Physics 114 - January 19, 2010

Reminders

- No workshops this week
  Begin Mon., Jan. 25
- A-labs begin wk Jan. 25 - 28
- B-labs begin wk Feb. 1 - 4
- Problem Set 1 is posted on Web
  Due this Thursday

Any questions about
Syllabus/course organization?

Last Time - Electrostatics

- two types of charge

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

- Coulombs law

My hero!

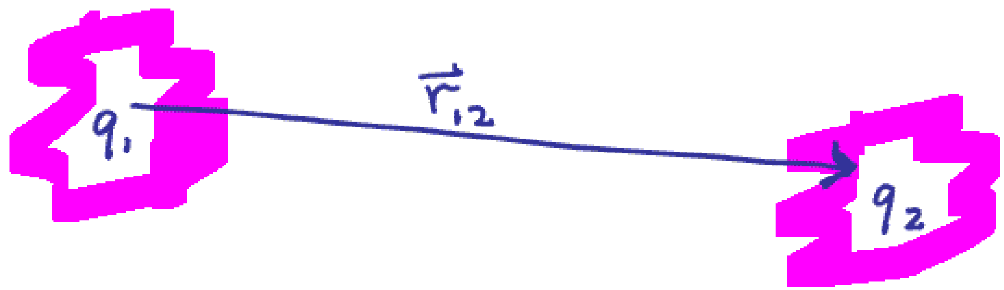
Charles Coulomb

$$k = \frac{1}{4\pi\epsilon_0} = \text{constant}$$

Permittivity of free space

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

inverse square force... just like gravitation



- Electric charge is conserved

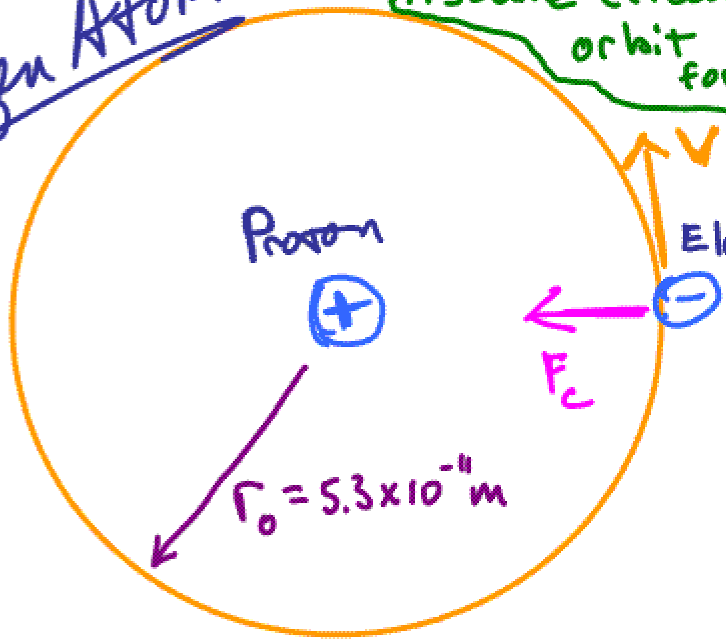
$$|e| = 1.6 \times 10^{-19}\ C$$

C ≡ coulomb not to be conf. w/ speed of light c

- Electric charge is quantized

Hydrogen Atom

Assume circular orbit for now



F_c = Centripetal force

$$F_c = \frac{k|e|^2}{r_0^2} \quad \text{Coulomb}$$

$$= \frac{m_e V^2}{r_0} \quad \text{Newton}$$

$$\frac{k|e|^2}{r_0^2} = \frac{m_e V^2}{r_0}$$

Plug in

$$\left(\begin{array}{l} M_e = 9.11 \times 10^{-31}\ \text{kg} \\ k = 8.99 \times 10^{9}\ \frac{\text{Nm}^2}{\text{C}^2} \\ r_0 = 5.3 \times 10^{-11}\ \text{M} \\ |e| = 1.6 \times 10^{-19}\ \text{C} \end{array} \right)$$

