# Driven Oscillation of Mass and Spring

## Equipment

| | | |
|---|---|---|
| 1 | Motion Sensor | PS-2103A |
| 1 | Density Set | ME-8569 |
| 1 | Spring set | ME-8999 |
| 1 | Braided String | SE-8050 |
| 1 | Table Clamp | ME-9472 |
| 1 | 45 cm Rod | ME-8736 |
| 1 | Large Rod Base | ME-8735 |
| 1 | String Vibrator (From UI-5802) | WA-9857 |
| 1 | Patch Cords (From UI-5802) | SE-9750 |
| | Thick construction paper and tape | |

## Introduction

The String Vibrator is used to drive the mass and spring, and the resulting oscillation is recorded using the Motion Sensor. The driving frequency is varied to observe the response above, below and at the resonance frequency of the system. The piece of blue construction paper taped to the bottom of the oscillating mass adds damping to the system caused by the air friction drag.

## Setup

1. Use two patch cords to connect the String Vibrator to Output #1 on the 850 Interface.

2. Use the table clamp and 45 cm rod to support the String Vibrator out over the edge of the table as shown in Figure 1. Note that the vibrator is positioned label side down, with the patch cords coming out the bottom.

3. Position the Motion Sensor on the floor below the String Vibrator, and plug the sensor into the interface. In PASCO Capstone, set the sample rate to 50 Hz.

4. Tie a short loop of string through the hole in the plastic cylinder from the Density Set.

5. Cut a 15 cm x 15 cm square piece of construction paper.

6. Tape the plastic cylinder to the center of the square as shown in Figure 2.

7. Select the three short, weak springs from the Spring Set. Suspend the cylinder with paper damper from the driver of the String Vibrator using the three springs in series as shown in Figure 3.

8. Adjust the height so that the paper damper is about 30 cm above the Motion Sensor.

9. Click on the properties (gear) icon for the Motion Sensor in the Hardware Setup window. With the mass hanging at equilibrium (not moving), click Zero Sensor Now. Later, if your oscillation data is not centered on zero, repeat this step.

   Note: In this lab, you will vary the driving frequency to see the effect on the amplitude of the oscillation. The damping created by air friction on the blue paper fastened to the bottom of the cylinder causes the motion to settle down more quickly, making it easier to see the changes.

