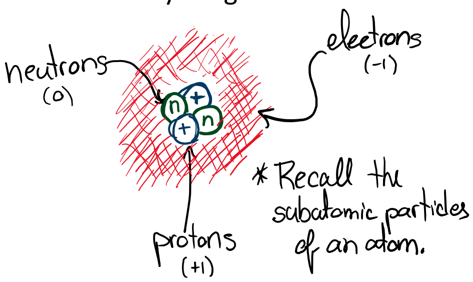
Lesson 6.1: The Electric Force

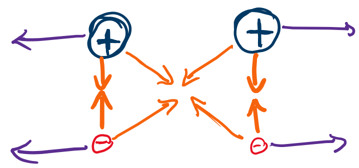
Unit 6: Electrostatics

Static Electric Charges:

Everything in electrostatics comes from what electrons can and can't do.



Like charges repel and unlike charges attract at a distance.



A neutral body is attracted to either a positively or negatively charged body.

Law of conservation of charge: electric charge is never created nor destroyed, it is conserved like momentum, energy, and mass.

The electrification of objects:

The electrification of an object refers to the process of electrons being transferred from an object with lower affinity for electrons to one with higher affinity for electrons.

The triboelectric series to the right show's materials ranging in electron affinity.

positive (low electron affinity)

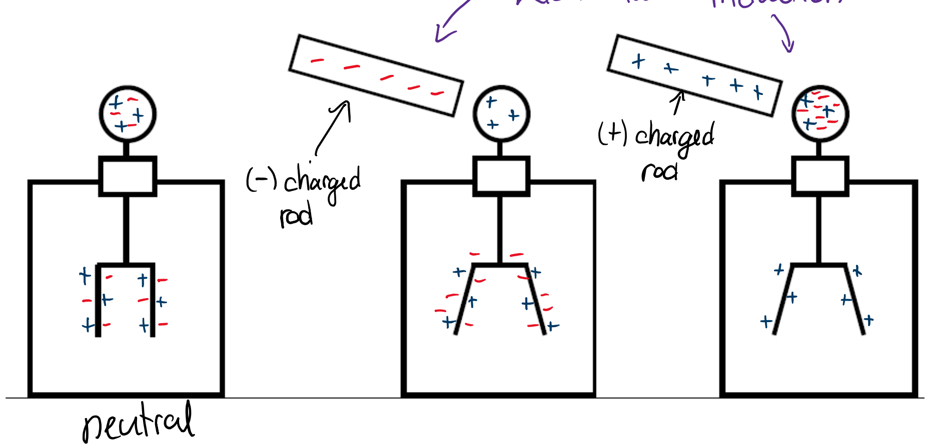
negative (high electron affinity)

dry skin
leather
glass
human hair
wool
cat fur
silk
paper
cotton
rubber
polyester
PVC

Charging Electroscope

Electroscopes can demonstrate the existence of charge through charging through contact (conduction) where charge is transferred, or charging without contact (induction) where the charge is reliant on the proximity of charged objects.

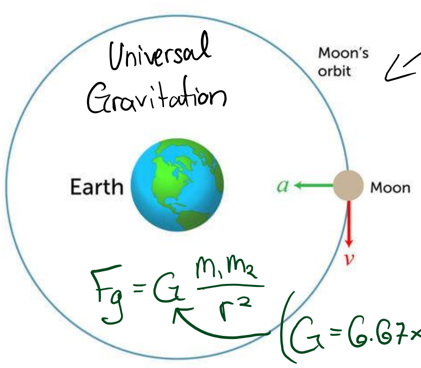
Electrostatic Induction



Task: *Use the different triboelectric materials to create charge distributions on different objects.*	
Use the electroscopes to determine what materials formed the largest charge through ***conduction*** *(widest leaf separation).*	*Explore how far away from the electroscope a charged object needs to be to* ***induce*** *a charge. Use different materials and record observations.*

The Electric Force: Coulomb's Law

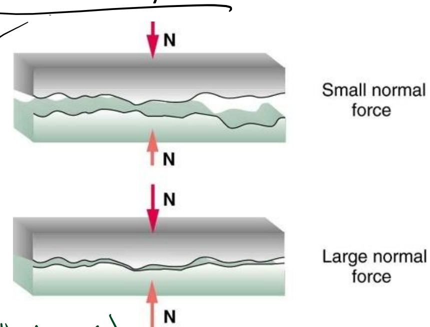
We've encountered all forms of forces in the course so far. Electrostatic repulsion and attraction are non-contact forces—this should look familiar to you.

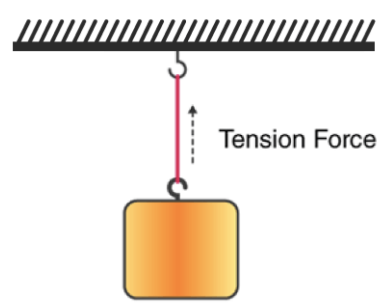


Universal Gravitation

$F_g = G\frac{m_1 m_2}{r^2}$

$(G = 6.67\times10^{-11}\ Nm^2/kg^2)$





Coulomb's Law:

$$\boxed{F_e = k\frac{Q_1 Q_2}{r^2}}$$

F_e = Electrostatic Force (N)

Q = Charge (C - Coulombs)

r = radius (m)

k = Coulomb's Constant

= $9.0\times10\ Nm^2/C^2$

Elementary Charge

*The charge of a proton or electron.

