Phriction Phreaque-Out Part II

Apparatus: board, light pulley, string, scissors, cleaning fluid, paper towels, hockey pucks with hooks, angle indicators, tape, table clamps, mass hangers with slotted mass sets, method for raising and lowering board (could be a human or a system of rods, bases and right angle clamps), **smart pulleys?**

Goal: Determine the value of μ_k between a hockey puck and a board. By determining this in several different ways you should get practice with a variety of FBD's, force equations, and algebra.

Preparation: Thoroughly clean the board and puck surfaces and let them dry for at least 2 minutes. Do not touch the board or puck surfaces after cleaning. **Handle the puck by the sidewall; do not touch the circular faces.** If the puck falls on the ground or a surface gets touched, simply clean it again and wait 2 more minutes.

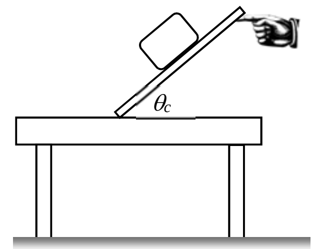
Common to all methods listed on the next page:
You will need to do FBD's and get force equations. After doing this, you need to solve those force equations for μ_k.
In each equation, you should have an acceleration term.
This implies we must measure acceleration in each method to determine μ_k.
Use one of the following methods to get accelerations for each method:

- Stopwatch to get $time$, meterstick to get distance, kinematics to get a
    - Only works well if acceleration if total travel time is more than a second.
- Smart pulley to get plot of v vs t, slope to get a
    - Only decent method if acceleration is large
    - Requires looking at data point by point to ensure plot only includes times while puck on board.
- Tracker to get plot of v vs t, slope to get a

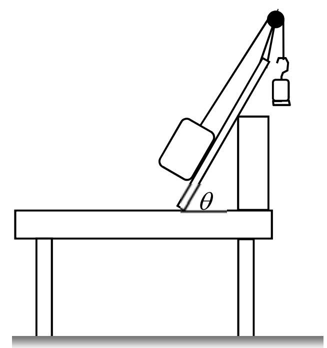
To turn in:
For this week, your intro should start with a sketch of the apparatus and an FBD for method 1 (draw them side by side and don't skimp on the size).
Don't forget to include a coordinate system so I can follow your work.
Then list the force equations centered on their own lines.
Finally, derive equation for μ_s from the force equations.
Repeat this so I have a sketch, FBD, force equations, and derivation for Methods 1, 2, and 3.
I won't be looking at grammar, just your diagrams, equations, and derivations.

Tabulate your data.
For each measurement, be sure to also tabulate your angles and, for Methods 2 & 3, your masses.
In total you should have 15 measurements of μ_k (5 from each method)
Determine the average and standard deviation of your eight measurements to determine your best estimate of μ_k and the associated statistical error.
Obtain the averages from all other groups in the class. Determine the best estimate of μ_k for the class and the associated statistical error.

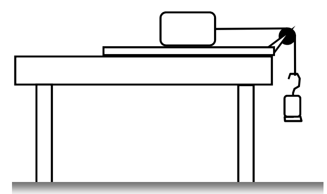
Method 1:
Start with the board horizontal. Place the puck on the board (handle puck by the edges). As slowly and smoothly as possible, raise the board. While you raise the board, monitor the angle indicator. At the instant the puck starts to slip, note the angle. The angle at which slipping onsets is called the critical angle (θ_c). Select an angle at least 10.0° above the critical angle while holding the puck at rest. Release the puck from and record the elapsed time to slide a known distance. Use this to determine at least 5 values of μ_k. Have Excel do all the math for you…



Method 2:
Now attach a string to the puck and run it over the pulley to a mass hanger as shown in the 2nd figure at right. You set-up should allows you to set the angle and leave the apparatus fixed at that angle for several minutes (see 3rd and 4th figures at right). You will use an angle of 60.0°. Make sure your design can accommodate all of these angles.



Once you have your appratus set-up, ensure that the string is parallel to the board by making adjustments to the pulley. For each angle, determine the *largest* possible hanging mass (m_2) to be used without causing the puck to slip *up* the plane. Select a <u>*significatnly larger*</u> value of m_2. The blocks should slide. Release the system from rest and record the elapsed time for the puck to travel a known distance. Use this information to determine at least five values of μ_k. Note: if the puck is travelling quickly, try to use as long a distance as possible. This is a tough one sometimes…



Method 3: Now lay the board flat. Select a hanging mass that is sufficent to cause the puck to slide. Determine at least 5 values of μ_k and tabulate them. Have Excel do all the math for you…