

**TEACHER INFORMATION**

# Up and Down: Damped Harmonic Motion

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

**CBR2:** 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.

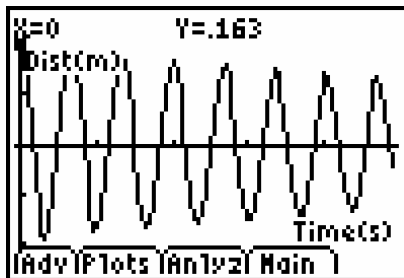
Option III—the Go! Motion connects to the TI-84 Plus graphing calculator's USB port using a Calculator USB cable (order code: GM-MINI) sold separately by Vernier Software & Technology.

2. 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.
3. If your spring or Slinky is particularly stretchy, you may want to omit the mass hanger. The sample data were collected with a miniature Slinky taped to a paper plate.

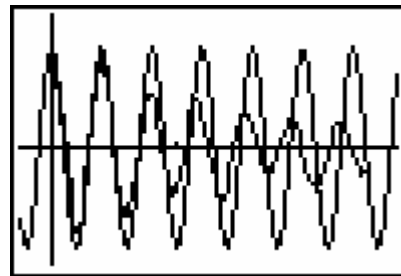
## Activity 27

- Be sure the plate is suspended directly over the Motion Detector. Don't allow the plate to come closer than 50 cm to the detector.
- If you have students hold the Slinky instead of using fixed supports, remind the students to hold their hands motionless. It is easy to pump the system up and down, or move the hand from the position used for zeroing the Motion Detector. For this reason a fixed support will give better quality data, but a hand-held spring can be used.

## SAMPLE RESULTS



Raw data in EasyData

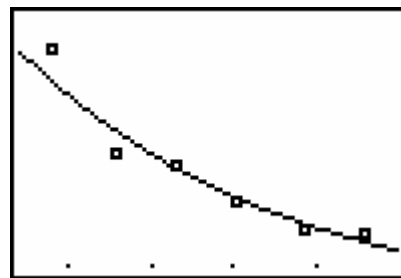


Distance data and cosine model

L1	L2	L3	3
0	1.6	.00508	
.1	3.2	.0359	
.2	4.6	.0331	
.3	6.1	.0256	
.4	7.7	.0187	
.5	9.2	.0178	
.6			

L3(1) = .0603

Peak amplitude data entered in lists

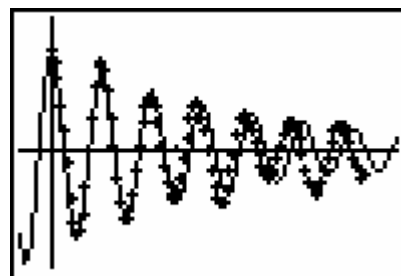


Peak amplitude data with exponential fit

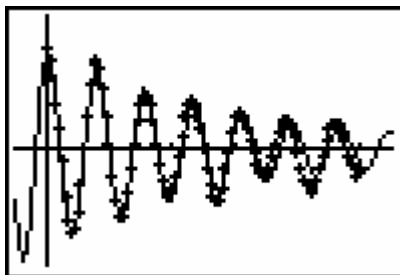
```

Plot2 Plot3
\Y1= Y2*cos(B*(X-
C))
\Y2=.06805445153
724*.85456869281
489^X
\Y3=
\Y4=
    
```

Composite model equation



Composite model and data



Optimized composite model

## DATA TABLE

<b>A</b>	0.0692 m
<b><math>t_1, t_2</math></b>	1.6, 3.2 s
<b>T</b>	1.6 s
<b>C</b>	1.6 s
<b>composite model</b>	$y=0.068*(0.85)^x * \cos(3.92(x-1.6))$

## ANSWERS TO QUESTIONS

1. The model equation fits the oscillating part of the data, but the amplitude is only approximately correct for early times. At later times, the amplitude is quite wrong.
2. The composite model fits well, reflecting both the oscillatory part and the decaying amplitude part of the experimental data. The period could fit better, however.
3. Increasing the size of  $B$  makes for a better fit of the model to the data. It looks like my period measurement was a little low, possibly due to 0.1 s time resolution of the graph.
4. Starting the plate going with a larger displacement from the equilibrium position would make the multiplicative constant larger in the exponential function. Using a smaller plate (less damping) would make the decay constant in the exponential smaller. Using a stiffer Slinky would make the period smaller, making  $B$  larger. Changing the starting time of data collection could change  $C$ .