Question: Does increasing the mass of an object change the static and kinetic coefficients of friction between it and another surface?

Hypothesis: Increasing the mass of an object has no effect on the coefficient of friction.

Strategy:

1. The mass was increased by iteratively adding blocks on top of the initial mass, made of wood.
2. The mass was placed at the end of a track made of metal.
3. For static friction, the end of the track with the mass was raised up until the mass started accelerating.
4. For kinetic friction, the mass was moved by pulling on it with a force sensor, keeping acceleration close to 0, which measured the pulling force. A motion sensor was then used to measure the position, velocity, and acceleration.

Data:

Number of Metal Weights	Mass (kg)	μ_k
0	0.1337	0.18
1	0.6293	0.18
2	1.1271	0.17
3	1.6264	0.17
4	2.1228	0.17

# of Metal Weights	Mass (kg)	Height of Inclined Plane (cm)	Length of Inclined Plane (cm)	Angle of Inclination (degrees)	μ_s
0	0.1337	78	227.5	20.05	0.365
1	0.633	82	227.5	21.13	0.386
2	1.1311	80	227.5	20.59	0.376
3	1.63	78	227.5	20.05	0.365
4	2.1157	80	227.5	20.59	0.376

Analysis: The free body diagrams show the forces acting on the mass in the kinetic friction and static friction examples.

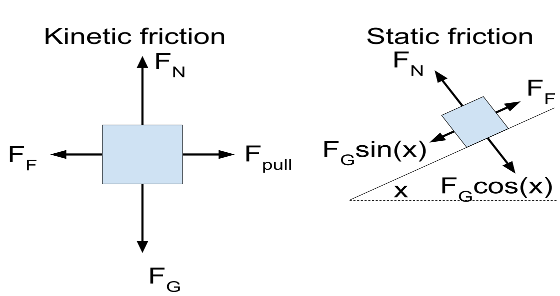
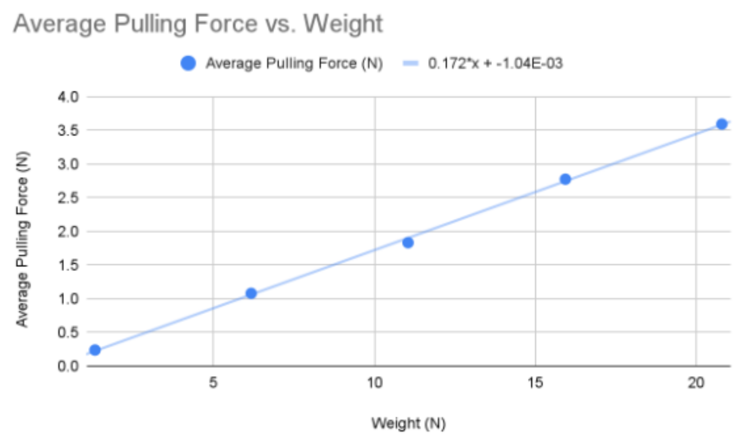


Figure 1: free body diagrams

In the kinetic friction diagram, the horizontal acceleration is 0, so the pulling force is equal to the friction force. The vertical acceleration is also 0, so the force of gravity is equal to the normal force.

Figure 2: average pulling force vs weight



The slope is the pulling force divided by the weight. Substituting the equalities stated above, the slope is equal to the friction force divided by the normal force, which is the coefficient of friction. The graph's line of best fit shows the slope to be 0.172, which matches up with the table above.

In the static friction diagram, the object does not move, so $F_F = F_G\sin(x)$, and $F_N = F_G\cos(x)$. The mu, F_F/F_N, is then equal to $F_G\sin(x)/F_G\cos(x)$, which simplifies to tan(x). The table above shows the angle values for different masses. They were roughly equal, so the static coefficient stayed the same.

These findings confirm the hypothesis. It makes sense that the coefficient stays the same because the two surfaces are not changing.

Obviously, the data were not exactly equal. There are multiple places this error could have come from. For kinetic friction, while David tried to keep the acceleration to 0, it did fluctuate and so did the pulling force. The sensor also might not have picked up some of the movements of the object due to the changing height. For static friction, the plane had grooves on each side that affected the object's ability to move, which were hard to avoid.