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# Electrostatics

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Honors Physics

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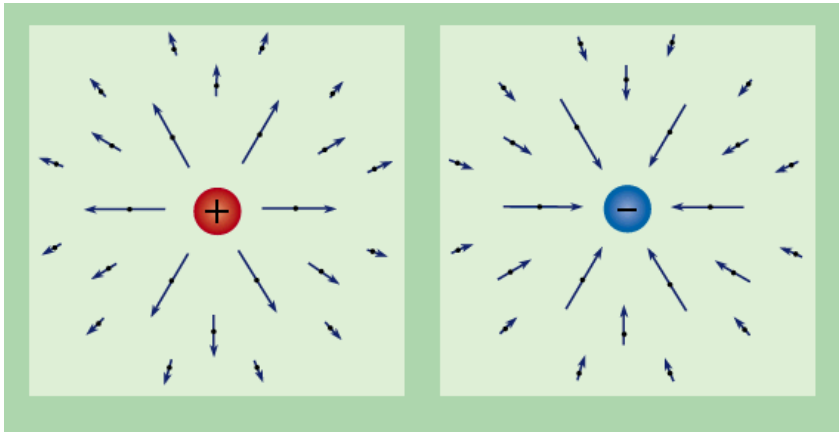
# Electric Charge

“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.
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# Electric Charge – The specifics

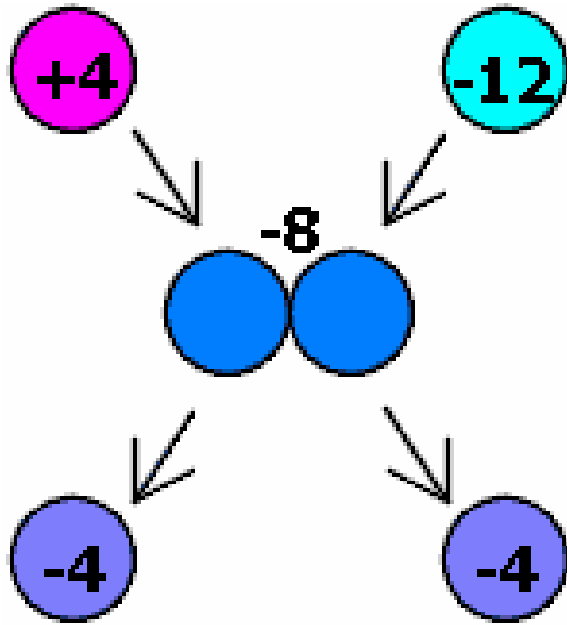


- The symbol for CHARGE is “q”
- The unit is the COULOMB(C), named after Charles Coulomb
- If we are talking about a SINGLE charged particle such as 1 electron or 1 proton we are referring to an ELEMENTARY charge and often use,  $e$  , to symbolize this.

Particle	Charge	Mass
Proton	$1.6 \times 10^{-19}$ C	$1.67 \times 10^{-27}$ kg
Electron	$1.6 \times 10^{-19}$ C	$9.11 \times 10^{-31}$ kg
Neutron	0	$1.67 \times 10^{-27}$ kg

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# 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.

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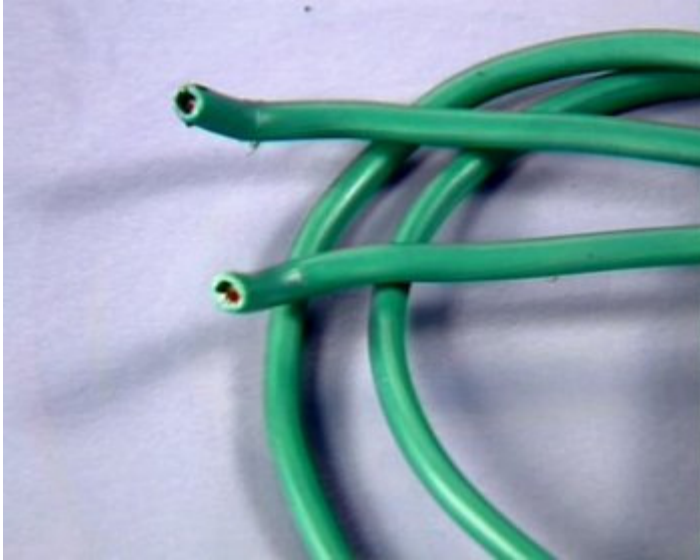
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# Conductors and Insulators

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 through it.

**Insulators:** Restrict the movement of the charge



Conductor = Copper Wire  
Insulator = Plastic sheath

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# Charging and Discharging

There are basically 2 ways you can charge something.

