Question:

What is the relationship between incline (sinθ) and acceleration of a cart traveling along a metal track in a modified Atwood's machine?

Hypothesis:

The relationship between slope incline and acceleration will be linear and equal to $\frac{-m_1 g}{m_1+m_2}$.

Strategy:

- The angle of the metal track's incline was varied by stacking different numbers of the same textbook under one end of the track. The acceleration of the cart was measured using a Vernier motion detector.
- Sine theta was graphed vs. acceleration to investigate and confirm if their relationship is linear and if the slope of the graph was equal to $\frac{-m_1 g}{m_1+m_2}$.
- Sine theta was found by taking the proportion of the measured incline's height to its measured hypotenuse. Approximate angle measures of the incline were found by taking the inverse sine of the sine theta values.

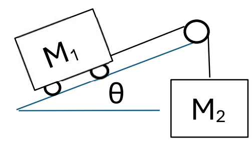

Figure 1: Model of Modified Atwood's Machine

Collected Data:

Masses of the cart and hanging weight were kept constant at 0.301kg and 0.15kg respectively.

Angle Measure (Degrees)	Sine Theta	Average Acceleration (m/s^2)
0	0	3.0993
2.323	0.041	2.8273
4.651	0.081	2.6807
6.986	0.122	2.3253
9.646	0.168	2.0567

Analysis:

These free body diagrams show the forces acting on the masses during this experiment.

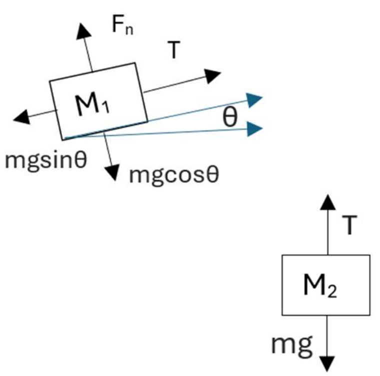

Figure 2: Free Body Diagrams

Positive motion was defined as moving up the incline for m_1, while positive motion was downwards for m_2. Based on free body diagrams, these two equations are derived.

$$T - m_1 g sin\theta = m_1 a$$

$$m_2 g - T = m_2 a$$

Adding these two equations and isolating for the variable "a" provides this final equation.

$$m_2 g - m_1 g sin\theta = m_1 a + m_2 a$$

$$a = -\frac{m_1 g sin\theta}{m_1 + m_2} + \frac{m_2 g}{m_1 + m_2}$$

With this final equation, a linear relationship can be shown between the variables "sinθ" (IDV) and "a" (DV), where the slope is equal to $\frac{-m_1 g}{m_1+m_2}$ and the y-intercept is equal to $\frac{m_2 g}{m_1+m_2}$.

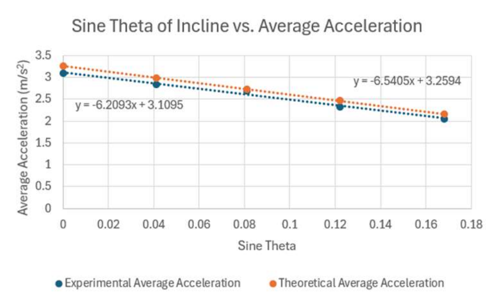

Figure 3: Experimental & Theoretical Data

Figure 3 confirms that this relationship is linear, with the experimental slope in blue being equal to -6.2093N/kg. To check for percent error, the values of m_1, m_2, g, and sinθ were plugged into our derived equation and a line of best fit for this theoretical acceleration was created in orange. The theoretical slope of this line was -6.5405, which has a 5.33 percent error compared to our experimental slope. The experimental slope was likely lower than the theoretical because of the friction of the cart's wheels on the track, reducing acceleration. Error could have also occurred from manually measuring the hypotenuse of the incline and its height.