

Lab Group Members:

## PHYSICS 101 MOTION

Motion is the term used to describe how an object's position changes with time. This change can occur at a constant rate, at a changing rate, or at no rate at all. Velocity is the quantity that describes the position's rate of change. Acceleration describes how that rate changes – that is, how the velocity changes with time.

From a mathematical approach, motion can be understood by the set of kinematic equations. However, the implicit relation between the three kinematic quantities (position, velocity, and acceleration) can also be understood from the graphs of these variables. In fact, the basic definition of these quantities is as follows:

$$v = \frac{\Delta x}{\Delta t} \quad \text{Velocity is the rate of change of position.}$$
$$a = \frac{\Delta v}{\Delta t} \quad \text{Acceleration is the rate of change of velocity.}$$

In this lab, you'll explore the inter-relationship between position, velocity, and acceleration from a descriptive and graphical perspective.

### I. DESCRIBING MOTION

Discuss the following scenarios with your group, and write down a *description* of the motion (no equations or graphs). For example:

*“An object moves at constant velocity.”*

Description of position: The object's position changes at a constant rate per unit time.

Description of velocity: The object velocity is constant.

Description of acceleration: The object's velocity is not changing, so there is no acceleration.

**A. “An object is motionless.”**

Description of position;

Description of velocity:

Description of acceleration:

**B. “An object accelerates uniformly from rest for 10 seconds, then coasts at a constant velocity.”**

Description of position;

Description of velocity:

Description of acceleration:

**C. “An object travels at constant velocity, then uniformly slows to a stop.”**

Description of position;

Description of velocity:

Description of acceleration:

**D. “An object travels at constant velocity, then immediately turns around and travels at the same speed in the other direction.”**

Description of position;

Description of velocity:

Description of acceleration:

## II. GRAPHICAL DESCRIPTION OF MOTION

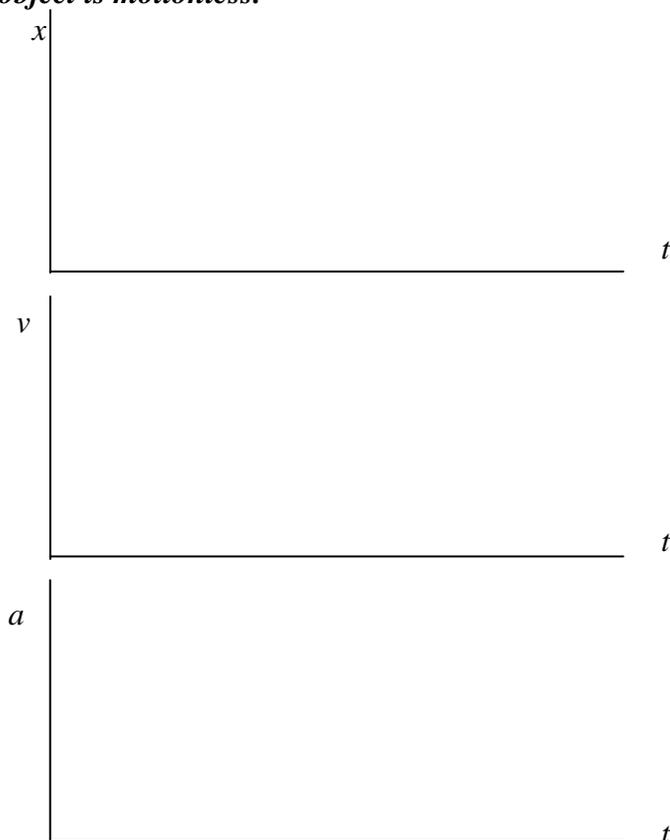
Drawing graphs of position, velocity, and acceleration should follow naturally from descriptions of motion such as those in part I. In this section, you will construct motion graphs (one for position vs. time, one for velocity vs. time, and one for acceleration vs. time), for the same scenarios as before. As you construct your graphs, be sure to line them up according to the time axis.

As you construct your graphs, we can re-interpret the equations on page 1 as follows:

$$v = \frac{\Delta x}{\Delta t} \quad \text{Velocity is the slope of position vs time.}$$

$$a = \frac{\Delta v}{\Delta t} \quad \text{Acceleration is the slope of velocity vs time.}$$

### A. “An object is motionless.”



***B. "An object accelerates uniformly from rest for 10 seconds, then coasts at a constant velocity."***



***C. "An object travels at constant velocity, then uniformly slows to a stop."***



**D. “An object travels at constant velocity, then immediately turns around and travels at the same speed in the other direction.”**

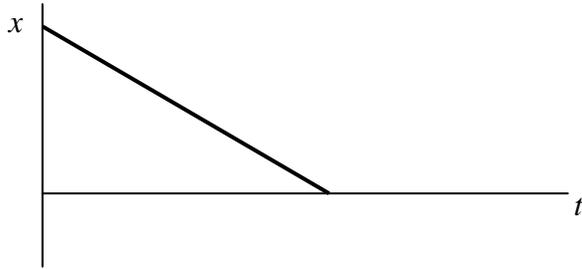


### **III. FEEL THE MOTION! CREATING GRAPHS WITH THE MOTION SENSOR**

This part of the experiment uses a motion sensor to detect the motion of your body as you move back and forth along a straight line. The motion sensor emits sound waves that are reflected by your body and then detected by the sensor. By measuring the elapsed time between emitted and received sound waves the sensor allows the computer to compute and graph position-time diagrams of your motion ( $x$  vs  $t$ ). The computer can also produce velocity-time graphs ( $v_x$  vs  $t$ ) and acceleration-time graphs ( $a_x$  vs  $t$ ). For best results, keep your distance from the sensor in the range 0.5 m to 3.0 m.

