

Physics 20 eLab Centripetal Force

Background:

As a pendulum bob travels in its circular path, it is acted on by a centripetal force. It is the tension of the string that makes the bob of the pendulum follow its circular path. When the bob is at the very bottom of the pendulum swing, the force on the bob is a combination of force of gravity and the tension generated due to the circular motion.

In this lab, you will analyze the force on the pendulum bob as it swings so as to determine the centripetal force.

The Question:

What is the centripetal force on a pendulum?

Variables:

This experiment involves these variables: bob mass, string length, pendulum frequency, centripetal force. Identify and state the manipulated, responding, and controlled variables in this investigation.

Materials:

- force sensor
- 2 USB links
- lab clamp, lab stand and support rod
- string
- ruler
- hanging mass (50 g)
- photogate
- photogate port

Procedure:

Step 1:

Plug the force sensor into the USB link (that is connected to the computer).

Attach the force sensor to the support rod that is connected to the lab stand. Use the other USB link and photogate port to connect a photogate to the computer. Attach the string and mass to the hook at the bottom of the force sensor so that the mass hangs in between the two ends of the upward-oriented photogate.

Step 2:

Prepare DataStudio for data collection. Several steps must first be performed to properly collect data for this experiment.

First, ensure that photogate is configured to collect data as "photogate and pendulum".

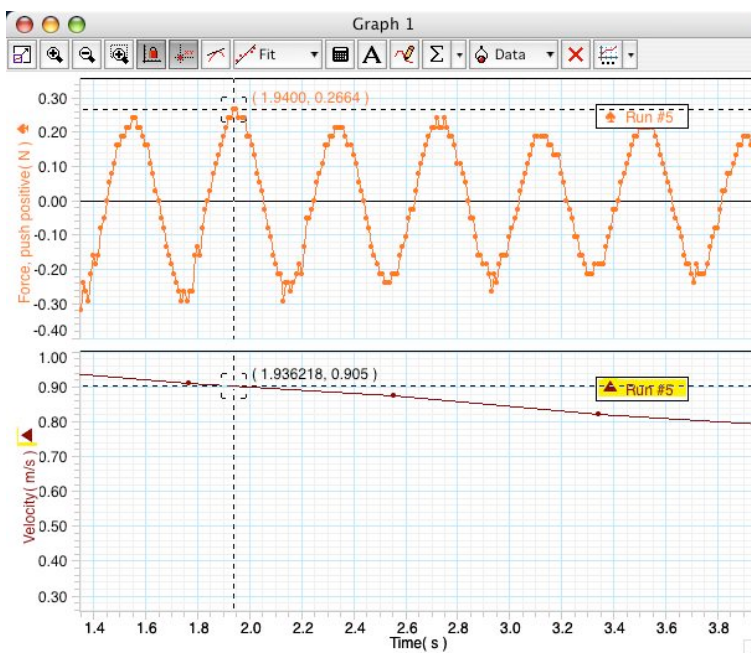
Second, configure the force sensor to display a force vs. time graph. This is the default display for the sensor, so it may already be on your screen. Drag the pendulum velocity icon from the summary window onto the force vs. time graph. This will create a dual graph, with both force and pendulum velocity being measured on the same time scale.

Third, you must make some adjustments to the sensor settings. Measure the width of your pendulum bob and enter this as a constant for pendulum width in the setup window for the photogate.

You also need to increase the sampling rate of the force sensor. Increase the sampling rate to 100 Hz. This can also be done in the setup window by clicking on the force sensor icon.

Step 3:

Press the ZERO button on the force sensor to tare the sensor. Pull the pendulum bob upward and let go, so that bob swings freely in the photogate. Make sure the pendulum bob does not strike the photogate - if you are using a longer string, it would be advisable to use a rubber stopper as a pendulum bob, just in case it strikes the photogate (to prevent damage). Press START in DataStudio, and allow the bob to swing back and forth several times. Press STOP in DataStudio. Your resulting data should look something like this (if your data is closely spaced, you may need to use the autoscale and zoom select buttons to visualize the data better):



Step 4:

Use the Smart Tool in the force graph to place the crosshairs at the at the peak of one of the oscillations of the pendulum that indicate maximum force. Because the force sensor was zeroed while the bob was hanging the force of gravity is eliminated, therefore the force reading represents the centripetal force. Use the Smart Tool in the velocity graph to line up the crosshairs vertically with the crosshairs in the force graph. Record the force and velocity values in a data table such as the one shown below. Repeat the Smart Tool measurements for force and velocity for several of the peaks on your DataStudio graph.

If you have not already done so, determine the mass of the pendulum bob and the length of your pendulum.

Trial #	Bob mass (kg)	Pendulum length (m)	Velocity (m/s)	Fc measured (N)	Fc calculated (N)	Fc % Difference
1						
2						
3						
4						
5						

Analyzing and Interpreting:

1. Use the mass of the bob, the length of the pendulum and the recorded velocity to calculate the centripetal force. Enter this value in your date table as the "calculated" value. Repeat this calculation for all trials.
2. Compare the measured centripetal force to the calculated centripetal force by calculating the percentage difference between the two values. How do these values compare?
3. If there is a significant difference between centripetal force measured and calculated values, what are some possible reasons for the difference?

Applying and Connecting:

4. If your goal was to increase the amount of centripetal force exerted in a pendulum system, describe and explain two ways in which this could be accomplished.

Forming Conclusions:

5. Write answers to the following questions: What is the centripetal force on a pendulum, and how is it calculated?
6. Pendulum systems are often adjusted by changing the pendulum length and bob mass. Design and conduct an experiment that calculates centripetal force and determines the effects of varying pendulum length and bob mass.