Friction

In this laboratory, we study friction between a wood block and a metal ramp.

Make sure that you have the following pieces of equipment.

- a long metal ramp
- a wood block
- weights
- Vernier LabPro computer interface box
- Dual-Range Force Sensor

Our goal in this activity is to find the coefficient of kinetic friction μ_k between the wood block and the metal ramp.

1 Preparation

Please get some paper towels or a clean cloth and wipe the metal ramp and the wood block. We want these surfaces to be free of dust, dirt, and grease, so that we can collect good data.

Make sure that the force sensor is plugged into the Vernier LabPro computer interface box, and that the interface box is plugged into the computer. The interface box has a power cable that also needs to be plugged in. The force sensor has two settings: ± 10 N and ± 50 N. Use the ± 10 N setting.

Start Logger Pro 3.1 on the computer. You may have to click OK to a few dialog boxes that are setting things up. On the main menu of Logger Pro 3.1, choose Experiment - Zero. This will properly zero out the force sensor.

Now, try a little test. On the main menu of Logger Pro 3.1, choose Experiment - Start Collection. The computer will start collecting data from the force sensor and continue for 10 seconds. If the force sensor is not being pushed or pulled, it should read very close to zero. If you pull gently on the hook of the force sensor, you should get a positive reading. If you push (again, gently) on the hook, you should get a negative reading. If you stop pushing or pulling, you should get zero again. Confirm that all of this works before going on.

2 Measurements with a horizontal ramp

Record the mass of the wood block.

On the main menu of Logger Pro 3.1, choose Experiment - Start Collection. The computer will start collecting data from the force sensor and continue for 10 seconds. Use the force sensor to pull the block across the ramp at a slow, constant velocity. After you collect the force data, select a region on the graph where the force is level and seems representative of the force required to pull the block at a slow steady rate. Click on the STAT button at the top of the screen to get the mean force value for that region. Record that force.

Draw a free-body diagram for the wood block as it is being pulled across the metal ramp. Include all of the forces that act on the block.

Explain, using your free-body diagram and Newton's second law, how you will find the normal force that acts on the block.

Explain, using your free-body diagram and Newton's second law, how you will find the frictional force that acts on the block.

Now repeat this process of pulling the block and measuring the force of pulling (with the force sensor), except put some additional mass on top of the block.

Record your data in the table below.

Mass added	Normal force	Frictional force
0 kg		
0.3 kg		
0.5 kg		
0.8 kg		
1.0 kg		
1.3 kg		
1.5 kg		

Make a graph of frictional force as a function of normal force. Find the slope of this graph. What is the meaning of the slope?

3 Measurements with an inclined ramp

Remove the weight from the wood block that you used in the previous section. Remove the force sensor from the wood block. Tilt the metal ramp and let the block slide down the ramp. Change the angle of the ramp until the block slides down the ramp at a slow, constant velocity. It should take at least 5 seconds for the block to slide down the ramp.

Use a protractor to measure the angle at which the block slides down the ramp at a slow, constant velocity.

Draw a free-body diagram for the wood block as it slides down the ramp. Include all of the forces that act on the block.

Find the normal force acting on the block as it slides down the ramp.

Find the frictional force acting on the block as it slides down the ramp.

Find the coefficient of kinetic friction between the block and the ramp when the ramp is inclined.

How does this coefficient of friction compare to what you found for a horizontal ramp?