The origin of the  $x$ -axis is chosen at the motion sensor, and the positive  $x$  direction is the direction away from the sensor and toward you. In the exercises that follow, you will either be given a description in words, or a graph of position, velocity, or acceleration vs. time. In all cases, provide the other ways of describing the motions. For example, if a description in words is given, draw all three graphical ways of representing the motion. Similarly, if a position vs. time graph is given, provide the description of the motion in words, along with the other graphical ways of describing the motion. **After you have made your predictions, check them by performing the experiment and observing the graphs on the computer. Note that the motion sensor instructions are given on p. 9.**

## 1st Motion



Words:

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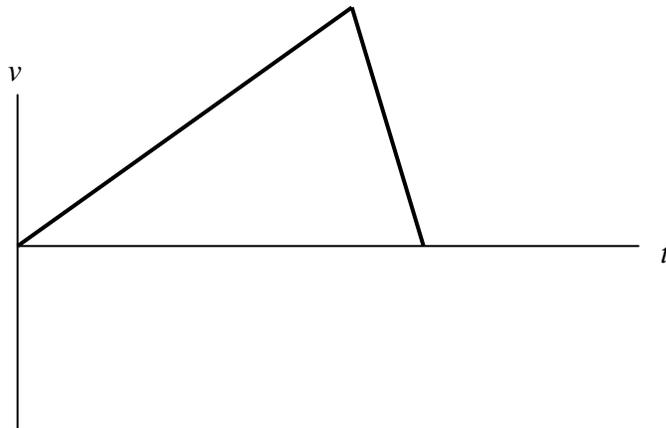
Other Graphs:

## 2nd Motion

Words: Move at a slow steady pace from a point 0.5 m from the source to a point 2 m from the source and then immediately move back to your starting point at twice the speed you were moving away.

Graphs:

**3rd Motion**



Words:

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Other Graphs:

**QUESTION**

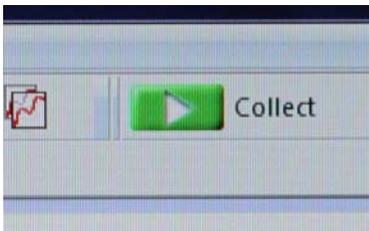
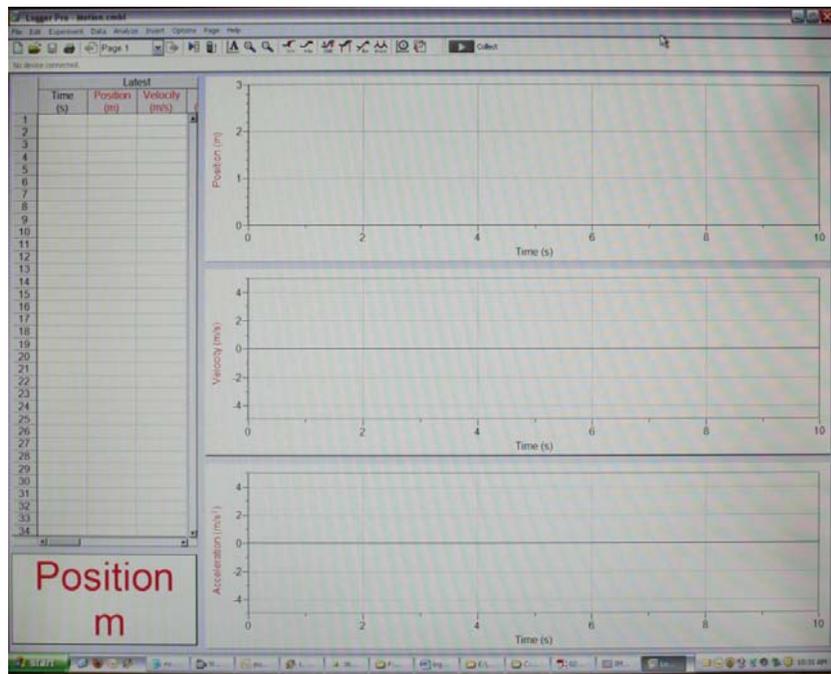
How are position, velocity, and acceleration related, graphically?

## Using the Vernier sensors and the Logger Pro software for the Physics 101/253 “Motion” lab



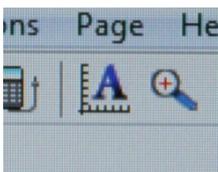
To begin with, make sure your motion sensor and LabPro sensor hub are connected. They should already be plugged in for power and connected to the computer via USB. If not, plug the motion sensor into one of the digital ports on the left side of the LabPro hub. The LabPro should be connected to one of the available USB ports on the computer and plugged into the power outlet on the bench.

On the computer desktop, open the “Physics Lab Files” folder, and within it open the “Logger Pro” folder. Double click the “Motion” file to open it with the Logger Pro program. Your screen (shown at right) should now show a data table, position readout, and graphs for position, velocity, and acceleration vs. time.



When you are ready to start your data collection, you can either click on the green “Collect” button (shown at left) or press the space bar on the keyboard.

After a second or two (the graphs will display “Waiting for data ...”) you will hear the sensor start clicking and you can perform the experiment. The sensor will collect data for 10 seconds, but you can stop the data collection at any time by either clicking the red “Stop” button (where the green “Collect” button used to be) or pressing the space bar. If you are not happy with your data, you can click “Collect” (or hit the space bar) again and the program will record over your previous data.



You can adjust the scale on your graphs to get a clearer picture of the data by clicking on the “Autoscale” button (shown at left). This will automatically scale the axis to fit your data best from top to bottom. You can also manually adjust the axis by left-clicking the top and bottom numbers on the axis scale and inputting your own value.