Lab ~ Changing Motion & Error

Prelab

1. Can one have a constant speed in the presence of an acceleration that acts along the line of motion?

ANS: Yes, a body can have a constant speed and still be accelerating. For example you **revolve a stone connected by a string in a circular motion**. You will notice the stone rotates with a constant speed and yet have a centripetal acceleration which is directed towards the centre of the circle. The line of motion in this case is circular.

2. Can one have a constant velocity in the presence of an acceleration that acts along the line of motion?

ANS: An object with a constant acceleration should not be confused with an object with a constant velocity. Don't be fooled! If an object is changing its velocity -whether by a constant amount or a varying amount - then it is an accelerating object. And an object with a constant velocity is **not accelerating**.

3. Can instantaneous velocity and average velocity have the same value? If you think 'yes', give an example.

ANS: If **the object is moving with a constant velocity**, then the average velocity and instantaneous velocity will be the same.

4. Make a v-t graph for the following cases of one dimensional motion.
    a. A person walks at constant negative acceleration. The person starts walking at x = +5 m.
    b. A person experiences positive acceleration, which increases at a small constant rate. The person starts with an initial speed -2 m/s.
5. Complete Error exercise from class.

Experiment

Purpose of Experiment

To get familiar with the use of lab software and motion detector.

Activity 1 ~ Making Velocity and Position Graphs

Using the Ipad, Graphical GW, and the godirect motion detector you will create position-time and velocity-time graphs.

Procedure

1. Open Graphical GW on the Ipad, then open a new experiment. Select wireless device, choose the correct ID# of your motion detector.

2. Set collection time to 10 seconds:

3. Click on the collect button when you are ready to collect data. Data collection will stop after 10 seconds.
4. Walk away from the detector slowly and steadily. Repeat until you make nice smooth graphs. Screenshot your graphs and share them either by airdrop to a lab members phone to be shared with your group or by email.
5. Walk toward the detector slowly and steadily, stand still for 2 seconds, then walk away from the detector fast and steadily. Screenshot your graphs and share them with your lab group.

Analysis

1. In 4, was the acceleration constant or changing? How can you tell?
2. In 5, describe the acceleration.

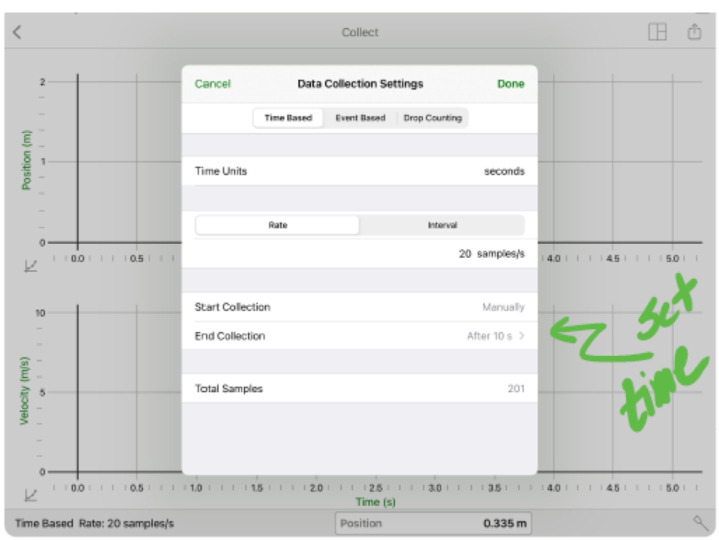
Activity 2 ~ Calculating Average Velocity and other Statistics

Using the Ipad, Graphical GW, and the godirect motion detector you will create position-time and velocity-time graphs.

Procedure

1. Open Graphical GW on the Ipad, then open a new experiment. Select wireless device, choose the correct ID# of your motion detector.
2. Set up your dynamics track (use 2 m track), end stop, and motion detector as shown below. The angle should be between 5 and 10 degrees.

3. For the first trial, begin with the cart at the top of the incline. Click on the collect button



and release the cart when you are ready to collect data. Data collection will stop after 5 seconds. Screenshot your graphs and share them with your lab group.

