Simple Harmonic Motion–Mass on a Spring

Mechanics: simple harmonic motion, spring constant	GLX setup file **shm spring**

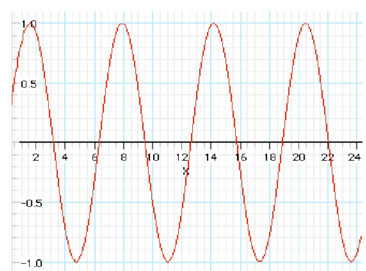
Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Force Sensor	PS-2104
1	Large Base and Support Rod	ME-9355
1	Rod, 45 cm	ME-8736
1	Double Rod Clamp	ME-9873
1	Equal Length Spring Set (red spring)	ME-8970
1	Balance	SE-8723
1	Hooked Mass Set	SE-8759

Purpose

The purpose of this activity is to measure the period of oscillation of a mass on the end of spring and compare the measured value to a theoretical value that is based on the mass and the spring constant of the spring.

Background

Imagine a mass that is in equilibrium at the end of a spring that is hanging vertically from a support. If the mass is pulled down a small distance and released, the spring exerts a restoring force, $F = -kx$, where ***x*** is the distance the spring is displaced from equilibrium and ***k*** is the spring constant of the spring ($k = \frac{F}{x}$). The negative sign indicates that the force is directed opposite to the direction of the displacement of the mass.



Simple harmonic motion

The speed of the mass increases as it moves toward its equilibrium point. It continues to move above the equilibrium point and stops at a height where its potential energy closely matches the kinetic energy it had as it passed the equilibrium point. From this point it moves downward again, gaining speed as it falls. When it moves below the equilibrium point, it begins to stretch the spring again, and the pattern of motion is repeated.

For a mass on an ideal, massless spring, the motion is simple harmonic motion. The period of oscillation for an object in simple harmonic motion depends on the mass, m, and the spring constant, k.

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

As the mass oscillates up and down, the energy changes between kinetic and potential form. If friction and drag are ignored, the total energy of the system is constant.

Preview

Use a Force Sensor to measure the force exerted on a spring as it is stretched. Use the Xplorer GLX to record and display the force. Determine the period of motion from the graph of force versus time. Compare the period to a theoretical value.

Safety Precaution

- Follow all directions for using the equipment.

Procedure

GLX Setup

1. Turn on the GLX (⏻) and open the GLX setup file labeled **shm spring** (check the Appendix at the end of this activity.)

- The file has a graph of Force (N) versus Time (s). The file is set up so force is measured 40 times per second (40 Hz) and a positive signal from the sensor means a pull is applied.

2. Connect the Force Sensor to one of the sensor ports on the top end of the GLX.

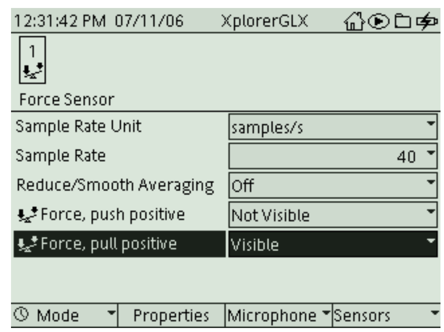


Fig. 1: File setup

Equipment Setup

1. Attach the hook that's included with the Force Sensor to the end of the sensor.
2. Use a rod and support stand, a clamp, and a second rod to mount the Force Sensor vertically so its hook end is down.
3. Carefully measure and record the mass of the spring and then hang the spring from the sensor's hook.
4. Measure and record the mass of a 500 g hooked mass and hang it from the spring.

Record Data

1. Make sure the mass and spring are motionless. Press the tare button on the Force Sensor to zero the sensor.
2. Pull the mass down to stretch the spring about 15 cm. Release the mass and let it oscillate a few times.
3. Press Start (▶) on the GLX to begin recording data
4. Continue recording for about 10 seconds.
5. Press Stop (▶) to end data recording.

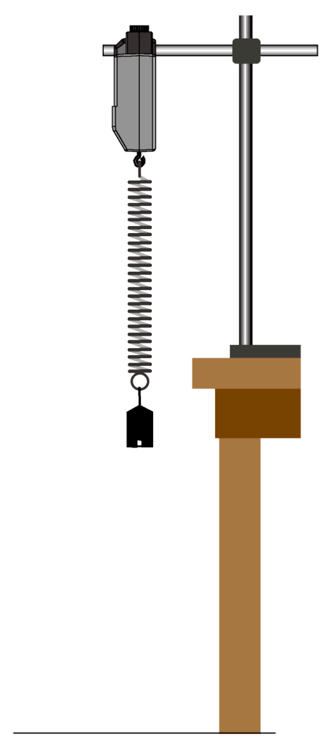


Fig. 2: Equipment setup

Analysis

Use the graph of force versus time to measure the period of oscillation of the mass on the spring.

