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Activity Sheet 1

What determines the amount of friction between two surfaces?

I. Forces

Try pushing a block around on a table.
What direction do you have to push in to make it move?

____

If you also push down on the block, does it become harder or easier to push it around? ____________________

Hold a block against the wall. How hard do you have to push to make it stay up? What sort of force is holding it up? (Remember: What direction does gravity act in? What direction does friction act in? What direction do your hand and the wall push in? Where are the sliding surfaces in this case?)

____

Can you summarize what you have learned here about friction?

Think about this:

Even though friction acts *parallel* to sliding surfaces, the maximum amount of friction force depends partly on the *perpendicular* force holding them together.

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Activity Sheet 2

Is friction the hero or the villain?

Now that you know a little about what friction is, let's think about whether friction is "good" or "bad." You may be aware that scientists and engineers have tried for many years to produce machines without friction. You may even have seen ads for automotive additives that claim to eliminate friction. If you could do this, it would mean that you could start something moving and never have to push it again. Just like pushing someone on a swing: if you stop pushing, and they don't pump, the swing will eventually stop. Of course perpetual motion has never been achieved, although a good many failed designs can be found. Scientists have only been able to eliminate friction in some extremely unusual, extremely cold situations. There is no practical way to do it.

1. What ways can you think of to reduce friction? Name at least three.

2. Can you think of examples from your life that use these ways of reducing friction?

But do you want to completely eliminate friction?

3. Name at least three activities where friction is necessary.

4. Name at least three tools or objects that require friction to function.

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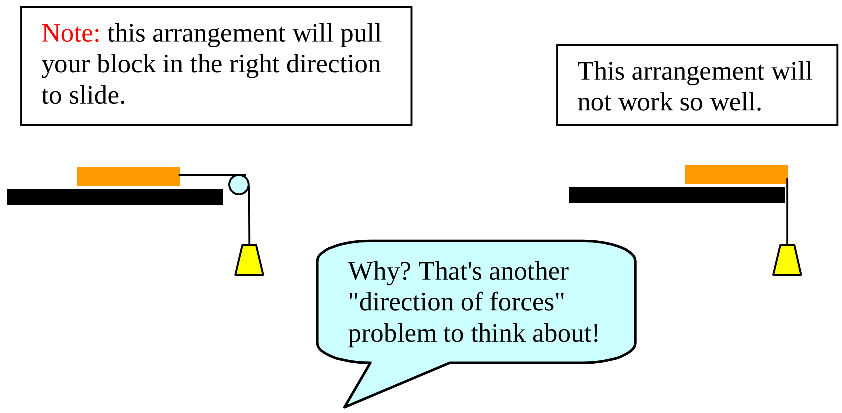
Activity Sheet 3
Some Experiments with friction

Use a friction board to see how well your block slides on different surfaces. You can try to measure the difference in a couple of ways:

1. Attach weights to the block and let the weights hang over the side of the table. What is the minimum weight required to pull the block?



2. Put the block on the board and tilt it to find the minimum angle that will let the block slide down the board. (It may be easier to measure how high the high end of the board is when the block slides. If you also measure the length of the board, you can calculate the angles later.)

Write down your observations and compare with other scientists.

Surface	Angle when block starts to slide
Cardboard	
Cork	
Foam	
Sandpaper	

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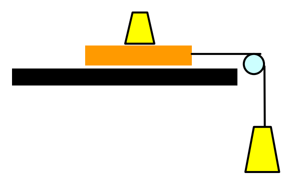
Activity Sheet 3

Some Experiments with friction (cont'd)

3. Now, let's put this information together with what you just learned about how perpendicular forces affect friction. Using the "weight method," repeat the experiment you just did with different weights on top of the block to change the gravitational force pulling the block down on the table.

Your experiment should look like this:



Record your results here:

Cardboard		Cork		Foam		Sandpaper	
Weight on top	Weight to pull	Weight on top	Weight to pull	Weight on top	Weight to pull	Weight on top	Weight to pull
0		0		0		0	

Later, you may want to make a graph showing how the weight on top (perpendicular force) is related to the weight to pull (friction force). What do you think such a graph would look like?

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Activity Sheet 3

Some Experiments with friction (cont'd)

4. Finally, use the blocks to look at the difference between static and kinetic friction. You should be able to find a combination of weights, or an angle, that will slide the block only after you have given it a small initial tap. This tap adds enough force to overcome static friction, and after the block has started moving, it keeps sliding because it needs a smaller force, equal to the kinetic friction, to keep going.

