Project #1: Does the period depend on the amplitude of the oscillation?

1. Set up MacMotion and the motion detector to measure the vertical position of the mass on the spring. Set the data rate to 50 points per sec. For this project, use a 150g mass.

Make a prediction: Two identical springs each have identical masses hanging from them. If one mass is displaced 1cm and let go, and the other mass is displaced 10cm and let go, which will have the longer period (time to go down and back up once)?

2. Record 10 oscillations (cycles) for 3 different initial amplitudes (see table below). Use the MacMotion data to find the average period and frequency of each:

<table>
<thead>
<tr>
<th>initial amplitude</th>
<th>elapsed time for 10 cycles</th>
<th>average period</th>
<th>average frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q: Do you think the period of the spring-mass oscillator depends on the initial amplitude? (You should base your decision on a comparison of the fractional change of the period to the fractional change in the amplitude.)

Q: Why average over 10 cycles instead of using just use 1 cycle?
Project #2: Does the period of a spring-mass oscillator depend on the mass?

Make a prediction: If the mass of the oscillator is doubled (say, $100g \rightarrow 200g$), will the period be twice as long, or something else? Explain your reasoning.

1. Record 10 oscillations for different masses (see table). Use the MacMotion data to find the average period and frequency.

<table>
<thead>
<tr>
<th>mass (g)</th>
<th>elapsed time for 10 cycles</th>
<th>average period</th>
<th>average frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q: Describe qualitatively how the period depends on the mass.

Q: Quantitatively, does the period’s dependence on mass agree with the theoretical prediction? Recall that the equation relating the period to the mass and spring constant is:

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

(You should compare the theoretical ratio of periods for different masses to the experimental ratio using your data.)

Project #3: Does the period of a spring-mass oscillator depend on the spring constant?

Make a prediction: If you now use 2 springs side-by-side, will the period (say, for the $200g$ mass) increase or decrease? Please explain your reasoning.
1. Do the experiment for a 200g mass and find the average period and frequency. How does this period compare to the period for the single spring system (from before)?

\[ T_{2\text{ spr}} = \quad \quad \quad T_{1\text{ spr}} = \quad \quad \quad \]

Q: How does the effective spring constant \( k_{2\text{ spr}} \) for the 2 spring oscillator compare to the spring constant \( k \) for the single spring oscillator?  
Hint: Calculate the ratio \( k_{2\text{ spr}} / k_{1\text{ spr}} \) using the equation relating period, spring constant, and mass. Then plug in the values for period and mass.

Homework:

H1. Draw a position vs. time graph for a spring-mass oscillator showing 2 complete cycles. Show and label the amplitude and period.

H2. For a spring-mass oscillator, if the mass increases by a factor of 4, what happens to the period? Explain.

H3. What are the units of \( T \) (period), \( f \) (frequency), and \( k \) (spring constant)?
H4. A simple harmonic oscillator (SHO) oscillates according to the equation 
\[ x = A \cos(2\pi ft) \], where \( A = 2 \) meters and \( f = 1 \) Hz. What will be the position of the mass for the following times? (Hint: \( 2\pi ft \) is in radians, not degrees!!) Show how you calculate your values.

\[
\begin{align*}
t &= 0.00 \text{ sec} \\
t &= 0.25 \text{ sec} \\
t &= 0.50 \text{ sec} \\
t &= 0.75 \text{ sec} \\
t &= 1.00 \text{ sec}
\end{align*}
\]

H5. Make a position vs. time graph of the previous question’s data:

H6. Label the points on the above graph that have minimum and maximum magnitudes of velocity and acceleration.