AP Physics Unit 4: Newton’s Laws

Lab 4-3: The Coefficient of Static Friction

**Purpose:**

In this experiment you will measure the coefficient of static friction, (μs) between two surfaces in two different ways.



**Materials:**

Wood block

Wood board

Masses

String

Pulley

**Procedure:**

Part 1:

1. Place a block on a wooden board, broad side down, and gradually increase the angle of the incline from zero. At first, static friction keeps the block stuck to the incline. As the angle increases, the component of the gravitational force downhill along the incline increases, and the uphill static friction increases in step, so that the net force on the block remains zero. But the static friction can increase only to a certain size; when the angle gets big enough, the downhill force exceeds the maximum static friction, and the block breaks loose and starts sliding downhill. We call the angle at which this happens the **angle of repose**, **θ***r*.

2. Measure and record the angle of the board, **θ***r*, when the block breaks away and slides down.

3. Repeat four times, for a total of five trials. For consistent results, use the same face of the block each time, and start the block from the same place on the board each time. Calculate the average of these **θ***r* ‘s.

4. **Repeat** this procedure with the wooden block lying on one of its **narrow** sides.

Part II:

1. Measure and record the mass of the block, *mb.*

2. Lay the board flat on the table. Attach one end of the string to the block and the other end to the mass hanger. Drape the mass hanger over the pulley, and place the block broad side down on the board.

*3.* Add mass slowly and gently to the hanger until the block breaks away from the board and begins to move. Record the total mass (including the hanger).

4. Repeat four times, for a total of five trials. Again, for consistent results use the same face of the block each time, and start the block from the same place each time. Also, remove all of the mass from the hanger after each trial, and start adding weight from scratch in the next trial.

5. Find the average mass that was needed to start the block to move. Calculate the *weight* of this mass, which gives the maximum force of static friction *Ff* (max). Calculate the normal force *Fn* between the block and the table.

6. Repeat this procedure four times, each time adding 0.100 kg to the top of the block, so that you end up with five series of trials, with added masses of 0, 0.100, 0.200, 0.300, and 0.400 kg.

**Data:**





**Data Analysis:**

1. Starting with the diagram below for Part I, draw a free-body diagram with the various forces acting on the block, just before it breaks loose, and use Newton’s Second Law to derive an equation to solve for the maximum value of static friction. Use this equation to find the coefficient of friction for each trial and record this in your data table for Part I.



2. Now use the diagram below for Part II, and draw a free-body diagram for each object of the forces acting on them just before the block breaks loose. Use Newton’s Second Law to derive and equation to solve for the maximum value of static friction. Use this equation to find the coefficient of friction for each trial and record this in your data table for Part II.



**Conclusions:**

1. Make some comments and conclusions about the nature of the frictional force. Things you might consider: Does the frictional force depend on the area of surface contact? How does the coefficient of friction vary with the normal force? Etc.

More on back!

2. You should get approximately the same value for μ*s* in each trial. Find the **percent difference** between the two methods by finding the difference between them (subtract one from the other) divided by the average of the two and multiplying by 100%. Give a **detailed** discussion of sources of error.

$$\%Difference= \frac{\left|Trial 1-Trial 2\right|}{\frac{Trial 1+Trial 2}{2}} x 100\%=$$