Introduction to Simple Harmonic Motion

Hooke’s Law

For a mass on a spring system, by Hooke’s Law we know that there will be a restoring force acting on the mass when it is displaced from its equilibrium position. This restoring force is written as $F_x = -kx$, since the force is proportional to the displacement $x$, and opposite in direction. In Hooke’s Law, $k$ is the spring constant.

For an oscillating mass $m$ on a spring system, angular frequency $\omega$ is related to the mass and spring constant with the relationship

$$\omega = \sqrt{\frac{k}{m}}. \tag{1}$$

Simple Harmonic Motion

In this experiment you will be investigating some of the basic properties of periodic motion. In general, any motion that repeats itself at regular intervals is called oscillatory, periodic, or harmonic motion. Examples of periodic motion can be found almost anywhere; boats bobbing on the ocean, the pendula of grandfather clocks, and vibrating violin strings.

Simple Harmonic Motion (SHM) satisfies the following properties:

1. Motion is about an equilibrium position.
2. Motion is periodic.

The main purpose of this laboratory is to become familiar with some of the parameters of oscillatory motion, and to investigate the dynamic relationships that define SHM. You will also investigate Hooke’s Law.

For a system undergoing SHM, the displacement with respect to the equilibrium position, $x$ (as a function of time, $t$), can be described by

$$x(t) = A\cos(\omega t) \tag{2}$$

where $A$ is the maximum displacement or amplitude of the motion and $\omega$ is the angular frequency of the motion. The period is the time taken for one complete oscillation, and can be expressed mathematically as

$$T = \frac{1}{f} \tag{3}$$

where $f$ is the frequency of the motion.
The frequency is defined to be the number of oscillations that the system completes in one second. The symbol for frequency is \( f \) and its SI unit of measure is hertz (Hz), \( 1 \text{ Hz} = 1/\text{s} \) (1 oscillation per second).

The angular frequency \( \omega \) is defined in terms of the frequency \( f \):

\[
\omega = 2\pi f . \tag{4}
\]

We may combine the above equations to find the equation for period to be

\[
T = 2\pi \sqrt{\frac{m}{k}} . \tag{5}
\]

A sketch of \( x \) vs \( t \) looks like
Prelab Questions

These questions need to be completed before entering the lab. Please show all workings.

<table>
<thead>
<tr>
<th>Marker’s Initials</th>
<th>complete</th>
<th>incomplete</th>
</tr>
</thead>
</table>

Prelab 1

\[ T = 2\pi \sqrt{\frac{m}{k}} \]

Square both sides of the equation above. If we plot \( T^2 \) vs. \( m \), what is the expression for the slope of this graph?

Prelab 2

An unstretched vertical spring has length of \( L_1 = 7.35 \pm 0.05 \text{ cm} \). A \( 500.0 \pm 0.1 \text{ g} \) mass is hung on the spring which then stretches it to a length \( L_2 = 12.50 \pm 0.05 \text{ cm} \). Calculate the spring constant \( k \) and its uncertainty. Show your workings.
Name and Student Number: ____________________________________________

Date: _____________________________________________________________

Partner: __________________________________________________________

Table 1:

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Uncertainty</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_1$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$L_2$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

QUESTION 1:
Table 2:

<table>
<thead>
<tr>
<th>Mass (g)</th>
<th>Time for 10 oscillations (s)</th>
<th>Average Time (s)</th>
<th>Period, T (s)</th>
<th>$T^2$ (s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>Trial 2</td>
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<td></td>
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</tr>
<tr>
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QUESTION 2:

QUESTION 3:
Table 3:

Be sure to include a copy of your Period Squared vs Mass graph with your lab report.

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Uncertainty</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
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<td></td>
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<tr>
<td>Intercept</td>
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</tr>
</tbody>
</table>

QUESTION 4:

QUESTION 5:

CHECKPOINT:

To be signed after you have produced your three graphs.

Staple graph to the opposing page
QUESTION 6:

QUESTION 7:

A) 
B) 
C) 
D) 
E) 

QUESTION 8: