PHY 157
Simple Harmonic Motion
(Experiment 2)

Name: ______________________________

1 Introduction

Simple harmonic motion (SHM) is vibratory motion caused by a linear restoring force. The best known linear restoring force is the force exerted by a stretched or compressed spring. This force, call the *spring force*, is given by the expression

$$F = -kx \tag{1}$$

where F is the spring force in newtons, x is the displacement in meters from the resting or equilibrium position of the spring, and k is a constant with units of N/m called the *spring constant*. The spring constant is a measure of the strength of the spring. The minus sign indicates the restoring nature of the force, making it positive for negative displacements and negative for positive displacements.

When a mass m is attached to a hanging spring, the weight of the mass pulls the spring down to a resting position called the *equilibrium position*. At this position, which we set to $x = 0$, the weight of the mass acting downward just balances the spring force acting upward. If the mass is now displaced above or below this equilibrium position and released, it vibrates with SHM. In SHM, one round trip of the mass from any position back to the same position, *moving in the same direction*, is called a *cycle* of the motion. The time interval for the mass to travel one cycle is called the *period* of the motion. The maximum displacement, either positive or negative, is called the *amplitutde* of the motion. An important property of SHM which distinguishes it from other types of harmonic motion is that **its period is independent of its amplitude**. When the amplitude is larger, the spring causes the mass to move faster along the cycle so that the time for one cycle remains constant. The theoretical formula for the period of SHM is given by

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

2 Apparatus

- Medium length spring
- Large tripod stand
- Clamp and horizontal rod
- Meter stick
- 5 g mass hanger
- Small masses (3–20 g, 1–10 g, 1–5 g)
- Stopwatch

3 Procedure

In this experiment you will hang a spring vertically from a support rod. A mass m attached to the lower end will stretch the spring to an equilibrium position. At equilibrium, the spring force pulling upward is equal to the weight pulling downward. When placed in motion, the system will vibrate about this equilibrium position with SHM.

1. **Setup.** A horizontal rod is attached to a large tripod stand. Raise the horizontal rod so that it is about 1.2 to 1.5 meters above the floor. Slip one end of the spring over the horizontal rod and hang the 5 g mass hanger from its other end. Place 30 g on the hanger (total mass = 35 g).

2. **Relationship Between Period and Amplitude.** Use the following table:

Displacement (cm)	Time for 10 cycles (sec)	Period (sec)
3.0		
6.0		
9.0		

(a) With a total mass of 35 g on the spring (30 g of weights, plus 5 g for the hanger), displace the spring about 3 cm and release. Using the stopwatch, determine the amount of time required for 10 cycles of the mass and record the result in the table. Divide this result by 10 to find the average period of motion, and record this result in the table.

(b) Repeat for displacements of 6 cm and 9 cm.

(c) Does the period depend on the amplitude?

3. **Relationship Between Period and Mass.** Use the following table:

Mass (g)	Time for 10 cycles (sec)	Period (sec)
35.0		
50.0		
70.0		

(a) With a total mass of 35 g on the spring (30 g of weights, plus 5 g for the hanger), displace the spring and release. Using the stopwatch, determine the amount of time required for 10 cycles of the mass and record the result in the table. Divide this result by 10 to find the average period of motion, and record this result in the table.

(b) Repeat for total masses of 50 g and 70 g.

(c) Does the period depend on the mass?

4. **Measurement of the Spring Constant.** Use the following table:

Added mass m (g)	Force = mg (N)	Displacement x (cm)	Spring constant k (N/m)
20			
30			
40			

(a) Start with a total mass of 35 g on the spring (30 g of weights, plus 5 g for the hanger). Measure the position of the hanger plate.

(b) Add 20 g of weights to the hanger, and measure the new position of the hanger. Record the change in position as the displacement in the table.

(c) Add another 10 g of weights (total of 30 g added) to the hanger and repeat. Record the change in position in the second line of the table.

(d) Add another 10 g of weights (total of 40 g added) to the hanger and repeat. Record the change in position in the third line of the table.

(e) Compute the spring constant for each line in the table using Equation (2) ($k = mg/x$). Record the results in the table.

(f) Find the average spring constant by computing the mean of the spring constants in the table. Record your result here: ____________