Physics 114 - January 20, 2015

- P.S. 1 is posted on the class website
- Thursday 11:05-1:45 workshop section

  → Moved to 10 am to Noon in B+L 480

  Feel free to adjust your registered wkshop section
  To open slots . . .

- Will want you to hand in P.Sets in TA boxes across hall from B+L 106 — deposit in Box of your section leader

  Stay Tuned for Leader ⟷ Section mapping
  Will give Plan B if NOT settled by Thursday

Last Time

discussed how class will operate

Questions ?

Started

"Electrostatics"

electric force

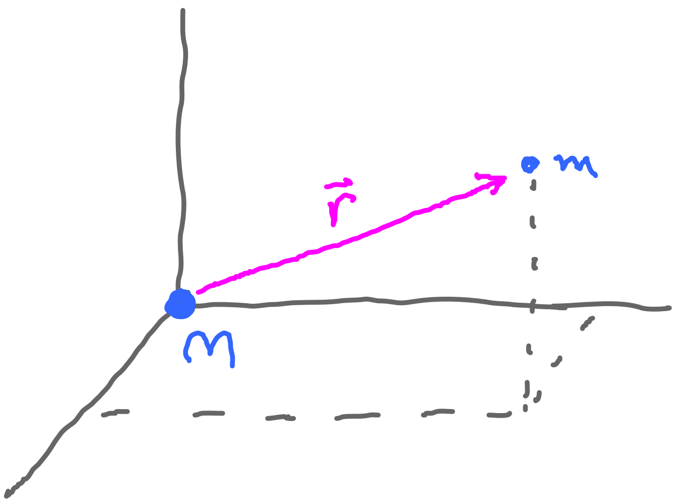
charges not moving

Coulomb's Law

~1785

$q_1 \xrightarrow{\vec{r}_{12}} q_2$

Gravitation



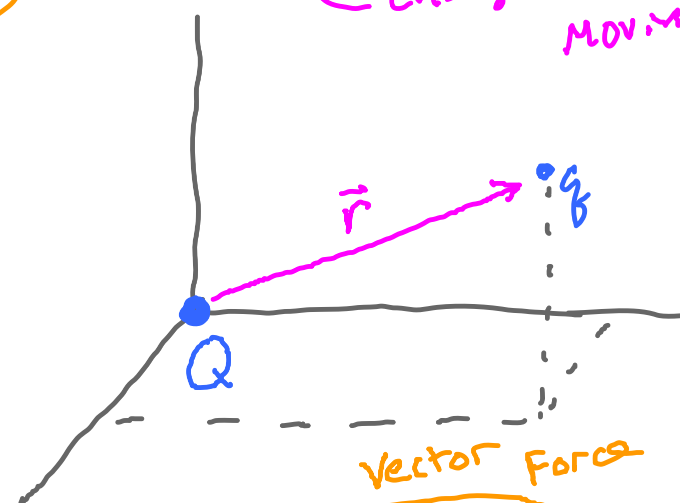
$$\vec{F}_{M\,on\,m} = -\frac{GMm}{r^2}\,\hat{r}$$

M, m only +

ElectroSTATICS

Electric Force

charges NOT moving



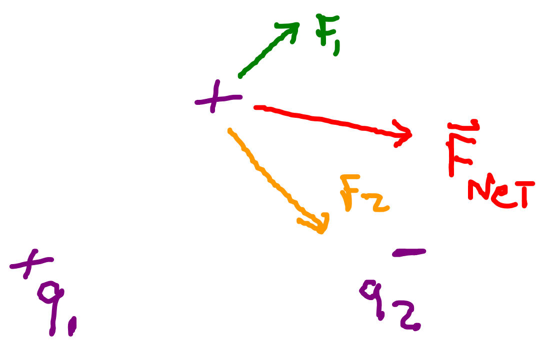
Vector Force

$$\vec{F}_{Q\,on\,q} = \frac{kQq}{r^2}\,\boxed{\hat{r}}$$

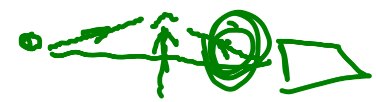
Q, q each come as "+" or "−"