4. Select the graph icon in the lower left corner of the graph, turn on interpolate. This will allow you to view the x and y coordinate for any point along the curve just by selecting that point. Read 10 values of velocity along a portion of your graph where the velocity is smooth, use them to calculate the average (mean) velocity in excel.

5. Select view statistics and set the boundary of data to be evaluated. This will give you statistical data for your curve. How does your calculated mean compare with the statistical mean? Screenshot your graph with the statistical information visible and share them with your lab group.

6. Select curve fit then linear fit. Set the boundary for the data. This will give you the equation for the best fit line. Screenshot your graph with the equation for the line information visible and share them with your lab group. How does the velocity from the position time graph compare to the velocities in 4 and 5.

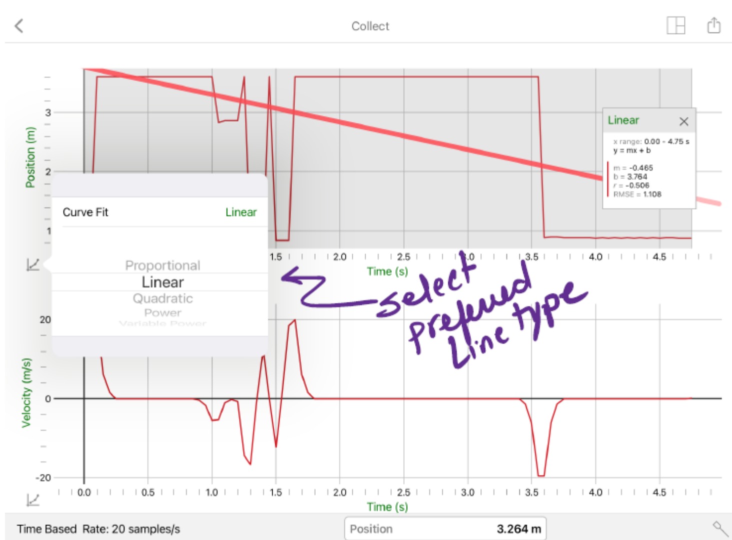
7. For the second trial, begin with the cart at the bottom of the incline. Click on the collect button and push the cart up the ramp when you are ready to collect data. Data collection will stop after 5 seconds. Screenshot your graphs and share them with your lab group. Repeat steps 4, 5, and 6 for this scenario.
8. Under Analyze select Tangent. This will give you the slope of the line at any specific point. What does the slope of the line represent? Identify the slope when the cart was on the way up and at the top. What did you discover about the acceleration at each of these points?
9. View and export the data for your graph as a csv file.

Analysis

1. Was the acceleration constant or changing in each case? How can you tell?
2. Was there any point in the motion where the velocity was zero? Explain.
3. Was there any point in the motion where the acceleration was zero? Explain.

Activity 3 ~ Error Analysis

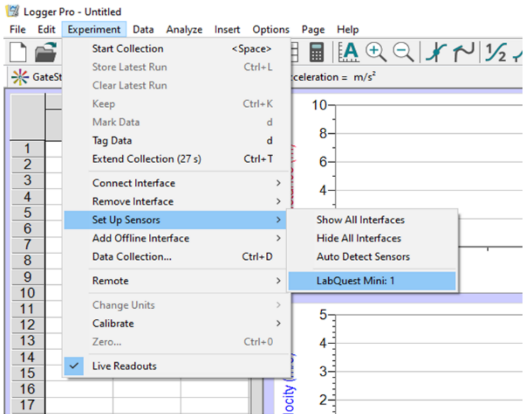
Using the laptop, Loggerpro, photogate, and picket fence you will create position-time and

