TEACHER INFORMATION

Simple Harmonic Motion

1. Editable Microsoft Word versions of the student pages and pre-configured TI-Nspire files can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. Students often have a hard time relating textbook discussions of simple harmonic motion to experimental data. This activity has them determine the parameters in $y = A\cos(2\pi ft + \phi)$ for their own data. Since ϕ is difficult to guess, the model $A\cos(2\pi\mathbf{b}(x - \mathbf{c}))$ is used where $\phi = -2\pi\mathbf{b}*\mathbf{c}$.

3. Students tend to use a larger amplitude than is needed, causing the stand to flex or the mass to fall. A 10 cm amplitude should be the largest used in this lab.

4. Students may have difficulty entering and adjusting the model. Refer to the instructions for using models in *Appendix B* or *Appendix C.*

5. Be sure the Motion Detector can “see” the mass throughout its range of motion. The position graph is much easier to use for troubleshooting than the velocity graph. Using a 2.5 to 3 inch diameter circular piece of index card attached to the bottom of the mass can help the motion detector see the mass. However, the card will dampen the oscillations slightly.

6. Motion detectors without a mode switch do not properly detect objects closer than 0.5 m. As a result, such motion detectors must be farther away from the experiment than described in the student notes. In contrast, Motion detectors *with* a mode switch will detect objects as close as 0.15 m. Ideally, an experiment will be set up so that the target is nearly this close at the point of closest approach, giving the best possible data.

7. Inexpensive or bent springs will not give sinusoidal velocity graphs. The best springs are sold as “simple harmonic motion” springs. Some long springs sold for studies of waves can be cut into sections and used for this lab, although these are still not as good as specialized harmonic motion springs.

8. If your spring is much different from 10 N/m stiffness, you may need to adjust the mass used to keep the period around one second.

9. If the ring stand flexes during oscillation, the motion will not be simple harmonic. A rigid support is needed.

10. The motion of the mass should be only up and down, with no side-to-side sway. Internal oscillations of the spring can also affect the motion.

11. A wire basket should be used to protect the Motion Detector from falling weights; it should be positioned such that the Motion Detector can “see” through it. Large twist ties or Zip ties should be used to securely attach the mass to the spring.

12. In this experiment, we have the students lift the mass to start the oscillation, rather than pulling down on the mass. This makes it less likely the mass will fly off the spring.

13. The TI-Nspire must be in radian mode for this experiment.

    For Handhelds: To verify the mode, hover the cursor over the battery indicator. To change the setting, Press [on] then select Settings ► Settings ► General.

    For Computers: To verify the mode, hover the cursor over Settings label along the bottom of the screen. To change the setting select Settings ►Document Settings from the File menu.

ANSWERS TO PRELIMINARY QUESTIONS

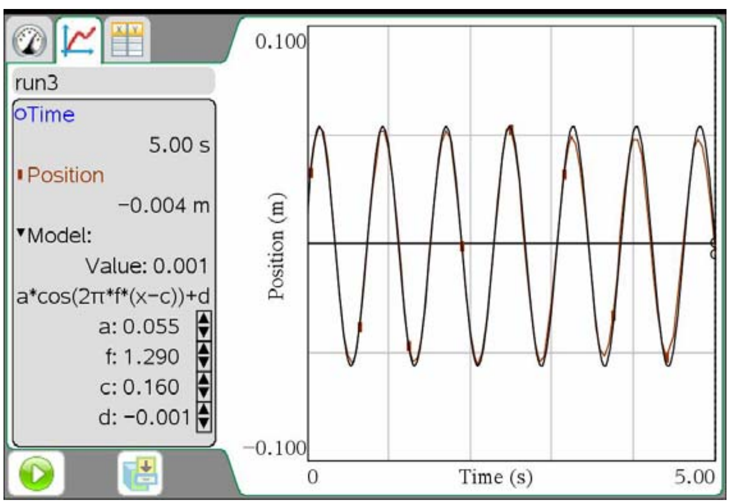
1. Sketches should be similar to data graphed above. (Note that any origin can be chosen by the student.)

2. The zero velocity points should correspond to the maximum and minimum distances from the origin. The sign of the slope of the position plot should correspond to the sign of the velocity at a specific time.

SAMPLE RESULTS

Table 1				
Run	Mass (g)	*A* (m)	*T* (s)	*f* (Hz)
1	200	0.021	0.65	1.54
2	200	0.059	0.65	1.54
3	300	0.055	0.80	1.25

Model equation with parameters	0.055*cos(2π*1.29*(x – 0.160) – 0.001



Pendulum data shown with model.

The parameters in the textbook equation that corresponds to the model equation are *A* (0.055), *f* (1.29), and ϕ (-1.3). A value of 0.055 for *A* corresponds to a 5.5 cm maximum displacement from equilibrium. A value of 1.29 for *f* corresponds to a frequency of 1.29 Hz.

ANSWERS TO QUESTIONS

1. Answers will vary. The position graphs of the collected data should be similar to the student predictions.

2. Answers will vary. The velocity graphs of the collected data should be similar to the student predictions.

3. The zero velocity points should correspond to the maximum and minimum distances from the origin. The velocity has the largest magnitude when the mass is passing through the equilibrium position.

4. When the velocity has the largest magnitude, the mass is passing through the equilibrium position. When the velocity is zero, the mass is at a maximum or minimum position. The sign of the slope of the position plot should correspond to the sign of the velocity at a specific time.

5. The frequency, f, is approximately the same for the two amplitudes used. To demonstrate that the frequency is independent of amplitude would require measuring the frequency at many additional amplitudes.

6. The frequency, f, does depend on the mass, since the frequency was smaller for the larger mass.

7. The sample data above show a nearly completed adjustment of the model to the data. Increasing values of ϕ shift the graph to the left and accounts for the position of the mass when data collection begins.

8. Doubling the amplitude, A, will change the model plot, increasing the maximum distance from the detector, and decreasing the minimum distance.

9. If f is doubled, the plot of the model will complete twice as many cycles during the time plotted.