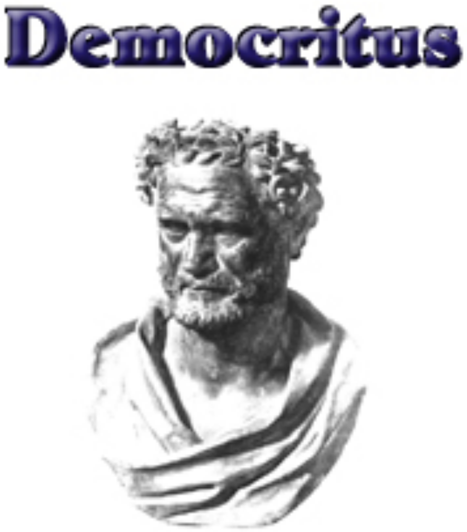
HISTORY OF ATOMIC STRUCTURE

The search for the atom began as a philosophical question. The natural philosophers of ancient Greece began the search for the atom by asking such questions as: What is stuff composed of?
What is the structure of material objects?
Is there a basic unit from which all objects are made?

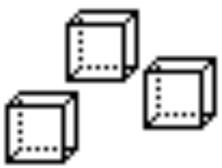
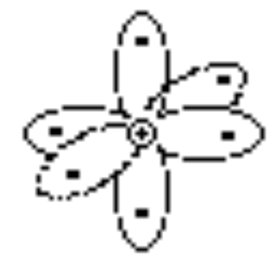
As early as 400 B.C., some Greek philosophers proposed that matter is made of indivisible building blocks known as *atomos*.



Atomos in Greek means indivisible.
To the early Greeks, matter could not be continuously broken down and divided indefinitely. This indivisible building block of which all matter was composed became known as the atom.

From the 1600s to the present century, the search for the atom became an experimental pursuit. Several scientists are notable; among them are Robert Boyle, John Dalton, J.J. Thomson, Ernest Rutherford, and Neils Bohr.

Our Changing View of the Atom

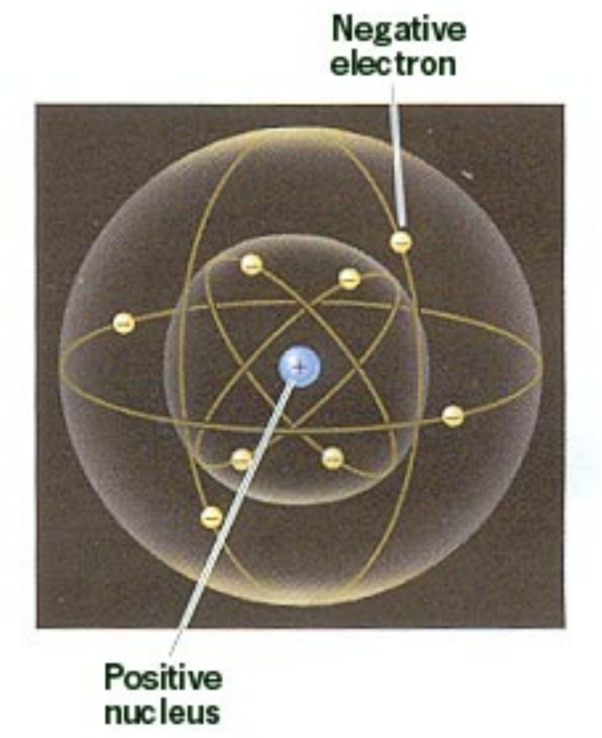
"Atomos" are the building blocks of matter.	Negative electrons are embedded in a sea of positive charge.	Positive charge is located within a central nucleus.	Electrons are in circular orbits with quantized energy levels.	Electrons occupy regions of space whose shape is described by complex mathematical equations.
				
Early Greek Philosophers	J.J. Thomson	Ernest Rutherford	Neils Bohr	Quantum Mechanics
400 B.C.	1898 – 1903	1911	1913	Modern Model

The conclusions regarding atomic structure are:

All material objects are composed of atoms.
There are different kinds of atoms known as elements; these elements can combine to form compounds.

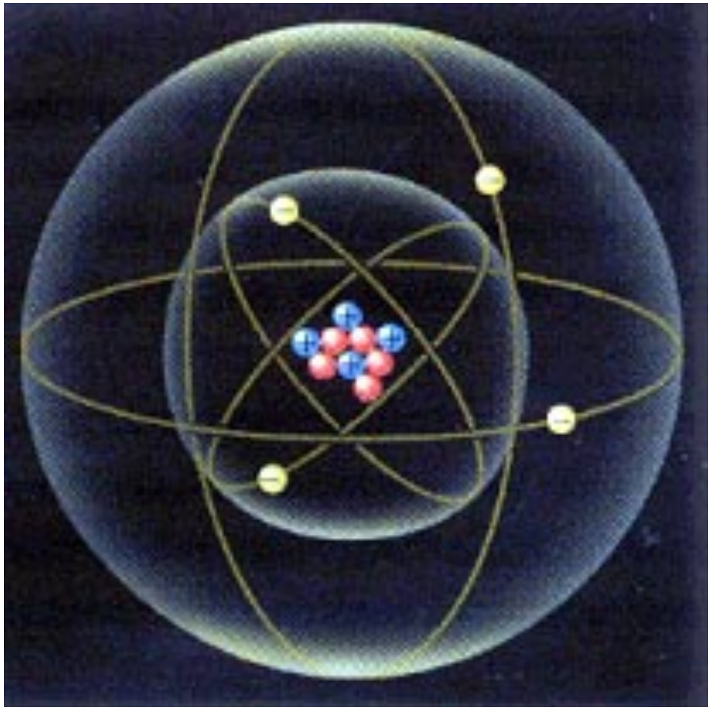
Different compounds have distinctly different properties.
Material objects are composed of atoms and molecules of these elements and compounds, thus providing different materials with different electrical properties.

