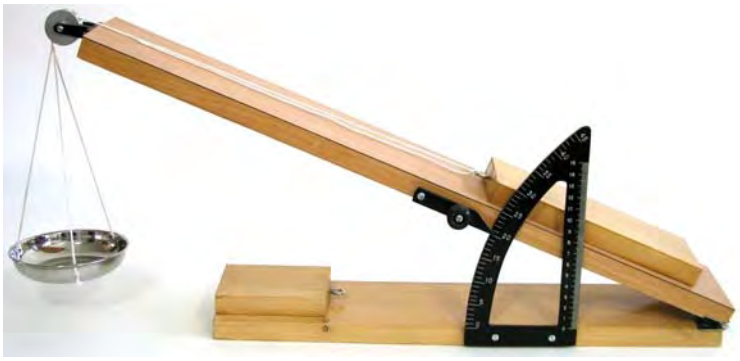
611-0055 (40-161) Friction on an Inclined Plane



Introduction: friction is found in all circumstances involving motion. It is not a fundamental force; instead, it is derived from interactions between electromagnetic forces. This feature makes it impossible to determine the friction force by starting from first principles. Instead, the friction force must be calculated empirically.

There are two types of dry friction: *static* and *kinetic*. Static friction describes the interaction between two materials when both are at rest. For example, a book resting on a shelf will experience some friction. If the shelf is angled, static friction may hold the book in place. Kinetic friction describes the friction force between two objects when they are sliding together. Using the first example, picture the book sliding across the shelf. It will take some energy to keep the book in motion because of the power of kinetic friction.

To quantify the friction force, the *coefficient of friction* is used. This value is represented by the Greek letter μ, and describes the ratio between the friction force between two objects, and the strength of the force holding them together. It is usually between 0.3 and 0.6, although some materials exceed this range. Rubber on concrete can have a value greater than 1; while PTFE on PTFE can have a value as low as 0.04. To date, there is no known material with a value of zero.

The *normal force* is the strength of the force holding two objects together. In the case of a mass resting on a surface, the normal force is equivalent to its weight. If the surface is tilted, the normal force will not be exactly perpendicular to the surface. This causes its value to become less.

Description: our inclined plane is designed to help your students understand the principles of friction. After unpacking all of the components, you will need to assemble it. Start by placing the large protractor onto the two screws, and tighten them to hold the protractor in place. You will want to have the curved side of the protractor facing the pulley. There is a bracket mounted to the upper board; this will fit along the curve of the protractor, allowing you to set the angle of the board. A wing-nut on this bracket can be tightened, holding the board in place.

Included in the set are two small boards and a piece of steel. These boards have a different coating on each side, each of them with it's own coefficient of friction. The steel piece is bare on one side, and painted with a slick paint on the other. Also included are a weight pan and a length of string.

Operation: to calculate the coefficient of friction, you will first need to choose a slider and an angle for the inclined plane that you wish to use. Then, obtain the mass of the slider. Note: you will also need a set of known masses in order to perform this experiment.

After you have the mass of the slider, you will need to calculate the normal force. If the inclined plane is level, the normal force will be equal to the sliders mass multiplied by g. However, the experiment is of little value with a level inclined plane. To calculate the normal force of the slider on an incline, use the following equation: $F_{normal} = m \bullet g \bullet \cos\theta$, where

m= the mass of the slider
g= gravity, equal to 9.81 m/s^2
θ= the angle of the inclined plane

Gravity also acts on the slider in another way; it causes the slider to slide down the inclined plane. The magnitude of this force is given by the following equation: $F = m \bullet g \bullet \sin\theta$,

m= the mass of the slider

g= gravity, equal to 9.81 m/s^2

θ= the angle of the inclined plane

In order to determine the coefficient of friction, you will need to calculate the frictional force. This frictional force resists the force of gravity trying to pull the slider down the plane. An easy way to determine this force is to start with the slider on a level plane. Slowly raise the plane until the slider 'breaks loose' and travels down the plane. Note the angle at which it does this. Using this angle, determine the force gravity applies to the slider using the above equation. The static friction force will be equal to this. In order to determine the coefficient of friction, use the following equation: $F_{friction} = \mu F_{normal}$. In this case, μ represents the coefficient of friction.

The coefficient of friction is different for static and kinetic friction. Above, we determine the coefficient of static friction. Now, we will calculate the coefficient of kinetic friction.

Choose an angle for the inclined plane, and a slider. Use the above equations to determine the normal force and the force of gravity that pulls the slider down the plane. Next, run the string over the pulley, and attach it to the weight pan and the slider.

Next, place weights in the pan until the slider begins to move at a steady pace up the track. You can calculate the force the weights are applying to the slider by using the equation F=mg.

When the slider begins to move at a steady pace, calculate the force needed to pull it up the inclined plane. Since you have already calculated the force of gravity pulling the slider down the track, the difference between these two forces is the frictional force. Use the equation $F_{friction} = \mu F_{normal}$. This will give you the coefficient of kinetic friction.

Note: the coefficient of kinetic friction should be less than the coefficient of static friction.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. **Designed and prototyped in the U.S.A.** Made in China.

May we suggest:

611-0080 Friction Box: Use this wood box to determine the coefficient of friction with loads. High quality wood box features an open top, ring at one end and two non-slip strips on the bottom. 15 x 9 x 8 cm in size.

611-0082 Friction Cube: Show how different frictional characteristics affect the force required to move a stationary body. The friction cube includes 4 different surfaces on a two inch wood cube. The friction cube comes with a hook on one side for towing against inclined panes and other surfaces. The four surfaces are: Sandpaper, Vinyl, Paper, and Wood.