Simple Harmonic Motion – Procedure – Alternate Lab

EQUIPMENT

Stand apparatus (table clamp, vertical bar, horizontal arm)

Spring

Slotted masses and hanger

Pendulum bob

Meterstick

PROCEDURE

Please print the worksheet for this lab. You will need this sheet to record your data.

Spring Oscillations

You will be using two different principles to determine the stiffness of a spring, and also comparing the outcomes of two methods. One method involves measuring the stretch resulting from an applied force and using Hooke's Law,

$$|\mathbf{F}_{\text{spring}}| = ks. \tag{1}$$

The second method involves measuring the oscillation period of a mass hanging on the spring and using the relationship among mass, spring constant, and oscillation period,

$$T = 2\pi\sqrt{\frac{m}{k}}. \tag{2}$$

For more details about these equations, see Simple Harmonic Motion – Concepts[1].

Using Hooke's Law

1 Assemble the stand with a horizontal arm and hang the spring from the arm. Measure the length of the unstretched spring.

2 Hang the empty mass hanger from the spring, and record its mass (50 g) in Table 1. Determine the amount of elongation (stretch) caused by this mass, and record it in Table 1 as well.

3 Add 40 g to the hanger and record the new amount of stretch.

4 Repeat this process 4 more times, recording each value in Table 1.

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[1] ../lab_7_1/manual.html

5 Using linear regression[2] and Hooke's Law, determine the value of the spring constant.

Using a Graph of T^2 vs. m

Next, you will determine the spring constant using the concepts of simple harmonic motion. In order to be able to do this, you will need to determine the period of oscillation. The best methods involve finding the time for multiple oscillations and then dividing by the number of oscillations to get the period. For this reason, you will be entering the time for 3 oscillations into Table 2.

> One easy and accurate method for measuring the period is to record the spring bouncing up and down with your laptop's camera. If your laptop has a camera, you should have QuickTime®, iMovie®, or Windows Movie Maker® on your computer. If not, you can download VLC Media Player® for free from this website[3]. You can determine the frame rate of the video from the information menus, then count the number of frames involved in 3 oscillations. Dividing the number of frames by the frame rate (in frames per second) will yield a time for the 3 oscillations in seconds.
>
> To get the frame rate, check in the following places: In iMovie®, Preferences → Video and look for the fps number; in Quicktime®, Window → Show Movie Inspector and look for the fps number (or use Command+i); in VLC®, Window → Media Information (or Command+i) → Codec Details, click the arrow by the "Streams" until you find the video stream (usually "Stream 1") and find the frame rate.

Once you are ready to begin, follow this procedure.

1 Suspend 200 g from the spring (this includes the hanger's mass), pull it down a short distance, and release to begin oscillations.

2 Using the video capture method described above, record the time for 3 vibrations.

3 Perform 3 total trials, averaging the times together, to increase accuracy. Finally, determine the period of a single oscillation from this average time.

4 Repeat the measurements three more times, doing three trials of each and making each mass used at least 20 g different from each other. **Don't use less than 100 g!**

5 Using linear regression[4] and the equations of simple harmonic motion, determine the value of the spring constant.

6 How does the value of the spring constant compare for your two methods? What might have contributed to any discrepancy you found?

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[2] ../regression/manual.html
[4] ../regression/manual.html

Simple Pendulum

For a simple pendulum, the relationship among period, pendulum length L, and the acceleration due to gravity is very similar to the mass-spring equation above. If the pendulum is moving only through small angular distances, the relation is

$$T = 2\pi\sqrt{\frac{L}{g}}. \tag{3}$$

Using a Graph of T^2 vs. L

1 Construct a simple pendulum by hanging the large metal bob by a string from the horizontal bar of the stand assembly. Make your length at least 1.2 m. (You will need to have the pendulum hang over the edge of the table.)

2 Record the length of the pendulum. Note that the length should be the distance from the pivot point to the *center of mass* of the pendulum bob.

3 Using the same methods as you used with the mass and spring, determine the amount of time for one oscillation (i.e., the period) with multiple trials averaged together, and then **calculate** the experimental value of the period.

4 Change the length of the pendulum by at least 20 cm and follow all the steps above. Do four total measurements, varying the length by at least 20 cm. The easiest way to change the length is just to wrap the string around the support arm a few times to shorten it.

Important notes:

Use only small displacement angles when swinging the pendulum (less than 20° from vertical) and don't use a pendulum length less than 50 cm.

5 Using linear regression[5] and the equations of simple harmonic motion, determine the experimental value of the acceleration due to gravity.

[5] ../regression/manual.html

