MEASUREMENT OF HUMAN RESPONSE TIME

Objective: To determine the response time of the human visual-motor system and to communicate this value with an appropriate statement of its error.

Apparatus: Meter stick, masking tape, a partner, and a calculator/computer.

Theory:

A) Objects in Free Fall

The time between the stimulus and the response of a system is called the system's response time. In this experiment, one partner will drop a meter stick and the other will catch it. The stimulus is seeing the release of the meter stick, while the response is catching the meter stick. Since the meter stick will be a freely-falling body once it is released, the time of its fall (the response time) is related to the distance by

$$d = \frac{1}{2} g t^2 \qquad \text{, (eq.1)}$$

where *d* is the distance, *t* is the time, and *g* is the acceleration due to gravity. Solving this equation for the time *t* gives:

$$t = \sqrt{\frac{2d}{g}} \qquad \text{. (eq.2)}$$

If the distance is expressed in meters, and the value of *g* is 9.80 m/s^2 (the accepted average value for the acceleration due to gravity on Earth), the equation will yield a value of *t* in seconds.

B) Statement of Measurement Results

The true value of measured quantity, such as human response time, can never be stated exactly for two reasons. (1) Measurements cannot be made with an infinite amount of accuracy; thus, every measurement must include an *uncertainty* that is associated with the measuring device, determined by the instrument's precision. This tolerance value for the measurement (for instance, ± 1 mm, or ± 5%) tells us a range of values that the measurement probably lies within. (2) The value of the measurement itself changes due to *random* variations of the environmental conditions in which that quantity exists. For example, the level of a person's concentration changes while that person is repeatedly generating a response to a visual stimulus. Therefore, the response time will change over time and might have a slightly (or largely) different value from the average value at any given instant. However, if the response time is measured many times, then the average of these measurements may be taken as an indication of the true value.

The average value, $\bar{x}$, of all the measurements is defined as the sum of the measurements (x_1, x_2, x_3, … x_N) divided by the number of measurements, *N*:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N} = \frac{(x_1 + x_2 + x_3 + \ldots + x_N)}{N} \qquad \text{(eq. 3)}$$

The *random error* associated with this value must then be determined from the distribution of the data. One method for doing this is to calculate the standard deviation, σ, of the data. The standard deviation is based on a statistical treatment of the data and communicates the variation, or amount of precision, in the data, and is given by:

$$\sigma = \sqrt{\frac{1}{(N-1)}\sum_{i=1}^{N}\left|x_i - \bar{x}\right|^2} \qquad \text{(eq. 4)}$$

Using the standard deviation as an indication of the random error produces an error range that allows us to predict what another measurement of the quantity would be, which is what is reported as the result of the experiment, $\bar{x} \pm \sigma$.

In reporting a final result, it is proper to report whatever the largest estimate of uncertainty may be, whether it is the propagation of measurement uncertainties, or the uncertainty due to random error. Quantities such as the length of a solid object are usually dominated by measurement error, while a quantity such as human response time would be dominated by random error. This suggests that single measurements are sufficient for some quantities but multiple measurements are required for others. Human response time is one such quantity which requires multiple measurements.

Procedure:

Part 1.

1. Place a strip of masking tape on the lab table as shown in figure 1. It should have two marks approximately 2.5 cm apart.

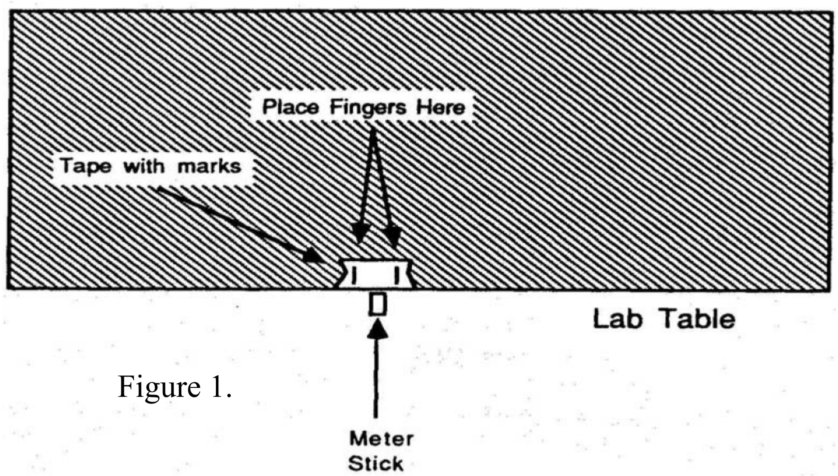

Figure 1.