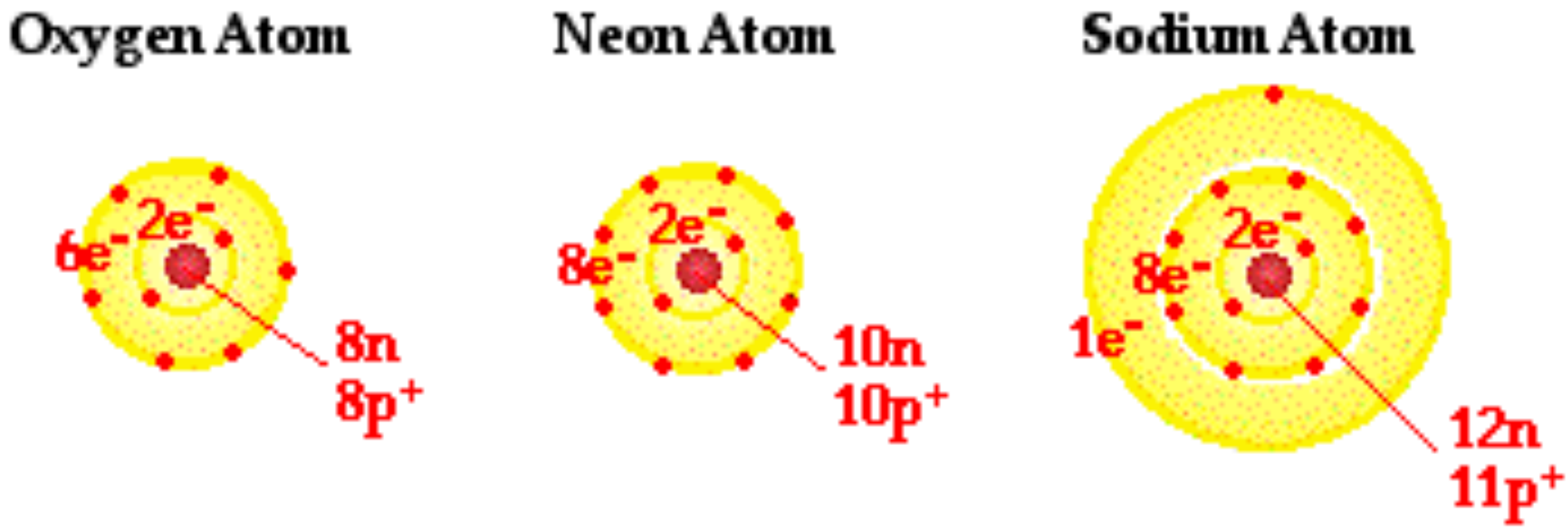
An atom consists of a nucleus and a vast region of space outside the nucleus.
Electrons are present in the region of space outside the nucleus. They are negatively charged and weakly bound to the atom.
Electrons are often removed from and added to an atom by normal everyday occurrences.



The nucleus of the atom contains positively charged protons and neutral neutrons.

These protons and neutrons are not removable by usual everyday methods. It would require some form of high-energy nuclear occurrence to disturb the nucleus and subsequently dislodge its positively-charged protons.





Atoms are composed of protons and neutrons located in the nucleus and electrons which are positioned in the surrounding regions of space known as electron shells.

ELECTRIC CHARGE

Electric charge, like mass, is one of the basic properties of certain of the elementary particles of which all matter is composed.
There are two kinds of electrical charges, *positive* (+) and *negative* (-).

Benjamin Franklin named the charges (+) and (-).

An electrically neutral object is an object that has a balance of protons and electrons.
In contrast, a charged object has an imbalance of protons and electrons.

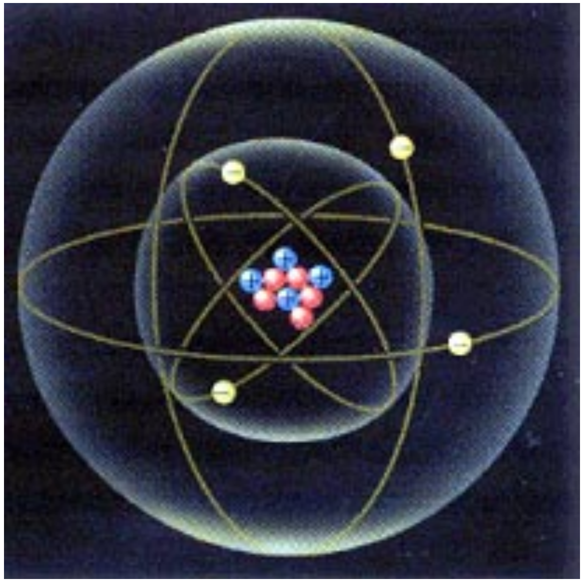
Positively-Charged	Negatively-Charged	Uncharged
Possesses more protons than electrons	Possesses more electrons than protons	Equal numbers of protons and electrons

The unit of charge is the *coulomb* (C).

$1\ C = 6.25 \times 10^{18}$ electrons or protons

The charge carried by the *electron* is represented by the symbol $-q$, and the charge carried by the *proton* is $+q$. A third particle, which carries no electrical charge, is the *neutron*.

$$q = 1.6 \times 10^{-19}\ C$$



10.1 An object has - 1 C of charge. Calculate the number of electrons it contains.

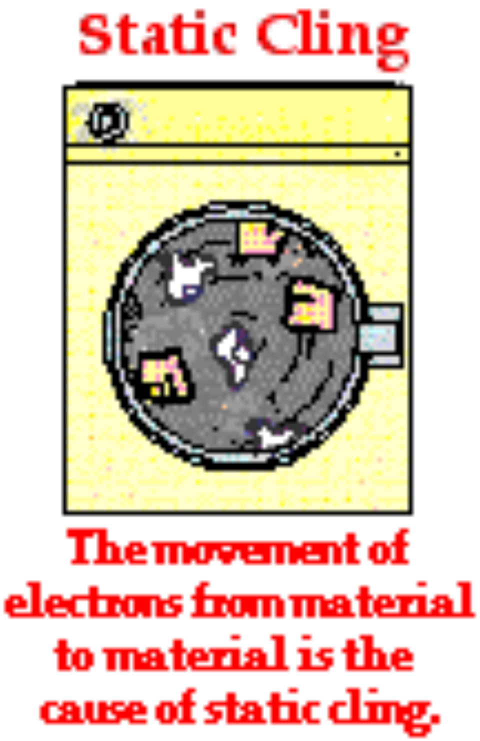
q = *1 C*

1 electron = 1.6×10^{-19} C

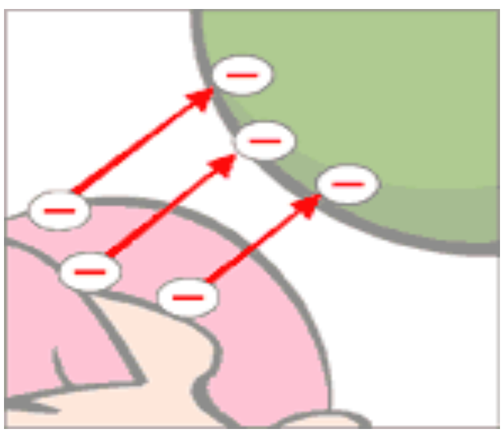
$$\left(\frac{1 \text{ electron}}{1.6\text{x}10^{-19} \text{ C}}\right)\left(\frac{1\text{C}}{}\right) = 6.25\text{x}10^{18} \text{ electrons}$$

