About the Lesson

In this activity, students will explore variables that will make a pendulum change how fast it oscillates. As a result, students will:

- be able to measure the period of a pendulum.
- explore what variable changes the period of a pendulum.

Vocabulary

- period
- frequency
- variable
- pendulum

Teacher Preparation and Notes

- Decide beforehand which set up option that students are to use to be prepared for the materials needed. Or allow students to choose their method. Each option has different advantages and limitations.
- Water is listed in the materials needed for this activity. If preferred, you can use sand instead of water to change the mass of the pendulum. A funnel may be needed to help pour the sand into the can.
- Decide how many cycles you want students to be able to see in the plot. The default duration will give at least 2 periods. Adjust the sampling time according to your preference.

Activity Materials

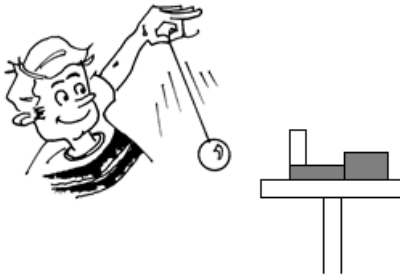
- Compatible TI Technologies:

  TI-84 Plus*
  TI-84 Plus Silver Edition*
  TI-84 Plus C Silver Edition
  TI-84 Plus CE

** with the latest operating system (2.55MP) featuring MathPrint™ functionality.*

- CBR 2™ motion sensor unit with mini-USB connecting cable
- Vernier EasyData® App
- String
- Empty aluminum soda can (with pull-tab still intact)
- Water or sand
- Ruler or Ring Stand

Set Up options:



Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

- Swing_Thing_Student.pdf
- Swing_Thing_Student.doc

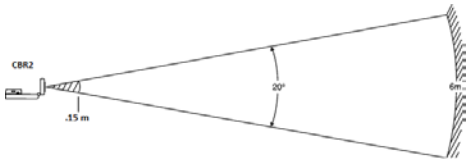
Tech Tip: While using the EasyData app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:

Introduction to Swing Thing

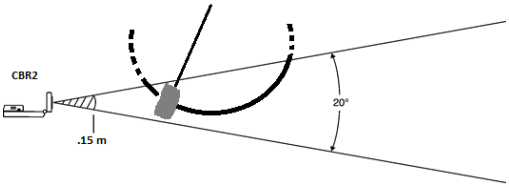
The concepts of period and frequency may need some instruction prior to this activity. But the guided investigative format of this activity will help students solidify their understanding.

Teaching Notes:

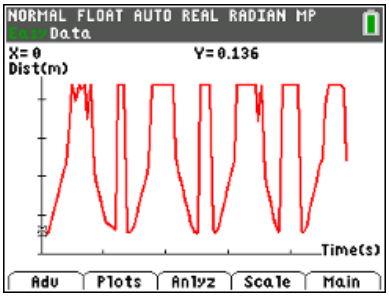
- The path of the CBR 2 beam is not a narrow, pencil-like beam, but fans out in all directions up to 10° in a cone-shaped beam.



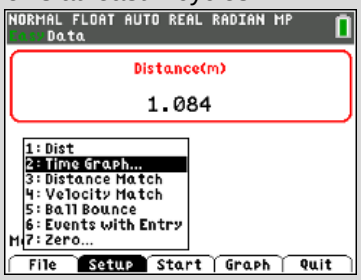
- Keeping the amplitude of the pendulum small will help keep the pendulum within the path of the CBR 2 beam. To make sure the pendulum does not get closer than 0.15 m, the center of rotation needs to be a suitable distance from the CBR 2.

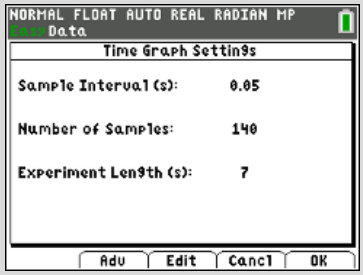


- If the pendulum is swinging outside the CBR 2 beam, the graph may look like this example.



