Motion on an Inclined Plane

Purpose: To find the mathematical model for displacement (Δx), velocity (v) and acceleration (a) vs. time for an object starting form rest and rolling down a (fairly) frictionless inclined plane or ramp.

"TELL ME,BERNIE;WHEN DID WE START GOING DOWNHILL?"

You will either be using a cart and an inclined air track, a cart and a metal ramp, or a ball and a ramp with one photogate at the start and one at the finish. As the cart/ball passes through the first photogate it starts the time and as it passes through the second photogate it stops the time. Find this time for at least 6 different displacements, 3 trials each. Displacement is the difference in position between photogates (for example, if one photgate is at 15.0 cm and the other is at 67.0 cm, the displacement is 67.0cm–15.0cm = 52.0cm). Make sure you always start the cart/ball from rest!!!! Also a small angle of incline makes for larger times and greater accuracy.

Do your hypotheses for each of the mathematical models before you begin the experiment!!!

Not sure what the graphs will look like? Experiment with a motion detector connected to a LabPro and a computer. Open LoggerPro3. Go to **File>Open>Probes and Sensors>Motion Detector>Motion Detector.cmbl**. The screen that comes up should have 3 graphs: position, velocity and acceleration vs time. If the "Collect" button is not green, go to **Experiment>Connect Interface>LabPro** and choose **USB.** Try walking with a motion similar to what the cart/ball will have on the hill. Print your graphs as part of your hypothesis (you still need to write out your hypothesis in words and explain how you walked to make the graphs).

PROCEDURE NOTES:

Set-up for LabPro and Computer:

Connect LabPro to computer. Hook first photogate into DIG1 and second photogate into DIG2 of LabPro. . Go to **File>Open>Probes and Sensors>Photogates>Pulse Timer-Two Gates.cmbl**. If the "Collect" button is not green, go to **Experiment>Connect Interface>LabPro** and choose **USB.** Begin data collection. In the table, record the value under "Time from Gate 1 to Gate 2 (s)" or "PT (s)". "PT" stands for "Pulse Time".

Set-up for LabQuest:

Daisy chain photogates as shown to the right. Plug the first photogate into DIG1 of the LabQuest. Tap "Mode". Change "Photogate Mode" to "Pulse" and select "OK". Tap the data table button (the middle button in the upper right). Begin data collection. You should see a table like the one below. Record the time under "Pulse (s)" which gives the time to pass from one gate to the other.

Time (s)	Gate State	Pulse (s)	Velo (m/s)
0.0000	Blocked		
0.22140	Unblocked		
1.42756	Blocked	1.427562	0.350
1.690686	Unblocked		

Ignore "Velo (m/s)"—that gives an average velocity if you program the LabQuest with the distance between gates.

Data Analysis:

1. Use "Logger Pro" to graph "Δx vs t". Even though Δx is your independent variable, graph it on the y-axis. Find the mathematical model.

2. Instantaneous velocity is given by the slope of the tangent to the "Δx vs t" curve at any particular time. You will be putting your equation or mathematical model for "Δx vs t" into a TI-83 calculator. Follow attached instructions for finding the slope of the tangent at 6 different times. (time is the x-value on the calculator, velocity is the slope of the tangent.) Make a table of these values. Use "Logger Pro" to graph "v vs t". Find the mathematical model.*

3. Acceleration is $a=\Delta v/\Delta t$ which is the slope of your "v vs t" graph. Draw an "a vs t" graph and find the mathematical model.*

4. Compare the acceleration to the value of the slope in your "Δx vs t" graph. How do these two numbers compare? Write a general equation for Δx in terms of a and t.

***DON'T FORGET to describe the process for getting values for your velocity and acceleration graphs in your data analysis section.**

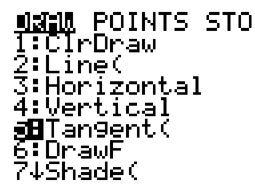
Finding Slope of Tangent With TI Calculators

After performing the inclined plane lab, you should obtain a graph whose equation is $x = kt^2$. To determine the instantaneous velocity at a given time, find the slope of the tangent to the curve, using a TI calculator.

1. Enter your equation using the [y=] key. Choose [window]. Set Xmin to 0, and Xmax to include your greatest time. If you set the Ymin= –10 then the x-axis is far enough above the bottom of the screen to not interfere with the values displayed when you trace along the curve. Set Ymax to include your largest displacement.

2. Choose [graph] to display the graph in the window you've just sized.

3. Now choose the [draw] function, [2nd][prgm], and choose 5: Tangent. Type in the desired x-value or time, then hit [enter]. The calculator draws a tangent line and gives you its equation from which you can get the slope.



You can draw as many as 6 tangents to the curve (by repeating step 3) w/o getting too confused. If you'd like to clean things up, you can go back to the [draw] function, [2nd][prgm], then choose 1: ClrDraw; that erases the tangents, while leaving the original parabola. Then, go back to [window] and reset the value of Xmax, and you're ready to go on.

Anyway, use these values for a plot of v vs t using LoggerPro.