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

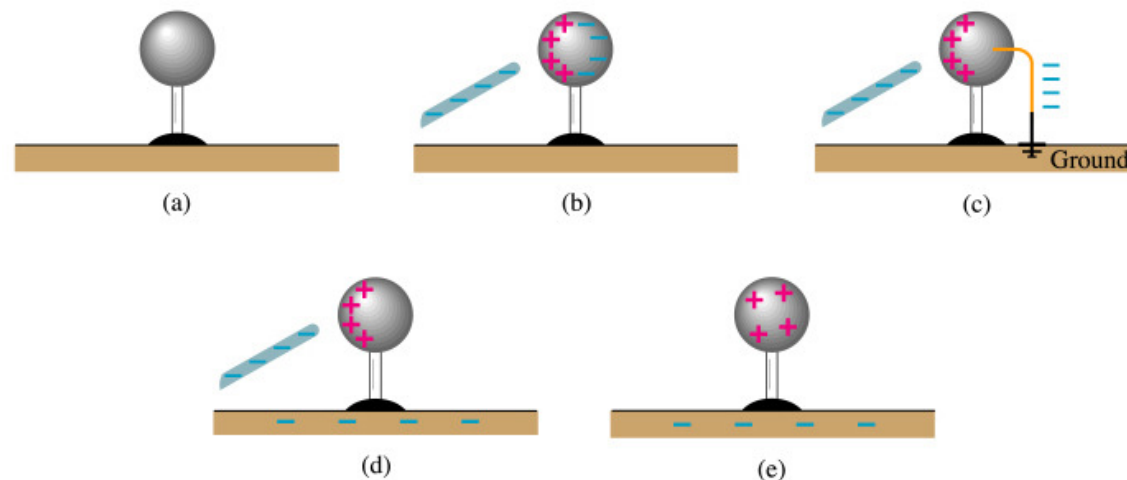


“BIONIC is the first-ever ionic formula mascara. The primary ingredient in BIONIC is a chain molecule with a positive charge. The friction caused by sweeping the mascara brush across lashes causes a negative charge. Since opposites attract, the positively charged formula adheres to the negatively charged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

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# Induction and Grounding

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



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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:

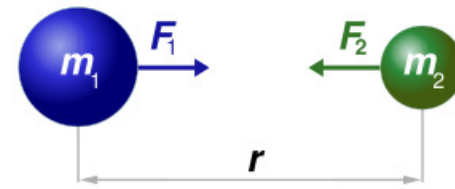
$$F_g \propto Mm \quad F_g \propto \frac{1}{r^2}$$

$$F_E \propto q_1q_2 \quad F_E \propto \frac{1}{r^2} \quad F_E \propto \frac{q_1q_2}{r^2}$$

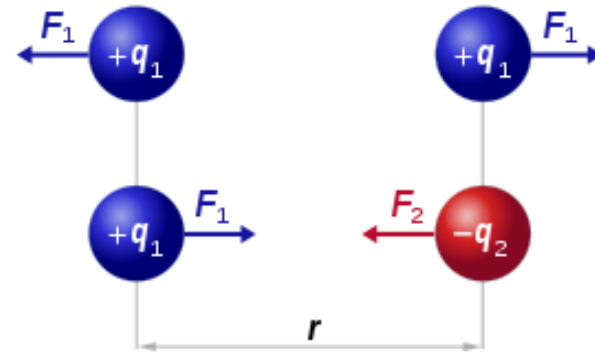
$k$  = constant of proportionality

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

$$F_E = k \left| \frac{q_1q_2}{r^2} \right| \rightarrow \text{Coulomb's Law}$$



$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$



$$F_1 = F_2 = k_c \frac{q_1 \times q_2}{r^2}$$

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# Example

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

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

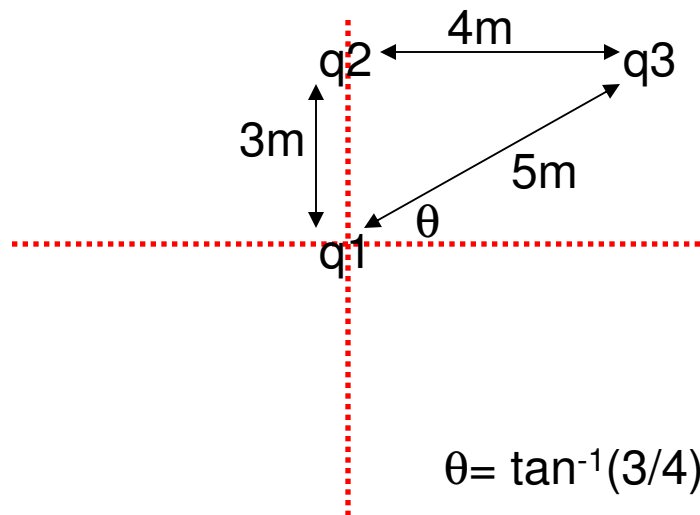
$$r = \sqrt{(8.99^9) \frac{(12)(6)}{(136.5)}} = 68,900.31 \text{ m}$$

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# What if you have MORE than 2 charges?

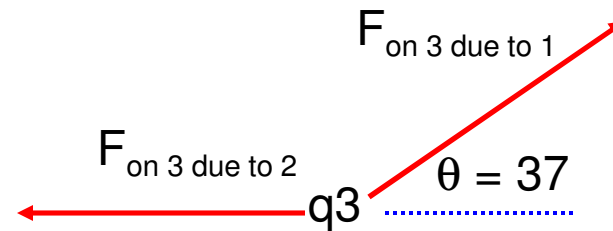
Electric Forces are vectors, thus all rules applying to vectors must be followed.

