PHY 101 Lab Exercise 2: Visualizing Motion

Team members:

Goals:

PHY 101 is devoted to the concept of *energy*. We start the course with the visualization and measurement of motion, since the foundation of our idea of energy comes from the study of motion.

One good way to describe the motion of some object is to say *where* it was at *what time*. We can call this the "position as a function of time", usually written *x(t)*. Another name for *x(t)* is the "trajectory" of the object.

In lab, we want to measure the things that we think about in physics. So, we start your lab course with the question of how we can measure *where* an object is at various *times*.

Materials:

Meter sticks
Metal angle brackets

PC with ULI interface for measuring instruments

PASCO Motion Sensor (also known as a "sonic ranger")

Activity:

1. *<u>Use of meter stick to measure static positions.</u>*

   Pick a spot on your lab bench, just to the right of your PC, to be a reference point for your position measurements. (Physicists and mathematicians call such a point the "origin of coordinates."

   Put down an angle bracket some distance away from the origin. Using a meter stick, measure the position of the angle bracket with respect to the origin. Write it down here:

How precise is your measurement?

Now, move the angle bracket farther from the origin, and measure its location again. What is its position now?

When you moved the angle bracket from the first position to the second position, you caused a *displacement*. How big was the displacement?

2. <u>*Use of sonic ranger to measure static positions*</u>

Now you will make your first use of the computerized measuring equipment.

First, follow the instructions in the Appendix to set up your computer to make measurements with the sonic ranger. (Computer booted up, application Logger Pro running, file Motion Detector opened, one graph displayed.) Also, check to be sure that the PASCO Motion Detector ("sonic ranger") is plugged into Port 2 of your ULI interface box.

Next, click on the button labeled "Collect" near the top of the screen. When you hear a clicking sound, move your hand around near the front of the sonic ranger. Do you see a relationship between the position of your hand and the height of the blue line of the graph on the computer? What is the relationship?

Now you are ready to try some real quantitative measurements of position and displacement using the sonic ranger. Set the sonic ranger at the spot you called your origin of coordinates, and leave the meter stick aligned as you had it before. Place the angle bracket at the first position from part *1.*, then click on the "Collect" button on the screen. After a few seconds, move the angle bracket to the second position.

Make a sketch of the graph that appears on the screen:

What part of the graph corresponds to the angle bracket sitting at the first position? What part of the graph corresponds to the angle bracket sitting at the second position?

Now read off the positions of the angle bracket at the two locations. For rough measurements, you can just read the graph by eye. What are the two positions?

For more accurate results, bring up the *measurement cursor*. Turn it on by clicking on the button labelled "*x=?*" on the toolbar *near* the top of the screen. Then you should see a vertical line that will move across the graph as you move the mouse, and a little window near the top of the graph that reads the graph by giving the value of distance *D* as a function of the time corresponding to where you place the cursor.

What are the positions of the angle bracket at position one and at position two?

What was the displacement of the angle bracket between the two positions?

Comment on the similarities and differences between position and displacement measurements made with the sonic ranger, compared with those made with just a meter stick.

3. *Measurement of x(t) for moving object using the sonic ranger*

Hook your sonic ranger onto the end of your aluminum track. Push the cart along the track and Collect some data. Fiddle with the angle-adjustment knob on the sonic ranger until you can see the cart all the way to the end of the track. (Tipped upwards a bit is probably best.) Ask your TA for help on this step if you need it.

Now, try a measurement of the position of the cart as a function of time $x(t)$, as it moves down the track. Set the cart in motion, so that it takes 6 or 7 seconds to reach the end of the track. (The Leader sets it in motion, and the Scribe prepares to catch the cart if it is in danger of falling off the end of the track.)

Make a sketch of the graph that you see on the screen.

4. *Using the sonic ranger to measure accelerated motion*

Put an angle bracket under the rail, so that it is tilted by an interesting amount. Start the cart rolling upward along the rail. Give it a strong enough push to make an interesting motion, **but don't let the cart fall off the end of the rail**.

After practicing a few times, measure the motion of dynamics cart as it rolls along the tilted track. Make a graph of the position of the cart as a function of time. Sketch the graph here:

What is the shape of the graph of $x(t)$? How does it differ from what you saw before, from the cart rolling on the level track? Why does tilting the track make a difference?

How would you most simply describe the motion of the cart? Constant position? Constant velocity? Constant acceleration?

Switch the computer display to "Three panes". Set up the second graph to display velocity of the cart, and the third graph to display its acceleration. How are those kinematic quantities defined? How might the program calculate them?

Sketch all three graphs here:

5. *Thinking back on what you have learned.* **These are the questions for *each student* to be sure to understand before leaving your studio meeting.**

First, imagine what kind of motion corresponds to x = constant. Sketch the graphs of $x(t)$, $v(t)$, and $a(t)$.

Next, think of what kind of motion corresponds to v = constant. Sketch the graphs of $x(t)$, $v(t)$, and $a(t)$.

Now, think of what kind of motion corresponds to a = constant. Sketch the graphs of $x(t)$, $v(t)$, and $a(t)$.

Which of these three kinds of motion has constant kinetic energy? Explain your reasoning.