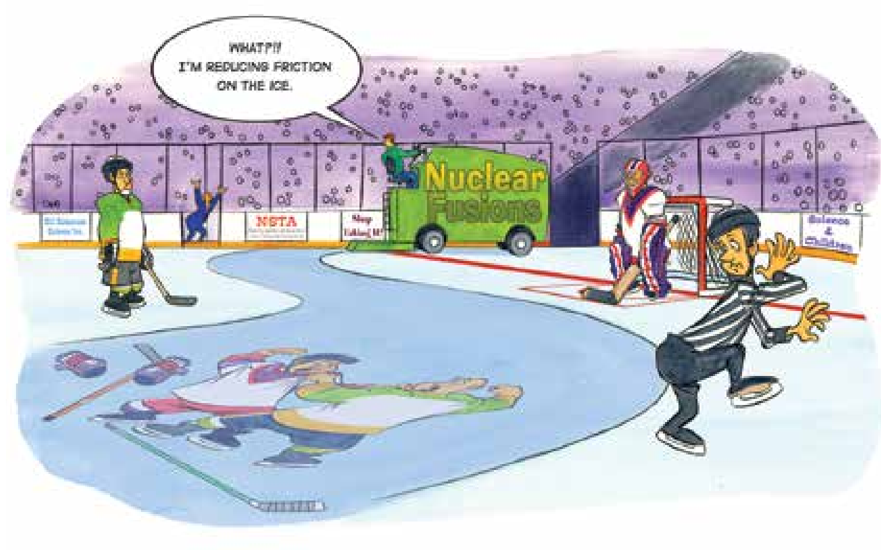
Science 101

Background boosters for elementary teachers

Q: What Causes Friction?

By Bill Robertson



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A: This might seem like a trivial question, because friction is simple, right? Friction is a force between surfaces that pushes against things that are moving or tending to move, and the rougher the surfaces, the greater the friction. Well, not exactly. I'm going to have you do a few things that might change your understanding of friction, and then I'm going to explain why friction was invented in the first place. Yes, I said "invented."

Get yourself a rectangular-shaped object such as a block of wood, a brick, or a small box that is somewhat heavy. Find a flat surface on which to slide your object. Obviously, if you're using a brick or other rough object, it wouldn't be smart to slide it along the dining room table or kitchen countertop. Place your rectangular object on one of its sides and slide it along the surface. Note how hard you have to push in order to keep the object moving. Then place your object so a different side is touching the surface, and repeat (see Figure 1). If you happen to have a spring scale or a force probe that hooks up to your computer, use those to get a number that reflects how hard you have to push (or pull) in order to keep the object moving each time.

Again place your rectangular object on the surface and note how hard you have to push or pull to keep it moving. Then place a heavy object on top of your rectangular object and repeat. Is it harder, easier, or just the same to push or pull the object? See Figure 2, and feel free to use a spring scale or force probe.

You no doubt discovered the following things: You have to push or pull with about the same force to keep the block moving regardless of the amount of the block's surface area in contact with the surface on which it's sliding. When you add something heavy to the top of the block, it's harder to keep the block moving. These observations are consistent with a standard, common-sense understanding of what causes friction. It's caused by irregularities in the two surfaces "catching" on each other as they slide. The more irregularities, the greater the friction. Check out Figure 3, page 62.

This model explains what you've observed so far. Adding weight to your object pushes the surfaces closer together, which should increase the effect of the irregularities and thus increase the friction. The amount of surface area in contact between the surfaces doesn't matter, because the larger the area of contact, the more spread out the weight of the object is. That means the surfaces aren't pressed together as much, and that makes up for the fact that there are more points of contact. And this model of friction also explains why the friction force is greater just before you get something moving than after it's moving. With a bit of momentum, the object is less affected by those irregularities.

To show that this model of friction doesn't explain everything, get a baking dish with a completely flat bottom (that means no ridge around the edge). Slide this dish across a very smooth surface (the kitchen countertop would be good here) and note how difficult it is to keep it moving. Now pour some water onto the smooth surface, place the baking dish on top of the water, and try sliding it again. As long as the bottom of the baking dish is completely flat, you'll find it more difficult to slide it when there's a thin layer of water between the surfaces.

