AP Physics C: The Tortoise and the Hare Lab

Raja Williams

September 2023

1 Objective

The Tortoise and the Hare Lab seeked to predict, test and determine the meeting point of two constant velocity buggies when both start moving towards each other, or toward the same point. Two buggies were assigned to each group, as well as two lines on the floor to denote starting locations for the buggies and for predicting the meeting point. One of these buggies is around twice the speed of the other.

2 Procedure

1. Measure the distance between the assigned lines.

2. Utilizing a meter stick, measure the amount of time it takes each buggy to go 1 meter using a stopwatch, specifically paying attention to the front wheel of the buggy. A diagram is visible in Figure 1.

3. To predict the meeting point of the two buggies, solve a system of equations utilizing the distance measured in Step 1 and calculated speeds from Step 2. Lay down a piece of tape on the floor at the predicted meeting point.

4. Then, set both buggies off side by side to test the predictions from Step 3. A video with a timer visible in frame should be recorded for later reference of timing. Use the tape to see if prediction is correct.

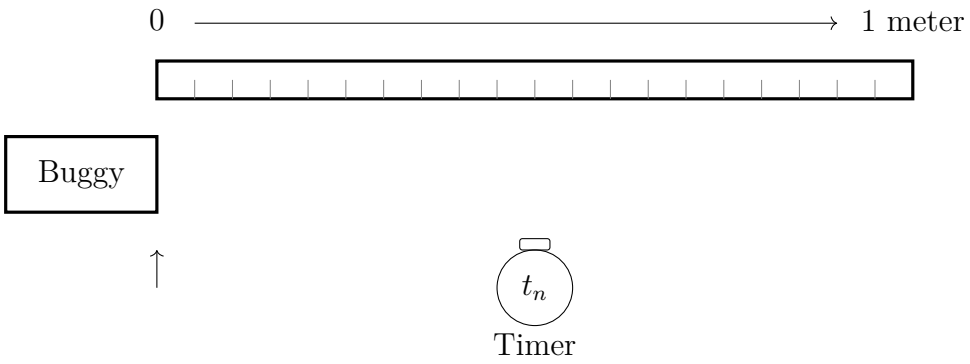

Figure 1: Abstract diagram of Step 2 setup.

3 Observations and Data

We were assigned Lines 6 and 8, with both buggies going the same direction. The distance measured between Lines 6 and 8 was 112 cm or 1.12 meters.

We received Buggy D and Buggy M, designated Buggy 1 and Buggy 2 respectively.

Buggy	Trial	Travel Time (1 m)
Buggy 1	Trial 1	5.13 seconds
	Trial 2	5.38 seconds
	Trial 3	5.21 seconds
Buggy 2	Trial 1	2.85 seconds
	Trial 2	2.84 seconds
	Trial 3	2.82 seconds

Figure 2: Buggy Travel Time by Trial

When the buggies were tested, both reached the same position at $T+5.71$ seconds, where T is the time at which the buggies started moving. The predicted meeting point was clearly off by several buggy lengths.

4 Analysis

First, the times from each buggy and their trials were averaged. Final calculations visible in Figure 3.

Buggy	$\bar{t}$	1 m/$\bar{t}$
Buggy 1	5.24 seconds	0.191 m/s
Buggy 2	2.84 seconds	0.352 m/s

Figure 3: Buggy Average Travel Time and cart speed

The speed of each buggy can be calculated by using

$$\frac{1 \text{ meter}}{\bar{t} \text{ seconds}} \quad m/s \tag{1}$$

where $\bar{t}$ is the average of amount of seconds measured for one buggy. Final calculations for $\bar{t}$ is visible in Figure 3.

There is some uncertainty in the measurements given due to human reaction time of the person holding the timer. We converted measurements and calculations to cm and cm/s at this point, as most were under 1 m and/or m/s. Then, we solved the system of equations given in equation 2.

$$\begin{aligned} x_P &= 19.1 \text{ cm/s} \cdot t_P + 112 \text{ cm} \\ x_P &= 35.2 \text{ cm/s} \cdot t_P \end{aligned} \tag{2}$$

Solving for t_P,

$$\begin{aligned} 35.2 \text{ cm/s} \cdot t_P &= 19.1 \text{ cm/s} \cdot t_P + 112 \text{ cm} \\ 16.2 \text{ cm/s} \cdot t_P &= 112 \text{ cm} \\ t_P &= 6.91 \text{ seconds} \end{aligned} \tag{3}$$

This means that the buggies will meet at a predicted $T + 6.91$ seconds, where T is the time at which the buggies both start moving. To find the distance at which the buggies meet, the t_P value computed was plugged in to equation 2.

$$\begin{aligned} x_P &= 35.2 \text{ cm/s} \cdot t_P \\ x_P &= 35.2 \text{ cm/s} \cdot 6.91 \text{ seconds} \\ x_P &= 243.23 \text{ cm} \end{aligned} \tag{4}$$

When the buggies were tested against each other, the predicted t_P from equation 3 was 1.2 seconds more than the actual result of $t_E = 5.71$ seconds. It is unclear what x_E is from the recorded video.

5 Conclusion

The primary source of error can be attributed to human error of the operator holding the timer in Step 2. The reaction time of the operator as well as the imprecision of trying to measure the timing at a vague point (where the front wheel meets the end of the meter stick) made our predicted values t_P and x_P very imprecise.

In the end, our group was not able to determine the actual meeting point x_E, at least to a precision of less than multiple tens of centimeters.