Kinetic and Static Coefficients of Friction

(revised Fall 2007)

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.

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 fishing line-sinker plum bob will read another value. **You must subtract these two values** to get the correct angle which we call θ 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 weight (on the electronic scales) the mass of each block you are using today.

Next you should perform the following experiments:

(1) I want you to measure the coefficient of kinetic and static 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 by measurement in the two different ways.

For the rest of the lab, I want you to measure the coefficients only by tilting the plane.
(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 by tilting the plane.

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

You will want
(2)
(1) With the large cork side of your block next to the plane, attach enough weight to the weight hanger so that the block will move with a slow constant velocity when given a small push. The minimum amount of weight which will satisfy this condition should be recorded in your notes. Next, place more weight on your mass hanger so that you can measure the static coefficient of friction as I indicated in the movie.

(2) Repeat these experiments for each side of your block. You will want to record the area of your block to get an idea of how the coefficient of friction depends upon area. In your lab report, be sure to talk about how the area affects the results.

(3) Find the kinetic and static coefficients for the block with sandpaper attached.

(4) Find the kinetic and static coefficients on the wide side.

(5) For all of the wooden blocks, you should test to determine how close the measured coefficients are. You can do this by tilting the plane until the mass

slides (when given a small tap) and also when the mass slides (when not given a small tap).

If you remember from class, when the plane is tilted, the coefficient of friction is given by:

$$\tan\left(\theta_{a=0}\right)=\mu .$$

Thus, you can measure the angle to get the coefficients.
For the wooden blocks, the percent deviation between the two methods of measurement is given by:

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

You can find the analysis for the mass connected to the inclined plane on the electronic handout entitled “Analysis of the inclined plane” on our website and also in the class worksheets. You should work through this analysis for your benefit and understanding. There is also a spreadsheet for this lab to help with the calculations. Be sure to save each under different names on your I drive.

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.