

Visual Physics 218 – Harmonic Motion [Lab 6]

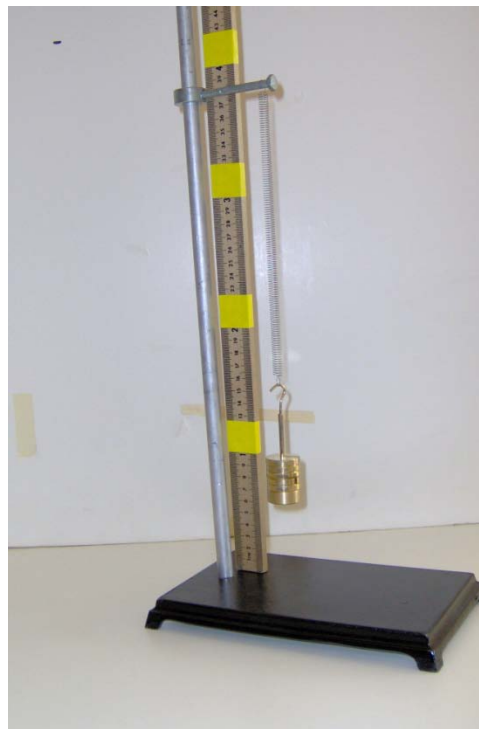
Springs (up to their elastic limit) obey Hooke's law, $F = -kx$. But $F = ma = m \frac{d^2x}{dt^2}$, so combining the two equations, you get a second order differential equation, $m \frac{d^2x}{dt^2} + kx = 0$, or

$\frac{d^2x}{dt^2} + (k/m)x = 0$. This equation is satisfied by $x = A \sin(\omega t)$, when $\omega = \sqrt{k/m}$. Harmonic motion is, by definition, any motion that satisfies an equation like this.

In this lab you will be observing harmonic motion and using it to determine the spring constants of two springs and the effective spring constants of the springs in series (end to end) and in parallel (side by side).

The springs have relatively low spring constants, so don't over-stretch them, and 100 g is the maximum mass you should attach.

Set up the spring, stand and meter stick on the lab table as shown in the picture. Aim the camera directly at the spring/mass set and as close as possible but still see the entire motion and not get parallax errors. Make sure you keep track of which video is for which spring, and how much mass you have on that spring for that video.



Attach a mass to the spring and pull it down a small distance and let it go, so that the mass starts oscillating. The distance doesn't in principle matter, but you don't want the mass to fly off at the top of the motion, and you want it to oscillate as close to straight up and down as possible.

When you insert the video into LoggerPro, you might see a little movement of the spring and mass to the side, try to pick your vertical axis so that it's in the middle of that oscillation (so that any errors you get will tend to cancel out). Instead of using Excel to graph your data, you're going to use LoggerPro to fit a sine graph to your data. To do that, go to "Analyze" then "Curve Fit", pick the appropriate axis to fit, scroll down under "General Equation", the third from the bottom should be a sine curve. If part of your data doesn't look like a sine function, you can select the part to fit on the top part of the dialog box, then click "try fit". LoggerPro will calculate

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the parameters of the function for you, record the A and B coefficients. A is the amplitude of oscillation, and B is the angular frequency.

You will do this experiment a lot of times, you'll do 3 different masses for each individual spring, and additionally, you'll do three mass for the springs in parallel and the springs in series, which comes out to be 12 videos. The only data you need for each is the amplitude, frequency, and the mass you attached. When you do the springs in parallel, use a paper clip or something to make sure the springs don't get tangled together.

In your lab report, create a table giving the amplitude, frequency, attached mass, and calculated spring constant for each video.

Does the frequency have a (strong) relationship to the amplitude of oscillation?

When you have multiple springs, you can think of them as one effective spring. For springs in series, the $1/k_{\text{eff}} = 1/k_1 + 1/k_2$, and for springs in parallel, $k_{\text{eff}} = k_1 + k_2$. Using an average value for your two individual springs, calculate the effective spring constant for two springs in parallel and in series, and compare to your measured spring constants for that situation.

EQUIPMENT LIST FOR LAB 6:

Camera (memory card and AC charger)
Heavy duty stand with finger clamp
Meter stick
Rod and stand assembly (with bolt to hold the spring)
2 Springs (on the bolt)
Mass hanger (50g) and slotted masses (20g – 6 each)

THINGS TO DO AT THE END OF THE LAB SESSION:

1. Replace the heavy stand, rod, clamp on the lab table.
2. Replace the camera (with the LCD view finder window closed) on the shelf of the lab table.
3. The meter stick should be put on the shelf of the lab table.
4. The memory card should be left in the slot in the computer monitor.
5. Leave the other items in neat order on the lab table.