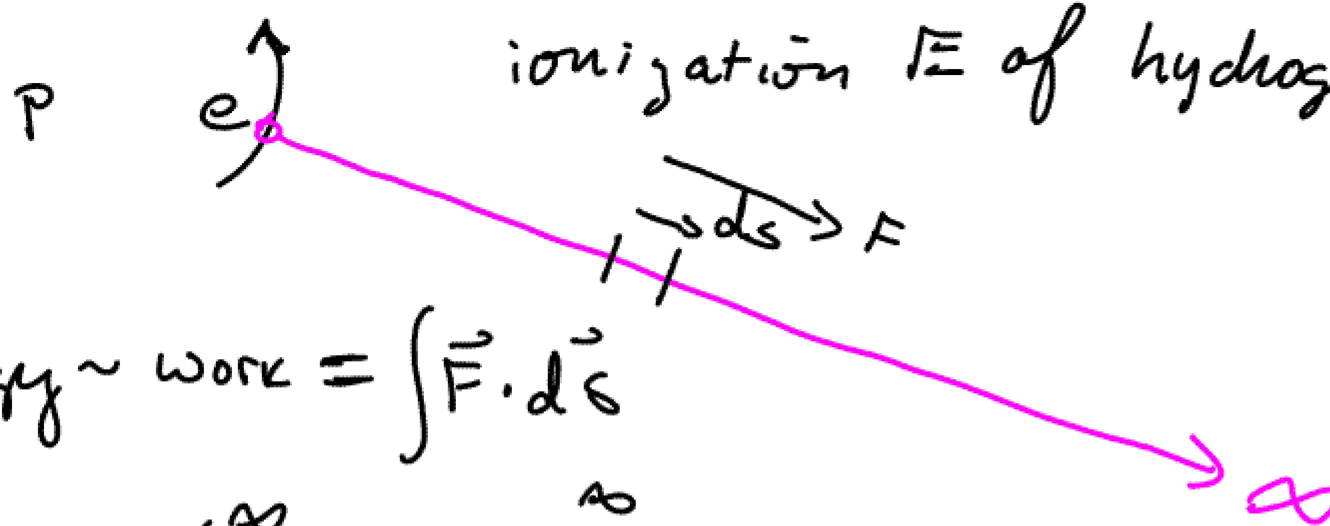
Solve for V

Rough value for velocity of e^- in H atom in "Bohr model" ground state

later in term

$$V = 2.2 \times 10^{6}\ \text{m/s} \sim 1\%\ \text{speed of light}$$

ionization E of hydrogen



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

$$\text{Work} = \int_{r_0}^{\infty} \vec{F} \cdot d\vec{s} = \int_{r_0}^{\infty} \frac{k|e|^2}{r^2} dr = k|e|^2 \underbrace{\int_{r_0}^{\infty} \frac{dr}{r^2}}_{\left. -\frac{1}{r} \right]_{r_0}^{\infty}}$$

$$w = k|e|^2 \left[\underbrace{-\frac{1}{\infty}}_{0} + \frac{1}{r_0} \right] = \frac{k|e|^2}{r_0} = 4.3 \times 10^{-18}\ \text{J}$$

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

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

True value ionization E hydrogen
13.6 eV

e^- already moving – must take this into account

$$KE = \frac{1}{2} M_e V^2 = \frac{1}{2}\left(9.11\times10^{-31}\,\text{kg}\right)\left(2.2\times10^{6}\,\text{m/s}\right)^2$$