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Activity Sheet 4
Where does all that energy go?

What happens to all that force that we keep applying to overcome friction? Where does the energy go?

1. Try rubbing your sandpaper across the friction board, what do you notice? Now rub it more quickly, what do you feel? What does this tell you about friction and energy? (Hint: If you're having trouble, think about someone trying to start a fire by rubbing two sticks together, what happens?)

2. Now, as you rub the sandpaper across the board, consider one of your other senses. What do you sense, and what does this tell you about friction and energy? (Hint: Consider this proverb: The squeaky wheel gets the ______ .)

3. Now that you've used your sandpaper for a while, compare it to a new piece of sandpaper, what do you notice and what does this tell you about friction and energy?

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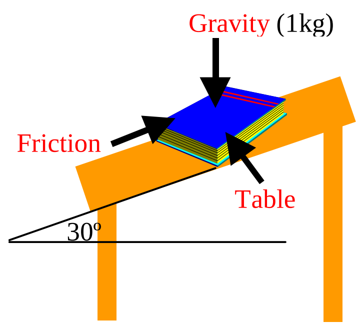
Activity Sheet 5

A geometry problem: How does friction balance the force of gravity?

Look at the force arrows (vectors) in this picture. Remember, a downward force must be balanced by an equal upward force, and a push to one side must be balanced by an equal push to the other side (What famous scientific law tells us this?)



Here, we want to figure out the size of the table force and the size of the friction force. Gravity is pulling straight down on the book, and the table is pushing up and to the left. Friction is pushing to the right, so this should balance the leftward push of the table. But friction is also pushing up, so friction and the table share the job of fighting gravity! How can we figure the forces out?

Here is a list of what we need to know for sure:

1) the weight of the book (1 kg)
2) the angle of the table with the floor (30º)
3) the direction of all the forces:
   a) gravity acts straight down
   b) friction acts up at 30º to the floor
   c) the table pushes at 90º to friction (because the table pushes perpendicular to its surface, and friction pushes parallel to it).

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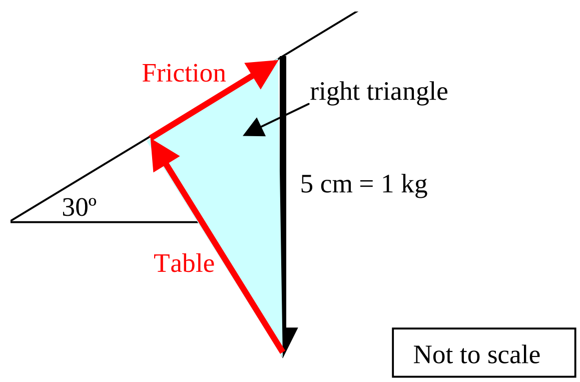
Activity Sheet 5

A geometry problem: How does friction balance the force of gravity? (cont'd)

Here's how we can use geometry to solve our problem:

1. Choose a scale for drawing our forces. Let's let 5 cm = 1 kg.
2. According to this scale, draw an arrow 5 cm long, straight down, to represent the weight of the book and the force of gravity. (Use the space on the next page.)
3. Using a protractor, draw a line at 30º to the "ground" (or 60º to the gravity arrow).
4. Line up one side of a square corner, like the edge of a piece of paper, with the 30º line. Slide it along the line until you find a right triangle with the gravity arrow as the hypotenuse (long side). Trace out this triangle.
5. One side of this triangle is the friction force, and one side is the table force. Look at the original figure to remember which is which, and which way they point. The forces in this diagram "add up" geometrically because you can follow all of the arrows around the triangle, back to the starting point.



6. Now, measure the lines for the friction force and the table force, and use our scale of 5 cm = 1 kg to convert that into the magnitude of the forces. You should have something like this:

Friction	= 2.5 cm = 0.50 kg
Table	= 4.3 cm = 0.87 kg

7. Now, using the same method, solve the problem assuming that the table is at a 45° angle and the book now weighs 2 kg.

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Activity Sheet 6
Friction: Understanding Your Tortoise

1. If you could redesign your tortoise now, how would you make it travel down the ramp more slowly?

2. Do you think that two pieces of wood rubbing together would have more or less friction than wood rubbing against smooth metal? Why?

3. Why do you think that oil is spread on metal parts that rub against each other (like in a car engine)?

4. Is friction good or bad for walking?

5. Friction with the air slows down a race car. How is a race car shaped to reduce air friction?