Centripetal Force of a Pendulum Demonstration

A pendulum mass is supported by a small-diameter, light-weight carbon fiber rod. It is hung from a force sensor, which in turn is supported on the shaft of a rotary motion sensor. The angle of the pendulum swing and the force along the support rod are simultaneously plotted as functions of time.

In addition, a graph of Angle swing vs. Force can also be displayed.

Investigations with different release angles and length of pendulum can be performed.

To perform the demonstration:

1. Clamp the pendulum stand with rotary motion sensor to the table.

   Attach the force sensor with pendulum to the bare shaft end of the rotary motion sensor, using the special adapter shaft and thumb screw.

2. Plug the rotary motion sensor yellow plug into DIGITAL CHANNELS 1 and the black plug into 2. Connect the force sensor DIN plug to ANALOG CHANNELS A.

Use a student or a second stand with rod to hold the sensor cables out of the way such that the force sensor swings freely.

3. Start Capstone and open:

   "K:\Physics\Demonstrations\
   Centripetal Force Pendulum.cap".

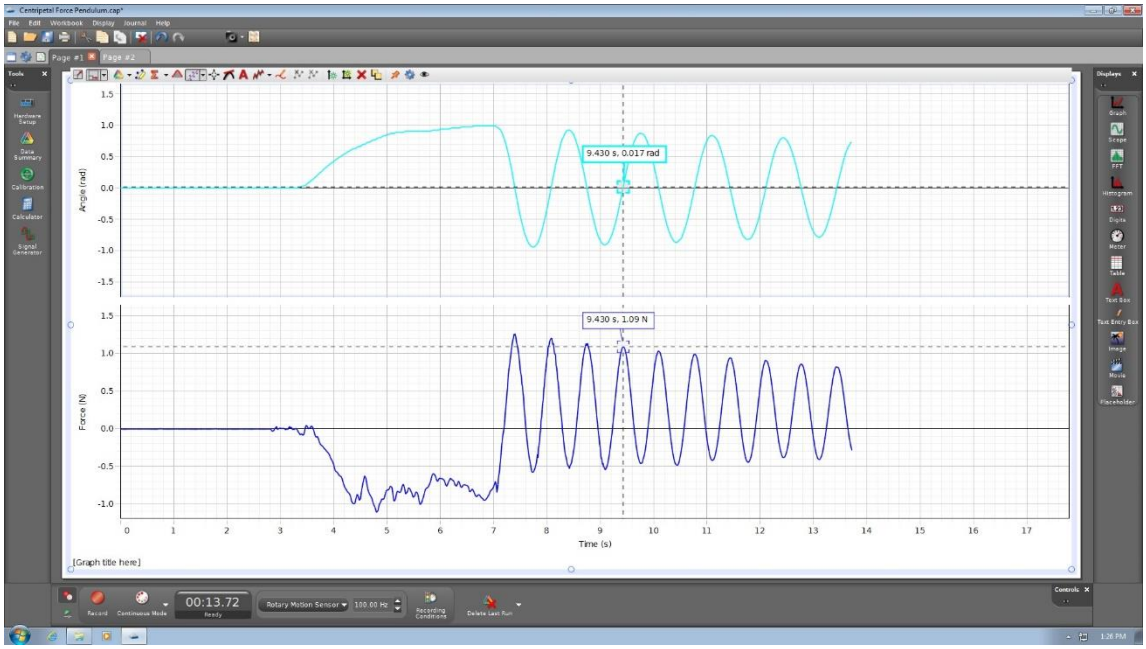
4. With the pendulum at rest at the bottom of its swing, press the Tare button on the side of the force sensor. This means that the at rest force on the force sensor will be zero.

   Also note that the angle measured by the rotary motion sensor will be zero at the bottom of the swing.

5. Click on **Record** and pull the pendulum bob up to an angle of about 1.0 radians as displayed on the graph (about 60 degrees).