ELECTROSTATICS:

The study of the behavior of stationary charges

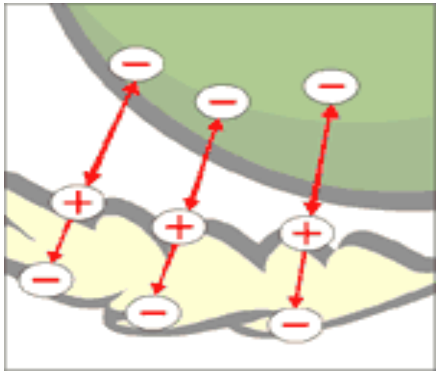


Rub a balloon on a wool sweater or on your hair.



When you rub the balloon, negative electrical charges, or electrons, pass from your hair to the balloon.

Now move the balloon close to some bits of paper.



As you can see, the balloon's electrons repel the papers' electrons and attract their positive charges.

ELECTRIC CHARGE

Rubbing certain electrically neutral objects together (e.g., a glass rod and a silk cloth) tends to cause the electric charges to separate.

In the case of the glass and silk, the glass rod loses negative charge and becomes positively charged while the silk cloth gains negative charge and therefore becomes negatively charged.

After separation, the negative charges and positive charges are found to attract one another.

Add this to your notes:

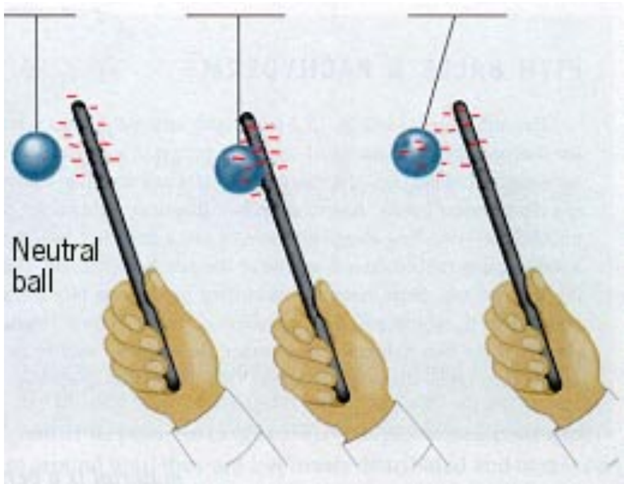
Natural fibers tend to lose electrons (become POSITIVE)
Examples: Wool sweaters, hair, animal fur, silk

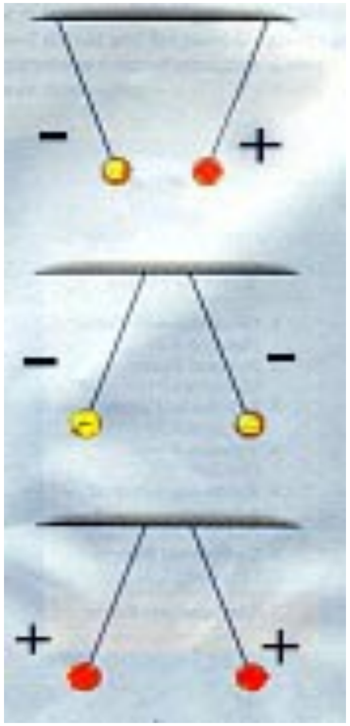
Synthetic materials tend to gain electrons (become NEGATIVE)
Examples: Polyester, plastic wrap, silicon, vinyl

Some materials tend to stay neutral.
Examples: Cotton, paper, wood

Demonstration:
Determining charge and charging objects.

If the glass rod is suspended from a string and a second positively charged glass rod is brought near, a force of electrical repulsion results. Negatively charged objects also exert a repulsive force on one another.



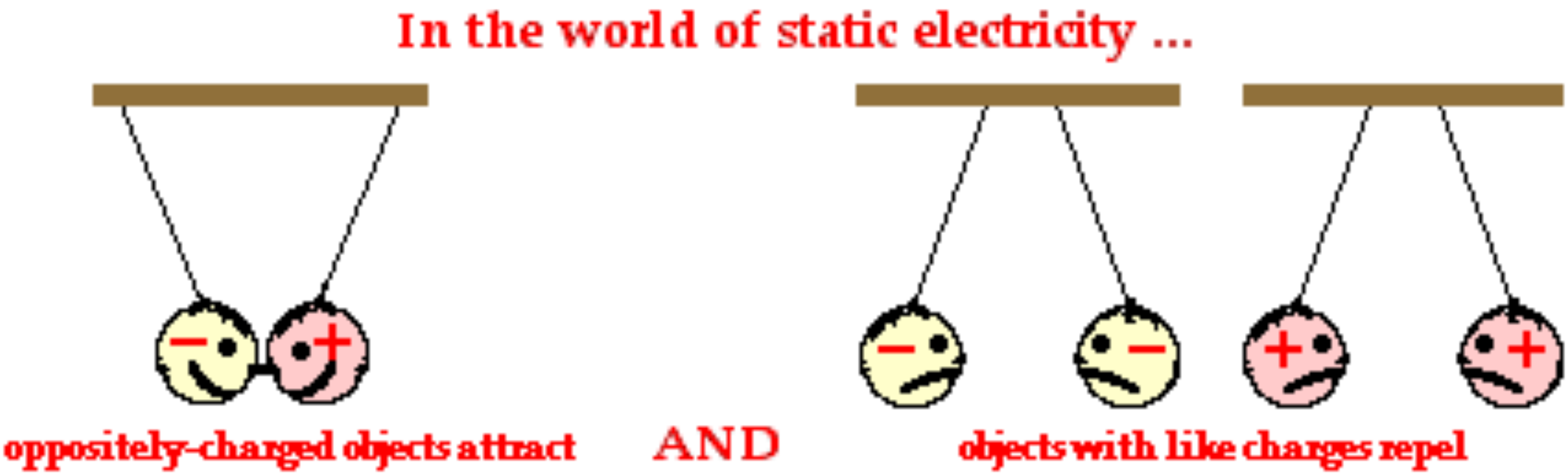


These results can be summarized as follows: ***unlike charges attract and like charges repel***

