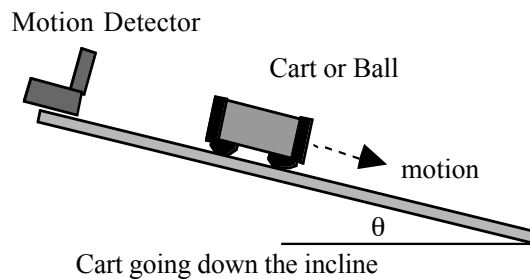


Going Downhill – EZ

Introduction:

This lab will serve as an introduction to some of the processes and features you will use in the next few weeks of your physics class as you study how the world works in more detail.

In the diagram, a dynamics cart or a ball is released to roll down an inclined plane. Ultrasonic chirps from the Motion Detector are used to track the resulting motion and the graphs that follow provide a picture of the motion.



In this version of the lab, you will employ a graphing calculator to acquire the data, to display the graphs and to analyze the graphs.

Purposes:

- Study the motion of an object rolling down an incline.
- Learn how to use the data collection hardware and software.

Equipment:

Inclined plane (ramp or dynamics track), laboratory cart or ball, protractor, graphing calculator: TI-83+ or TI-84+, motion detector: Vernier Go! Motion or TI CBR2 or Vernier Motion Detector and LabPro or Vernier Motion Detector and CBL2.

Setup:

1. Set up the inclined plane or dynamics track as shown above with an angle of approximately 2° .
2. **Go! Motion or CBR2:** Connect the motion detector directly to your TI-84+ using the USB-to-Mini-USB cable or a mini-phone jack link cable. Connect the motion detector to your TI-83+ using a mini-phone jack link cable.
-OR-
Vernier Motion Detector: Connect the motion detector to your LabPro or CBL2, plugging it into the Dig/Sonic port. Power the interface with batteries or an external power supply. Connect the calculator to the interface using the appropriate link cable.
3. Launch *Easy Data* by pressing **APPS** then using **▼** to navigate to *EasyData*. When it is highlighted, press **ENTER**.
4. The default data collection scheme is a Time Graph lasting 5 seconds. This is shown right above the menu items. To **change the time for data collection**, use these steps:
 - a. Press the button under **Setup**
 - b. Press **2** to select **Time Graph...**
 - c. Press the button under **Edit**
 - d. Press the button under **Next** to keep the time between samples at 0.05 second (20 samples/s)
 - e. Use the left-arrow key and **[DEL]** to erase the 100 then type **60**
 - f. Press the button under **Next** to learn that data collection will last 3 s
 - g. Press the button under **OK**

Procedure:

1. Set the cart or ball on the incline so it is at least 15 cm away from the motion detector.
[This distance must be at least 50 cm if your Vernier Motion Detector has the older blue case.]
2. Initiate data collection by pressing the button under **(Start)**. When clicks are heard coming from the Motion Detector or Go! Motion, release the cart or ball to roll smoothly down the incline. Go to the **Analysis** section.
3. When you have completed your analysis with one angle, repeat for a different angle if asked by your instructor.

Analysis:

1. Examine the position vs. time graph. You should have one section that is smoothly curved beginning at your starting position and going to the end of the incline. Focus your attention on this section:
 - a. Press the button under **[Anlyz]**
 - b. Press **7** to select **Select Region...**
 - c. On next screen press the button under **(OK)**
 - d. Use the right-arrow key to move the blinking cursor to the beginning of the curved section then press the button under **(OK)**
 - e. Use the left-arrow key to move the blinking cursor to the end of the curved section then press the button under **(OK)**
2. Describe the shape of the graph line. Is the curvature uniform, or does it curve more rapidly either at the beginning or at the end? Which? What does this tell you about the motion of your cart or ball?
3. Check for linear fit:
 - a. Press the button under **(Anlyz)**
 - b. Choose **Linear Fit** by pressing **2**
 - c. You will be presented with the values for **a** and **b** in the equation $y = ax + b$. Note that these are the same as **m** and **b** in $y = mx + b$.
 - d. Press the button under **(OK)**
 - e. The next screen shows your original data points and then the linear fit line plotted over them. How well does this fit? This visual display allows you to see the degree to which your function is the one you are seeking.
4. Check for quadratic fit:
 - a. Press the button under **(Anlyz)**
 - b. Choose **Quadratic Fit** by pressing **3**
 - c. You will be presented with the values for **a**, **b** and **c** in the equation $y = ax^2 + bx + c$. Record these values in the data table in these instructions.
 - d. Press the button under **(OK)**
 - e. The next screen shows your original data points and then the linear fit line plotted over them. How well does this fit? This visual display allows you to see the degree to which your function is the one you are seeking.
5. To examine the velocity vs. time graph, press the button under **(Plots)**. Type **2** to choose **Vel(m/s) vs Time**.
6. You should have one section that is smoothly changing. Describe the shape of the graph line. Is the value constant, or does it change over the course of the run? Which portion has the larger value, the beginning or end of the run? What does this tell you about the motion of your cart or ball?

7. For your velocity vs. time graph, repeat step 3 above. How well does a straight line fit with the data you collected? If it fits well, repeat step 3, this time recording the values for **a** and **b** in your data table.
8. According to theory, in the position graph your coefficient **a** is 1/2 of the acceleration. Based on this, what is the acceleration **a₁** of your cart or ball?
9. The slope of a velocity vs. time graph is the acceleration. Based on the velocity graph, what is the acceleration **a₂** of your cart or ball?
10. Compare the two values you obtained for acceleration by calculating the percentage difference:

$$\% \text{ difference} = |\text{difference}| / \text{average} = |a_1 - a_2| / (1/2 (a_1 + a_2))$$

Data Table:

Quantity	Units	Run 1	Run 2
Angle, θ			
<u>Position Graph</u>			
a			
b			
c			
a₁			
<u>Velocity Graph</u>			
a			
b			
a₂			
% Difference			

Ending:

To conclude your data collection, press the button under $\sqrt{\text{Main}}$. Then press the button under $\sqrt{\text{Quit}}$. The screen that appears shows you where your data is stored in the calculator. If you are going to examine it further, you need to know this information so note it. If you are going to upload the data to a computer using Logger Pro, you will need to know which lists the data is stored in, also. Now press the button under $\sqrt{\text{OK}}$ to exit *EasyData*.