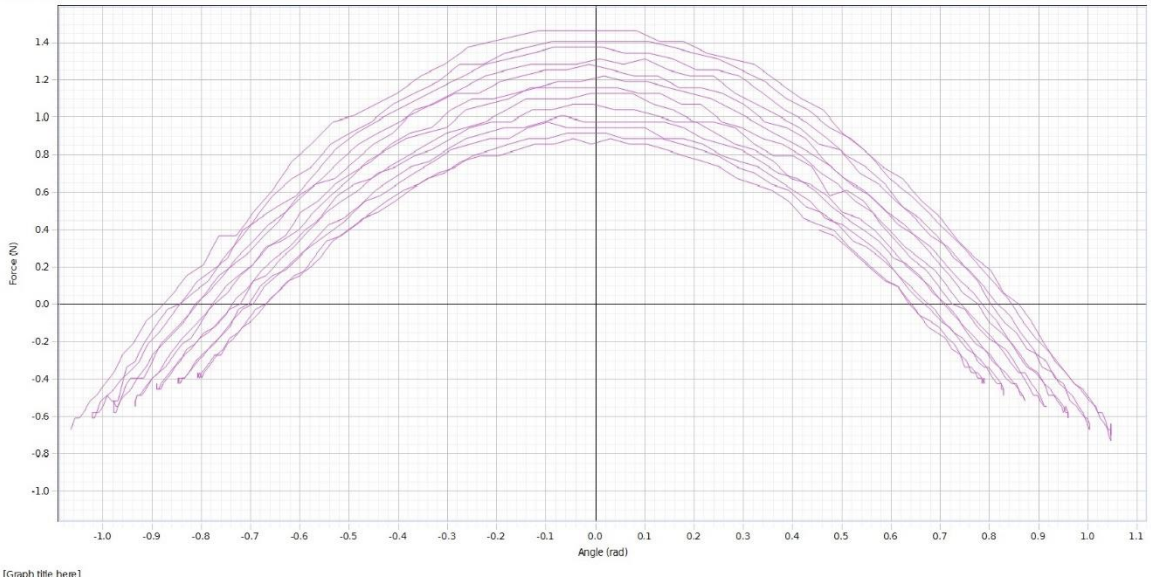
6. Release the pendulum and let it swing for about 8-10 cycles.

7. Click on **Stop**.



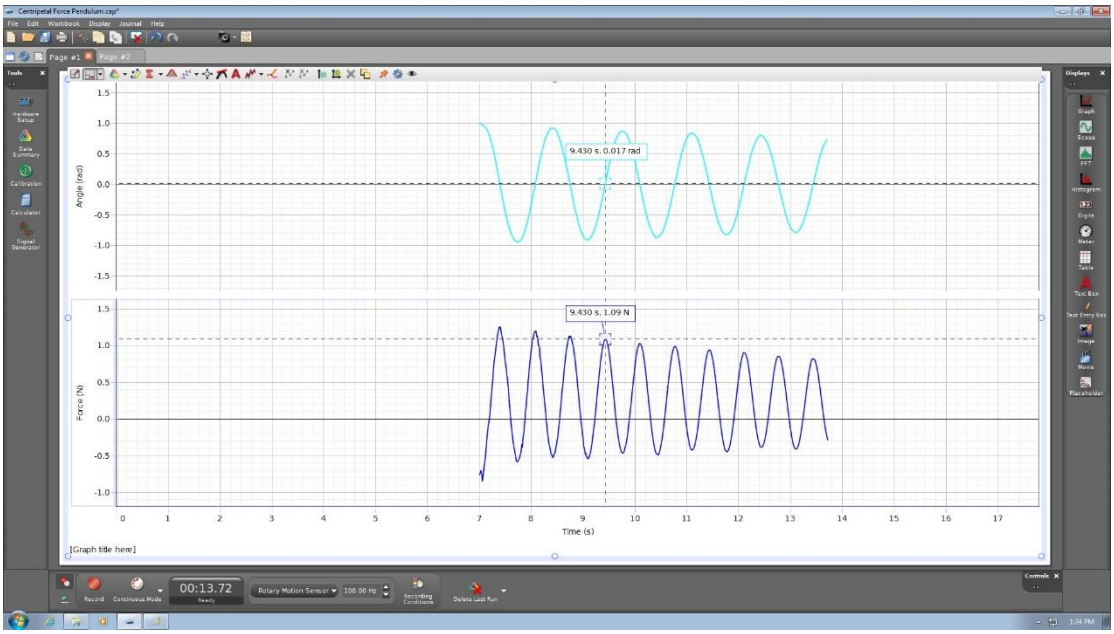
8. Use the "Show coordinates…" graph tool to locate various parts of the Angle vs. Time graph and the corresponding time points on the Force vs. Time graph. The maximum centripetal force occurs when the pendulum is at the bottom of its swing (0 radians) and minimum at the maximum angles left and right.

9. Now change to the "Page #2" tab to show the graph of Force vs. Angle. You may need to click on "Allow simultaneous viewing…" and select Run #1 to get the new run to display.



This graph shows how the force in the rod varies with the angle of swing: maximum at 0 radians at the bottom of the swing and negative (less than the "zero" force when the mass hangs at rest) at the extreme angle. During each swing, the amplitude (and force) decays a bit.

10. The above graph will have extraneous lines unless the data collected before the pendulum is released is deleted from both the Angle vs. Time and Force vs. Time graphs from time 0 up to after the pendulum is swinging—and the same end time must be used for both deletions.



Click on the Angle vs. Time graph on Page #1 to make it active and click on the "Highlight range" button. Drag the box around the data from time 0 to (in this case) 7 seconds. Click on the "Delete data" button and confirm. Right-click on the highlight box that is still showing in the graph and select "Delete Highlighter".

Now, click on the Force vs. Time graph below to make it active and click on the "Highlight range" button. Drag the box around the data from time 0 to (again) 7 seconds. Click on the "Delete data" button and confirm. Again, right-click on the highlight box that is still showing in the graph and select "Delete Highlighter".

11. Change to the "Page #2" tab to show the graph of Force vs. Angle with cleaned-up data.