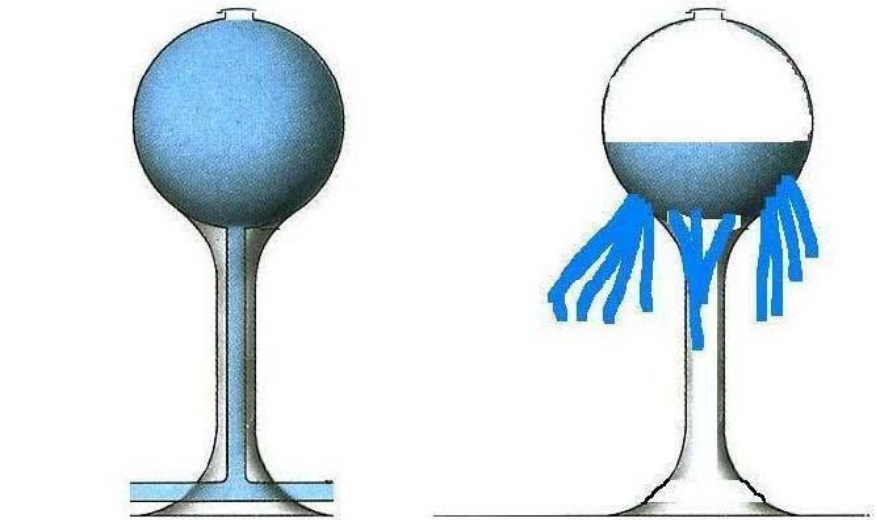
Traditional: 08-01
Themed: 05-01

Electricity: “The movement of charges”

Static electricity

- There are two types of electricity: Static and Current
- Static means “stationary”, not moving
- Current means flowing
- A static shock is a sudden, one-time burst of charge
- Water can flow, just like electrons. Which example is most like static electricity?

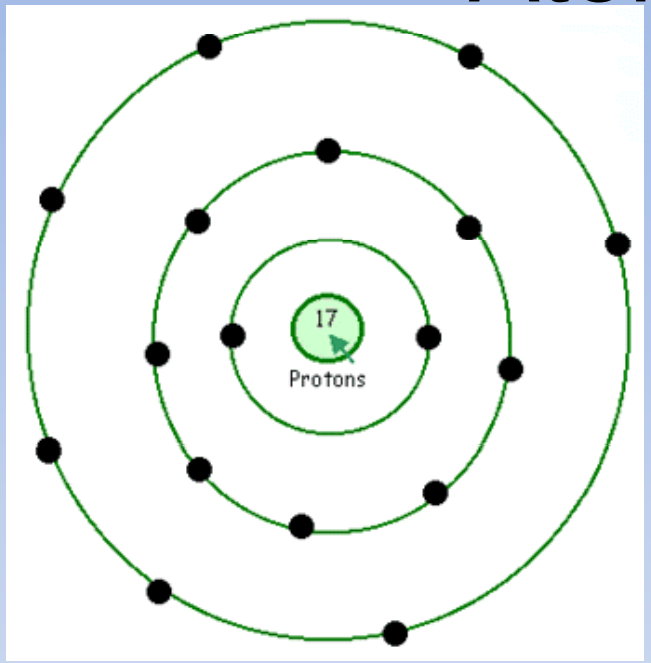


Water flows in steady state stream (current)

