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Static and Kinetic Friction

Download FrictionForcevsTime.cap for 850 interface with Capstone

Download FrictionLab2.ds for ScienceWorkshop interface (black sensor)
Download FrictionLab2-GLX.ds for GLX interface (blue sensor)
Download FrictionLab-pasport.ds for Pasport interface (small interface without screen for blue sensor)

Name: __________________________________ Date: ________________

Lab Partners: ______________________________

Purpose: To study static friction and kinetic friction between the lab table and an friction block.

Materials:

Windows PC	High Sensitivity Force Sensor
Capstone application	Friction block from Pasco Track (with felt side)
String	Balance or scale (1 to 5 kg max)
ScienceWorkshop, 850 Interface	500 g mass bars or weights (4)

Part I - Starting Friction

1. Open the Capstone file , you will see a graph named “Friction Force Vs. Time.”

2. Measure the mass of the felt Friction block with at least two mass bars or 1 kg of mass on it and record the total mass in the data table below.

3. Connect the Force Sensor to the computer interface

4. Tie one end of string to the Force Sensor and the other end to the friction block.

5. **Practice pulling the friction block** with the Force Sensor using this straight-line motion: Very slowly and gently pull horizontally with a small force. Very gradually, taking at least one <u>full second</u>, increase the force until the friction block starts to slide, and then keep the block moving at a constant speed for another second. You should take practice data and throw them away until you are good at starting smoothly and pulling at a constant speed. Practice with different amounts of added mass.
6. Hold the Force Sensor in position, ready to pull the friction block, but with no tension on the string. Click on the "Start" button, then press the "Tare" button on the sensor to set the Force Sensor to zero.
7. Pull the friction block as before, making sure to increase the force gradually. Repeat the process as needed

until you have a graph that reflects the
desired motion, including pulling the friction block at a constant speed once it begins moving.

Data Set 1

Mass of felt friction block + added mass	(in kg)
Peak (magnitude) starting force	(in N)
Average force to keep constant speed.	(in N)

In DataStudio print out the graph of force vs. time recorded (Print a copy for each report being turned in.). Label on the printed copy the portion of the graph corresponding to the friction block at rest (due to static friction), the time when the friction block just started to move, and the time when the friction block was moving at a constant speed (with kinetic friction).

Part II - Peak Static Friction and Kinetic Friction

In this section, you will measure the peak static friction force and the kinetic friction force as a function of the normal force on the friction block. In each run, you will pull the friction block, as before, but by changing the masses on the block, you will vary the normal force on the friction block. Changes in mass of 0.5 kg produces a good range of values.

1. Start with several masses on the Felt Friction Block (2 to 3 kg is good if there are enough weights).
2. Click "Start" to begin collecting data and pull as before to gather force vs. time data.
3. Repeat step 2 for two more measurements with the same mass and average the results to determine the reliability of your measurements. Record values in both data tables ("Peak Static Friction" and "Kinetic Friction".tables).
4. Repeat steps 2 and 3 for different total masses to obtain friction values for at least 5 different values of the combined masses. Record the values in your data table.

Data Tables

Note that each trial produces data for **both tables**. The peak friction force is data about the static friction while the average force during the "constant speed" section is data about the kinetic friction. The first two columns in the tables should be identical.

Peak Static Friction

Total Mass (in kg)	**Normal Force (in N)**	**Trial 1 F_f peak(N)**	**Trial 2 F_f peak(N)**	**Trial 3 F_f peak(N)**	**Average Peak Static Friction (N)**

Kinetic Friction

Total Mass (in kg)	**Normal Force (in N)**	**Trial 1 F_f ave. (N)**	**Trial 2 F_f ave. (N)**	**Trial 3 F_f ave. (N)**	**Average (of averages) Kinetic Friction (N)**

Helpful Hints

1. Use a short string approximately 20 cm long.
2. Wipe the bottom of the friction block and the table where you will be doing the experiment to remove most of the dirt. This should help make the data values more consistent.
3. Practice pulling the block several times before making the measurement with a different mass.
4. The hardest case to pull smoothly is the one with least mass, save it for later when you have had more practice in pulling the block.
5. Try to use the same path for dragging on each pull of the block.
6. "Tare" (Zero) the force sensor before each pull.

Analysis

1. Still using the force vs. time graph you created in Part I, compare the force necessary to start the sliding to the force necessary to keep moving at a constant speed.
   How does the starting force compare to the force for constant speed? (Which is larger?)____________________________________

2. The *coefficient of friction* (μ) is a constant that relates the normal force between two objects (friction block and table) and the force of friction. Based on your graph from Part I, would you expect the coefficient of static (starting) friction to be greater than, less than, or the same as the coefficient of kinetic (sliding) friction? ______________________________

3. For Part II, calculate the *normal force* of the table on the friction block alone and with each combination of added masses. Since the friction block is on a horizontal surface, the normal force will be equal in magnitude and opposite in direction to the weight of the friction block and any masses it carries. Fill in the Normal Force entries for both Part II data tables.

4. Plot a graph in Excel for all the values of total mass to show maximum static friction force (y axis) vs. the normal force (x axis).

5. Since $F_{maximum\ static}\ (F_f) = \mu_s N$, the slope of this graph is the coefficient of static friction μ_s. Find the numeric value of the slope, including any units. Do not force the line to go through the origin. We will consider a non-zero intercept as an indication of some systematic errors.

   Use Excel to add a linear trend line and determine the equation of the trend line.
   Slope of line: _________________________
   Intercept of the line: __________________________ (Watch units!)
   Label this graph, including units, and <u>print a copy of the labeled graph (only the graph) to attach to this write-up</u>.

   Also use the provided spreadsheet to determine the uncertainty in the slope and intercept and record them.
   Uncertainty in the slope: _________________________________
   Uncertainty in the intercept: _____________________________ (Watch units!)
   Write the resulting value for μ_s. the slope, (in VUU format): _________________________________

   <u>Print the uncertainty spreadsheet, showing data, on a single sheet and attach to this write-up</u>.

6. In a similar graphical manner, find the coefficient of kinetic friction. Use a plot of the average kinetic friction forces vs. the normal force. Recall that $F\ kinetic = \mu_k$.N

   Should a line fitted to these data pass through the origin? ___________
   Use Excel to add a trend line, the equation of the trend line and the slope.
   Slope of line: _________________________
   Intercept of the line: __________________________ (Watch units!)
   Also use the provided spreadsheet to determine the uncertainty in the slope and intercept and record them.

   Uncertainty in the slope: ___________________________
   Uncertainty in the intercept: _________________________ (Watch units!)
   Write the resulting value for μ_k, the slope, (in VUU format): _________________________________

   <u>Again, print the labeled graph and the uncertainty spreadsheet and attach the two print-outs to this write-up.</u>