Friction Coefficient

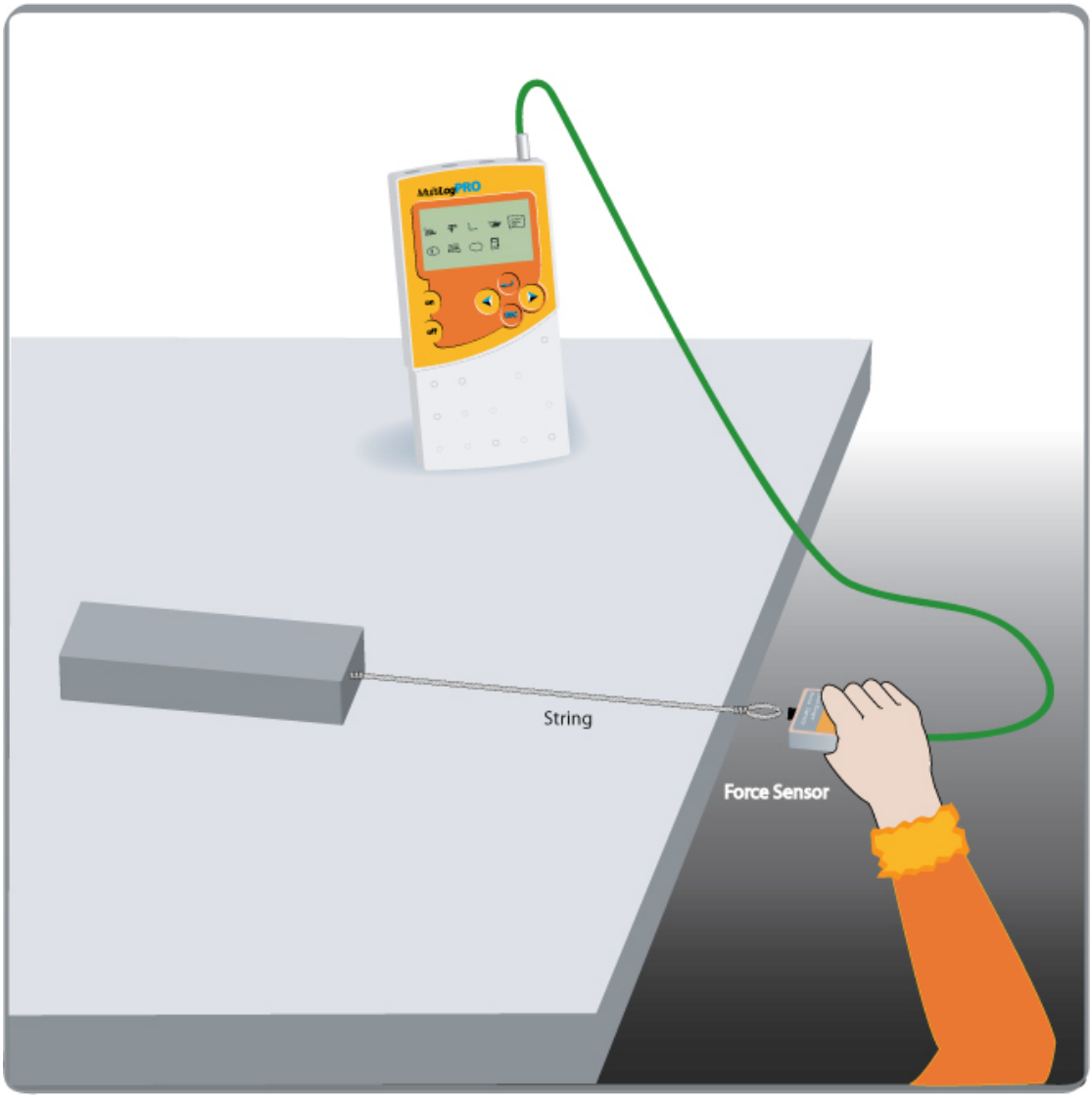

Figure 1

Introduction

Friction is the force that acts between two surfaces that slide or attempt to slide one over the other. For dry surfaces the friction depends on the types of surfaces and on the normal force acting between them.

When the surfaces are at rest with respect to each other the friction is static friction and its magnitude can vary from zero to a maximum value:

$$f_S \leq \mu_S N$$

Where f_S is the static friction, μ_S is the static friction coefficient and N is the normal force. When there is relative motion between the surfaces the friction is given by:

$$f_k = \mu_k N$$

Where f_k is the kinetic friction and μ_k is the kinetic friction coefficient.

In this experiment these relations are measured for a variety of surfaces.

