Question: Does the relationship between force, mass, and acceleration of a cart part of a Modified Atwood's Machine traveling along an inclined plane (as shown in Figure 1) obey Newton's Second Law?

Hypothesis: The relationship between the hanging weight and acceleration will be linear. The slope of the graph will equal to the force of gravity divided by the total mass ($\sin(\theta)m_1 + m_2$). The y-intercept should equal - $-\frac{m_1 g}{2(m_1+m_2)}$.

Strategy:

- The hanging mass and the mass of the cart will be varied using different weights. The resulting acceleration will be measured using a Vernier motion detector.
- The total mass will be calculated and kept constant where $Total\ mass = \sin(30)\, m_1 + m_2 = 0.5m_1 + m_2$
- The hanging weight (m_2) was graphed as compared to acceleration to verify the slope being equal to acceleration, which will be the force of gravity being divided by the total mass

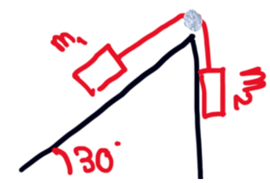

Figure 1: Lab Setup

Data:

Total Mass: = ($0.5m_1 + m_2$) = 0.40405 kg

Mass of Cart (kg)	Hanging Mass (kg)	Acceleration (m/s^2)
0.3817	0.2132	0.442
0.3617	0.2232	0.783
0.3417	0.2332	1.116
0.3217	0.2432	1.51

The acceleration is an average of 3 trials

Analysis:

Friction was determined negligible for the experiment and theta equals 30°. Assuming this, a free body diagram was created to show the forces acting on each block.

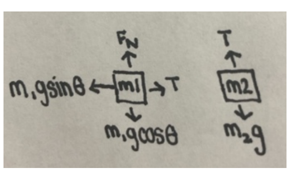

Figure 2: Free-body Diagrams

Using these two diagrams, two equations were created.

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

$$m_2 g - T = m_2 a$$

By combining these two equations, another equation was created.

$$2m_2 g - m_1 g sin\theta = 2m_1 a + 2m_2 a$$

After further simplifying this equation to solve for a, we end up with the equation

$$a = \frac{m_2 g}{m_1 + m_2} - \frac{m_1 g}{2(m_1 + m_2)}$$

This equation shows that there is a linear relationship between the hanging mass and the acceleration. This means that the slope of line will be equal to $\frac{g}{m_1+m_2}$.

When graphed, the linear relationship is evident.

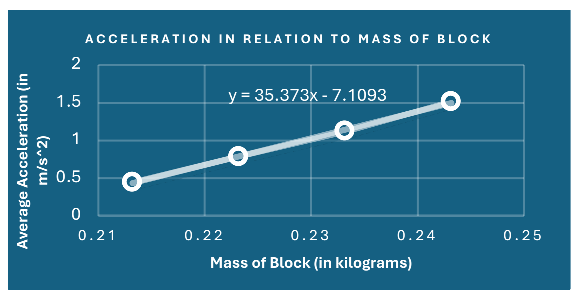

Figure 3: Graph of Hanging Weight VS Acceleration

The expected value is 24.25 m/s^2 which means than the percentage error is 45.87%. This shows that the acceleration was higher experimentally. These are two reasons for this. The main reason is that the calculation for keeping our mass constant was wrong as we used $0.5m_1 + m_2$instead $m_1 + m_2$ due to calculation errors. If the mass was kept constant the correct way, the slope would equal gravity. The second reason is the angle. In the equation, the y-intercept correlates directly to the angle. A smaller angle would lead to a larger y-intercept, and as a result, a higher acceleration. Thus, the actual angle might have been smaller than measured, which would cause a higher acceleration.