Question: How does increasing the opposing fan force on a cart traveling on an Atwood track affect its acceleration?

Hypothesis: Fan force and acceleration will have a negative linear relationship. The slope of the graph of acceleration vs. fan force will be equal to the negative total mass of the system.

Strategy:

Figure 1: Fan force collection set up

- Fan forces (per level) were obtained by attaching the cart to a force sensor using a string. The sensor was zeroed, the fan was turned on, and the tension in the string was measured (Fig. 1)
- The fan force opposing the motion of the modified Atwood's machine was manipulated. The resulting acceleration was measured with a Vernier motion detector (Fig. 2)
- Both mass 1 and mass 2 (the total mass of the system) were kept constant.
- The acceleration of the system was graphed against the measured fan forces to verify that the slope was equal to the negative total mass of the system, i.e. cart, fan, paper clip, and washers

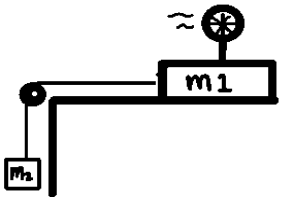

Figure 2: Acceleration vs fan force set up

Data:

Total mass = 0.4703 kg, m_1 = 0.4497 kg, m_2 = 0.0206 kg

Fan Force (N)	Acceleration (m/s²)
0	0.228
0.120	0.118
0.185	0.035
0.223	-0.019
0.254	-0.100

Analysis:

Figure 3 shows the free-body diagrams for the masses in the modified Atwood machine.

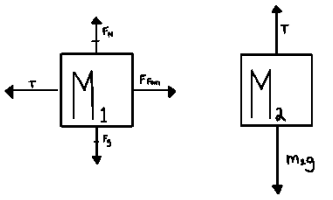

Figure 3: Free Body Diagrams

Friction was negligible for the cart's wheels and positive motion was defined as traveling left and/or downwards. The following equations were derived for masses 1 and 2, respectively.

$$T - F_{Fan} = m_1 a$$
$$m_2 g - T = m_2 a$$

Added together and linearized to show a linear relationship between F_{Fan} and acceleration, they yield:

$$F_{Fan} = -(m, +m_2)a + m_2 g$$

F_{Fan} is the y-value, $-(m_1 + m_2)$ is the slope, and $m_2 g$ is the y-intercept. A graph of fan force vs. acceleration for this experiment models the linear relationship and draws comparisons between the experimental and theoretical total masses.

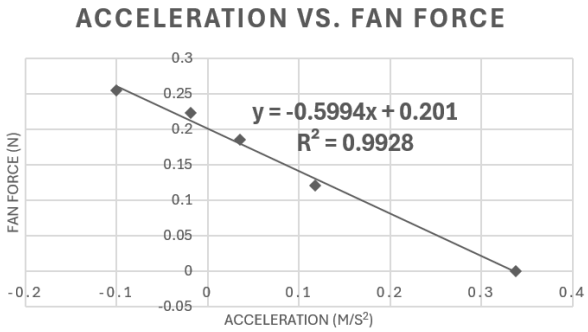

Figure 4: Fan Force vs. Acceleration

The experimentally measured total mass, 0.4703 kg, was 21.54% less than the expected value, 0.5594 kg. In contrast, the experimental y-intercept (m2g), 0.20188 N, is only 0.437% greater than the theoretical value, 0.201 N (Fig. 4). The lower experimental mass infers that the acceleration values found were too small. Potential reasons for this could be friction between the wheels and track or additional air resistance, which would decrease acceleration. Alternatively, the side of the ramp with the pulley could have been angled higher, reducing the acceleration of the cart. Lastly, if our fan forces were overestimated (not zeroed), the acceleration would be smaller than expected.