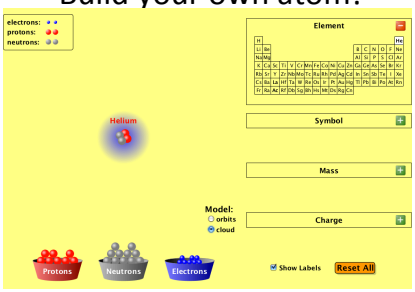
Static electricity

Why do my socks stick together after I dry them?

Lecture 19 :
Begin static electricity

Reminders:
HW 8 due Monday 5th at midnight
Reading quiz Thurs

Build your own atom!



http://phet.colorado.edu/en/simulation/build-an-atom

Atoms, Electrons and Ions

The atom

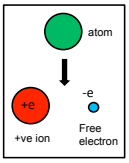
Electron "cloud".
Negatively charged
Occupies most of volume of atom

Nucleus
Contains protons and neutrons
Positively charged
99.9% of mass is concentrated in tiny nucleus,

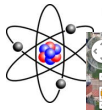
Atoms have equal number of protons and electrons, so total charge is *zero*.
⇒*They are electrically neutral*

The same is true of most ordinary objects (made of atoms.)

You can pull electrons off atoms. This leaves 2 *charged* particles :
- Unbound (free) electrons (negatively charged)
- Positively charged ions
(ion = atom with unequal number of protons and electrons)



A word about scales of the atom



If the nucleus were the size of this room, where are the electrons?.

The nucleus is ~10,000 times smaller than the atom…

Source of electricity: Electric charges

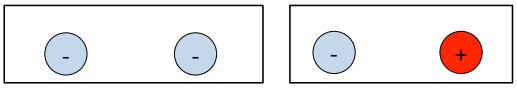
Everything (earth, you, the table etc) made of tiny particles called atoms
Atoms are made up of 3 even tinier particles:
Electrons, neutrons and protons

Particle	Charge	Mass
Electron	-e	9.11×10^{-31} kg
Proton	+e	1.67×10^{-27} kg
Neutron	0	1.67×10^{-27} kg

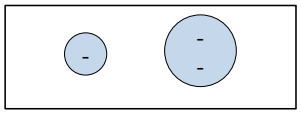
e = 1.6×10^{-19} Coulombs
Coulomb (C) is the unit of charge

Static electricity: What happens when charges are stationary
Electricity (and electric currents): What happens when charges (usually electrons) are moving

Sorting out how charges interact

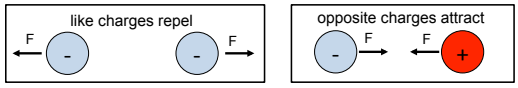


What if I have twice the charge as before?

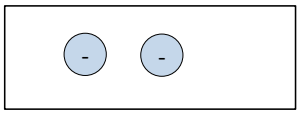


a) Half the force as before
b) Same force as before
c) Twice the force as before
d) Four times the force

Sorting out how charges interact

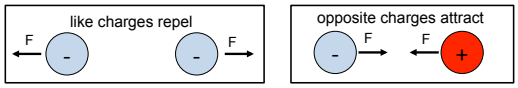


What about the distance, what if they are closer?

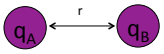


a) Less force
b) Same force as before
c) More force

Putting this together: Electric Force



Consider 2 'point' charges, A and B. What force does charge A feel?



Observed behavior:
- Force depends on q_A and q_B : More charge, more force
- Force depends on distance between them (r) : less distance, more force

Coulomb's Law:
$Force_{of\ B\ on\ A} = \frac{kq_Aq_B}{r^2}$

- Describes the force between 2 point charges
- k is Coulomb constant = 8.99 x 10^9 N m^2/C^2
- q_A and q_B are amount of charge in coulombs (C)
- r is separation in m

1 Coulomb = 6 x 10^{18} electron charges!

Electric Hockey Simulation!

$Force_{of\ B\ on\ A} = \frac{kq_Aq_B}{r^2}$

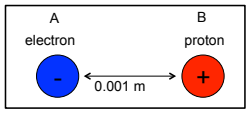
Place charge (B) 2cm from charged puck (A). See charged puck fly away

Now place charge (B) 1 cm away from charged puck (A).
Compared to previous situation force on A will be:

a. half as large, b. same size, c. twice as large, d. four times larger
e. something else.

Place charge (B) 1cm away from charged puck (A) as in previous Q.
Add a second charge to B, right on top of first.
Compared to previous question, force on A is:

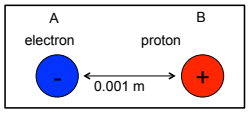
a. ½, b. same, c. x 2, d. x 4, e. something else.



What is force between them?
Calculate and write down answer.

$Force_{of\ B\ on\ A} = \frac{kq_Aq_B}{r^2}$

k is Coulomb constant = 8.99 x 10^9 N m^2/C^2
e = 1.6 x 10^{-19}C



What is force between them?
Calculate and write down answer.