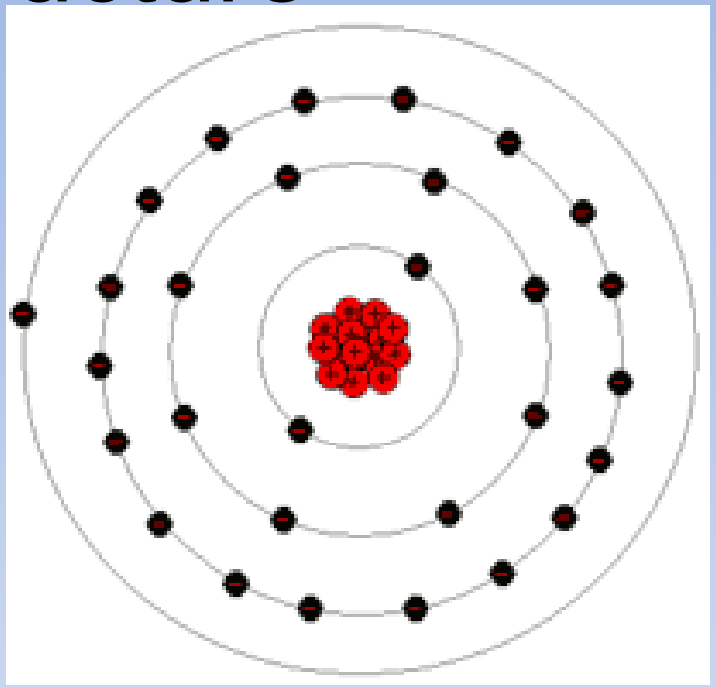
Bottom bursts open and all the water gushes out suddenly.

A fact you should know: Ben Franklin came up with the system for charges we still use today.

Atomic structure



Non-metal (Cl): 7 valence electrons



Metal (Cu): 1 valence electron

- Remember there are only two kinds of charges: electrons & protons
- Metals don't mind giving up electrons…their electrons roam around freely
- Non-metals are looking for a couple more electrons to complete their valence shell, they hold on tightly to their valence electrons
- Which one of these will conduct electricity (charges MOVE)?
- Which particle moves (electron/proton)? Which is a conductor? Why?

Building up static charge

- Conductors can’t build up electric charges very well since electrons spread out evenly everywhere
- Insulators accumulate charge on the surface since electrons can’t flow through
- A balloon is made of rubber, an insulator: electrons can be rubbed onto the surface and stay there

What happens when you charge up a balloon with your hair?

- Charges rub off from one surface to another
- One surface is more attractive to electrons than the other surface and electrons accumulate on the preferred surface

Will the balloon attract/repel a metal can?

- What's happening & why?
- Electrons are free to roam around in metals…will they move toward or away from negatively charged balloon?

Will a negatively charged balloon attract, repel, or neither on a wood door?

- Make a prediction and then let’s see….

Will the balloon attract/repel a wood door?

- Electrons are not free to roam around, but they are free to spend more time in one part of the atom than the other (polarize)

