Question: Does the relationship between the force, angle of incline, and acceleration of a cart traveling along an inclined plane in a modified Atwood Machine prove Newton's Second Law of Motion?

Hypothesis: The relationship between the angle of incline and acceleration will be linear.

Strategy:

- The angle of incline was increased by increasing the number of books that were used to prop up the track the cart was moving along
- The acceleration was measured using a Vernier motion detector
- m_1 and m_2 were kept constant
- A metal block was added to the cart to make sure that F_{m2g} overcame F_T
- The measured acceleration was graphed compared to the calculated theta to show the relationship between theta and acceleration

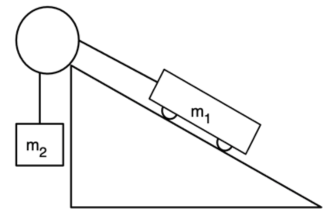

Figure 1: Modified Atwood's machine with cart

Data:

Book height (cm)	Hypotenuse (cm)	g	Car Mass (g)	Metal Block Mass (g)	m1 (kg)	Wood block (m2) (kg)
4.2	203	9.8	502	498	1.0000	0.1342
# of Books	**Height of slope (cm)**	**Theta (degrees)**	**Acceleration (m/s^2)**			
8	33.6	9.527	0.1626			
9	37.8	10.732	0.3210			
10	42.0	11.941	0.5008			
11	46.2	13.155	0.6813			
12	50.4	14.376	0.8087			

Theta was found by taking the inverse SIN of the height of the inclined plane divided by the hypotenuse.

Analysis:

Figure 2 shows the free body diagrams with forces in the Modified Atwood's Machine.

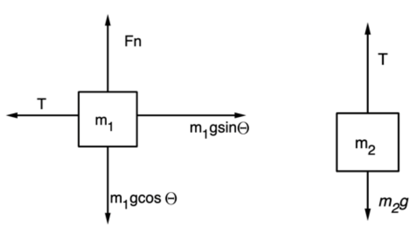

Figure 2: Free Body Diagrams

Friction between the cart and the track is negligible because the cart's wheels spin freely. The following equations are created using Newton's Second Law of motion F = ma. Positive motion is defined as down the incline for the cart, and down for the hanging mass.

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

These equations can be combined and rearranged to form the equation:

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

This equation indicates that there is a linear relationship between the angle of incline and the acceleration. When SIN increases in value, the numerator in the above equation increases in value, which in turn increases the value of the acceleration. There are no exponents in this equation so the relationship cannot be quadratic or exponential.

A graph of the experimental acceleration shows that the relationship is linear. The R^2 value is very close to one meaning that acceleration is dependent on the angle of incline.

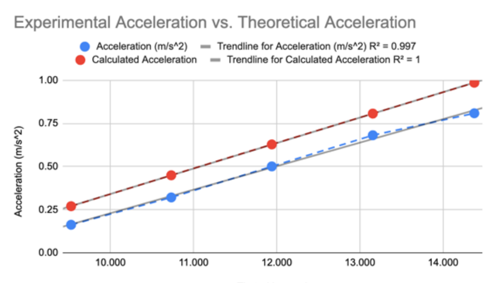

Figure 3: Acceleration vs Angle of Incline

The theoretical acceleration was found by taking the angle of incline and plugging it into the rearranged equation above. Using the theoretical acceleration, the percent errors for the different angles of incline range from 15.57% to 39.80%. In this case, it is more likely that the experimental acceleration is closer to the true acceleration because the final rearranged equation for acceleration does not account for the friction between the cart and the track. Including friction in the equation would reduce the acceleration.