Kinetic and Static Coefficients of Friction

Introduction

You should recall from class the analysis of the inclined plane. This is important to be sure that you understand since you will see related problems again. I have reproduced this analysis on the class home page for your benefit. You should also watch the short movie that I made about the inclined plane. This is intended to help you with today's lab.

Materials & Equipment

You will need a weight hanger, two blocks (one with cork on it and one without) and also one block with sandpaper. There are also additional blocks that I want you to work with.

Read these two important details carefully!

(1) A very important detail:
Weigh and record the mass of the blocks you are using in this lab!

(2) A second important detail:

This is an important note regarding your angular measurement. The compass has 90 degrees pointing normal to the plane. The thread-weight plum bob will read another value. **You must subtract these two values** to get the correct angle which we call θ (keep it positive) reflecting the inclination of the plane. Your result should be something around roughly 40 degrees or so, not 85 degrees.

Setup

You should construct your equipment as was indicated in the movie. I will have an example set up for you in lab. You will want to choose an angle of about 35^0 for the inclination of the plane in all cases. Record the angle in your lab writeup.
You will want to weigh (on the electronic scales) the mass of each block you are using today.
Please note this: there are 2 methods to measure the coefficient of friction… the harder way and the easier way. I want you to use the harder method only 2 times today. For all subsequent work, use the easier method.

Next you should perform the following experiments:

(1) I want you to measure the coefficients for static and kinetic friction for your wooden (only wood) block using two methods. First (a) add enough weight to your weight hanger until the system starts to slide (on its own). This provides a measurement of the static coefficient of friction. Then, (b) I want you to measure the

kinetic coefficient of friction by adding weights to the hanger and giving the block a small push as indicated in the movie. (c) and (d) I then want you to measure each of these values by tilting the plane (in the case of the static coefficient, don't give small pushes, in the case of the kinetic coefficient, do give small pushes). Be sure to do the tilting of the plane only after you have finished (a) and (b). You will be able to obtain the relative error between the two methods of measurement. Don't be distressed if they are not in perfect agreement. They really should not be in exact agreement although they ought to be close. This is because there are more experimental uncertainties for the first method.

For the rest of the lab, I want you to measure the coefficients only by tilting the plane. The coefficient of friction measured by the tilting method is given by:

$$\mu = \tan(\theta).$$

This is calculated on the spreadsheet helper for this lab.

(2) Measure wide cork block side and narrow cork block side for area (use the metal rulers here). Then find the static and kinetic coefficients by tilting the plane. You will be able to have an indication as to how strongly area influences the frictional force from these experiments.

(3) Measure the static and kinetic coefficients of glass on wood.

(4) Measure the static and kinetic coefficients of the paperboard on paperboard.

(5) Measure the static and kinetic coefficients of sandpaper on wood. Use the block with sandpaper on it for this purpose.

For the wooden blocks, the percent deviation between the two methods of measurement is given by:

$$\%\ \text{deviation} = \frac{|\text{measurement}_1 - \text{measurement}_2|}{\frac{1}{2}(\text{measurement}_1 + \text{measurement}_2)} \times 100$$

You should work through the analysis for your benefit and understanding. In particular, please make sure that you can obtain all necessary components required to derive the acceleration and the equations of motion for the blocks. There is also a spreadsheet for this lab to help with the calculations. Be sure to save each under different names on your root directory.

Note: only for the wooden block will the entire spreadsheet apply. In the other cases, you will only calculate the coefficients of friction by tilting the plane.

In your lab writeup, I would like for you to answer the following questions based upon your measurements. For each material, (cork on wood, wood on wood, etc), what is the value of the static and kinetic coefficients of friction? Also, from a comparison of your measurements with different areas, does this coefficient depend upon area? You will need to include your observations in your lab write up in addition to the normally required portions of the lab writeup. You should attempt to answer these questions based upon the % deviation.