Coulomb Interaction:

1) Electric charge ↔ electron $-e$

proton $+e$

a) 2 kinds of charges

$e = 1.6 \times 10^{-19}$ C ↑ coulomb

b) charges are conserved

can't be created singly

c) charges are quantize

$e^- + e^+ = 0$

electron positron photon

$q = \pm Ne$

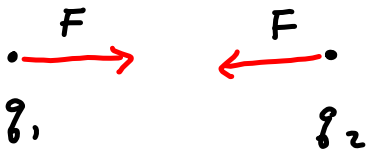
Coulomb interaction between charges

if $q_1 q_2 > 0$

same charges repulse

$$F = k \frac{|q_1||q_2|}{r^2}$$

acts along the straight line between the charges



if $q_1 q_2 < 0$

unlike charges attract

$$k = 10^{-7} c^2 \; N\frac{m^2}{C^2}$$

c ← speed of light

← Coulomb

$c = 2.99792 \times 10^8 \; m/s$

$\sim 3 \times 10^8$

$k = 10^{-7} \; 9 \times 10^{16}$

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

or $8.99 \times 10^9 \; N m^2/C^2$

Ex 1: $q_1 = 1\ C \quad q_2 = 1\ C$

$r = 1\ m$

$F = k\frac{1 \cdot 1}{1^2} = 9 \times 10^9\ N$

$N \cong 0.22\ lb$

$\sim \frac{1}{4}\ lb$

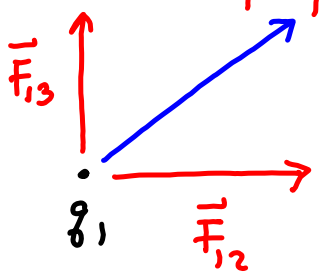
1) 1 C is $= \frac{1}{4} 9 \times 10^9\ lb$

a huge amount of charge! $\cong (2 \times 10^3) 10^6$ Ton

2) $\mu C = 10^{-6}\ C$ $\quad nC = 10^{-9}\ C$

For more than 2 charges

↳ Superposition



↳ force between 2 charges is ind of any othe charges

The force exerted by q_2 on q_1

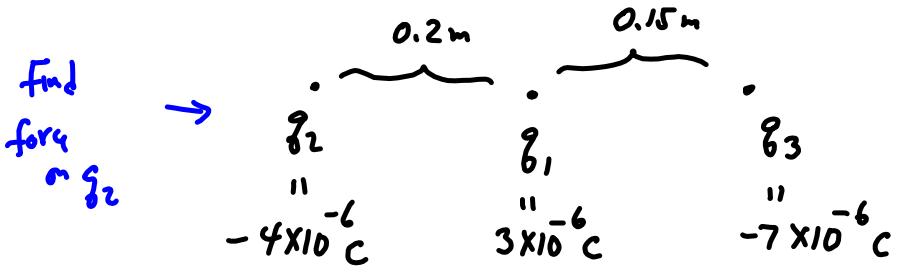
F_{12} on 1 by 2

q_3

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13}$$

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \vec{F}_{15} + \ldots$$

Ex 2 three charges on a line



Find the total force on q_1

$$F_{13} = k\frac{|q_1||q_3|}{(.15)^2} = \frac{9\times10^9\ 3\times10^{-6}\ 7\times10^{-6}}{(.15)^2} = \frac{9\times3\times7\times10^{-3}}{2.25\times10^{-2}} \quad (1.5\times10^{-1})^2 = (1.5)^2 10^{-2}$$

$$= \frac{9\times21}{2.25}\,10^{-1} = 8.4\ N$$

$$F_{12} = \frac{k|q_1||q_2|}{(.2)^2} = \frac{9\times10^9\ 3\times10^{-6}\ 4\times10^{-6}}{4\times10^{-2}} = \frac{9\cdot3\cdot4}{4}\,10^{-1}$$

$$= 2.7\ N$$

$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13}$

$= -2.7\ N + 8.4\ N$

$= 5.7\ N$

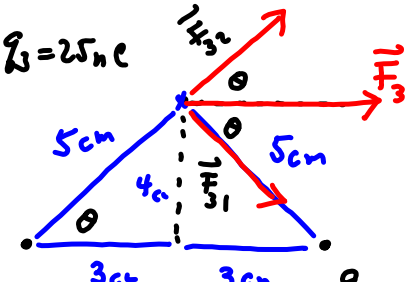
Your turn: What is the force on q_2 due to $q_1 + q_3$?

A) 4.8 N B) −0.6 N C) −4.8 N D) 0.6 N ✓

$F_{21} = F_{12} = 2.7$ $F_{23} = 2.1$ $\vec{F}_2 = \vec{F}_{21} + \vec{F}_{23}$

$= 2.7 - 2.1 = 0.6\ N$

Ex 3 : $q_3 = 25\,nC$



Find the total force on q_3

q_2 = 12 nC

q_1 = −12 nC

q_1 & q_2 forms dipole

$\vec{F}_3 = \vec{F}_{32} + \vec{F}_{31}$

$F_{31} = 1.08 \times 10^{-3}\,N$

$F_{32} = k\dfrac{|q_3||q_2|}{(5\times10^{-2})^2} = \dfrac{9\times10^{9}\,25\times10^{-9}\,12\times10^{-9}}{25\times10^{-4}}$ $\quad a = 10^{-2}\,m$

$= \dfrac{9\cdot 25\cdot 12\ 10^{-9}}{25\times10^{-4}} = 108\times10^{-5}$

$= 1.08\times10^{-3}\ N$

$F_3 = F_{32x} + F_{31x}$

$= F_{32}\cos\theta + F_{21}\cos\theta = 1.08\times10^{-3}\,N\ 2\cos\theta$

$\cos\theta = \frac{3}{5}$ $\quad = 1.08\times10^{-3}\,2\frac{3}{5} = 1.3\times10^{-3}\,N$

what is force on $q_3 = -25\,nC$?

A	B	C	D
up	down	to the left $-1.3\times10^{-3}\,N$	to the right