Electrostatics

Honors Physics

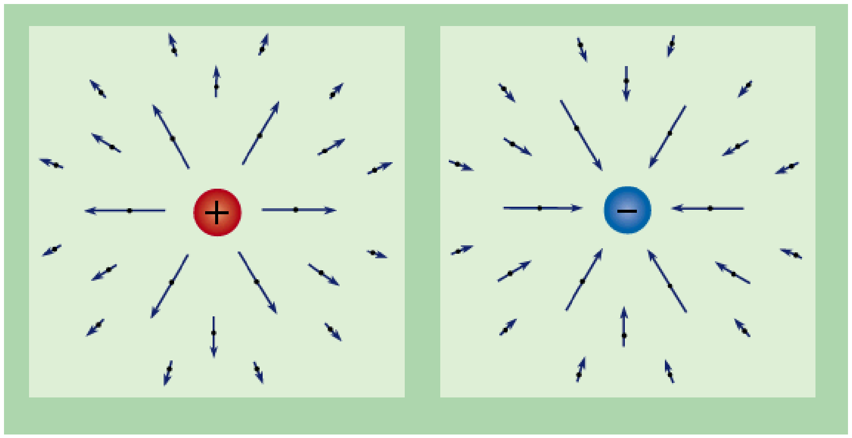
Electric Charge

"Charge" is a property of subatomic particles.

Facts about charge:

- There are 2 types basically, positive (protons) and negative (electrons)
- LIKE charges REPEL and OPPOSITE charges ATTRACT
- Charges are symbolic of fluids in that they can be in 2 states, STATIC or DYNAMIC.

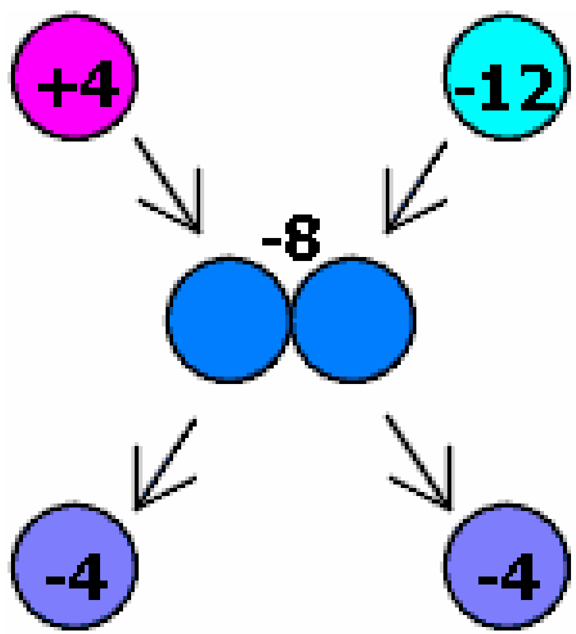
Electric Charge – The specifics



•The symbol for CHARGE is “q”
•The unit is the COULOMB(C), named after Charles Coulomb
•If we are talking about a SINGLE charged particle such as 1 electron or 1 proton we are referring to an ELEMENTARY charge and often use, ***e*** , to symbolize this.

Particle	Charge	Mass
Proton	$1.6x10^{-19}$ C	$1.67\ x10^{-27}$ kg
Electron	$1.6x10^{-19}$ C	$9.11\ x10^{-31}$ kg
Neutron	0	$1.67\ x10^{-27}$ kg

Charge is "CONSERVED"



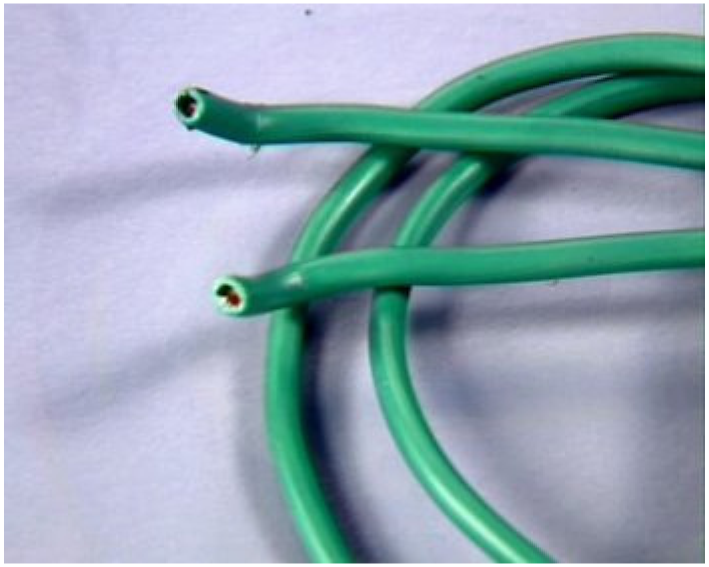
Charge cannot be created or destroyed only transferred from one object to another. Even though these 2 charges attract initially, they repel after touching. Notice the NET charge stays the same.

