Experiment 2: Uniform Circular Motion

Experimental Materials:

- Logger Lite Software
- Vernier LabPro Interface
- Cicular Motion Apparatus/power cord
- Vernier Differential Voltage Probe
- small weight on spring

Setting Up the Experiment:

The apparatus includes a viewer to facilitate measuring the radius of the mass’s motion, \( r_m(\omega) \). It is a white teflon block with a black viewing tube and it slides in a slot in the top cover of the apparatus. A small nail protrudes down into the slot and should be placed to engage the loop of the brass wire that has a LED taped to it; that is so the LED will move to illuminate the mass as you try to read its position. (This all works better if the room lights are dim.) Another nail protrudes into the viewing tube and can be lined up over the black stripe around the mass; the same nail also allows you to read the radius on the scale.

You need to know the mass \( m \) of the round weight. The one I used had \( m = 8.5 \text{ gm} \); use this value for your experiment. (If you use an incorrect value for the mass, the experiment will still work normally, but the spring constant you find will be incorrect.)

Attach the mass and spring to the hook on the shaft inside the box. Then connect the apparatus to its 12V power supply via the connector on the side.

You should replace the side cover to the box before you turn on the motor. The weight moves at fairly high speed and would give a nasty whack to your finger if it were hit by it. Turn on the circular motion apparatus and try different speeds to see how it behaves.

You will use the Logger Lite program \textit{CircMotionLite.gmb1} to measure the rotation period, \( T \), of the mass, and from that calculate the angular rotation frequency \( \omega = 2\pi/T \).

A voltage probe should be connected from channel 1 of the Vernier LabPro interface to the two banana jacks on the apparatus that are farthest away from the speed control knob. Match the colors of the plugs and jacks.

As the motor rotates, a magnet in the counterweight triggers a reed relay on the top cover of the box and makes a voltage pulse every time the magnet passes under the relay. The voltage is normally close to 0, but rises to between 3 and 4 V when the magnet closes the reed relay. The program \textit{CircMotionLite} acts like an oscilloscope to detect these voltage pulses. You will have to count the number of pulses in a known period of time and calculate the angular frequency of rotation, \( \omega \), of the motor shaft.

The way to make your measurements is to set the shaft speed with the knob on the apparatus, wait at least 30 seconds for the speed to stabilize, and measure the radius \( r_m(\omega) \).
of the circular motion. After you have measured \( r_m(\omega) \), compute the angular velocity \( \omega \) of the rotation.

- You should make measurements for at least five different values of \( \omega \) that give \( r_m(\omega) \) between 5 and 10 cm.

- You should enter your \( \omega \) and \( r_m(\omega) \) data in an Excel spreadsheet and carry out a fit to see how well the model described in the Pre-Lab assignment describes the behavior you observed.

- You should analyze your results to determine the force constant of the spring in your apparatus and whether there is evidence for an initial tension in the spring (as described on page 5 of these instructions).

- You should turn the Worksheet for this experiment describing your results. The Worksheets will be available in the classroom. A copy is included as the last page of these instructions.

- Use the data input link on today’s web page to enter the value you obtained for \( \omega_c \). There are several different springs on the apparatuses for this experiment. When your instructor plots a histogram of \( \omega_c \) we can see how many different springs there are.

Making Measurements:

Start the program *CircMotionLite*. Go to the Experiment menu and select “Data Collection.” You may set parameters, including collection length and sampling rate, to your liking (default values are 1 sec and 1000 samples/sec; the maximum sample rate is 10,000 samples/sec).

The “Collect” option (green play button) will start the program measuring the voltage on channel 1, alternatively, you can hit the space bar to commence measuring.

The program will start to record the voltage immediately and will continue for the length of time set in the Data Collection window (1 sec or less is usually enough). You should then see a plot like the one in the graph below.
You could determine the shaft rotation period $T$ from this graph by finding the time interval between the first and last voltage peaks and then dividing by the number of peaks; the angular velocity $\omega$ will be $2\pi/T$.

In a spreadsheet, record the angular velocity that you computed from the period and the radius you measured. Also, enter these values on the Worksheet for the experiment.

Do more measurements to find the radius $r_m(\omega)$ of the mass’s circular motion for at least four more different angular velocities to give values of $r_m(\omega)$ between 5 and 10 cm. Allow the speed to stabilize for at least 30 s before you make each measurement.

Once you have completed these measurements of $r_m(\omega)$ vs. $\omega$, you should make a plot of $r_m(\omega)$ vs. $\omega$ on your spreadsheet. Does it exhibit the expected behavior?