APPENDIX B- SAMPLE FORMAL LAB REPORT

Purpose of the lab report: to report what you did, what you observed, and what it means.

Sample Formal Laboratory Report

Checking the Speedometer of a Car
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Abstract: The accuracy of a speedometer reading in a 1997 Toyota corolla was tested by measuring the time it took the corolla to travel a range of distances (0-200m) when driven at a constant speed of 100km/h, as measured using the speedometer. The experimental speed measurements were consistent with the speedometer reading. However, uncertainty in the experiment was ± 4.0 km/h, so speedometer inaccuracies of ± 4.0 km/h or less cannot be ruled out.

Introduction: I am often unsure of how reliable my speedometer is, so verifying its accuracy could help me avoid costly tickets. One 2002 study [1] found that car speedometer readings were on average 2.2 km/h faster than the true speed. In this experiment, we tested the accuracy of the speedometer in a 1997 Toyota corolla by driving the corolla at a constant speed down a straight road and measuring the time it took for the corolla to cover a range of distances.

We modelled the car as a point particle and assumed that the car maintained a constant velocity during the experiment. The position x of a particle with constant velocity will obey the equation

$$x = vt + x_0$$

Where v is the velocity of the car, t is the time elapsed past some initial time, and x_0 is the position of the car at time zero. By measuring the position of the car at a series of times, and fitting the data to the above relationship, we were able find an experimental velocity for the car, which could then be compared to the velocity displayed on the speedometer.

Methods: A long straight stretch of road was identified near Largo MD. A traffic cone was placed along the side of the road. A tape measure was used to measure distances 50m, 100m, 150m, and 200m along the road away from the cone, and cones were placed at each of these four locations (Figure 1). Five stopwatches were coordinated to the nearest 1/100th of a second. Five observers each took one of these watches and stood by each of the cones. A driver in the corolla then drove the car along the stretch of road, maintaining a constant speed of 100km/h according to the speedometer. Each of the five observers noted the time when the car passed him or her.

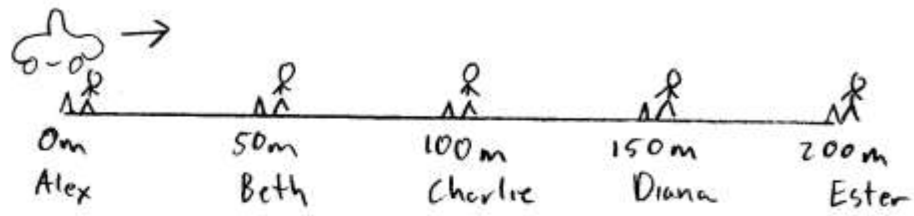

Figure 1.

Data: The times recorded by each observer are reported in the table below:

Observer	Location (±0.1m)	Time (±0.25s)
Alex	0m	11:59:12.59
Beth	50m	11:59:14.67
Charlie	100m	11:59:16.05
Diana	150m	11:59:17.86
Ester	200m	11:59:19.85

The main factor causing uncertainty in the location measurements was the difficulty in stretching the tape measure perfectly straight. The main factor causing uncertainty in the time measurements were possibly varying reaction times of the observers.

The driver observed that the speedometer did not vary more than 2km/h from 100km/h during the time in which she drove the car. Therefore the uncertainty in the speedometer reading was ±2km/h.

Analysis:

In order to simplify our analysis we first define time t = 0 to be the time the car passed the cone at x = 0m. Our time data was then expressed as the amount of time elapsed after the car passed the first cone.

Observer	Location (±0.1m)	Time (±0.25s)
Alex	0m	0
Beth	50m	2.08
Charlie	100m	3.46
Diana	150m	5.27
Ester	200m	7.26

Since for an object moving with constant velocity, $x = vt + x_0$, we expect that if we plot the position vs. the time we will get a linear graph, and the slope of that graph will be the velocity of the car. Figure 2 shows this graph.

