Spot Speed Study

Engineering H191

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Instructor: Dr. Kathy Harper       Class Section: 1:30

Lab Section: Thursday, 1:30-3:18

Date of Experiment: 10/6/11
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1. Introduction

The purpose of this experiment was to determine if the speed limit enforcement in a given area was effective. By timing how long it took a car to drive a fixed distance, the approximate speed, in miles per hour, of the car could be determined. By timing as many cars as possible, numerous data points were collected. The speeds and frequencies of the observed cars were then used to calculate mode, percentiles, pace, average speed and deviation.

A thorough description of how the experiment was carried out can be found in Section 2, Experimental Methodology. Section 3 of this report, Results and Description, contains observed and calculated data. These results are analyzed in Section 4, Discussion. A summary and concluding statements made from this experiment can be found in Section 5, Summary and Conclusions.

2. Experimental Methodology

A stopwatch was used for the experiment. The flagger was at the south end of the marked area, while the recorder and timer were at the north. The safety engineer moved between the groups. The marked area was 176 feet long. Each time the front of a car would enter the speed trap, the flagger would signal to the timer, who would begin timing. Flagging was done in a manner that would not distract drivers. When the car exited the speed trap, the timer would announce the time to the recorder, who would mark a tally in the correct time slot. Figure A1, in Appendix A, shows the data collection sheet used for the experiment. Slots were established by an upper limit and a lower limit that were 2 seconds apart. The limits were measurements of time, in seconds, that corresponded to a measurement of speed, in miles per hour. The time, location, weather and road conditions were also recorded. The safety engineer was in charge of
ensuring that everyone stayed out of the road. Group members were instructed to rotate positions during the observation period. The group was positioned on the east side of Olentangy River Road. The cars observed were northbound cars in the right lane. Figure A2, in Appendix A, shows the layout of the experiment. The group’s location is indicated by a star and the letter “H.” Cars were observed on October 6, 2011 from 2:00 until 3:00 in the afternoon. It was a sunny day and the road conditions were good. After an hour, data collection was discontinued. As many data points as possible were recorded.

3. Results and Description

The raw data was organized and observed results for 112 vehicles are displayed in Table C1, of Appendix C. This set of data is used for all the calculated values throughout the experiment.

From the collected data, relative frequency and cumulative frequency of the cars in each speed interval were calculated. The relative frequency is calculated as a percent; the number of cars in the interval divided by the total number of cars, multiplied by 100%. The cumulative frequency is the sum of the percentages of vehicles travelling at or below the maximum speed of the group. For the 35mph speed interval, this would mean adding the relative frequencies of the 33mph, 31mph, 29mph, 27mph and 25mph speed intervals to the relative frequency for the 35mph speed interval to get 17.86% cumulative frequency. The values for relative and cumulative frequency are found in Table 1, on page 4 of this report.
The range of time, originally two seconds, was changed to four seconds to produce a graph with one mode peak, rather than two. If two mode peaks appeared in the graph, the pace and the percentage of vehicles in the pace could not be accurately calculated. With two peaks, the graph does not have a smooth, consistent curve nor does it have a central tendency. Neighboring pairs of intervals were combined to create a single mode graph. By adding the maximum speed and minimum speed of each interval, and dividing the sum by two, the average speed for the adjusted interval was calculated. The adjusted frequencies and speeds are shown in Table C2, in Appendix C.

The results from Table C2 were plotted on two graphs- one graph showing relative frequency, the other showing cumulative frequency. These graphs are found in Figure C1 in
Appendix C of this report. Table 2, below, shows the data that was read from Figure C1, as well as calculated values from equations 1, 2, and 3.

**Table 2:** Values determined from Figure C1 and mathematically calculated values

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Mode (mph)</td>
<td>42</td>
</tr>
<tr>
<td>50\textsuperscript{th} Percentile Speed (mph)</td>
<td>43.2</td>
</tr>
<tr>
<td>10 mph Pace (x to y mph)</td>
<td>36.8-46.8</td>
</tr>
<tr>
<td>Percent of vehicles in pace (%)</td>
<td>58%</td>
</tr>
<tr>
<td>15\textsuperscript{th} percentile speed (mph)</td>
<td>35.7</td>
</tr>
<tr>
<td>85\textsuperscript{th} percentile speed (mph)</td>
<td>50.1</td>
</tr>
<tr>
<td>Average Speed (mph)</td>
<td>42.43</td>
</tr>
<tr>
<td>Estimated Standard Deviation (mph)</td>
<td>7.00</td>
</tr>
<tr>
<td>Calculated Standard Deviation (mph)</td>
<td>6.33</td>
</tr>
</tbody>
</table>

