Physics 142 - Sept. 7, 2010

- Workshops begin week of Sept. 13
- Prob Set 1 due Thursday, Sept. 9

  Please put in box outside my office door

  (B+L 203 E)

- Feel free to email me with questions
- Also TA office hours Monday 2:30 - 3:30 B+L 426

  Tuesday 10-11 B+L 304

Last Time

Electrostatics

- two types of charge
- Coulombs law

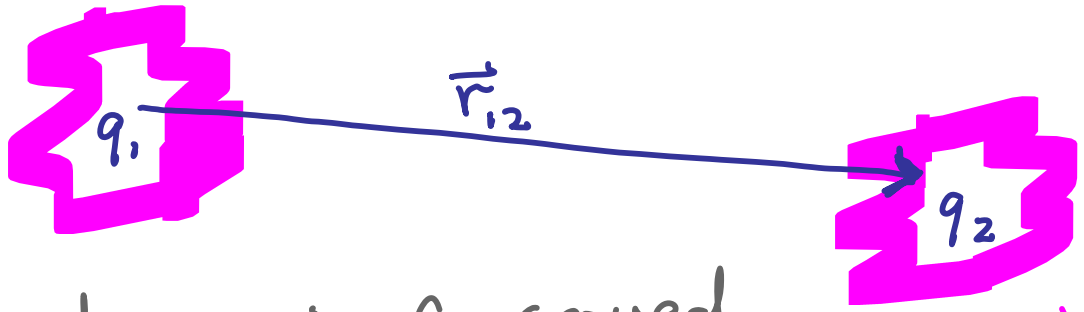
$$\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$$

$$k = \frac{1}{4\pi\varepsilon_0} = \text{CONSTANT}$$

Proportionality Const. Sets scale. Not to be confused w/ k... Boltzmann's constant

ε_0: Permitivity of Free space

inverse square force... just like gravitation

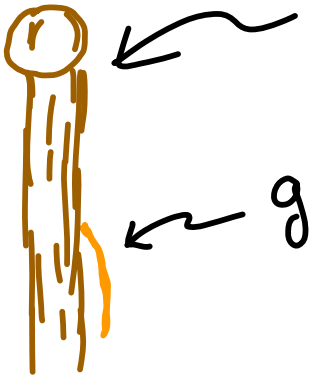


- Electric charge is Conserved
- Electric charge is quantized

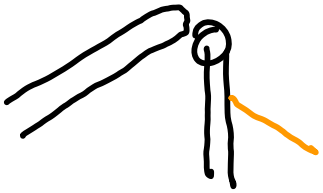
|charge of electron| $= |e| = 1.6 \times 10^{-19}$ C