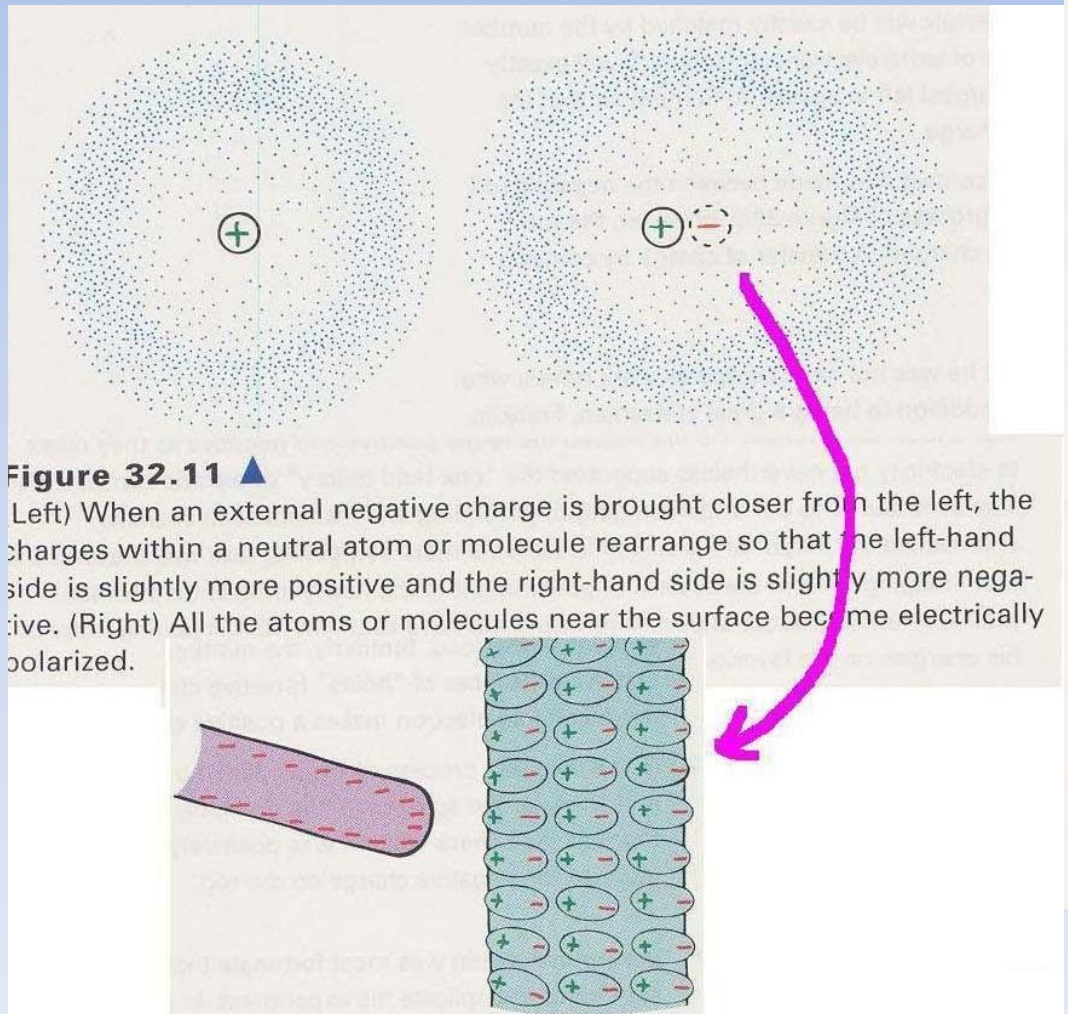


Figure 32.11 ▲
(Left) When an external negative charge is brought closer from the left, the charges within a neutral atom or molecule rearrange so that the left-hand side is slightly more positive and the right-hand side is slightly more negative. (Right) All the atoms or molecules near the surface become electrically polarized.

