a base for allocating resources for maintenance and improvement of highways and to establish highway system usage trends.

- **Peak hour volume (PHV)** is the maximum number of vehicles that pass a point on a highway during a period of sixty consecutive minutes. This volume is used for functional classification of highways, geometric design standards selection, capacity analysis, development of operational programs, and development of parking regulations.

**4-18**

Data collected at a parking lot indicate that a total of 300 cars park between 8 a.m. and 6 p.m. 10% of these cars are parked for an average of 2 hr, 30% for an average of 4 hr, and the remaining cars are parked for an average of 10 hr. Determine the space-hours of demand at the lot.

Use Equation 4.12: \[ D = (0.10)(300)(2) + (0.30)(300)(4) + (0.60)(300)(10) \]

\[ D = 2,220 \text{ space-hours} \]

**4-19**

If 10% of the parking bays are vacant on average (between 8 a.m. and 6 p.m.) at the parking lot of problem 4-18, determine the number of parking bays in the parking lot. Assume an efficiency factor of 0.85.

Use Equation 4.12:

\[ 2220 + (2220)(0.10) = 2442 \text{ space-hours (assuming 10% vacancy)} \]

\[ (0.85)(10)(N) = 2442 \]

\[ N = 288 \text{ spaces} \]