Consider three point charges,  $q_1 = 6.00 \times 10^{-9} \text{ C}$  (located at the origin),  $q_3 = 5.00 \times 10^{-9} \text{ C}$ , and  $q_2 = -2.00 \times 10^{-9} \text{ C}$ , located at the corners of a RIGHT triangle.  $q_2$  is located at  $y = 3 \text{ m}$  while  $q_3$  is located  $4 \text{ m}$  to the right of  $q_2$ . Find the **resultant** force on  $q_3$ .

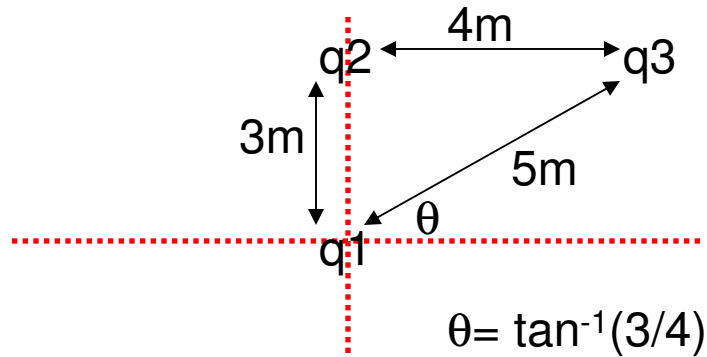


$$\theta = \tan^{-1}(3/4)$$

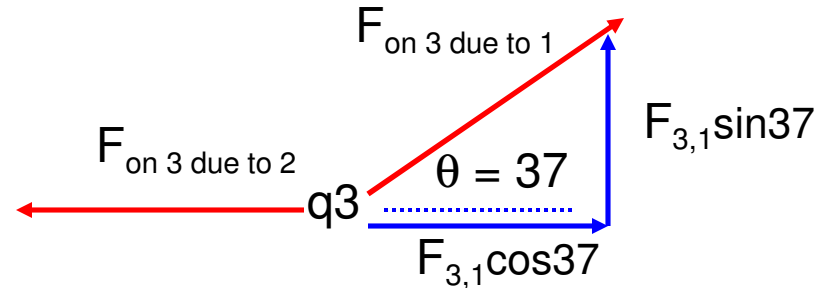
Which way does  $q_2$  push  $q_3$ ?  
Which way does  $q_1$  push  $q_3$ ?



# Example Cont'



$$\theta = \tan^{-1}(3/4)$$



$$F_{3,2} = (8.99 \times 10^9) \frac{(5.0 \times 10^{-9})(2 \times 10^{-9})}{4^2}$$

$$F_{3,2} = \mathbf{5.62 \times 10^{-9} \text{ N}}$$

$$F_{3,1} \cos 37 = \mathbf{8.63 \times 10^{-9} \text{ N}}$$

$$F_{3,1} \sin 37 = \mathbf{6.50 \times 10^{-8} \text{ N}}$$

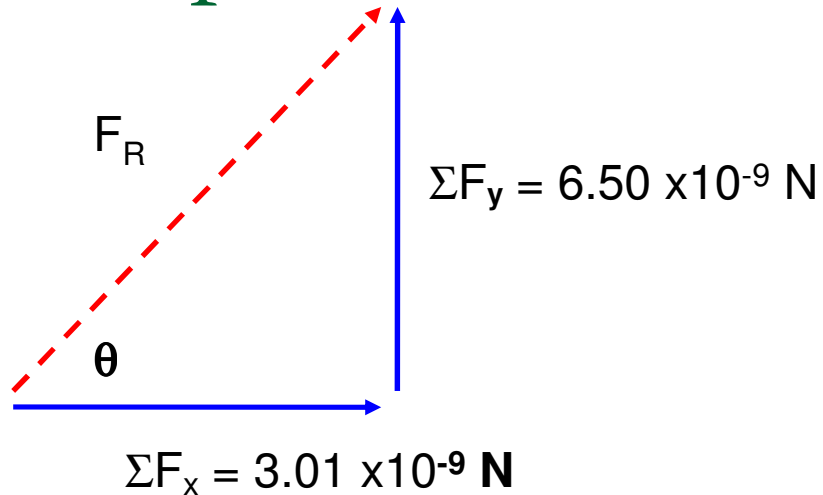
$$F_{3,1} = (8.99 \times 10^9) \frac{(6 \times 10^{-9})(5 \times 10^{-9})}{5^2}$$

$$F_{3,1} = \mathbf{1.08 \times 10^{-8} \text{ N}}$$

$$\sum F_y = F_{3,1} \sin 37 = \mathbf{6.50 \times 10^{-8} \text{ N}}$$

$$\sum F_x = 8.63 \times 10^{-9} - 5.62 \times 10^{-9} = \mathbf{3.01 \times 10^{-9} \text{ N}}$$

## Example Cont'



$$F_R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = 7.16 \times 10^{-9} \text{ N}$$

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