

Central Question: Does the relationship between force, mass, and acceleration of a cart traveling along an inclined plane with a fan acting on it obey Newton's Second Law?

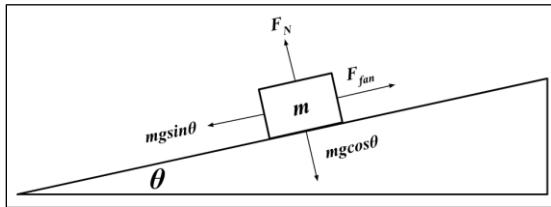


Fig. 1: Free Body Diagram of Setup

Hypothesis: The relationship between fan force and acceleration will be linear. The slope of the graph of acceleration vs. fan force will be equal to the reciprocal of the total mass of the system.

Experimental Approach:

1. Measure the fan force on each fan speed setting using a force sensor and the Vernier app.
2. Set up the inclined plane at an angle that will result in at least one fan speed setting pushing the cart back up the ramp. For this experiment, this angle was approximately 3.486°.
3. Measure the acceleration of the cart along the ramp at each of the fan settings using a Vernier motion detector.

Data:

Total mass of the system: 0.433 kg

Fan Force (N)	Acceleration (m/s ²)
0.000	-0.510
0.118	-0.186
0.167	-0.083
0.201	0.001
0.252	0.049

The acceleration is an average of three trials.

Analysis:

For this experiment, friction between the cart and track was assumed to be negligible due to the free motion of the cart's wheels, and motion down the ramp was considered negative. Using Newton's Second Law, which dictates that $F_{net} = ma$, the following equation was created.

$$F_{fan} - mg \sin \theta = ma$$

Isolating for a results in the following equation:

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

The final equation shows that there is a linear relationship between the cart's acceleration and the applied fan force, with the slope of the graph between them being the reciprocal of the total mass in the system.

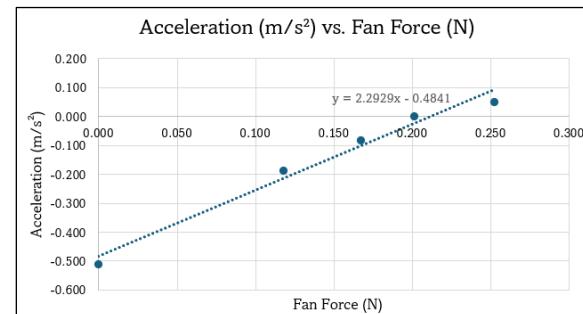


Fig. 2: Acceleration vs. Applied Fan Force

The reciprocal of the slope, or the experimental mass, is approximately 0.436. This means the measured mass is 0.693% higher than expected. The theoretical y - intercept of the graph is -0.596, so the observed value is 18.75% higher than expected. Potential sources of this error include failing to zero the acceleration sensor, which affects the cart's initial acceleration, and incorrectly calibrating the inclined plane, which affects the value of θ .