Acceleration on an Inclined Plane Lab

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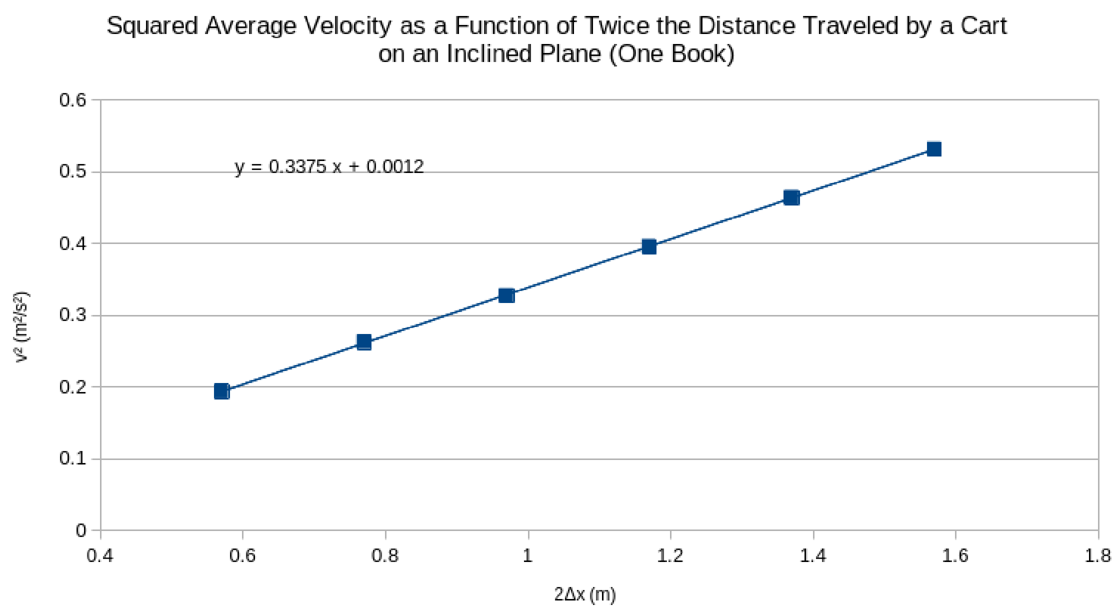
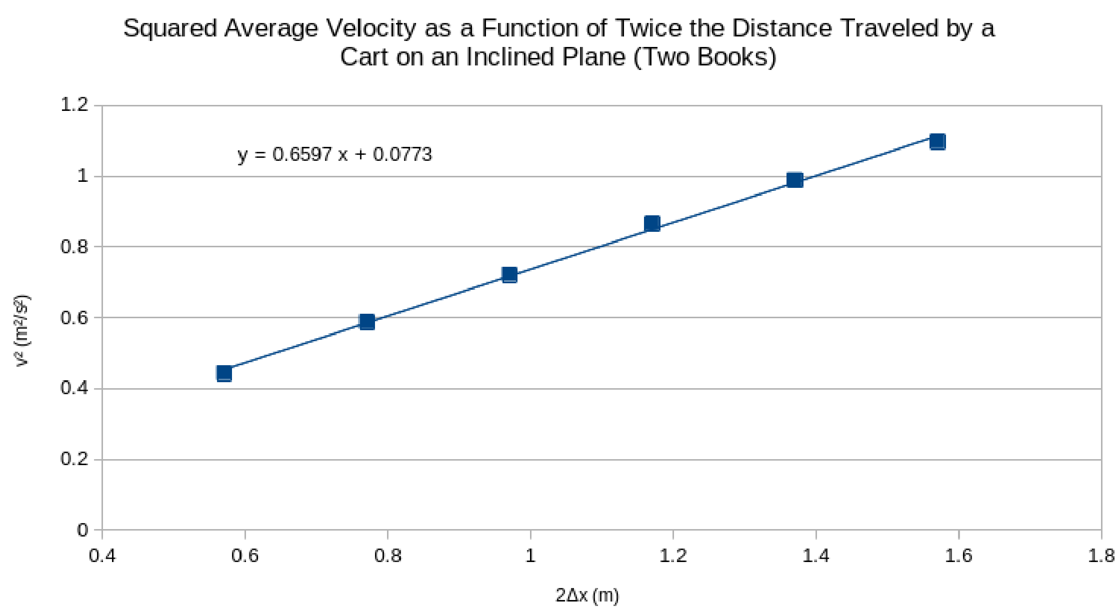
Analysis

Graphs





Calculations

Measurement Pair	Equation	X-axis	Y-axis	Slope
Δx, v	$v^2 = v_0^2 + 2a\Delta x$	$2\Delta x$	v^2	a