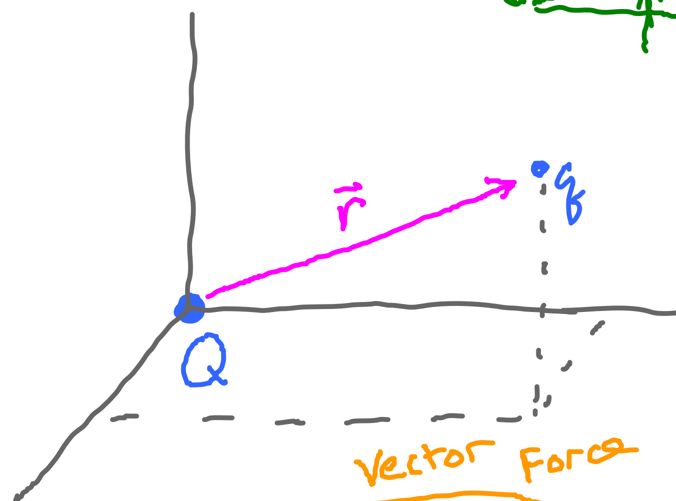
Force ...

So is a vector



Charge in coulombs, C (MKS)





Vector Force

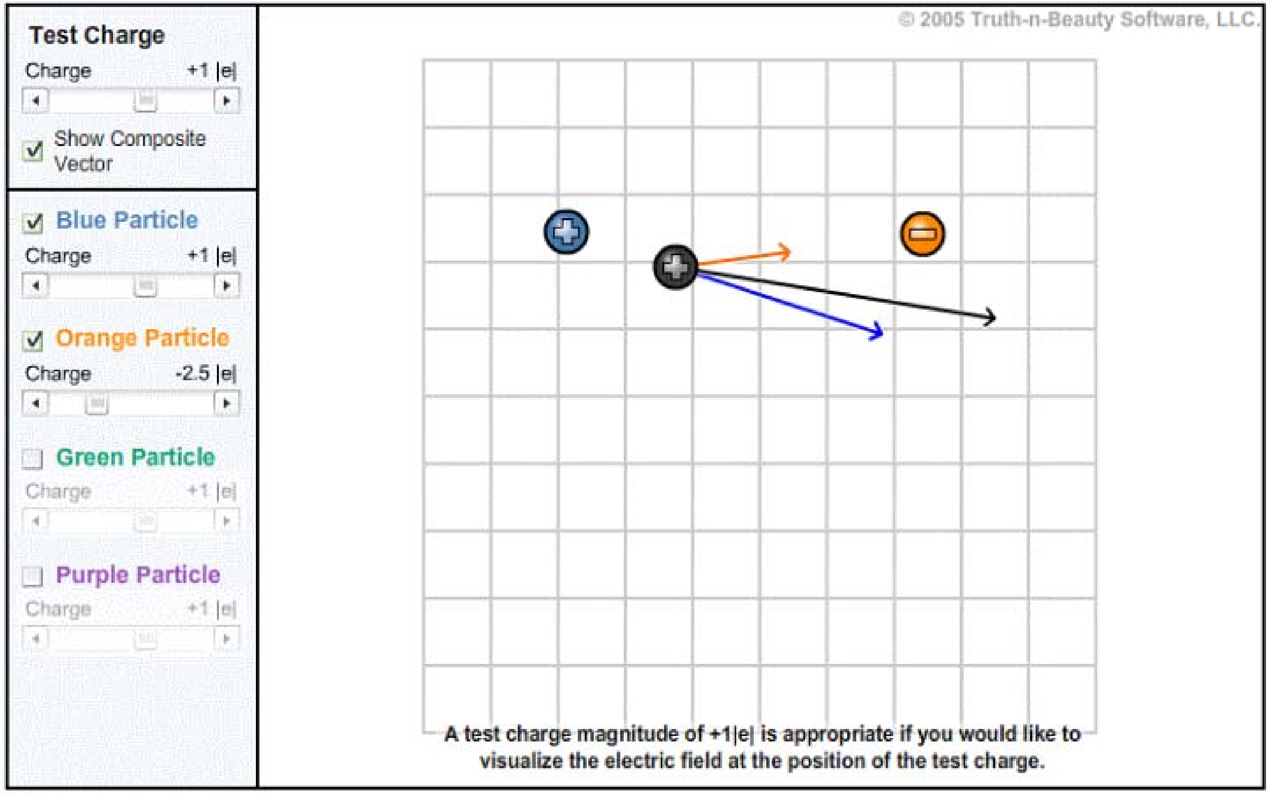
$$\vec{F}_{Q\,on\,q} = \frac{\boxed{k}\,Q q}{r^2}\,\boxed{\hat{r}}$$

