Force: Electrostatics

May 20, 2016 9:45 AM

The Smallest unit of charge known in nature is the charge on an electron or proton. This is called the elementary charge.

$|e| = 1.602 \times 10^{-19}$C (The unit for charge is the Coulomb C)

Particle

Electron (e)
Charge: $-e = -1.602 \times 10^{-19}$C
Mass: $m_e = 9.11 \times 10^{-31}$kg

Proton (p)
Charge: $e = 1.602 \times 10^{-19}$C
Mass: $m_p = 1.67 \times 10^{-27}$kg

Neutron (n)
Charge: no charge or 0 C
Mass: $m_n = 1.67 \times 10^{-27}$kg

Alpha Particle (α) is the Helium nucleus which is 2 protons and 2 neutrons
Beta Particle (β) is a high energy electron

Rule for Charges

Like charges repel and opposite charges attract. Two charges that exert a force of attraction or repulsion on each other is described by Coulomb's law.

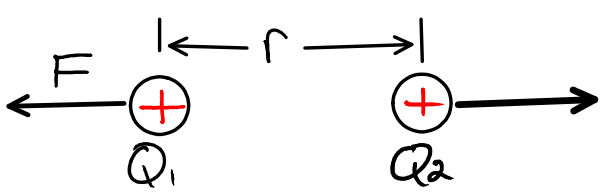
Coulombs Law

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

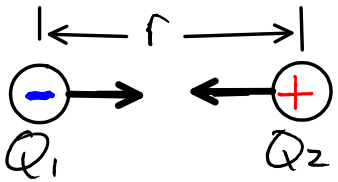
$$F = \frac{kQ_1Q_2}{r^2} \qquad \text{Unit: Newton (N)}$$

$$k = 9 \times 10^9 \ \frac{N \cdot m^2}{C^2}$$

Q_1: charge of first Particle
Q_2: charge of 2nd Particle
r: distance between the Particles centers

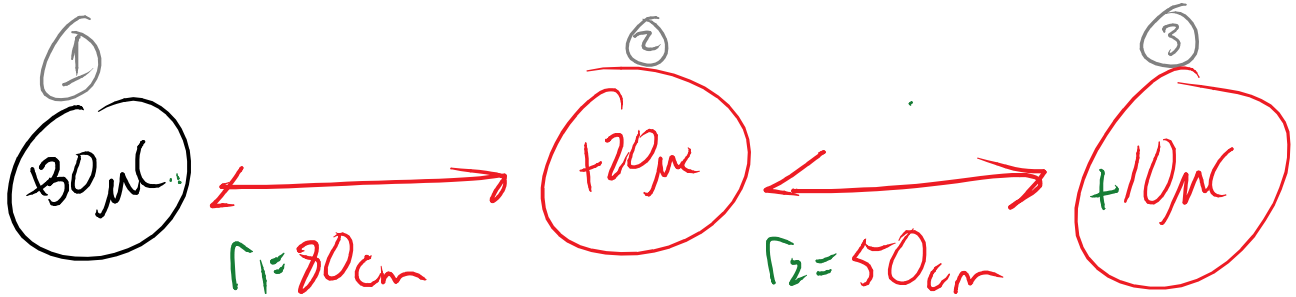


F: Positive = repulsion



F: negative = attraction

Example 1:

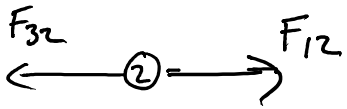


$m = 10^{-3}$

$\mu = 10^{-6}$

$n = 10^{-9}$

Find F_{net} on Charge (2)



$$F_{12} = \frac{KQ_1Q_2}{r^2} = \frac{(9\times10^9)(30\times10^{-6})(20\times10^{-6})}{(0.8)^2}$$

$$= 8.4375\,N$$

$$F_{32} = \frac{KQ_3Q_2}{r^2} = \frac{(9\times10^9)(10\times10^{-6})(20\times10^{-6})}{(0.5)^2}$$

