FRICTION

PURPOSE:

Friction is one of those things you just can't get rid of. The amount of friction can be reduced but never totally eliminated, nor would it always be advantageous to do so. Without friction cars wouldn't move, people couldn't walk, nor could any object in motion stop without retrorockets. In this lab we will explore friction in linear and circular circumstances.

THEORY:

For us, the magnitude of friction is merely the product of μ and **N**, where μ is the coefficient of friction and **N** is the normal or perpendicular force mentioned above, referenced to the plane of action. The coefficient of friction is a dimensionless quantity generally between zero and one which describes the stickiness between two surfaces, zero being not sticky at all and one being very sticky. It is a quality of the interface of the two surfaces. Ice and sand have a particular μ, while ice and steel have another. Without going into extraordinary detail, μ depends on the smoothness of the interface and the adhesion or cohesion between the substances (adhesion for unlike materials, cohesion for like materials, primarily electronic attraction). The way to enhance or reduce friction is by introducing another material into the interface, such as sand or oil. Aside from changing the electronic attraction between the original substances, sand or oil changes the smoothness of the surfaces. This is why sand is sprinkled onto an icy sidewalk. Oil fills the gaps, the bumps and valleys, on the surfaces and smoothens the surfaces out, but it also isolates the original objects and allows them to move more freely by "floating" one object against another. The oil separates into very fine layers in the interface which slip against each other, allowing objects coated with the oil to slide easily. There are many other methods to change μ, but most rely on some variation of these themes. Friction is not dependent on surface area. While this might be a surprising result, consider that, for a given object, the force per unit area goes up as the contact area goes down, effectively canceling any advantage in less contact area. The normal force is the force perpendicular to the plane of motion. For instance, for an object sliding horizontally, the normal force is equal to its weight, mg. If one pulls the object with a force **F** at an angle of 45^o, the normal force is lessened by **F** sin 45^o. If the object were on an inclined plane, the normal force would be mg cos θ, where θ is the angle of inclination. If $\theta = 0^o$, we have the first case, N = mg. If $\theta = 45^o$, N = 0.707mg. If $\theta = 90^o$, N = 0.

Thus, the magnitude of the friction force is given by equation 1:

$$f = \mu N$$

Friction always opposes motion.

We will study two kinds of friction, static and kinetic, under several circumstances. Static friction is the friction which opposes ``first motion", that is, the friction of an object at rest. It is, at its maximum, greater than kinetic friction. Static friction force equals the applied force until that maximum is reached. The object then breaks free and moves with acceleration (if the applied force is not reduced). In a sense, it takes more force to pop the objects out of their bumps and valleys than to keep them sliding. Kinetic friction is the friction of sliding, and is constant if the surfaces don't change in composition or smoothness.

EQUIPMENT:

- block
- inclined plane

- masses
- string

TASK 1:

To find the coefficient of static friction on an inclined plane;

Refer to figure 1:

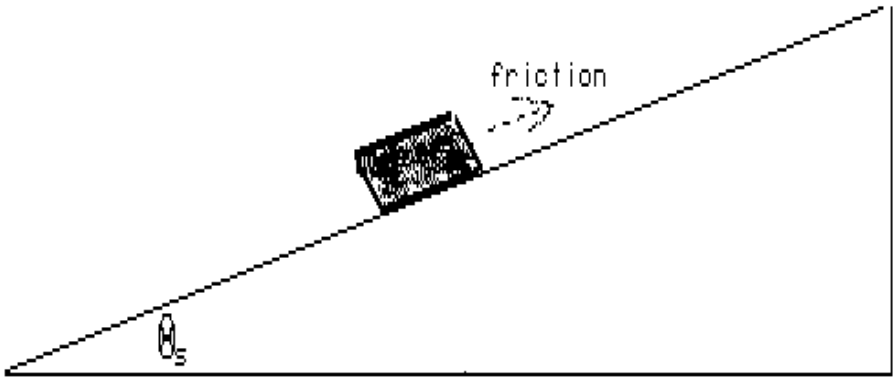

fig 1

If the object is on the verge of sliding, the coefficient of static friction is given by the tangent of the angle where the object begins to slide. Therefore,

$$\mu = \tan \Theta$$

a) Place the block on the inclined plane. Very slowly increase the angle of the plane until the block is on the **verge of slipping**. Read the angle to find the coefficient of static friction.

b) Repeat two more times. Alternate between you and your lab partner. Average the three values of the angle.

c) Calculate the coefficient of static friction by using the average value of the angles.

TASK 2:

To determine the coefficient of static friction between a wood block and a surface using a horizontal surface.

a) Connect the system as shown in figure 2.

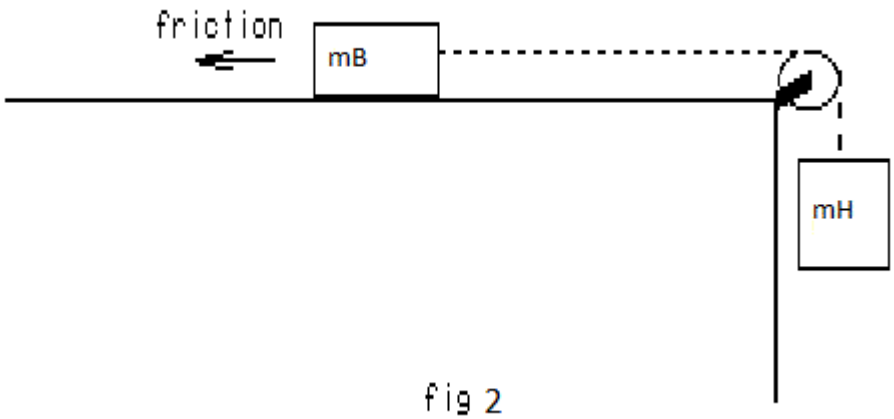

fig 2

b) Slowly add masses to the hanger until the block is on **verge of slipping**. Record the mass hung from the string.

c) Mass the block. The coefficient of static friction is simple the ratio of the mass hung from the string to the mass of the block. That is:

$$\mu = mH/mB$$

d) Repeat step (b) two more times and calculate the average of the three values of the mass.

e) Calculate the coefficient of static friction by using the mass of the block and the average value of the hanging masses.

d) Calculate the **percent difference** between the values of the coefficient that you obtained in **tasks 1 and 2**. If the difference is large find out why and fix it.

TASK 3:

To determine the coefficient of kinetic friction using a non horizontal surface.

a) As in task 1 put the block on the plane and slowly raise the plane. However, this time raise the plane only until the block slides at constant speed **when given a small push to overcome static friction**. Again the coefficient of kinetic friction is the tangent of the angle.

b) Repeat two more times alternating between you and your lab partner. Average the three values of the angle.

c) Calculate the coefficient of kinetic friction by using the average value of the angles.

TASK 4:

To determine the coefficient of kinetic friction between a block and a surface using a horizontal surface.

a) Repeat Task 2 but this time add masses to the hanger until the system moves with a constant speed **when given a small push to overcome static friction.**

b) As before the coefficient of kinetic friction is the ratio of the mass hung from the string to the mass of the block.

c) Repeat two more times and average the three values of the mass.

d) Calculate the coefficient of kinetic friction by using the mass of the block and the average value of the hanging masses.

e) Calculate the **percent difference** between the values of the coefficient that you obtained in **tasks 3 and 4.** If the difference is large find out why and fix it.