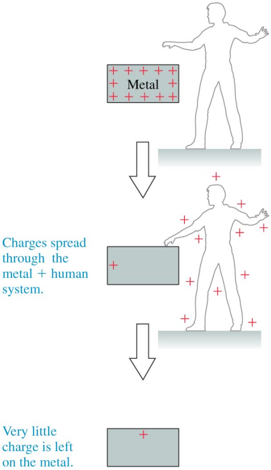
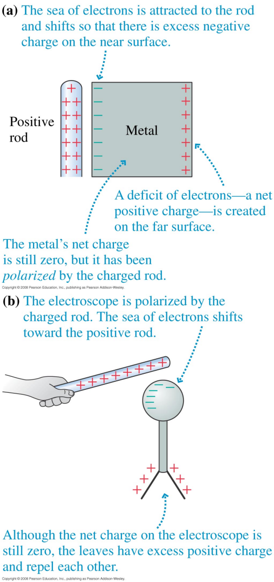
Discharging



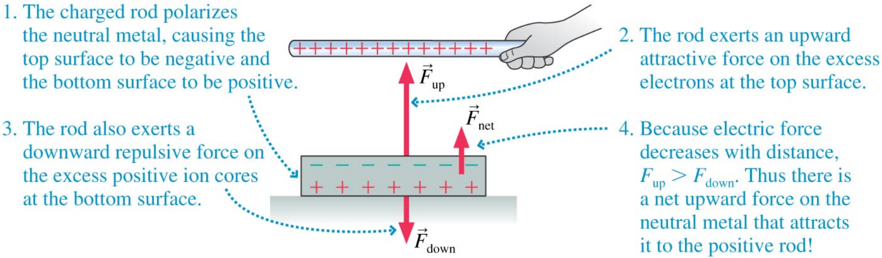
- Place two conductors in contact with each other and the charge gets shared.
- A human is composed mainly of salty water, making us good conductors (Na+ and Cl- ions).
- For example, touch a positively charged conductor, donate electrons to the metal and share the net positive charge over your combined surfaces. You become positively charged.
- The earth is a giant conductor which we can purposely share charge with - through grounding.
- Moist air is also a conductor – a poor one. Charged objects in air slowly lose their charge.

Charge Polarization



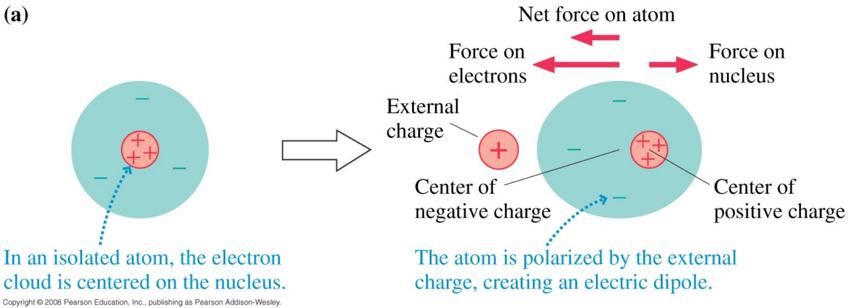
- We understand that objects can have a net positive or negative charge. However, why do neutral objects get attracted to charged objects without touching?
- The presence of a charged object can polarize another object.
- The object is neutral, but positive and negative charges become separated.
- The positive ions also attract the surface electrons, quickly creating an equilibrium and ensuring that the object de-polarizes once the charged rod is removed.

Charge Polarization



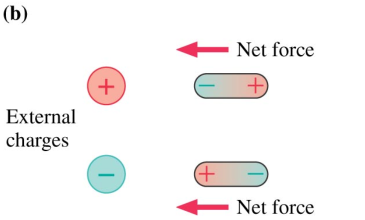
- The slight charge separation caused by polarization creates a net force on the object.
- If electic forces decrease with distance, then the net force will be attractive: the attraction of the closer negative charges is greater than the repulsion of the farther positive charges.
- Net attraction also occurs if the rod is negatively charged: because then the polarization is reversed.
- A neutral object is attracted to a charged object!

