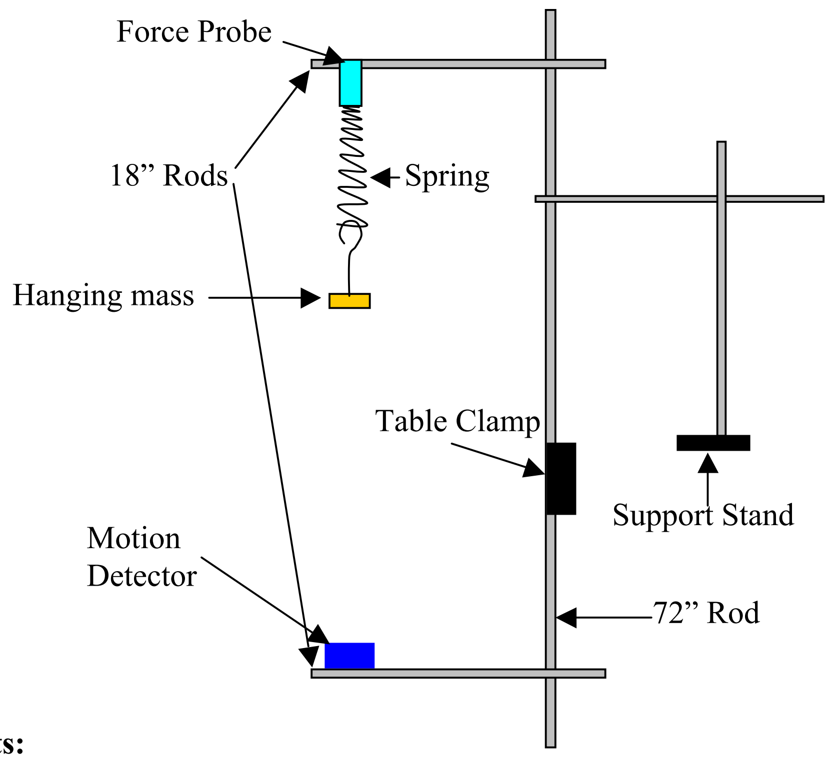
Name:
Date:
Lab Partner:

Physics 4A Lab: Simple Harmonic Motion

Objective: To investigate the simple harmonic motion associated with a mass hanging on a spring. To use hook's law and SHM graphs to calculate the spring constant and describe the motion with angular frequency, amplitude, period, velocity and acceleration.



Equipments:

- Force Probe
- IMAC with Power Adapter
- Support Stand and Rods
- Motion Detector
- Graph Papers and Rulers
- Lab Pro and Power Supply
- Table Clamp
- Spring
- Hanging Mass with extra weights
- Meter Stick

Theory:

We will be using a spring hanging vertically, stretched by weights connected to its lower end. If we neglect the mass of the spring, a free body diagram for the hanging mass gives:

$$F_{net} = mg - kx = 0$$

in equilibrium. The displacement, x, is measured from the equilibrium position of the spring without added mass. In the lab, we will vary the mass m and measure the corresponding displacement x for each mass. Since

$$mg = kx$$

a graph of mg versus x will have a slope of k, the spring constant.

Simple harmonic motions can be described by four quantities: angular frequency, amplitude of position, velocity and acceleration in the following equations.

$$\varpi = \sqrt{\frac{k}{m}}$$

$x(t) = A\cos(\varpi t)$, where A is maximum displacement

$v(t) = -v_0 \sin(\varpi t)$, where v_0 is maximum velocity = ωA

$a(t) = a_0 \cos(\varpi t)$, where a_0 is maximum acceleration = $\omega^2 A$

A simple harmonic oscillator consisting of a massless spring with constant k, and a mass m will have a period of oscillation

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

Solving for m gives

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

So a graph of m versus T^2 will be a straight line through the origin with a slope of $\frac{k}{4\pi^2}$.

We will test this equation by varying the mass and measuring the period of oscillation.

Procedures:

Part 1: Hooke's Law

1. Hang the spring onto the force sensor hook and measure how much it hangs from the hook to the bottom of the spring. Begin adding masses to the spring and measure the displacement, x, to fill in data table 1.

Table 1: Hooke's Law

Mass ( )	Weight ( )	Displacement x ( )

Part 2: SHM oscillation

1. Align the force probe and motion sensor, there should be about a 0.6- 0.75 m distance between the two.

2. Open the experimental file SHM.cmbl in the Simple Harmonic Motion folder of Physics Labs fold to graph the position, velocity and acceleration (all vs. time) simultaneously.

3. Place a total mass of about 150 g onto the spring and pull downward about 0.1 – 0.15 meters (3-5 inches) and let go, the spring and mass will begin to oscillate.
Record the exact mass in table 2.

4. Record the data for position, velocity and acceleration while the mass/spring combo is oscillating. Record in Table 2 the number of full cycles on one of the graph and the times for that number of cycles.

Table 2: Oscillation Period

Trial	Mass ( )	# of cycles	time for # of cycles ( )	Period ( )
1				
2				
3				
4				
5				
6				

5. Repeat steps 3 and 4 using different hanging mass to get different periods for the oscillation to complete table 2.

Data Analysis:

1. Plot the weight versus the displacement x of the stretch in the spring from the data in Table 1. Draw a best fit line and calculate the slope of this graph. Attach the graph to the end of this report. The slope of this line should be the spring constant k, show your calculation in the empty space below.

2. For table 2, determine the period by dividing the time for the cycles divided by the number of cycles and record the value in Table 2. Show a sample calculation below.

3. To check the relationship between the position and acceleration graphs, for the last trial (trial #6), from your position graph, record the period, calculate the angular frequency, $\omega = 2\pi/T$, and maximum acceleration, $a_0 = \omega^2 A$ (using the measure amplitude of the position). Show calculations below. Record these values from your acceleration graph. Compare the values of the maximum acceleration obtained from these two graphs and explain any discrepancy.

From position graph:

T = ___________, ω =___________, A =____________, expected a_0 = _____________

From acceleration graph:

T = ________________, ω =_________________ measured a_0 = __________________

Show the calculate for the % difference of a_0

% difference of a_0 = ____

4. Graph m versus T^2 from the data in Table 2. Draw the best fit line and pick two points that are not data points on the lines to calculate the slope. From the slope determine the spring constant. Show your calculations below. Attach the graph to the end of the report.

Question and Conclusion:

1. Does your measurement of the spring constant in part 2 match the value from part 1? What is the percent difference? What are some sources of errors in the measurement of the spring constant in each part of the experiment? Estimate the magnitude of the errors. Which value of spring constant, k, from part 1 or part 2 do you think is closer to the true value and why?