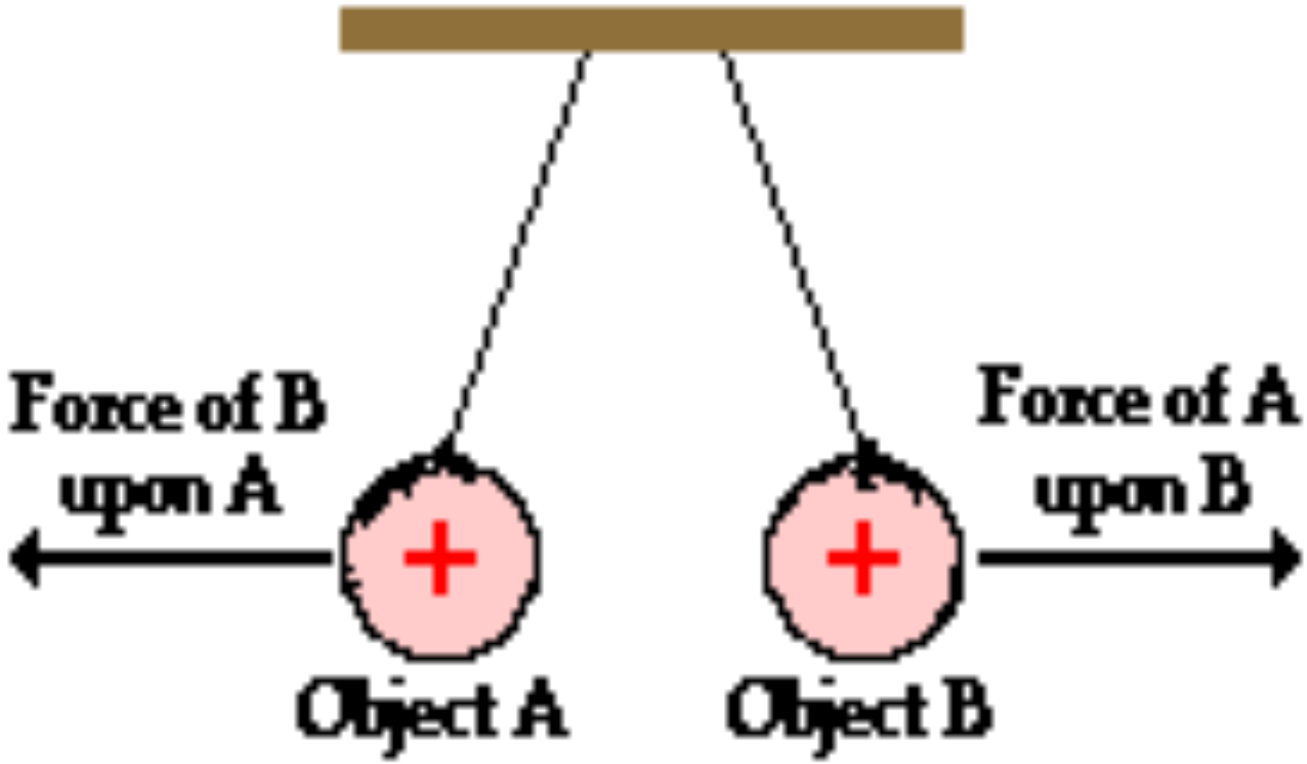
CHARGE INTERACTIONS

Any charged object can exert an electric force upon other objects - both charged and uncharged objects. Electric forces are forces-at-a-distance.

