Question: Does the relationship between force, mass, and acceleration of two weighted cars on different inclined planes follow Newton's second law?

Hypothesis: The relationship between the acceleration and difference of the masses (m_1-m_2) will be linear, and the slope of the line should be the gravity multiplied by the sin of the angle divided by the sum of the masses.

Strategy:

- We will have two tracks of the same length on the same inclination of 65 degrees (Figure 2).
- One cart will be placed on each ramp and attached with a string over a pulley
- The total weight will be the same for each trial, but weights will be transferred from one car to the other
- The acceleration of the heavier car will be measured using a Vernier motion detector
- The weight difference will be graphed against the measured acceleration to verify that the slope was equal to the sum of the masses divided by gravity multiplied by the sin of the angle.

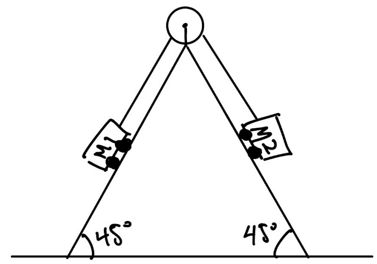

Fig:1 Modified Atwood's Machine

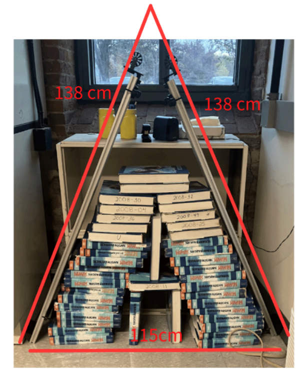

Figure 2: This is the setup for the experiment. The measurement for the leg of the isosceles triangle is 138 cm.

Data:

Calculated Averages		
Mass of Car 1 (g)	Mass of Car 2 (g)	Acceleration (m/s^2)
930	300	4.443
804	426	2.588
678	552	0.873

We ran three experiments and then took the average of the three trials for our data table. The combined mass of the cars stayed the same at 1230 grams. We shifted the weights from Car 1 to Car 2 for each trail to get the different weights.

Analysis:

The forces on the masses in our modified Atwood's machine are shown in Figure 3. There is no need to factor in Friction because the wheels were spinning freely. The ramps were set at the same angle so θ_1 and θ_2 are equal. In a regular Atwood machine, acceleration is found by finding the difference of masses, multiplying it by gravity, and dividing that total value by the sum of the masses. This can be derived from the free-body diagram (Figure 3).

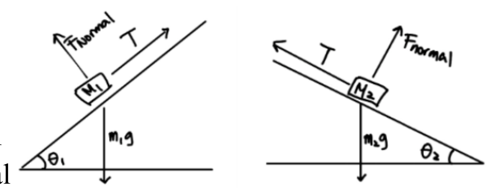

Figure 3: Free body diagrams for the two cars.

Since both the masses are on inclined planes, the force on the mass down the direction of the plane would be m * g * sin(θ). To find the expected acceleration, we used the formula to the right. We also rewrote the equation to represent the differences in the masses. This 'new' equation shows a relationship between the differences in the masses and acceleration.

Given $\theta_1 - \theta_2$

$$\frac{m_1 \sin(\theta_1) g - m_2 \sin(\theta_2) g}{m_1 + m_2} = a$$

$$m_1 - m_2 = \frac{a(m_1 + m_2)}{g \sin\theta}$$

$$\frac{m_1 + m_2}{g \sin\theta} a = \text{the slope}$$

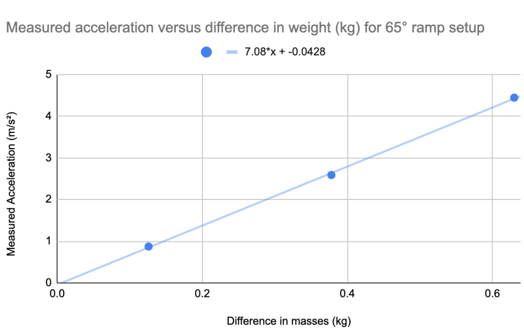

Figure 3: Measured acceleration vs. difference in mass for a 65-degree ramp

We graphed the difference in mass vs acceleration, showing a linear relationship. The slope should equal (m1 + m2) / gsin(θ). Since the data is linear, we can conclude that the acceleration and the differences of the masses are directly proportional. We calculated the expected value by dividing 9.8*sin(65) by 1.23kg[the sum of the weights], to get an expected slope of 7.22. The actual slope was 7.08, which is only a 2% error.

A source of error could be air resistance and friction. Air resistance was present and slowed down the cars, but it may not have affected them as much as friction. Even though we did not account for friction, there is a possibility that the car wheels were generating some friction against the tracks. This would cause energy to be lost, so the speed of the carts would be slower. Friction could be a factor as to why our slope was 2% less than the expected slope. A more accurate model could be designed by factoring in friction.