

Purpose

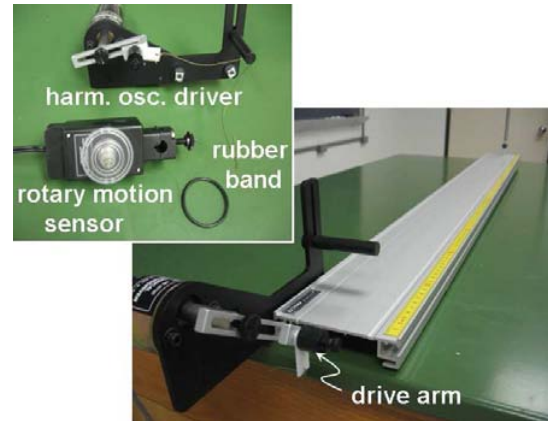
In today's lab you will be investigating resonance in a driven, oscillating mass-and-spring system.

Materials

2 springs with the same k , collision cart, dynamics track, string, harmonic oscillator/driver, low-voltage power supply, motion sensor, rotary motion sensor, table clamp, posts

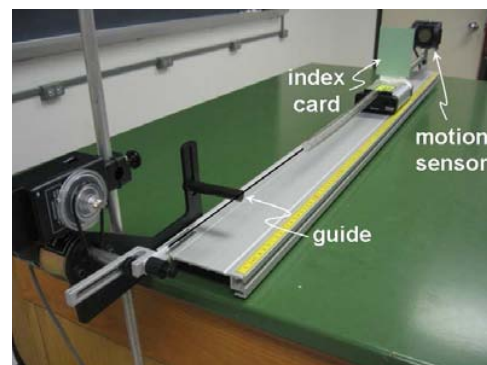
Preliminaries

1. Set up the dynamics track as indicated in the figure at right. Attach the post on the screw leg and level the track. Mount the harmonic oscillator/driver to the dynamics track. Attach a metal bar to the slot on the harmonic oscillator. Mount the rotary motion sensor on this bar, as is indicated in the figure below.



2. Unscrew the drive arm of the oscillator and attach the rubber band to the shaft on the medium pulley of the rotary motion sensor. Adjust the height of the rotary motion sensor so as to put tension on the rubber band. Re-attach the drive arm. Adjust the length of the driving arm to about 2.5 cm. Connect the power cable of the oscillator to the DC output of the power supply.

3. Cut a piece of string about 40 cm long, tie one end of it to the hole on the white plastic piece of the drive arm of the oscillator and thread the other end through the hole in the guide. Ultimately, we will attach two springs to the collision cart. One spring will also attach to the post at one end of the track. The other spring will be attached to the string leading from the harmonic oscillator driver. Mount the motion sensor onto the post. Attach an index card on the cart using masking tape.



- ! DO NOT attach the springs just yet. We have to determine the values of the spring constants first.
4. Connect the motion sensor to Channels 1 and 2, and the rotary motion sensor to channels 3 and 4. In Data Studio, activate the motion sensor, select Position for the quantity to be measured, and set the sample rate to 20 Hz. Click channel 3 and select Rotary

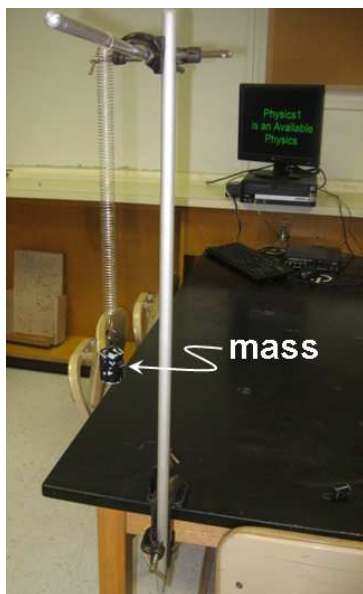
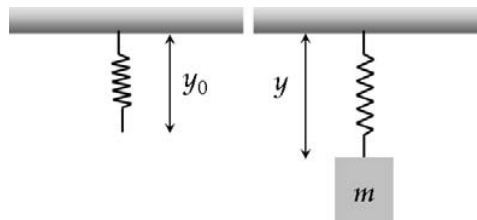
Motion Sensor for the instrument and select Angular Velocity (rad/s) for the quantity to be measured. Drag the position and velocity icons to a single graph.

- Copy the Excel workbook from the course web site to the My Documents directory. Open it in Excel and complete Table 1 on the resonance worksheet.

Spring Constant

A stretched spring exerts a force that is proportional to the distance y that it is stretched from its equilibrium position y_0 : $F = -k(y - y_0)$. For a spring hanging vertically, adding a mass to the spring will result in an extension of the spring until the gravitational force acting on the mass is balanced by the spring force:

$$mg = -k(y - y_0). \quad (1)$$



- Hang the spring from a crossbar assembly as shown in the figure at left.
- Use a two-meter stick to measure the equilibrium position y_0 of the spring. Record this value in Table 2. Attach a 50 g mass to the spring and let it hang freely. Now measure the new length y of the spring. Complete Table 2 of the resonance worksheet.
- Repeat step 2 for the second spring. Complete Table 3 of the resonance worksheet.

Resonance


As we saw in the previous lab on periodic motion, mechanical systems can oscillate with a so-called natural frequency $\omega_0 = 2\pi/T$, where T is the period of oscillation. In today's lab, we will investigate the behavior of a system driven at different frequencies ω . When $\omega = \omega_0$, the system will display very large amplitude oscillations. This phenomenon is called *resonance* and ω_0 is also known as the resonance frequency.

- Connect the springs to the collision cart and mount the motion sensor. The drive frequency is determined by the voltage supplied to the oscillator/driver system. Start by setting the voltage to about 1V and collect data for at least 30 s. Don't click Stop in Data Studio. Increase the voltage by increments of 0.5 V until you reach 5 volts, recording for 30 s at each voltage setting, then Click Stop.

! DO NOT exceed 12 V on the power supply.

! The rotary motion sensor keeps track of the motion of the drive arm of the harmonic oscillator while the motion sensor tracks the motion of the cart.


? Describe what happens to the amplitude of oscillation as the drive frequency is increased.

 Paste the graphs generated into a Word document for submission with the handout (include the statistics).

2. From the angular velocity graph, determine the drive frequency of the system at resonance. Record the value in Table 4 on the resonance worksheet.

? Predict what you think would happen to the resonance frequency if we increase the mass of the cart.

3. Verify your prediction by doing repeating step 1 with an additional bar mass on the cart. Repeat again with two bar masses added to the cart. Record your data in Table 4 on the resonance worksheet.

 Paste the graphs generated into a Word document for submission with the handout (include the statistics).

? So, what happens to the resonance frequency as we increase the mass of the cart?

4. Complete Table 4. Note that the natural frequency ω_0 of the spring-mass system you used above is given by $\omega_0 = \sqrt{(k_1 + k_2)/m}$, where k_1 and k_2 are the spring constants and m is the mass of the oscillating system.

? From the different trials that you conducted, how does the resonant frequency found compare with the natural frequency of oscillation of the spring-mass system? Justify your answer.

Making Connections



Can a singer with a perfect pitch really shatter glass? Explain your answer.



Soldiers normally march in unison. When approaching a bridge, the soldiers are commanded to break step (stop marching in unison). Why?