Inclined Planes

Objective

The objective of this lab is to understand the force of friction as well as to measure the coefficient of static friction between different objects and the inclined planes cutouts.

Background

Friction forces involve tangential forces generated between contacting surfaces. There are several different types of frictional forces, but in this lab dry friction will only be dealt with. Dry friction occurs when unlubricated surfaces of two solids are in contact under a condition of sliding or a tendency to slide. The friction force always occur tangent to the surface in contact, and opposing direction of the objects motion or impending motion (see figure 2). Before the object slides, or up to the point of slippage there is a region known as static friction where the object is not in motion. The static friction force can have a value anywhere from zero up to and including the maximum value. This maximum value of friction (F_{max}) is proportional to the normal force (N) given in this equation:

$$F_{max} = \mu N$$

The coefficient of static friction (μ) is a constant used to measure how much friction something has when it isn't moving with two specific materials. Static friction deals with Newton's third law where there are equal and opposite forces acting on the two solids that are in contact.

Once the frictional force is greater than or equal to the maximum frictional force, the forces acting on the surfaces become imbalanced and the solids slide. This is an example of Newton's first law which states that a body will stay in constant motion unless acted upon by an unbalanced force.

Purpose

In the inclined planes lab you will be analyzing different surfaces and solids by using the maximum static friction force equation as seen above to calculate the coefficient of static friction. You can use different objects and surfaces to compare different materials.

Materials

1. Inclined plane model
2. Inclined plane rectangular friction cutouts (aluminum metal, wood, carpet)
3. 2 Objects of each: metal washers, aluminum mini vents, and wooden plugs.
4. A measuring tool in meters or feet.

Procedure

Part 1:

1. Place the aluminum metal friction cutout onto the inclined plane.
2. Place the wooden plug object onto the friction cutout as seen in figure 1.
3. Measure the hypotenuse distance from the center of the object to bottom of the inclined plane (r).
4. Raise the inclined plane until the moment the object starts to slide down the inclined plane, then measure the height from the center of object (h) as seen in figure 1.
5. Calculate the angle (θ) using trigonometry.

    a. θ =____________________

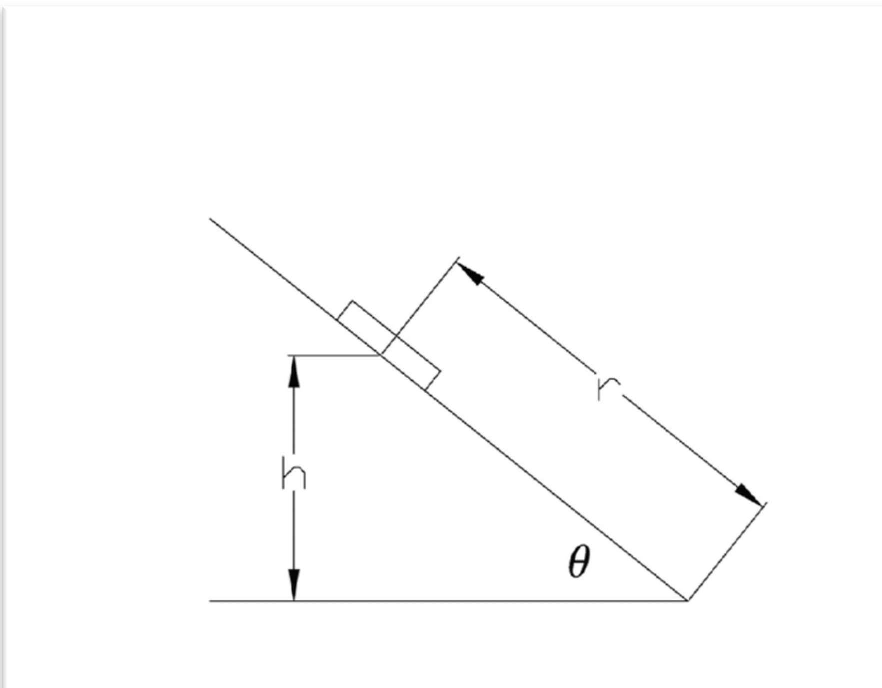

Figure 1 : Lab Procedure

6. Repeat steps 1-5 with the wooden rectangular friction cutout and the metal washer to find the angle θ.
7. Repeat steps 1-5 by using different combinations of the rectangular and objects to find the angle θ.