C = Coulomb not to be confused w/ speed of light c

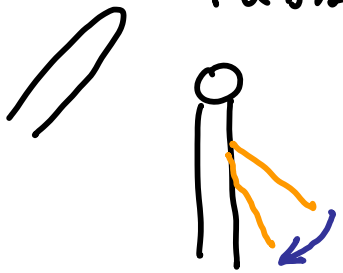
Electric charge + Electroscopes



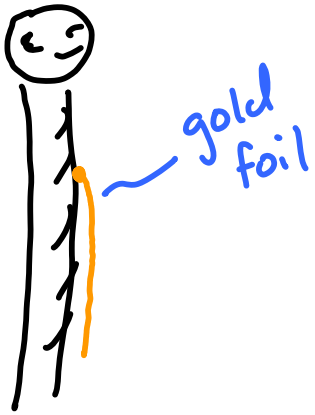
lucite rod
rubbed w silk

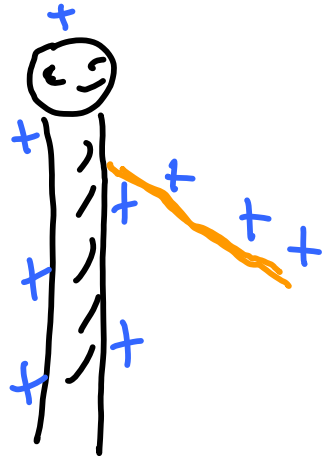


rubber rod
rubbed w fur

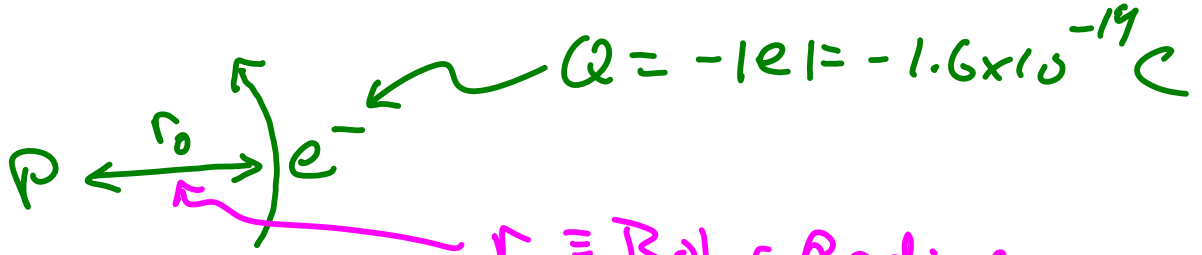


Vice versa we start w other rod





H atom (Bohr)



(a) How does em force compare to grav. force between e^- and p?

$$F_{EM} = \frac{k q_1 q_2}{r_{12}^2} = \frac{8.99\times10^{-9}\ \frac{NM}{C^2}\ (1.6\times10^{-19})^2}{(5.29\times10^{-11}\ m)^2}$$

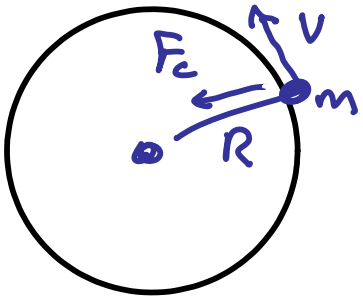
$$F_{em} = 8.2 \times 10^{-8}\ N$$

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

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

gravitation is vastly weaker than the other known forces of Nature

(b) what is the speed of e^- ?



$$F_c = \frac{m v^2}{R}$$

m_e

$F_c = F_{em}$

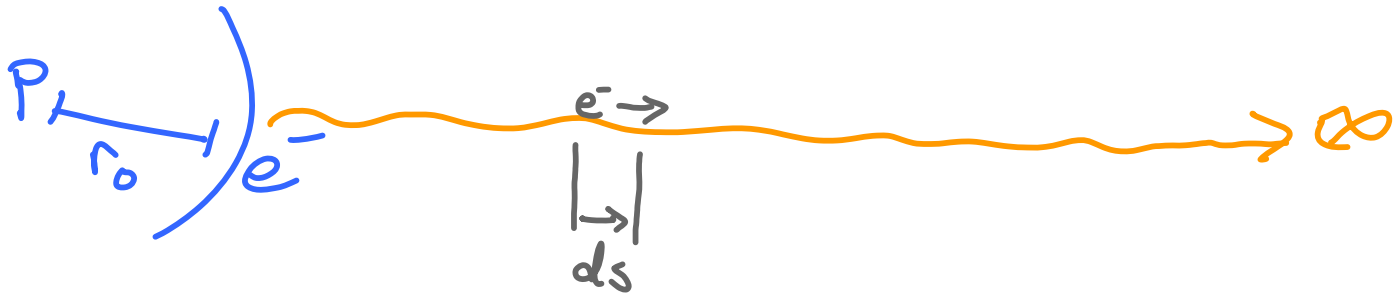
$R = r_0$

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

~1% speed of light

(c) Energy it takes to ionize the H atom

$$\text{Energy} \sim \text{work} = \int \vec{F} \cdot d\vec{s}$$



(A)
$$W = \int_{r_0}^{\infty} \vec{F} \cdot d\vec{s} = \int_{r_0}^{\infty} \frac{k|e|^2}{r^2} dr = k|e|^2 \int_{r_0}^{\infty} \frac{1}{r^2} dr$$

