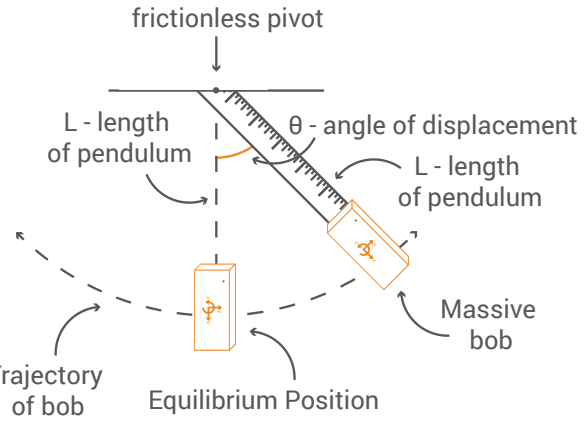
Properties of a Wave with Simple Harmonic Motion

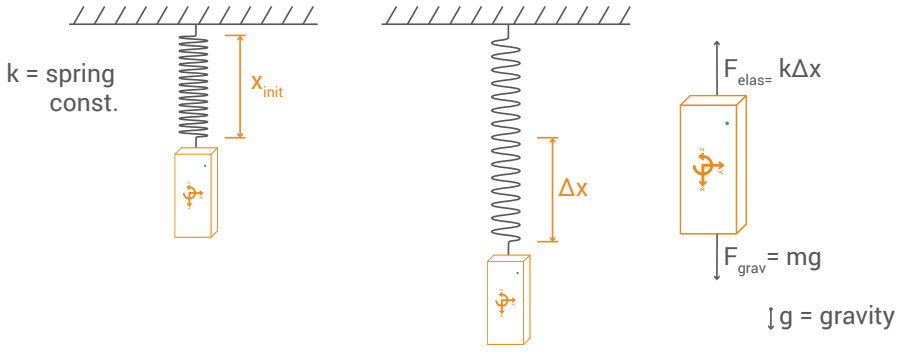
Exploration

Simple Harmonic Motion is a periodic or oscillating motion where the forces of the movement cause a particular motion to continually repeat. The back and forth of a pendulum, like in an old grandfather clock, the ticking of a classic metronome, or the up and down movement a bungee jumper can all be examples of harmonic motion. Using PocketLab you can investigate how to mathematically model harmonic motion through two classic examples, a swinging pendulum and a mass-spring system.

Materials

- PocketLab
- Meter stick with hardware for pendulum
- Ring stand attachment for pendulum
- Spring
- Mass set
- 3M command strip or duct tape
- Ring stand





Objective

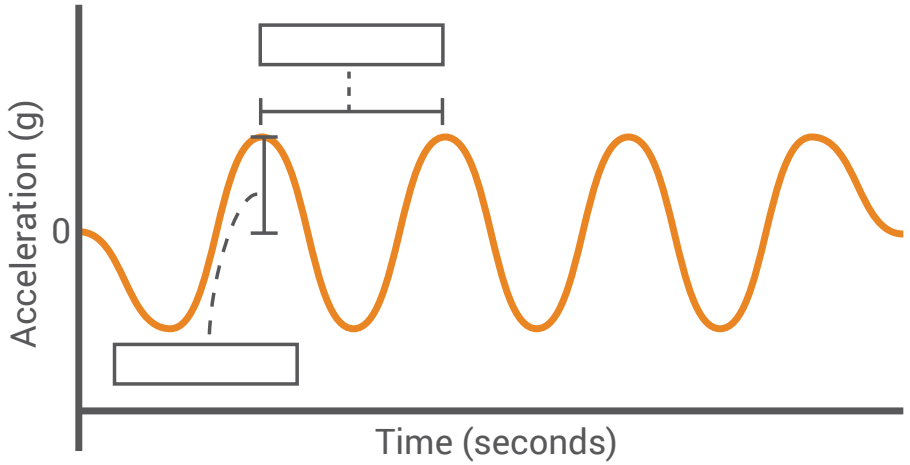
In this experiment, students will:

1. Use PocketLab's gyroscope and the scientific method to discover what variables affect the harmonic motion of a swinging pendulum.
2. Use PocketLab's accelerometer and the scientific method to discover how mass affects the harmonic motion of a mass-spring sytem.
3. Determine and describe how harmonic motion can be mathmatically modeld through wave graphs.

Part 1: How can we graph harmonic motion?

