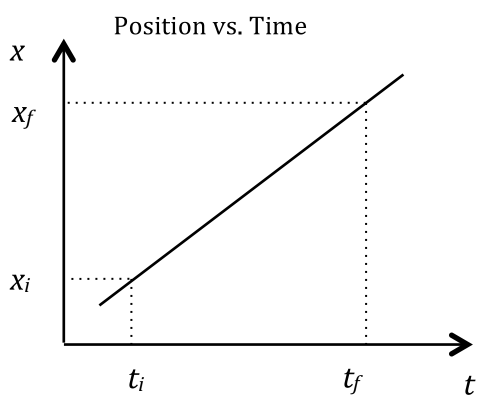
One Dimensional Motion

Goal: To better understand one-dimensional motion by observing a glider moving on an air track, and to interpret position vs. time graphs and velocity vs. time graphs that describe the motion of the glider.

Lab Preparation

To prepare for this lab you will want to review position vs. time graphs and velocity vs. time graphs. Knowing what the general shapes represent (such as what does a straight horizontal line mean on a v vs. t graph) will make the lab much more understandable.

Slopes of position vs. time graphs and velocity vs. time graphs are very important as they give us valuable information about the graphs. Consider the position vs. time graph below.



If the slope is taken of this graph we get the following:

$$\text{Slope} = \frac{Rise}{Run} = \frac{\Delta x}{\Delta t} = v_{av}$$

Thus the slope of a position vs. time graph is velocity. The slope of a velocity vs. time graph gives the average acceleration of the object.

Equipment

The **air track** levitates a glider, which can move smoothly along the track with little friction. The air-track expands slightly as the temperature increases. Thus, for best results, the air supply should be turned on and the system should be allowed to warm up before making any measurements. Once you begin your measurements, you should leave the air supply on until all needed measurements are completed.

In the latter parts of this lab you will use an **ultrasonic motion detector** to collect data for graphing. This device emits a burst of high frequency sound that reflects from nearby objects, including the glider. The receiver portion of the device then detects the arrival of the echo. The motion detector is controlled by computer and can emit many pulses each second to produce a set of position and time data that records the position as time passes.

Procedure

Please handle the air-track gliders with care and do not slide them without the air supply on.

I. Observe

Turn on your air supply and leave it on throughout the experiment. Release the glider from a point about 1.2 meters from the lower end of the track. Observe the motion of the glider as it bounces and rebounds up the track from the bumper. You can make several trials as you proceed through the next steps; just make sure you use a consistent starting point.

II. Position vs. Time Graph

The goal here is to make a qualitative sketch of the glider's position as it changes with time for four bounces.

When making your graph, first make your scales on the graph. For the position let 1 cm in your graph represent 20 cm along the air-track. Let the glider's starting position (the release point) to be at x = 0 (this doesn't have to be x = 0 on the scale on the air track) and let the +x direction be downhill. For your time, count how many seconds (or use the clock) to see how long it takes to go through 4 bounces and use this as your maximum value on the time scale.

Now that you have your scales ready try to sketch the graph. Remember that the steepness (slope) of a position vs. time graph indicates how fast the glider is moving. When it is moving the fastest, the graph should be the steepest.

Once you have your graph sketched, label points along the time axis corresponding to when each of the four bounces occurs with B_1, B_2, B_3, and B_4. Also mark the times corresponding to when the glider returns closes to its starting point on each rebound with R_1, R_2, R_3, and R_4.

III. Velocity vs. Time Graph

Next sketch a qualitative graph of the glider's velocity throughout its motion. You will want to draw this graph directly below your x vs. t graph and use the same time scale so you can line up the bounces and rebounds and thus compare the graphs. Do not worry about putting a scale on the graph for velocity.

Remember that the steepness (slope) of a velocity vs. time graph represents acceleration. When attempting to sketch this graph, consider what is accelerating the cart. Also consider if that acceleration changes during its motion.

Once again label the points B_1, B_2, B_3, B_4 and R_1, R_2, R_3, R_4.

Once done with both sketches, check them with your lab instructor before proceeding on to the next section.

IV. Measurements

Obtain an ultra-sonic motion detector from your lab instructor. You will use this device to record the motion of the glider. The motion detector cannot measure objects close to it so mount the detector in its stand around 50 cm behind your glider's starting point. Aim it carefully along the air-track at the glider (see Figure 1). Aiming slightly high can avoid problems with reflection from the track. To help line the motion detector up, look straight into the motion detector from the other end of the air-track and observe the reflection of the track in the motion detector. Make sure there are no other objects on the table that the motion detector might pick up on.

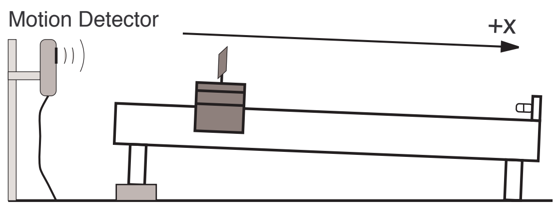


Figure 1

Open up the 1-D Motion file in the PHYS 1001 folder; making sure you read any pop up menus that might appear. Put the glider at its starting place and click "collect" and then release the glider after about 2 seconds. After the data collection stops (or you can stop it after 4 round trips), observe your graphs. Make several trials, adjusting the alignment of the motion detector until you are certain the detector is properly tracking the glider throughout its full journey.

Make sure your graphs have proper labels for your axes, proper units, and a graph title. Print your final graph results, but do not delete your graphs on the computer yet.

V. Interpreting the graphs

On your printed graphs label the points B_1, B_2, B_3, B_4 and R_1, R_2, R_3, R_4.

Use the graphs obtained from the motion detector to answer the following questions. There are many tools on the computer to help you answer these. Your lab instructor can help you with these tools if needed.

1. In words, at what points in the motion is the glider's instantaneous velocity zero?

2. Is the glider's acceleration ever positive? Negative? Describe when in the motion each occurs and explain clearly how you determine this from the velocity vs. time graph.

3. From your velocity vs. time graph calculate the average acceleration of the glider between the first and second bounces. Do this two ways:
   a. calculate using the computer and
   b. calculate on your printed velocity vs. time graph by drawing a best fit straight line extended to the borders and manually finding the slope of this line (you can use the computer to obtain the coordinate points where the extended line hits the borders).

4. From your velocity vs. time graph calculate the average acceleration of the glider between the third and forth bounces. How does this compare with your average acceleration between the first and second bounces?

5. From your velocity vs. time graph, use the computer to calculate the average acceleration during the second bounce, i.e. while the glider is in contact with the bumper.

When finished with your lab return the ultrasonic motion detector to your lab instructor and clean up your lab station.

Homework

Make a sketch of how acceleration changes with time for your glider. Once again label the points B_1, B_2, B_3, B_4 and R_1, R_2, R_3, R_4. Write a short paragraph explaining why the graph looks the way it does.