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

$$W = k|e|^2 \frac{1}{r_0} \simeq 4.3 \times 10^{-18} \text{ Joules}$$

$$1 \text{ Joule} = 6.2 \times 10^{18} \text{ eV} \quad \text{(electron-Volt)}$$

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

True Value = 13.6 eV

good # to know - Sets scale of energy for chemistry

Too big ... what are we missing?

e^- already Moving ... already has energy

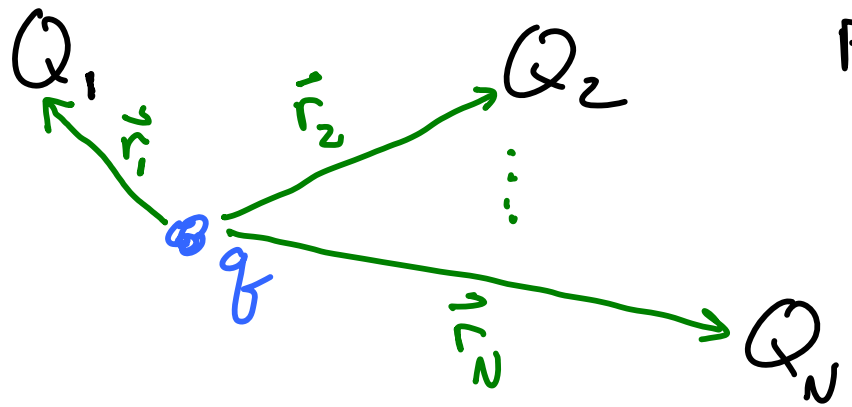
$$KE \text{ of } e^- = \frac{1}{2} m_e v_e^2 = \frac{1}{2}\left(9.11 \times 10^{-31} \text{kg}\right)\left(2.2 \times 10^6 \text{ m/s}\right)^2$$

$$= 13.6 \text{ eV}$$

$$W - KE_{e^-} = 13.3 \text{ eV}$$

pretty good!

