

TEACHER INFORMATION

What Goes Up: Position and Time for a Cart on a Ramp

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
cableUSB
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.

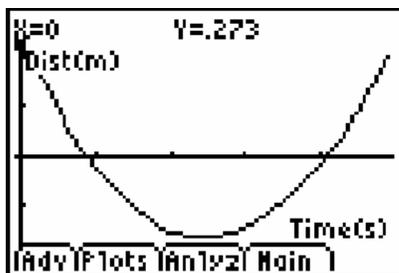
Option III—the Go! Motion connects to the TI-84 Plus graphing calculator's USB port using a Calculator USB cable (order code: GM-MINI) sold separately by Vernier Software & Technology.

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.

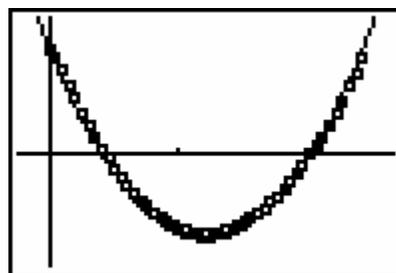
Activity 10

3. A four-wheeled dynamics cart is the best choice for this activity. (Your physics teacher probably has a collection of dynamics carts.) A toy car such as a Hot Wheels or Matchbox car is too small, but a larger, freely-rolling car can be used. A ball can be used, but it is very difficult to have the ball roll directly up and down the ramp. As a result the data quality is strongly dependent on the skill of the experimenter when a ball is used.
4. If a channeled track which forces a ball to roll along a line is used as the ramp, a ball will yield satisfactory data.
5. Note that the ramp angle should only be a few degrees above horizontal. We suggest an angle of five degrees. Most students will create ramps with angles much larger than this, so you might want to have them calculate the angles of their tracks. That will serve both as a trigonometry review and ensure that the ramps are not too steep.
6. It is critical that the student zeroes the Motion Detector in a location that will be crossed by the cart during its roll. If the cart does cross the zero location (both on the way up and the way down), there will be two x -axis crossings as required by the analysis. If the student does not zero the Motion Detector, or zeroes it in a location that is not crossed by the cart during data collection, then the analysis as presented is not possible.
7. If the experimenter uses care, it is possible to have the cart freely rolling throughout data collection. In this case (as in the sample data below) there is no need to select a region or adjust the time origin, saving several steps.

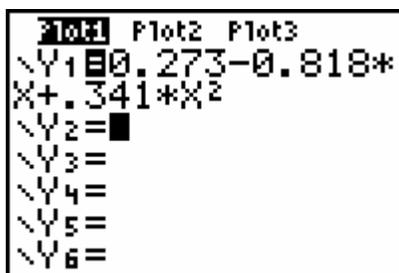
SAMPLE RESULTS



Raw Data in EasyData



Data with parabolic model



Model equation

DATA TABLE

y-intercept	First x-intercept	Second x-intercept
0.273	0.40	2.0

Product of x-intercepts	0.8
Sum of x-intercepts	2.4

<i>a</i>	0.341
<i>b</i>	-0.818
<i>c</i>	0.273

ANSWERS TO QUESTIONS

1. Model equation is $y = 0.273 - 0.818x + 0.341x^2$ (depends on data collected).
2. Model parabola is an excellent fit, as expected since the vertices were taken from the experimental data.
3. Regression quadratic equation is $y = 0.285 - 0.797x + 0.326x^2$, or nearly the same as that obtained using the vertex form.
4. The parameters in the calculator's regression are nearly the same as those determined from the vertex form of the equation.
5. The Motion Detector records distance *away* from itself. Since the detector was at the top of the ramp, the cart was at its closest (minimum distance) to the detector when the cart was at its highest point.
6. If the experiment were repeated with the Motion Detector at the bottom of the ramp, the distance data would still be parabolic. However, the parabola would open downward, and the coefficient a would change sign.