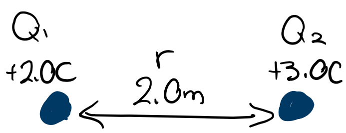
proton = $p^+ = +1.60\times10^{-19}C$

electron = $e^- = -1.60\times10^{-19}C$

Example 1 – *# of electrons in a charge*: How many electrons are in -1.0 C of charge?

$$\frac{1e^-}{-1.6\times10^{-19}C} = \frac{xe^-}{-1C} \qquad \boxed{x = 6.25\times10^{18} \text{ electrons}}$$

Example 2 – *Force between two charged particles:* Find the electrostatic forces between a +2.0 C charge and +3.0 C charge 2.0 m apart.

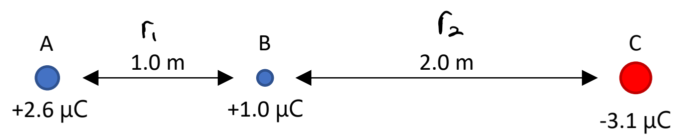


$$F_e = k\frac{Q_1Q_2}{r^2}$$

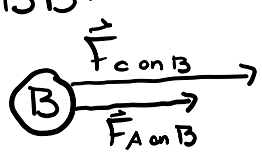
$$= \frac{(9.0\times10^9)(2)(3)}{(2)^2}$$

$$\boxed{F_e = 1.35\times10^{10} N}$$

Example 3 – *Electric force involving 3 charges in a line:* Calculate the net electrical force on B.



FBD:



$$\vec{F}_{net} = \vec{F}_{A \text{ on } B} + \vec{F}_{c \text{ on } B}$$

magnitude of charge only (no ±)
* vector came from FBD

$$F_{net} = k\frac{|Q_AQ_B|}{r_1^2} + k\frac{|Q_cQ_B|}{r_2^2}$$

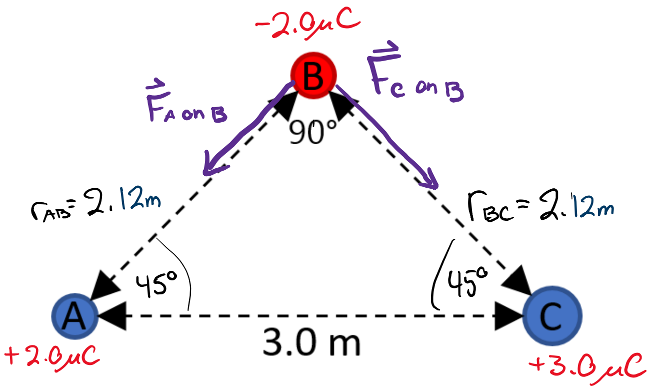
$$= \frac{(9.0\times10^9)(2.6\times10^{-6})(1.0\times10^{-6})}{(1.0)^2} + \frac{(9.0\times10^9)(3.1\times10^{-6})(1.0\times10^{-6})}{(2.0)^2}$$

$$\vec{F}_{net} = 0.0234N + 0.006975N$$

$$\boxed{= 3.04\times10^{-2} N}$$

****There are many ways to solve problems with 3 charges in triangulation. Components of right-angled triangles, Pythagoras, cosine law, and sine laws are all accessible here. Your use of them depends on the problem and you.*

Example 4 – Electric force involving 3 charges in a right-angle triangle: Find the net force on B.

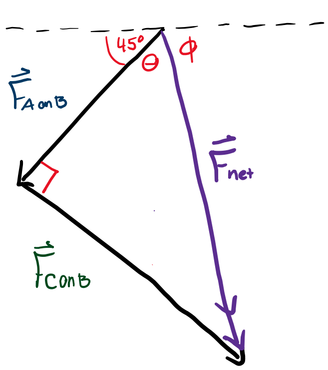


Since it's a 90-45-45 △

$r_{AB} = r_{BC} = 3 \sin 45$

$= 2.12\text{m}$

FBD:



$$\vec{F}_{A\ on\ B} = K\frac{Q_A Q_B}{r_{AB}^2}$$

$$= \frac{(9.0\times10^{9})(2.0\times10^{-6})^2}{(2.12)^2}$$

$$= 8.01\times10^{-3}\text{N}$$

$$\vec{F}_{C\ on\ B} = K\frac{Q_C Q_B}{r_{BC}^2}$$

$$= \frac{(9.0\times10^{9})(3.0\times10^{-6})(2.0\times10^{-6})}{(2.12)^2}$$

$$= 1.20\times10^{-2}\text{N}$$

$$\vec{F}_{net} = \sqrt{F_{A\ on\ B}^2 + F_{C\ on\ B}^2}$$

$$= \sqrt{(8.01\times10^{-3})^2 + (1.20\times10^{-2})^2}$$

$$\vec{F}_{net} = 1.44\times10^{-2}\text{N}$$

$$\theta = \arctan\left(\frac{1.2\times10^{-2}}{8.01\times10^{-3}}\right)$$

$$= 56.3°$$

$$\phi = 180 - 45 - 56.3$$

$$= 78.7°$$

$$\boxed{\text{Force on B} = 1.44\times10^{-2}\text{N},\ 78.7°\text{ S of E}}$$

Assignment: Sander-Gore Pgs. 169-170 #'s 1-10