Like charges repel and unlike charges attract

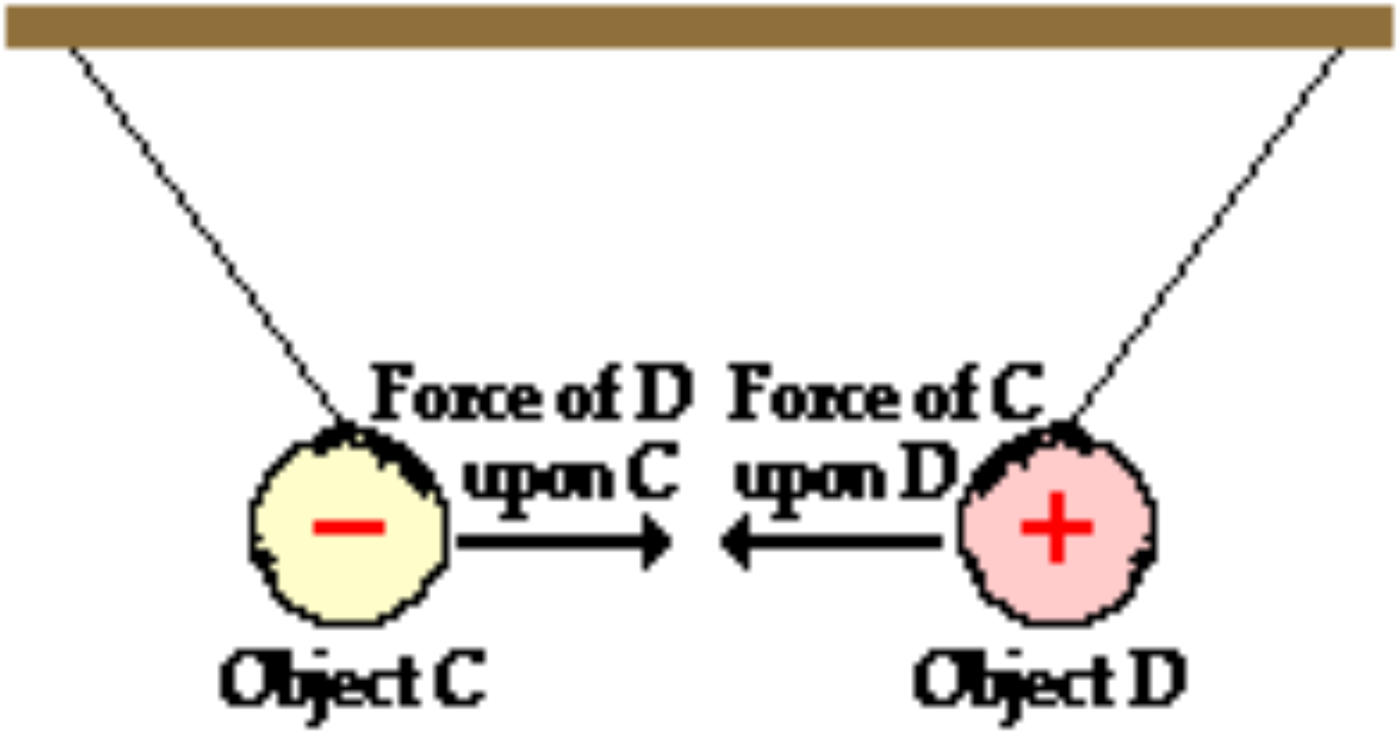


Like Charges Repel



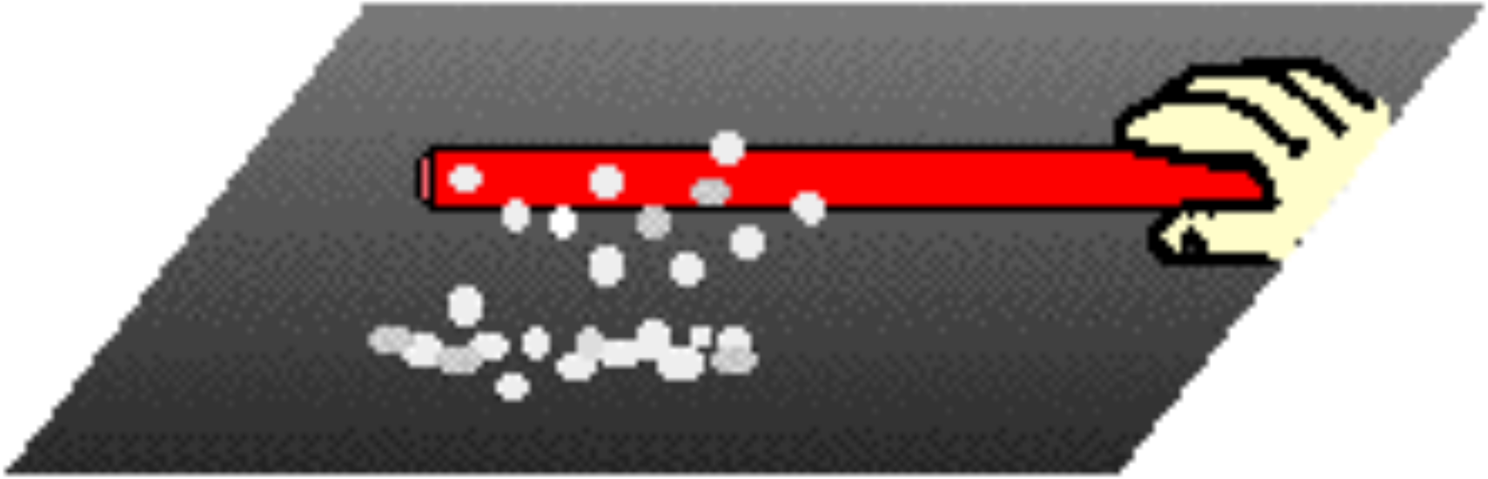
Repulsive forces act between like-charged objects, pushing them away from each other.

Opposite Charges Attract



Attractive forces act between opposite charged, pulling them towards each other.

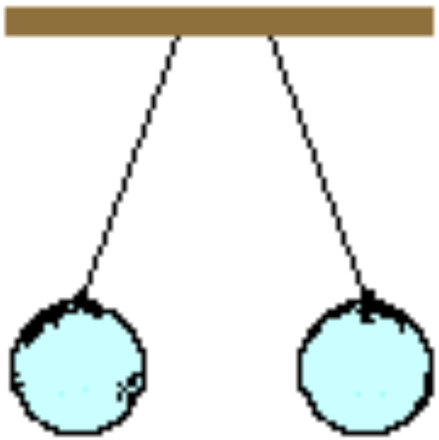
Charged and Neutral Objects Attract



A plastic golf tube charged by rubbing with animal fur will attract neutral paper bits.

Case I.

Repulsive Interactions



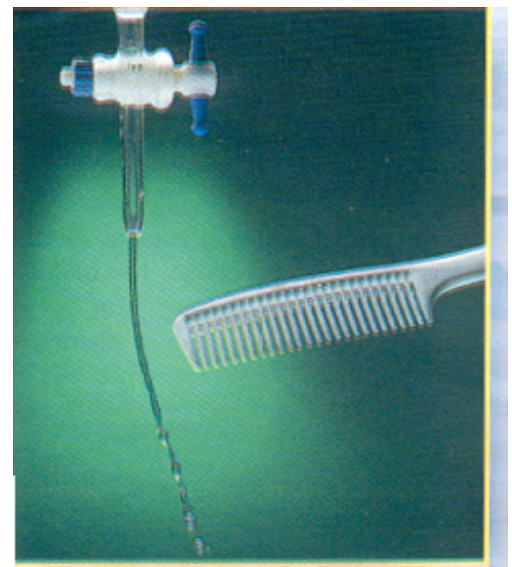
Repulsive interactions provide convincing evidence that both objects must be charged.

Case II.

