

Static and Kinetic Friction

(Vernier)

Introduction:

If you try to slide a heavy box resting on the floor, you may find it difficult to move. *Static friction* is keeping the box in place. There is a limit to the magnitude of static friction, so eventually you may be able to apply a force larger than the maximum static force, and the box will move. We model static friction, F_{static} , with the inequality $F_{static} \leq \mu_s N$, where μ_s is the coefficient of static friction and N the *normal* force exerted by a **surface** on the object. The normal force is defined as the perpendicular component of the force exerted by the surface. In this case, the normal force is equal to the weight of the object.

Once the box starts to slide, you must continue to exert a force to keep the object moving, or friction will slow it to a stop. The friction acting on the box while it is moving is called *kinetic friction*. Both static and kinetic friction depend on the surfaces of the box and floor and on how hard the box and floor are pressed together (the normal force). We model kinetic friction with $F_{kinetic} = \mu_k N$, where μ_k is the coefficient of kinetic friction. In this experiment, you will use a force sensor to study static friction and kinetic friction of a small block on a table.

Objectives:

- To investigate the importance of contact area for frictional forces
- To investigate the importance of the contact force (normal force) for friction
- To investigate the importance of speed for kinetic friction
- To gain experience with the force sensor and investigating graphs in Logger Pro

Materials: computer with Logger Pro software, force sensor, Word program, string, wooden block with hook, balance, and additional masses, Logger Pro file “friction.cmb1” or experiment files

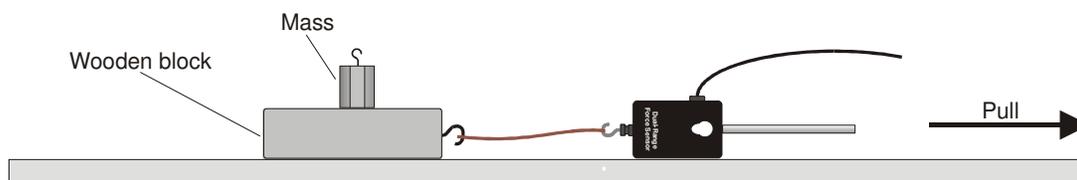
Procedure:

1. Measure the mass of the block, and record it in the data table.
2. Connect the force sensor to the computer, load the Logger Pro program, and load experiment “friction.cmb1” (which is also Experiment 12a in the Vernier “Physics with Computers” folder).

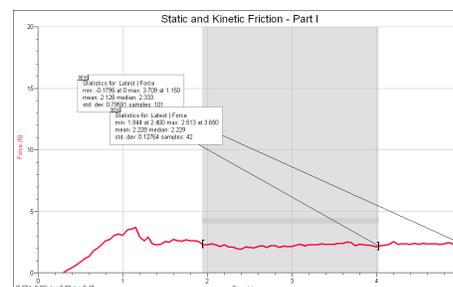
Note: *The sliding surfaces are very important in these experiments. Select an area of uniform table roughness to work on, and clean the surface of the block or wrap it in paper to assure a uniform surface. If your results do not agree with your expectations, irregular surfaces are likely the reason!*

Part I. Contact Area Investigation

- Tie one end of a string to the hook on the force sensor and the other end to the hook on the wooden block. **Place the wide side of the block on the sliding surface.** Place a total of 1 kg masses on top of the block, fastened so the masses cannot shift. Practice pulling the block and masses with the force sensor using a straight-line motion; slowly and gently pull horizontally with a small force. Very gradually, taking one full second, increase the force until the block starts to slide, and then keep the block moving at a constant speed for another second. You are now ready to start!



- Hold the force sensor in position, ready to pull the block, but with no tension in the string. Click Zero at the top of the graph to set the force sensor to zero.
- Click  to begin collecting data. Pull the block as before, taking care to increase the force gradually. Repeat the process as needed until you have a graph that reflects the desired motion, including pulling the block at constant speed once it begins moving.
- Your graph should look similar to the one at the right.



- *Optional: Open Microsoft Word. and at the top of a blank page type "Graphs for friction lab". You will paste the graph from this section to that Word document to print later as an example of your work. Minimize the Word document, and return to the Logger Pro program. Copy the graph from Logger Pro to Word by right clicking on the graph, copy, then return to Word and paste. You will turn in this graph with your report.
- Find the static force value.** Examine the data by clicking the **Statistics** button, . The maximum value of the force occurred when the block started to slide. Read this value of the *maximum* force of static friction from the floating box, and record the number in your data table. **Calculate** the *normal force* of the table on the block. Since the block is on a horizontal surface, the normal force will be equal in magnitude and opposite in direction to the weight of the block and any masses it carries.
- Find the kinetic force value.** Drag across the region of the graph corresponding to the block moving at constant velocity. Click on the **Statistics** button again, and read the average (or mean) force during the time

interval. This force is the magnitude of the kinetic frictional force.

10. Record the static and kinetic friction values for the block with the wide side in contact with the table.
11. Rotate the block so that its narrow side makes contact with the table and repeat steps 4, 5, 8, and 9. Record the static and kinetic values for the block with the narrow side in contact with the table.

Part II. Normal Force Investigation

12. Increase the normal force on the block by adding another 1 kg mass to the block, and use the wide side for the rest of this investigation. Create another set of data for the larger normal force and record on the laboratory report sheet.

Part III. Sliding Speed Investigation:

13. Using the wide side of the block and the 2 kg mass weight, measure the kinetic friction using the techniques above for a slow and somewhat faster motion (constant speed) of the block. Record your data on the Laboratory Report.

Static and Kinetic Friction

Laboratory Report

Part I. Contact Area Investigation

Mass of block with 1 kg mass	kg
Normal force on block	N

Trial	Static friction (N)	Kinetic friction (N)
Wide side		
Narrow side		

Part II. Normal Force Investigation

Mass of block with 2 kg mass	kg
Normal force on block	N

	Static friction (N)	Kinetic friction (N)
Wide side		

Part III. Sliding Speed Investigation

Trial	Kinetic Friction (N)
Slow speed	
Faster speed	

Analysis of Results:

Creating good friction data is difficult, and your results may vary significantly from other researchers. You should state your conclusions below, based upon your results, and be prepared to defend your results in any class discussion. However, you should be prepared to accept consensus results of the class where your data is doubtful.

1. Within the estimated error of your measurements, does the contact area of the block make a significant difference in the static and/or kinetic frictional force? If so, how?
2. Within the estimated error of your measurements, does the contact force (normal force) of the block make a significant difference in the static and/or kinetic frictional force? If so, how?
3. When pulled at a constant speed (not accelerating), does the speed of sliding friction make a significant difference? If so, how?