Course and Section_______ Names ___________________________

Date___________ _________________________________

SIMPLE HARMONIC MOTION EXPERIMENT

Equipment

Vertical rod, clamp, spring, cart, rod stand adapter, mass hanger, mass set, meter stick

Introduction

In this experiment, you will measure the spring constant *k* using two different methods and compare your results.

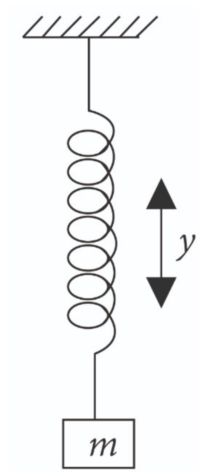
Hooke's law for a spring states that the magnitude of the force exerted by a spring is

$$F = kx \qquad (1)$$

where *x* is the displacement of the spring from equilibrium.

Given a spring obeying the Hooke's law, a mass hung from the end of the spring will undergo simple harmonic motion. That is,

$$y(t) = A\sin(\omega t + \varphi) \qquad (2)$$



where y*(t)* is the vertical displacement, *A* is the amplitude of oscillation (maximum displacement from equilibrium), $\omega = 2\pi f$ is the angular frequency related to the period as $\omega = 2\pi/T$, and φ is a phase angle. Substituting Eq. (2) into Eq. (1) and using Newton's 2^{nd} law of motion, it can be shown that

$$\omega = \sqrt{\frac{k}{m}}\ , \quad or \quad T = 2\pi\sqrt{\frac{m}{k}} \qquad (3)$$

Thus, *k* can be measured statically using Eq. (1) or dynamically using Eq. (3).

From Eq (2) the velocity and the acceleration of the oscillating mass is

$$v(t) = A\,\omega\cos(\omega t + \varphi) \qquad a(t) = -A\,\omega^2\sin(\omega t + \varphi)$$

Preliminary Questions

1. Which mass hanging from the same spring has a longer period of oscillation T ? A 0.6 kg or a 0.7 kg ?

2. Sketch a graph of $y(t)$ vs. t for the two cases $\varphi = 0$ and $\varphi = \pi/2$. Refer to Equation 2.

3. Sketch the two graphs of *velocity* vs. *time* corresponding to the graphs in question 2.

4. Sketch graphs of *acceleration vs. time* corresponding to the graphs in question 2.

5. At which point(s) in its cycle does the mass have its greatest speed?

(a) $y = \pm A$ (b) $y = 0$ (c) same at all points.

6. At which point(s) in its cycle does the mass have its greatest potential energy?

(a) $y = \pm A$ (b) $y = 0$ (c) same at all points.

PART 1 – Static measurement

Procedure

Step 1. Hang the mass holder at the end of the spring. Add an appropriate mass value to obtain a vertical displacement of about 3-5 cm. Measure the displacement.

Step 2. Repeat for increasing values of the mass and collect your data in the table below. The mass *m* must include the mass of the holder.

m (kg)	displacement (m)

Step 3. Plot the F (= mg) versus x and determine k from the slope of the line. Submit your graph with your report.

$$k =$$

PART 2 – Dynamic measurement

Step 1. Open the file: **"F-t.cap"** contained in the T\:Capstone. This file will open Capstone and display two graphs of the force vs. time. You only need to work with one graph. Set the sample rate of the force sensor to 200 Hz.

Step 2. Add a mass on the hanger and displace it from equilibrium. Pull it down a bit and then let it go. Observer its oscillatory motion.

Step 3. Select the data which display the oscillation of the force vs time. Fit the data with a sine wave and determine the period T from your fit parameters. Print and submit a copy of one of the the sin wave fit.

Step 4. Repeat for increasing values of the mass and collect your data in the table below. The mass m must include the mass of the holder.

m (kg)	ω (r/s)	T (s)	T^2 (s^2)

From Eq. (3), squaring both sides we obtain

$$T^2 = \frac{4\pi^2}{k} m$$

Analysis

7. Plot T^2 (on the y-axis) versus m (on the x-axis). You can use Excel for example and find the slope of your fit.

slope = ________

8. Determine k from the numerical value of the slope.

$$k =$$

9. What is the color of the spring you have used?

Analysis

10. Compare the values of k determined in PART 1 and PART 2. Calculate the percentage difference.

%difference = ___________

11. Suppose we did this experiment on the Moon (where $g = 1.6\ m/s^2$) for a given fixed value of the mass. What effect, if any, would this have on the two parts of this experiment?

PART 1 with $F = k\,\Delta y$ F: weight Δy: vertical displacement.

	Compare
F_{EARTH} vs F_{MOON}	
Δy_{EARTH} vs Δy_{MOON}	
k_{EARTH} vs k_{MOON}	

PART 2 with A: Amplitude v: vertical velocity of oscillation.

	Compare
T_{EARTH} vs T_{MOON}	
m_{EARTH} vs m_{MOON}	
v_{EARTH} vs v_{MOON}	
A_{EARTH} vs A_{MOON}	
k_{EARTH} vs k_{MOON}	

12. What is the meaning of the y - axis intercept in your straight line fit in PART 2?
From equation (3) if m is = 0 then T should be zero, but as you see from your fit it’s not.
Sure there are experimental errors but that is not the reason.
Hint: the issue is how equation (3) has been used to describe PART 2.