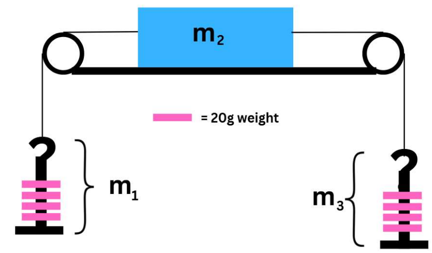
Question: How does changing masses on a three-mass modified Atwood's machine affect acceleration of the system?

Hypothesis: Acceleration of the system will be directly proportional to the difference of masses of the two hanging objects when the total mass of the system is kept constant.

Strategy:



- The overall mass of the system is kept constant. This is done by using hooked carriers for small weights and transferring the weights around the system but keeping the total amount of weights constant.
- The acceleration of the system is measured using Vernier Graphical Analysis and finding the slope of the velocity graph over the period of time.
- The acceleration was plotted against the difference in mass between the hanging masses to confirm the linear relationship between these variables. The slope of this line is acceleration due to gravity over the sum of masses in the system.

Data:

We had 8 20g masses in total (represented in pink in the diagram). Each of the hooked attachments weighed 50g. We started with 4 on each side. We conducted 5 tests, moving a weight from one side to the other each time. For each test, we conducted 3 trials and averaged the observed accelerations for more accurate data.

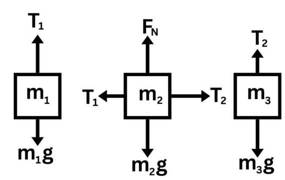
Mass & Acceleration Data

Trials	Mass 1	Mass 2	Mass 3	Avg. Acc.
1	130	282.3	130	0
2	150	282.3	110	0.6765
3	170	282.3	90	1.372
4	190	282.3	70	2.052333333
5	210	282.3	50	2.759666667

Analysis:

First, we found the relationship between the masses and acceleration, as shown in purple. Acceleration is directly proportional to the difference of mass 3 and mass 1. Thus, the slope of a graph between the difference in mass and acceleration is equal to g over the sum of masses. The expected value of the slope is 0.0181 m/kgs², and the experimental slope was 0.0172 m/kgs², shown in the graph to the right. This leaves a percent error of 4.97% less than the expected value. This discrepancy is likely due to friction in the system, as friction would lower the overall acceleration of the system and thus the slope of acceleration vs. mass difference. Additionally, though we used the levelling app, there could have been a slight slope on the table that would impact acceleration. The R^2 value was 1, proving that the relationship between acceleration and difference in masses is a strong positive linear association. Overall, the data proves our hypothesis of acceleration being directly proportional to the difference of the masses.

Free Body Diagrams



Calculations

$$m_1 a = T_1 - m_1 g$$
$$m_2 a = T_2 - T_1$$
$$m_3 a = m_3 g - T_2$$
$$(m_1 + m_2 + m_3)a = m_3 g - m_1 g$$
$$a = \frac{g}{(m_1 + m_2 + m_3)}(m_3 - m_1)$$

$$\frac{g}{(m_1 + m_2 + m_3)} = \frac{9.8}{(282.3+130+130)} = 0.0181\ m/kgs^2$$

Acceleration v. Mass Difference