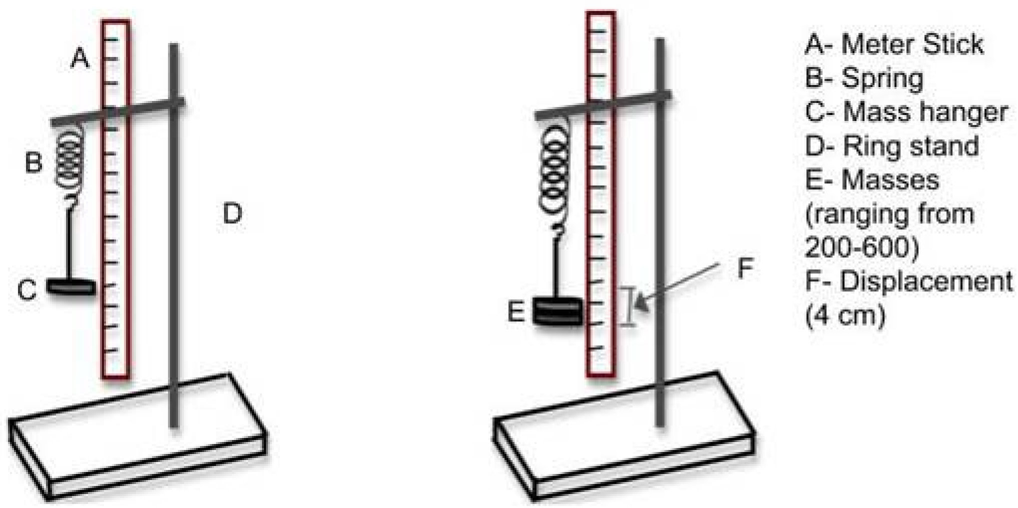
Isaiah Wood
Group Member 1, Group Member 2

Simple Harmonic Motion in a Spring

Purpose

The purpose of this experiment was to measure the spring constant, period and amplitude of a spring. The secondary purpose was to graph the movement of the spring in terms of the three base kinematics functions.

Procedure



Before beginning the lab, we assigned tasks to each of the members of the group. One person would hold the stand to prevent it from tipping. One person would use the stop watch to time five full cycles of oscillation from the spring. One person would measure the displacement and amplitude of the weight on the spring. One person would release the spring to allow it to begin oscillating. We then set up the experiment by tying a string to a stand and tying a spring to the string. We grabbed three masses of weights varying between 200g and 600g, a stopwatch and a ruler.

First we measured to distance from the stand to the bottom of the spring with a ruler, this is called M_E. Then we attached the smallest weight to the bottom of the spring, as pictured above, and let it reach an equilibrium point, then measured the distance from the top again and named this $M_{1E.}$ After pulling the mass down 3.0cm, again measured by a ruler, we released it and timed five full cycles using our stopwatch and labelled this as T_1.

This process was repeated for each of the two other masses, changing our labelling so that the subscript number represented the trial.

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Data

Period Measurements for a Spring with Varying Mass

Mass (g)	150g	200g	300g
Trial 1 – Time for 5 Cycles	2.03s	2.25s	2.56s
Trial 2 – Time for 5 Cycles	2.15s	2.21s	2.55s
Trial 3 – Time for 5 Cycles	2.11s	2.28s	2.62s

Data Analysis

This section will be broken into sections based on the values being calculated.

Period:

To calculate the period, we took the time for five complete cycles to occur, and averaged over the three trials. Then we divided by the number of cycles to calculate the time for one cycle, or the period of the spring system.

For mass = 150g: Average time for 5 cycles = $\frac{2.03+2.15+2.11}{3} = 2.096s$ so the average time for the period with mass = 150g was $T_{150g} = \frac{2.096}{5} = 0.419$ seconds.

REPEAT x2

Frequency:

The frequency is the reciprocal of the period, so $f_{150g} = \frac{1}{T_{150g}} = \frac{1}{0.419} = 2.384Hz$.

REPEAT X2

Spring Constant:

The spring constant can be calculated using Hooke's Law. To do this we needed to measure two distances. The distance from the stand to the bottom of the spring, without a mass, was measured as 10.2cm while the distance from the stand to the bottom of the spring, with 150g mass, was measured as 13.4cm. So the displacement from weight $x = 13.4 - 10.2 = 3.2cm$ or $0.032m$. Using Hooke's Law:

$$F = -kx$$

$$k = \frac{-F}{x}$$

$$k = \frac{-mg}{x}$$

$$k = \frac{-(-9.806)(.150)}{.032}$$

$$k = 46\ N/m$$

REPEAT X2 for certainty

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Kinematics

The second purpose of this lab was to graph the kinematics of the spring system. We based all of these calculations of the first mass, 150g. The equations required for this are the following:

$$x(t) = Acos(2\pi f t)$$

$$v(t) = -v_{max} \sin(2\pi f t)$$

$$a(t) = \frac{-kA}{m} \cos(2\pi f t)$$

To complete these equations, a few things are required to be known:

f: We calculated frequency to be 2.384Hz

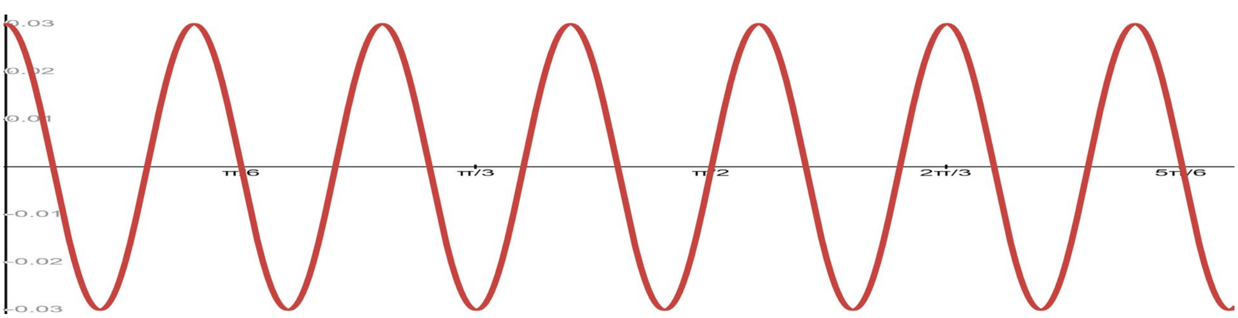
A: The Amplitude was measured to be 3.0cm, or 0.030m

v_{max}: The Maximum Velocity can be calculated by using the following equation

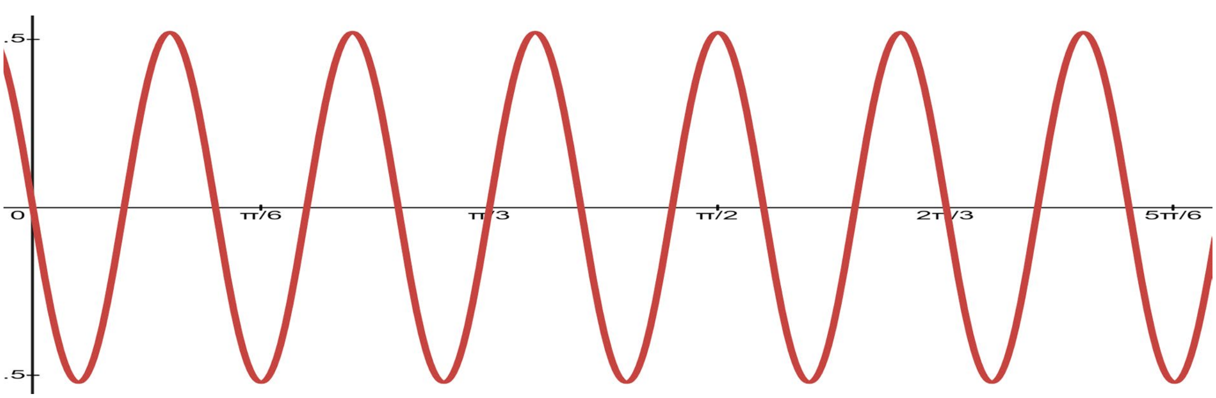
$$v_{max} = A\sqrt{\frac{k}{m}} = 0.03\sqrt{\frac{46}{.150}} = 0.52\ m/s^2$$

These were then plugged into the equations and graphed on Desmos.

Displacement as a Function of Time



Velocity as a Function of Time



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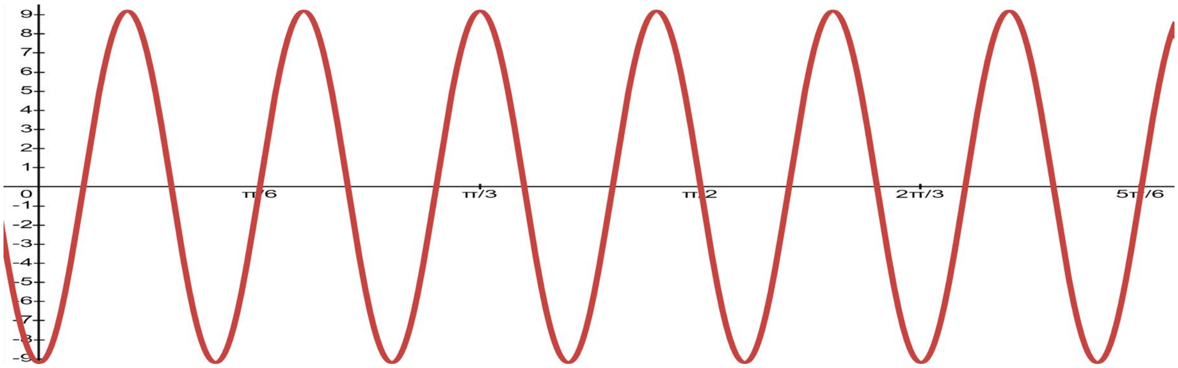
Acceleration as a Function of Time



Conclusion

We identified that the spring constant can be calculated by measuring a spring before and after adding a mass and that its motion follows a sinusoidal wave pattern. In measuring, our material was not very sturdy or well maintained so many of the measurements are imperfect. In particular, with the largest mass, many of our calculations were estimated because the spring didn't bounce smoothly.

We calculated the spring constant of our particular spring to be 46 N/m. In terms of the sinusoidal wave pattern, we determined the displacement with the mass of 150g to be equal to

$$x(t) = 0.03cos(2\pi(2.384)t)$$

While the velocity and acceleration are waves of similar form. The period and frequency were easily calculated using a stop watch and varied according to the mass. Since the equation for the period of a spring is $T = 2\pi\sqrt{\frac{m}{k}}$ we are able to identify that our experiment only had one variable in terms of period and frequency, which was the mass of the weight. So, the fact that we stretched it the same amount each time didn't necessarily matter.