The mode, 42mph, was determined to be the highest point on the Relative Frequency Graph, which is equal to the speed at which the most cars travelled. Values for 50\textsuperscript{th} Percentile Speed; 43.2mph, 15\textsuperscript{th} Percentile Speed; 35.7mph, and 85\textsuperscript{th} Percentile Speed; 50.1mph, were read directly from the Cumulative Frequency Graph in Figure C1. The pace, 36.8mph to 46.8mph,
was calculated by finding two points on the Relative Frequency Graph that were 10 mph apart. Because the abscissa scales were the same for both graphs, lines were extended from the two endpoints of the pace on the Relative Frequency Graph down to the Cumulative Frequency Graph in order to determine the percent of vehicles in the pace, which was 58%. The calculated values- average speed; 42.43mph, estimated standard deviation; 7.00mph, and calculated standard deviation; 6.33mph- were found using Equations 1, 2 and 3 respectively. The sample calculations are found in Appendix B of this report.

**Average Speed**

\[ \bar{x} = \frac{\sum n_i S_i}{N} \]  \hspace{1cm} (1)

- \( n = \) frequency of observations in group \( i \), cars
- \( S = \) middle speed of interval \( i \), mph
- \( N = \) total number, cars
- \( \bar{x} = \) average speed, mph

The values for \( n_i S_i \), for all speed groups, can be found in Table C3 in Appendix C.

**Estimated Standard Deviation**

\[ S_{est} = \frac{P_{85} - P_{15}}{2} \]  \hspace{1cm} (2)

- \( P_{85} = 85^{th} \) percentile speed, % of cars
- \( P_{15} = 15^{th} \) percentile speed, % of cars
- \( S_{est} = \) estimated deviation, mph
Calculated Standard Deviation

\[ s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{N-1}} \]  

\( x_i \) = middle speed of interval, mph
\( \bar{x} \) = average speed, mph
\( N \) = total number, cars
\( s \) = standard deviation, mph

4. Discussion

The raw collected data, as shown in Figure C1, shows that there is a medium amount of dispersion in collected data. Dispersion, in this case, refers to “the scattering of values of a variable around the mean or median of a distribution.” (www.dictionary.com, 10/25/11) Dispersion shows how widespread the data points were, and deals with the value of standard deviation, or the average of the differences in mean speed and group speed. The cars, on average, were 6.33mph away from the mean of 42.43mph. By analyzing the results in Table 1, one can see that 63.39% of cars were within one standard deviation of the mean. The remaining 36.61% of cars had wide dispersion. The dispersion of data may have come from drivers travelling at speeds faster speed limit. 10.71% of cars were recorded to be travelling at the posted speed limit, 35mph, while 82.14% of cars were travelling faster than 35mph. The wide range in driving speeds may have accounted for the dispersion of the data.

The mode of the graph shows that there is one central tendency. Central tendency refers to “the tendency of samples of a given measurement to cluster around some central value.” (www.dictionary.com, 10/10/11) The “central value” of this experiment is the mode, 42mph. Most of the cars in the experiment were travelling at this speed. There is a central tendency, or
mode, in the graph because there is a speed limit, and cars have a tendency to drive the speed limit, or in this case, 7mph over the speed limit.

Dispersion of data in a speed trap may vary under different conditions. For instance, at the Indy 500 during normal green flag conditions, one might expect to see very little dispersion. If the cars are all travelling at approximately the same speed—even if the speed is very fast—there will be little difference in the speed of the cars and therefore, narrow dispersion. If a spot speed study was conducted on High Street on a Saturday evening in the spring, with moderate pedestrian traffic, many stop lights and no rain, one might expect to see a wider dispersion of data. With cars accelerating and decelerating due to stoplights and waiting on pedestrians and other vehicles, the collected data may span a wide range of values.

Errors may have occurred due to the rotation of team members, distractions to drivers, lane-changing cars and the imperfect method of flagging. With rotation of team members through the different positions, flagging and timing methods may have varied slightly. This could have affected times and values recorded. Inaccuracies may have occurred with the change of each position. Flagging, although intended to be done in subtly, may have distracted drivers. This distraction may have caused them to change their speed, resulting in an inaccurate recorded speed value. Cars that were changing lanes travelled extra distance and were therefore timed for a longer distance than the other cars. This ambiguity was not addressed in the method of recording, so the lane-changing cars were recorded at a slower speed than they were actually travelling. The method of flagging was fairly basic and imprecise. A wave of the hand could have been delayed and the timing, likewise, could have been slightly off. This would have produced an inaccurate speed for the car.
5. **Summary and Conclusions**

The purpose of this spot speed study was to determine the range of speeds in a speed zone of 35mph and to determine if the legal speed limit enforcement was effective. In this experiment a 176-foot length of road, on Olentangy River Road, was marked off and cars travelling through the zone were timed. The time, in seconds, that the vehicle took to travel the length of the trap was converted to miles per hour on a given record sheet. The data from the observations was manipulated and used to calculate the values of average speed, standard deviation, mode, percentiles, and pace. From this data, conclusions can be made as to the effectiveness of the speed enforcement in the area.