$$k = 8.99\times10^{9}\ \frac{Nm^2}{C^2} = \frac{1}{4\pi\epsilon_0}$$

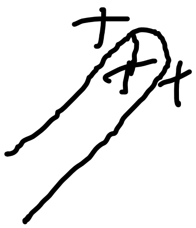
Permittivity of free space

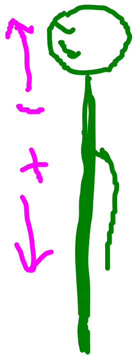
$$\epsilon_0 = 8.85\times10^{-12}\ \frac{C^2}{Nm^2}$$

Play with Coulomb Applet — link on class website

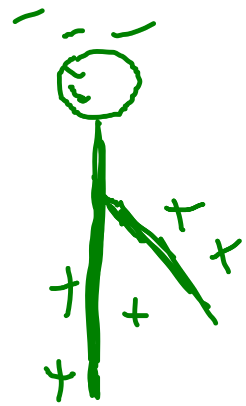


Electroscope demo





conductor



- Electric charge is conserved

- Electric charge is quantized

  unit $|e| = 1.6 \times 10^{-19}$ Coulombs

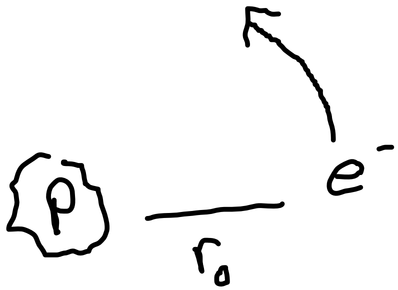
quarks $\quad u \quad c \quad t \leftarrow +\frac{2}{3}|e|$

$\qquad\qquad d \quad s \quad b \leftarrow -\frac{1}{3}|e|$

protons
uud

neutron
udd

What, in your opinion, is the single most important number in chemistry?



H atom

Bohr atom

r_0 = Bohr radius

$= 5.29 \times 10^{-11}\ m$

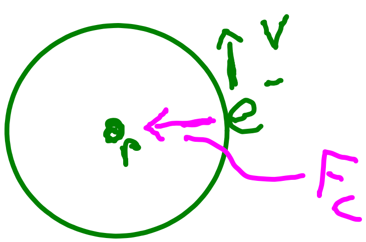
How does EM force compare to ~~Force~~ force of gravity bet particle,

$$F_{EM} = \frac{k q_1 q_2}{r^2} = \frac{8.99 \times 10^{-9} (1.6 \times 10^{-19})^2}{(5.29 \times 10^{-11}\ m)^2} = 8.2 \times 10^{-8}\ N$$

$$F_{gr} = \frac{G M_e M_p}{r_0^2} = 3.6 \times 10^{-47}\ N$$

$$F_{em}/F_{gr} = 2.3 \times 10^{39}$$

What is the speed of the e^- ?



$$F_c = \frac{m_e v^2}{r}$$

$$F_{em} = \frac{m_e v^2}{r}$$

$$V = 2.2 \times 10^6\ m/s$$

$\sim 1\%$ of c

How much energy does it take to ionize H ?

$$\text{Energy} \approx \text{Work} = \int_{r_0}^{\infty} \vec{F} \cdot d\vec{s} = \int_{r_0}^{\infty} \frac{k|e|^2}{r^2} dr = k|e|^2 \int_{r_0}^{\infty} \frac{1}{r^2} dr$$

$$= k|e|^2 \left[-\frac{1}{r} \right]_{r_0}^{\infty} = k|e|^2 \left[-\cancel{\frac{1}{\infty^2}}^{\,0} - \frac{-1}{r_0} \right] = \frac{k|e|^2}{r_0}$$

$$= 4.3 \times 10^{-18} \text{ Joules}$$

$$1 \text{ Joule} = 6.2 \times 10^{18} \text{ eV}$$

electron volts

$$26.9 \text{ eV} = \omega$$

ionization energy for H = 13.6 eV

KE of moving e^- at r_0

$$\frac{1}{2}m_e v^2 = \frac{1}{2}(9.11\times10^{-31}\,kg)(2.2\times10^{6}\,m/s)^2 = 13.6\,eV$$

ionization energy $= W - KE = \underline{\underline{13.3\,eV}}$

Q

$\cdot \, q$