1. Set up the mass-spring system so it looks like the system diagram on the previous page. Attach one end of the spring to the ring stand clamp and the other end to the PocketLab with mass.
2. For Part 1 the mass attached to the PocketLab will remain constant.
3. Attach the PocketLab to the mass using the 3M command strips or duct tape.
4. Connect the PocketLab to the PocketLab app. Select the Acceleration graph and turn off the z- and y-axis so only the x-axis graph is displaying.
5. Hold the PocketLab and mass so the spring is at equilibrium (the spring isn't stretched or compressed).
6. Begin a data recording (use the video function if available).
7. Release the PocketLab and mass. Carefully observe how the graph models the motion you are seeing.
8. Stop your recording. Play the video of the graph in the review mode by clicking the "Play" button. Write down your observations about how the graph models the repeated motion of the mass-spring system.

- Period and Amplitude: The period of a graph represents the cycle length of a wave and the amplitude represents the heigh of the wave. In the graph below, label the period and amplitude.



- What is the period of the graph modeling in the harmonic motion of the mass-spring system? What is the amplitude of the graph modeling in the harmonic motion of the mass-spring system? Explain your answer using your observations from your data recording.

Part 2: How does the mass affect the period and amplitude of the harmonic motion of a mass-spring system?

Mass-spring Hypothesis:

- Write two hypotheses. The first should predict how increasing the mass will affect the period of the harmonic motion of a mass-spring system. The second should predict how increasing the mass will affect the amplitude of the harmonic motion of a mass-spring system. For both hypotheses make sure to explain your reasoning using previous knowledge and observations, perhaps from Part 1.

Design and perform your mass-spring experiment:

- With your group discuss how you can use the given materials to design a controlled experiment that will test your hypotheses. Write out the method of your experiment step-by-step and be sure to clearly state any independent, dependent and control variables. Also include how you will analyze the collected data to determine whether your hypothesis is valid or invalid.
- Test your hypotheses. When recording data with the PocketLab app, use the video function if available. Record your collected data and qualitative observations you notice as you change the mass.

Mass-spring Conclusion:

- Were your hypotheses valid or invalid? Explain.
- Thinking about your qualitative observations and collected data, how does the mathematical model (graph) represent how the energy in the mass-spring system is affected by the changing mass? Explain.

Part 3: Which variables affect the period and amplitude of a pendulum?

1. Set up the pendulum so it looks like the system diagram on page 1. Put the bolt through the hole at the top of the meterstick and loosely attach the nut. Then, use the ring clamp and the ring stand to hold the bolt so the pendulum will swing freely. You may need to have the pendulum hang over the edge of a desk.
2. Connect the PocketLab to the PocketLab app. Select the Angular Velocity graph. Turn off the x- and y-axis so only the z-axis is graphed. That should be the axis the pendulum is rotating about.

1. With just the PocketLab attached, take some time with your group to play around with the pendulum. Let the pendulum swing and observe how the graph changes.
2. Begin a data recording (use the video function if available).
5. Bring the pendulum back and release it. Carefully observe how the graph models the motion you are seeing.
6. Stop your recording. Play the video of the graph in the review mode by clicking the "Play" button. Write down your observations about how the graph models the repeated motion of the mass-spring system. In your observations, include what you think the period and amplitude of the graph model in the harmonic motion of the pendulum.

Pendulum Hypothesis:

- Examine the system diagram for the pendulum. You will need to test how three variables, mass of the bob, angle of displacement, and length of the pendulum, affect both the period and amplitude of the pendulum. Predict how each independent variable will affect the period and amplitude of the pendulum.

Design and perform your pendulum experiment:

- With your group discuss how you will design a controlled experiment that will test your hypotheses. Use the system diagram to show how the independent variables can be changed. Write out the method of your experiment step-by-step and be sure to clearly state the independent, dependent and control variables for each part of the procedure. Also include how you will analyze the collected data to determine whether your hypothoses was valid or invalid.

Pendulum Conclusion:

- Were your hypotheses valid or invalid? Explain.
- Thinking about your qualitative observations and collected data, how does the mathematical model (graph) represent how the energy in the pendulum is affected by the changing of the different independent variables? Explain.
- When conducting an individual trial with both the pendulum and the mass-spring system, did the amplitude of the graph stay the same throughout the data recording, or did it change over time? If it changed, explain how.
- The wave graph produced by the PocketLab in your experiemtns is a mathmatical model of the oscilatting motion of a pendulum and mass-spring system. In this mathematical model, how does the amplitude's change over time relate to the energy of the oscilating motion of the pendulum or the mass-spring system? Explain your answer.