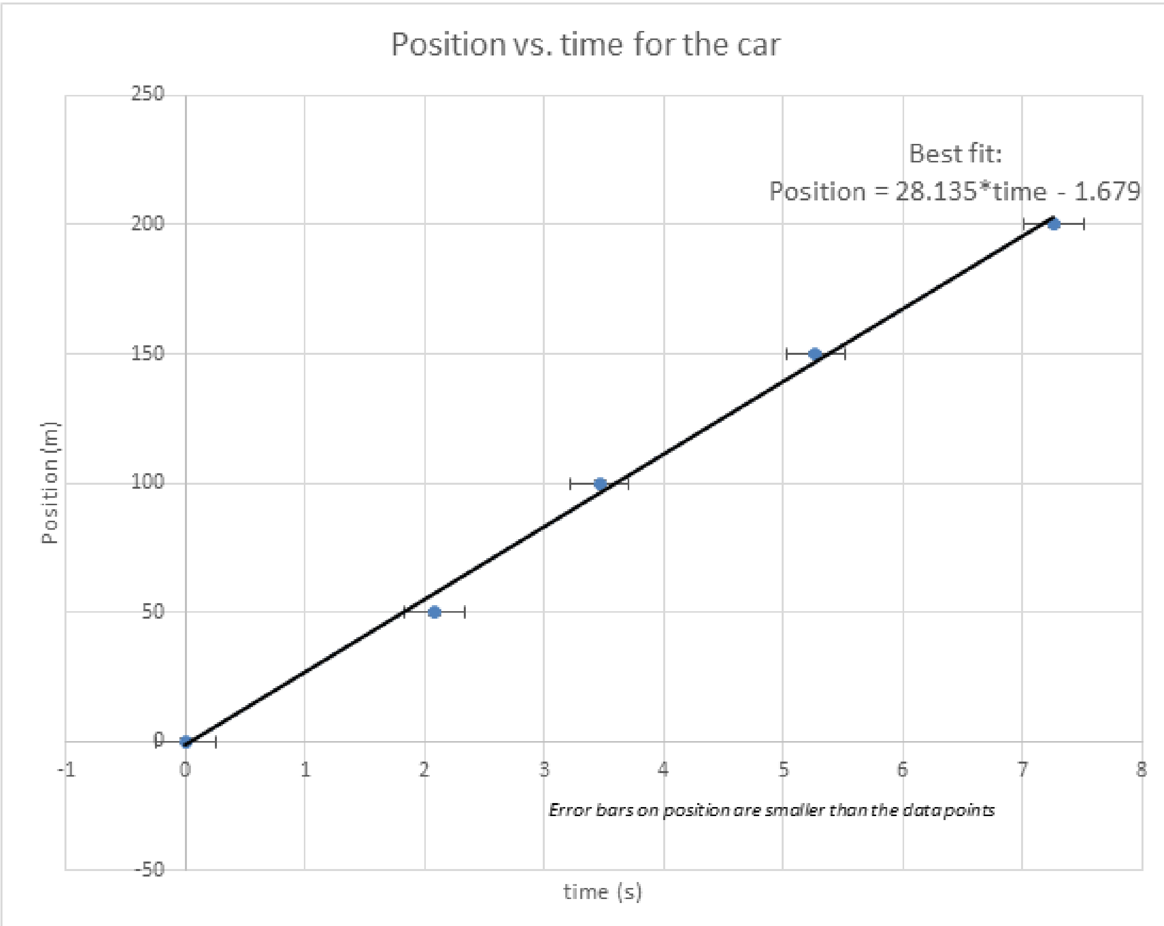

Figure 2.

A linear regression of the data has an r^2 value of 0.9965 indicating that the data is in fact quite linear, confirming that the car was travelling at close to a constant velocity.

Using the regression equation we are able to find the explicit function for the position as a function of time:

$$x = (28.1(m/s))*t - 1.68m$$

The slope of the regression line, 28.1 m/s, is the experimental estimate for the speed of the car.

The uncertainty in the speed was estimated using a Monte Carlo simulation. This simulation generated 500 random sets of data assuming normal distributions centered around the data points and with standard deviations equal to the uncertainties of the data. A best fit line was then fit to each of the generated sets of data. The reported uncertainty in the velocity, 0.5 m/s, is the standard deviation of the best fit slopes. The final experimental velocity is therefore 28.1 $\pm$ 0.5 m/s.

Conclusion:

The velocity as measured by the speedometer was 100 km /h = 27.8 m/s. The uncertainty in this value was 2 km/h = 0.6 m/s. The discrepancy between the speedometer measurement and the experimental measurement is therefore 28.1 – 27.8 = 0.3 m/s. Our total uncertainty is 0.5 m/s + 0.6 m/s = 1.1 m/s. Since the discrepancy is less than the uncertainty, our experimental measurement of the speed of the car is consistent with the speedometer value. However, this experiment only shows that the speedometer value is accurate within a fairly broad range: our experimental was expected to be accurate to only ± 1.1m/s = ± 4.0 km/h. Therefore, our experiment could have detected speedometer errors of only 4.0 km/h or greater. It is still possible that the speedometer is inaccurate by as much as about 4 km/h. More accurate measurement methodologies are required to more fully test the accuracy of the speedometer.

References:

1. Fredrick, Hans. "The Accuracy of Vehicle Speedometers". http://www.ehow.com/info_12209329_accuracy-vehicle-speedometers.html. Accessed 9/25/2012.