Friction force

Objectives:

- To study kinetic friction and its relationship to the normal component of the contact force
- To determine the kinetic friction coefficient

Introduction:

We encounter friction at almost all times during the day. Friction between our foot and the floor helps us walk. Friction is a resistive force that acts along the tangent to the tow surfaces in contact when one objects slides across another.
Two laws describe the friction between two surfaces:

1. The ratio of the frictional force and the normal force is a constant and equals the coefficient of friction, m, which only depends on the nature of the two surfaces in contact.
2. The friction force is independent of the area of contact.

When a force is applied to an object resting on a surface, it will not move until the force applied to it is greater than the maximum force due to static friction. The coefficient of static friction (m_s) is simply the ratio between the maximum static frictional force (f_s) and the normal force (n):

$$\mu_s = \frac{f_s}{n}, \qquad (1)$$

where ***n*** is the normal force. For object on horizontal surfaces the normal force equals the weight of the object:

$$n = F_G = m\,g. \qquad (2)$$

To keep the object moving at a constant speed, a force must be applied to the object equal in magnitude and opposed in direction to the kinetic frictional force. Hence, the coefficient of kinetic friction (μ_k) is the ratio between the kinetic frictional force (f_k) and the normal force (n):

$$\mu_k = \frac{f_k}{n}. \qquad (3)$$

List of equipment:

Motion sensor, force sensor, interface, USB cable, computer running Data Studio software, wooden block, weights (200g, 300g, 500g and 1000g), aluminum track.

Procedure:

A. Connecting the equipment and preparing for data acquisition

A1. Connect the interface to the computer, turn on the interface, and turn on the computer.

A2. Connect the Motion Sensor's plugs into Digital Channels 1 and 2 on the interface (make sure the yellow stereo jack goes into #1, see Fig. 1).

A3. Connect the force sensor plugs into Channel A of the interface (Fig. 1).

A4. Open "Data Studio" software. Click on "Create an experiment" icon to start your lab experiment. At this time you should be able to see three separate panels:

a. “Experimental setup” containing a picture of the interface.
b. “Data” window that will collect your experimental data (to the left of “Experimental setup” window).
c. “Displays” panel that will allow you to visualize the experimental data.

A5. In order to tell the interface what kind of sensor is attached, click on “Add Sensors and Instruments” button shown in “Data Studio”.
a. Select the motion sensor from the digital sensor list.
b. Select the force sensor from the analog sensors list.
To connect any selected sensor drag-and-drop it over the picture of the interface.

A6. Drag the data icon called “velocity” from the upper right panel called “Data” and releases it on top of the Graph “Display” panel. Repeat the procedure for the force graph.

A7. Attach the force sensor to the hook of the wooden block (Velcro dawn) with a piece of wire so that the block can be pulled away with the probe.

A8. Press the "zero" button on the side of the force sensor.

A9. Place the motion sensor so it sees the wooden block as you pull it away from the motion sensor. Collect data as you pull away the system very slowly and steadily (at constant speed).

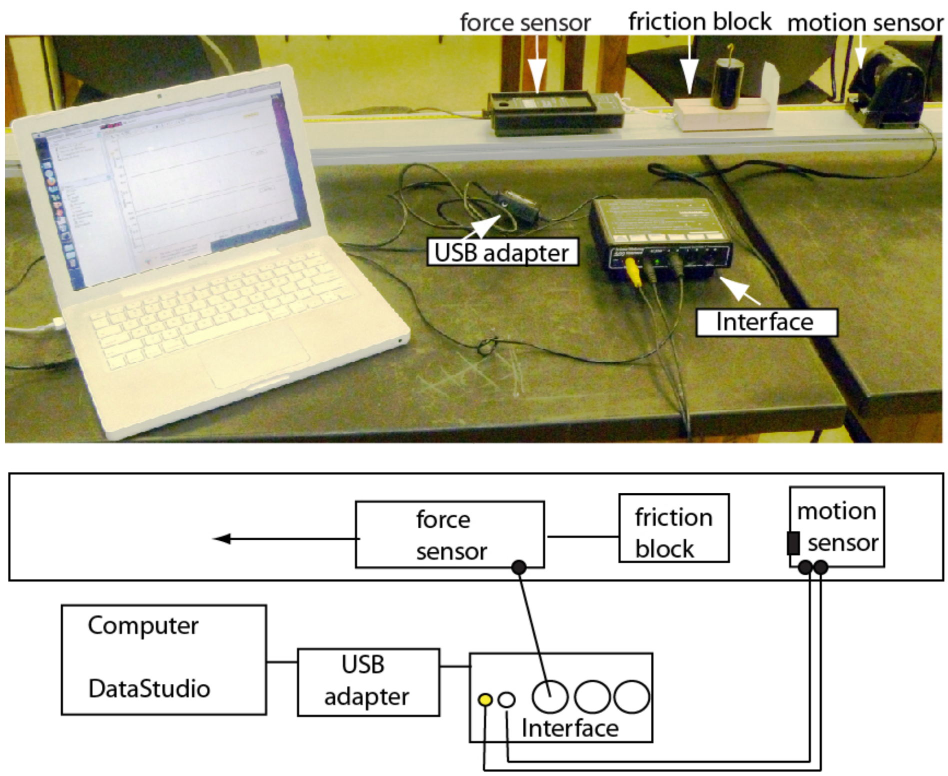

Figure 1. Experimental set up includes the interface, motion sensor, force sensor, friction block, USB adapter, track and computer running Data Studio software. The upper panel shows an actual picture of the experiment and the lower panel shows the required connections.

B. Determine the relationship between the normal and the kinetic friction force

B1. Find the mass of the wooden block and record it here (with units) m= ____________.

B2. Sketch a free body diagram here:

B3. Place the wooden block with Velcro side against aluminum track.

B4. Place a weight on top of the wooden block and zero the force probe.

a) Pull the wooden block across the track with at constant speed. Make sure that you pull the wooden block horizontally.
b) Use Analyse -> Statistics to estimate the mean pull force.
c) Record your data in Table 1.

Table 1: The dependence of the kinetic friction force on the normal force for Velcro against aluminium surfaces

Mass (Kg)	Normal force (N)	Friction force (N)	$\mu_k = \frac{f_k}{n}$

B5. Place another mass on the wooden block and repeat the steps B3. **Make sure that you zero the force probe before each trial!**

B6. Based on table 1, compute the mean coefficient of kinetic friction μ_k=_________ for Velcro against aluminum surfaces.

B7. Print one copy of the velocity and pulling force and attach it to the lab report.

B8. Repeat the procedure steps B4-B7 for the wooden block with wood against aluminum track. Record the normal force, friction force and calculate de friction coefficient in table 2

Table 2: The dependence of the kinetic friction force on the normal force for wood against aluminium surfaces

Mass (Kg)	Normal force (N)	Friction force (N)	$\mu_k = \frac{f_k}{n}$

The mean coefficient of kinetic friction between wood and aluminium is μ_k= __________

Questions

1. Does the friction force appear to depend upon the weight of the object being pulled? If so in which case is the friction larger?

2. Does your data suggest that the kinetic friction force is approximately proportional to the normal force?

3. How does the friction coefficient from table 1 compare to the friction coefficient from table 2? Which one is larger? How do you explain any difference that may exists?

4. What sources of error are present in your measurements?

5. Sand is often placed on an icy road because the sand:
   a) Decreases the coefficient of friction between the tires of a car and the road
   b) Increases the coefficient of friction between the tires of a car and the road
   c) Decrease the gravitational force on a car
   d) Increases the normal force of a car on the road.

   Explain.