TEACHER INFORMATION

Bounce Back: The Exponential Pattern of Rebound Heights

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. 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.

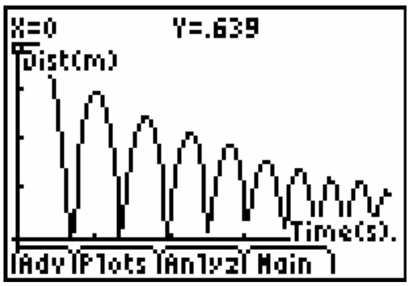
3. A basketball works well for this activity. Avoid using a soft or felt-covered ball such as a tennis ball as the surface prevents good detection by the Motion Detector.

4. The Motion Detector cord must not get between the ball and the detector during data collection.

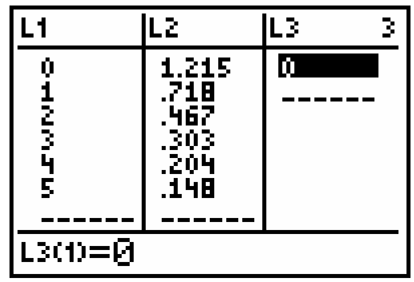
5. The activity is best done by a group of three students: one to hold the detector, another to release the ball, and a third to operate the calculator.

6. Hold the ball from the sides, and release it by quickly moving hands outward and out of the detection cone of the Motion Detector.

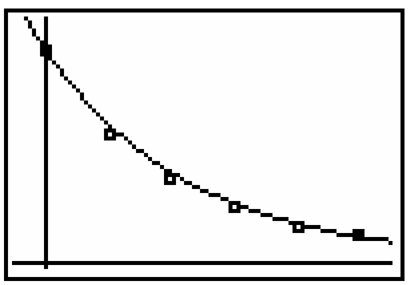
SAMPLE RESULTS



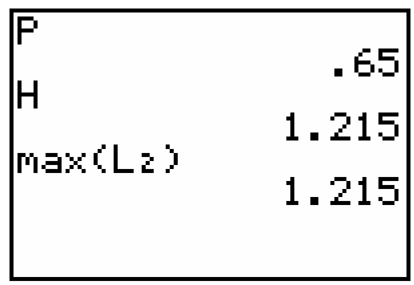
Collected bounce data from EasyData



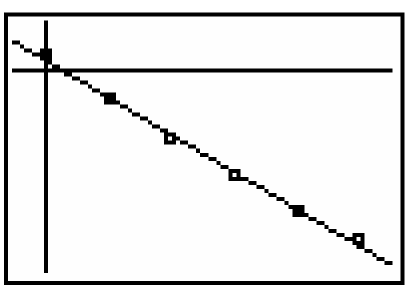
Rebound data in Lists



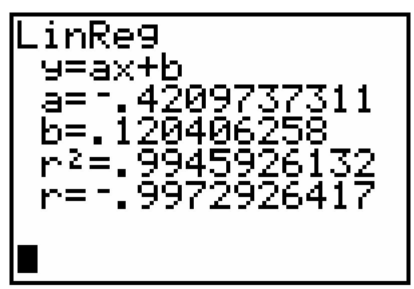
Rebound height *vs*. bounce number



Model parameters



ln (bounce height) *vs*. bounce number



linear fit of ln(bounce height) *vs*. number

DATA TABLE

Bounce number	Maximum height (m)
0	1.215
1	0.718
2	0.467
3	0.303
4	0.204
5	0.148

ANSWERS TO QUESTIONS

1. At $x = 0$, then $y = hp^x = h$, since $p^0 = 1$ regardless of the value of p. (Well, as long as $p \neq 0$!)

2. A model equation that fits the observed exponential is $y = 1.215 * (0.65)^x$.

3. $y = -0.420x + 0.120$.

4. The linear regression fits the log graph very well. It looks like we have a good model for the behavior of the bouncing ball.

5. From the identical position of $\ln p$ and a in the model and regression equation, they must have the same value. $\ln h$ and b have the same relationship. The numerical values are very similar, with $\ln p = -0.43$ and $a = -0.42$, and $\ln h = 0.19$ and $b = 0.12$.

6. If the less-resilient ball were dropped from the same starting height, then the h values would be the same. However, the less-resilient ball wouldn't bounce as high so p would be smaller.

7. Using the original model, we have the following computation. Since the number of bounces has to be an integer, it would take a total of **six** bounces to reach a rebound height of less than 10% of the initial value. This result will depend both on the ball and on the surface on which the ball is bouncing.

$$y = 1.215(0.65)^x$$
$$0.1 = 0.65^x$$
$$\ln(0.10) = x\ln(0.65)$$
$$x = 5.25$$