The reason water makes things more difficult in the above situation is that water is attracted to each surface via electric forces (we call this *adhesion*) and the water molecules are also attracted to one another (we call this *cohesion*). By being attracted to each surface and to itself, the water acts as a very weak "glue" that keeps the two surfaces from sliding across each other smoothly. If you have pieces of completely flat sheet metal around, try sliding them across each other. If they're really flat and really smooth, you'll find the sliding is not easy. The reason, again, is electric forces between the surfaces. In this case, it's an attraction between like substances (the sheet metal). Because the attraction is between like substances, we again call this cohesion. It's even possible to weld two pieces of smooth metal together by sliding them across each other in a vacuum. I should clarify here that putting a liquid such as water between the surfaces does not always increase the friction. In fact, liquids usually reduce friction, as you know if you've driven on wet roads and used a lubricant to reduce friction between moving parts of any mechanism. The reason the water increases friction in the above case is that it's a very thin layer. A thicker layer would make the dish slide easier.

So, for most examples of friction, a model of irregular surfaces trying to slide across each other is sufficient. But in other situations, the source of

FIGURE 1.

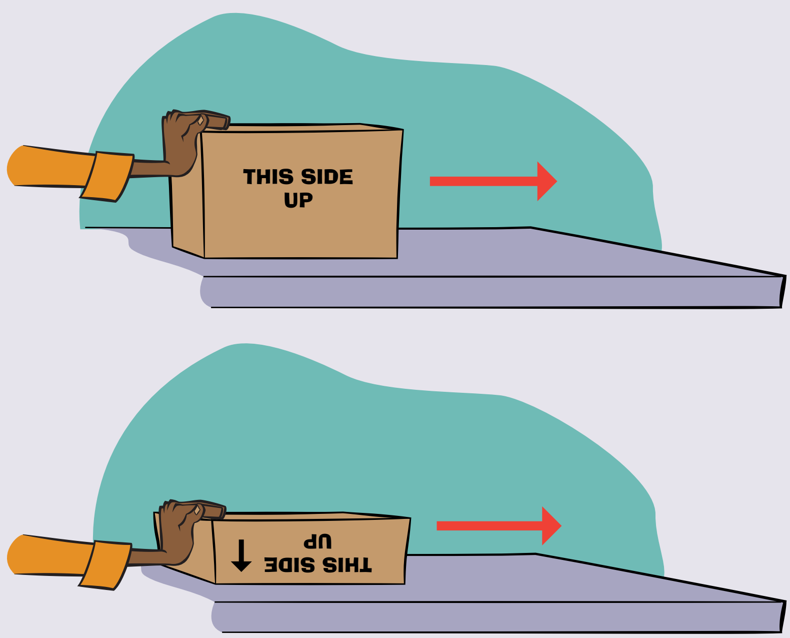
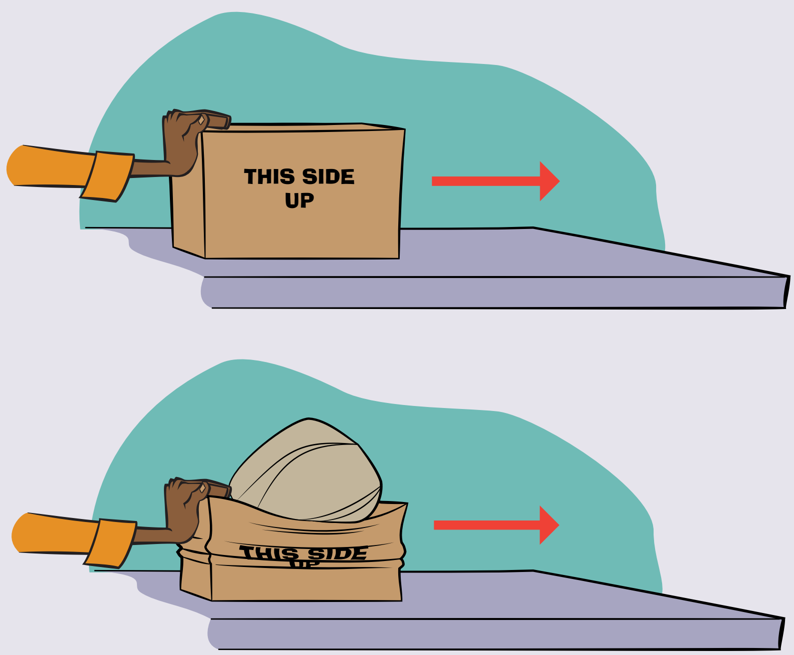