Conductors and Insulators

The movement of charge is limited by the substance the charge is trying to pass through. There are generally 2 types of substances.

Conductors: Allow charge to move readily though it.

Insulators: Restrict the movement of the charge



Conductor = Copper Wire
Insulator = Plastic sheath

Charging and Discharging

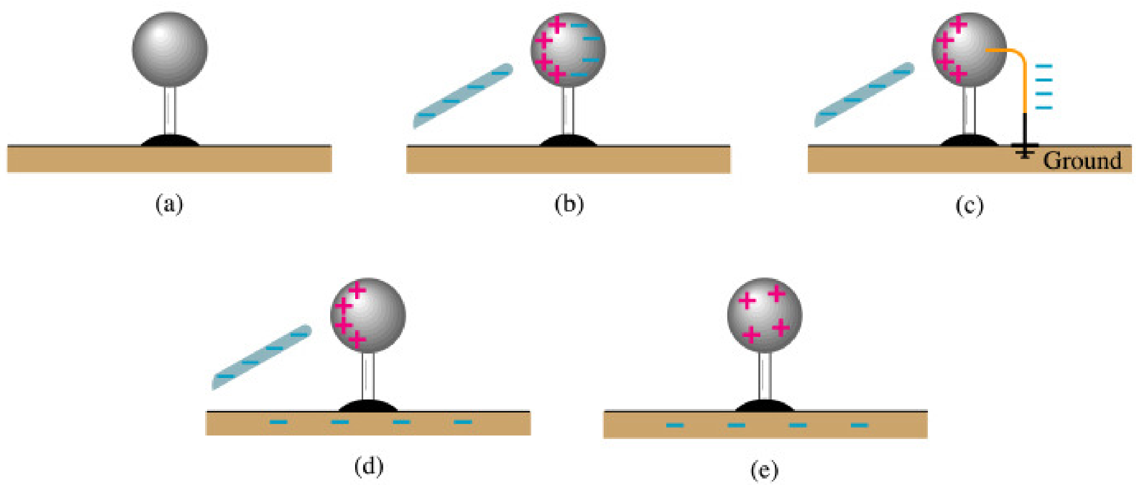
There are basically 2 ways you can charge something.

1. **Charge by friction**
2. Induction

"BIONIC is the first-ever ionic formula mascara. The primary ingredient in BIONIC is a chain molecule with a positive charge. The friction caused by sweeping the mascara brush across lashes causes a negative charge. Since opposites attract, the positively charged formula adheres to the negatively charged lashes for a dramatic effect that lasts all day."

Induction and Grounding

The second way to charge something is via INDUCTION, which requires NO PHYSICAL CONTACT.

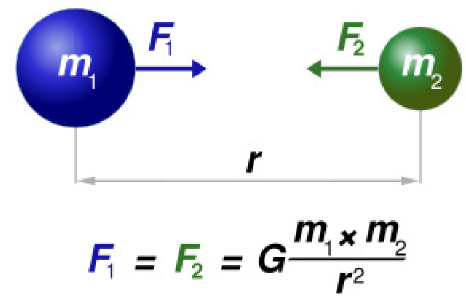


We bring a negatively charged rod near a neutral sphere. The protons in the sphere localize near the rod, while the electrons are repelled to the other side of the sphere. A wire can then be brought in contact with the negative side and allowed to touch the GROUND. The electrons will always move towards a more massive objects to increase separation from other electrons, leaving a NET positive sphere behind.

