**Dynamics Lab: The Relationship Between Hanging Mass and Acceleration in a System with Constant Total Mass**

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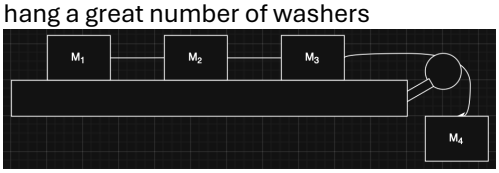
**Question:**
How is the relationship between acceleration and mass affected by the mass distribution on a pulley system?

**Hypothesis:**
The acceleration will increase as the mass decreases from the side that is on the track and increases on the hanging weight in a linear manner.

**Strategy:**

- The attached two blocks had a friction component ($m_1$ & $m_2$) created by the felt attached to them to a cart ($m_3$). Hanging from the cart was a 50g weight ($m_4$) that allows more weight to attach to it and hang a great number of washers

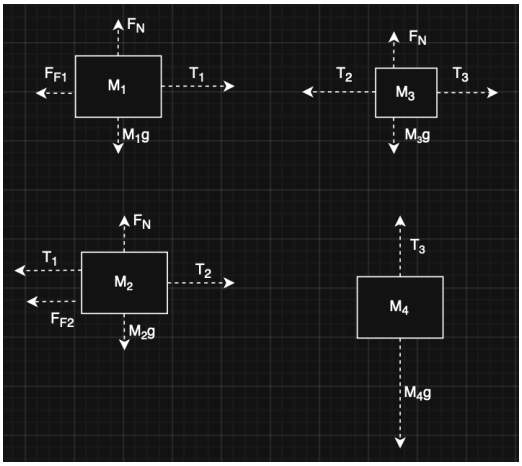



- The total mass of the system was kept constant as the washers just changed positions between $m_3$ and $m_4$ rather than being taken on and off. 20g was moved from $m_3$ to $m_4$ in each trial
- The relationship between the hanging mass and the found acceleration was then graphed and cross-checked to make sure it held accurate to the expected equation of the system. To measure this, we used an application that connected the cart to a computer that gave the data.

**Data:**
The total mass of the system is .7404kg (740.4g)

| Mass of Hanging Weight vs Acceleration | |
|---|---|
| Acceleration (m/s/s) | Mass of hanging weight (g) |
| 0.2 | 40 |
| 0.34 | 60 |
| 0.5 | 80 |
| 0.8 | 100 |
| 1.03 | 120 |
| 1.3 | 140 |
| 1.66 | 160 |

**Analysis:**
The free-body diagrams in the figure below show the forces on the masses in the modified Atwood's machine:



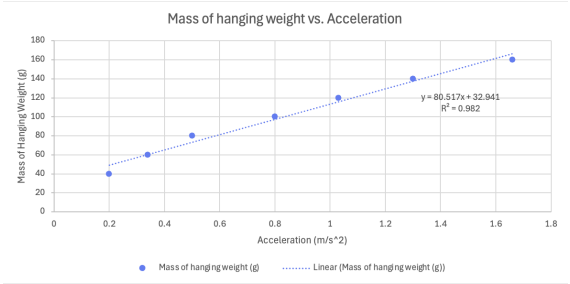

From these free-body diagrams, we can get the equation:
$$m_{4g} - \mu m_1 g - \mu m_2 g = (m_1 + m_2 + m_3 + m_4) * a$$

Which can be simplified to:

$$m_4 = \frac{m_{total}}{g} * a + \mu(m_1 + m_2)$$

This now looks like the familiar form of y=mx+b, where $m_4$ = y, $\frac{m_{total}}{g}$ = m, etc.

When graphed, the relationship between hanging mass and acceleration looks like this:




The real $\frac{m_{total}}{g}$ value of the system is 75.55, making our lab 6% less than the expected value. Because the acceleration is slightly less than expected, we can assume that this small difference is most likely because of friction in the pulley or the friction between the track and the cart. Overall, the results of this experiment support the model for a modified Atwood machine and show the linear relationship between the hanging mass and the acceleration when the total mass of the system is constant.