$$F_{net} = F_{12} - F_{32}$$

$$= 8.4375 - 21.6$$

$= 8.9375 - 21.6$

$= -13\,N$

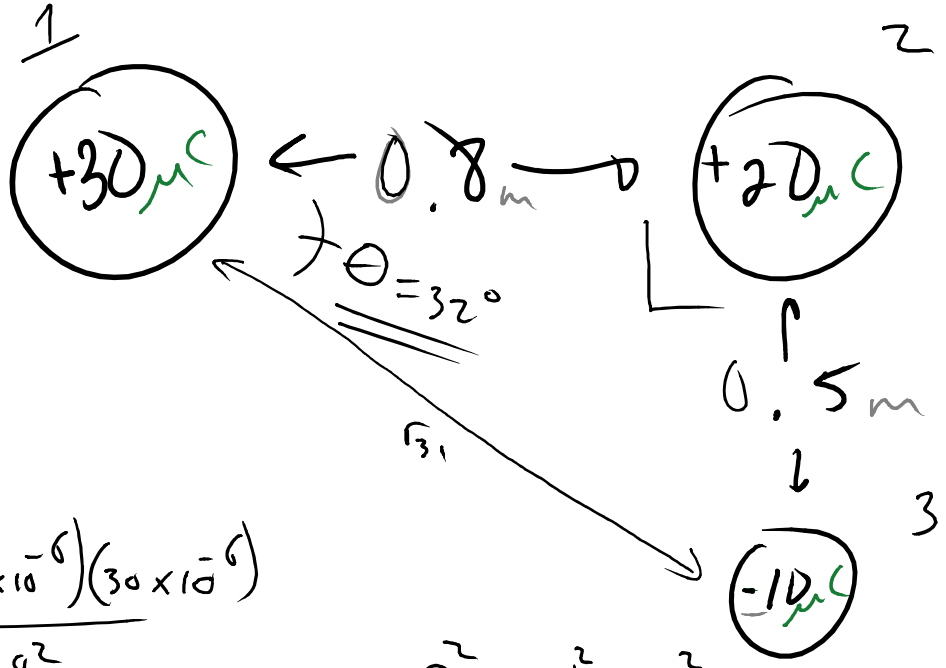
$(0.5)^2$

$= 21.6\,N$

FNet is 13 N Left

Example 2:

What is FNet on the 30 μC charge?



$$F_{21} = \frac{kQ_2Q_1}{r^2}$$

$$= \frac{(9\times10^9)(20\times10^{-6})(30\times10^{-6})}{0.8^2}$$

$$= 8.4375\,N$$

$$r_{31}^2 = 0.8^2 + 0.5^2$$

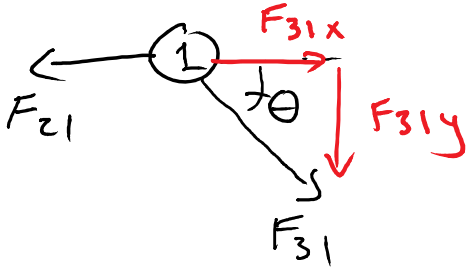
$$F_{31} = \frac{K\,Q_3\,Q_1}{r_{31}^2}$$

$$F_{31} = \frac{(9\times10^{9})(-10\times10^{-6})(30\times10^{-6})}{0.8^2+0.5^2}$$

$$F_{31} = -3.034\ N$$

↑ attraction

Force diagram



$F_{31x} = F_{31}\cos\theta$

$= 3.034\cos 32$

$= 2.573\ N$ Right

$F_{31y} = F_{31}\sin\theta$

$= 3.034\sin 32$

$= 1.608\ N$ down

$= 1.608\,N$ down

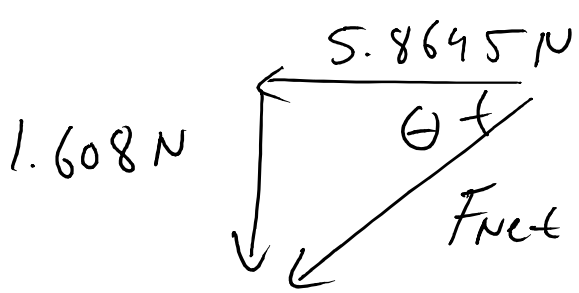
$= 2.573\,N$ Right

$F_{Net_x} = F_{31x} - F_{21}$

$= 2.573 - 8.4375$

$= -5.8645\,N$

$F_{Net_y} = 1.608\,N$ down



$F_{Net} = \sqrt{5.8645^2 + 1.608^2}$

$= 6.081\,N$

$\theta = \tan^{-1}\left[\frac{1.608}{5.864}\right]$

$\theta = 15.3°$

Force on 30 μC charge is 6.081 N @ 15.3° S of W

Practice p. 497

Q: 11, 13

1. How many electrons make up -30 micro-coulombs of charge?
2. A 20 micro-coulomb charge is made of just protons. What is the mass of the charge?

$e^- = -1.602 \times 10^{-19}$

$p^+ = 1.602 \times 10^{-19}$

$m_p = 1.67 \times 10^{-27}\ kg$

$\#e = \dfrac{-30 \times 10^{-6}}{-1.602 \times 10^{-19}}$

$\#e = 1.87 \times 10^{14}$

$\#p = \dfrac{20 \times 10^{-6}}{1.602 \times 10^{-19}}$

$\#p = 1.25 \times 10^{14}$

$m_c = \#p \times m_p$

$= 1.25 \times 10^{14} \times 1.67 \times 10^{-27}$

$= 2.08 \times 10^{-13}\ kg$

Start working on the problems on page 497 (1-29) odd
Do what you can do. We will go over more electro statics ~~this~~ next week.

$F = \dfrac{kQ_1Q_2}{r^2}$ $\quad k = 9 \times 10^9\ \dfrac{N \cdot m^2}{C^2}$

$|e| = 1.602 \times 10^{-19}\ C$ — elementary charge for electron & proton