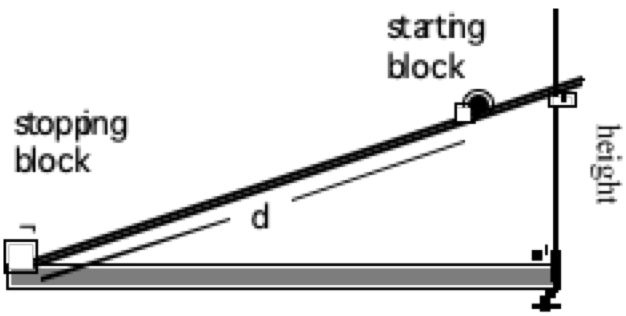
Experiment 3

GALILEO'S INCLINED PLANE and FREEFALL

EQUIPMENT

Graphing program	*1 aluminum rail track*
Galileo program	*1 stopping block w/ rubber band*
Averaging values program	*1 stopwatch*
1 long rod	*1 c-clamp*
1 table clamp	*1 metric ruler*
2 balls of like diameter but unlike mass	*Basketball*
Motion detector	*Medicine ball*
Lab pro interface	*USB cord*
Lab pro power supply	



INTRODUCTION

The purpose of this exercise is to recreate an experiment performed by Galileo in the seventeenth century, and show how we can use modern equipment to prove the same hypothesis today.

Using measurements of time and distance Galileo determined the correct relationship between the distance an object falls in an interval of time. Galileo believed that the speed of objects in free fall increases in proportion to the time of fall. In other words, he believed that free falling objects accelerate uniformly. Aristotle, on the other hand, believed that the acceleration is dependent upon the mass.

Since free fall was much too rapid to measure, Galileo looked for another way to investigate free fall acceleration. He made the assumption that a ball rolling down an inclined plane would gain speed in the same way as an object in free fall, only at a slower rate. With this in mind he began working on the relationship between the distance the ball rolled along an incline and the time it took to do so.

He found mathematically that this distance is proportional to the square of the time the ball rolls. Since Galileo's assumption that freely falling objects and rolling balls would accelerate in the same way was correct, this relationship between distance and time also applied to free fall. The equipment available to Galileo could easily measure the quantities of time and distance. Thus he found a way to bypass the difficulties of measuring instantaneous speed.
In this experiment an apparatus (see the illustration) similar to Galileo's will be used. Also, a motion detector will be used to measure the freefall accelerations for a basketball and a racquetball. The data you collect will allow you to decide for yourself if Galileo was correct.

PROCEDURE

Data can be found YouTube video

https://youtu.be/tjLRvoLAdJE

1. Verify that the 100cm mark is elevated to 7cm. Record the height on the data sheet. [Caution: Not 7 inches!]
2. Try to orient 1-meter scale taped to the inclined track so that the stop block is aligned with its zero mark at the bottom.
3. Place the steel ball on the incline, at 100 cm from the stop, blocking its descent with a ruler or pencil. This is the distance d, the ball will roll down the incline.
4. Release the sphere by quickly moving the pencil away from it along the incline. Time the descent of the ball with a stopwatch. The end of the descent is best marked by the sound of the ball striking the stopping block. Record the time. Do two more trials

with the ball rolling this distance. Record the times in the data chart. **Make sure you start and stop the watch in the same manner each time.**

Input data into data table on page 3

5. Repeat steps 3 and 4 for all indicated distances. Don't forget to do three trials for each distance.
6. Use a calculator compute the average time taken for each distance. If you have EXCEL, you may use spreadsheet that is provided on lab website to complete the data table.
7. Construct a graph of time versus distance. This means put distance on the horizontal axis and time on the vertical axis. You can use EXCEL or a program called Graphical Analysis to plot graph.

   You can download graphical Analysis from the website below.

https://www.vernier.com/product/graphical-analysis-4/

Video on how to use graphical Analysis

https://www.youtube.com/watch?v=pc7Q_67WWFs

8. Construct a graph of time squared versus distance. This means put distance on the horizontal axis and time squared on the vertical axis. Print the graph.
9. Using the plastic ball, note it is much lighter than the steel ball, do three trials from 100cm and average the time it took for the ball to descend.

CONCLUSIONS

If two quantities are directly proportional a graph of one plotted against the other will be a straight line. Thus, making a graph is a good way to check the relationship between the two quantities.

One of your plots should be a line and the other will not be a line. A useful way of telling which is a line and which is not, is to perform a linear fit on both plots. If the origin (i.e., 0,0) is a valid plot point (which it is in this experiment), then the linear fit will go through the origin and the fit of the curved (nonlinear) set of data will not.

Experiment 3
DATA SHEET

Name: ___________________________

Section: __________________________

Mass of metal ball = 28.2 g

Distance (d) (cm)			**TIMES (sec)**	**Avg. Time (t) (sec)**	**Avg. Time squared T^2 $(sec)^2$**	**Calculated Acceleration cm/sec^2**
	Trial 1	**Trial 2**	**Trial 3**			
100						
85						
70						
55						
40						
25						
0	0	0	0	0	0	0

Average calculated acceleration for steel sphere = ____________________

Mass of plastic ball = 4.3g

Distance (d) (cm)			**TIMES (sec)**	**Avg. Time (t) (sec)**	**Avg. Time squared T^2 $(sec)^2$**	**Calculated Acceleration cm/sec^2**
	Trial 1	Trial 2	Trial 3			
100						

Calculated acceleration for plastic sphere = ___________________

Calculated acceleration (m/s/s/) = 2*distance/time squared/100

Note that we divided by 100 to convert cm to meters which gives us acceleration in units of **m/s/s/**.

Questions-Galileo's inclined plane

1. Which one of your graphs supports Galileo's findings? Be sure and explain why. (See conclusions)

2. Look at the results of the measurements made in step 9. Does the acceleration depend on the mass of the ball? Explain your answer.

3. In what way does your answer refute or support Aristotle's ideas on falling bodies?

4. What are possible causes for your data in not exactly falling on a straight line? What are the most likely causes of experimental uncertainty in the measurements that you made?

5. In Appendix C (Graphing) of your text there is a plot Figure C.3 which is very similar to the graph of time vs. distance. **You will notice that the primary difference is that time is on the y-axis and distance is on the x-axis.**

   Why did you plot it the way that you were asked to plot it? Hint. The y-axis is the dependent axis (generally the behavior you are interested in. Also, were clocks very precise then?