Simple Harmonic Motion

1^{st} year physics laboratories

University of Ottawa

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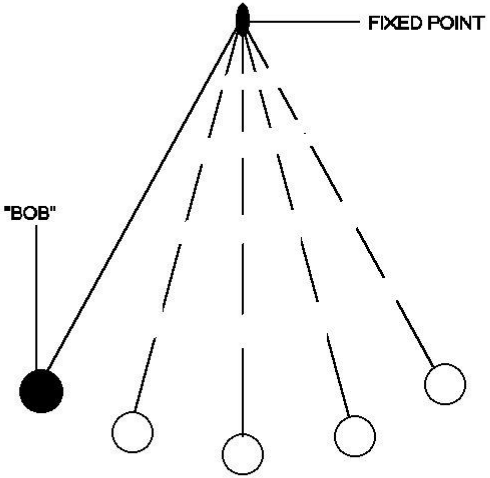


INTRODUCTION

- A mass on a spring will oscillate in simple harmonic motion (SHM). In this experiment you will investigate this type of motion where an object moves back and forth along a fixed path.
- If a mass on a spring is pulled down then released, the spring exerts a restoring force, $\vec{F} = -k\vec{x}$, where $\vec{x}$ is the distance the spring is displaced and k is the "spring constant" of your spring.

INTRODUCTION (cont.)

- For a mass oscillating in SHM on an ideal spring (spring has no mass), the period, $\boldsymbol{T}$, is given by $\boldsymbol{T = 2\pi\sqrt{\frac{m}{k}}}$.
- If the spring has mass, the corrected equation for the period is:

$$\boldsymbol{T = 2\pi\sqrt{\frac{m + \gamma m_s}{k}}}$$

where $\boldsymbol{m_s}$ is the mass of the spring and $\boldsymbol{\gamma}$ is a constant between 0 and 1 which depends on the type of spring used.

- For a regular uniform spring, $\boldsymbol{\gamma}$ is equal to 1/3. You will determine the $\boldsymbol{\gamma}$ value for the conical harmonic motion spring you will use in this experiment.

OBJECTIVES

- Collect position vs. time data for a mass oscillating in SHM on a hanging conical spring and determine the best fit equation for the position vs. time graph.
- Relate the variables in your best fit equation to the physical parameters in your system.
- Compare the force constant of your spring obtained by static measurements with that found using dynamic measurements.
- Estimate the spring's correction factor, $\boldsymbol{\gamma}$, to calculate the effective mass of your spring.

SAFETY WARNING!

- Never **hang masses** above the motion detector **without using the motion detector guard** (cage).
  - Dropping a mass on the detector could cause serious damage to it.
- Please **do not overstretch the spring** beyond its elastic limit.
  - You need only use small amplitude oscillations (a few cm).
- Always **find an equilibrium point** for your mass on the spring and **pull gently to start the oscillations**.
  - Please do not let the masses fall from an arbitrary height to begin oscillations.

PRELIMINARY WORK

- Both the force and motion sensors should be connected to your Labquest Mini device. In Logger Pro you should see values for force and position.
- The motion detector should be set to "track" and the force sensor set to "10 N".
- Prepare the setup as shown in Fig. 1 (next slide).
- Put 300 g on the mass hanger and let it equilibrate, then zero both your sensors.
- Collect position vs. time and force vs. time data and fit your curves with a sinusoidal function: **A*sin(B*t+C)+D**

