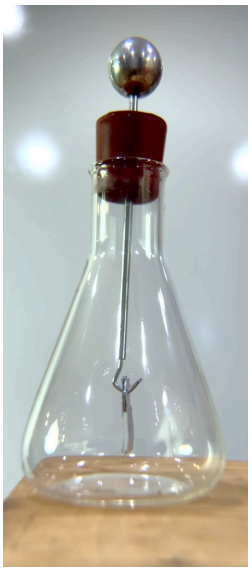
Flipping Physics Lecture Notes:
Charging via Conduction and Induction
https://www.flippingphysics.com/conduction-and-induction.html



An electroscope is an instrument for demonstrating electric charge. This electroscope has a metal ball on top of a vertical metal rod with a hook on the end of it and two thin foils of aluminum hanging from the hook. The metal ball, rod, hook, and two aluminum foils are electrically insulated from the surroundings via the rubber stopper and glass flask.

Charge by Conduction:

- charge the balloon
- bring balloon close to electroscope and foils move apart
- touch balloon to electroscope
- electroscope is charged by conduction
- touch electroscope with hand and foils fall down to original positions

In order to charge the balloon, we rub fur on balloon. This causes electrons to move from the fur to the rubber balloon. The fur now has excess positive charge and the balloon has excess negative charge. This is called charging by friction. Before balloon is close to the electroscope the net charge on electroscope equals zero. The electroscope has an equal number of protons and electrons. The balloon has larger number of electrons then protons.

The negatively charged balloon is brought close to the electroscope, however, the electroscope and the balloon have not touched yet. The aluminum foils are pushed away from one another. The foils must have the same charge. The foils must have an electric force pushing them apart.

We can use the Law of Charges to determine the charge on the foils. We know protons do not easily move because they are in the nucleus of the atoms. That means the electrons are the ones that move. So, the electrons in the electroscope, which are negatively charged, are repelled by the negative charges in the balloon and flow down to the metal foils. That must mean, when the balloon is brought near the electroscope, the metal foils have an excess of electrons, or a net negative charge, and an electric force pushes the metal foils away from one another. That means the top of the electroscope has a net positive charge because there are fewer electrons than protons in the ball at the top of the electroscope. However, realize the electroscope still has a net neutral charge.

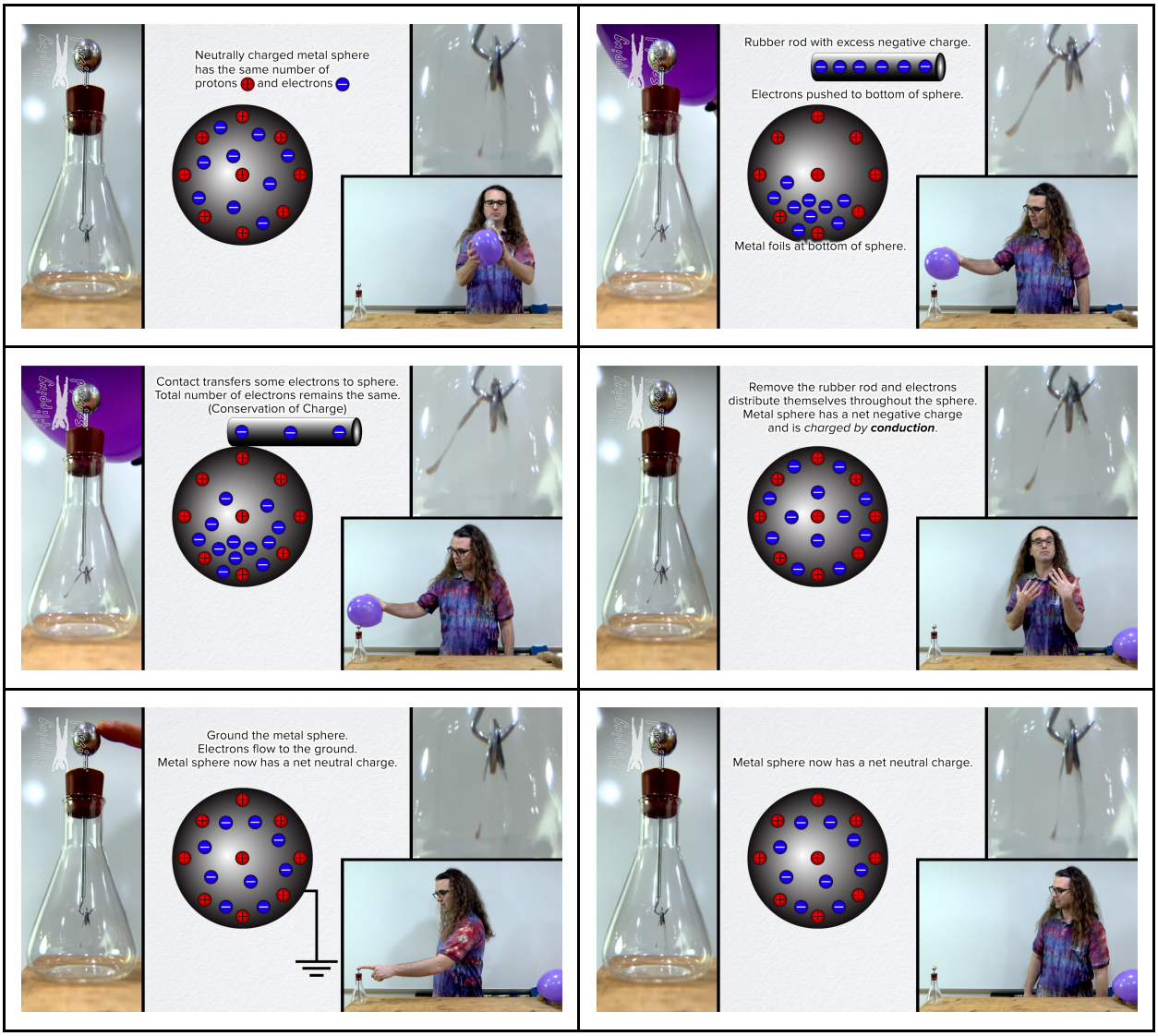
When the balloon touches the electroscope, electrons transfer from the balloon to the electroscope. The balloon and electroscope now both have excess electrons, however, total number of excess electrons in the system remains the same. This is called Conservation of Charge. Because the balloon and electroscope have excess electrons, the foils also have excess electrons and repel one another.