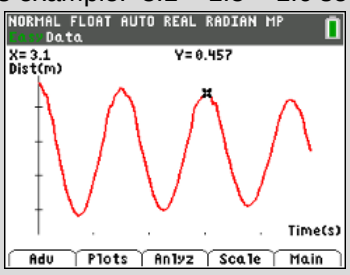
Tech Tip: The student directions use the default Experiment Length (5 s.). If this is not working well for students, you can change the sampling time to a different duration. Select window [Setup], and the **2: Time Graph** settings. Follow the menus, to enter the values shown. The example shows lengthening the collection time to 7 seconds. As students investigate the longest pendulum, they may need more time to get a graph that shows at least 2 cycles.

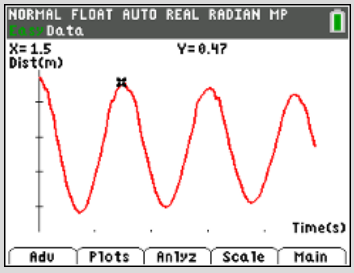




Tech Tip: When students have made a graph, to calculate the period of the pendulum, they can use the right and left arrow keys to move through the data. The coordinates of each data point appear at the top of the screen. This can be used to find the coordinates of either two consecutive peaks or two consecutive valleys. Then students subtract the x-coordinates to find the period of the pendulum.

In this example: 3.1 – 1.5 = 1.6 seconds





Looking at the Results

1. What are two factors do think you can change about the pendulum that would change the period?

   Student answers will vary.

   Sample response: The length of the pendulum changes the period. To a lesser degree, the period depends on the amplitude. But with the limitations of the CBR 2, students may not be able to accurately investigate the effects of amplitude. The mass of the pendulum does not change the period.

2. Predict how the period will change when you increase each factor.

   Student answers will vary.

3. Investigate the first factor (variable) and record the data in the table.

   Student answers will vary.

   Sample data for investigating the effects of increasing the mass of the pendulum. Students can use the graduated cylinder to put measured amounts of water in the can.

		Period (sec.)
30 cm length	Empty can	1.3
30 cm length	20 ml added	1.3
30 cm length	40 ml added	1.3

4. Investigate the second factor (variable) and record the data in the table.

   Student answers will vary.

   Sample data for investigating the effects of increasing the length of the pendulum.

		Period (sec.)
30 cm length	Empty can	1.3
50 cm length	Empty can	1.6
70 cm length	Empty can	1.9

5. Summarize your findings by describing what happens to the period of the pendulum when you increase each factor.

   Student answers will vary.

   Sample response: When the length of the pendulum is increased, the period will increase. When the mass of the pendulum is increased, the period will stay the same. For larger amplitudes, the period gradually increases with increases in amplitude.

Going Further

1. Which factor changed the period the most? If you cut that variable in half, did the period get cut in half? What does this tell you about the relationship between the variable and the period?

   Student answers will vary.

   Sample response: The period of the pendulum changes most with changes in the length of the pendulum. If the length is cut in half, the period is not divided in half. So pendulum length and period are not directly related. The pendulum length varies with the square of the period.

2. The frequency of a swinging pendulum tells how many cycles it completes per second. Frequency and period are related by the formula:

$$Frequency = \frac{1}{Period}$$

Using the data you collected, find the frequencies for two of the pendulums that you made.

Student answers will vary.

Sample response: For the sample data, for 30 cm pendulum, the frequency is 0.77 cycles per second. For 70 cm pendulum, the frequency is 0.53 cycles per second.

3. How would frequency change if a pendulum's period is tripled? Be specific.

Student answers will vary.

Sample response: If the pendulum's period is tripled, its frequency would be one third its original value.

4. Complete this sentence: When the **length** of a pendulum is increased, the frequency of the pendulum **decreases.**