Equipment

- Blocks of several materials (e.g. wooden block and a brick)
- Scales to measure the mass of the blocks.
- String.
- Force sensor.
- MultiLogPRO or Nova or TriLink data logger

Equipment Setup Procedure

1. Connect the data logger to the serial port of the computer.
2. Turn on the data logger.
3. Connect the force sensor to the I/O 1 port of the data logger.
4. Assemble the equipment as shown by figure 1
   - Attach the one end of the string to the block.
   - Attach the other end of the string to the force sensor so that pulling the sensor will drag the block along. The force sensor will measure the force acting on the block.
5. Click **Setup Wizard**  on the main toolbar and program the data logger according to the setup specified below

Data Logger Setup

Sensors:

Input 1: Force ±10N (or ±50N)

Rate:

100 samples per second

Recording time:

5s (500 samples)

Experimental Procedure

1. Measure the mass.

2. Click **Run**  on the upper toolbar to begin recording data

3. Hold the Force sensor in your hand and Pull it. Make sure that the string is horizontal and gradually increase the applied force. When the block starts moving maintain a constant velocity. Only when the block moves in constant velocity the friction is exactly balanced by the force acting on the block.

4. Click **Stop**  on the main toolbar.

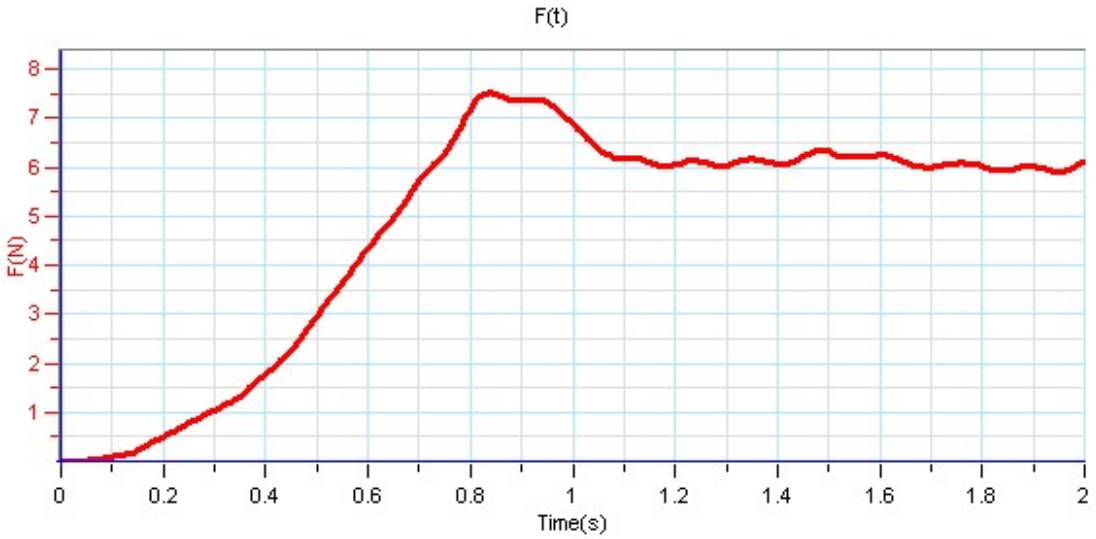

Figure 2

5. Save the data: click **Save**  on the main toolbar

6. Repeat the experiment with different materials. Remember to save the data from every experiment under different names.

Data Analysis

1. Use the cursor to measure the maximum value of the force measured by the sensor before the block starts moving. This is the maximal value of the static friction. Use this value to calculate μ_S the static friction coefficient

***The Cursor**: You can display up to two cursors on the graph simultaneously.*

Use the first cursor to display individual data recording values, to select a curve or to reveal the hidden Y-axis.

Use two cursors to display the difference between two coordinate values or to select a range of data points.

***To display the first cursor:** Double click on an individual data point or click **Cursor**  on the graph toolbar. You can drag the cursor with the mouse onto any other point on the plot, or onto a different plot. For finer cursor movements use the forward and backward keys on the keyboard.*

The coordinate values of the selected point will appear in the information bar at the bottom of the graph window.

***To display the second cursor:** Double click again anywhere on the graph area or click **2nd Cursor**  .*

The information bar will now display the difference between the two coordinate values.

***To remove the cursors:** Double click anywhere on the graph area, or click **1st Cursor** a second time.*

***To remove the 2nd cursor:** Click **2nd Cursor** a second time.*

2. Find the average value of the force: use the cursors to select the kinetic part of the graph. Click **Analysis** on the menu bar, then click **Statistics**

3. Repeat these procedures and compare the different coefficients

Further Suggestions

1. A motor can be used to pull the string. This will ensure a more steady velocity.

2. To explore the effect of different velocities on the friction (theoretically there is none) you may use a motor to pull the string and change the velocity by changing the frequency of the motor's rotor.

3. You can perform a series of experiments to determine the effect of the normal force on the friction: you have to change the mass of the block (by putting extra weights on it) without changing the surface. You can then use a spreadsheet to produce a graph of the friction vs. the normal force and derive the friction coefficient from the slope of this graph.