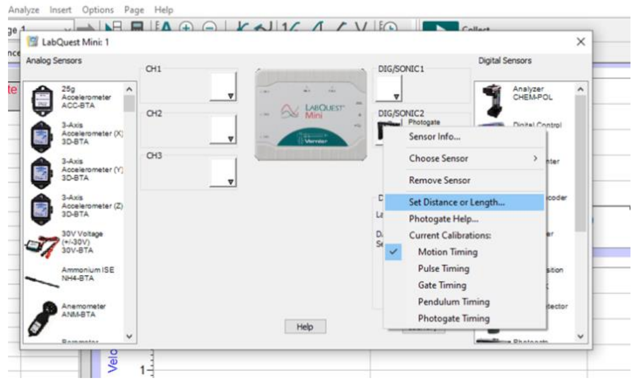


velocity-time graphs. You will use a photogate to determine the acceleration of a freely falling object. Once you complete this exercise you will answer the following questions:

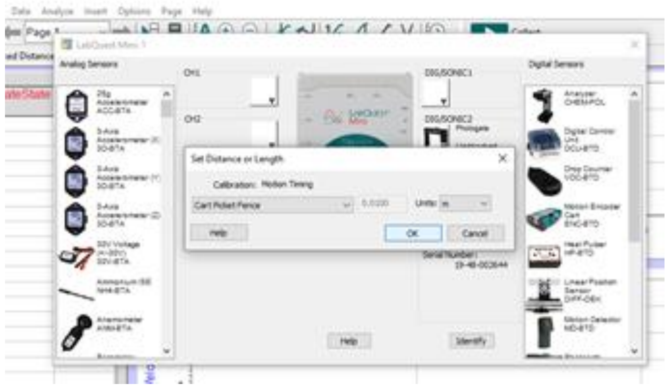
> How do I decide if the value I obtained is “close enough” to the accepted value?
>
> If I were to repeat the experiment several times, within what range would I expect my values to fall?

Procedure

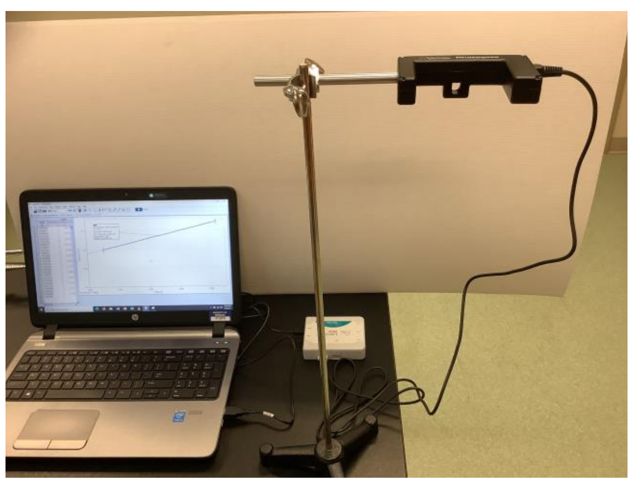




1. Connect the photogate to the LabQuest Mini. Connect the LabQuest Mini to the computer



and open LoggerPro. Make sure the sliding door on the photogate is open.



2. Fasten the photogate to a support rod as shown. Make sure the photogate is horizontal.

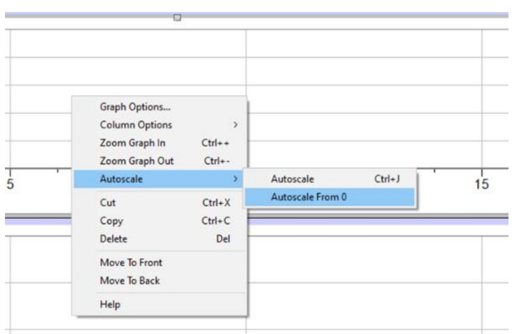
3. Set up data collection in LoggerPro.
    a. Experiment/Set up Sensors/LabQuest Mini/Set Distance or Length
    b. Select cart picket fence.

