Question: How does increasing friction affect the acceleration of a cart traveling along a metal track in a modified Atood's machine?

Hypothesis: The relationship between the acceleration of the cart and the friction will be a negative linear slope because acceleration will decrease as friction increases. The y-intercept will be positive and equal to the hanging mass times gravity divided by the sum of the total mass in the system.

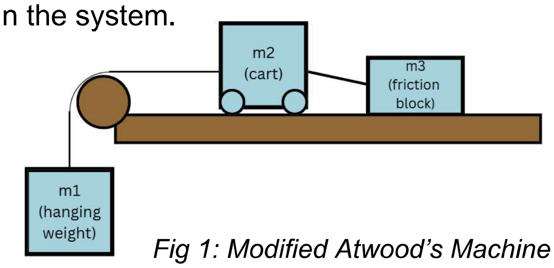

Fig 1: Modified Atwood's Machine

Strategy:

- To cause friction, we attached a wooden block covered with felt to the back of the cart. We varied the number of weights on the wooden block to increase the amount of friction of the block with the metal track.
- We kept the mass of the total system constant. At any point, there were only 4 weights on the cart and block combined. We started with 4 weights on the cart and moved them one at a time onto the friction block in each trial. We also assumed that there is no friction caused by the cart, so the friction is only produced by the wooden block.
- The hanging weight was kept constant with one weight.
- The friction block (m_3) was graphed against the acceleration to find the slope, which is $\frac{-\mu g}{m1 + m2 + m3}$

Data:

Total mass of the system (m_1+m_2+m_3): 1.0804 kg

Mass of hanging weight (m_1): 0.1529 kg

# of weights on friction block	m2: cart (kg)	m3: block (kg)	avg acceleration (3 trials) (m/s^2)
0	0.7958	0.1317	1.01
1	0.6699	0.2576	0.73
2	0.544	0.3835	0.47
3	0.4181	0.5094	0.21
4	0.2922	0.6353	0.04

Analysis:

The free-body diagrams in Figure 2 show the forces on the three masses in the modified Atwood's machine.

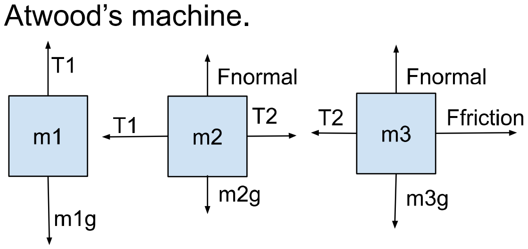

Figure 2: Free Body Diagrams

Friction between the cart and track is negligible because the cart's wheels spin freely. Positive motion is to the right of the cart and down of the hanging mass. Equations from the diagram are:

$m_1g-T_1=m_1a$	$T_1-T_2 = m_2a$	$T_2-F_{friction}=m_3a \rightarrow T_2-\mu m_3g=m_3a$

By manipulating these equations to remove T1 and T2, we can write an equation in the form of y=mx+b with acceleration as y and m_3 as x:

$$a = \frac{-\mu g}{m1+m2+m3}m3 + \frac{m1g}{m1+m2+m3}$$

When we graph our data, $\frac{-\mu g}{m1+m2+m3}$ should be the slope and $\frac{m1g}{m1+m2+m3}$ should be the y-intercept. This equation indicates that there is a negative linear relationship between friction force ($\mu g m3$) and acceleration.

The graph of the data confirms this: The slope is -1.95 $\frac{m}{kg*s^2}$ and the y-intercept is 1.24 $\frac{m}{s^2}$.

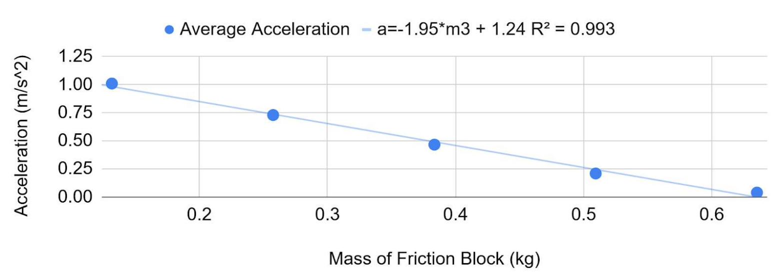

Figure 3: Mass of Friction Block vs Acceleration

The actual y-intercept is 1.387$\frac{m}{s^2}$. This means the data is 10.59% smaller than expected. A likely source for why the observed acceleration was less than it should have been is that we assumed the cart had no friction, even though it actually would. Additionally, the hanging mass wobbled during its fall, and air resistance was not accounted for, both of which likely slowed down the hanging mass's acceleration.