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Physics 50 Section 0, Fall 2024
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Module 0 Lab Report
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In this module I determined my reaction time by measuring how far a dropped object fell before I could close my fingers around it. If an object is released from rest and falls a distance d before it is caught, the time between release and catch is $t = \sqrt{\frac{2d}{g}}$, where g is the acceleration due to gravity, or 9.8 m/s^2. If I am trying to catch the object as soon as possible, then this time represents my reaction time: the time for me to realize that the object has been dropped and close my fingers around it. For the object we used a metal ruler (see Figure 1). My lab partner held the ruler and released it at unpredictable times, so that I was truly reacting to external events. My hand was held near the ruler before it was dropped, with my thumb and fingers just a centimeter or so from the front and back of the ruler as shown on the left in Figure 1. This way, the time to actually move my fingers was minimized, and t represents as accurately as possible the time for my neural processes (sensing the drop and sending the motor impulse to my hand).

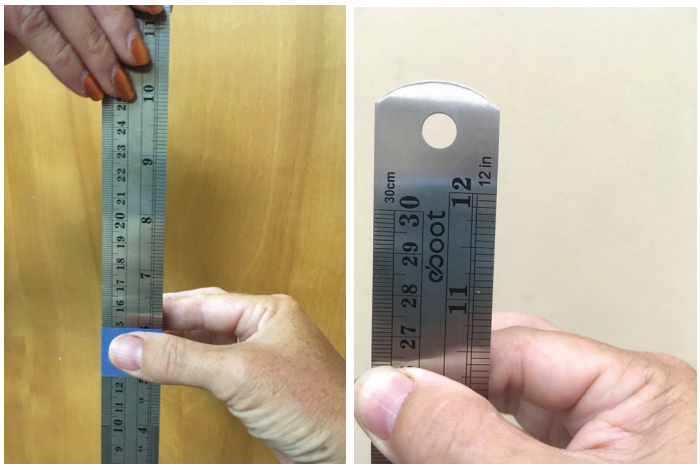

Figure 1: Ruler before being released (left) and after being caught (right). The initial position is set to the top of the blue tape, at 15 cm on the ruler's markings. The measured final position in the image at right is 26.3 cm.

Blue masking tape was used to mark the initial height of my hand. The blue tape was wrapped around the ruler with its top edge at the 15-cm mark. Before each trial, my lab partner held the ruler steady (holding it from the top), while I positioned my fingers about a centimeter away from the ruler so that the top of my thumb and index finger were level with the top of the blue tape. Sometimes my partner's hand shook so this was hard to accomplish, but I estimate variations of no more than 0.3 cm in the initial height of my fingers. My partner then released the ruler and I caught it by pinching my fingers closed, as shown on the right in Figure 1. I

Page: 1

Number: 1

The report starts with a concise statement of the overall point of the lab: what was measured/determined and, in broad strokes, how.

Number: 2

Background theory that drives the structure of the experiment is presented. Notice that the variables d, t, and g are defined within this sentence where they first appear.

Number: 3

Here are some procedural details and the reasons they were important in making the result reliable.

Number: 4

Figures are numbered and have informative captions. Often, a photo of the apparatus and/or stepping through a sample measurement can help demonstrate the overall experimental process.

Number: 5

Each figure is referenced (by number) in at least one place in the main text where readers should look at it.

recorded the position of the top edge of my thumb after each catch, using the ruler markings. I subtracted the initial position of 15 cm from this final position to find the distance *d*.

This procedure was repeated ten times, giving an average *d* value of 8.9 cm and an SEM of 1.3 cm. Using $t = \sqrt{\frac{2d}{g}}$ and propagating error through this formula ($\delta t = \delta d \frac{1}{\sqrt{2gd}}$), we determined my reaction time to be 0.134±0.010 seconds. This is significantly larger than my lab partner's reaction time of 0.115±0.008 seconds, determined by the same method, but similar to the reaction times of some classmates. My lab partner plays a lot of video games, so we speculate that she has trained her reaction time to be shorter through practice.

Based on the standard error in *d*, variation between trials is clearly the dominant source of uncertainty in this experiment. It is much more important than the difficulty of lining up my fingers with the initial tape mark, noted above to cause no more than 0.3 cm of variation. (Note: variation from initial alignment is also already included in the trial-to-trial variation we recorded.) We initially tried this experiment with a clear plastic ruler instead of the metal one, and the variation was even larger with it. We are not sure why the plastic ruler gave less consistent results, but I believe it might be because the transparent ruler made it easier to be distracted by background movement. We used the metal ruler for our official data because it gave more consistent data, leading to a more precise result. However, some variations in the data are still puzzling, as shown by a histogram of *d* measurements (Figure 2).

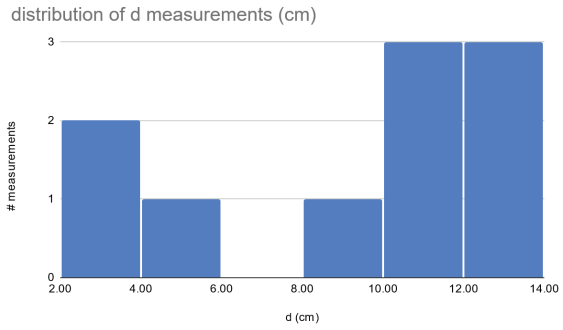

Figure 2: Histogram of individual *d* measurements

Most measurements fall between 8 and 14 cm, but there is a separate cluster of smaller values (2-5 cm). With more trials it might become clearer whether these points are anomalous and should be excluded; with the existing data, excluding the three smallest trials changes the result by less than its uncertainty. It is possible that the smaller measurements were times when I was already closing my fingers before my partner released the ruler. In one or two cases I actually did accidentally grab the ruler while trying to line my fingers up with the tape mark. To reduce the chance of this happening in future measurements, my partner could wait to release the ruler until I had finished lining up my fingers and called out "ready."

Page: 2

Number: 1

The report gives the number of repeated trials and explains what raw errors were used, and how, to get the uncertainty of the final result.

Number: 2

The report includes a reality check on the results. In some experiments, this could be a comparison to an accepted value of the quantity measured. Any comparison should always take into account the uncertainty of the result; in this case, the reaction times of the two partners differ by much more than their individual uncertainties. That's what justifies the use of the word "significantly."

Number: 3

The main final result is given with an uncertainty and units. Though extra digits are carried through calculations up to this point, the report gives the final result and its uncertainty to a precision consistent with what that uncertainty IS.

Number: 4

The report shares some reflections on the main sources of uncertainty in the final result. A short discussion explains how that dominant source of uncertainty has already been minimized, and suggests possible avenues for improvement if anyone repeats the experiment.

Number: 5

It is not always useful to show a histogram of individual trials. In this case, the histogram is helpful because it illustrates a key point being made in the report: the two separate clusters of distances that might indicate an inconsistency of experimental procedure that could be corrected in the future. The lesson for your reports is NOT to always show a histogram of trials. It is to show (not just tell) whatever information is most relevant to your analysis of the experiment's strengths and weaknesses.