13100 Friction Block Set

Purpose:

To investigate the properties of sliding and static friction.

Additional Required Materials:

Spring Scale (2.5 Newtons)
Tape
Smooth clean table top
Additional Weights (books)
Graph Paper

Discussion:

Whenever one object slides over another, each object exerts a frictional force on the other. This frictional force is always in a direction opposite that of the motion. It is easiest to label and treat friction as a force, but it is an unusual example of a force. Friction acts only when one tries to move something. Are there any other examples of a "force" that sometimes is present and sometimes is not?

Friction is a very important force. Although 20% of an automobile engine's power may be used to counteract the forces of internal friction, friction is still a good force to have around. Without friction it would not be possible to walk; cars would not move; you could not hold a pencil to write, and if you could, it wouldn't leave a mark on the paper! With all things considered, friction is a good force to have around.

Experiments:

Begin by placing the wood block without the mirror face down on a clean, flat, horizontal surface such as a desk or lab bench. Gently push it around to feel how much force is required to move it. Tip the block on edge and again gently push it around the table top. Do you notice any difference in the necessary force to push the block? Lay this block flat on the table and place the second block on top of this. Push them both around. Is the force required to move them greater? Lay each block on the table and hook them both together. How much force is required to move the blocks this time, more or less than when the blocks were stacked together? More or less than a single wooden block?

By performing these brief experiments you have begun to notice that friction has some dependance upon the weight and size of the block. Lets examine these conditions in more detail.

Constant mass, different surface areas:

Take the wooden block without the mirror and lay it down on the table top. Attach the spring scale to the hook and begin to pull the block. What do you notice as you begin to pull? When you first start to pull, the scale indicates larger and larger forces until a definite force is reached when the block begins to move. If you continue to pull with this same force the block will begin to accelerate. If you slowly decrease the force with which you are pulling the block, it will slow to a constant speed. The force indicated by the scale is now balanced by the force of **sliding friction**. The force indicated by the scale just before the block began to move was balanced by the force of **static friction**. Notice that the force of static friction is larger than the force of sliding friction.

Record the force of static friction and sliding friction for several trials using the plain wooden block. Tip the block on edge and record the force of static friction and sliding friction for several trials. How do these two sets of data compare? The friction between the block and the table is not influenced by the surface area of the block. This is an important observation and applies to most dry, flat surfaces over a wide range of conditions.

Different surfaces, constant mass, constant surface area:

Lay the wooden block with the wood side down on the table top. Use the spring scale to measure the static and sliding friction of this block. Turn the block over so that the mirror side is down. Again measure the static and sliding friction. Tape the sandpaper (rough side up) to the top of the table. Place the wood side of the block on the sandpaper and measure the static and sliding friction. How do these three sets of values compare? Compare the amount of friction with the type of surface. Generally speaking, do the smoother surfaces have more or less friction than the rougher surfaces?

Place the mirror with the sandpaper glued to the back on the table top with the sandpaper side up. Place the wooden block without the mirror on top of this. With the spring scale, pull on the wooden block. What happens? Does the mirror slide on the table first or does the wooden block slide off of the sandpaper? Draw a force diagram showing all of the forces on each block. What is the force of static friction between the mirror and the table? What is the force of static friction between the sandpaper and the wooden block? Are these two frictional forces the same value? Why?

Turn the mirror and sandpaper block over so that the sandpaper is against the table. Again, place the wooden block on top of this. Pull the wooden block with the spring scale. Which block slides first? Draw a second force diagram showing all of the forces on each block. What is the force of static friction between the sandpaper and the table? What is the force of static friction between the wooden block and the mirror?

In this last example you are illustrating the fact that the force of static friction can be any value **up to** a certain limit. In this last case you found that the force of static friction between the table and the sandpaper was at **most** equal to the force of static friction between the glass and wood block and this was well **below** the maximum value of static friction between the table and sandpaper. Once the wood block began to slide, then the static friction between the table and the sandpaper was equal to the force of sliding friction between the glass and wood block.

Increasing the weight of the block, constant surface area:

Lay the wood block without the mirror on the table top. Choose several (5 or 6) equal mass books or weights. Measure the force of static friction by pulling the block with the spring scale. Note the force indicated by the scale just before the block begins to slide. Make these measurements for the block alone then repeat the experiment using 1, 2, 3, 4, then 5 books or weights stacked on the block. Record this information in a data table then plot it on a graph placing the weight used on the horizontal axis and the frictional force on the vertical axis. Is this plot a straight line? If it is, can you determine the proportionality constant that relates the frictional force to the weight of the block? This proportionality constant is called the coefficient of static friction and is written μ_s.

Repeat the above procedure, except record the force of sliding friction this time. Remember, the force of sliding friction is that force indicated by the spring scale when the block is sliding with a constant speed. Record and plot your data as you did before. Is this plot a straight line? What is the coefficient of sliding friction? This term is written μ_k (the k stands for kinetic friction).

Conclusions:

With these experiments we have shown that the maximum force of static friction between any pair of dry unlubricated surfaces follows these two empirical laws: 1) Friction is approximately independent of the area of contact over wide limits. 2) Friction is proportional to the normal force (or the weight that was stacked on the block).

Time Allocation:

To prepare this product for an experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.