$$= 13.6 \text{ eV}$$

$$E_{\text{ionization}} = 26.9\text{ eV} - 13.6\text{ eV}$$

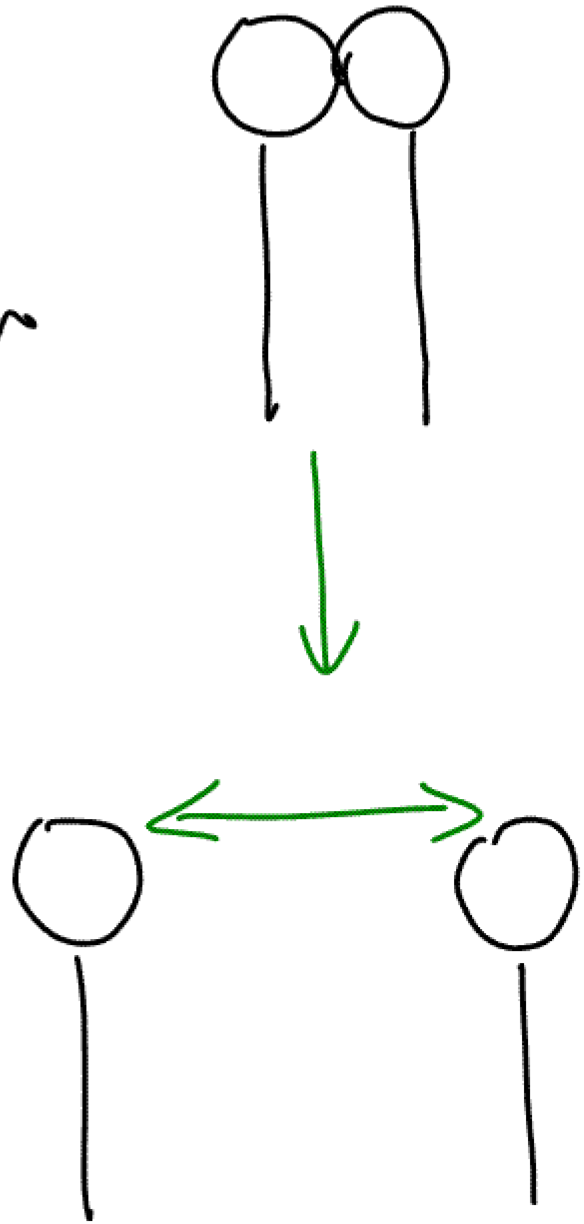
$$= 13.3 \text{ eV}$$

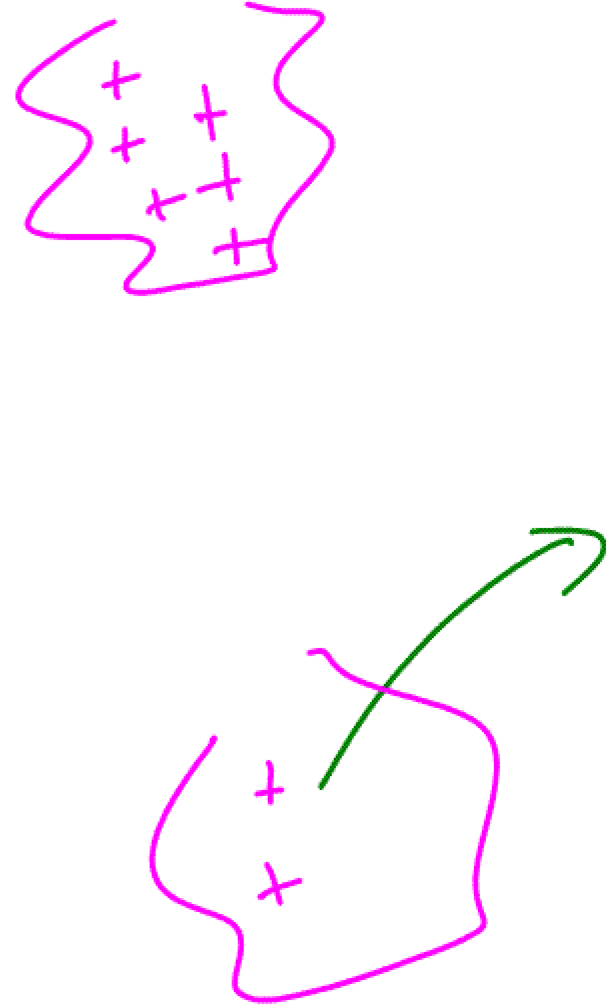
Fairly close to Accepted value

Wow!

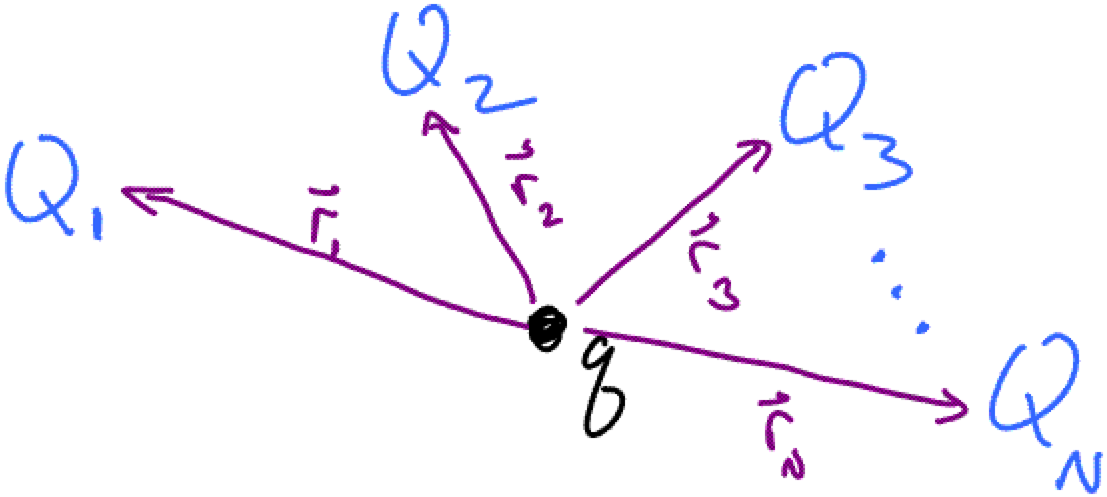
physics is Sooo cool!