Attractive Interactions

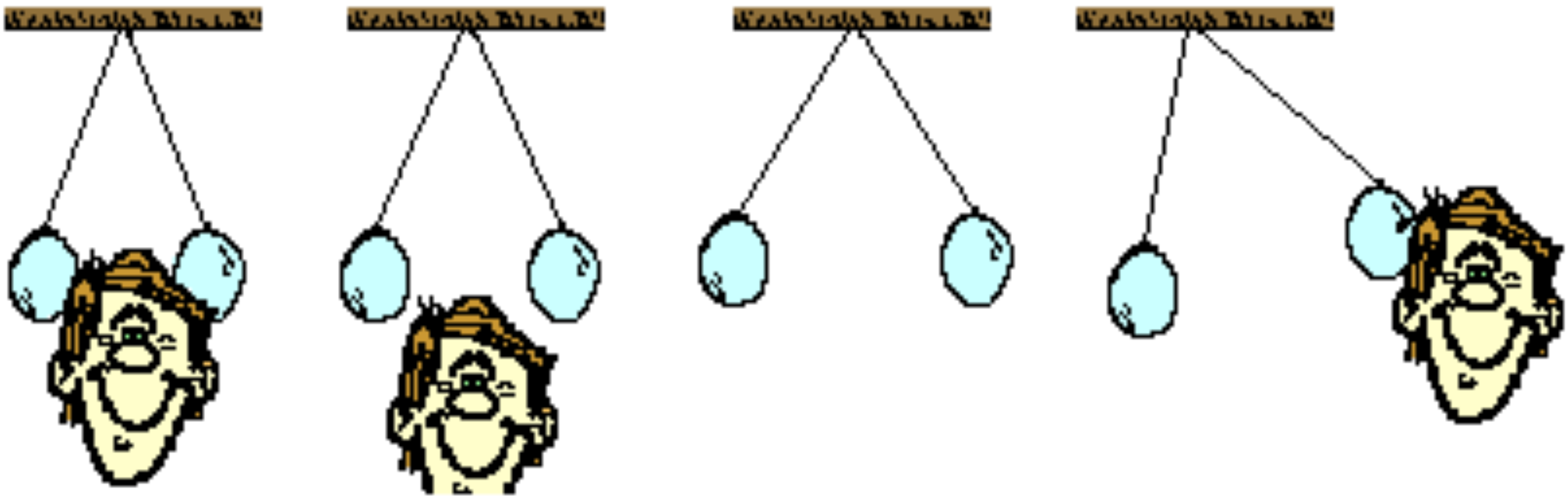
Attractive interactions can lead one to conclude that at least one of the objects is charged.

Any charged object - whether positively-charged or negatively-charged - will have an attractive interaction with a neutral object. Positively-charged objects and neutral objects attract each other; and negatively-charged objects and neutral objects attract each other.



Charged comb attracts neutral bits of paper.

Charged comb attracts neutral water molecules.



Two balloons rubbed on human hair will become negatively-charged and have an attractive interaction with the hair. If the hair is removed, the balloons repel.

PreAP Physics Thursday, February 16

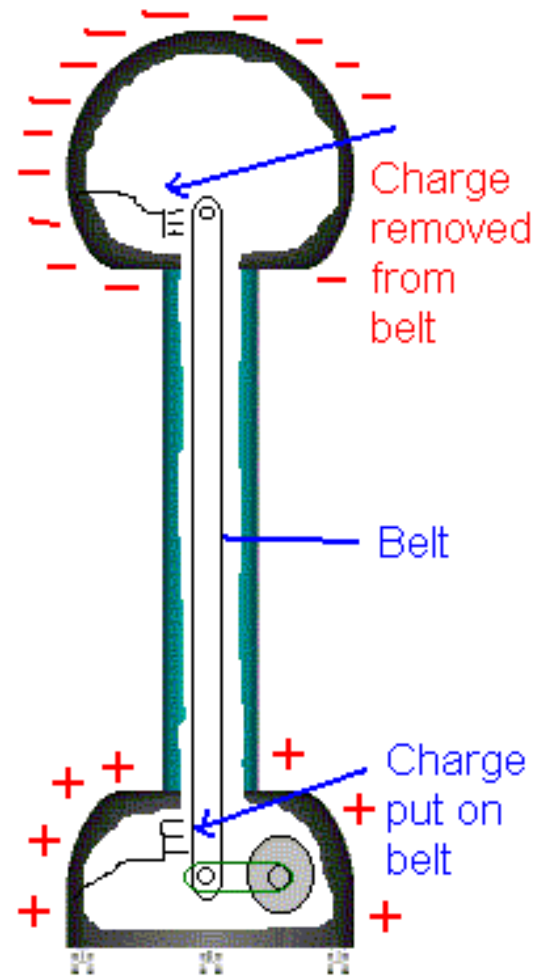
LAST CALL for green tickets!

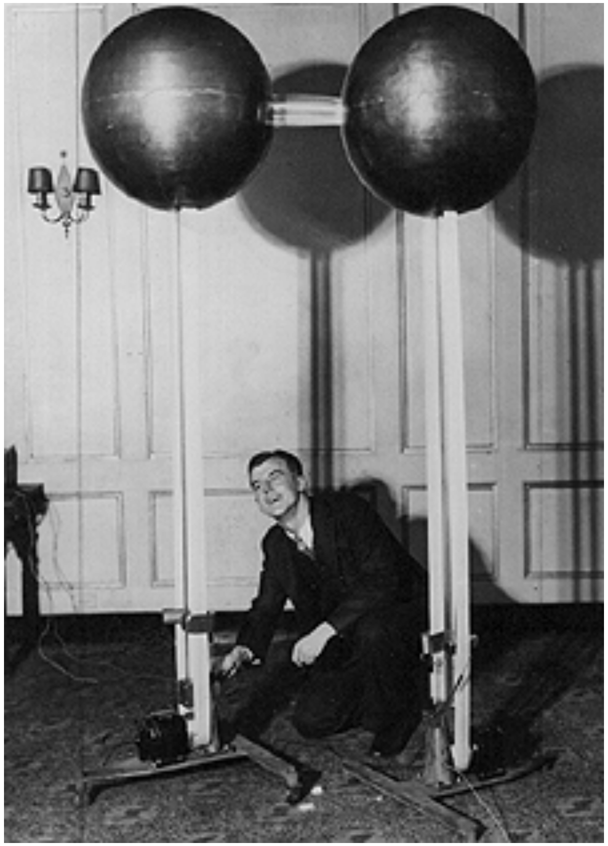
Pick up the lab sheet
from the side table.

Copy this diagram
onto the back.

Title it
"The Van de Graaf Generator"

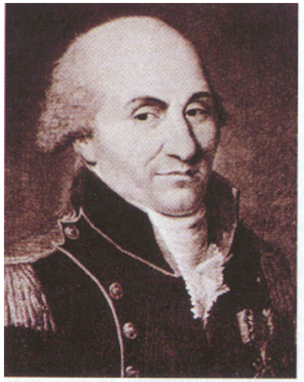
Great detail is NOT
necessary.