Incline	Line of Best Fit	Constant to Solve For	Calculation
1	$v^2 = 0.3375(2\Delta x) + 0.0012$	a	$a = 0.3375\ \frac{m}{s^2}$
2	$v^2 = 0.6597(2\Delta x) + 0.0773$	a	$a = 0.6597\ \frac{m}{s^2}$

Explanation

The purpose of this lab was to find the acceleration of a cart traveling on an inclined plane based on the velocity, in meters per seconds, and distance traveled, in meters. Our procedure consisted of the following steps. First, we constructed an incline by resting one side of the ramp on a book. From there, we measured the height and hypotenuse of the triangle formed by the table, ramp, and book. After creating the incline, we were ready to gather velocity and distance data by releasing the cart from different positions on the ramp and recording velocity readings from a photogate sensor. Before doing so, however, we measured the position of the photogate sensor on the ramp to calculate the distance traveled by the cart. Once we had this value, we started releasing the cart from different positions on the ramp, starting at 100 centimeters and working downward in increments of 10. We calculated the distance traveled and average velocity over three trials for five release points. Once we finished gathering data for one incline, we created another using two books instead of one and repeated the procedure.

After recording the data for the two inclines, I derived a method of calculating the cart's acceleration by linearizing the graph of the appropriate kinematics equation and equating the acceleration to the slope of that graph's line of best fit. Since we had data on distance traveled, velocity, and initial velocity, I started with the equation $v^2 = v_0^2 + 2a\Delta x$. The cart was released with an initial velocity of 0 $\frac{m}{s}$, so the equation could be simplified to $v^2 = 2a\Delta x$. The measurement variables were Δx and v, and the constant to solve for is a, so the equation can be linearized by setting the X-axis to $2\Delta x$ and the Y-axis to v^2, making the slope of the graph the acceleration. From there, I used linear regression on the data we collected with the new axes to find the lines of best fit. Since the linearized equation is $v^2 = a(2\Delta x)$, the slopes of the lines of best fit were equal to the acceleration for both inclines.

Conclusion

Evaluation of Results

Our experimental acceleration values for the first and second inclines were 0.3375 $\frac{m}{s^2}$ and 0.6597 $\frac{m}{s^2}$, respectively. To find the theoretical acceleration, I used the dimensional measurements for each triangle. For the first incline, our measurements for the height and hypotenuse were 3.8 centimeters and 122 centimeters, respectively. Therefore, our theoretical acceleration is $g\ sin(\theta)$ or $9.8\frac{m}{s^2} \times \frac{3.8}{122}$, which evaluates to 0.3052 $\frac{m}{s^2}$. Similarly, the height and hypotenuse of the second incline were 7.8 centimeters and 122 centimeters, respectively, so the theoretical acceleration is again $g\ sin(\theta)$ or $9.8\frac{m}{s^2} \times \frac{7.8}{122}$, which evaluates to 0.6266 $\frac{m}{s^2}$. The percent error for the first incline was $\frac{0.3375 - 0.3052}{0.3052} \times 100$, or 10.6%. The percent error for the second incline was $\frac{0.6597 - 0.6266}{0.6266} \times 100$, or 5.3%.

Sources of Error

There are a couple of sources of error to consider for this experiment. Firstly, friction between the cart and the ramp could have caused it to go slower, lowering experimental velocity and, therefore, experimental acceleration. Sometimes, the cart wasn't aligned on the center of the ramp, which could have resulted in even more friction and, again, lower experimental velocity and acceleration. Also, when we were following the procedure, there were times when we bumped into the photogate sensor, offsetting its position slightly, which could have caused the measured distance to vary somewhat across our trials. Given our positive percent error, we might have bumped the sensor further along the ramp, which could have caused higher velocity readings and experimental acceleration because the cart was traveling a longer distance. Additionally, our measurements of distance may not have been exact. There was an aspect of estimation when establishing the position of the center of the photogate sensor to calculate the distance traveled, and there was some slight variance in where we released the cart across trials. If our measured distance were lower than the actual distance, that would explain the higher experimental acceleration. Along with the experimental data, the calculation of the theoretical acceleration has room for error itself, considering the possibility of human error in measuring the triangle dimensions. Another possible explanation for our positive percent error would be that we measured the dimensions out to be smaller than they really were, which would cause us to have a theoretical acceleration that is smaller than it should be. This experiment's most likely sources of error were imprecision in the distance, velocity, and triangle dimension measurements due to the offset of the photogate sensor, variance in the cart’s release point, and general human error in measurement and approximation.