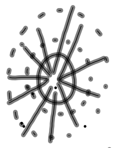
Chapter 14 - Fields + Forces

§14.1 Laws of Force



$SA = 4\pi r^2$ (sphere)

as r increases, then there will be less "lines" per m^2

100 sticks in your styrofoam ball:

at 1m from centre: $\frac{100}{4\pi(1)^2} = \frac{100}{4\pi}$ sticks/m^2

x2 → at 2m from centre: $\frac{100}{4\pi(2)^2} = \frac{100}{16\pi}$ sticks/m^2 (x $\frac{1}{4}$)

Recall: $F_g = \frac{Gm_1m_2}{r^2} \Rightarrow F_g \propto \frac{1}{r^2}$

F_g is __always__ attractive

Consider charged objects:

like charges → repel

unlike charges → attract

Coulomb → determined the relationship between the electrostatic force and charge + separation

$F_Q \propto q_1$

$F_Q \propto q_2$

$F_Q \propto \frac{1}{r^2}$ ← inverse square law is common in Physics

Combining proportionalities:

$F_Q \propto \frac{q_1 q_2}{r^2}$

$F_Q = \frac{kq_1q_2}{r^2}$ looks like! $\left(F_g = \frac{Gm_1m_2}{r^2}\right)$

Coulomb's Law

where F_Q is the electrostatic force (N)

k is Coulomb's Law constant ($9.0\times10^9\ \frac{N\cdot m^2}{C^2}$)

q_1 and q_2 are the charges (C)

r is the separation (m)

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$q_1 = -8.0\mu C$

$F_Q = 0.50N$ (attractive) ⊖ + ⊕

$q_2 = \pm 5.0\mu C$ (+?)

a) What is the sign of q_2? ⊕

b) r = ?

$F_Q = \frac{kq_1q_2}{r^2}$

$r^2 = \frac{kq_1q_2}{F_Q}$

DO NOT PUT SIGNS ON CHARGES

$r^2 = \frac{(9.0\times10^9\ \frac{N\cdot m^2}{C^2})(8.0\times10^{-6}C)(5.0\times10^{-6}C)}{0.50N}$

$r = 0.85m$

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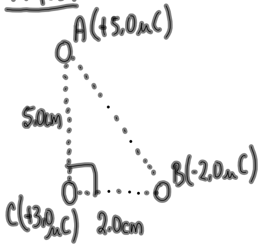
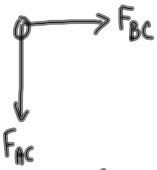


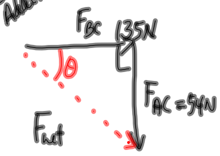
Draw a FBD for C:



F_{net} on C = ??

Since we only have two forces and they are at a right angle, draw a vector addition diagram.

Vector Addition Diagram



$F_{AC} = \frac{kq_Aq_C}{r_{AC}^2}$

NO SIGNS!

$F_{AC} = \frac{(9.0\times10^9 \frac{N\cdot m^2}{C^2})(5.0\times10^{-6}C)(3.0\times10^{-6}C)}{(0.050m)^2}$

$F_{AC} = 54N$

$F_{BC} = \frac{kq_Bq_C}{r_{BC}^2}$

$F_{BC} = \frac{(9.0\times10^9 \frac{N\cdot m^2}{C^2})(2.0\times10^{-6}C)(3.0\times10^{-6}C)}{(0.020m)^2}$

$F_{BC} = 135N$

To find F_{net}:

$c^2 = a^2 + b^2$

$c^2 = 54^2 + 135^2$

$c = 145.4N$

$\tan\theta = \frac{opp}{adj}$

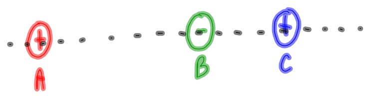
$\tan\theta = \frac{54N}{135N}$

$\theta = 22°$

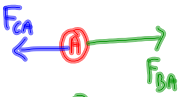
The net force on C is 145N [22° cw from the line joining B+C.]

[22° cw from + x-axis

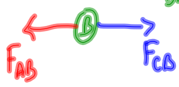
What if you have 3 charges in a line:



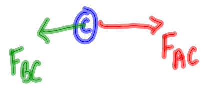
Draw a FBD for A:



Draw a FBD for B:



Draw a FBD for C:



TODO

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