Question: Does changing the normal force on a hanging object change its coefficient of friction?

Hypothesis: Increasing the hanging weight tied to the cart will have no effect on the coefficient of friction between the cart and the track.

Strategy:

- The hanging mass in a modified Atwood's machine was varied by hanging various numbers of weights from the base weight tied to the string.
- The resulting acceleration was measured using two photogates' measures of velocity and used to solve for the cart's coefficient of friction.

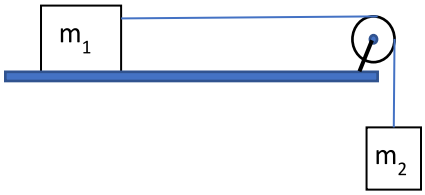

Fig 1: Modified Atwood's machine

Data:

Mass of Cart (m_1): 0.299 kg

Distance between photogates: 0.146 m

# of added weights	Total Mass	Velocity 1 (V_0)	Velocity 2 (V)
0	0.349	0.000	0.000
1	0.369	0.000	0.000
2	0.389	0.000	0.000
3	0.409	0.187	0.440
4	0.429	0.317	0.615
5	0.449	0.369	0.702
6	0.469	0.530	0.878
7	0.489	0.579	0.942

The acceleration is an average of seven trials

Analysis:

The free body diagrams in Figure 2 show the forces on the masses in the modified Atwood's machine.

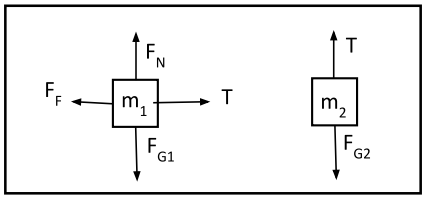

Figure 2: Free Body Diagrams

The following equation was used to find the acceleration from the two velocities we obtained from the photogates and the distance between them. The results from the acceleration calculation are listed in figure 3.

$$v^2 = v_0^2 + 2a\Delta x$$
$$2a\Delta x = v^2 - v_0^2$$
$$a = \frac{v^2 - v_0^2}{2\Delta x}$$

Using Newton's second law, the following equation was used to find the coefficient of friction.

$$Fnet = m(total)a$$

$$m_2 g - \mu m_1 g = (m_1 + m_2)a$$
$$m_2 g - m_1 a - m_2 a = \mu m_1 g$$
$$\mu = \frac{m_2 g - m_T a}{m_1 g}$$

a	0	0	0	0.00543	0.00951	0.0122	0.0168	0.0189
μ	0	0	0	0.292	0.355	0.315	0.300	0.320
Total Mass	0.349	0.369	0.389	0.409	0.439	0.449	0.469	0.489

Figure 3: Acceleration and μ calculation

The total mass of the system was increased each test by adding weights, indicating that the acceleration each test was expected to increase. As we changed the normal force acting on m_2, the coefficient of friction remained nearly constant between different weights of m_2. The most likely source of slight differences across values of μ was the reaction time for reading the velocity values from the photogate. The coefficient of friction was 0 for the first 3 trials, as the cart was not moving. Thus, these values can be disregarded when calculating μ.