The setup

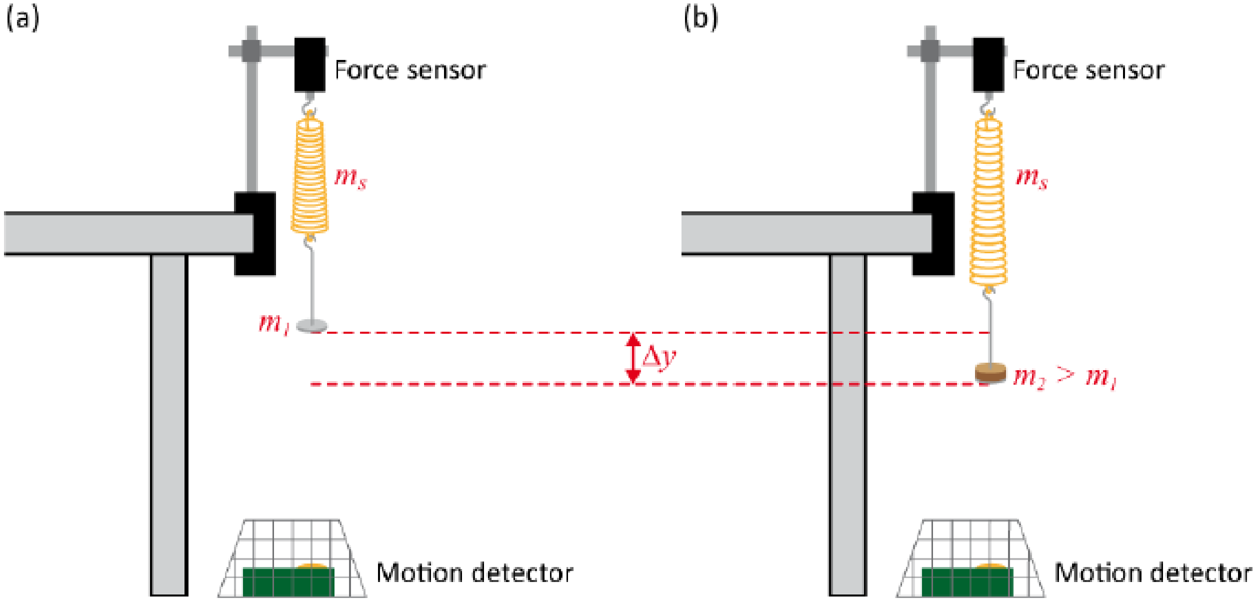
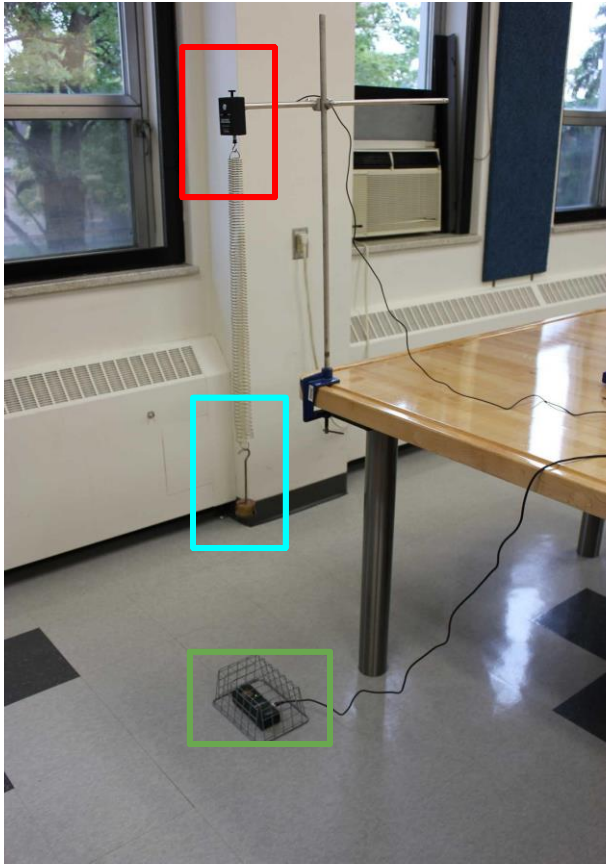
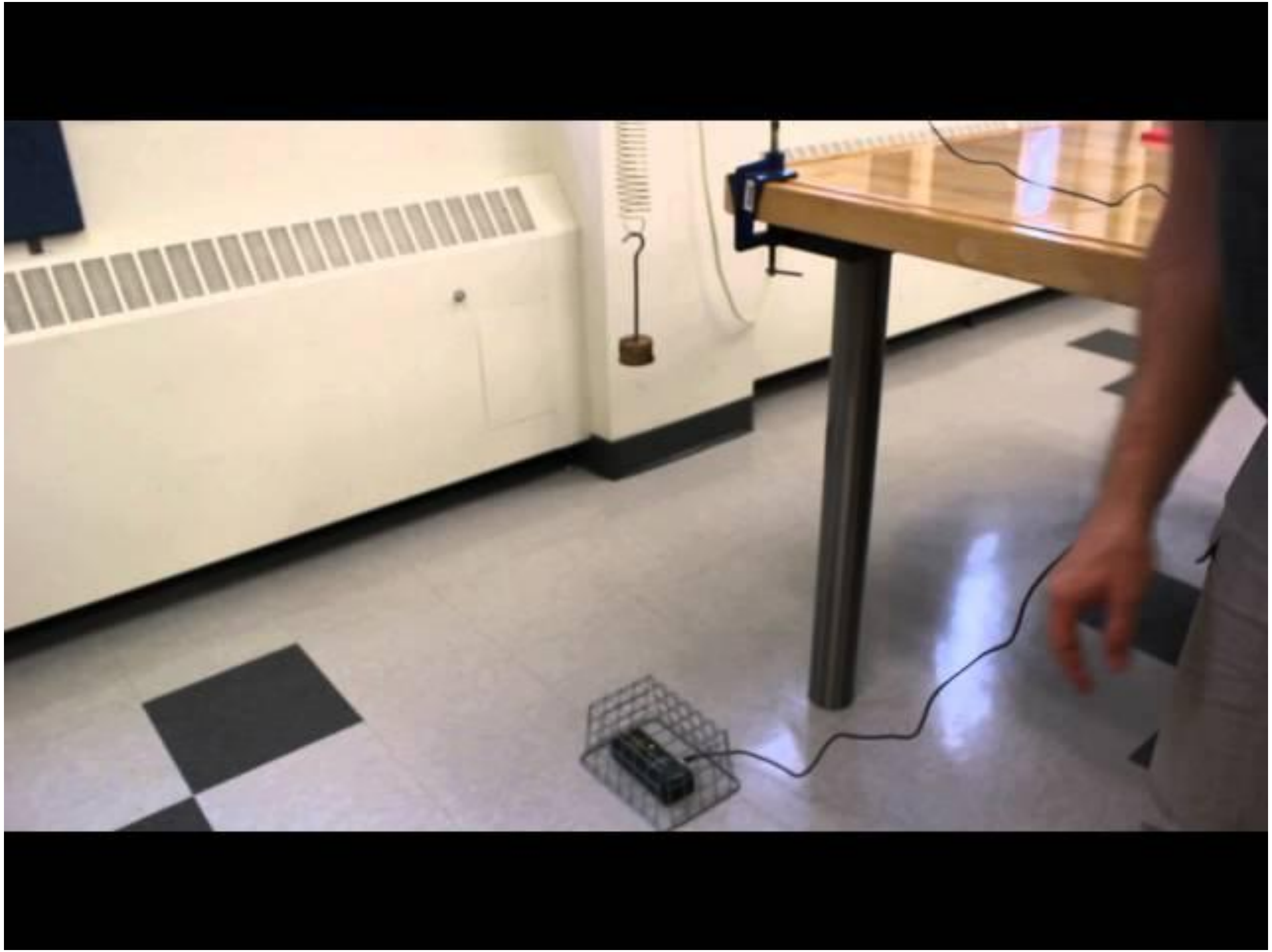


