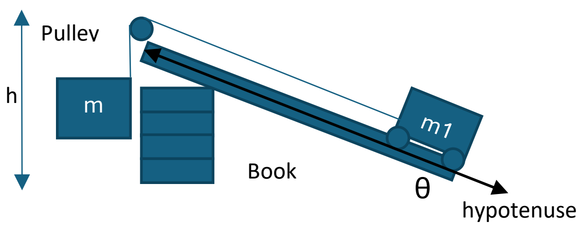
Dynamics Investigation Lab

Question: How does the angle of an incline affect the acceleration of a cart attached to a string connected to a hang weight in a modified Atwood's machine system?

Hypothesis: The slope of sin(θ) vs acceleration (a) is $-\frac{(m_1+m_2)}{m_1 g}$ (kg/N), and the intercept is $\frac{m_2}{m_1}$.

Strategy:

Figure 1: Set up for the experiment



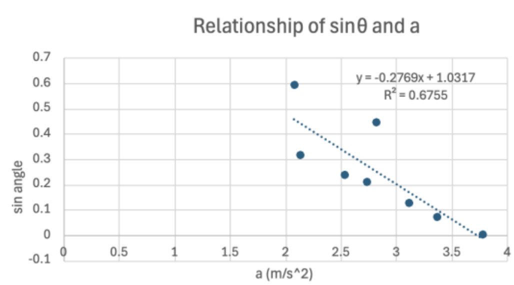
We create an incline by putting books at the end of the ramp with the pulley. Then, we measure the bottom of the books to the top of the ramp, which is height, and the length from the top of the ramp extended to touch the ground (the hypotenuse). Then, we calculate the sin of the angle using the equation: $\frac{h}{l}$ (h is height and l is the hypotenuse). After that, we let go of the weight and let it hit the floor, which pulled the cart to the top of the ramp. Next, we used vernier graph to obtain the acceleration of the cart by taking the slope of the velocity of the cart. We tested 8 different heights to generate 8 different angles. Finally, we graph the data points to determine the relationship between sin(θ) and the acceleration of the cart.

Data:

Table: Change in the hypotenuse and height causes the change in sin(θ) which causes a change in acceleration.

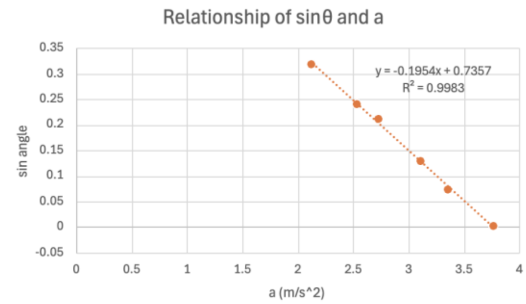
hypotenuse	height	sin angle	a (m/s^2)
	0cm	0	3.778
210cm	15cm	0.071497	3.368
176 cm	22.2 cm	0.126199	3.114
149cm	31.2cm	0.209397	2.735
147cm	35cm	0.238093	2.541
139cm	44cm	0.316543	2.133
131cm	58.3cm	0.445042	2.826
126cm	75cm	0.595244	2.082

Graph 1:



The equation for this graph is sin(θ) = -0.2769a +1.0317

Graph 2:



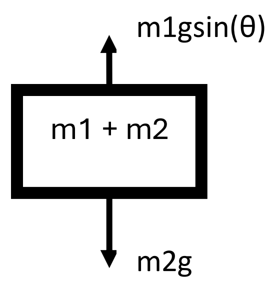
The equation for this graph is sin(θ) = -0.1954a + 0.7357

Graph 2 is created with the removal of 2 outliers at sin(θ) equals 0.445 and 0.595. Because of their deviation from the general trend of the other points, we believe that an error may have occurred in measuring these two datapoints. This is reflected in the R^2 value of graph 1 that is only 0.6755, which increases to 0.9983 in graph 2. The high R^2 value is to be expected as the relationship is supposed to be perfectly linear.

Analysis:

The derivation to figure out the relationship between the sin(θ) and acceleration:

Figure 2:



Using the free body diagram and the equation F=ma, the following equation can be achieved: $m_2 g - m_1 g\sin(\theta) = (m_1 + m_2)a$

Which derived into:

$\sin(\theta) = \frac{m_2 g - (m_1+m_2)a}{m_1 g}$. Then, the equation for the slope and the intercept is shown in the hypothesis. The cart was 0.300 kg, and the weight was 0.2105 kg. Therefore, the slope, in theory, is - 0.1736 (kg/N), and the intercept is 0.7017. The percentage error of the slope is -12.56%, and the intercept is -4.845%. The error with slope can be explained by underestimating the height of the system, causing the slope of the incline to be higher than expected and the calculated sin(θ) to be greater. Hence, the slope of the relationship obtained from the experiment is higher in magnitude, showing that the acceleration decreases faster than expected. The error of the intercept comes from the fact that the slope of the graph is more negative, resulting in a higher intercept than expected.