POSITION AS FUNCTION OF TIME

(L-42)

Under normal circumstances, this would be a run-and-shoot lab in the sense that your grade would be generated *during* lab. We will be modifying the process by using an on-line mass/spring system to replicate what you would have done in class.

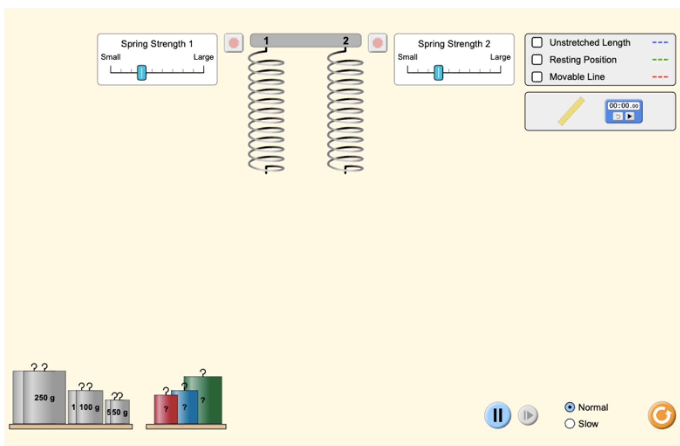
The whole idea is to generate the information needed to write out the *position as a function of time* equation for a mass/spring system (i.e., animate $y = A\sin(\omega t + \phi)$. You will be told when to start the stopwatch, so will be able to figure out the phase shift ϕ), and once you have it, you will be asked to use it to determine where the mass will be at some given time after the stop watch has started.

This means we need to create an oscillating mass/spring system, then accumulate some information.

PROCEDURE--DATA

Part A: (the on-line mass/spring system)

a.) Begin by going to https://phet.colorado.edu/. Once in, click on SIMULATIONS in the top ribbon. This will produce a pull-down menu. Click on PHYSICS in the menu. On the page that shows, scroll down to and open the MASS AND SPRINGS: BASIC file. Clicking on the thumbnail that comes up will give you three options. Open the BOUNCE option. Once done, you should see a page that looks like:



b.) Use only the left spring and attach the 250 grams mass to it. Notice you can stop the mass from oscillating up and down by click-and-holding when the cursor is hovering over the mass (this is no small feat when the mass is moving—you'll need to practice some to get it to work). You can also reposition the mass to make for a smaller amplitude, or no amplitude at all, using that technique. Give it a try. You'll need this skill later.

c.) Position the slider in the SPRING STRENGTH 1 box (upper left-hand corner) on the second notch.

d.) Stop the mass from oscillating.

e.) The box in the upper right-hand corner has three tools:

i.) An UNSTRETCHED POSITION option that identifies where the spring's end will be with no mass attached. Click on this option.

ii.) A RESTING POSTION option that identifies where the mass/spring's equilibrium position is. Click on this option (you should find that it's line is located through the hook of the motionless mass—for easy viewing, make all measurements relative to the hook). And:

iii.) A MOVEABLE LINE option which you can put anywhere you want. Click on this option (we'll use it later).

f.) By this point, you should know the relationship between the angular frequency ω, the spring constant k and the mass. You know the mass (it was .250 kg). We need the spring constant.

The yellow bar in the second box down in the upper right-hand corner is actually a CENTIMETER STICK. Grab it and use it to measure the distance between the spring's unstretched position and its position at equilibrium. In the write-up, you will use THAT information to determine the spring's spring constant k.

