Fascinating Education Script
Fascinating Intro to Chemistry Lessons

Lesson 1: Forces

Slide 1: Introduction

Slide 2: Forces

Hi. My name is Sheldon Margulies, and we're about to learn what things are made of and what's holding them together.

Look at your desk, or a pencil on your desk, or the seat you're sitting on. How come they remain solid? Why don't solids melt or even evaporate into the air?

Water disappears if you wait long enough, so why doesn't everything just evaporate like water?

There must be some force holding each individual thing together. What are those forces? In fact, what is a force?

A force is something that can push or pull something.
You already know three forces, because you've seen an electrical force turn the blades of a fan, you've seen a magnetic force attract a piece of iron, and you've seen gravitational force pull things back to earth.

Let's talk a little about each of these forces, because each of them plays an important role in chemistry.

Slide 3: Gravitational force

What's a gravitational force? What does it do?
It pulls you back to earth. If you jumped out of an airplane, you'd fall to earth because of gravity.

The gravity we feel every day comes from the earth, but guess what, every object has a little bit of gravity around it. The earth, being so large, has so much more gravity than anything else that we don't sense the gravity pulling us toward much smaller objects.

All it takes to generate gravity is a mass, something you can touch, and feel, and see.

We think of gravity as only pulling downward. That's because we live on the surface of the earth, so the earth is always below us. Gravity, though, pulls in all directions, not just downward, because gravity extends from the earth, or from any mass, in all directions in what we call a gravitational "field."

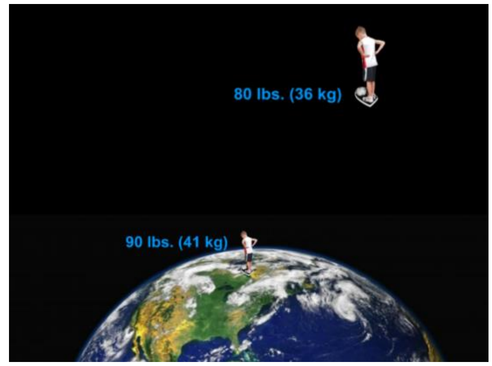
So, there's really two parts to gravity. One part is the mass generating the gravity, and the other part is the gravitational field extending out from the mass in all directions.

Sitting alone, a mass and its gravitational field around the mass don't produce a gravitational force. A gravitational force develops only when another mass enters a gravitational field.

When one mass with its gravitational field does enter the gravitational field around another mass, each mass generates a gravitational force of attraction. For example, we're in the sun's gravitational field and the sun is in our gravitational field, so the sun's gravitational force is attracting the earth toward the sun, while at the same time, the earth's gravitational force is attracting the sun toward the earth.

Now suppose you're in your house or apartment. You are a mass in the earth's gravitational field. The earth is exerting a gravitational force on you and pulling you toward the earth. Because the earth is right below you, you feel the earth's gravitational force pulling you downward. How would you measure the strength of the earth's gravitational force of attraction?

Step on a scale and weigh yourself.



Suppose you weigh 90 pounds, or 41 kilograms.

Now let's get way up above the earth and step on the scale. Now you weigh less. Why? What's changed? Has the mass of the earth changed? Has your mass changed? Has the earth's gravitational field changed? What's changed to make the gravitational force in space less than it is on the surface of the earth?

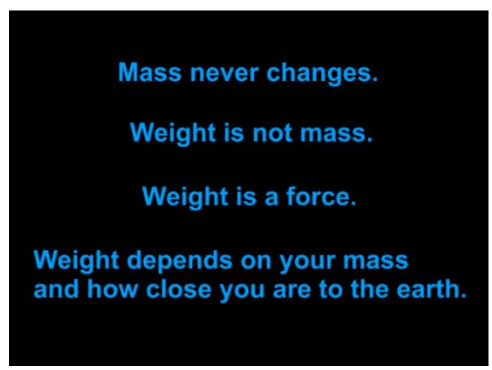
The mass of the earth hasn't changed. Neither has your mass changed. Why not? Because your mass stays the same wherever you are. The amount of stuff inside you is the same on earth as it is in outer space.

So, what did change when you got further away from the earth?

The strength of the earth's gravitational field changed. It got weaker. The strength of a gravitational field diminishes – it gets less -- as you get further and further away from the source of the gravitational field. And if you reverse this, the closer you get to the surface of the earth, the stronger the gravitational field.

What a bathroom scale measures is the force generated by your mass inside the earth's gravitational field.

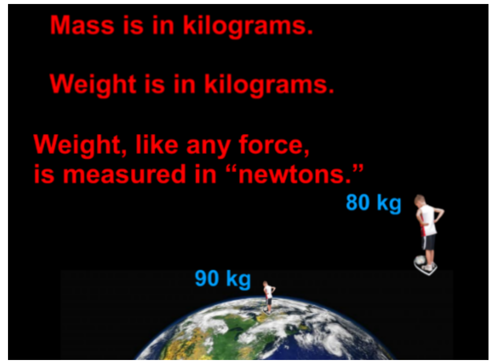
Here's what I want you to remember. Your mass, or the mass of any object, doesn't change just because you move further from the earth. Mass is how much stuff you're made of. That never changes no matter where you are.



