Acceleration Down an Incline

There is a well-known story that Galileo dropped two objects of different weights from the Leaning Tower of Pisa in order to show that all objects accelerate toward the Earth at the same rate, regardless of their weight as long as air resistance is negligible. Historians, however, are quite certain that Galileo never performed such an experiment.

Galileo's experiments with acceleration involved rolling balls down an inclined plane. He did this out of necessity because of his inability to make precise measurements of the short time intervals needed for measuring the acceleration of objects in free fall. The inclined plane's angle could be adjusted until the time for the ball to roll to the end was long enough for even the crude time-measuring devices of his day to produce useful results.

In this exercise, you will examine acceleration by measuring the time needed for an object to roll various distances down an inclined plane – much like Galileo did around 400 years ago.

Purpose:

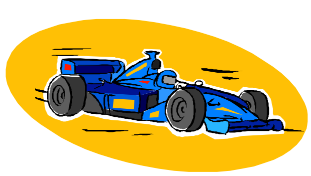
1. Examine the acceleration of an object rolling down an inclined plane
2. Determine the shape of a "**Distance vs Time**" graph for an accelerating object
3. Determine the mathematical relationship between the distance and time an object travels while it is accelerating

Materials:

inclined plane, "Hot Wheels" car, track, stopwatch, meter stick or measuring tape
(**Note: marbles may be used if toys cars and track are unavailable**)

Procedure:

1. Measure and mark from one end of the inclined plane the distances indicated in the data table.
2. Place your inclined plane on something (a book?) so that one end is slightly elevated. Be sure to support the track so that it does not bow.
3. Use the stopwatch to determine how much time is needed for the car (marble) to roll each indicated distance down the incline. Record this time in the data table.
4. Perform two time trials for each distance and average them.
5. Use MS Excel to make a graph of "**Distance vs Time**."
6. Use the MS Excel "Add Trendline" function to draw and calculate the best-fit curve to your data points. Place this on your graph.
7. Answer the questions at the end of this activity.



Distance, *meters*	**Time, *seconds***		**Average Time, *seconds***
	Trial 1	**Trial 2**	
0.10			
0.20			
0.30			
0.40			
0.50			
0.60			
0.70			
0.80			
0.90			
1.00			
1.20			
1.40			
1.60			
1.80			
2.00			
2.10			

Questions:

1. How does a "**Distance vs Time**" graph of accelerated motion compare with a "distance vs time" graph of non-accelerated motion (constant velocity)?

2. How can you tell by looking at a "**Distance vs Time**" graph whether or not the object has constant or changing speed?

3. What does the shape of your graph and the "best-fit" equation tell us about the mathematical relationship between distance and time for a uniformly accelerating object?

4. When looking at his data, Galileo discovered that an object would travel 4 times as far (2^2) in twice the time, 9 times as far (3^2) in triple the time, 16 times as far in (4^2) in quadruple the time, etc...

Use your graph to find the ....

time to travel 0.40 m ____	time to travel 0.10 m ____	ratio = ____
time to travel 0.60 m ____	time to travel 0.15 m ____	ratio = ____
time to travel 0.80 m ____	time to travel 0.20 m ____	ratio = ____
time to travel 1.00 m ____	time to travel 0.25 m ____	ratio = ____
time to travel 1.20 m ____	time to travel 0.30 m ____	ratio = ____
time to travel 1.60 m ____	time to travel 0.40 m ____	ratio = ____
time to travel 2.00 m ____	time to travel 0.50 m ____	ratio = ____

time to travel 0.90 m ____	time to travel 0.10 m ____	ratio = ____
time to travel 1.35 m ____	time to travel 0.15 m ____	ratio = ____
time to travel 1.53 m ____	time to travel 0.17 m ____	ratio = ____
time to travel 1.80 m ____	time to travel 0.20 m ____	ratio = ____
time to travel 2.07 m ____	time to travel 0.23 m ____	ratio = ____

5. Do your results seem to agree with Galileo's discovery? _____ Why/Why not?

6. What could you do in order to experimentally test whether or not all objects accelerate at the same rate, regardless of their weight?

7. How do you think the angle of incline affects this experiment?

8. What should happen to the **time values** in your data table if the incline is made steeper?

9. What should happen to the **ratios** in question #4 if the incline is made steeper?

10. List possible sources of error in this lab.