2. Partner #1 will suspend a meter stick vertically with the 50 cm mark at table top level. (This means so that half of the meter stick is above the table top and half is below.) Record this as the starting position on the meter stick, P_0 = 0.500 m.

3. Partner #2 will place his fingers in pincer fashion with the sides of his fingers on the two marks in a manner such that when the meter stick is dropped, he/she can catch it by pinching the fingers closed across the table top.

4. Without warning, partner #1 (holding the meter stick) will release it (being careful not to throw it downwards) and partner #2 will attempt to catch it between their fingers as quickly as possible. Record on partner #2's data sheet the value of the catching position on the meter stick, P_i.

5. Repeat step 4 fourteen times (a total of 15 data points).

6. Change positions with your partner and repeat steps 2 through 6.

Part 2.

1. Place 3 pieces of masking tape on the lab table, such that the outer two pieces of tape are about 25 cm apart. The third piece of tape (in the middle) should be 12.5 cm from each other piece of tape.

2. Partner #1 will suspend the meter stick vertically in front of the middle piece of the masking tape with the 30 cm mark at table top level (70 cm above the table top and 30 cm below it).

3. Partner #2 will place his/her hands on the outer marks of the masking tape in a manner such that when the meter stick is dropped, he/she can catch it by clapping hands together across the table top.

4. Repeat steps 4-6 in Part 1 for this set-up.

Data Analysis:

Part 1.

1. Determine the distance, d, that the meter stick fell during each trial by subtracting the catching position, P_i from the starting position, P_0.

2. Calculate the response time, t_i, for each trial using equation 2.

3. Calculate the average response time, $\overline{t_1}$, using equation 3.

4. Calculate the standard deviation, σ_1, of the data using equation 4. First, calculate the residuals for each trial by finding the absolute value of the difference between the response time for that trial and the average response time. Second, calculate the column of data for the residuals squared by squaring the column of residuals. Finally, sum the residuals, divide by the number of data trials minus one, and take the square root of the result.

5. Find the relative percent deviation of your response time to 0.162 ± 0.035 s, which is the historical average time for the class. The percent deviation for the mean response time is given by:

$$\frac{\left|\overline{t_1} - 0.162\right|}{0.162} \times 100\% .$$

Part 2.

1. Determine the distance, d, that the meter stick fell during each trial by subtracting the catching position, P_i from the starting position, P_0.

2. Calculate the response time, t_i, for each record of distances using equation 2.

3. Calculate the average response time, $\overline{t_2}$, using equation 3.

4. Calculate the standard deviation, σ_2, using equation 4 and the columns on the data sheet.

Discussion Questions:

1. Examine the response time during the first trials of each experiment. Is any “learning curve” evident? How does inclusion of these data points affect your final average?

2. In averaging all the data trials and applying the standard deviation as an estimate of error, we are assuming that the data follows a normal distribution pattern (like a bell-shaped curve). Frequently, we speak of a signal to noise ratio, where the signal refers to the strength or accuracy of the average value and the noise in the data refers to the precision, where the standard deviation is a measure of this noise. The signal to noise ratio is inversely proportional to the number of data trials by an approximate factor of $\frac{1}{\sqrt{N}}$ (from the equation for the standard deviation). In this experiment, you did 15 trials. To increase the signal to noise ratio by a factor of two, the noise (i.e., standard deviation) would have to be reduced by a factor of two. How many data trials in total would you have to take to decrease the noise in your data by a factor of two, assuming the data is normally distributed?

3. Compare the response time and error obtained from the response system in Part 1 of your experiment with that obtained from the response system in Part 2. What can be said about the difference in response times? If you were to plot this data on a graph, would it be possible to choose a mathematical function with which the data could be fit?

Lab Report Format:

Your lab report for this experiment should contain:

1. Pre-lab (objective, theory, sketch of the experimental setup, and procedure).
2. Neatly filled out data page.
3. Sample calculations: For this lab, an example needs to be shown for calculation of: d, t, σ (the final part of the calculation, excluding calculations for the residuals and residuals^2, which should be on your data sheet), the percent deviation from the class average, and the calculation for your answer of discussion question 2.
4. Results: State your results (in the form of a sentence) for both parts of the experiment. Make sure they are properly rounded and have the correct number of significant digits. Compare your result from Part 1 with the class average by stating the percent deviation, and also comparing the range of values (your mean minus your uncertainty through your mean plus your uncertainty) to the equivalent range of values for the class average. Is your determined response time within the uncertainty range of the average class response time?
5. Conclusions: Address the answers to the three discussion questions above, and how these might or might not have affected your experimental results.