Question: Does the relationship observed between net force (F), acceleration (a), and mass(m) when the mass of an object on a frictionless surface is increased while propelled by a constant force obey Newton's Second Law?

Hypothesis: If the mass of a cart on a frictionless surface is increased, and the force applied to it is constant, then the acceleration will decrease, in accordance with Newton's second law.

Strategy:

- A fan running at a constant speed was placed on top of a wheeled cart to propel it.
- The weight of the cart was varied over 5 groups by adding metal weights to the cart.
- Using Vernier Graphical Analysis with the cart, the velocity and acceleration of the cart when the fan was at full power were measured.
- The average acceleration and average slope of velocity (also acceleration) were averaged to get an accurate value for acceleration in each of the three trials at each weight.
- A graph comparing the reciprocal of the cart's mass to its acceleration was made to find the slope, a/(1/m), or m*a, to find the force applied by the fan (assuming F_F is negligible)
- A Vernier force sensor was connected to the wheeled cart while running the fan, measuring the actual force applied by the fan (the average of three trials)

Data:

# of weights	cart mass (kg)	a_{avg} (m/s^2)	1/m (kg^{-1})
0	0.4333	0.583	2.3079
1	0.5591	0.448	1.7886
2	0.685	0.356	1.4599
3	0.8106	0.293	1.2337
4	0.9363	0.255	1.068

***The acceleration of each group is an average of three trials**

Trial #	Force (N)
1	0.299
2	0.278
3	0.266
Average:	**0.281**

Analysis and Conclusions:

This free-body diagram models this situation:

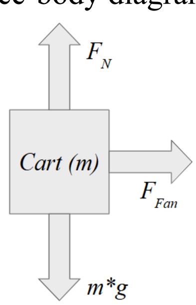

Figure 1:
Free body diagram

Based on the free body diagram, the forces in the axis of motion have the following equation:

$$m*a = F_{Fan}$$

assuming that friction is negligible. Because F_{Fan} remains constant, as the mass increases, the acceleration must decrease. To model this as a linear function, we can consider our independent variable $\frac{1}{m}$, giving us the relationship $a = (\frac{1}{m})*F_{Fan}$ graphed below.

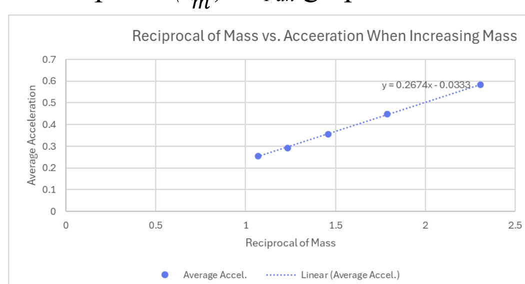

Figure 2: Graph of $\frac{1}{m}$ vs. acceleration as mass was increased. **This relationship is linear, obeying F=ma, Newton's second law. As mass increases ($\frac{1}{m}$ decreases), accel. decreases, proving the hypothesis.**

The force of the fan (the graph's slope, 0.267) was compared to the measured value, 0.281, meaning the experimental value was 4.98% less than the expected value. This is understandable because the force measurement would not be impacted by friction, though the trials were, thus reducing the measured net force.