Robert Van de Graaf
United States - Physicist
December 20, 1901 – January 16, 1967

COULOMB' S LAW



Coulomb's Law **states that two point charges exert a force (*F*) on one another that is directly proportional to the product of the magnitudes of the charges (*q*) and inversely proportional to the square of the distance (*r*) between their centers. The equation is:**

$$F = \frac{kq_1q_2}{r^2}$$

F* = *electrostatic force (N)
q* = *charge (C)
k* = $9x10^9$ *N. m²/C²
r* = *separation between charges (m)

10.6 A plastic ball has a charge of +10 nC. How many electrons does it have?

$q = 10\text{x}10^{-9}$ C

1 electron = $1.6\text{x}10^{-19}$ C

$$\left(\frac{1 \text{ electron}}{1.6\text{x}10^{-19} \text{ C}}\right)\left(\frac{10\text{x}10^{-9} \text{ C}}{}\right) = 6.25\text{x}10^{10} \text{ electrons}$$

10.7 What is the magnitude and direction of the force on a charge of +4 nC that is 5 cm from a charge of +50 nC?

$q_1 = +\ 4x10^{-9}$ C
$q_2 = +\ 50\ x10^{-9}$ C
$r = .05$ m

$$F = \frac{kq_1q_2}{r^2} = \frac{9x10^9(4x10^{-9})(50x10^{-9})}{(0.05)^2}$$

= $7.2x10^{-4}$ N, repulsive (away from each other)

10.8 **Two charges, one of +5 x10^{-7} C and the other of -2 x10^{-7} C attract each other with a force of 100 N. How far apart are they?**

q_1 = +5 x10^{-7} C
q_2 = -2 x10^{-7} C
F = 100 N

$$F = \frac{kq_1q_2}{r^2}$$

$$Fr^2 = kq_1q_2 \qquad r^2 = \frac{kq_1q_2}{F}$$

$$r = \sqrt{\frac{kq_1q_2}{F}} = \sqrt{\frac{9x10^9(5x10^{-7})(2x10^{-7})}{(100)}} = 3x10^{-3}\ \text{m}$$

10.9 Consider two charged objects. One carries a charge of 18 μC. When the two are separated by a distance of 0.9 m, there is a force of 2.7 N between them. What is the charge on the second object?

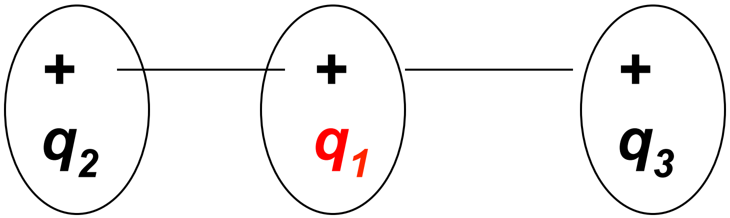
$q_1 = 18x10^{-6}$ C
$r = 0.9$ m
$F = 2.7$ N

$$F = \frac{kq_1q_2}{r^2}$$

$$Fr^2 = kq_1q_2$$

$$q_2 = \frac{Fr^2}{kq_1} = \frac{2.7(0.9)^2}{9x10^9(18x10^{-6})} = 1.35x10^{-5}\ \text{C}$$

10.10 A charge q_1 of +1 μC is placed halfway between a charge q_2 of +5 μC and a charge q_3 of +3 μC that are 20 cm apart. Find the resultant force on the +1 μC charge. Draw a sketch:

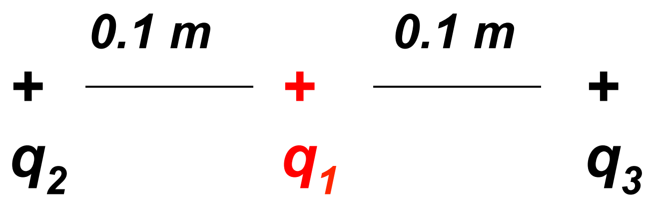


a. What are the interactions of the + 1 μC charge?

q_1 interacts with q_2

q_1 interacts with q_3

b. **Write down the data paying attention to the distances between the charges and the units!**



$q_1 = +1 \times 10^{-6}$ C

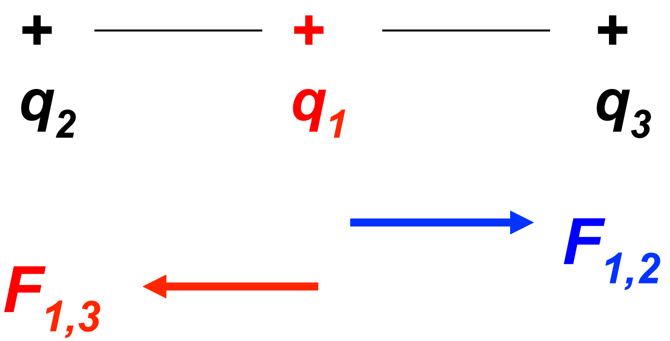
$q_2 = +5 \times 10^{-6}$ C

$q_3 = +3 \times 10^{-6}$ C

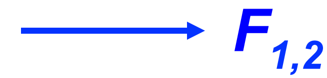
$r_{1,2} = 0.1$ m

$r_{1,3} = 0.1$ m

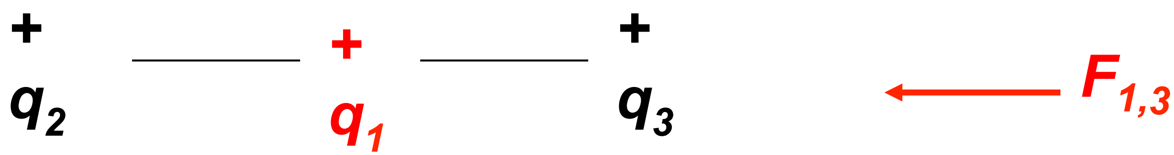
c. Draw the FBD of the interactions mentioned above. Clearly label the forces.



d. Calculate the forces.