$Force_{of\ B\ on\ A} = \frac{kq_Aq_B}{r^2}$

Force between particles = -2.3 x 10^{-22} N

What does the minus sign mean?

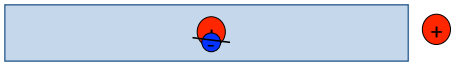
a) Force on electron points to left
b) Force on electron points to right

Summary of electrical materials:

In a conductor (think: metal), free electrons can move around
electrons are **not attached** to single atoms

Summary of electrical materials:

In an insulator, electrons remain bound to atoms

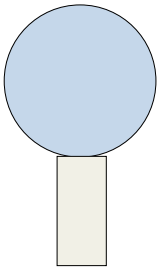


Static Electricity Experiments

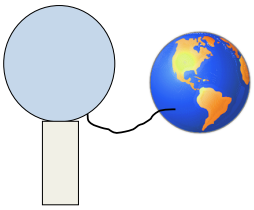
Think like an electron!!

Here is the van de Graaff machine. Its purpose is to put a lot of negative charge on the *conducting* sphere. Where does all the charge go?

a) To the middle of the sphere
b) All around the surface of the sphere
c) To the top of the sphere
d) To the bottom of the sphere
e) Somewhere else

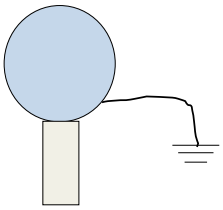


What is electrical ground?



- A grounded object is connected by a wire to the earth
- The earth is like a big reservoir for supplying or receiving excess + and – charges
- So big that it can gain or lose a few charges and always remain essentially neutral
- Wire provides an easy path for charges to/from the earth
- Grounded object is always at zero volts

What is electrical ground?



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Pom-pom demo

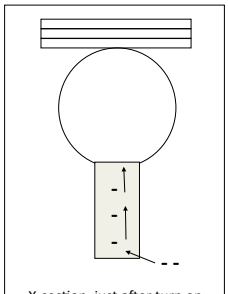
Attach Pom-pom to top of VdG and turn on.
What will happen?

a) Nothing
b) Sparks will fly from pom-pom
c) Nasty smell of burning pom-pom will develop
d) Pom-pom strands will stand on end and repel each other

Demo of pie plates stacked on Vandegraaff.

Turn on VG ⇒ put lots of extra electrons on sphere. What will happen to the plates?

a. Nothing, will stay there.
b. All will fly off at same time and stick together.
c. Top one will fly off, then next to top then next etc.
d. All will fly off at same time and separate.

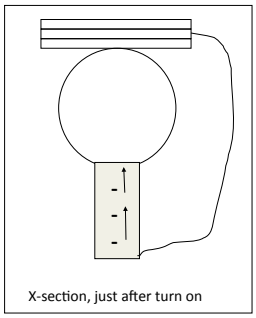


X-section, just after turn on

Now hook up wire to middle plate.

Turn on VG, what happens to the plates?

a. Nothing, will all stay there.
b. Top one will fly off, then next to top then next etc.
c. Only ones above where wire is hooked will fly off.
d. All above wired plate will all fly off at same time .
e. Something else



X-section, just after turn on

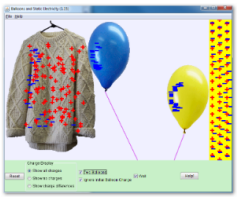
Balloon demo: Rub a balloon on sweater and stick it to the wall. What attracts the balloon to the wall?

After I have rubbed the balloon on my sweater, predict what charges will be on the balloon and on sweater

a. Both have extra + charges.
b. Both have extra - charges
c. Balloon has extra + or - charges, sweater neutral,
d. Sweater has extra + or - charges, balloon neutral
e. Either sweater has extra - and balloon extra + or balloon extra – and sweater extra +.

Look at Phet and find out……..

Balloon Sim



http://phet.colorado.edu/en/simulation/balloons

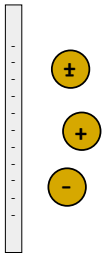
Rub a second balloon on the sweater.
The two balloons will ..

a. attract, b. repel, c. not exert a force on each other

Move charged balloon close to wall. What will happen?

a. Wall is neutral (no extra + or -) so will not be affected.
b. - charges in wall will move away, + towards balloon
c. + charges in wall will move away, - towards balloon.
d. - charges in wall will move away, + don't move.

Electrostatic dust rag (think Swiffer™).
Rub it on surface, it's very good at attracting electrons and so becomes negatively charged.



What kind of dust will this negatively charged rag pick up best?

a. Only dust with positive charges.
b. Only dust with negative charges.
c. The rag will pick up all dust equally.
d. The rag will pick up dust with positive charges, and also neutral dust particles, just not as well.
e. The rag will pick up dust with negative charges, and also neutral dust particles, just not as well.

Bring uncharged metalized mylar balloon up to Van de Graaff.

Predict what will happen:

1. Before it touches
2. After it touches

1. Before touching
   a. Not affected by VdG
   b. Attracted to it
   c. Repelled

2. After touching
   a. Not affected by VdG
   b. Attracted to it
   c. Repelled