Dynamics Lab Investigation

Question: Does the relation between force, mass, and acceleration in a modified Atwood's machine remain consistent with Newton's 2nd law when an additional force of a fan is applied to the cart?
Hypothesis: The fan's force will be constant, which means that the graph of the hanging force and acceleration will remain linear but will have a nonzero y-intercept. The value of the y-intercept will represent the force of the fan on the cart.

Strategy:

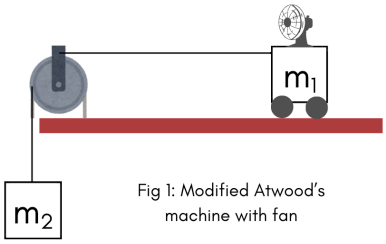

Fig 1: Modified Atwood's machine with fan

- The hanging mass in the modified Atwood's machine was increased by increments of 0.02 kg by hanging different numbers of weights onto a paper clip attached to a string. This string passed over a pulley and attached to a cart equipped with a fan. The fan was placed in the opposite direction of the cart's motion, serving as a counteracting force. The acceleration of the cart was measured using a Vernier motion sensor.
- The fan was set to the same mode through the experiment. The total mass of the system was kept constant by having all unused weights be placed on the cart so that the sum of the hanging and cart masses remained the same.
- The hanging force was graphed against acceleration and the y-intercept of the trendline was used to determine the fan's force. To verify the experimental value of the fan's force, it was compared to the value measured by a force sensor attached to the cart with the fan.

Data:
Direct measurement of Fan's force: 0.271 N

Hanging Mass (kg)	Acceleration (m/s^2)
0.0505	0.35
0.0705	0.68
0.0905	1.01
0.1105	1.37
0.1305	1.68

*Acceleration values are an average of 3 trials

Analysis:
The free body diagrams in figure 2 show the forces acting on the masses in the system (hanging weight and cart).

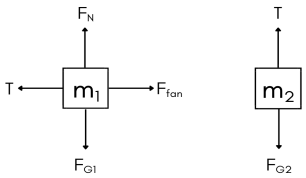

Figure 2: Free Body Diagrams
Friction is not considered because it is negligible due to the smoothness between the track and cart's wheels. Positive motion is defined to the left for the cart and down for the hanging weight. These equations are based on the free body diagrams:

$$T - F_{fan} = m_1 a$$
$$F_{G2} - T = m_2 a$$

The sum of these 2 equations is:

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

This equation demonstrates the linear relationship between the force of gravity on the hanging mass and acceleration. F_{fan} is also represented as the y-intercept of the equation.
The graph of the hanging force vs. acceleration confirms its linearity and its y-intercept is 0.292 N.

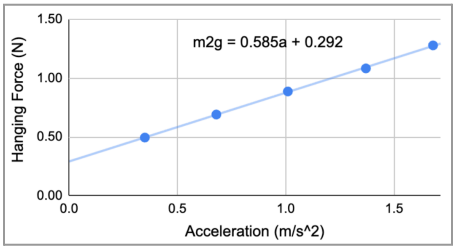

Figure 3: Hanging force vs. Acceleration

The actual F_{fan} = 0.271 N, so the experimental value for F_{fan} is 7.7% larger than the accepted value. This means that the acceleration values taken were smaller, which could be due to the small amount of friction between the tracks and wheels or between the string and pulley, causing the cart to slow down. Additionally, the force of the fan could've been inconsistent and produced a higher force than previously measured.