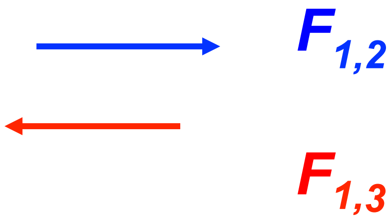
q_1 = +1 x10^{-6} C
q_2 = +5 x10^{-6} C
q_3 = +3 x10^{-6} C
$r_{1,2}$ = 0.1 m
$r_{1,3}$ = 0.1 m



$$F_{1,2} = \frac{kq_1q_2}{r^2} = \frac{9x10^9(1x10^{-6})(5x10^{-6})}{(0.1)^2} = \textbf{4.5 N}$$

$$F_{1,3} = \frac{kq_1q_3}{r^2} = \frac{9x10^9(1x10^{-6})(3x10^{-6})}{(0.1)^2} = \textbf{2.7 N}$$

e. Find the net force: magnitude and direction.

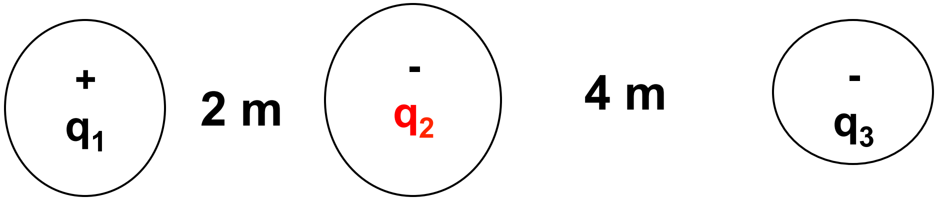


$$F_R = F_{1,2} - F_{1,3}$$

$$= 4.5 - 2.7$$

$$= 1.8 \text{ N, right}$$

10.11 **A + 4 μC charge lies 2 m to the left of a – 5 μC charge. A – 6 μC charge lies 4 m to its right. What is the resultant force on the center charge? Draw a sketch:**

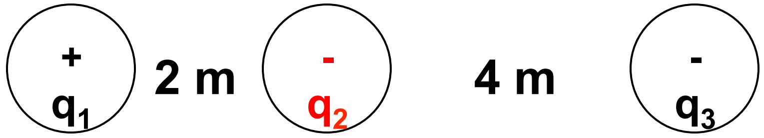


a. **What are the interactions of the - 5 μC charge?**

q_2 **interacts with** q_1

q_2 **interacts with** q_3

b. **Write down the data paying attention to the distances between the charges and the units!**



$q_1 = +\ 4\text{x}10^{-6}\ \text{C}$

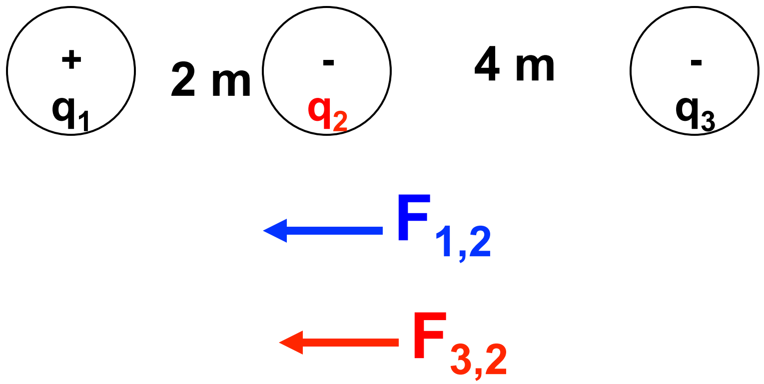
$q_2 = -\ 5\text{x}10^{-6}\ \text{C}$

$q_3 = -\ 6\text{x}10^{-6}\ \text{C}$

$r_{1,2} = 2\ \text{m}$

$r_{2,3} = 4\ \text{m}$

c. Draw the FBD of the interactions mentioned above. Clearly label the forces.



d. Calculate the forces.

q_1 = + 4x10^{-6} C
q_2= - 5x10^{-6} C
q_3 = - 6x10^{-6} C
$r_{1,2}$ = 2 m
$r_{2,3}$ = 4 m

← $F_{1,2}$

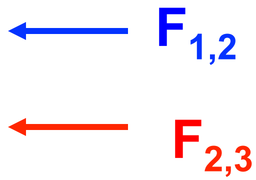
← $F_{2,3}$

$$F = \frac{kqq}{r^2}$$

$$F_{1,2} = \frac{9x10^9(4x10^{-6})(5x10^{-6})}{(2)^2} = \mathbf{0.045\ N}$$

$$F_{2,3} = \frac{9x10^9(5x10^{-6})(6x10^{-6})}{(4)^2} = \mathbf{0.0168\ N}$$

e. Find the net force: magnitude and direction.



$$F_R = F_{1,2} + F_{2,3}$$

$$= 0.045 + 0.0168 = 6.18\times10^{-2}\ \text{N, left}$$

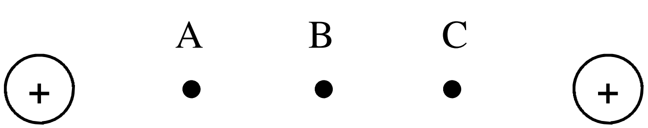
PreAP Physics Wednesday, February 22

Homework set 31: Due Friday at end of class

Quiz tomorrow: Everything through Coulomb's Law

UT HW 5-1 will be available Friday. Due Wednesday.

Warmup:



8. Use the diagram at the left to answer which way a charge move in the following situations: L, R, or S (stays).

A. _____ If a positive charge is put at A?
B. _____ If a negative charge is put at C?
C. _____ If a negative charge is put at B?
D. _____ If a positive charge is put at C?

E. _____ If a 3.4μC charge is put at B?
F. _____ If a 8nC charge is put at A?
G. _____ If a –4.2C charge is put at C?
H. _____ If a –3.9μC charge is put at B?

Three charges lie along the x-axis. One positive charge, $Q1$ = 15 microcoulombs, is at $x=2.0$ m, and another positive charge, $q2=6.0$ microcoulombs, is at the origin. At what point on the x-axis must a negative charge, $q3$, be placed so that the resultant force on it is zero?

A metal sphere has a charge of –4C. It is touched to another metal sphere that is neutral to begin with.

A. Are the spheres conductors or insulators?

B. Will they allow electrons to flow?

C. Will the electrons attract or repel each other?

D. Will the electrons want to stay together or spread apart as far as possible?

E. What will be the charge of the right sphere afterwards?