Question: Does the relationship between the fan force, mass, and acceleration of a cart traveling along an elevated metal ramp obey Newton's Second Law?

Hypothesis: The relationship between fan force and acceleration will be linear. The slope of the graph of Fan Force vs. acceleration will be equal to 1 divided by the total mass of the system.

Strategy:

- The force of the fan was modified by changing the fan speed setting to numbers 0 to 4. The fan was also placed on a 3-degree incline. Additionally, the fan force was calculated with the use of a force sensor.
- The fan was placed backward so it would act as a push force up the ramp, against gravity. Hence, the upward movement is positive, and the downward movement is negative.
- The measured acceleration vs. the applied force (Fan Speed) was graphed to verify that the slope was equal to 1 divided by the total mass of the system (The fan and cart).

Fig 1: Ramp with fan attached to cart

$(mg\sin\theta - F_{pull} = ma)\frac{1}{m}$

$g\sin\theta - \frac{1}{m}F_{pull} = a$

constant, slope, x, y

Data:

Total mass of system: 0.4326 kg
Angle measure: 3.486 degrees

Fan Speed	Fan Force (N)	Average Acceleration (m/s²)
0	0	-0.509933333
1	0.118	-0.185666667
2	0.167	-0.083
3	0.201	0.001
4	0.252	0.049333333

The acceleration is an average of three trials

Analysis:

The free body diagram in Figure 2 shows the forces on the system (the cart and the fan) on a ramp.

Fig 2: Free Body Diagram

Initially, we assumed that friction is negligible because the cart's wheels spin freely. The following equation is based on the free-body diagram. Positive direction is defined as up the ramp, and the negative direction is defined as down the ramp.
The second equation allows us to portray Newton's Second Law in a linear mx + b = y format. This equation indicates that there is a linear relationship between the force of the fan and the acceleration of the system. The slope of the line would be the coefficient of the inverse of the system's mass (the fan and cart).

The graph shows the acceleration vs. the Fan Force data for the experiment which shows that the relationship between the two variables is linear, and the slope is 0.29 kg.

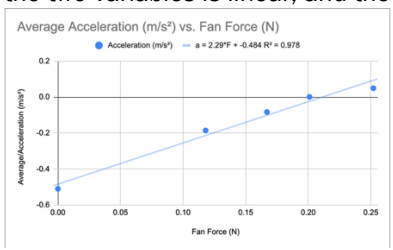

Figure 3: Average Acceleration (m/s2) vs. Fan Force (N)

The actual mass of the system is 0.4326 kg, with an expected slope of 2.29 1/kg (the inverse of the mass). This means that the inverse mass found from the acceleration data is 0.90% smaller than expected. The fact that it is smaller indicates that the measured acceleration values of the cart were less than expected. A source of error would be the friction between the wheels and the track as the friction would decrease the acceleration. Another source of error would be measure of the table's angle which we didn't account for down to the decimal (We only used the level app on our phones to get a whole number measurement of 0, but there might have been a slight decimal angle of the table itself).