Analysis:

At incline 1, we measured the velocity of an object rolling down a slope at distances of 0.05, 0.1, 0.2, 0.4, 0.6, and 0.8 meters, recording three trials for each distance. We then averaged the velocities in Google Sheets to obtain a mean velocity for each point. The same procedure was repeated for incline 2, which was steeper and therefore expected to produce higher velocities.

Once all the data was collected, the next step was to find a way to represent the relationship between velocity and distance with a linear graph. We know the relevant kinematic variables:

- v^2 (measured velocity)
- $v_0 = 0$ m/s (since the object starts from rest)
- Δx (distance traveled)
- a (acceleration, assumed constant due to gravity).

The kinematic equation that relates these quantities is:

$$v^2 = v_0^2 + 2a\Delta x$$

Since $v_0 = 0$, this simplifies to:

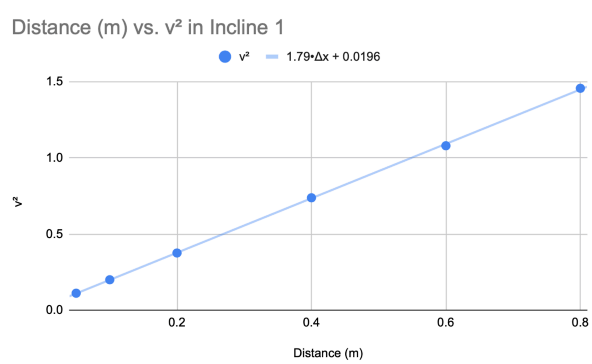
$$v^2 = 2a\Delta x$$

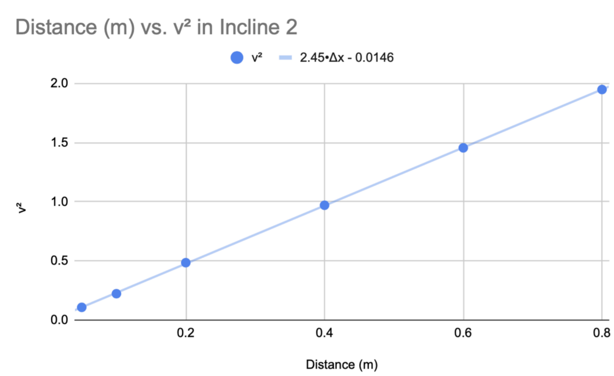
At first glance, this equation looks quadratic. However, if we plot v^2 on the y-axis and Δx on the x-axis by substituting y for v^2 and x for Δx, the equation takes the linear form: $y = 2ax$

This is equivalent to the slope-intercept form, $y = mx + b$, with slope $m = 2a$ and intercept $b = 0$. In other words, plotting v^2 against Δx produces a straight line, and the acceleration can be determined directly from the slope of the best-fit line as:

$$a = ½ \bullet m$$

Using Google Sheets, I squared the velocity values, plotted Δx versus v^2, and added trendlines with equations for both inclines. These graphs allow us to visualize the linear relationship and calculate the acceleration for each incline from the slopes.





Incline 1 Line of Best Fit: $v^2 = 1.79\Delta x + 0.0196$

Incline 2 Line of Best Fit: $v^2 = 2.45\Delta x - 0.0146$

Using the graphs, we can calculate the acceleration for each incline. For incline 1, the slope of the line of best fit is 1.79. Since the slope corresponds to $2a$, dividing by 2 gives an acceleration of:

$$a = \frac{1.79}{2} = 0.895\, m/s^2$$

For incline 2, the slope of the trendline is 2.45. Dividing by 2 leads to the acceleration becoming:

$$a = \frac{2.45}{2} = 1.225\, m/s^2$$

These results are consistent with expectations, as the steeper incline produces a larger acceleration.

Conclusion:

Now that we have the experimental values for the acceleration in both incline 1 and 2, we can compare that with the expected value. This value is found by using the equation $a = gsin\theta$, where g is the magnitude of the acceleration ($9.8\, m/s^2$), and θ is the angle of the incline (the angle opposite the stack of books supporting the ramp).

In incline 1, $sin\theta = \frac{opp}{hyp} = \frac{11.6}{108.4}$.

Using this, the acceleration can be found by multiplying $sin\theta$ by the magnitude of gravity, which gives:

$a = 9.8 \bullet \frac{11.6}{108.4} = 1.049\, m/s^2$

In incline 2, $sin\theta = \frac{opp}{hyp} = \frac{15.5}{109.6}$.

Using this, the acceleration can be found by multiplying $sin\theta$ by the magnitude of gravity, which gives:

$$a = 9.8 \bullet \frac{15.5}{109.6} = 1.386\, m/s^2$$

Using these values, the percent error can be found using the equation:

$$\%\, error = \left|\frac{expected\ value - experimental\ value}{expected\ value}\right|$$

In incline 1:

$$\% \, error = \left| \frac{1.049 \, m/s^2 - 0.895 \, m/s^2}{1.049 \, m/s^2} \right| = 14.68\%$$

In incline 2:

$$\% \, error = \left| \frac{1.386 \, m/s^2 - 1.225 \, m/s^2}{1.386 \, m/s^2} \right| = 11.62\%$$

Lab Results:

Incline 1:

Experimental Value: $0.895 \, m/s^2$

Expected Value: $1.049 \, m/s^2$

Percent Error: 14.68%

Incline 2:

Experimental Value: $1.225 \, m/s^2$

Expected Value: $1.386 \, m/s^2$

Percent Error: 11.62%

Sources of Errors:

- One source of error comes from how the angle of the incline was measured. Since we could not directly measure the angle, we instead measured the hypotenuse of the ramp and the height of the stack of books with a meter stick. This method is limited in precision because the meter stick is rigid, marked only to the nearest tenth of a centimeter, and difficult to align perfectly. As a result, the calculated angle may have been slightly smaller than the true angle, which would make the expected acceleration appear lower than it actually was.

- Another factor is friction between the cart and the track. Although small, this force opposes the motion of the cart, reducing its acceleration compared to the theoretical value. Similarly, air resistance, while minor, also acts against the cart's motion. Even at lower speeds or less steep angles, air resistance is still present and contributes to a lower measured acceleration.
- On top of this, any small delay or problem with the photogate's detection changes the measured velocity and therefore affects the v^2 values used to find the slope, possibly causing the measured acceleration to be lower than it actually is.
- Finally, there may have been inaccuracies in the measurement of displacement along the track. Because the stick on top of the cart was tilted toward the photogate sensor during the experiment, the recorded distances may have been slightly longer than the true distances traveled by the cart. This would distort the relationship between velocity and displacement, and affect the calculated acceleration.

Final Statement:

Although the measured accelerations (0.895 and $1.225\ m/s^2$) are lower than the predicted values (1.049 and $1.386\ m/s^2$), they show the expected trend of larger acceleration for a steeper incline and are within a reasonable experimental error range. Due to a multitude of sources of error, it can be expected that the experimental values are different from the expected ones, and it is reasonable to assume that a percent error between 10 and 15% is not out of the ordinary.