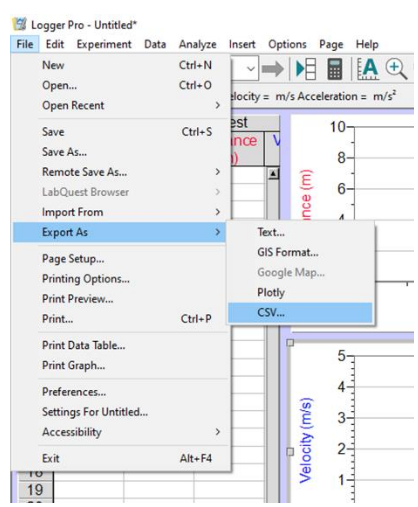
c. Remove all graphs except the velocity-time graph. Right click on the graph an select autoscale from 0.

4. Hold the picket fence vertically just above the photogate, start collecting data, and release the picket fence. Make sure that it does not strike the photogate as it passes through the arms.
5. Using the tools in the toolbar, perform a linear fit on the graph of velocity-time. Use SNIP to save a copy of your graph. Take a moment to discuss what the slope and intercept of the line of best fit represent.
6. Export the data associated with this graph as a csv file.
7. Based on your discussion, predict whether either of these quantities would change if you were to drop the picket fence through the photogate from a higher point. Test your prediction.
8. To see how repeatable the values of the slope are, repeat Steps 4 and 5 three more times. Be sure to record your values of the slope and intercept for each trial.

Analysis

1. How do you account for the fact that the values of the slope were nearly the same, whereas the values of the intercept were much more variable?
2. It is highly unlikely that you obtained identical values of the slope of the best-fit line to the velocity-time graph for each of your trials. How might you best report a single value for the acceleration due to gravity, a_g, based on your results? Perform the necessary calculation in excel.
3. How does your experimental value compare to the generally accepted value (from a text or other source)? Determine the percent difference between the value you reported and the generally accepted value. Note that if you simplify your units of slope, they will match those





of the reported values of a_g.

Activity 3 Continued ~ Error Analysis

Your determination of the percent difference does little to answer such questions as, "Is my average value for a_g close enough to the accepted value?" or "How do I decide if a given value is too far from the accepted value?" A more thorough understanding of error in measurement is needed. Every time you make a measurement, there is some *random error* due to limitations in your equipment, variations in your technique, and uncertainty in the best-fit line to your data. Errors in technique or in the calibration of your equipment could also produce *systematic error*. We'll address this later in the experiment. In order to better understand random error in measurement, you must return to your experimental apparatus to collect more data.

Procedure

1. Begin the data-collection program as you did before and drop the picket fence through the photogate another 20 times, bringing the total number of trials to 25. Since you are now investigating the variation in the values of a_g, you need only record the value of the slope of the best-fit line to the velocity-time graph for each trial.

   To facilitate the evaluation of the data you must add it to your excel file and create a representative table. Determine the average value of a_g for all 25 trials. How does this compare with the value you obtained for the first 5 trials? In which average do you have greater confidence? Why?

2. Sort the data in ascending order and construct a histogram to display the frequency of the values of a_g you have obtained. You will need to decide how best to configure the features of the histogram so as to represent the distribution of your values in the most meaningful way.

   In what range (minimum to maximum) do the middle 2/3 of your values fall? In what range do roughly 90% of the values closest to your average fall? Use excel to generate the statistics of your histogram.

3. One way to report the precision of your values is to take half the difference between the minimum and maximum values and use this result as the uncertainty in the measurement. Determine the uncertainty in this way for each range of values you determined in Step 2. In what place (tenths, hundreds, thousandths) does the uncertainty begin to appear? Discuss whether it is reasonable to report values in your average beyond the place in which the uncertainty begins to appear. Round your average value of a_g to the appropriate number of digits and report that value plus the uncertainty.

Analysis

1. **Standard Deviation** When you obtained the statistics for your histogram, you may have noticed that, in addition to minimum and maximum values, and the mean and median, the standard deviation (std. dev.) was also provided. In excel calculate the standard deviation of your raw data. Write a brief explanation describing what standard deviation measures. If the standard deviation for your values of slope were four or five times as great as it was, how would that affect the shape of your histogram?

2. The value for a_g varies according to your location. Do a web search for "Earth gravity" and explain why the value varies.