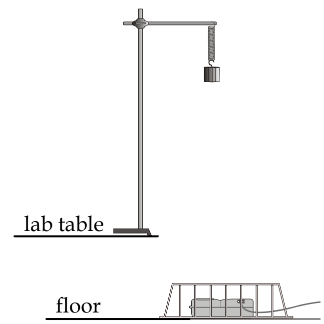
Physics Lab 8: Periodic and Circular Motion

Today's lab has 2 main sections. In the first section, you will use the motion detector to measure motion for a situation we have not yet modeled, one in which neither the velocity nor the acceleration is constant. You will set up and measure the ***periodic motion*** of a mass attached to a spring moving up and down. In the second section, you will learn to use a new kind of sensor: a rotary motion sensor. The rotary motion sensor measures ***angular position*** vs. time, and calculates ***angular velocity*** from the angular position vs. time results. This allows you to make measurements related to ***circular motion***. By coupling the motion of a tumble buggy (which moves with constant linear speed) to the rotary motion sensor, you will investigate the connection between linear speed and angular speed.

Part I: Periodic Motion

Complete by 10:45/1:45.

CAUTION: The Motion Detector will be on the floor, with a mass hooked to a spring moving up and down above the detector. Use the protective screen and take care to make sure the mass does not fall onto the Motion Detector.



(image modified from Vernier Physics with Computers)

a) Your goal is to obtain 8 good position vs. time graphs that show several cycles of up and down motion (one cycle is called a ***period***) for various combinations of spring, mass, and initial displacement (see the table on the front board).
b) **Each time you change a mass or a spring, allow the system to come to equilibrium, and then Zero the sensor.** Make sure the Triggering (under Experiment: Data Collection) is set to Start Data Collection when Increasing Across 0.
c) Gather and assemble your equipment as in the demonstration station and in the figure. Attach Spring 1 to the spring hook and attach some mass to the bottom of the spring. Let the mass come to its ***equilibrium*** (rest) position; you can help it out by gentling damping the vibrations. Draw a sketch of your experimental setup in your notebook.
d) Pull the mass straight down a small distance from equilibrium, and release it from rest (this distance is the ***amplitude***). Obtain several good position vs. time graphs. Rename your best run as 'spring01'.
e) Repeat with the same set-up but with a larger amplitude (but not too large – too large an amplitude will result in the spring "bunching up" at the top of its path). Rename your best run as 'spring02'.
f) Still with Spring 1, with a different mass and for two different amplitudes.
g) Switch to Spring 2, and do two different masses with two different amplitudes.

Part II: Angular Motion

Complete by 11:15/2:15.

a) Obtain a Rotary Motion Sensor. Attach the 3-step pulley using the mounting screw. Close LoggerPro, hook the Rotary Motion Sensor up to your LabQuest, and then launch LoggerPro again. You should see two graphs: an Angle (rad) vs. Time (s) graph, and a Velocity (rad/s) vs. Time graph (this might/should be an Angular Velocity (rad/s) vs. Time (s) graph).
b) Start collecting data, and turn the pulley clockwise and counterclockwise to determine which direction is positive and negative as measured by the Rotary Motion Sensor. No need to save this.
c) Using the conversion factor 1 rev = 360^{o} = 2π (rad), determine the angular displacement (in degrees and in rad – get both in terms of π and as a decimal equivalent; only keep 2 or 3 decimal places) for a quarter revolution, a half revolution, a full revolution, and 1.5 revolutions, and record these in your notebook. Show at least one full calculation including conversion factors, and organize your results into a table.
d) Start collecting data. Rotate the pulley a quarter revolution in the positive direction and hold fixed for about 0.5 seconds. Continue to a half revolution, and hold fixed for about 0.5 seconds. Continue to a

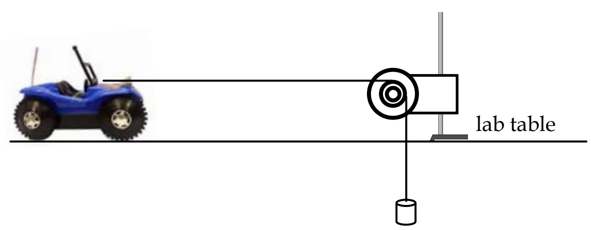
full revolution (hold fixed for about 0.5 seconds), then continue to 1.5 revolutions and hold fixed for about 0.5 seconds.

e) Compare your graph to the numbers you calculated. Save this with a useful name.
f) You may want to practice the following before collecting data. Change the data collection time as needed. Your goal is to obtain angular position vs. time data for the following motion of the pulley: 2 full positive rotations at approximately constant angular speed that take approximately 2 seconds; Pause for approximately 0.5 seconds; 1 full negative rotation at approximately constant angular speed that takes approximately 6 seconds; Pause for approximately 0.5 seconds; 2 full negative rotations at approximately constant angular speed that take approximately 2 seconds; Pause for approximately 1 second; 4 full positive rotations at approximately constant angular speed that take approximately 2 seconds; Pause till end. Obtain this angular position vs. time graph. Save with a useful name.
g) You may want to practice the following. Hold the Rotary Motion Sensor so that the pulley is oriented horizontally. Spin the pulley so that it spins freely, slowing to a stop on its own (due to friction). Note: if you spin the pulley too fast, the sensor might not be able to properly measure its angular position at first. Change the data collection time as needed. In a single run, obtain data for spinning the pulley in the positive direction, slowing to a stop on its own, stopped for approximately 0.5 seconds, then spinning the pulley in the negative direction, slowing to a stop on its own, stopped until end. Save with a useful name.

Part III: Linear and Angular Motion

Complete by end of session.

a) Your goal is to obtain 6 angular position vs. time graphs and 2 linear position vs. time graphs. One set will be for a tumble buggy with one battery, and attached to the Rotary Motion Sensor for each of the 3 pulley diameters. You will also obtain the linear position vs. time for the one battery tumble buggy. The other set will be for the tumble buggy with two batteries, also attached to the Rotary Motion Sensor for the 3 pulley diameters.
b) Gather and assemble your equipment as in the demonstration station and the figure. Note that the main reason for the hanging mass is to maintain tension in the string so that the linear motion of the tumble buggy turns the pulley. Therefore the hanging mass does not need to be very large; just the mass hangar itself should do. The figure shows the tumble buggy moving towards the sensor; you may find it works better to have your tumble buggy move away from the sensor. Draw a sketch of your experimental setup in your notebook.



c) As usual, you may want to practice before collecting data. Start with one battery, and have the string go over the large diameter pulley. Obtain good position vs. time data, and rename your best run as 'oneBatteryLargeDiameter'.
d) Repeat for the medium diameter and small diameter pulley, renaming the best runs as 'oneBatteryMediumDiameter' and 'oneBatterySmallDiameter'.
e) Use the Motion Detector to obtain a linear position vs. time graph, renaming the best run as 'oneBatteryLinear'.
f) Repeat, but this time with 2 batteries, to obtain 'twoBatteryLargeDiameter', 'twoBatteryMediumDiameter', and 'twoBatterySmallDiameter' and 'twoBatteryLinear'.

Part IV: Preparing for Analysis

If you complete the data collection with time left over, consult with Krishna to get ahead on analysis tasks.