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Section B
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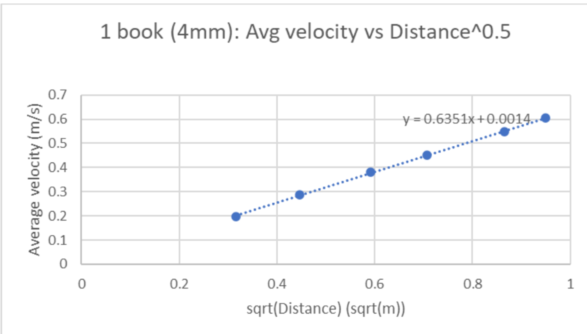
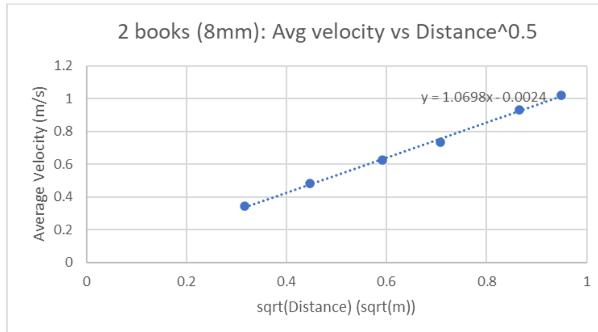
Acceleration on an Inclined Plane

Graphs:





Analysis:

The results of the lab suggest that with an inclined plane as the mean of travel for a rolling cart, an increase in the angle of depression correlates to a greater acceleration. In testing, the angle of depression was increased by raising the starting point of a metal ramp (4cm and later up to 8cm) while keeping the height of the endpoint constant.

$$y = mx + b \qquad\qquad V_f^2 = V_i^2 + 2ax$$
$$V_f = \sqrt{2a\Delta x} + V_i \leftarrow \qquad V_f = \sqrt{2ax} + V_i$$
$$V_f = \sqrt{2(a)}\,\Delta x + V_i$$

In order to linearly graph this scenario, researchers converted the equation: $V_f^2 = V_i^2 + 2a\Delta x$ into the form of y=mx+b or slope intercept form. When solved for V_f and put into slope intercept form, the equation becomes $V_f = \sqrt{2a\Delta x} + V_i$. Data collection provided values for V_f with a photogate and Δx with a meter-stick. Data was then graphed with a y value equivalent to the final velocity and an x value equivalent to the square root of the displacement. The resulting slopes (sqrt(2*acceleration)) were solved for and equated to 1.069 sqrt(m)/s at 8cm and 0.6251 sqrt(m)/s at 4cm. When the slopes were used to solve for acceleration, the accelerations equated to 0.572 m/s^2 at 8cm, and 0.204 m/s^2 at 4cm (the b-value is assumed to be a negligible initial velocity).

2 books: $\sqrt{2a} = 1.0698 \frac{\sqrt{m}}{s}$

$2a = 1.144 \frac{m}{s^2}$

$\boxed{a = 0.572 \frac{m}{s^2}}$

1 book: $\sqrt{2a} = 0.6351 \frac{\sqrt{m}}{s}$

$2a = 0.4084 \frac{m}{s^2}$

$\boxed{a = 0.204 \frac{m}{s^2}}$

expected: $a = g(\sin(\theta))$ | expected: $a = g(\sin(\theta))$

The difference between the two accelerations (from the two different heights) suggests that a steeper fall correlates to a higher acceleration. With an 8cm starting height, the acceleration was roughly 0.204 m/s^2 whereas with a 4cm starting point the acceleration was 0.572m/s^2. This makes sense when given the equation for acceleration on a slope, $a=g(\sin(\theta))$ where a is the acceleration, g is the acceleration due to gravity (~9.8m/s^2) and theta is the angle of depression. Using the equation, it can be observed that an increase in theta will result in an increase of the acceleration.

expected: $a = g(\sin(\theta))$

$a = 9.8(\sin(3.78))$

$\boxed{a = 0.646 \frac{m}{s^2}}$

expected: $a = g(\sin(\theta))$

$a = 9.8(\sin(1.79))$

$\boxed{a = 0.306 \frac{m}{s^2}}$

Theta was observed to be 3.783° at 8cm and 1.79° at 4cm. The expected values for acceleration were 0.646 m/s^2 at 8cm and 0.306m/s^2 at 4cm. The expected values are much higher than the observed accelerations (justification provided in conclusion), but it can be deduced that when the angle of depression is higher, the acceleration will increase in magnitude.

Conclusion:

A percent error for acceleration was calculated using the observed acceleration and the expected acceleration. The expected values for acceleration were 0.646 m/s^2 at 8cm and 0.306m/s^2 at 4cm while the observed values for acceleration were 0.204 m/s^2 at 8cm and 0.572m/s^2 at 4cm. It is important to note that these values are positive. When using the ground as a reference point, the accelerations and velocities would be negative. For the purposes of this experiment, the accelerations and velocities were positive.

$$\%\text{error} = \frac{a_{expected} - a_{observed}}{a_{expected}} = \frac{0.646\frac{m}{s^2} - 0.572\frac{m}{s^2}}{0.646\frac{m}{s^2}}$$

$$\%\text{error}_{2\ books} = 11.5\%$$

$$\%\text{error} = \frac{a_{expected} - a_{observed}}{a_{expected}} = \frac{0.306\frac{m}{s^2} - 0.204\frac{m}{s^2}}{0.306\frac{m}{s^2}}$$

$$\text{error}_{1\ book} = 33.3\%$$

With a starting height of 4cm, the error was 33.3% (the observed acceleration was 33% lower than expected) whereas with a starting height of 8cm it was 11.5% (the observed acceleration was 11.5% lower than expected). Some possible explanations for this discrepancy reside in the limitations of this experiment. Firstly, there is friction in all moving components of the apparatus whereas there is no friction considered in the expected acceleration calculations. Among the many sources, there is friction in the wheel bearings, between the wheels and the cart, between the wheels and the ramp and between the cart and the air. This would cause the observed cart to travel and accelerate slower which is why the observed accelerations are lower than the expected accelerations.

In the calculation for the expected value, there may have been inaccuracies in the dimensions used to calculate the angle measurement (theta). This could skew the data in either direction depending on the direction of error.

Additionally due to the release method, there is no exact consistency in initial velocity. This could skew data in either direction but is not likely the primary source of error. When done by hand, it is impossible to remain consistent when releasing the cart without a small initial velocity, the b-values on both graphs represent those initial velocities. A more automated or mechanical release system would help fix this issue.

Lastly, each time the cart hit the end-stopper, the whole apparatus shook, potentially disturbing the photogate position. Whenever this was observed, researchers returned the apparatus to its previous arrangement but inconsistencies in repositioning are possible as a result of non-perfect measuring tools.

In conclusion, this lab showed researchers many things about acceleration on an inclined plane and the factors that are involved. Understandings of the implications of friction, the relationship between angle of depression and acceleration, and of kinematics as a whole were improved significantly. The findings suggest that a higher angle of depression correlates to a higher acceleration. Overall, this lab was successful in its purpose, educating researchers on kinematics and acceleration on inclined planes.