Question: Does the relationship between force, acceleration and mass of a cart pulled by a modified Atwood's machine obey Newton's Second Law with an additional opposing force?

Hypothesis: The relationship between the weight hanging off the Atwood's machine and the cart's acceleration will be linear. The measure of the opposing force would be the y-intercept of line in the graph.

Strategy:

- The mass hanging off the Atwood's machine was increased by adding more 20-gram weights to the original 50-gram hook. The hook was tied to the cart with a piece of fishing line, and mass was kept constant by having unused washers on the cart, so that the sum of the mass hanging off the Atwood's machine and the mass of the cart stay the same.
- A fan was attached to the cart to oppose its forward motion
- Acceleration of the cart was measured using a Vernier motion detector
- The total applied force was graphed against the measured acceleration to verify that the slope equals the total mass of the system

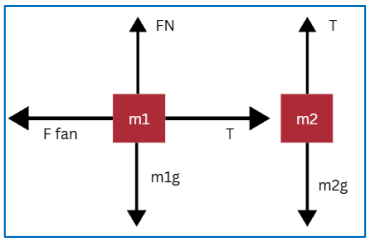
Data:

Hanging Mass (kg)	Avg Acceleration (m/s^2)	Hanging Mass x G
0.0505	0.35	0.4949
0.0705	0.68	0.6909
0.0905	1.01	0.8869
0.1105	1.37	1.0829
0.1305	1.68	1.2789

The acceleration is an average of 3 trials

Analysis:

The free body diagram shows the forces acting on the cart and the mass hanging off the Atwood's machine.



Based on free body diagrams, we can derive the following equations.

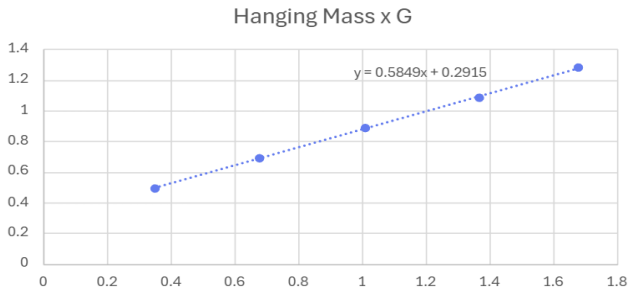
$T - F_{fan} = m_1 a$ $\qquad$ $m_2 g - T = m_2 a$

The sum of these equations gives us:

$$m_2 g = (m_1 + m_2)a - F_{fan}$$

These equations assume that friction between the track and the cart is negligible. These equations indicate that the relation between gravity, a hanging mass, and acceleration is equal. The slope of this line would be equal to the total mass of the system. The y-intercept of this line is the opposing force provided by the fan.

The Graph: The graph proves that the relationship between these 3 factors is linear even with an opposing force.



The slope of the graph is slightly higher than the measured mass of the system. This means that the actual acceleration would be a little lower than the theoretical acceleration. The main source of this difference is the presence of friction between the wheels of the cart and the track that is ignored in the calculations. Other sources could include a slight upward inclination in the ramp and friction around the axle of the pulley.