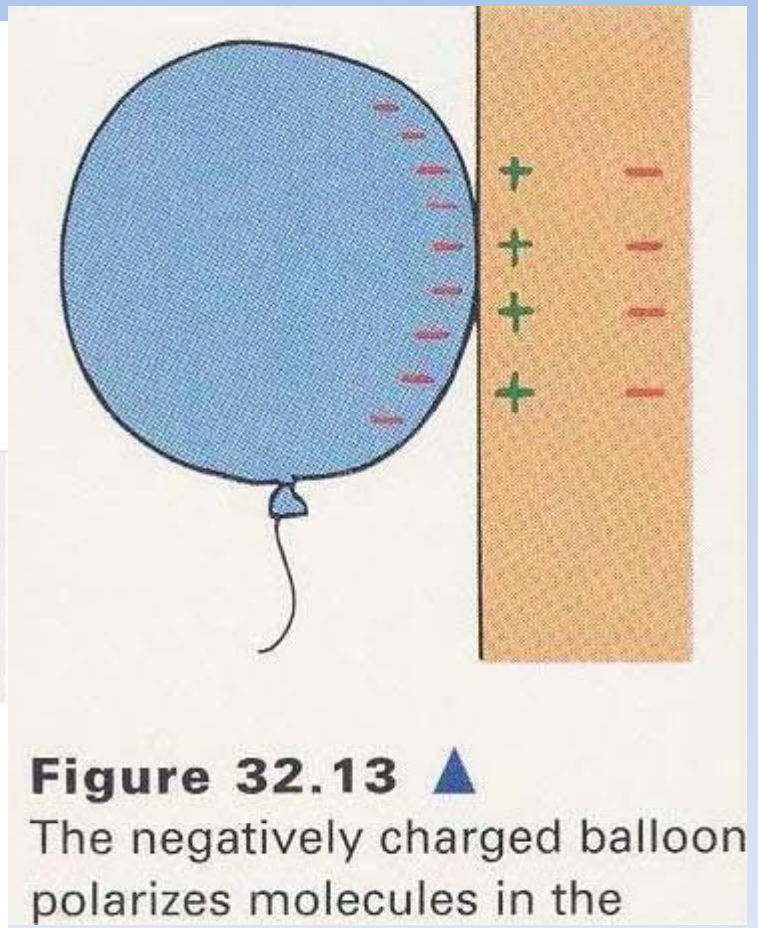


Figure 32.13 ▲
The negatively charged balloon polarizes molecules in the

Will a magnet attract/repel/neither a negatively charged balloon?

- Make a prediction and then let’s see!

Magnetic forces and electrical forces are related, but not the same

- Magnets don’t attract or repel electrically charged particles
- We’ll learn about the relationship between electricity and magnetism in January!

Math – Coulomb's law

- Compared to gravity and every day forces, electrical are HUGE!
- If you could take a single gram of hydrogen and separate the electrons and protons by 1 m, the force would be the same as everyone in the world pulling with 400,000 tons!
- This implies there really aren't that many electrons being rubbed onto the balloon
- The equations/constants we need are in your study guide…..

Coulomb's law

$$F = k \frac{q_1 q_2}{r^2}$$

$$e = 1.60 \times 10^{-19}\ C$$

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

$$Q = ne$$

Coulomb's law

"Fundamental Charge":

The charge on an electron (same as on a single proton). Sign is + for protons and – for electrons.

k: Coulomb's constant

Coulomb's law sample problem

- What is the force between two protons and three electrons separated by 5 nanometers? (nano is 10^{-9}): it's expected you still know nano, micro, milli, kilo, mega and giga

(-5.53×10^{-11} N), *r = 5E-9, Q1 = +3.2E-19, Q2 = -4.8E-19*

- Is it an attractive or repulsive force? How do you know?
- What would happen to the force if
  a. Both charges were doubled? Tripled?
  b. The charges were brought twice as close?
  c. The charges were brought three times as far?

Second Coulomb's law sample

- How many charges would it take to lift up a 2.5 g balloon assuming the balloon is 3.0 mm from an equally charged positive object? (2.5 g weighs .025 N on earth).

(3.125×10^{10} charges (+ and -)

How? Coulomb's law: $Q^2 = 2.5E\text{-}17$, $Q = 5E\text{-}9$, use $Q = ne$ to find n

Important Coulomb's law idea

- Can you have ½ an electron? ¼ of a proton?
- Is it possible to have ½ the charge of an electron or ¼ the charge of a proton?
- All charges must be integer multiples of the fundamental charge (n x 1.6 x 10^{-19} C)
- Example: Which (if any) is possible?

1. A net charge of 4.0 x 10^{-19} C
2. A net charge of 4.0 x 10^{-18} C

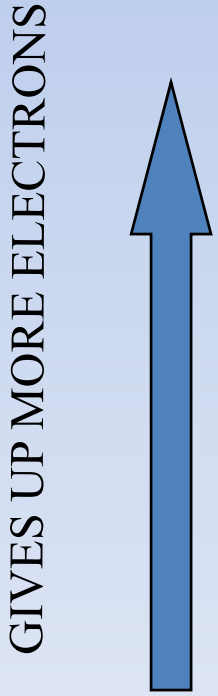
Triboelectric series

Who really, really wants those electrons?

