Galileo's Experiment – Lab 2 College Physics

In this lab you will make quantitative measurements of the motion of a rolling ball down an incline in similar fashion to 17^{th} century Galileo. From the measurements you should be able to decide if Galileo's definition of acceleration was appropriate ($d \propto t^2$, that is: the distance is proportional to the square of the time). Given the limitations of time measuring devices in Galileo's time, a method to slow down motion was devised. Galileo studied rolling balls on gentle inclines rather than freely falling objects because he believed that in both cases, objects underwent uniform acceleration. Galileo's definition of uniform acceleration was "equal increases in speed in equal times".

Pre Lab Questions:
1. List some observations that led people of Galileo's time to believe that heavier objects fall faster than light objects.
2. Drop two different size balls from the same height at the same time. Did the larger one hit first, last, or at the same time?
3. What would happen if you again simultaneously dropped the two balls, but this time released the small ball from a distance 30 cm above the larger ball. Would the distance between the two balls increase, decrease, or remain the same while they fall?

Procedure 1: The Old Fashion Way…
You will set up a gentle inclined 2m V track with a stop block at the end. You will use a stopwatch to measure your time intervals. Keeping orderly records, you will measure the times of descent for several different distances, keeping the angle of inclination the same and using the same ball. Repeat EACH descent distance four times and determine the average time for each distance. Hint: Starting the ball at the top by using a ruler to release it will yield more consistent results.

From your data collected, plot a graph of distance vs. $time^2$. If your two quantities are indeed proportional as Galileo predicts then you should see a distinctive pattern emerge.

Using the relationship $d = ½ a t^2$ calculate the acceleration for each of your distances used.

Procedure 2: The Modern Way…
Using the same incline, position a sonic ranger at the top of the track so that the sonic head is aimed down the track to sense the rolling ball. Secure into a usable position and connect to your interface. Position your ball about 40 cm from the detector, using a ruler to aid in its uniform release. Start your sonic ranger and release the ball once you hear the ranger begin to click. **Neatly sketch** your position vs. time graphs and your velocity vs. time graphs for the motion recorded.

Click on the velocity vs. time graph. Using the examine tool, move the cursor to a point that corresponds to approximately 25% down the incline. Record in a data table that you construct the information for time and velocity for each of the next ten points, each 0.2 seconds apart. Add a column that shows the change in speed between successive points.

Determine the slope of your **v** vs. **t** graph and the average value of acceleration. Show your work.

Try fitting various functions to the position vs. time curve using the function icon. Choose the simplest function fits your data well. Record the equation and the parameters of the fitted equation. Repeat with your velocity vs. time graph. Be sure to include all curve fit information.

Analysis:

1. Does your data support or refute Galileo's definition of uniform motion, "equal increases in speed in equal intervals of time" for each of the two methods? Explain.
2. Was Galileo's assumption of constant acceleration for motion down an incline valid? How does your data support your answer?
3. Look at the curve fit of the velocity vs. time graph. Does the fitted function have a constant slope? What are the units? Record the slope data.

Extensions:

1. Use the motion detector to examine the acceleration of a rubber ball in free fall. The detector should be positioned on the ceiling. Relate your observations to the Galileo experiment. Determine the acceleration of the ball and compare it to the accepted value of 9.8 m/s^2. Find the percentage error.

2. Using a sonic ranger and calculator, secure the sonic ranger at the top of a gentle inclined V track as before. Set the ranger to record velocity. Roll a ball gently UP the track toward the ranger so that it comes within about 40 cm and then starts back down the incline again. Practice a few times. Record the motion of the ball as it experiences an up and down the track motion to the down only motion earlier in this lab. Is the acceleration the same value throughout the entire up and down motion? Is the velocity always the same sign?