charging by induction demo





Electrostatics is a Vector force

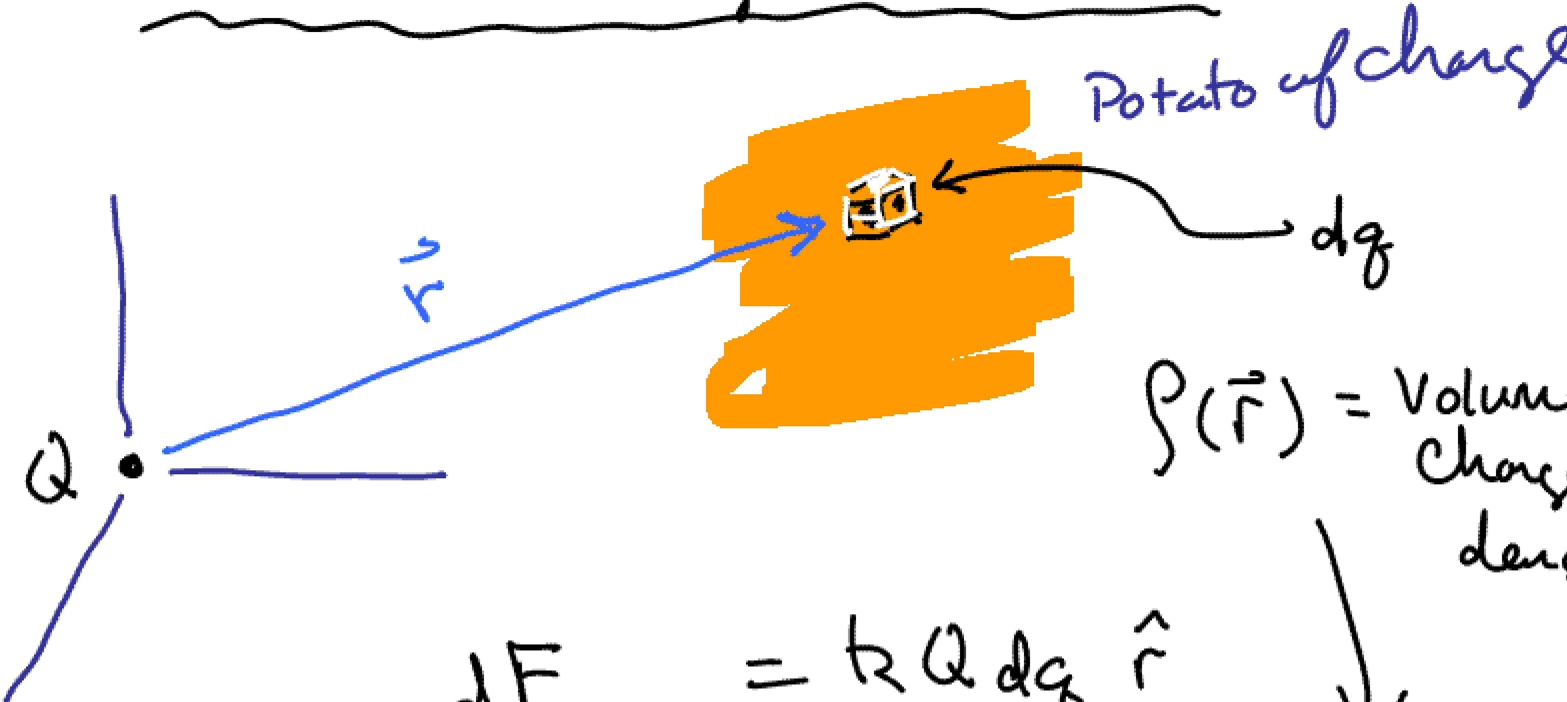


Force on q due to discrete Point charges

$$\vec{F}_{NET} = \vec{F}_{Q_1} + \vec{F}_{Q_2} + \cdots + \vec{F}_{Q_N}$$

$$\vec{F}_{NET} = \frac{kQ_1 q}{r_1^2}\hat{r}_1 + \frac{kQ_2 q}{r_2^2}\hat{r}_2 + \cdots + \frac{kQ_N q \hat{r}_N}{r_N^2}$$

Continuous charge distribution



$\rho(\vec{r})$ = volume charge density

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

$$dF_{q \text{ due to } dq} = \frac{kQ\,dq}{r^2}\,\hat{r}$$

$$\left(\vec{F} = \int_{\substack{\text{charge}\\ \text{volume}}} \frac{kQ\,dq}{r^2}\,\hat{r} \right)$$

$$\boxed{\vec{F} = \int_{\substack{\text{charge}\\\text{volume}}} \frac{kQ\rho(\vec{r})\,dv}{r^2}\,\hat{r}}$$

Volume charge distribution

ρ vol charge density

coul/M^3

Plane or Surface charge distribution

σ surf. chg density

coul/M^2

linear charge distribution

λ linear chg density

coul/M

$+q$ — $\vec{E} = \dfrac{kQq}{r^2}\hat{r} \Big/ q$

$$\vec{E} = \frac{kQ}{r^2}\hat{r}$$

$\vec{E} \equiv$ Electric field $\equiv \vec{F}/q = \dfrac{\text{Force}}{\text{charge}}$ on a "+" Test charge placed at the given Point

Fields are nothing New to you...