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What causes lightning and thunder?

Lightning!

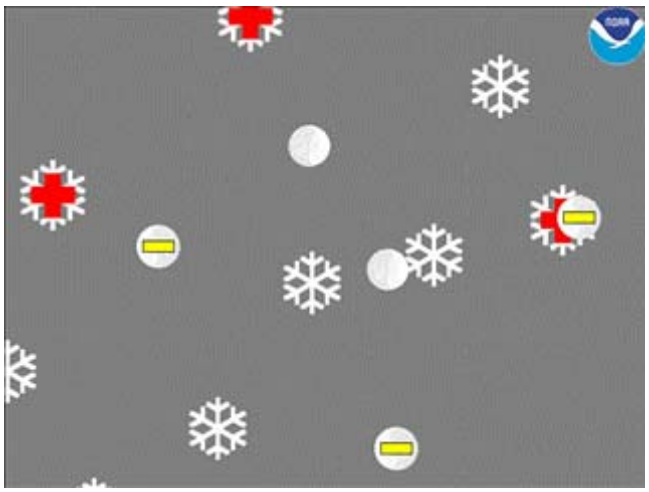
Zap! You just touched a metal doorknob after shuffling your rubber-soled feet across the carpet. Yipes! You've been struck by lightning! Well, not really, but it's the same idea.

Your rubber-soled shoes picked up stray electrons from the carpet. Those electrons built up on your shoes giving them a static charge. (Static means not moving.) Static charges are always "looking" for the first opportunity to "escape," or discharge. Your contact with a metal doorknob—or car handle or anything that conducts electricity—presents that opportunity and the excess electrons jump at the chance.

What causes lightning?

So, do thunderclouds have rubber shoes? Not exactly, but there is a lot of shuffling going on inside the cloud.

Lightning begins as static charges in a rain cloud. Winds inside the cloud are very turbulent. Water droplets in the bottom part of the cloud are caught in the updrafts and lifted to great heights where the much colder atmosphere freezes them. Meanwhile, downdrafts in the cloud push ice and hail down from the top of the cloud. Where the ice going down meets the water coming up, electrons are stripped off.



It's a little more complicated than that, but what results is a cloud with a negatively charged bottom and a positively charged top. These electrical fields become incredibly strong, with the atmosphere acting as an insulator between them in the cloud.

Click image for animation.

Credit: John Jensenius

When the strength of the charge overpowers the insulating properties of the atmosphere, Z-Z-Z-ZAP! Lightning happens.

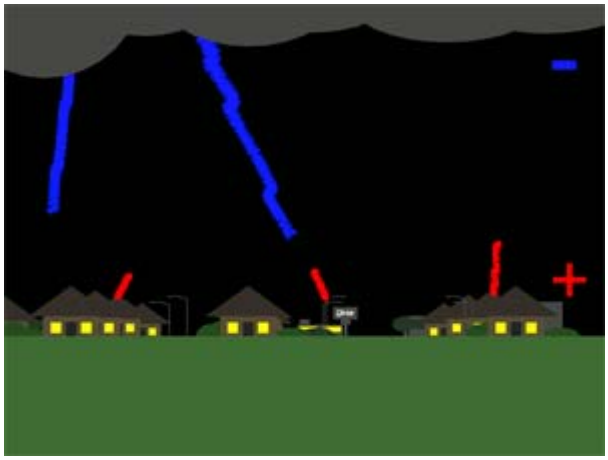
How does the lightning "know" where to discharge—or strike?

The electric field "looks" for a doorknob. Sort of. It looks for the closest and easiest path to release its charge. Often lightning occurs between clouds or inside a cloud.

But the lightning we usually care about most is the lightning that goes from clouds to ground—because that's us!

As the storm moves over the ground, the strong negative charge in the cloud attracts positive charges in the ground. These positive charges move up into the tallest objects like trees, telephone poles, and houses. A "stepped leader" of negative charge descends from the cloud seeking out a path toward the ground. Although this phase of a lightning strike is too rapid for human eyes, this slow-motion video shows it happening.

As the negative charge gets close to the ground, a positive charge, called a streamer, reaches up to meet the negative charge. The channels connect and we see the lightning stroke. We may see several strokes using the same path, giving the lightning bolt a flickering appearance, before the electrical discharge is complete.



Click for larger animated image

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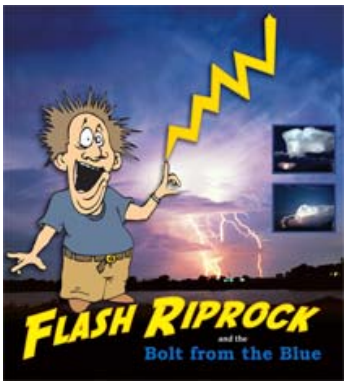

Each year, about 400 people in the U.S. are struck by lightning while working or playing outside. About 50 people are killed and several hundred more are left to cope with permanent disabilities.

How can I stay safe in a lightning storm?

Here are some important rules to remember about lightning safety:

1. First rule of lightning safety: No place outside is safe near a thunderstorm.
2. Plan your outdoor activities so that you can get to a safe place in case a thunderstorm develops.
3. Remember: When thunder roars, go indoors! If you can hear thunder, the storm is near enough to you to pose an immediate threat; after the thunder ends, wait 30 minutes before resuming outdoor activities
4. If thunder clouds are anywhere near, you should not be outside. Lightning can travel long distances. It doesn't have to be raining overhead for lightning to strike. Don't wait until the "last minute" to seek shelter. You don't want to be a victim of a "bolt from the blue."
5. If you are outside, go inside an enclosed building. You are also fairly safe in a vehicle, if the windows are up and you do not touch any metal.
6. Once inside a closed building, stay away from windows, showers, sinks, bath tubs, and electronic equipment such as TVs, radios, corded telephones and computers.
7. If you are caught outside and can't get to a safe place, there are things you should avoid so that you don't increase the chance of being struck. Never take shelter under a tree and stay away from other tall things like utility and flag poles, but avoid open areas and high ground. Stay away from metal bleachers and fences. Never lie on the ground as that increase the chances for being struck by dangerous ground current.

What causes thunder?

In a fraction of a second, lightning heats the air around it to incredible temperatures—as hot as 54,000 °F (30,000 °C). That's five times hotter than the surface of the Sun!

The heated air expands explosively, creating a shockwave as the surrounding air is rapidly compressed. The air then contracts rapidly as it cools. This creates an initial CRACK sound, followed by rumbles as the column of air continues to vibrate.

If we are watching the sky, we see the lightning before we hear the thunder. That is because light travels much faster than sound waves. We can estimate the distance of the lightning by counting how many seconds it takes until we hear the thunder. It takes approximately 5 seconds for the sound to travel 1 mile. If the thunder follows the lightning almost instantly, you know the lightning is too close for comfort!

What does lightning look like from space?

Lightning observed by the GOES-16 Geostationary Lightning Mapper (GLM) illuminates the storms developing over southeast Texas on the morning of February 14, 2017.

Lightning is an important part of weather forecasting. The Geostationary Lightning Mapper instrument on the GOES-R series satellites can detect lightning activity over nearly the whole Western Hemisphere.

Scientists use data from GOES-R series satellites, along with data from the Lightning Imaging Sensor on NASA's Tropical Rainfall Measuring Mission satellite, to study lightning. This complete picture of lightning at any given time will improve "now-casting" of dangerous thunderstorms, tornadoes, hail, and flash floods.

How likely is lightning to strike a person?