Question: How does varying the mass of an object with friction that is being dragged by a cart traveling along a metal track in a modified Atwood's machine affect acceleration?
Hypothesis: If the mass of the object with friction is increased, then the acceleration will decrease, showing a linear relationship with a negative slope because the increased mass will cause an increased friction force that opposes the tension.

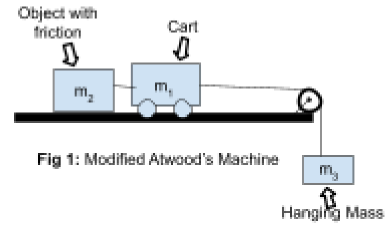


Fig 1: Modified Atwood's Machine

Strategy:
- m_2 was varied by placing different amounts of weights on the block.
- The total mass was kept constant by placing unused weights on the cart so that when the sum of the masses was included in the equation, the equation remained linear with a constant slope.
- m_2 was graphed vs. the measured acceleration. The slope can help determine the coefficient of friction.

Data:
Total mass of the system: 1.0803kg

Number of weights on friction block	Mass of Friction Block (kg)	Acceleration (m/s^2)
0	0.1317	1.01
1	0.2576	0.73
2	0.3835	0.47
3	0.5094	0.21
4	0.6353	0.04

Acceleration is averaged across 3 trials.
Analysis:
The free-body diagrams in Figure 2 show the forces on the masses in the modified Atwood's machine.

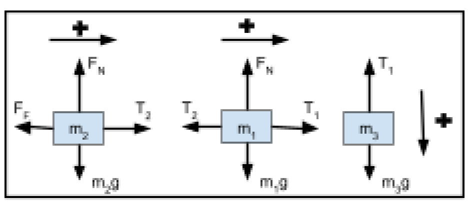


Fig 2: Free Body Diagrams

Friction between the cart and the track is negligible because the cart's wheels spin freely. m_2 has an unknown coefficient of friction. The equations below are based on the free-body diagrams:

1) $m_3g - T_1 = m_3a$ 3) $T_1 - T_2 = m_1a$

2) $T_2 - \mu m_2g = m_2a$

The sum of all these equations is as shown:

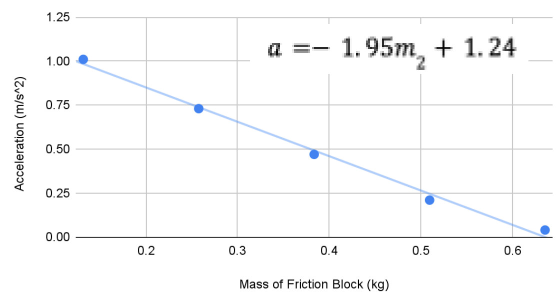
$$m_3g - \mu m_2g = (m_1 + m_2 + m_3)a$$

The equation can be rearranged to isolate acceleration on one side and separate m_2 from its coefficient.

$$a = m_2\frac{-\mu g}{(m_1+m_2+m_3)} + \frac{m_3g}{(m_1+m_2+m_3)}$$

This equation shows a linear relationship between m_2 and acceleration. Figure 3 shows a graph of the acceleration vs m_2. It shows that the relationship is linear, with a y-intercept of 1.24 and a slope of -1.95. This means that as m_2 increases, acceleration decreases, proving our hypothesis.

Fig 3: Acceleration (m/s^2) vs. Mass of Friction Block (kg)



From the equation, it is clear that the slope represents the negative coefficient of friction multiplied by gravity divided by the total mass. The slope is -1.95. Using the slope, equation, and masses, it can be determined that the coefficient of friction between m_2 and the track is 0.215. The actual y-intercept is 1.39, indicating the measured value of 1.24 had a percent error of -10.8%. The measured acceleration was lower than expected, which would have resulted in a lower measured y-intercept. Some likely sources of error include the table not being perfectly level. The table could have been slightly leaning up on the pulley side, which slowed the acceleration. The hanging mass also wobbled at times, which could have reduced the acceleration somewhat. When it moved side to side, it reduced the gravity coefficient.