KINETIC FRICTION

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**OBJECTIVE:** To observe the properties of kinetic friction. More specifically, to observe how the coefficient of kinetic friction depends on the interacting materials, their surface area, the normal force between them and the surface velocity.

**THEORY:** By using a pulley system and two masses attached by a string which passes over the pulley, an environment to calculate the coefficient of kinetic friction is created. The pulley is configured so that one mass (m) is suspended of the edge of a flat surface while the other mass (M) is free to move horizontally across that surface. When the first mass isn’t in equilibrium then it will accelerate downwards causing the second mass to slide across the surface. As the second mass moves across it experiences resistance due to the frictional force. So the net force on the system due to Newton’s 2nd Law states that Fnet = (mass \* acceleration) – friction.

Ffriction = *k* \* Fnormal , (*k* = kinetic coefficient)

Substituting frictional force into Newton’s 2nd Law and solving for *k* derives the equation:

*k* = (m/M) – (1 + (m/M)) \* (a/g) , (a = calculated acceleration, g = gravity).

**PROCEDURE:** A rectangular wooden block with a felt pad on two sides was weighed and its mass was determined. A smooth aluminum panel was placed on a flat tabletop and a pulley system was placed at the edge of the table. A cord was tied to the wooden block and was then placed over the pulley, then a second mass was tied to the other end of the string. The pulley was connected to a *DataStudio* program which would measure the slope of the velocity graph around a specific velocity (v) to give a calculated average acceleration.

First, the wooden block (M) was placed with the large felt surface facing down and and held so that the string was directly in line with the pulley as a dangling mass (m) of 75 grams was attached to it. After releasing M an acceleration was recorded and the process was repeated two more times. An average calculated acceleration was measured and *k* was calculated. This process was repeated for the large wooden side, the small felt side and the small wooden side.

This same process was then used when the dangling mass (m) was changed to 100 grams and then 125 grams.

Next, the process was repeated for the large felt surface and the large wooden surface except for each time the dangling mass increased (m), 50 grams of mass was placed on the rectangular block (M).

**DATA:** Below are the data tables from the experiment. Note: the average acceleration was calculated by adding the three experimental accelerations and then dividing that number by three.

Felt, Large Surface, Constant Normal Force, Variable (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.04 | 0.289 |
| 119.5 | 100 | 1.25 | 2.26 | 0.413 |
| 119.5 | 125 | 1.5 | 3.56 | 0.303 |

Wood, Large Surface, Constant Normal Force, Variable (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.48 | 0.216 |
| 119.5 | 100 | 1.25 | 2.84 | 0.305 |
| 119.5 | 125 | 1.5 | 3.46 | 0.324 |

Felt, Small Surface, Constant Normal Force, Variable (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.10 | 0.279 |
| 119.5 | 100 | 1.25 | 2.94 | 0.286 |
| 119.5 | 125 | 1.5 | 3.64 | 0.286 |

Wood, Small Surface, Constant Normal Force, Variable (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.07 | 0.284 |
| 119.5 | 100 | 1.25 | 2.83 | 0.306 |
| 119.5 | 125 | 1.5 | 3.62 | 0.290 |

Felt, Large Surface, Variable Normal Force, Constant (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.04 | 0.284 |
| 169.5 | 100 | 1.0 | 1.91 | 0.306 |
| 219.5 | 125 | 1.0 | 1.82 | 0.278 |

Wood, Large Surface, Variable Normal Force, Constant (v):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (M), grams | (m), grams | (v), m/sec | (a) average, m/s2 | *k* |
| 119.5 | 75 | 1.0 | 2.48 | 0.216 |
| 169.5 | 100 | 1.0 | 1.78 | 0.301 |
| 219.5 | 125 | 1.0 | 1.71 | 0.296 |

Sample Calculations:

Average acceleration = (trial #1 + trial#2 + trial#3)/3

(2.04 + 2.02 + 2.07)/3 = 2.04 m/s2

*k* = (m/M) – (1 + (m/M)) \* (a/g), where (a = calculated acceleration, g = gravity)

*k* = (75 g/ 119.5 g) – (1 + (75 g/ 119.5 g)) \* (2.04 m/s2) \* (9.8 m/s2) = 0.289

Average *k* = (0.289 + 0.413 + 0.303)/3 = 0.335

**RESULTS:** Average *k*

Felt, Large Surface: 0.335

Felt, Small Surface: 0.284

Wood, Large Surface: 0.282

Wood, Small Surface: 0.293

% difference between wood and felt surfaces = (felt – wood)/((felt + wood)/2)\*100

% difference small surface: 3.11%

% difference large surface: 17.2%

**ERROR ANALYSIS:** Opportunity for error to occur includes the position of the string relative to the block and pulley because the most accurate reading of acceleration occurs when the string is parallel to the aluminum surface and at a 180 degree angle with the pulley. In addition as the wooden block slides across the surface it sometimes would sway from side to side and change the angle of the force vector. Another factor that could cause error is the elasticity of the string and the string possibly slipping in the pulley.

**CONCLUSION:** *k* is not dependent on velocity since the coefficient of kinetic friction is the same regardless of velocity. However the force of friction will change according to the velocity. If velocity is constant then the *k* will remain the same. The mass of the object doesn’t affect the average *k*. The coefficient of kinetic friction is only dependent on the materials involved.