The Electric Dipole

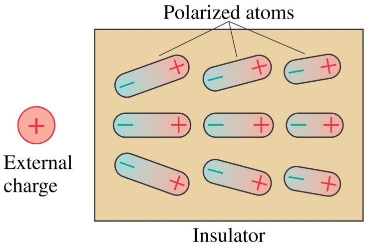


- So far we have been talking only about conductors. But we know that a charged rod will pick up paper (an insulator).
- In this case the charge will polarize the atoms.
- The atom forms an electric dipole

The Electric Dipole

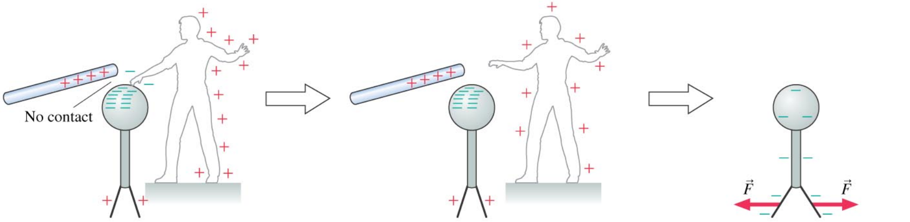


Electric dipoles can be created by either positive or negative charges. In both cases, there is an attractive net force toward the external charge.



- So, an insulating medium can be polarized.
- Each individual atom is polarized leading to a net force of attraction.

Charging by Induction

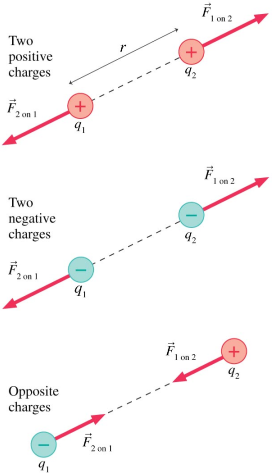


1. The charged rod polarizes the electroscope + person conductor. The leaves repel slightly due to polarization, but overall the electroscope has an excess of electrons and the person has a deficit of electrons.

2. The negative charge on the electroscope is isolated when contact is broken.

3. When the rod is removed, the leaves first collapse as the polarization vanishes, then repel as the excess negative charge spreads out. The electroscope has been *negatively* charged.

Coulomb's Law (26.4)



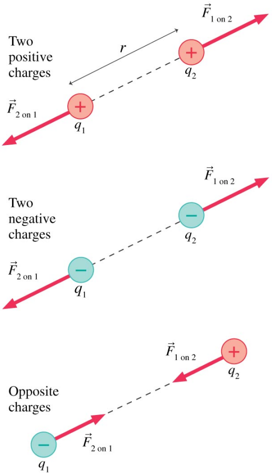
- We need a quantitative understanding of these attractive and repulsive forces.
- Coulomb's Law states

$$F_{1 \text{ on } 2} = F_{2 \text{ on } 1} = \frac{K|q_1||q_2|}{r^2}$$

  Where the direction of F is along the line connecting the two particles, like particles repel and opposites attract.
- K is the electrostatic constant and is

$$K = 9.0 \times 10^9 \ \text{Nm}^2/\text{C}^2$$

Coulomb's Law



- We can instead define the permittivity constant as

$$\epsilon_0 = \frac{1}{4\pi K} = 8.85 \times 10^{-12}\ \mathrm{C^2/Nm^2}$$

- This allows us to re-write Coulomb's Law as

$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1||q_2|}{r^2}$$

- This is the standard way of writing Coulomb's law because it it mathematically convenient, as we will see later.
- In vector form:

$$\vec{F}_{1\text{ on }2} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}_{1\text{ to }2}$$

Observations About Coulomb's Law

1. Coulomb's Law applies only to point charges.
2. Coulomb's Law applies only to electrostatics
3. Electric forces, like other forces, can be superimposed

$$\vec{F}_{\text{net on j}} = \vec{F}_{\text{1 on j}} + \vec{F}_{\text{2 on j}} + \vec{F}_{\text{3 on j}} + \cdots$$