Weight is not mass. Weight is a force. Weight is a force that will move you toward the earth if you're not holding on. That force of attraction toward the earth is measured with a scale. The bigger your mass, the stronger the force and thus, the more you weigh. And the closer you are to earth, the stronger the earth's gravitational field, and thus, the more you weigh.

It makes sense that the bigger you are, the more you weigh, and the closer you are to the surface of the earth, the more you weigh. What doesn't make sense is that we measure both the mass of something and the weight of something in grams or kilograms. A kilogram is a thousand grams.

Suppose your mass is 90 kilograms**.** That mass never changes: your mass is 90 kilograms on earth and 90 kilograms in outer space. Yet, on a kilogram scale, your 90 kilograms will decrease to 80 kilograms in outer space. How can that happen if your mass doesn't change? Mass doesn't change. What changed is your weight, which is the force generated by that mass. We mistakenly describe weight in kilograms. What's happened over the years is that we use kilograms to measure both mass and weight, but we shouldn't.

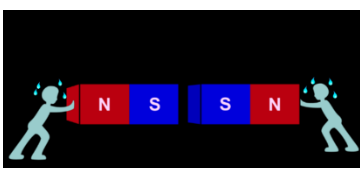


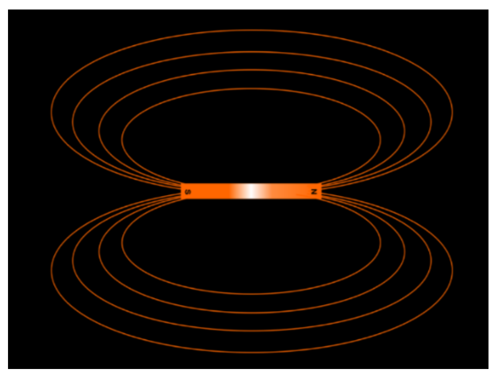
The reason it happened is that we've gotten used to weighing things on earth where something's mass and weight never change. So instead of using a different term for weight, we just used something's mass in kilograms to describe its weight. It's a mistake, I know. The term we should be using for weight is the term we use for force, and that is "Newtons," after Sir Isaac Newton who lived around 1700 and figured this all out.

In the American system, we also use one term to refer to both mass and weight, but in our case, we use weight to refer to mass. "Pounds" is a measure of force, and "slugs" is a measure of mass, but no one talks about slugs of mass.

So, when we say you weigh 111.5 kilograms, what we're saying is that your 111.5 kilogram mass generates the force you see on the scale.

Slide 4: Magnetic force



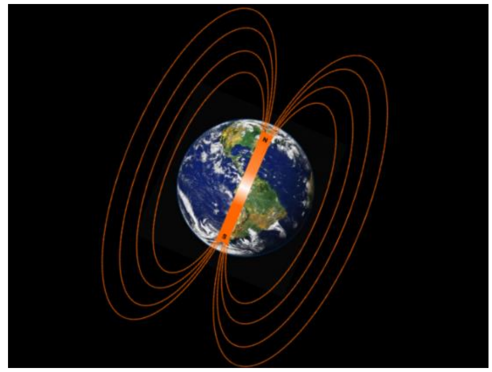


As for magnetic forces, you've all played with magnets and discovered that two north poles and two south poles of a magnet push against each other, while the north and south poles of a magnet attract each other.

The north and south poles of a magnetic each generate a magnetic field around them. Because the north and south poles attract each other, their magnetic field lines curve toward each other.

How many of you have played with a compass? A compass needle points north and south. Why? Why does the needle always point north and south? What magnetic field is the compass needle being attracted to?

The earth! The earth is a giant magnet because of huge deposits of magnetic iron buried deep inside the earth.

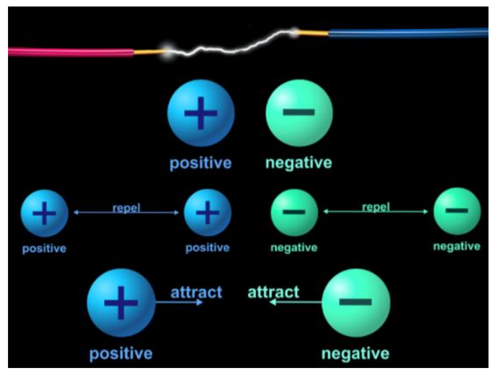


The magnetic north and south poles of the earth are close to the real north and south poles, but not right at the north and south poles.

The earth, then, generates two forces, a gravitational force and a magnetic force.

Slide 5: Electrical charges

If a gravitational force comes from objects like the earth, and a magnetic force comes from magnets, where does an electrical force come from?
An electrical force comes from electrical charges. I've never seen an electrical charge, but I've felt them when I got an electrical shock.



There are two kinds of electrical charges: positive and negative. Each electrical charge is surrounded by an electrical field just like a mass is surrounded by a gravitational field and a north or south magnetic pole is surrounded by a magnetic field.

Like the two north ends of a magnet, two positive electrical charges push each other away. They "repel" each other. Two negative electrical charges also repel each other.

