Question: Does the surface area of a dragged object affect its coefficients of friction (Mu)?

Hypothesis: Surface area will not affect the coefficients of friction for a dragged object because although there is a greater area which friction acts on for a larger surface, there is less pressure from gravity throughout that surface. Pressure and area are inversely proportional.

Strategy:

- This lab has two experimental components: an apparatus to measure the static coefficient of friction and another to measure the kinetic coefficient of friction.
- The first apparatus consists of an angled wooden board with a cardboard box of gloves sliding down it. The board starts off parallel to the ground and then is slowly raised until the box starts to slide. The height of the board is measured at this point. This is done to find the critical angle of the system, with that, the coefficient of static friction can be found. Repeat this process for the other side of the box (different surface areas).
- The second apparatus consists of the same box and board, but the board stays parallel to the ground the entire time. Instead of gravity acting as the force, this time a constant force (no acceleration) is applied to drag the box over the board to determine the kinetic coefficient of friction. A force sensor was used to track the force, in newtons, of the force applied to start to move the box (force of friction). This number can be used to calculate the coefficient of kinetic friction. Repeat this process for the other side of the box (different surface areas).
- The surface area of the sides of the box were graphed vs. the coefficients of friction to determine whether surface area affects the coefficients of friction

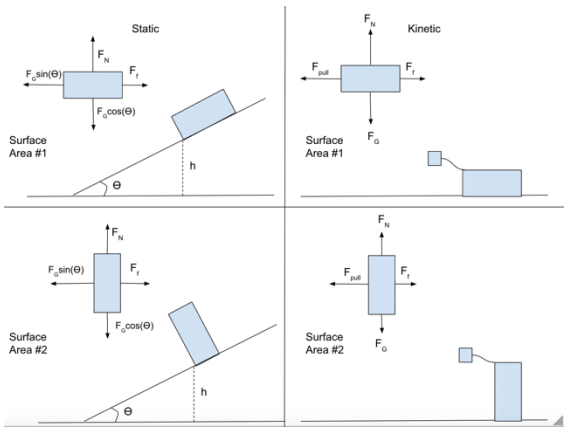

Fig 1: Diagram of the four experimentations done with the FBD of the box

Data:

Mass of the cardboard box: 0.15kg

Length of the hypotenuse for static friction calculations: 1m

Surface Area (cm^2)	Height which box starts to slide (cm) (static)	Force of Friction (N) (kinetic)
84	33	0.38
84	30.5	0.38
84	30.5	0.38
138	32	0.4
138	28.5	0.4
138	36.5	0.4

Units are not in m because the numbers are too small

Analysis:

The mu of static friction can be found by taking the inverse tangent of the angle which the slope makes with the horizontal. Because the hypotenuse of the triangle is locked at 100cm (1m), the height at which the box starts to side can be measured to find the angle (by using inverse sin). Now that the angle is known, the tangent can be taken, yielding the mu of static friction. Below is the proof of how mu can be found using by taking the tangent of the angle.

$$F_G \sin(\theta) - F_F = 0$$
$$F_G \sin(\theta) = F_N \mu$$
$$mgsin(\theta) = mgcos(\theta)\mu$$
$$\mu = \tan(\theta)$$

Using the heights from the data table, the angles and static mu turn out to be:

Surface Area (cm^2)	Angle (deg)	Mu (static)
Sample Calculation	$\sin^{-1}$(height/100)	tan(angle)
84	19.27	0.35
84	17.76	0.32
84	17.76	0.32
138	18.66	0.34
138	16.56	0.30
138	21.41	0.39

Average static mu for surface area of $84cm^2$ is 0.33, $138cm^2$ is 0.34.

By definition, the mu of kinetic friction can be found by dividing the force of friction (measured by the sensor) by the normal force of the object. In the case of the second experiment, the normal force turns out to be just the weight of the object (mg), as there are no other vertical forces acting on the object.

Using the forces of friction from the data table, kinetic mu turns out to be:

Surface Area (cm^2)	Mu (kinetic)
Sample Calculation	Force of friction/1.5N
84	19.27
84	17.76
84	17.76
138	18.66
138	16.56
138	21.41

The weight of the box is mg = 1.5N

Average kinetic mu for surface area of $84cm^2$ is 0.25, $138cm^2$ is 0.27.

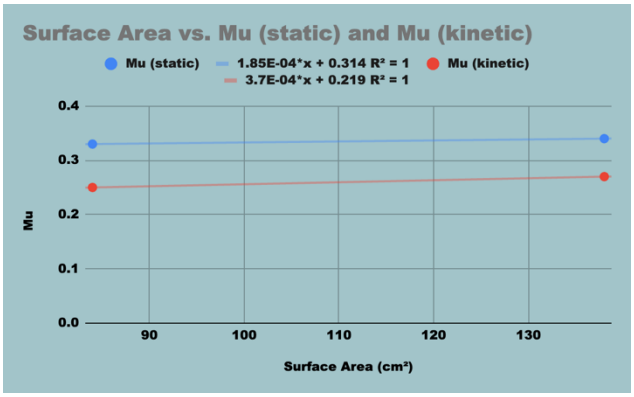

Fig 2: Graphs of surface area vs. mu (static) and mu (kinetic)

From the graphs of the surface area of the sides of the box vs. the coefficients of friction (average of the trials), it can be reasonably inferred that surface area does not affect the coefficient of friction. The surface areas between the sides of the box differs by almost double ($54cm^2$), but the coefficients of friction only differ by 1 or 2 hundredths.

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