Question: Does the surface area of an object affect the coefficient of friction (kinetic)?

Hypothesis: The coefficient of friction will not change for the same surface material regardless of surface area.

Strategy:

- The focus of this experiment was dragging the block of wood we had with the weight attached to it at an equal and constant velocity, so that the acceleration of the wood block would be 0 making the calculations. We measured and calculated the surface area of each of the sides: 10 square inches, 5 square inches, and 2 square inches.
- The weight was attached to the wood block using duct tape and was used to make the block have more weight, so that when it was dragged along the tile, it would not fall over easily. We avoided putting tape on any of the sides being used to drag along the floor to make sure there were no other materials being involved that could add or subtract from the coefficient of friction.
- We dragged the wood block along the tile for a length of 1 meter and had 5 different trials where we measured the force using the force measurer. Then we averaged the 5 trials for each of the 3 sides of the wooden block to get the average force needed to make the block move (but not accelerate) for each side. We pulled the block using a string attached to a hook and pulled at a direction parallel to the tile and floor.
- Additionally, the pull force was again not causing acceleration, but just the force to move the object in an equal and constant velocity, so it would be more easy to solve for the kinetic coefficient of friction and the frictional force in general.

Data:

Total mass of the system: 0.6336 kg

Sides and the pull force displayed below:

Trials	Side A →10 in^2 (force N)	Side B → 5 in^2 (in N)	Side C → 2 in^2 (in N)
1	1.820	1.669	2.134
2	1.79	1.643	2.107
3	1.73	1.691	2.164
4	1.894	1.683	2.132
5	1.83	1.667	2.185
Average	**1.8128**	**1.6706**	**2.1624**

The forces used to calculate are averages of five trials.

Analysis: This free body diagram shows all the horizontal and vertical forces acting on that block, and since all 3 sides used are of the same block, the free-body diagram for each side is the same. We used the pulling force to measure the frictional force as well, and since the block had positive velocity, we know the pull force is greater than the force of friction.

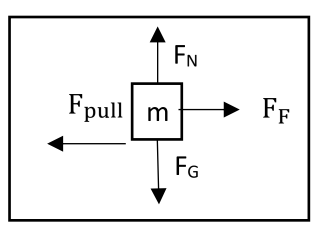

Figure 2: Free Body Diagrams

We will use the following equations to figure out the normal force acting on the wood block, and then the frictional force. Using the relationship between the frictional force and normal force, we can figure out the kinetic coefficient of fraction for all three sides and surface areas.

$$F_{net} = m * a$$
$$F_F = \mu_k * F_N$$

First, let's calculate the normal force acting on each of the sides of the wood block. Since each side of the object has the same mass, the normal force for each side/case would be the mass times gravity (9.8), so that would be 6.2093 N. Next, let's find the force of friction for each side. We know the acceleration is 0, so using the first equation the net force for each side will be 0.

We also know the pull force, so $F_{pull} - F_F = 0$. That means side A has a frictional force of 1.8128 N, side B has a frictional force of 1.6706 N, and side C has a frictional force of 2.1624 N acting on the wood block.

Then, $F_F = \mu_k * F_N$, so for each side we can write the following equations replacing the variables:

Side A: $1.8128 = \mu_k * 6.2093$ → $\mu_k = \mathbf{0.292}$

Side B: $1.6706 = \mu_k * 6.2093$ → $\mu_k = \mathbf{0.269}$

Side C: $2.1624 = \mu_k * 6.2093$ → $\mu_k = \mathbf{0.348}$

Now, looking at these values, our data shows that the opposite of our hypothesis was proven. The coefficient of friction does not stay the same, regardless of surface area. The calculated coefficients of friction do not stay constant or similar, as the coefficient of friction for sides A and B (10 in^2 and 5 in^2 respectively) are somewhat similar, however the smallest side in regard to surface area, side C, had the largest coefficient of friction. Some reasons for this may be that the weight was positioned differently for side C since we didn't want to wood block to tip over easily, and the greater force was pushing down. Also, we know the data for side C should be correct since it was very consistent over our trials. Another reason is that side C also was somewhat different than the other 2 sides. It was rougher in a sense and was not as smooth and the other because it had some holes and parts that were not sanded as much. This would make sense as to why side C had a larger coefficient of friction and higher pulling force because there was more friction occurring. If we were to re do this experiment, then we would definitely make sure that the levels of smoothness and materials are all the same, or as similar as possible since some materials like wood are not always perfect.