TEACHER INFORMATION

Swinging Ellipses: Plotting an Ellipse

1. There are currently four Motion Detectors that can be used for this lab activity. Listed below is the best method for connecting your type of Motion Detector. Optional methods are also included:

   Vernier Motion Detector: Connect the Vernier Motion Detector to a CBL 2 or LabPro using the Motion Detector Cable included with this sensor. The CBL 2 or LabPro connects to the calculator using the black unit-to-unit link cable that was included with the CBL 2 or LabPro.

   MDC cable

   CBR: Connect the CBR directly to the graphing calculator's I/O port using the extended length I/O cable that comes with the CBR.

   Optionally, the CBR can connect to a CBL 2 or LabPro using a Motion Detector Cable. This cable is not included with the CBR, but can be purchased from Vernier Software & Technology (order code: MDC-BTD).

   I/O cable

   CBR 2: The CBR 2 includes two cables: an extended length I/O cable and a Calculator USB cable. The I/O cable connects the CBR 2 to the I/O port on any TI graphing calculator. The Calculator USB cable is used to connect the CBR 2 to the USB port located at the top right corner of any TI-84 Plus calculator.

   Optionally, the CBR 2 can connect to a CBL 2 or LabPro using the Motion Detector Cable. This cable is not included with the CBR 2, but can be purchased from Vernier Software & Technology (order code: MDC-BTD).

   I/O cable

   USB cable

   Go! Motion: This sensor does not include any cables to connect to a graphing calculator. The cable that is included with it is intended for connecting to a computer's USB port. To connect a Go! Motion to a TI graphing calculator, select one of the options listed below:

   Option I–the Go! Motion connects to a CBL 2 or LabPro using the Motion Detector Cable (order code: MDC-BTD) sold separately by Vernier Software & Technology.

   Option II–the Go! Motion connects to the graphing calculator's I/O port using an extended length I/O cable (order code: GM-CALC) sold separately by Vernier Software & Technology.

   Option III–the Go! Motion connects to the TI-84 Plus graphing calculator's USB port using a Calculator USB cable (order code: GM-MINI) sold separately by Vernier Software & Technology.

2. You may want to have students view the velocity *vs*. time graph before creating the phase plot. The velocity values are positive when the bob is moving away from the detector, and negative when moving toward the detector.

3. When connecting a CBR 2 or Go! Motion to a TI-84 calculator using USB, the EasyData application automatically launches when the calculator is turned on and at the home screen.

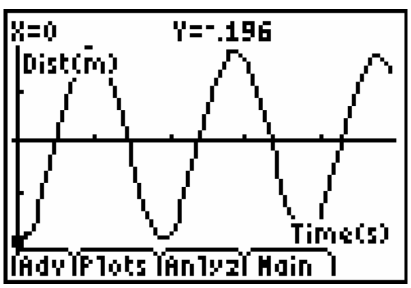
4. Avoid using a soft or felt-covered ball for the pendulum bob, as the ultrasonic waves from the motion detector tend to be absorbed by these surfaces. A ball with a hole drilled through its center works well as a pendulum bob. Other objects such as a fishing bobber or an empty soft drink can also work well.

5. A common misconception among students is the expectation that motion plots will match the path of a moving object. You may want to ask your students why the phase plot is elliptical even though the pendulum did not follow an elliptical path.

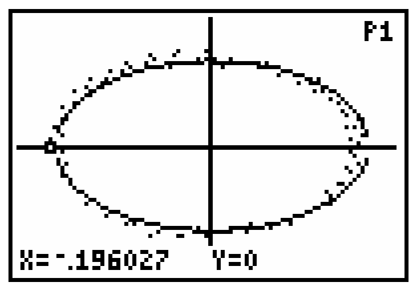
6. In Step 2 of the analysis we ask the student to determine a typical intercept. That is, we are asking for a judgment call, similar to judging when a manually-determined parameter is optimized. If a student is uncomfortable with this step, you might have him or her average all the positive *x*-intercepts and use that value. Other intercepts can be determined in the same way.

7. In entering the ellipse model, the Y2 entry can also be –Y1, but we've chosen to have the student enter the entire expression rather than dig into menus for the equation variables. You may choose to have students do it differently.

SAMPLE RESULTS



Raw distance data in EasyData motion is centered on *y*-axis



Phase plot with ellipse

DATA TABLE

First *x*-intercept	Second *x*-intercept	*a*
–0.196	0.182	0.189

First *y*-intercept	Second *y*-intercept	*b*
–0.552	0.574	0.563

ANSWERS TO QUESTIONS

1. The motion data and the superimposed ellipse match well, as they must since the vertices were taken from the motion data.

2. The velocity is largest in magnitude when the position value is passing through zero. These moments correspond to the *y*-intercepts at the top and bottom of the ellipse. The velocity is zero when the position value is at an extreme. These moments correspond to the *x*-intercepts at the left and right edges of the ellipse.

3. If the amplitude of the pendulum's motion were increased, both the maximum velocity and the maximum distances would increase. Those increases would directly increase both *a* and *b*, making for a larger ellipse.