Simple Harmonic

Introduction

The objective of this lab was to evaluate Hooke's law and the theory of simple harmonic motion through a virtual simulation to spring motion with a mass.

Theory

The formula of frequency is 1/T, where $T = 2\pi\sqrt{m/k}$. Amplitude is in neither of these equations, therefore it can be concluded that amplitude has no effect on period and frequency.

Spring constant can be calculated using Hooke's law or the formula for frequency.

Hooke's law:

F=-kx

ma=-kx

k=-x/ma

Frequency formula:

$T = 2\pi\sqrt{m/k}.$

$f = 1/2\pi\sqrt{m/k}$

$f^2 = 1/4\pi^2(\frac{m}{k})$

$1/f^2 4\pi^2 = m/k$

$K = m/f^2 4\pi^2$

Theoretically, these formulas should result in the same k value.

Procedure

All experiments were carried out in the springs lab section of the PHET Colorado website.

Experiment 1:

1. Equip the ruler and place the orange, numbered weight onto the spring. Allow it to rest at equilibrium and ensure there is no damping.
2. Use the slider in the upper left corner to change the weight of the mass to any desired weight. Do not change the weight, damping, or spring constant for this experiment.
3. Calculate the period of the mass for several different amplitude values by using the ruler and red line to mark a reference point, then using the timer to track the time required for the mass to oscillate successfully a certain number of times.
4. Repeat the previous step to obtain four sets of data total.

Experiment 2:

1. Equip the ruler and place the orange, numbered weight onto the spring. Allow it to rest at equilibrium and ensure there is no damping.
2. Use the adjustable red line to denote a constant amplitude. Use the slider in the upper left corner to change the weight of the mass to any desired weight. Do not change the amplitude, damping, or spring constant for this experiment.
3. Calculate the period of the mass for several different weights, by using the timer to track the time required for each mass to oscillate successfully a certain number of times.
4. Repeat the previous step to obtain four data sets total.

Experiment 3:

1. Using the ruler, note the position of the bottom of the spring when no mass is hung from it.
2. Equip the orange mass to the spring. Calculate the distance from the top of the mass hung to the tip of the spring when no mass is hung from it. Ensure the only part measured is the spring itself, not the mass.
3. Repeat the previous step to obtain four masses total.

Results

Experiment 1:

200g is the value of the constant mass for this experiment

Amplitude (cm)	Time (s)	# of oscillations	Period (s)	Fz (hz)
10	11.43	10	1.143	0.874891
20	11.49	10	1.149	0.870322
30	11.46	10	1.146	0.8726
40	11.47	10	1.147	0.87184

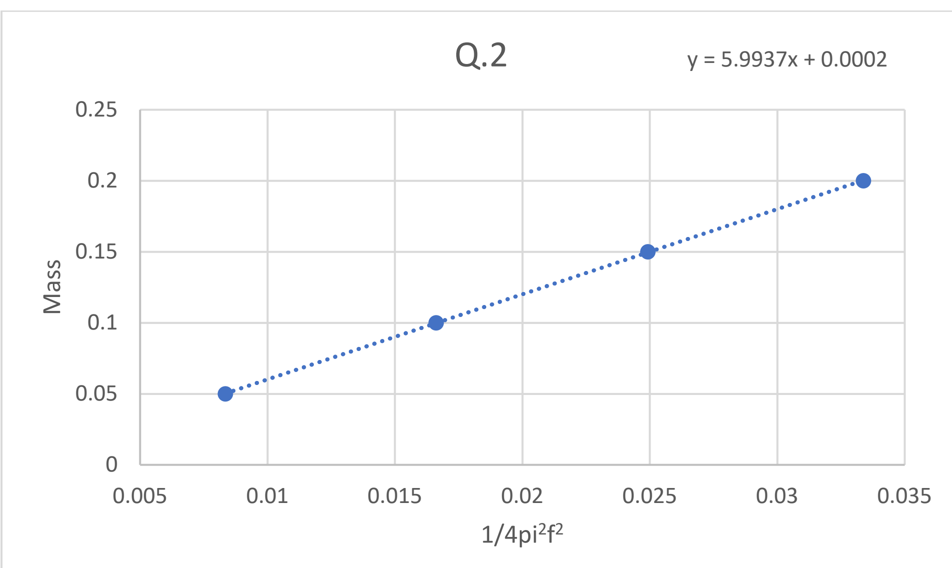
According to the data, the amplitude has no effect on the period of a simple harmonic oscillation. The period of each amplitude can be rounded to 1.14s, and frequencies can be rounded to 0.87hz. Although a slight difference in the value of each period exists, it can be written off as human error, since timing of each mass was done by human eye and estimation. The data is congruent with the estimations of the pre-lab. The formula for Period in simple harmonic motion is $T = 2\pi\sqrt{m/k}$. Since amplitude is not in the formula, a change in amplitude should not result in a change in period.

Experiment 2:

0.2m is the value of the constant amplitude for this experiment.

Mass (kg)	Amplitude (m)	t (s)	t uncert (s)	# of oscillations	T (s)	Fz (hz)	$1/4pi^2f^2$
0.05	0.2	5.74	0.01	10	0.574	1.742160279	0.008345725
0.1	0.2	8.1	0.01	10	0.81	1.234567901	0.016619207
0.15	0.2	9.92	0.01	10	0.992	1.008064516	0.024926632
0.2	0.2	11.48	0.01	10	1.148	0.871080139	0.033382898

Without evaluating the data, it was evident that as the mass of the weight increased, the time it required to oscillate a certain number successfully increased as well.



The equation for period of a simple harmonic motion can be re-written as $m = k/4(\pi^2 * f\text{^}2)$, to reorganize mass as the dependent variable, and isolates k. Alternatively, the graph can be drawn with frequency on the y-axis and 1/ √ m on the x-axis. When the data is plotted with

$1/4(\pi^2 * f^2)$, the value of k can be represented by the slope of the linear graph. According to the graph, the spring constant is 5.9937, or 6.0 kg/s^2.

Example calculation:

$f = 1/T$

$= 1/ 0.81$

$= 1.234$ Hz

$1/4\ \pi^2 f^2 = 1/4(\pi^2 1.234^2)$

$= 0.0166$

Experiment 3:

Mass (kg)	Distance from ref (m)	Force (N)	uncert (m)	k (N/m)
0.05	0.1	-0.49	0.005	4.9
0.1	0.18	-0.98	0.005	5.44
0.15	0.26	-1.47	0.005	5.65
0.2	0.34	-1.96	0.005	5.76

$k_{avg} = 5.4375$ N/m

Example calculation:

$F = ma$

$F = -kx$

$-k = F/x$

$k = 0.98/0.18$

$k = 5.44$

The spring constant from experiment 1 is 6.0 kg/m^2, while the spring constant form experiment 2 is 5.4 N/m. The two values are within 0.6 of each other. If the experiment was conducted with a large number of samples, or higher levels of accuracy was implemented into the experiments, the two numbers could have been the same.

Discussion and Conclusion

According to the experiments, the following could be concluded:

- Amplitude has no effect on frequency and period in a simple harmonic system
- Heavier masses have longer periods

- The same spring constant can be calculated through two different methods:
  1. Through graphing, by plotting $1/4(\pi^2 * f\hat{}2)$ on the x-axis and m on the y-axis, or 1/ √ m on the x-axis and frequency on the y-axis.
  2. Through Hooke's law, F=-kx.