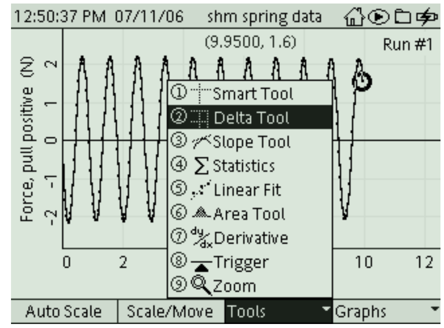


Fig. 4: Select 'Delta Tool'

1. Use the arrow keys to move the cursor to the peak in the graph. Press *F3* (F3) to open the Tools menu. Select 'Delta Tool' and press ✓ to activate your choice.
2. Use the arrow keys to move the cursor to the next peak in the graph.

- The 'Delta Tool' values for Δy and Δx are along the y-axis and x-axis respectively. Record the Δx value as 'Period 1'.

3. Use the arrow keys to move the cursor to the next peak in the graph (second peak from the first one you selected). Repeat the process to find the time from the first peak to the third peak of oscillation. Divide the time by 2 and record the value as 'Period 2'.
4. Repeat the process to find the time from the first peak to the third peak. Divide the time by 3 and record the value as 'Period 3'.
5. Do the same for the time from the first to fourth and first to fifth peak. Record the times as 'Period 4' and 'Period 5'.
6. Calculate the average period of oscillation from the five times you recorded.

- Because the spring is in motion at the same time that the mass oscillates up and down, part of the spring's mass contributes to the motion of the mass. To calculate a theoretical value for the period of oscillation, you need the 'effective mass' of the spring.

7. Calculate the 'effective mass' of the spring as one-third of the overall mass of the spring.
8. Calculate the theoretical value of the period of oscillation based on the mass and spring constant.

Compare the theoretical value for the period and the average of the measured values.

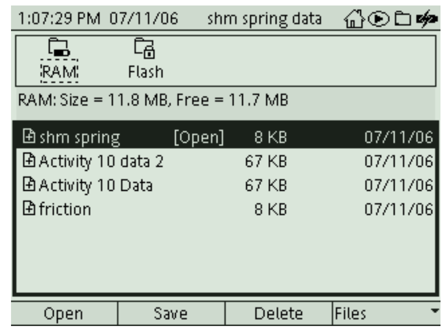
Extension

Repeat with a different spring. Repeat with different amounts of mass. Try other items that are elastic like a spring, such as a rubber band.

Appendix

Opening a GLX File

To open a specific GLX file, go to the Home Screen (press (Home)). In the Home Screen, select Data Files (Data Files) and press (✓) to activate your choice. In the Data Files screen, use the arrow keys to navigate to the file you want. Press *F1* (F1) to open the file. Press the Home button to return to the Home Screen. Press (F1) to open the Graph.

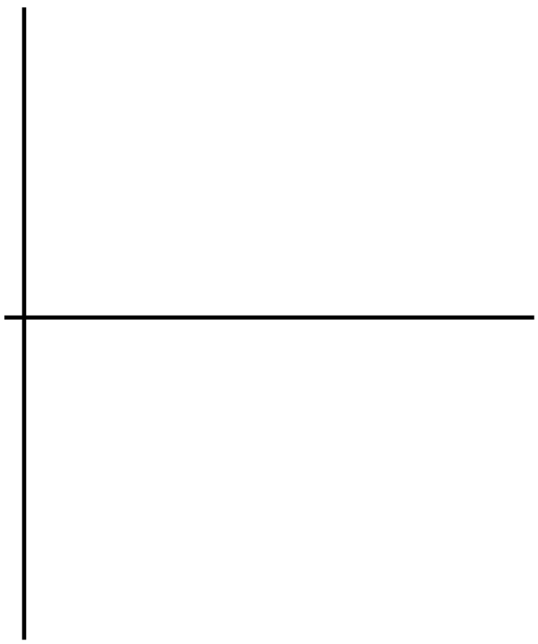


Lab Report - Activity 12: Simple Harmonic Motion–Mass on a Spring

Name ________________________________ Date ___________

Data

1. Make a sketch of your *force versus time* graph including labels for the y- and x-axes.



2. Record the value you are given for the spring constant, *k*, of your spring.

Item	**Value**
Spring constant, *k*	N/m

Data Table 1

Item	**Value (s)**
Period 1	
Period 2	
Period 3	
Period 4	
Period 5	
Average period of oscillation	

Data Table 2

Item	Value
Mass of the spring	kg
Effective mass of the spring (one-third mass of the spring)	kg
Mass of the hanging mass	kg
Mass, *m* (hooked mass plus effective mass of the spring)	kg

Calculation

1. Calculate the theoretical period, *T*, based on the mass, *m*, and the spring constant, *k*.

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

2. Calculate the percent difference between the theoretical value of the period of oscillation and the average period of oscillation.

$$\left|\frac{\text{theoretical value - measured value}}{\text{theoretical value}}\right| \text{x}100\%$$

Theoretical Period of Oscillation	s
Average Period of Oscillation	s
Percent Difference	%

Question

1. How well did your measured value for the period compare to the theoretical value?

2. Do your results support or not support the formula for the period of oscillation of a mass on the end of a spring?

