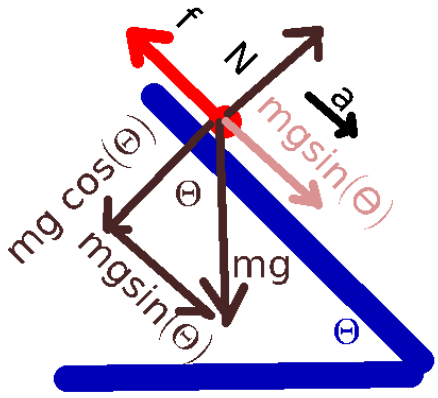
Lab 03 Kinetic and Static Coefficients of Friction Pandemic 3 Version 2022

You should download an app for your smart phone that will measure angles if your phone does not have one already. One I use is named clinometer from Google Play if you have an android phone in order to make quick measurements of the angles and it is free. There are also other choices available. I understand iphones may have this built into the system automatically.

Consider the following construction:



This shows the resolution of forces on an inclined plane. The gravitational force is reduced into parallel and perpendicular components to the surface of the plane. Doing this allows the acceleration to be parallel to the plane. We apply Newton's law here:

$$N - mg\cos(\theta) = 0$$
$$mg\sin(\theta) - f = ma$$
$$\text{and } f = \mu N$$

From the first equation, we have:

$$N = mg\cos(\theta)$$

and the frictional force is given by:

$$f = \mu N = \mu mg\cos(\theta) \quad .$$

We can then find the acceleration from the second equation:

$$mg\sin(\theta) - \mu mg\cos(\theta) = ma$$

Now solve this for the acceleration:

$$a = g\left[\sin(\theta) - \mu\cos(\theta)\right]$$

Now consider changing the angle so that the acceleration is zero. Note this does not mean the system can not still be moving, it just can not be accelerating. At this angle we have:

$$a = 0 = g\left[\sin(\theta) - \mu\cos(\theta)\right] \Rightarrow \sin(\theta) - \mu\cos(\theta) = 0 \Rightarrow \mu = \frac{\cos(\theta)}{\sin(\theta)} = \tan(\theta)$$

This means: place a material on an inclined plane and change the angle of inclination until the object starts sliding. We are going to experiment with this for kinetic and static coefficients today in the lab.

Kinetic and Static Coefficients of Friction

Introduction

You should recall from class the analysis of the inclined plane (this lab may be slightly ahead of class.) This is important to be sure that you understand since you will see related problems again.

A note about angles: You might want to install the **FREE** clinometer from Google Play if you have an android phone in order to make quick measurements of the angles. I believe iphones may already have this feature built in. For the Android, at least, It works quite well and seems to give better angle measurements than is obtained with the protractors. You will need to calibrate both methods of measurement.

Setup

The equipment consists of an inclined plane that you can change the angle of.

Brief summary of experiments to do:

(a) Mass dependence of static and kinetic coefficients.
(b) Area dependence of static coefficient:
cork on polyboard static on **wide area** and **narrow area** for area comparison
(c) pine on polyboard static and kinetic
(d) Glass on polyboard, static and kinetic
(e) Sandpaper on polyboard, static and kinetic
(f) High friction on high friction static and kinetic
(g) Several other materials (glass on wood, sandpaper on wood, etc.) static and kinetic.

You should perform the following tests:

(a) Mass dependence of the static coefficient of friction.

You have some white foam squares. You should measure the coefficient of static and kinetic friction of this with polyboard for the following masses: 0, 5g, 10g, 15g, 30g, 35g, 40g. Weights are placed into the slot in the foam as shown below. Plot the results in the helper. The slope of this will indicate any mass dependence of the static coefficient. In principle, there may be some slight mass dependence but only very slight.

The image below shows placement of masses into the white foam squares for measurement of mass dependence of static and kinetic coefficients.

(b) Measure wide cork block side and narrow cork block side for area (use the metal rulers here). Then find the static coefficient by tilting the plane. You will be able to have an indication as to how strongly area influences the frictional force from these experiments.

(c) pine on polyboard static and kinetic

(d) Measure the static and kinetic coefficients of glass on wood by tilting the plane.

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

(f) Measure high friction on high friction static and kinetic.

(g) Measure several other materials (glass on wood, sandpaper on wood, etc.) static and kinetic. These can be your choices of materials.

Discussions

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?

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.

From a compaison of your measurements with mass, does the coefficient of friction depend upon mass? If so, how strongly?

From your data, can a coefficient of friction be greater than 1?

What would happen if the coefficient were negative?