Simple Harmonic Motion

Fall 2009

Introduction

The purpose of this experiment is to measure the oscillation period of a spring–mass system in simple harmonic motion, and compare it to the period as predicted by theory.

Experiment

I. *Preliminary measurements*

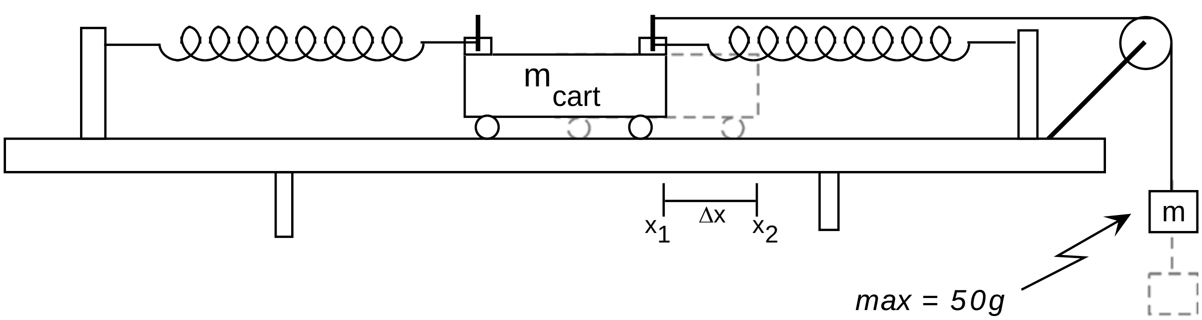
1. Remove the cart from the track, and use the balance to determine its mass. Separately, measure the mass of the black rectangular block (you'll need it later).
2. Check that the track is level; the cart should not move when no springs are attached.
3. Attach a spring to each end of the cart; they are held in place by removable screws.
4. Create a data table in your notes with the following headers:

m_{cart} = ______ kg m_{block} = ______ kg			x_1 = ______ m
Suspended mass, m (kg)	Position, x_2 (m)	Displacement $\Delta x = x_2 - x_1$ (m)	$F = mg$ (N)

II. *Measuring the spring constant, k*

You will measure the spring constant of the system by using *Hooke's Law*: $F = k\Delta x$. Hooke's Law states that there is a linear relationship between the change in spring length, Δx as the result of different forces (*weight*), F pulling on the spring. The spring constant, k is the proportionality constant between these two quantities; its value is determined by the physical characteristics of the spring: mass, thickness of wire, etc.

The change in spring length will be measured using the relative position of the cart on the track.



5. With the springs attached to the cart, record the equilibrium position of one end of the cart, x_1 (the cart should be at rest).

6. Attach the string to one end of the cart, and hang it over the pulley. Suspend 50 grams (the maximum) from the string, and measure the new position of the cart end, x_2. Calculate the change in spring length, $\Delta x = x_2 - x_1$.

   Note: To prevent over-stretching the springs, do not suspend more than 50 grams!

7. Calculate the weight of the suspended mass, and begin a graph of F vs. Δx.
8. Repeat the measurements with different masses, *being sure to plot your points as they are calculated*.
9. Use your graph to calculate k (if you use Excel for your calculation, enter Δx in the first column, then F. Be sure to include {0,0} on this graph). It's interesting to note that since both springs are acting on the cart, this analysis will give the effective spring constant for *both* springs.

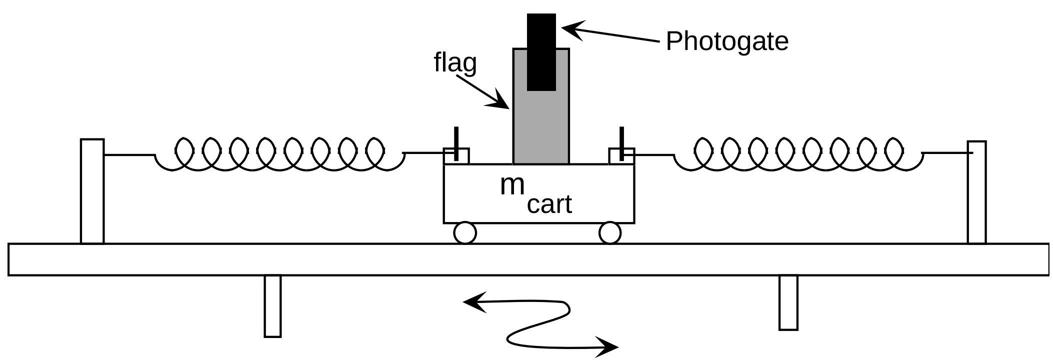
III. *Predicting the period of the Simple Harmonic Oscillator*

Newton's law applied to the oscillating system gives the period, T, in terms of the spring constant and the carts' mass, m_{cart}:

$$T = 2\pi\sqrt{\frac{m_{cart}}{k}}$$

10. Use this equation, and the value of k from your graph to make a prediction of the period. Also, calculate the period when the cart is carrying the black rectangular block.

IV. *Measuring the period of the SHO*



11. Remove the string from the cart.
12. The cart has a flag to interrupt the photogate beam. Put the photogate in "pend", 1*ms* mode, and adjust the photogate so that the beam is interrupted when the cart is at rest. Displace the cart approximately 15 *cm* and release it, recording the period. Repeat at least 10 times, then calculate $\langle T \rangle$.

    Note: Be sure to displace the cart the *same distance* for each trial

13. Repeat these measurements with the black rectangular block inside the cart.
14. Compare your measured and predicted periods.

Discussion

- Report your value for k, your predicted and measured (average) periods.
- Does the period of oscillation increase or decrease as the mass is increased? Does a more massive cart oscillate faster or slower?
- Discuss causes of error in this experiment.