MC-1: Errors & Motion
Lab Worksheet Name__________________________

This sheet is the lab document your TA will use to score your lab. It is to be turned in at the end of lab. To receive full credit you must use complete sentences and explain your reasoning clearly.

MC-1a Measurement and Error

No measurement is ever perfect but some are better than others. Scientists must compare their ideas (theories) with the outcome of experiments that measure things. How do we know we are “right” if we can’t measure things perfectly? There will always be some uncertainty but we can at least communicate to others the relationship between the theoretical prediction and the experimental measurements. We use statistical tools like the **mean** and **standard deviation** to describe our data. If the theoretical prediction is many standard deviations away from the experimental mean our theory is suspect, but not necessarily wrong. On the other hand when the theoretical prediction falls extremely close to the experimental mean we do gain faith in our theory, but it still could be wrong. Science progresses as increases in the measurement precision uncover discrepancies that force us to rethink our long held theories. You will make careful measurements in this course and they will uncover discrepancies in your own ideas about reality, but more on that later.

In this lab you will test a “clock” in your head using a clock in the computer. Assuming the computed clock is perfect you will measure the errors in your mental clock.

Work through the suggested procedure on page 18 of the lab manual and answer the questions below. There are places for you to record your data.

In the interest of fun each member should try to pass their finger through the photogate at exactly 2 second intervals. Make 50 or so passes and do not look at the computer or your watch as you do this.

1. Attach plots of each group member’s data to this worksheet. See Fig. 2 on page 17 for an example.

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2. Record the mean, standard deviation and standard error for each group member below. Standard error is called the *standard deviation of the mean* in your lab manual. If your data is not symmetric about the mean indicate to which side most if it lies with the words above or below.

Group Member	Mean	Standard Deviation	Standard Error	Symmetric about the mean?

3. Which data set seems to have the greatest systematic error? The greatest random error? Explain your reasoning making it clear you understand the difference between the two types.

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4. Test your understanding:

A. Given the following data set of five measurements: 2.0, 2.0, 4.0, 6.0 & 6.0 compute by hand the mean, standard deviation and standard deviation of the mean. Clearly circle or box your answers.

B. How many measurements would have to be made to reduce the standard deviation of the mean by a factor of **ten**?

C. Do you expect the standard deviation to change? Explain.

D. If these data included a constant systematic error of 0.4 (per measurement) would the above analysis show evidence of this fact? Explain

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MC-1c Motion, Velocity and Acceleration

Experiment I, Basic operation of the sonic ranger

Experiment I on page 25 of the lab manual will get you familiar with the sonic motion detector. It can be troublesome so do take time to practice getting “good” data (smooth curves). If the detector gets confused as to which reflected beep goes with which output beep the data points will not produce smooth curves. Follow the instructions in the manual but there is no need to answer the questions. When all group members are comfortable with the equipment move on to Experiment II.

Experiment II, Inclined plane motion

Follow the instructions on page 25-26 in the lab manual and check with your TA when you think you have “good” data before printing. Make a copy for everyone and staple them to this worksheet before you hand it in.

1. Label the intervals on your plots with statements like “moving up and slowing down”, “changing direction”, and “moving up and speeding up.” At the bottom of the ramp the cart bounces off of strong magnets but they only affect the cart when it is close to the magnets. Identify the intervals where the magnets are significantly affecting the motion of the cart. Finally figure out which direction is positive and negative then fill in the box below. Normally you will make this choice but here the computer has already decided. The +/- from your plot will tell you the direction the $\vec{x}$, $\vec{v}$, and $\vec{a}$ vectors point (up or down the ramp).

sign	+	-
direction		

2. The plots have the same time scale so you can correlate events on one graph with the others. Fill in the chart below for each condition in the left column. Read velocity off of the plot but calculate the acceleration from the velocity plot. Show your work on your plot. Fill in direction (up or down the ramp) as well as magnitude (always a positive number).

	$\lvert\vec{v}\rvert$	Dir.	$\lvert\vec{a}\rvert$	Dir.	Describe the motion
First time ½ way down the ramp					
Just before the first turn around at the bottom of the ramp					
Exactly at the first turn around at the bottom					
Just after the first turn around at the bottom					
First time ½ way up the ramp					
Exactly at the turn around at the top of the ramp					

3. How are the velocity and acceleration vectors in the chart above oriented with respect to each other in each case? Note: If a vector has zero magnitude then it has no direction. What is the relationship between the description of the motion and the relative directions of $\vec{v}$ and $\vec{a}$?

4. Are there any times in the chart above where the velocity is zero and the acceleration isn't? If so, where are they and how can that be? Explain your reasoning.

Answer the following by looking back at your plots.

5. What's going on when the acceleration is constant? Talk about the location of the cart as well as the velocity graph. Explain.

6. What's going on when the acceleration is **not** constant? Talk about the location of the cart as well as the velocity graph. Explain.