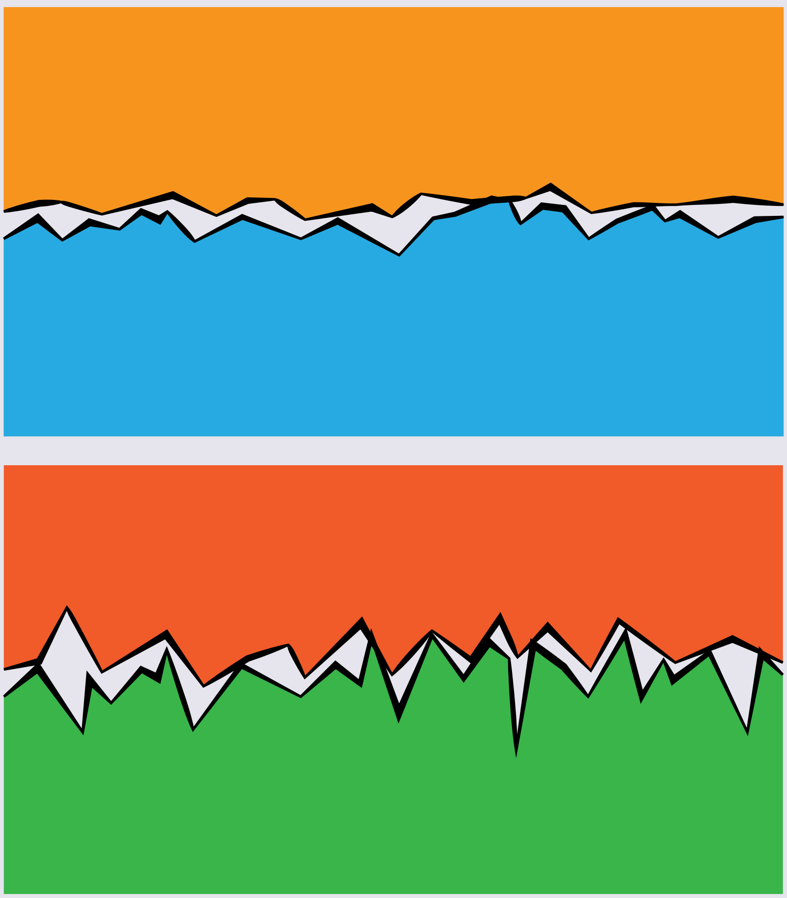
FIGURE 2.



the friction can be quite complicated, involving the attraction between atoms and molecules of the two surfaces. And I should mention that I'm only talking about sliding friction here. Rolling objects are a different story, as friction in that case actually works to help the object roll, so motion of the object is easier to accomplish.

It might surprise you to know that friction didn't always exist. Well, at least the *concept* of friction didn't always exist. Prior to around 1600 AD, the predominant view of motion was that of Aristotle. Objects made primarily of earth would naturally fall to the Earth and would stop on the Earth's surface, because basically that's where they belonged. What required an explanation was any continued motion of objects. Scientists/philosophers of the time came up with elaborate mechanisms to explain why a thrown object, for example, didn't just stop dead on the Earth where it belonged. There was no need for a "force of friction," because forces weren't needed to explain why things stopped or were difficult to keep moving.

FIGURE 3.



Around the time of Galileo (the 1600s), he and other scientists developed a new way of looking at things. This new way was that objects tended naturally to *stay* in motion in a straight line. With this view, one had to come up with an explanation for why things came to rest. Enter the force of friction. I stated in the beginning of the column that friction was invented, and depending on your philosophy of science, that could be a true statement. If friction is not necessary to explain what things do, then there really isn't a force of friction. Some might say that the force of friction was always there, waiting to be "discovered," and that's a valid viewpoint. I disagree with it, but it's valid! As I said, your take on this depends on your philosophy of science. Do we *construct* our knowledge (and perception of reality) of the world or does the reality of the world exist separate from our understanding of it? That's a subject for another column, but I figured I'd throw it out there just for kicks.

I should also mention that Leonardo da Vinci wrote about friction about 150 years before Galileo, but those works were not public knowledge. I also don't believe Leonardo used the word *friction*, but I could be wrong on that one. I put in that last comment so as not to create any friction between me and readers who are more informed than I on the subject. Yeah, bad joke. ■

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