Question: Does the relationship between the mass and acceleration of two carts on inclined planes follow Newton's Second Law?

Figure 1: Lab Setup

Hypothesis: The relationship between the difference of masses and acceleration will be linear. The slope of the difference of masses versus acceleration will be equal to gravity multiplied by the sine of the angle divided by the sum of the masses.

Setup & Diagram:

A modified Atwood machine was set up in the style of an isosceles triangle. Pulleys were attached to the top of the ramps The base of the triangle was measured to be 115 cm and the two ramps, including the length of the pulleys, were 138 cm. The angle between both legs and the base was 65 degrees. One car was set up on each ramp, each having different masses.

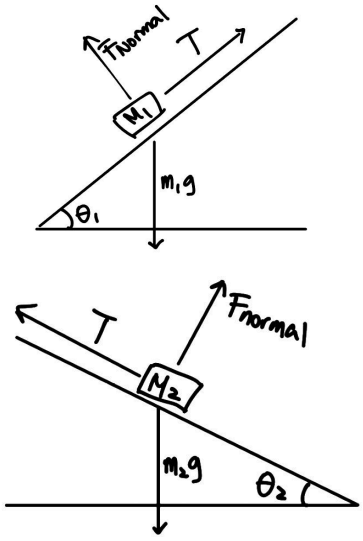


Fig. 2: Free body diagrams

Equations & Process:

The ramps were set to create an isosceles triangle with the ground, meaning that θ_1 and θ_2 were equal.

In a regular Atwood machine, acceleration can be found by finding the difference of masses, multiplying that value by gravity, and dividing that value by the sum of masses, which can be shown by the free body diagrams. Both of the masses in this experiment are on inclined planes. The force that a car has down the direction of the plane would be m * g * sin(θ). The equation for finding acceleration can be modified in order to accommodate this, as shown below:

$$a = (m_1 g\sin(\theta) - m_2 g\sin(\theta)) / (m_1 + m_2)$$

This equation can be rewritten to represent the differences of the masses as well. This version of the equation shows that there is a linear relationship between the differences of the masses and the acceleration.

$$m_1 - m_2 = a(m_1 + m_2) / g\sin(\theta)$$

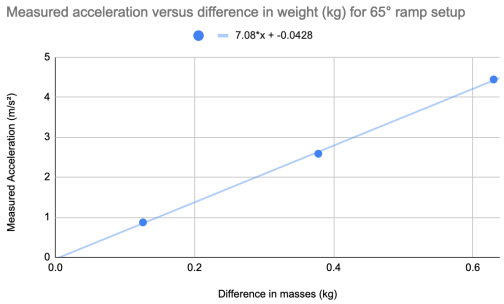
Data:

3 different car masses were tested on the Atwood machine, with the combined mass of the cars staying constant for all trials.

Mass of Car A (g)	Mass of Car B (g)	Average Acceleration (m/s^2)
930	300	4.443
804	426	2.588
678	552	0.873

Analysis:

Graphing the relationship between the differences of masses and acceleration gives:



As expected, the graph shows a linear relationship between the difference of masses and acceleration. To find the percent error between the expected and the experimental slope, the expected slope must be found first. The sum of the weights of the two cars is 1,230 grams, or 1.23 kilograms. Dividing 9.8 * sin(65) by this value gives an expected slope of 7.22, a 1.9% difference from the experimental slope.

For the sources of error that could have altered our experimental slope, friction and air resistance are likely causes. Friction would have counteracted the falling force of car A, decreasing its acceleration, and causing the experimental slope to be less than the expected slope. Air resistance likely did not have much effect on the falling force of the car, but could have been a very small factor in its value.