

## 8 Friction

Reading: IS FRICTION A DRAG?

Friction is a common, everyday occurrence. We deal with it in almost every aspect of our lives. We may even take it for granted. Without friction, erasure of our mistakes would be difficult. Stopping our car or bicycle at a stop sign would be almost impossible, as would walking, keeping food on our fork, lighting a match, or . . . well, let's not get carried away with this. Friction is obviously important to us.

Friction also has some nasty qualities. It eats our tires up and wears out our brakes. It is responsible for those ear-piercing sounds fingernails make when dragged across the chalkboard. Friction makes doors squeak and makes us work harder. Friction obviously has its less desirable consequences.

For our purposes, friction is a force which opposes the motion or attempted motion of two solid surfaces across one another. Notice that we are distinguishing it from **drag**, which is the opposing force created as something travels through a liquid or a gas.

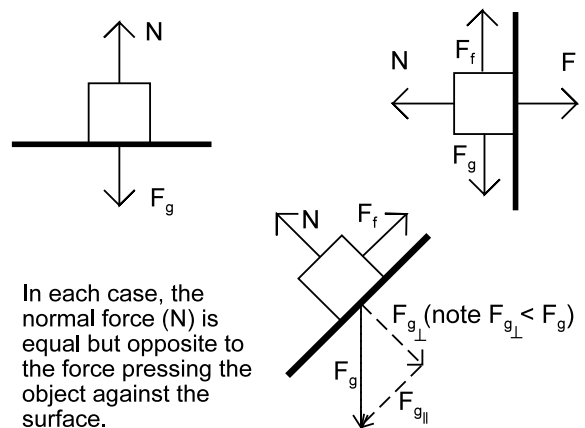
What causes friction? Centuries of study have yielded no completely reliable theory. The common-sense notion that the surface roughness or texture controls friction is countered by experiments showing that extremely smooth surfaces can yield large frictional forces. Scientists have theorized that such strange behavior comes from weak chemical bonds between surfaces, but that theory has not been fully supported by atomic-level friction experiments. For now, we must be content with describing the factors that control frictional force, without fully understanding the underlying mechanisms.

Several primary factors affect how much frictional force is available between two solid surfaces: the force pressing the surfaces together, the amount of applied force that friction opposes (consequently friction is different for an object this is sliding vs. not sliding), and the types of surfaces in contact. We will examine each of these in turn.

When an object pushes against a surface, the surface will apply an opposing force. Since this

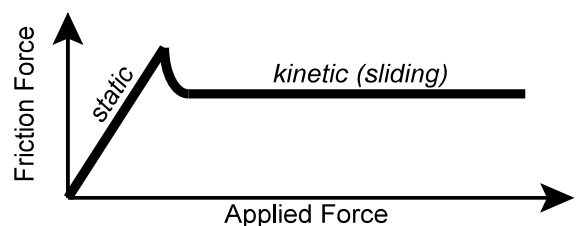
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reaction force is always perpendicular or "normal" to the surface itself, it is called the **normal force**.



Your lab work has shown that the normal force is directly proportional to the frictional force. Thus for the first time we see that a vertical force can *indirectly* affect horizontal motion. (For example, heavier objects press harder against floors, causing increased horizontal friction.)

The amount of friction is also affected by the amount of applied force that works to put the object into motion. In the lab you saw that the force required to start a block sliding is greater than that needed to maintain the slide. This is not an inertial effect, but a real difference in the frictional force. The amount of **static** friction that is *available* is always greater than the available **kinetic** friction. Static friction builds up from zero to a maximum value until the object begins to slide. Here we see that the amount of static friction is directly controlled by the amount of applied force that attempts to make the object slide.



During the slide, however, kinetic friction remains somewhat steady even if the speed varies. So we say that speed is NOT a factor that affects friction between two sliding solids, save that friction when

sliding is lower than the maximum friction available when not sliding.

Now suppose a ball of wood and a block of wood of equal weight were briefly shoved so they started moving across a table. Which would you expect to stop first? If you thought the block would stop first, you were right. The ball would continue to roll after the block had come to rest. This indicates that **rolling friction** is smaller than either kinetic or static friction. You might guess that this is because the ball has less surface area contacting the table at any point in time.

However, scientists have found that friction is NOT affected by the apparent area of contact if variables such as weight and material are controlled. So the apparent surface area between two solid surfaces is said to have NO effect on their frictional forces. Thus the exact reason why rolling friction is less than sliding friction remains unknown.

Finally, surface types affect friction. You know that smoother surfaces often (but not always!) yield less friction. You also know that lubricants can greatly reduce friction. A layer of oil between two surfaces reduces friction because the oil forms a thin film and, even though the layer is only a few molecules thick, prevents the two surfaces from coming in contact with one another. The friction between sliding solid surfaces is thus replaced by the smaller force of liquid drag.

Graphite, a carbon substance, is another common lubricant. Graphite, however, is solid. The molecular nature of graphite is such that the graphite crystals move quite easily over each other. When graphite is placed between two surfaces, the adhesion between the graphite and the surfaces is greater than that between the graphite crystals themselves. When the surfaces slide, it is the graphite crystals which are actually skidding.

Another way to reduce friction is to use bearings. Ball bearings are present in the wheel axles of many skateboards, bicycles, and automobiles. Since rolling friction is less than sliding friction, bearings alleviate much of the wear that would occur in the wheel and the axle. Oil, graphite, and bearings work well in reducing friction, but friction is still present in systems that employ them. An almost friction-free system is one that employs gases to separate two surfaces. Examples

of such systems include the air tracks used in physics labs and air hockey tables. Another way to reduce friction is to levitate surfaces magnetically.

We have seen that friction can be both helpful and destructive. It is a complex phenomenon which is still not fully explained. However, we do know some fundamental rules about its behavior which we can apply to a wide variety of situations.

## Questions

COMPLETE SENTENCES ONLY REQUIRED ON QUESTION 4

1. List the primary factors mentioned in the reading that affect friction.

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2. List two factors mentioned in the reading that friction between two flat solids does NOT depend on.

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3. Apply your knowledge of friction to list four ways to increase the friction on a vehicle in icy weather.

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4. A car is more likely to skid on a hill than on level pavement. Why is this? Include the concept of normal force in your answer.

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