Purpose:

* Determine the acceleration of a cart on an incline plane through graphical methods.
* Determine an experimental value of g by interpreting the acceleration of the cart as a component of g.

Equipment:

LabQuest Mini with USB cord	Dynamics cart
Computer with LoggerPro software	Incline plane & support blocks
Photogate and Photogate cord	Ring stand
Picket fence	Meter stick

Introduction:

When an object experiences free fall, it accelerates at a rate of –9.80 m/s^2 due to the force of gravity. This rate of acceleration affects all objects, as long as the objects move in a vertical direction and the effects of air resistance are ignored. However, an object is also accelerated by gravity even when its path is not strictly in a vertical direction. This lab will investigate the acceleration of gravity acting on a cart as it travels down an incline plane. It is modeled from an experiment originally performed by Galileo. Due to the difficulty in obtaining accurate measurements of objects in free fall, (he used his pulse to keep time), Galileo used objects on an incline plane, minimizing the gravitational component.

To analyze the acceleration of an object on an incline plane, we must remember that the acceleration of gravity is a vector, pointed directly towards the surface of the Earth. Thus, since the path of the cart is not strictly vertical, it does not experience the full effects of the acceleration of gravity. Instead, the acceleration of gravity can be thought of as a resultant vector, labeled as vector a_g, and broken down into two vector components as shown in the diagram below.
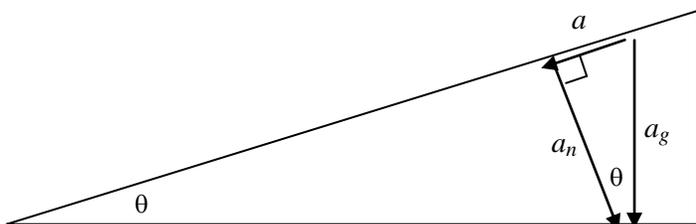

One acceleration vector component is directed with the motion of the cart as it travels down the incline plane. This vector is labeled as a in the diagram at left, as it determines the actual acceleration of the cart. The second acceleration vector component is directed into the incline plane and has no effect on the cart's motion, since it acts at a right angle to the path of the cart. This vector is labeled as a_n in the diagram at left, as it is a "normal" acceleration vector.

From geometric relations, we can also show that the angle of incline of the plane is equal to the angle θ between vectors a_g and a_n in the diagram above.

Procedures:

Place a support block approximately 10 cm in height under one end of the incline plane. Take appropriate length measurements to determine the angle of incline, θ_1, of the plane, recording your calculated angle in Data Table A.

Securely attach the picket fence to the dynamics cart so that it is positioned lengthwise and upright, as shown in the diagram at right.
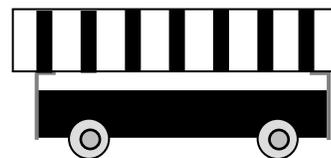
Procedures: *(cont)*

Securely attach the photogate to a support stand. Position the support stand so that the photogate extends over the incline plane. Turn the photogate head downwards so that the picket fence can move horizontally through the photogate as the cart rolls down the incline plane. Experiment with the cart and picket fence combination on the incline plane, making sure that the picket fence moves freely through the photogate as the cart rolls down the incline plane.

Insert the plug of the photogate cord into the DIG I port of the LABQUEST. Use the USB cord to connect the LABQUEST to the computer. Then open the "*Lab #3 Template*" LOGGERPRO file from the class web site or Shared folder.
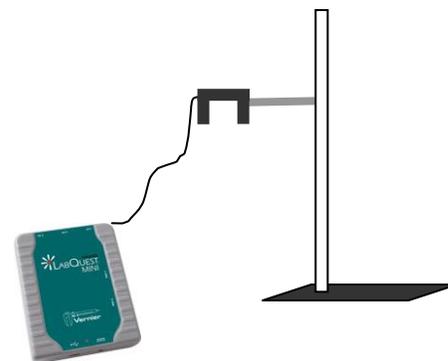
Position the cart at the top of the incline plane. Then click the green COLLECT button on the LOGGERPRO toolbar. Carefully allow the cart to roll down the incline plane. Be sure to have a member of your lab group catch the cart when it reaches the bottom of the incline plane.

Use the ANALYZE → AUTOSCALE commands to view the data collected. If necessary, repeat the experiment until the data collected is acceptable for analysis. Then save the LOGGERPRO file for Trial #1 on your home folder for future analysis. Repeat the experiment until you have obtained two additional data sets that are suitable for analysis. Save the data for these trials as well, being sure not to overwrite the file containing your previous trials.

Increase the support block under the incline plane to approximately 25 cm in height. Repeat the length measurements to calculate the new angle of incline and record this angle in Data Table B. Conduct three trials for the large angle of incline as well, saving each trial in a separate LOGGERPRO file.

Calculations:

Calculate the angle of incline for Data Table A and Data Table B. Include any measurements used for this calculation in your report.

Use the ANALYZE → CURVEFIT command to produce an appropriate regression line to determine the acceleration of the cart as it rolls down the incline plane. Print copies of your data, graphs and regression line from one of your trials to include in your report. *(NOTE: For best printing results, use the FILE → PAGE SETUP command to change the orientation to landscape and the FILE → PRINTING OPTIONS command to add a footer with your Name and Trial #.).*

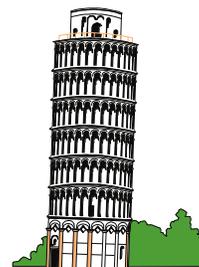Calculate the average acceleration of the cart for Data Table A and Data Table B.

Calculate an experimental value for the acceleration of gravity using the angle of incline and average acceleration of the cart for Data Table A and Data Table B. Include a vector diagram explaining your calculations in your report.

Calculate the percent error for Data Table A and Data Table B.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Discuss the accuracy of your calculations for the acceleration of gravity. What factors would contribute to any differences?

- What type of regression line did you use to calculate the acceleration of the cart? Why did you choose this particular regression line to make your calculations?

- Legend has it that Galileo performed another experiment in which he dropped two objects, one heavy and one light, from the Tower of Pisa. They both reached the ground at the same time. Have you done anything in your experiment that would verify this result? If so, what? If not, briefly describe modifications that would address this issue.

Data Table A: Low Angle of Incline

Angle of Incline = _____

	Acceleration of the Cart
Trial #1	
Trial #2	
Trial #3	
Average	

Experimental Value of g = _____

Error (%) = _____

Data Table B: High Angle of Incline

Angle of Incline = _____

	Acceleration of the Cart
Trial #1	
Trial #2	
Trial #3	
Average	

Experimental Value of g = _____

Error (%) = _____

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations – 8 pts
Analysis – 7 pts