Measuring your reaction time

Introduction

First, you must understand how you, as a person, reacts to a change in the environment. For instance, when the subject saw the experimenter drop the ruler, it took some time for the brain to realize that the ruler was being dropped. First, the nervous system must recognize a stimulus (the ruler being dropped), then cells in the nervous system called neurons relay the message to the brain, muscles and other nerves. The message travels from the brain finally delivered to your fingers. The motor neurons tell the muscles to catch the ruler.

- The average reaction time of a human is approximately between 0.15 s to 0.25 s. However, your reaction time is also affected by factors such as age, gender, intelligence, fatigue, and distraction.
- The purpose of this experiment is to investigate random errors in measurements. To do this we will analyze our reaction time. We will determine our average reaction time (with uncertainty) by catching a dropped meter stick. Finally, we will histogram our data to see if it approximates a Gaussian probability distribution.

Equipment: Meter stick

Theory

All measurements are subject to uncertainty. Measurement uncertainties fall into one of two categories: systematic and random errors. As the purpose of this experiment is to investigate random errors, systematic error will not be discussed. Random errors are those which result from unpredictable variations in the experiment. For example, an experiment may be subject to random temperature fluctuations that cannot be completely controlled. Random errors are described by a Gaussian probability distribution. Gaussian distributions are characterized by their bell shape and adherence to the following rule:

i. At least 68% of the data fall within one standard deviation of the mean.

ii. At least 95% of the data fall within two standard deviations of the mean.

iii. Almost all of the data fall within 3 standard deviations of the mean.

- The mean value (or average) of any set of measurements is just the sum of the measurements divided by the number of measurement. For a set of n data points (t_i)

$$\prec t \succ = \overline{t} = \frac{\sum_{i=1}^{n} t_i}{n} \qquad (1)$$

$$\prec t \succ = \frac{t_1 + t_2 + t_3 + \cdots\cdots + t_n}{n}$$

It is easy to group the values together using the frequency diagram.

$$\prec t \succ = \frac{1\times(t_1) + 2\times(t_2) + 4\times(t_3) + \cdots\cdots}{50}$$

t_1 occurs once, t_2 twice, t_3 four times etc.

If f_l be the frequency that any particular value "t" occurs, we can write $\prec t \succ = \frac{\sum_l f_l \cdot t}{n}$ Where $n = \sum_l f_l$,

- The **standard deviation ($\pm_t$)** of the set of data is given by:

$$\pm_t = \sqrt{\frac{\sum_{i=1}^{n} (\overline{t} - t_i)^2}{n-1}}$$

$\pm_t \equiv$ means standard deviation for the distribution of t-values. It is the width for the distribution since it depends on the distances of the individual measurements from the mean. The uncertainty in $\bar{t}$ is given by $¢_t = \frac{\pm_t}{\sqrt{n}}$. To generate our data set, we will calculate our reaction times from the equation $Y = \frac{1}{2}gt^2$ where Y the distance a meter stick falls before we can catch it and t is time.

Procedure

(1) One student holds a meter stick (vertically) at the upper end and the other student places two fingers around (but not touching) the 50 cm mark of the ruler.
(2) Without warning release the meter stick, so that it falls between the thumb and finger of the person catching the meter stick. The person catching should catch the meter stick as quickly as possible.
(3) Measure the distance Y the ruler falls through the catcher's fingers.
(4) Perform at least 50 trials and draw the histogram.
(5) Look at the spread in the data and calculate the resulting uncertainty.
(6) If you have a few values that are far off from all the other values you may decide to ignore them when you calculate your reaction time, but note in your lab report which measured points were not used. Use the relation: $t = \sqrt{\frac{2Y}{g}}$

Data

For this experiment a meter stick was suspended between the thumb and forefinger of my lab partner. My lab partner then released the meter stick and I recorded the distance the meter stick fell before I caught it.

No.	Y (m)	t(s)	t^2 (s^2)	No.	Y (m)	t(s)	t^2 (s^2)
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

- Draw a histogram for the above data:

Calculations

(show at least one sample calculation)
To calculate our reaction time:

Solve $Y = \frac{1}{2} 9.8 \times t^2 \Rightarrow t = \sqrt{\frac{Y}{4.9}}$. For example for $Y = 0.15\,m,\ t = \sqrt{\frac{0.15}{4.9}} = 0.175\,s$

Then, the average reaction time is: $\prec t \succ = \frac{t_1 + t_2 + t_3 + \cdots + t_n}{n}$

To find the standard deviation in t: $\pm_t = \sqrt{\frac{\sum_{i=1}^{n} (\bar{t} - t_i)^2}{n-1}}$, Finally, the uncertainty in $\bar{t}$ is: $¢_t = \frac{\pm_t}{\sqrt{n}}$.

Question: Use the reaction time determined in your experiment to compute how far a car that you were driving at 110 km/hr would travel, between the time you recognized the need to stop for an emergency and the time your foot would start to move toward the brake. Express the distance in meters

Example: How do you construct a histogram?

To construct a histogram from a continuous variable you first need to split the data into intervals, called **bins**. In the example below, **age** has been split into bins, with each bin representing a 10-year period starting at 20 years. Each bin contains the number of occurrences of scores in the data set that are contained within that bin. For the above data set, the frequencies in each bin have been tabulated along with the scores that contributed to the frequency in each bin.

Age:

36	25	38	46	55	68	72	55	36	38	67	45	22	48	91	46	52	61	58	55

Bin	Frequency	Scores included in bin
20-30	2	25,22
30-40	4	36,38,36,38
40-50	4	46,45,48,46
50-60	5	55,55,52,58,55
60-70	3	68,67,61
70-80	1	72
80-90	0	-
90-100	1	91