Now I touch the electroscope with my finger and the foils fall to their original positions. This is because touching electroscope grounds the electroscope. That means the electroscope is no longer electrically isolated and electrons transfer from electroscope into ground. After grounding, the electroscope has neutral charge. An Ideal Ground is an infinite well of charge carriers. We call it a “ground” because electrical circuits are literally connected to the Earth or the “ground”. And the Earth has, relatively speaking, an infinite number of electrons which we can pull from it, or we can give to it, again relatively speaking, an infinite number of charges. If something goes wrong in a circuit, the “ground” will serve as a way to balance out the charges. In this example, when I touch the electroscope, the electroscope is no longer electrically isolated and the excess electrons on the electroscope flow out of the electroscope into the “ground”, into me, and the electroscope is now electrically neutral, which is why the foils are no longer repelled from one another.

Two items to remember about Charging by Conduction:

1. The two objects have to touch. In this case the two objects are the balloon and the electroscope.
2. The two objects end with the same sign of net charge. In this case they both end with an excess negative charge. (Before the electroscope is grounded and ends with a net neutral charge.)

Charging by Conduction in pictorial form:



And now we switch to Charging by Induction:

- charge the balloon
- bring balloon close to electroscope
- ground the electroscope
- remove the ground
- remove the balloon and electroscope is charged by induction
- ground the electroscope

This time when the electroscope is grounded the negatively charged balloon is held near the electroscope, therefore, electrons in the electroscope flow into the ground. They do that because, according to the Law of Charges, like charges repel one another. So, some of the electrons in the electroscope flow from the electroscope into the ground. The ground essentially provides an escape route for electrons to leave the electroscope. But there are still electrons in the electroscope, just fewer than before, and many are in the metal foils of the electroscope because they are repelled from the electrons in the balloon. That gives the metal foils a net neutral charge and the two foils are not repelled from one another.

Then when the balloon is removed, the electrons in the electroscope are repelled from one another in the electroscope and get distributed throughout the electroscope. That leaves the electroscope with an excess of protons and a net positive charge. That is why the metal foils are repelled from one another, because the positive charges in the foils repel one another.

And then the electroscope is grounded. In this case, that means electrons are pulled from the ground into the electroscope to balance out the excess protons in the electroscope and leave the electroscope with an equal number of protons and electrons and a net neutral charge.

Two items to remember about Charging by Induction:

1. The two objects do not have to touch.
2. The two objects end with opposite sign of net charge. In this case the electroscope ends with an excess of positive charge and the balloon ends with an excess negative charge. (Before the electroscope is grounded and ends with a net neutral charge.)

Charging by Induction in pictorial form: