Question: How does increasing the total mass of a Vernier cart affect its acceleration under a constant fan force, as predicted by Newton's Second Law (F=ma)?

Hypothesis: According to Newton's Second Law (F=ma), if the Vernier fan applies a constant force, then as the total mass of the cart increases, its acceleration should decrease proportionally, showing that acceleration is inversely related to mass. Therefore, when the acceleration is plotted against the reciprocal of mass, a linear relationship should be observed with the slope representing constant fan force.

Strategy:

A Vernier fan was attached to a cart placed on a level metal track to minimize friction. The cart's acceleration was recorded in three trials for each mass condition, and the average acceleration was calculated. Up to four additional masses were added to the cart while keeping the fan force constant, resulting in five total mass-acceleration pairs. The fan's thrust was also measured separately using a digital force scale, taking three trials to determine an average fan force

Data:

# of weights	mass (kg)	Average Accel.
0	0.4333	0.583
1	0.5591	0.448
2	0.685	0.356
3	0.8106	0.293
4	0.9363	0.255

Mass and average acceleration recorded at each weight.

Force #1	Force #2	Force #3	Average Force
0.299	0.278	0.266	0.281

Measured force of the fan

Analysis:

Friction between the cart and the track is negligible because the cart's wheels spin freely. Applying Newton's Second Law, the relationship between acceleration and mass can be expressed as $a = F/m$ Therefore, plotting acceleration (a) versus the reciprocal of mass $(1/m)$ should produce a linear relationship where the slope represents the constant fan force (F).

$$a = 1/m \times F$$

In Figure 1, we plotted our data with the reciprocal of math on the X-axis and the average acceleration on the y-axis.

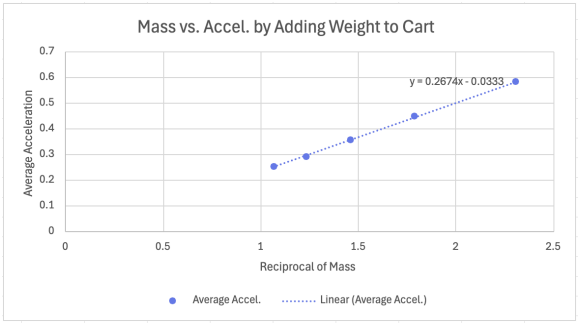

Figure 1: Reciprocal of Mass vs. Acceleration

The slope of Figure 1 is the calculated force from the fan. This value was then compared to the measured fan force obtained using the digital force scale, showing a difference of 4.8%. This small discrepancy (less than 5%) is not significant and may have resulted from minor variations in the fan's thrust or slight inconsistencies in zeroing the digital scale between measurements.