Electric Force

The electric force between 2 objects is symbolic of the gravitational force between 2 objects. RECALL:

$$F_g \,\alpha\, Mm \qquad F_g \,\alpha\, \frac{1}{r^2}$$

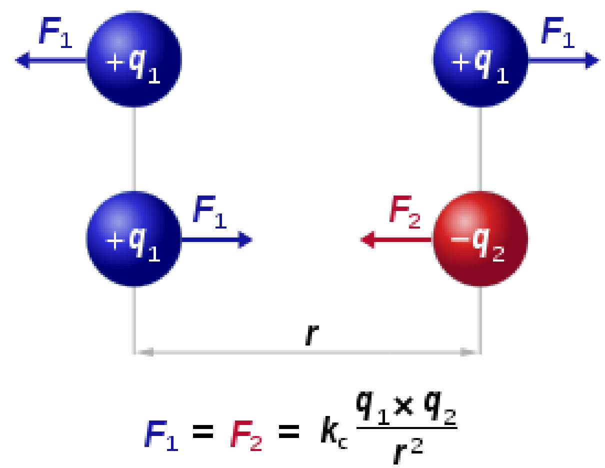


$$F_E \,\alpha\, q_1 q_2 \qquad F_E \,\alpha\, \frac{1}{r^2} \qquad F_E \,\alpha\, \frac{q_1 q_2}{r^2}$$

$k = \text{constant of proportionality}$

$$k = \text{Coulomb constant} = 8.99 x 10^9 \, \frac{Nm^2}{C^2}$$

$$F_E = k\left|\frac{q_1 q_2}{r^2}\right| \rightarrow Coulomb's\ Law$$



Example

Calculate the separation distance between a 12C charge and a 6C charge is the electric force between them is 136.5 N

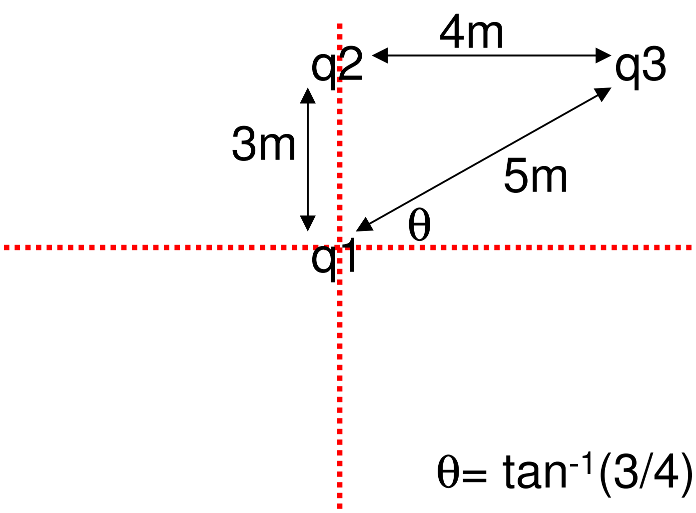
$$F_e = k\left|\frac{q_1 q_2}{r^2}\right| \rightarrow r = \sqrt{k\frac{q_1 q_2}{F_e}}$$

$$r = \sqrt{(8.99^9)\frac{(12)(6)}{(136.5)}} =$$ 68,900.31 m

What if you have MORE than 2 charges?

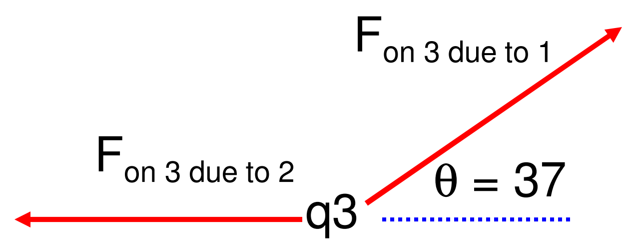
Electric Forces are vectors, thus all rules applying to vectors must be followed.

Consider three point charges, q_1 = 6.00 x10^{-9} C (located at the origin),q_3 = 5.00x10^{-9} C, and q_2 = -2.00x10^{-9} C, located at the corners of a RIGHT triangle. q_2 is located at y= 3 m while q_3 is located 4m to the right of q_2. Find the ***resultant*** force on q_3.

