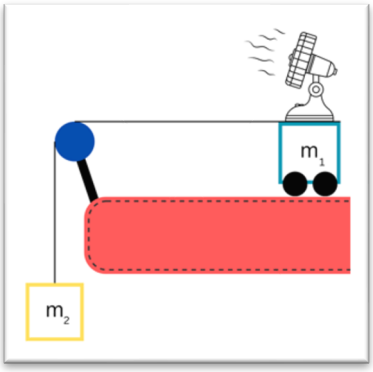
Investigative Question: What is the force of the fan in a system of a fan-propelled cart traveling along a metal track in a modified Atwood's machine obeying Newton's Second Law?

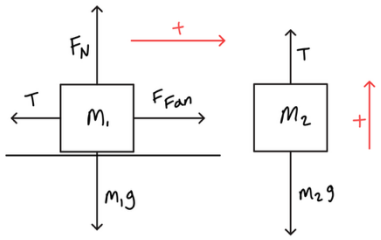
Hypothesis: The relationship between the hanging mass and acceleration will be linear. The slope of the best fit line should be $-\frac{g}{m_{\text{total}}}$ and the y intercept should be $\frac{F_{\text{fan}}}{m_{\text{total}}}$, where m_{total} is the total mass and F_{fan} is the force of the fan.

Strategy (with setup / diagram): To change the hanging mass while keeping the total mass of the system constant, weights were transferred between the cart and the hanging mass. In other words, when mass was added to the hanging weight, the same amount was removed from the cart. This ensured the total mass of the cart–pulley system remained the same. The fan attached to the cart provided a constant force pushing the cart away from the pulley. Acceleration was measured by using the sensor on the cart.



Hanging Mass (kg)	Acceleration m/s²
6	0.360333
11	0.265
16	0.171333
21	0.09072
26	0
31	-0.05223
36	-0.14367
41	-0.22167

The acceleration is the average of the three trials.



Positive motion is defined as to the right, up the hanging weight, in the direction of the fan. By using the free body diagram and looking at the masses as one body, the equation is as follows:

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

Converting it into $y = mx + b$ form and substituting m_{total} gives us:

$$-\frac{g}{m_{\text{total}}} m_1 + \frac{F_{\text{fan}}}{m_{\text{total}}} = a$$

Using the measured total mass as 0.529kg, this tells us the expected slope should be:

$$-\frac{g}{m_{\text{total}}} = -\frac{9.8}{0.529} = -18.53 \frac{\text{m}}{\text{s}^2 \cdot \text{kg}}.$$

The experimental slope (using the best fit line) was: $-16.38 \frac{\text{m}}{\text{s}^2 \cdot \text{kg}}$. The expected intercept is $\frac{F_{\text{fan}}}{m_{\text{total}}} = \frac{0.23}{0.529} = 0.435 \text{m/s}^2$, and the experimental intercept is 0.444m/s^2. The % error of the slope and y-int is 11.6% and 2% respectively.

Possible sources of error includes friction and fan thrust variability. Friction in the track and pulley opposes motion, which reduces the net force on the system and therefore makes the measured accelerations smaller, causing the experimental slope to be less steep (less negative) than the theoretical value. Fan thrust variability can cause the applied force to fluctuate slightly; if the fan produced slightly less force at times (likely due to battery drain or airflow), the y-intercept would decrease, lowering all acceleration values equally.