S2a Hooke's Law and Simple Harmonic Motion

This experiment examines two related ideas.

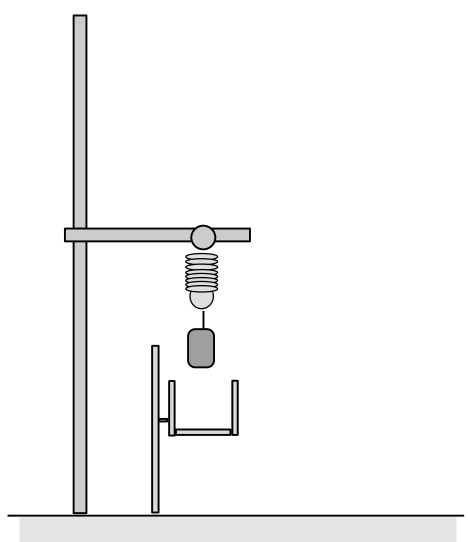
- Hooke's law relates the force that a spring exerts on a body to the stretch of the spring. Several trials are conducted where the stretching spring is measured when different amounts of force are applied. The data is graphically analyzed to establish the relationship and confirm Hooke's law.
- Simple Harmonic Motion (SHM) describes the motion of a body that regularly repeats its motion. This motion is over the same path which passes through an equilibrium position. It is considered simple because of a simple force law that describes the dynamics of the motion (such as Hooke's law). Two examples of SHM are examined, the spring and the pendulum.
    1. The period and frequency of oscillation for a spring mass system is measured using several different masses hung from a spring.
    2. The period of oscillation for a pendulum is measured using several different pendulum lengths and masses. Also, the energy of the pendulum is calculated in its potential form and then used to calculate the maximum velocity of the pendulum.

Apparatus spring, hooked masses (50,100,200 gram), string, meter stick, computer timing system, support rods

Procedures

The first steps are performed to obtain the spring constant for the given spring. Begin with the horizontal cross bar placed approximately 60 centimeters above the table top. Place the spring on the cross bar with the pointer on the bottom.

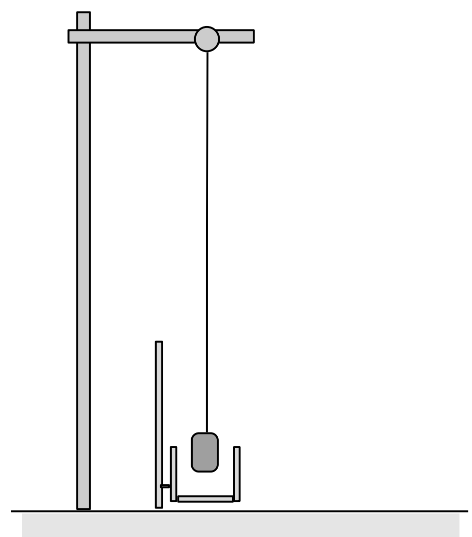
- Starting with the 100 gram mass on the spring record the position of the pointer using the meter stick. (Position the meter stick with the zero up and the 100 cm. mark on the table, then read the position of the pointer on the meter stick.)
- Repeat this procedure for mass combinations of 150 grams, 200 grams, 250 grams and 300 grams. (Be careful not to bend the pointer into a different shape while doing this part.)



- Calculate the weight in Newtons for each of the masses used.
- Construct a graph with the weight on the y-axis and the corresponding position on the x-axis.
- Draw a straight line through the data points on the graph and calculate the slope of this line.

This next series of steps are conducted to obtain the period and frequency of oscillation for the spring mass system. The computer timing system is used to obtain the period. Follow the separately provided computer instructions for logging on, activating the program.

- Beginning with the 100 gram mass on the spring, position the computer's timing gate so the pointer (attached to the spring) is between the two ends of the gate. The horizontal support rod for the spring may have to be adjusted up or down to obtain the correct arrangement. Also the gate support rod permits moving the gate up, down and rotationally. The pointer on the spring must be able to move up & down through the gate as the mass oscillates up & down from the spring.
- Pull the mass straight down approximately 2 to 3 centimeters and then release the mass. Make sure you are pulling it straight down and not to either side. The spring should be bouncing *only* up and down. If you notice any sideway motion, repeat. Once you have stable oscillations, start the computer collection of data. Allow 50 to 100 data samples to be collected before stopping.
- Follow the instructions on the provided computer sheet, for directions on how to analyze the data to obtain the period of oscillation.
- Repeat this procedure for mass combinations of 150 grams, 200 grams, 250 grams and 300 grams.
- Calculate the corresponding frequency of oscillation for each of the periods.



The oscillating behavior of a pendulum is similar to the spring mass system just observed. Begin by obtain the period of oscillation of the pendulum for several different pendulum lengths. Attach a string to the horizontal cross bar that previously held the spring. Use a string that is a little more than 100 centimeters long. Attach the 200 gram mass to the other end of the string. The string can be wound around the cross bar in order to change the length of the pendulum. Position the U-shaped timing gate pointing upward and slide it to the bottom of its support rod. Slide the gate under the hanging mass so that when it swings back and forth it will pass through the gate.

- Begin with a pendulum length of 40 centimeters measuring from the string attached at the cross bar to the center of the 200 gram mass.
- Pull the mass back about 10 centimeters from its rest position and then release the mass allowing it to swing back & forth through the timing gate. Once a stable swinging oscillation is achived start the computer data collection. After about 25 periods have been timed stop the timing cycles.
- Follow the instructions on the provided computer sheet, for directions on how to analyze the data to obtain the period of oscillation.
- Repeat this procedure for pendulum lengths of 50, 60, 70 & 80 centimeters.

The motion of the pendulum can also be examined from an energy point of view. The energy is conserved but continuously changing between gravitational potential energy and kinetic energy. The last trial of the pendulum was with an 80 centimeter pendulum. Assuming a 10 centimeter displacement from hanging rest when the pendulum was released, this corresponds to an approximate 1.25 centimeter rise in height for the center of mass. Using this rise of 1.25 centimeters calculate the potential energy of the pendulum before it was released. When the pendulum swings through the equilibrium position (its lowest point of travel) all the potential energy is transformed into kinetic energy. At this point the pendulum has it greatest velocity. Set the kinetic energy at this point equal to the potential energy before release and calculate the velocity. This would be the maximum velocity of the pendulum.

Experiment S2a Hooke's Law and Simple Harmonic Motion

Student Name______________________________________

*Lab Partner Name*______________________________________

*Lab Partner Name*______________________________________

Physics Course______________________________________

Physics Professor______________________________________

Experiment Start Date______________________________________

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Hooke's Law and Simple Harmonic Motion Data Sheet

Trial #	Position	mass	Force

Force = mass x gravity
gravity = 9.792 meters/second^2

Spring Constant = Slope

Spring Constant = ___________

Trial #	mass	Period	Frequency

Frequency = $\frac{1}{\text{Period}}$

Trial #	Length	Period

mass = ____________________________

rise in height = _____________________

Potential Energy = mass x gravity x height

Kinetic Energy = $^1/_2$ mass x velocity^2

Potential Energy = __________________

Given that Potential Energy at release = Kinetic Energy at equilibrium position then solve for the maximum velocity.

$$mgh = \frac{1}{2}mv^2$$
$$v = \sqrt{2gh}$$

velocity$_{(max)}$ = _______________________