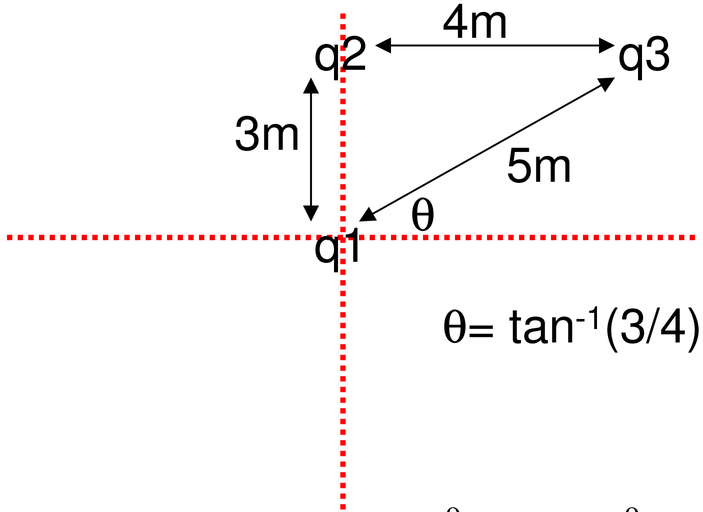


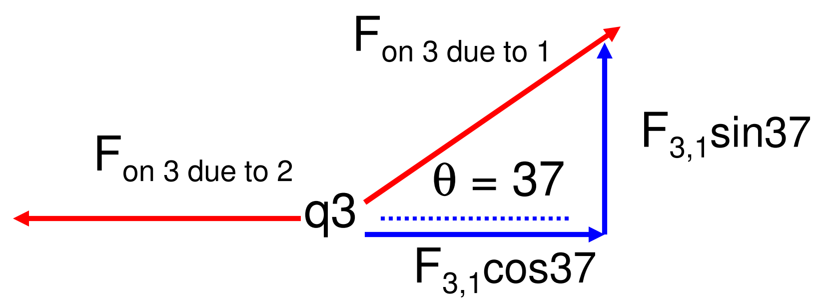
θ= $\tan^{-1}(3/4)$

Which way does q2 push q3?
Which way does q1 push q3?



Example Cont'





$$F_{3,2} = (8.99x10^9)\frac{(5.0x10^{-9})(2x10^{-9})}{4^2}$$

$F_{3,2} =$ **5.62 x10^{-9} N**

$$F_{3,1} = (8.99x10^9)\frac{(6x10^{-9})(5x10^{-9})}{5^2}$$

$F_{3,1} =$ **1.08x10^{-8} N**

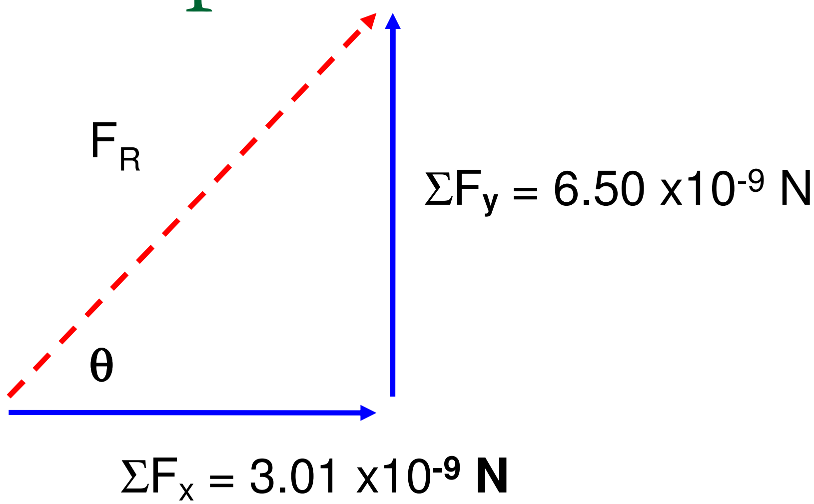
$F_{3,1}\cos 37 =$ **8.63 x10^{-9} N**

$F_{3,1}\sin 37 =$ **6.50 x10^{-8} N**

$\sum F_y = F_{3,1}\sin 37 =$ **6.50 x10^{-8} N**

$\sum F_x = 8.63x10^{-9} - 5.62x10^{-9} =$ 3.01 x 10^{-9} N

Example Cont'



$$F_R = \sqrt{(\sum F_x)^2 + (\sum F_y)^2} =$$ **7.16 x10^{-9} N**

$$\theta = \tan^{-1}\left(\frac{\sum F_y}{\sum F_x}\right) =$$ **65.2 degrees above the +x axis**