Course and Section_______ Names ____________________________

Date__________ ________________________________

SIMPLE HARMONIC MOTION SIMULATION

Introduction

In this experiment you will measure the spring constant using two different methods and compare your results.

Hooke's law for a spring states that

$$F = -k\,x \tag{1}$$

where x is the displacement of the spring from equilibrium, F is the force exerted by the spring, and k is the spring constant. The negative sign means that the restoring force is opposite in direction to the displacement.

If a spring obeys Hooke's law, then a mass attached to it moves in a simple harmonic motion when displaced from equilibrium and released. That is,

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

where A is the amplitude of oscillation (maximum displacement from equilibrium), ω is the angular frequency (rad/s) related to the frequency (Hz) and the period (T) by $\omega = 2\pi f = 2\pi/T$. The quantity φ is the phase which depends on when the timing starts. By substituting Eq. (2) into Eq. (1) and using Newton's 2nd law of motion, it can be shown that

$$\omega = \sqrt{\frac{k}{m}}, \quad \text{and} \quad T = 2\pi\sqrt{\frac{m}{k}}\,. \tag{3}$$

Thus, k can be measured statically using Eq. (1) or dynamically using Eq. (3).

Input your answers in Blackboard.

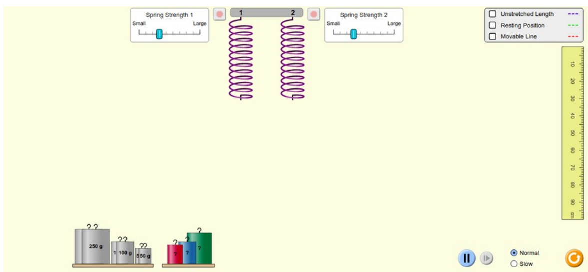
1 – Preliminary Questions

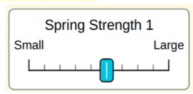
1. Which has a shorter period of oscillation T, a mass of 0.6 kg or a mass of 0.7 kg (same spring)?
2. What is the period of oscillation, T, of a mass of 0.5 kg attached to a spring with spring constant 0.25 N/m?

3. From Eq. 2, x varies from $-A$ to $+A$. At which location(s) does the mass have its slowest speed?
4. At which location(s) does the mass have its greatest potential energy?
5. At which location(s) does the mass have its greatest kinetic energy?
6. At which location(s) does the mass have its greatest total energy?

2 – Static measurement of *k*

Open the simulation (https://phet.colorado.edu/en/simulation/masses-and-springs-basics). Run the simulation and select *Stretch*.



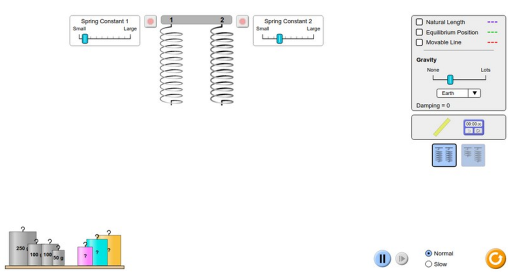
Set the value for the Spring Strength 1 to the fifth line: 

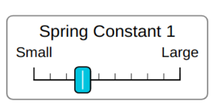
Hang the block of mass 50 g to the spring on the left and measure the vertical displacements Δy by using the ruler located on the right of the screen (you can drag it). Repeat for the block of m = 100 g and m = 250 g. Calculate F $(= mg)$ for each mass and make a plot of F vs Δy. Use g = 9.81 m/s^2.
7. Determine k from the slope of the line (see Eq 1).

Using the value of k find the unknown mass of the red, blue and green block,
8. What is the sum of the masses of the red and blue block?
9. What is the sum of the masses of the red and green block?
10. What is the sum of the masses of the green and blue block?

3 – Dynamic measurement of *k*

Open the simulation (https://phet.colorado.edu/en/simulation/masses-and-springst). Run the simulation and select *Intro.*



Set the Spring Constant to the third line: 

Hang the block of mass 100 g to the spring on the left and measure the period of oscillation T using the stop watch located on the right of the screen (drag the stop watch outside its box). It might be easier if Slow speed is selected. Repeat ten times your measurements of the period and record your data.

11. What is average value of *T*?
12. What is the standard deviation of *T?*
13. Use your average value of *T* and Eq. (3) to find the spring constant *k* (N/m)

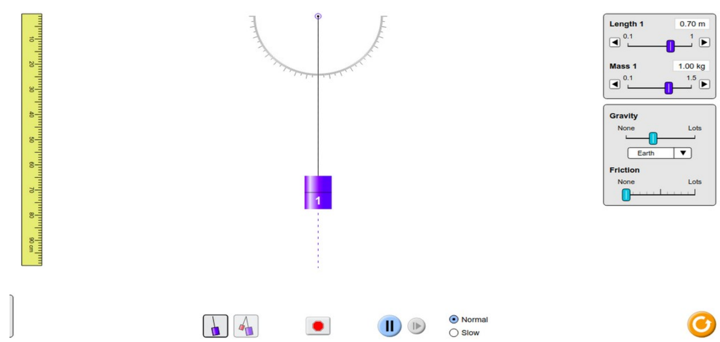
4 – Spring on the Jupiter

Use the same simulation entitled Masses and Springs. You can restart the simulation by clicking the yellow icon located at the bottom right. Use the same spring constant set at the third line. Hang the block of mass 100 g to one of the spring and compare the oscillation on Earth with the oscillations as the spring was placed on Jupiter (select Jupiter in the tab under Gravity).

14. How is the mass different on Jupiter?
15. How is the force *F* acting on the mass different on Jupiter?
16. How is the displacement Δ*y* different on Jupiter?
17. How is the period of oscillation T different on Jupiter?

5 – Pendulum

Open the simulation (https://phet.colorado.edu/en/simulation/pendulum-lab).
Run the simulation and select Intro.



Move (drag) the pendulum about 14 degrees away from its equilibrium position and observe the motion. Do not include friction.

18. How does the period *T* change as you decrease the mass ?
19. How does the period *T* change as you decrease the length ?
20. How does the period *T* change as you increase gravity ?
21. How does the period *T* change if you start over and move the pendulum at about 5 degrees away from its equilibrium position? (you might want to use the Stopwatch and the Slow motion).