Slip me Some Skin

Purpose: To measure μ_s and μ_k for a variety of surfaces. To examine the relationship between surface area and frictional forces.

Set-up
This lab uses a set of friction carts with different surfaces at the bottom (cork, felt, and Teflon) and a set of masses totaling 1250 grams and a triple beam balance. Attach Airlinks to the motion sensor and the force sensor and link them to the computer using Capstone. Using the graph and "*Add New Plot Area to the Graph Display*" icons, create two graphs – force vs time, and velocity vs time, with a common time axis. Set the sampling rate to 100 Hz.

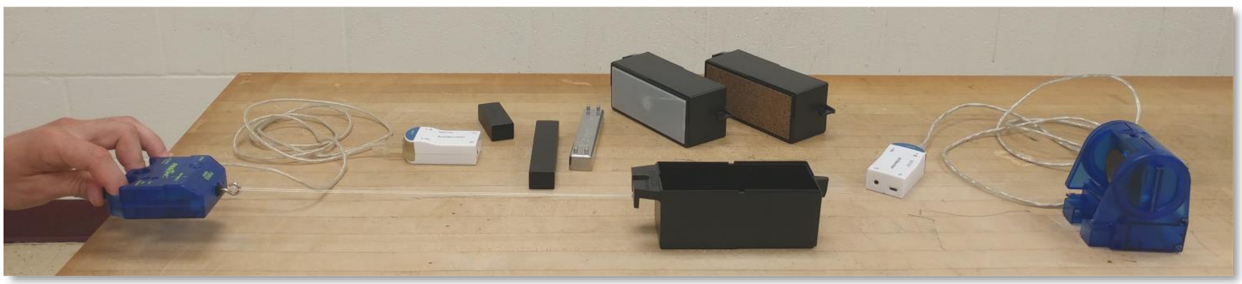

Fig. 1 - Set up for friction

Make sure your table is clear of debris; it may be necessary to wipe it off with a damp cloth to ensure a clean surface (make sure it is dry before collecting data). Measure the mass of each of the friction carts and the block masses and label them with a piece of masking tape.

Cut a piece of string and attach it to one of the friction carts (start with either the cork or felt cart) using a knot that is easy to untie, for example the larks head knot (see figure to the right).

Activity 1: Determining the Coefficients of Friction
Your aim is to (1) **determine the maximum force that you can apply to the friction cart before it starts sliding,** and (2) once it starts moving, **determine the force required to keep it moving with a constant speed**. The force sensor measures the force being applied to the cart at all times while through the motion sensor, the velocity of the friction cart is obtained. The motion sensor will aid the person pulling the friction cart to maintain as constant a speed as possible.

To do this, attach the force sensor to the end of the string as shown in Fig. 1 and position the motion sensor behind the friction cart. Before pulling, hold the force sensor horizontally and hit its Zero button. While the string is slack (no pulling yet), press the "*Record*" button, then the person holding the force sensor should slowly start to pull on the friction cart until it starts to move and once the cart starts moving, the person pulling should pull with a constant force so that the cart is moving with constant velocity for at about 5 seconds. This may require some practice.

From your resulting force vs time graph, determine **the maximum force F_{max} applied to the friction cart before it started sliding** and **the force $F_{while\ sliding}$ required to keep it moving with a constant speed** once the cart started moving. Record these two forces (in a data table using Excel) for five values of mass inside the friction cart: 1250g, 1000g, 750g, 500g & 250g (make sure you record the actual total mass you used for each case). It is suggested that you start with the largest mass and work your way down.

In Excel, plot a graph of F_{max} (before movement) vs. Normal Force (use the total mass to calculate the normal force) and a graph of $F_{while\ sliding}$ vs. Normal Force. Add a trend line to both graphs and find the slope and its error from the fit. **What does the slope of each of these graphs represent?**

Repeat this process for the other 2 surfaces. (You will likely be unable to collect quality data for 500g and 250g for the Teflon surface because the small forces involved may be below the resolution of the force sensors.)

Print from Excel one copy of your data tables and sets of graphs for each surface per group. Also, each group should print one copy of the best *v* vs. *t* and *F* vs. *t* graphs from Capstone for each surface type for the report.

Activity 2: Determine the Effect of Surface Area on Friction
For this part of the activity you will need to trade friction blocks with a neighboring group so that one group has two cork friction carts and the other group has two felt friction carts.

Put 1250g into one friction cart. Place the other similar block on top of the loaded block. Collect the same "Force" data as in Activity 1 and record these values in a new table.
Now hook the two blocks (with same surface type) together (one after the other) and distribute the 1250g as evenly as possible between them. Collect the force data for this new configuration. Record this data in your data table. Repeat this process for 1000g and 500g. Make a plot of the F_{max} (before movement) vs. Normal Force and the $F_{while\ sliding}$ vs. Normal Force for each configuration. **Note any differences or similarities of the results between the two configurations.** Print out the best graph obtained for each configuration.

Discussion/Questions:

1. What does the slope of the F_{max} vs Normal Force graph represent? What does the slope of the $F_{while\ slidung}$ vs Normal Force graph represent? Rank the three surfaces according to their friction coefficients.
2. What variables influence frictional forces?
3. What is the relationship between surface area and frictional forces, given the same normal force (mass)? Explain how your experimental results support your claim.
4. How does the normal force for the single surface configuration in Activity 2 compare to the normal force for the double surface configuration? Support your claim mathematically.