10. Create a graph of Position vs. Time.

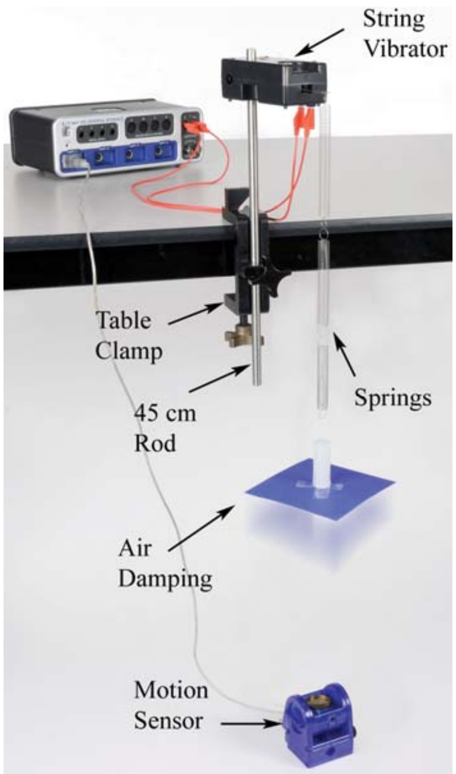


Figure 1: Driven Oscillations

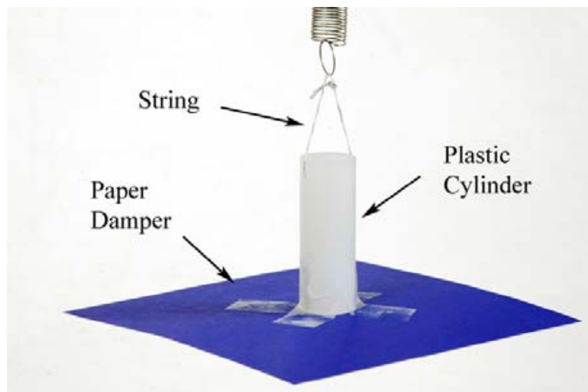


Figure 2: Adding the Damping

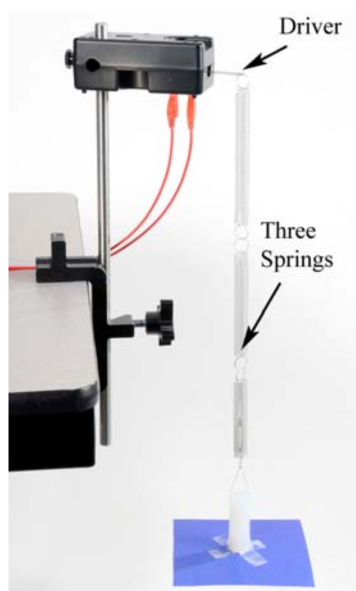


Figure 3. Three Short Weak Springs

## Procedure: Resonant Frequency

1. Displace the mass from equilibrium by 15 to 20 cm, and release.

2. Immediately click on Record, and take four or five periods worth of data.

3. Select a Damped Sine from the curve fit list.

4. Record the angular frequency, ω.

5. Displace the mass again, and take another run of data. Record the frequency of this run. Calculate the average angular frequency.

6. Repeat until you get a good, solid value for the average angular frequency.

## Driving Frequencies

7. Create a table as shown below. Freq, f, and A are User-Entered Data sets.

| | Freq | f (Hz) | A (cm) |
|---|---|---|---|
| 1 | Resonance – 0.3 | | |
| 2 | Resonance – 0.2 | | |
| 3 | Resonance – 0.1 | | |
| 4 | Resonance – 0.05 | | |
| 5 | Resonance – 0.02 | | |
| 6 | Resonance | | |
| 7 | Resonance + 0.02 | | |
| 8 | Resonance + 0.05 | | |
| 9 | Resonance + 0.1 | | |
| 10 | Resonance + 0.2 | | |
| 11 | Resonance + 0.3 | | |
| 12 | Resonance + 0.4 | | |

8. Calculate the linear frequency, f, where

$$\omega = 2\pi f$$

This is the resonant frequency (in Hz) of the spring and mass system. Record this value in row 6 in the right hand column of the table.

9. Set the frequency of the signal generator to the resonant frequency, and turn the output on. Do not exceed the max voltage of 6 V! Observe the resulting oscillation, then turn off the output.

10. Subtract 0.3 from your resonant frequency and enter this value in row 1 in the right hand column of the table. Continue the process and fill out the table for the rest of the values

In the next part, you will set the signal generator to each of these frequencies, and measure the resulting amplitude using the Motion Sensor. Each time you change the frequency, you will have to wait for the oscillation to settle down. If the amplitude is fluctuating, just wait a few seconds and try another run. Give it time to settle down to a steady value. If it continues to fluctuate, just try to estimate an average value for the amplitude.

11. Set the signal generator at the first (lowest) frequency in the table, and turn on the output. You can leave the generator on, even while you change frequencies.

12. For each frequency, measure the resulting amplitude (A) with the Coordinates tool, and enter the value in the table in the third column. Turn the output off when finished.

13. Create a graph of A vs. f.

## Resonance Curve

1. What determined the position where the resonance curve peaks?

2. Which way would the curve shift if you used the same springs but a larger oscillating mass?

3. What determines the height of the peak? What could you change to make it larger?

4. The String Vibrator is pushing and pulling on the spring the same at all frequencies. Why does it cause a big oscillation only near resonance? What is happening when it is far from resonance?