Charge and Coulomb's Law

AP Physics B

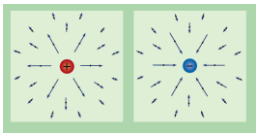
Electric Charge

"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.

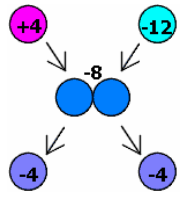
Electric Charge – The specifics



•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	1.6×10^{-19} C	1.67×10^{-27} kg
Electron	1.6×10^{-19} C	9.11×10^{-31} kg
Neutron	0	1.67×10^{-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

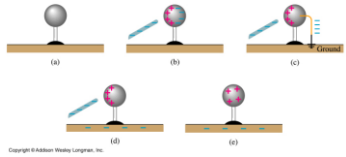
There are basically 2 ways you can charge something.

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:

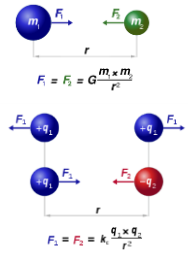
$$F_g \alpha Mm \quad F_g \alpha \frac{1}{r^2}$$

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

$k = \text{constant of proportionality}$

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

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



Electric Forces and Newton's Laws

Electric Forces and Fields obey Newton's Laws.

$$F_{Net} = F_e = F_g$$

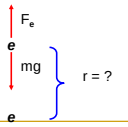
$$mg = k\frac{qQ}{r^2} = ma$$

Example: An electron is released above the surface of the Earth. A second electron directly below it exerts an ***electrostatic force*** on the first electron just great enough to cancel out the ***gravitational force*** on it. How far below the first electron is the second?

$$F_E = mg$$

$$k\frac{q_1 q_2}{r^2} = mg \rightarrow r = \sqrt{k\frac{q_1 q_2}{mg}}$$

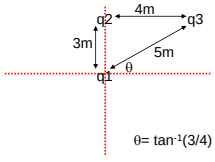
$$\sqrt{(8.99^9)\frac{(1.6x10^{-19})^2}{(9.11x10^{-31})(9.8)}} = \quad 5.1\text{ m}$$



Electric Forces and Vectors

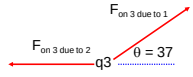
Electric Fields and Forces are ALL vectors, thus all rules applying to vectors must be followed.

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.

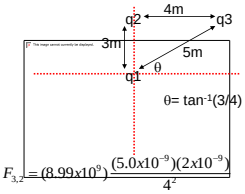


θ= tan^{-1}(3/4)

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



Example Cont'



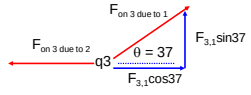
θ= tan^{-1}(3/4)

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

$F_{3,2}$ = **5.6 x10^{-9} N**

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

$F_{3,1}$ = **1.1x10^{-8} N**



$$\sum F_x = F_{3,1}\cos(37) - F_{3,2}$$

$$\sum F_x = 3.18x10^{-9}\,N$$

$$\sum F_y = F_{3,1}\sin(37) = 6.62x10^{-9}\,N$$

$$F_{resultant} = \sqrt{(\sum F_x)^2 + (\sum F_y)^2}$$

F_{res} = **7.34x10^{-9} N**

$$Direction = \theta = \tan^{-1}\left(\frac{\sum F_y}{\sum F_x}\right) =$$

64.3 degrees above the +x

Agenda (1/11/13)

- Do Now
- Charge & Coulomb's Law Practice Problems
- Electric Field Notes and Practice Problems
- Announcements

Practice Problem #1

The radius of a hydrogen atom is $r = 5.29 \times 10^{-11} m$.

- What is the ratio of the electric to gravitational force between a proton and an electron in a hydrogen atom?
- Find the speed of the orbital motion of electron.

Practice Problem #2

Two very small spheres are initially neutral and separated by a distance of 0.500 m. Suppose that 3×10^{13} electrons are removed from one sphere and placed on the other.

- What is the magnitude of the electrostatic force that acts on each sphere?
- Is the force attractive or repulsive?

Practice Problem #3

The attractive force between two point charges separated by 6 cm is 20 N.

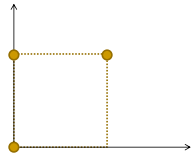
- What is the electrical force between the charges when they are separated by 12 cm?
- If the charges attracting have equal magnitudes, what is the magnitude of each charge?

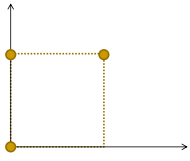
Practice Problem #4

Three positive charges lie on the *x*-axis; $q_1 = 25\mu C$ is at the origin, $q_2 = 10\mu C$ is at $x_1 = 2m$, and $q_3 = 20\mu C$ is a $x_2 = 3m$. Find the resultant force on q_3.

Practice Problem #5

Three charges, each equal to $+2.90\mu C$, are placed at three corners of a square that is 0.500m on a side. Find the magnitude and direction of the net force on q_3.





Electrostatics: Assignment #1

- Pg. 573-574 (#2, 7, 15, 19, 24, 29)
- Read and take notes on pg. 554-568
- Watch Electric Fields Video
- Download Electric Fields PPT from website.

Summary: Video Clip