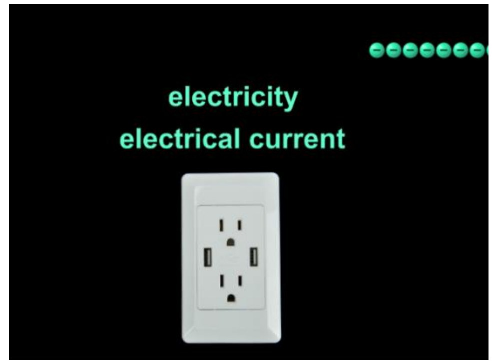
And like the north and south poles of a magnet, a positive electrical charge is attracted to a negative electrical charge, and vice-versa, a negative electrical charge is attracted to a positive electrical charge.

So opposite electrical charges attract, and like electrical charges repel.

Where can I find some electrical charges?

How about a battery? Do you see the plus and minus signs on this battery? The plus sign stands for positive electrical charges and the minus sign for negative electrical charges.

Slide 6: Moving electrical charges



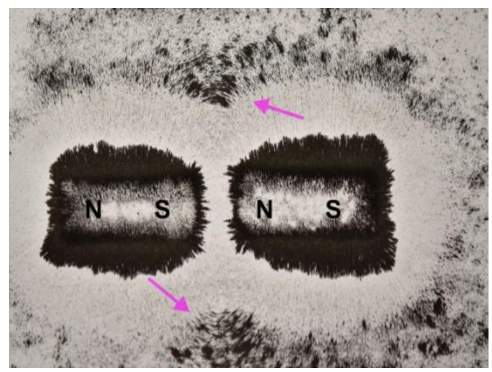
What do we call negative electrical charges when they are moving?

Electricity, or an electrical current – same thing.

What's coming out of a wall socket are negative electrical charges.

A lightning bolt is a huge number of electrical charges shooting through the air during a thunderstorm. Electricity and magnetism are related. Moving electrical charges create a magnetic field around themselves. Let me show you.

A magnet has a magnetic field around it. We can see the magnetic field by sprinkling these iron filings around the magnet.



See how the iron filings line up along the magnetic field lines curving between the north pole of one magnet and the south pole of the other magnet?

Look at this. When I sprinkled iron filings around this electrical wire and ran electricity through the wire, the iron filings right next to the wire changed from being scattered to lining up in a small circle around the wire.

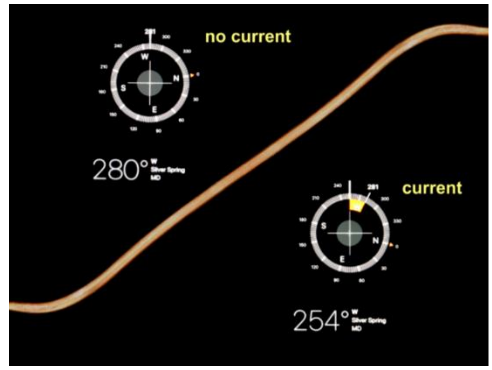
What does that mean?

The iron filings responded to a magnetic field by lining up in the direction of the magnetic field, but what was creating the magnetic field?

The electrical current traveling through the wire. Moving electrical charges create a magnetic field around themselves.

If you still don't believe me, let's place this compass near the wire before turning on the current. The letter N is pointing toward the earth's north pole, and the letter S is pointing toward the earth's south pole.

When we turn on the electric current, N and S change directions slightly in response to the magnetic field created around the wire by the electric current running through the wire.



It's now time to review what we've learned in this first lesson about gravitational, magnetic, and electrical forces.

Slide 7: What you know so far

1. We know that that there are three forces that push or pull without touching another object. Those three forces are gravity, electricity, and magnetism.

2. We know that a gravitational field surrounds every mass and extends outward from the mass in all directions.

3. We know that a gravitational force does not develop until a mass enters the gravitational field of another mass.

4. We know that there are two types of electrical charges: positive and negative.

5. Like the gravitational field surrounding a mass, an electrical field extends outward from a positive and negative charge in all directions.

6. And like gravity, an electrical force only develops when an electrical charge enters the electrical field surrounding another electrical charge.

7. Two positive electrical charges repel each other, and two negative electrical charges repel each other, but a positive and a negative electrical charge attract each other.

8. Unlike gravity, however, a moving electrical charge generates a magnetic field.

9. The magnetic field around a moving electrical charge encircles the path of the moving electrical charge.

10. A magnetic field surrounds the north pole and the south pole of a magnet, and each magnetic field points toward the opposite magnetic pole.

11. Electrical charges are stored inside a battery. The minus sign on a battery indicates the negative electrical charges and the positive sign on a battery indicates the positive electrical charges.

12. We detect the north and south pole of a magnet with a compass. When a compass detects a magnetic field, one end of the compass needle points toward the magnet’s north pole and the other end points toward its south pole.

13. The reason a compass points toward the north and south pole of the earth is that the earth itself is magnetic with its magnetic north pole close to the actual north pole of the earth and its south pole close to the earth’s actual south pole.