

**TEACHER INFORMATION****Meet You at the Intersection:  
Solving a System of Linear Equations**

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. This activity requires two Motion Detectors. If a Vernier LabPro interface is used, both detectors can be connected to a single interface. If the TI CBL 2 is used, or you are connecting your Motion Detectors directly to a calculator, you must use two interfaces/detectors and two calculators, and then transfer data to a single calculator for analysis.

### Activity 30

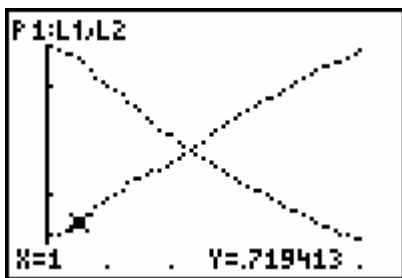
LabPros must have ROM version number 1.13 (code from TI) or 6.13 (code from Vernier), or newer. ROM versions x.12 and older do not fully support two Motion Detectors. To determine ROM version, notice the numbers shown on the title screen as EasyData is launched. For updates to ROM (also called firmware), see [www.vernier.com](http://www.vernier.com).

- 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.
- Place the Motion Detectors at waist-high level for each walker. The walkers should never be closer than 0.5 meter to the detectors. Clear the area of other materials such as desks or chairs.
- The walkers must maintain a constant and slow rate while walking directly toward or away from the Motion Detectors.
- The point-slope form of the line is used in this activity in case the walkers were not moving at the time data collection started. By using two points along the uniform motion portion of the graphs, the model lines will not be influenced by poor-quality data at the  $t = 0$  point.
- If your students have not seen the idea of solving a system of equations (Step 11) you may need to provide the following hint:

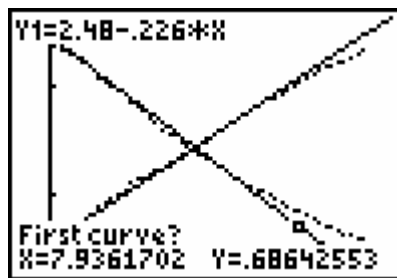
One easy way to solve this system of equations is to set the  $x$  sides equal to each other. After all, both are equal to  $y$ . You'll have an equation for  $x$ ; solve for  $x$  and find the value. Once you have your value for  $x$ , you can insert it in either equation to find the matching  $y$ .

This step of finding the solution to the system of equations is important for students to perform so that the calculator-provided solutions are verified. The activity has students find the intersection time and place by direct measurement, by graphical means, by the calculator intersection function and by solving the system of equations.

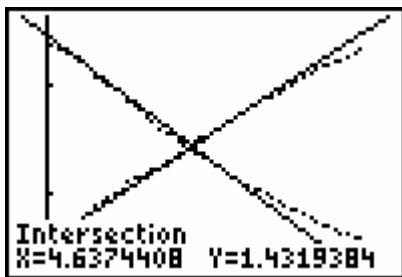
### SAMPLE RESULTS



Data from both walkers



Model lines with walker data, also first step of intersection search



Intersection search result

**DATA TABLE**

	<b>direct measure</b>	<b>graphical trace</b>	<b>calculator intercept search</b>	<b>solve equation system</b>
<b>intersection time</b>	4.5 s	4.60 s	4.63 s	4.63 s
<b>intersection position</b>	1.4 m	1.40 m	1.43 m	1.43 m

	<b><math>x_1, y_1</math></b>	<b><math>x_2, y_2</math></b>	<b>slope</b>	<b>intercept</b>
<b>walker one</b>	1.0, 2.26	6.0, 1.13	-0.226 m/s	2.48 m
<b>walker two</b>	1.0, 0.719	6.0, 1.70	+0.196 m/s	0.523 m

**ANSWERS TO QUESTIONS**

1. Walker one walks toward the detector, so the slope of that graph has decreasing values, or the negative slope graph.
2. Each model line fits the graph well, except at the end of data collection. It looks like the walkers did not maintain quite a constant speed as instructed.
3. The intersection values are all consistent with one another, although they are not identical. The calculator search intersection and the intersection from the solution to the system of equations are identical.
4. Yes, the walkers could both move away at the same speed from the detectors, starting at slightly different positions. Then the graphs would be parallel.
5. If one walker stood still, and the other moved out past the first and then back, again past the first walker, then there will be two intersections. The key is that the velocities of at least one walker must not be constant.