Lab 3: Applying Kinematics

There are two experiments. They are both testing experiments. Use the testing experiment rubric to determine what should be included in the lab report. If you are still unsure how to apply the rubric, then make use of the bullets in the testing experiment from lab 2 for guidance. However, some testing experiment rubrics not used in lab 2 may be useful for lab 3. A subset of the rubric will be used for grading. Be sure to incorporate error analysis using the weakest link rule detailed in the first part of this lab packet.

I. Testing Experiment: Falling Rock

A bitter controversy has recently broken out between the residents of a new housing estate, York Heights, and the Town Council over the safety of a number of large rocks that are perched on the slope of a hill just above the housing estate, which is surrounded by a lake. At the heart of the dispute is the relationship between the height above the edge of the cliff at which the rocks are balanced $h$ and the distance which the rocks will travel $d$ should they roll down the hill. A group of engineers has done a study and concluded that $h$ is directly proportional to $d$. However, a group of geologists repeated the study and concluded that $h$ is directly proportional to $d^2$. If the geologists are correct, then the rocks will land in the lake. If the engineers are correct, then the rocks will shoot over the lake and smash into the houses. Both sets of experts investigated the situation using apparatus consisting of a slope and a steel ball. In both cases, the steel ball was rolled down the slope from different heights and the resulting distance $d$ was measured. The Head of the Physics Department at OSU has been approached to resolve the controversy and now asks you to investigate the situation urgently with the same apparatus. He wants a full report detailing all aspects of the experiments, measurements, calculations, and graphs as well as your findings on who is right or wrong. In particular, he would like you to pay careful attention to the graph of $d$ vs. $h$ compared to the graph of $d^2$ vs. $h$, and how these graphs were used to determine the proportionality, as he will be showing them to reporters at a press conference later this week. He also advises that you should measure wide ranges of values for both $h$ and $d$, and that the point $(h, d) = (0, 0)$ should be included on both graphs.

II. Testing Experiment: Air Resistance

On the Descent of Cotton Balls: A Theoretical Perspective by J. K. Inklebottom and P. R. Priest

ABSTRACT

Cotton balls fall more slowly than rocks in most situations. We present an extension to the traditional Newtonian view of objects to include free-falling cotton balls.

Cotton balls are roughly spherical. If you drop them, then they fall.

It has been observed (Galileo and Snidely, 1998) that if you drop a rock and a cotton ball simultaneously from the top of a tower, then the rock will hit the ground first.
Evidently air resistance slows the cotton ball more than the rock. We suggest that its effect is greater because the cotton ball has less mass.

Our reasoning is this: Each air molecule, on impact, imparts a small force to a falling object. Using the traditional force formula: the sum of the forces is equal to the product of the object's mass and acceleration (Newton, 1687), we see that each collision effectively reduces the acceleration of any object falling through air by an amount that is inversely proportional to that object’s mass. Thus, the less massive cotton ball is slowed more than a comparably-sized and more massive rock.

Therefore, we should modify the formula for the distance fallen in a certain amount of time. Instead of the traditional formula:

\[ s = \frac{1}{2} gt^2 \]

where \( g \) is the magnitude of the acceleration due to gravity, we suggest that the correct model for falling cotton balls is:

\[ s = \frac{1}{2} kt^2 \]

where \( k \) is the magnitude of the object's acceleration and is smaller than \( g \). Though the truth of our theory seems self-evident, we await confirmation from experiment.