Figure 1 - Simple harmonic motion setup



The setup (cont.)

Small Amplitude Oscillations



k from static measurements

- Start with an empty mass hanger and zero both your sensors.
- Add 100 g to the spring and let it settle. Record the new position, Δy, and start filling in *Table 2*.
- Record the new position as you add mass to the hanger, 100 g at a time.
- Prepare your plot of extending force ($F = mg$) vs. position (Δy).

k from dynamics measurements

- We start with the equation for the period of oscillation and square it:

$$T = 2\pi\sqrt{\frac{m+\gamma m_s}{k}} \rightarrow T^2 = \frac{4\pi^2 m}{k} + \frac{4\pi^2 \gamma m_s}{k} \; .$$

- Record position vs. time data for small oscillations of the mass hanger and 100 g on the spring.
  - Perform a sinusoidal fit of your data and start filling in *Table 3*. Recall that **B** is the angular frequency ($\boldsymbol{\omega}$) of the oscillation.
- Record new position vs. time data as you add mass to the hanger, 100 g at a time. Complete *Table 3*.
- Prepare your graph of $\boldsymbol{T^2}$ vs. $\boldsymbol{m}$. (Recall $\boldsymbol{T = 2\pi/\omega}$).

Investigating Amplitude vs Frequency.

- Put 300 g on the mass hanger.
- Collect data for different amplitudes of oscillation (different values of $\Delta \boldsymbol{y}$) between 0.01 to 0.1 m.
- Perform a series of sinusoidal fits for your different runs.
- Note the **A** (amplitude) and **B** (frequency) values for your different sinusoidal fits and complete *Table 4*.

GRAPHS

- There are two graphs to create and submit for this lab. Use the “Uploading graphs” tool at the bottom of the experiment page in Brightspace.

Exp. 2 - Uploading graphs

Assignment

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Due February 17 at 6:00 PM   Starts Feb 6, 2023 12:01 AM   Ends Feb 17, 2023 6:00 PM

WARNING: DO NOT OPEN THIS ASSIGNMENT UNTIL YOU ARE READY TO SUBMIT YOUR GRAPHS DURING YOUR LAB SESSION!

Please upload the **two** graphs associated with Exp. 2 in this submission folder.

Your graphs **must be in PDF format** or else they will not be marked and you will receive a score of zero for this section.

You may **only make one submission** so please ensure that your graphs are to your satisfaction before submitting.
- PDF format with correct file name, landscape, title shown, axes labeled, etc...

CLEAN UP

- Turn off the computer and **don’t forget to take your USB key.**
- Replace the masses, mass hanger, spring, motion detector, and cage back on the table.
- Please recycle scrap paper and throw away any garbage. Please leave your station as clean as you can.
- Push back the monitor, keyboard, and mouse. Please push your chair back under the table.
- Thank you!

DUE DATE

The report is due at the end of the lab session.

PRE-LAB

Don’t forget to do your pre-lab for the next experiment!