

Motion 2 Lab 2

Equipment SWS, motion sensor, meter stick, air track+ 2 gliders, 2 blocks.

Reading (How to Use SWS)

Page 193 through 197

Page 206 to Match Data on page 208.

Data menu on page 210 to Integration on Page 213.

Advanced curve fitting on page 217 through page 223.

Page 226 beginning at Horizontal axis rescaling.

Air Tracks In this experiment you will be using an air track. This is a long straight triangular like beam that has many small holes in it. A blower pumps air through the holes. A glider placed on top of the air track floats on a cushion of air with relatively little friction. The blower sits on the floor and has a switch on the top. The blowers are noisy and run hot. Run them only when you need them.

Please handle the gliders carefully. They are expensive, and if dropped or abused often do not work well. Do not move the gliders on the air track without the blower on, as this will wear both the glider and air track. If the motion sensor is used to detect the gliders, the gliders may have a piece of cardboard at one end to reflect the sonic pulses. Put the cardboard toward the motion sensor.

1 Purpose

To study the relationships between position (x), velocity (v), acceleration (a), and time (t). In general, x , v , and a are vectors but we specialize to the one dimensional case where we may consider them as scalars. We also make the special assumption that a is a constant (In general, a may be a function of position and/or velocity and/or time).

2 Theory

The velocity v is defined as $v = \frac{dx}{dt}$ and the acceleration as $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$. If this last definition is integrated twice for $a = \text{constant}$, the two integrations yield

$$x = x_0 + v_0t + \frac{1}{2}at^2, \text{ and}$$

$$v = v_0 + at.$$

The constants x_0 and v_0 are the position and velocity when $t = 0$. The first equation is a parabola and the second a straight line. If these equations are graphed, by convention time is chosen as the horizontal axis and position and velocity as the vertical axes.

3 Part 1

3.1 Position, Velocity, Constant Acceleration

The motion sensor is used to measure the position of a glider on a tilted air track as a function of time. If there were no friction, Newton's 2nd law predicts that the acceleration

of the glider would be $g \cdot \sin \theta$, where g is the acceleration of gravity and θ is the angle between the air track and the horizontal. SWS calculates the velocity and acceleration from the position vs. time data. The acceleration does not depend on the glider mass.

Level the air track by turning on the blower, putting a glider on the track, and adjusting the single screw at one end of the air track so that the glider does not move. Measure the distance between the single supporting screw at one end of the air track and the line formed by the two supporting screws at the other end of the air track. Measure the thickness of the two blocks of wood with a meter stick and then raise the end of the air track that is supported by two screws with the thinner block. Calculate θ . On a scale, measure the masses of your 2 gliders.

Program SWS for the motion sensor. You may use the default trigger rate and default speed of sound. Program SWS for the graph display, choosing position, velocity, and acceleration. Place the motion sensor near the spring bumper at the high end of the air track so that the grill looks down the track. The motion sensor does not work for less than 0.4 m, so place an object under the air track 0.4 m from the sensor and start your gliders from that point. Turn on the blower, place the smaller glider on the track, and release the glider and click Rec at the same time. Click Stop just before the glider hits the end of the air track. Make a number of runs, making small adjustments in the orientation of the sensor until you get the best data you can. You will probably find that if the sensor points slightly up the data will be best.

For your best run, click the auto scale button and examine the three graphs in the display and discuss them. Are they what you expect and what is predicted by the theory? By inspection, are the graphs related, and if so, how? Is it reasonable that the velocity curve is noisier than the position curve, and the acceleration curve noisier than the velocity curve?

Click the statistics button and then the auto scale button. The graphs will rescale so they are not blocked by the statistics window. For the position plot choose curve fit and then power fit. For the velocity plot choose curve fit and then linear fit. For the acceleration plot choose mean. In the statistics window, y refers to the vertical axis and x to the horizontal axis. If your data points are noisy near the ends, draw boxes to exclude the noisy data but include as much good data as possible. Draw the boxes so that they all begin and end at the same times. Your boxes should be lined up vertically. For the velocity plot the acceleration is given by a^2 . Why? In the acceleration plot the average acceleration for the data in the box is given by the mean of y . Compare this to a^2 . Compare these values to the theoretical one. For the position plot, the notation means that $(x+a^3)$ is raised to the a^4 power. What is a^4 ? What does the theory say it should be?

3.2 Mass and θ Dependence

In the following experiments, use a^2 as a measure of the glider acceleration. Determine a^2 for a reasonable amount of data using the previous procedures.

Measure the acceleration for a glider of different mass for the same θ . Then change the θ by substituting the thicker block and measure the acceleration for the two different masses. Compare and discuss your results. Compare to the theory.

3.3 A Bigger Picture and Dissipation

Do the following for only one mass and one θ . Follow the procedures above except let the glider hit the end of the air track 3 times before clicking the stop button. Discuss your

graphs and results. Point out where on your graphs the glider hits the end of the air track. Does the velocity curve cross the axis (velocity=0) where you expect it to? Are the curves the same from bounce to bounce? If not, could you suggest why?