Electrostatics is a Vector Force

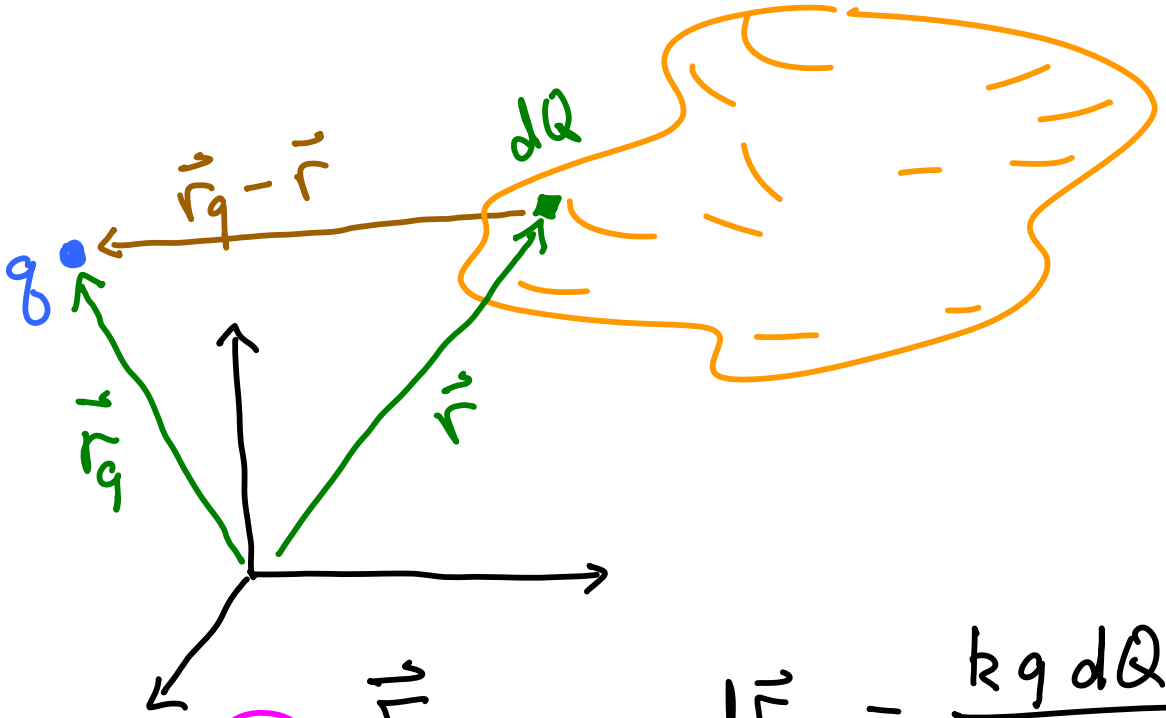


Force on q due to distribution of discrete Point charges

(A)
$$\vec{F}_{\substack{Net \\ on \\ q}} = \vec{F}_{Q_1} + \vec{F}_{Q_2} + \cdots + \vec{F}_{Q_N}$$

(B)
$$\vec{F}_{NET} = \frac{kQ_1q}{r_1^2}\hat{r}_1 + \frac{kQ_2q}{r_2^2}\hat{r}_2 + \cdots + \frac{kQ_Nq}{r_N^2}\hat{r}_N$$

F on q from continuous charge distribution



© $\vec{F}_{\text{on } q \text{ from } dQ} = d\vec{F}_{\text{due to } dQ} = \dfrac{k\,q\,dQ}{|\vec{r}_q - \vec{r}|^2}\,\hat{(\vec{r}_q - \vec{r})}$

general

$$\vec{F}_{\text{on } q} = \int_V \frac{k\,q\,dQ}{|\vec{r}_q - \vec{r}|^2}\,\hat{(\vec{r}_q - \vec{r})}$$

V = chg volume

(volumes)

$dQ = \rho(\vec{r})\, dv$

↳ volume charge density C/M^3

$dQ = \sigma(\vec{r})\, dA$

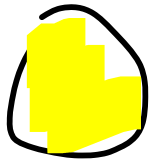
↳ area charge density C/M^2

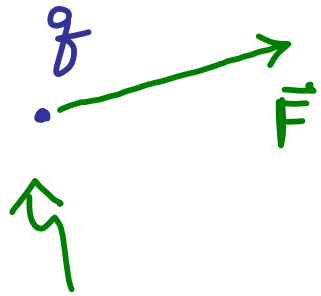
$dQ = \lambda(\vec{r})\, dl$

↳ linear charge density C/m

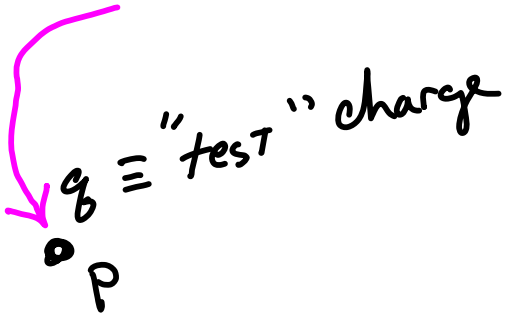
$$\vec{F}_q = \int_{\text{Vol of Charge}} \frac{kq\,\rho(\vec{r})\,dv}{|\vec{r}_q - \vec{r}|^2}\,\hat{(\vec{r}_q - \vec{r})}$$

very general





What causes
This Force



$$\vec{F}_q = \frac{k Q q}{r^2} \hat{r}$$

Electric Field $= \vec{E}_P = \vec{F}_q / q$

$$\vec{E}_P = \frac{k Q \cancel{q} \hat{r}}{r^2}$$

For point charge Q

Is the electric field real? For now we'll play pretend ...