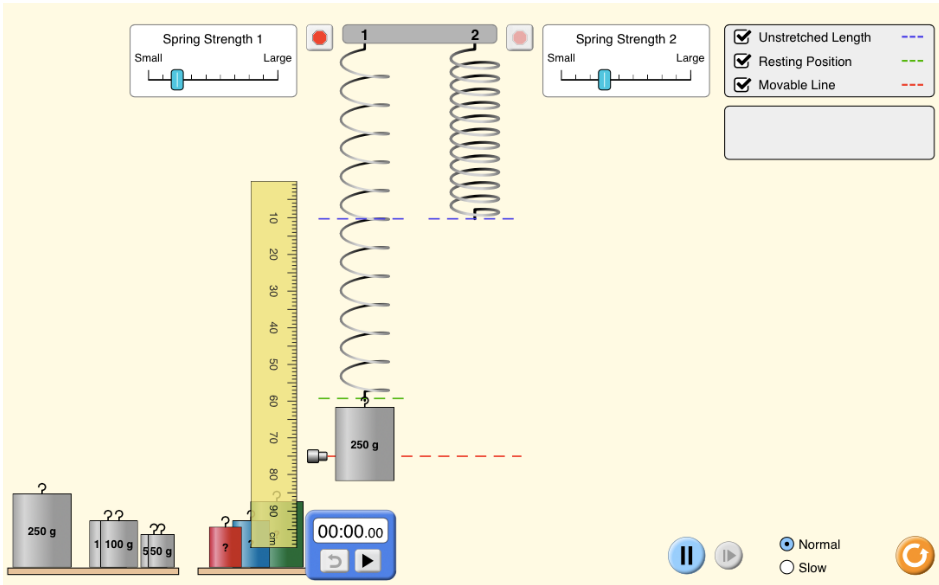
g.) You are going to want to use an oscillatory amplitude of .3 meters. We need to denote that position somehow. We are going to use the STOPWATCH to do this. In the sketch shown below, notice that I've positioned my CENTIMETER STICK so that the UNSTREETCHED POSITION is at the 10 cm mark, the system's equilibrium is at approximately at the 60 cm mark. For an amplitude of 30 cm, that means the mass will oscillate between the 90 cm mark and the 30 cm mark (30 cm on either side of equilibrium). To denote the maximum displacement at the bottom, I'm going to put the top edge of the STOPWATCH right at the 90 cm mark. (Note that that means that to get an oscillation with an amplitude of 30 cm, all I have to do is pull the mass's hook down to the top of the STOPWATCH and let it go!)

h.) You are going to need to identify two points in the motion. Those two points are:

i.) The mass's maximum displacement (which is to say, the amplitude A = .3 meters from equilibrium of its motion) and;

ii.) Where the mass is supposed to be at t = 0. That second bit of information will be emailed to your group on lab day. You will use the CENTIMETER STICK to identify that position, and will use the MOVEABLE LINE to denote that point. (Example: For the sake of argument, I am assuming that that point is at -A/2, so with the equilibrium point being at the 60 cm mark, and the amplitude mark being at 90 cm, -A/2 will be at the 75 cm mark. Notice that that is where I've put it in the sketch I've included below.) THIS LINE IS WHERE YOU WILL START THE STOPWATCH WHEN YOU MAKE YOUR RUN (that is, this line will denote where the mass is supposed to be at the t = 0 mark). Of course, you will have to be sure the mass is moving in the correct direction—toward equilibrium or away from equilibrium—at that moment, but that should all be baked into the phase shift calculation.

Anyway, that's the set-up. Below is a screen shot of what things should look like, more or less, before you start your run.



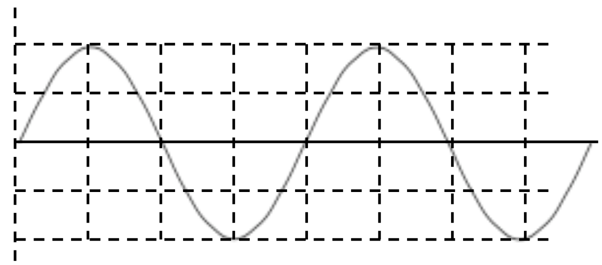
So now it's time to do the math.

Part B: (what you'll turn in)

1.) Identify the AMPLITUDE of your oscillatory motion (write it down—I just want to see that it has registered with you).

2.) Determine your spring's spring constant. Show relationships used before putting in numbers, and explain where you got the information used in the calculation (in short, BLURB well as you go). Box your result.

3.) Determine the spring's angular frequency. Again, show the relationship used before putting in numbers, and BLURB well. Box your result.



4.) I've sent you an email identifying where the mass should be (it's coordinate) and what it is supposed to be doing (going toward equilibrium or away from equilibrium) at t = 0. That means you know everything you need to know to determine the phase shift for the system. Do that calculation below. (I've provided a sine wave to the right for your convenience.)

5.) With all of the information accumulated above, write out the "y(t) = " expression (the only unknown variable in the relationship should be time *t*).

6.) Evaluate the expression generated in *Part 5* to determine the mass's *y-coordinate* as it will exist at t = 3 seconds.

7.) Set your clock speed to SLOW (bottom right-hand corner) so you can see the motion earily. Execute your run. I the mass is anywhere near to where you calculated it to be at t = 3 seconds, go out your front door and yell YIPPEEEEEEEEEE at the top of your lungs. If it isn't, figure out what went wrong (and if you can't, come talk to me—everyone should get their set-up to work!!!).