Question: Is the coefficient of kinetic friction altered by adding weight onto an object?

Hypothesis: If the weight of an object is increased (by adding more mass) which therefore increases the overall normal force, then the coefficient of friction between the two original surfaces will stay constant. This will result in a linear relationship between the normal force and the pulling force (x-component) of the object.

Strategy:

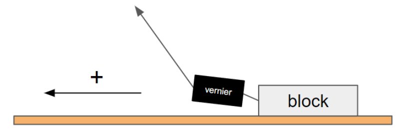

Figure 1: Setup of Experiment

- A block with a velcro surface was pulled across a wooden plank at constant speed. The pulling force was found using the Vernier force sensor. This process was repeated for multiple trials with additional objects added on top of the block.
- The pulling force needed to be angled upwards to ensure that the Vernier force sensor didn't touch the wooden plank and cause additional friction. It was attempted to keep this angle constant throughout each of the trials.
- The normal force vs. the x-component of the pulling force was graphed to verify that the constant slope was equal to mu, the coefficient of friction.

Data:

Each weight combination was pulled five times across the wooden plank. The average pulling forces of the five trials for each mass is listed below (Table 1). The angle above the horizontal of the pulling force was 28.9° for each trial.

object(s)	mass (g) ▲	avg Fpull
block	118.5	0.258
block + one washer	130.5	0.389
block + one rock	177.3	0.537
block + 2 rocks	255.8	1.002

Table 1: Experimental Data

Analysis:

The free body diagram in Figure 2 shows the forces on the object(s) as it was pulled across the wooden plank.

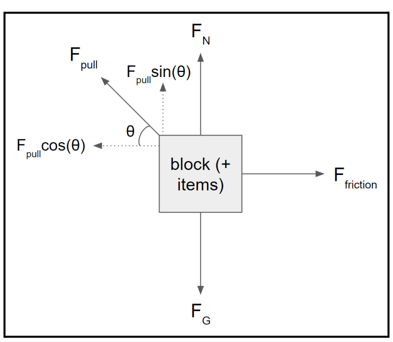

Figure 2: Free Body Diagram

Based on the forces acting upon the block and its additional items, the equation for Newton's second law of motion, $F_{net} = ma$, can be rewritten in the following way, with the left direction (in Figure 2) indicating positive motion.

$$F_{pull}\cos(\theta) - F_F = ma$$

The force of friction (F_F) can be rewritten as μ (the coefficient of friction) multiplied by normal force. Normal force in this model can be calculated by subtracting $F_{pull}\sin(\theta)$ from gravitational force, since the sum of $F_{pull}\sin(\theta)$ and F_N cancel out gravitational force. As a result, the equation can be rewritten as:

$$F_{pull}\cos(\theta) - \mu(mg - F_{pull}\sin(\theta)) = ma$$

Acceleration in this system was 0; therefore, the net force equation can be rewritten again as:

$$F_{pull}\cos(\theta) = \mu(mg - F_{pull}\sin(\theta))$$

This equation indicates that there is a linear relationship between the x-component (horizontal portion) of the pulling force ($F_{pull}\cos(\theta)$) and the normal force ($mg - F_{pull}\sin(\theta)$). The slope of the line should be equal to the coefficient of friction (μ) between the surface of the block and the wooden plank.

A graph of this relationship with the average values from each trial indicates a mostly linear relationship, with the slope equalling 0.615.

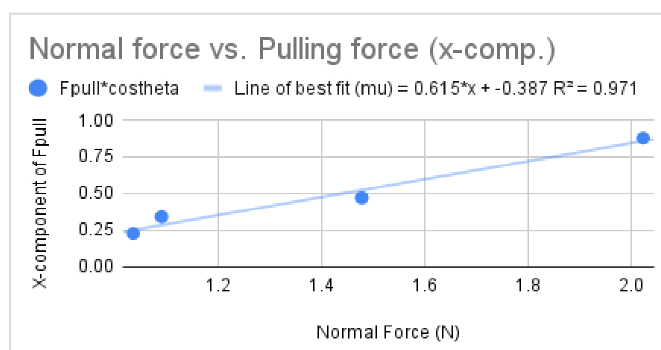

Figure 3: Graph Model of Data

The R^2 is very close to 1, which indicates that the line of best fit represents the data largely accurately. This supports the fact that weight does not affect the coefficient of friction between two surfaces. The minor discrepancies in the data is likely due to imperfect measurements of the F_{pull} angle above the horizon and inconsistencies in velocity.