- Triboelectric series is just a list of materials in a specific ORDER
- The order shows when two materials are rubbed together, which material will pick up electrons (acquire a negative charge)

TRIBOELECTRIC SERIES

When we rub two different materials together, which becomes positively charged and which becomes negative? Scientists have ranked materials in order of their ability to hold or give up electrons. This ranking is called the triboelectric series. A list of some common materials is shown here. Under ideal conditions, if two materials are rubbed together, the one higher on the list should give up electrons and become positively charged. You can experiment with things on this list for yourself .



TRIBOELECTRIC SERIES

+

your hand
glass
your hair
nylon
wool
fur
silk
paper
cotton
hard rubber
polyester
polyvinylchloride plastic

-

Gravitational force compared to electrical force

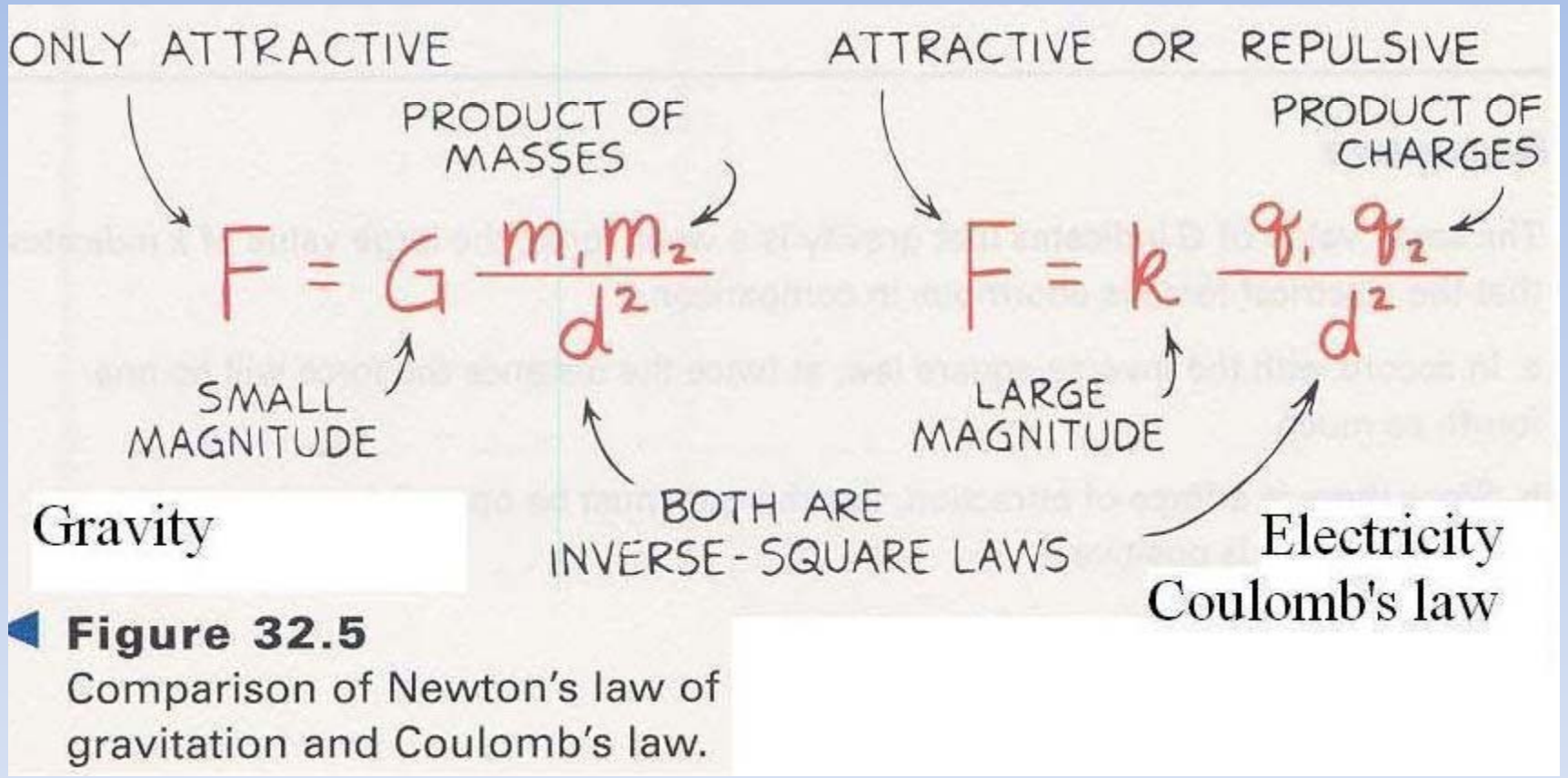


Figure 32.5
Comparison of Newton's law of gravitation and Coulomb's law.

What you should know: Gravity only attracts and is much weaker; We don't feel Electrical force because we're electrically neutral (can't neutralize mass)

Conservation of charge

- Fundamental: just like conservation of energy, mass, etc.
- If my hair loses 5 coulombs of charge (electrons), how many coulombs does the balloon gain?

Charging by induction vs. conduction

- Conduction means contact. Charged objects touches object being charged
- Induction means indirectly (non-contact)
- Charges get “stranded”, like castaways with no way home

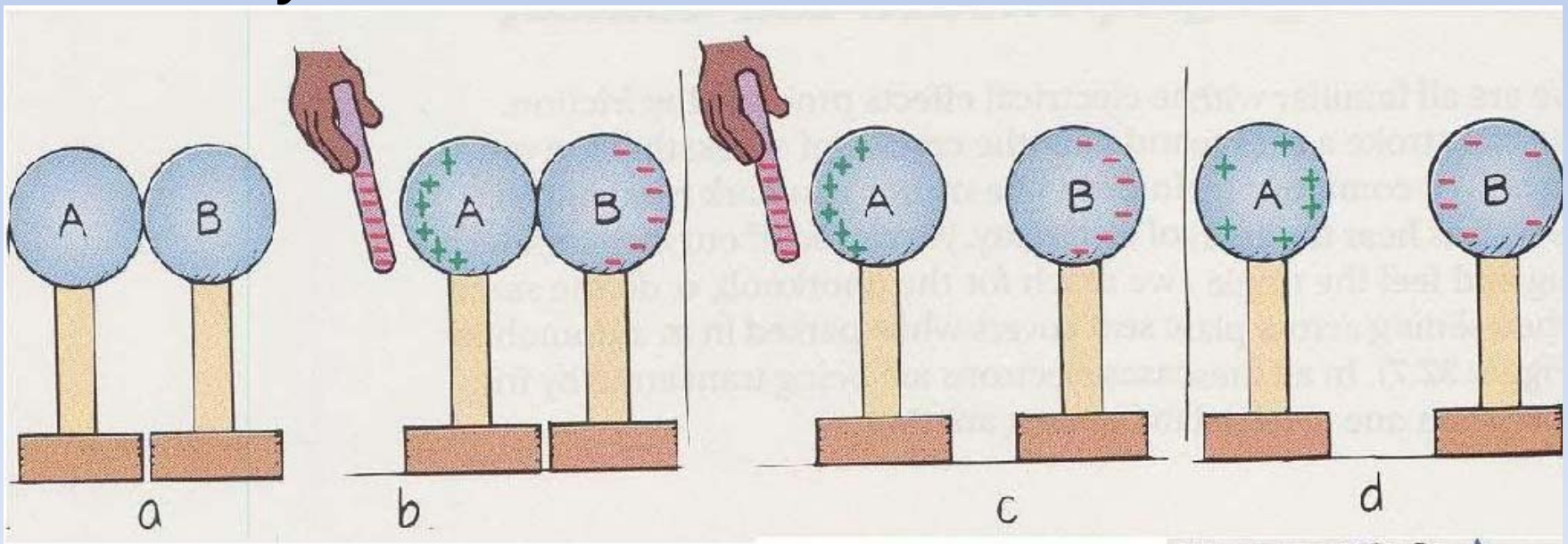
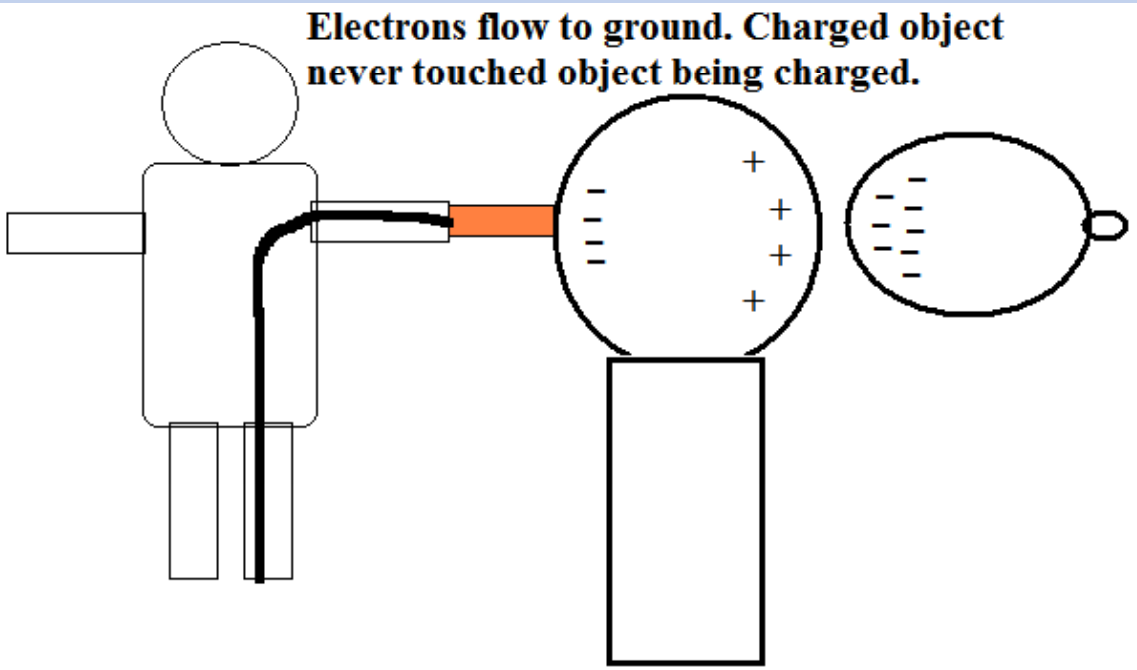