The methodology of the experiment could be altered to reduce error. First, it would be advisable to keep all team members in their original positions for the duration of the experiment. This would produce a uniformity that was not present in the original experiment. In order to avoid distracting drivers, a very slight signal could be done. Instead of a hand wave, a small twitch or subtle movement could be used, for example a head turn. Lane changing cars should not be counted because there is no way to accurately measure their distance. The issue of flagging conflicts with the issue of distracting drivers. The subtler the movement, the less likely a driver is to see it. At the same time, the subtler the movement, the less likely the timer is to recognize it quickly. If the team had a budget of $200, the experiment could be changed to reduce error. With $200, two radar guns could be purchased (http://www.radarguns.com, 10/12/11). With these tools, the exact speed of the travelling vehicles could be recorded. With two recorded speeds for each observed vehicle, a more precise and accurate value could be calculated. Radar guns would eliminate the error from rotation, lane-changing and imperfect flagging. If observed subtly, driver distraction could be eliminated.
The average speed of the experiment was calculated to be 42.43mph. This is 7.43mph over the posted speed limit of 35mph. The percentage of cars travelling at 45mph was 18.75%. With this statistic, it can be concluded that speed enforcement is not effective in this area. Further experiments could be carried out to collect more data on this subject. For instance, data collection should be taken at different times, different days and during different weather conditions. This would give more diverse and more accurate data. Future errors could be avoided by using a more precise method of recording and by having a better plan for how to record data. From the results collected in this study, it can be concluded that most data would produce results that show drivers to be travelling at speeds faster than the posted limit.
APPENDIX A

Experimental Setup
Figure A1: Experimental Set-Up, taken from “Spot Speed Slides- 2011”, FEH 191.01 Course Materials: <https://carmen.osu.edu> Accessed October 6, 2011
APPENDIX B

Sample Calculations
Average Speed of Group

\[ S_{ave} = \frac{S_{max} + S_{min}}{2} \quad (1) \]

Relative Frequency

\[ F_r = \frac{n}{N} \cdot 100\% \quad (2) \]

Cumulative Frequency

\[ F_{c,n} = F_n + F_{c,n-1} \quad (3) \]

Average Speed

\[ \bar{x} = \frac{\sum n_i S_i}{N} \quad (4) \]

\[ \text{Sum of all speeds in interval} \quad n_i S_i \quad (4a) \]

Standard Deviation

Estimated

\[ S_{est} = \frac{P_{95} - P_{15}}{2} \quad (5) \]

Calculated

\[ S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} \quad (6) \]

All calculations use the 30mph point, unless the entire scope of values is needed.

Sample Calculation for Average Speed of Group

\[ S_{ave} = \frac{32 + 28}{2} = 30 \text{ mph} \]

Sample Calculation for the Relative Frequency

\[ F_r = \frac{5}{112} \cdot 100\% = 4.46\% \]

Sample Calculation for the Cumulative Frequency

\[ F_{c,n} = 4.46\% + 0.89\% = 5.36\% \]
Sample Calculation for the Average Speed

*Sum of all speeds in interval*

\[ n_i S_i = 30\text{mph} \times 5 = 150\text{mph} \]

\[ \bar{x} = \frac{26 + 150 + 476 + 532 + 1344 + 1012 + 800 + 378 + 57}{112} = 42.63 \text{mph} \]

Sample Calculation for Standard Deviation

*Estimated*

\[ s_{\text{est}} = \frac{50\text{mph} - 36\text{mph}}{2} = 7.00 \text{mph} \]

*Calculated*

\[ s = \sqrt{\frac{(26 \text{mph} - 42.63 \text{mph})^2 + 5(30 \text{mph} - 42.63 \text{mph})^2}{112 - 1}} + \]

\[ \sqrt{\frac{14(34 \text{mph} - 42.63 \text{mph})^2 + 14(38 \text{mph} - 42.63 \text{mph})^2 + 32(42 \text{mph} - 42.63 \text{mph})^2}{112 - 1}} + \]

\[ \sqrt{\frac{22(46 \text{mph} - 42.63 \text{mph})^2 + 16(50 \text{mph} - 42.63 \text{mph})^2 + 7(54 \text{mph} - 42.63 \text{mph})^2 + 1(57 \text{mph} - 42.63 \text{mph})^2}{112 - 1}} \]

= 6.48 \text{ mph}
APPENDIX C

Figures and Tables
Figure C1: Graph of relative and cumulative frequencies(%) as applied to speeds of observed cars.
Table C1: Values determined from Figure C1 and mathematically calculated values

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Table C2: The sum of all speeds within each speed interval

<table>
<thead>
<tr>
<th>Middle Speed</th>
<th>Frequency</th>
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<tr>
<td>26</td>
<td>1</td>
<td>26</td>
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<tr>
<td>30</td>
<td>5</td>
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<td>57</td>
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<td>57</td>
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