Part 2:

1. Use the free body diagram in Figure 2 to solve for N and F_{max} in terms of m, g, and θ. (Hint: equal opposite forces exist as the model obeys Newton's third law.)

   a. F_{max} =_____________________________________

   b. N (normal force) =___________________________

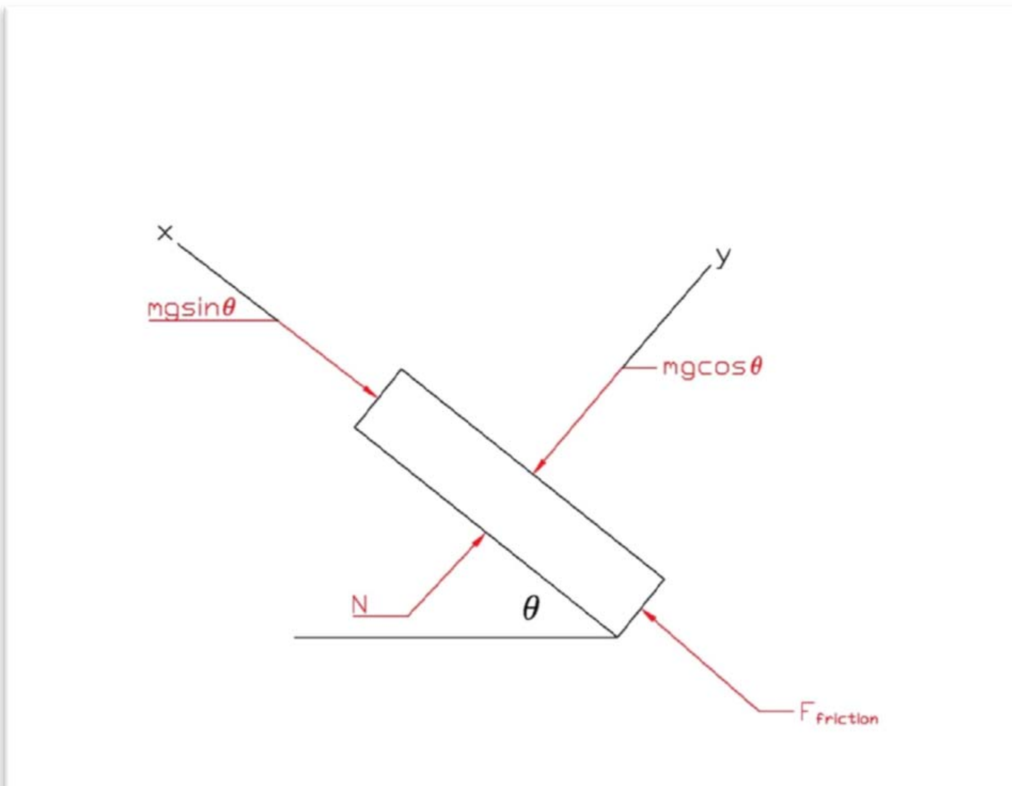

Figure 2: Free Body Diagram of object and Inclined Plane in Static Equilibrium

2. Assume that F_{max} is proportional to the normal force by the coefficient of static friction (μ).

$$F_{max} = \mu N$$

   Solve for μ.

   μ =____

Questions

1. What does a high coefficient of static friction mean?

2. What does a low coefficient of static friction mean?

3. Why doesn't the object slide at any angle θ?

4. Compare the measurements of the coefficient values of the aluminum metal rectangular friction cutout with the wooden plug ($F_{metal\text{-}wood}$) and the wooden rectangular friction cutout with the metal washer ($F_{wood\text{-}metal}$). Are these two values equal? Should they be equal?

5. If the actual coefficient of friction for $F_{metal\text{-}wood}$ is approximately 0.4, what is the percent error based on your experimental data?

   Use the equation:

$$Percent\ Error = \frac{|(actual\ data) - (experimental\ data)|}{actual\ data} \times 100\%$$