Figure 32.8 ▲
Charging by induction

Charging by induction vs. conduction

- Another means of charging by induction
- Note: not contact of charged object and object remains charged even when balloon is removed
- Charges get “stranded”, like castaways with no way home



(old notes)…Prefixes to MEMORIZE (for whole year)

- Why?
  - *How many Gigs does your I-pod have? Ever hear of nano technology? Songs take up about 4 MB of space? A common speed limit in Canada might be 80 km/hr, eh. I need a 2 TB drive to store all my files for school. My phone at home communicates at 5.8 GHz, my old phone used 900 MHz.*
  - *You need to know metric prefixes to buy the right thing and understand technology, rules of the road, medication doses. Etc.*
  - *These prefixes will follow you the rest of your lives and I'm holding you responsible to memorize them.*
- Sample problem: Green light's wavelength is about 450 nm. What is the frequency of this light in GHz? (667 GHz)

Prefix	Symbol	Amount as #	Amount as exponent
Tera	T	Trillion	10^{12}
Giga	G	Billion	10^{9}
Mega	M	Million	10^{6}
Kilo	K	Thousand	10^{3}
Centi	C	Hundredth	10^{-2}
Milli	m	Thousandth	10^{-3}
Micro	μ	Millionth	10^{-6}
Nano	n	Billionth	10^{-9}