Physics 114 - February 9, 2006

Class Stuff:

Exam 1 Time change
Will take place at 12:30 in Hoyt
NOT at 8am as stated in Syllabus

Interested in being a
Physics lab TA or Workshop leader?
→ See link on class web page

Project info sent via email
and posted on Web site

Hand out study group Announcements

Last Time:

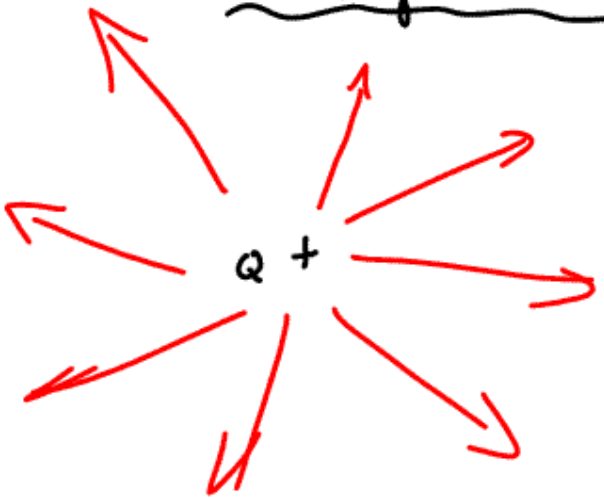
More work w/ Gauss' Law

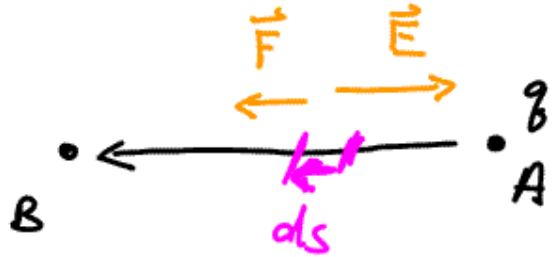
$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$

Along the way

- $\vec{E} = 0$ inside conductor (electrostatics)
- Excess charge on a conductor resides on the surface

Energy + Potential in Electrostatics





move along radial line

You move test charge q from point A to point B

how much work do you do?

$$W = \int_{r_A}^{r_B} \vec{F} \cdot d\vec{s} = \int_{r_A}^{r_B} F\,ds = \int_{r_A}^{r_B} qE\,ds = -\int_{r_A}^{r_B} qE\,dr$$

$\vec{F}$ is in same direction as Movement $d\vec{s}$

So $\vec{F} \cdot d\vec{s} = F\,ds$

$F = qE$ in Magnitude (direction already Accounted for in dot Product)

r gets smaller as s gets Bigger because Moving toward Q

$$-\int_{r_A}^{r_B} qE\,dr = -kqQ\int_{r_A}^{r_B}\frac{1}{r^2}\,dr = \left[\frac{kqQ}{r}\right]_{r_A}^{r_B} = \frac{kqQ}{r_B} - \frac{kqQ}{r_A}$$

Substitute for E

$$\int x^n dx = \frac{x^{n+1}}{n+1}$$

NOW - $r_B < r_A$ so 1ST term is larger

So work done is positive!

HAS to be this way because you MUST put work/energy into the system to move + test charge closer to +Q.

$\frac{W}{q}$ = Potential difference

$$\frac{W}{q} = kQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

$\Delta V = V_B - V_A = V_{AB}$ = Potential difference

1 Volt = $\frac{1 \text{ Joules}}{1 \text{ Coulomb}}$

Man of the Hour

1 Volt = 1 Joule/Coulomb

Count Alessandro Giuseppe Antonio Anastasio Volta

Como, Lombardy, Italy

1745 – 1827

Invented the Voltaic pile forerunner of the modern battery

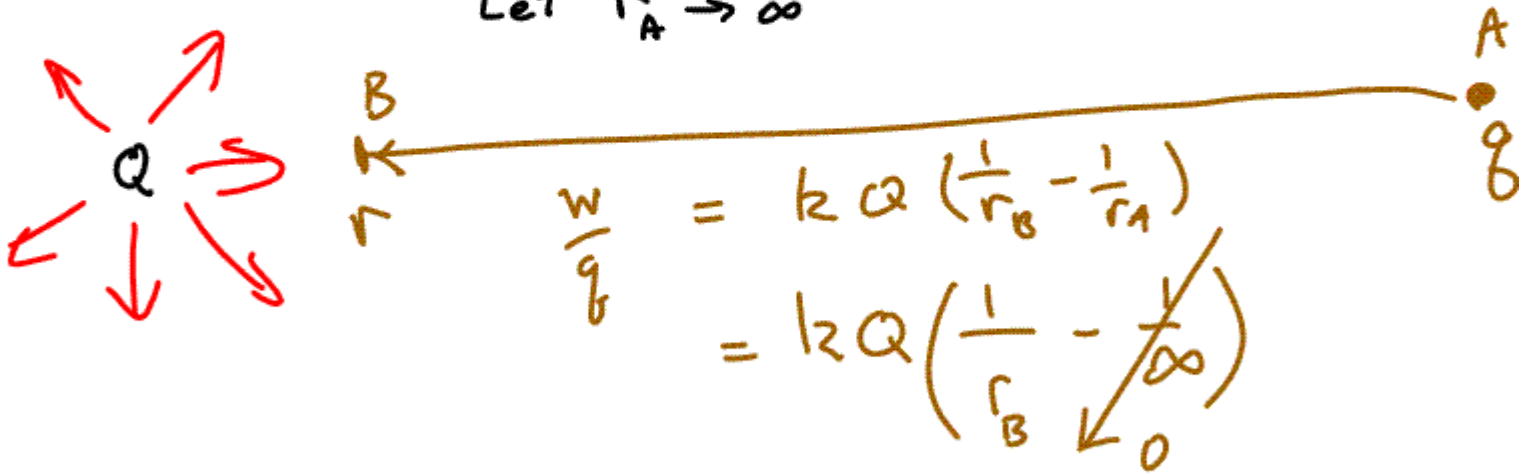
hopefully this man didn't go thru his whole life this pissed off

Mechanics

$$\Delta PE_{grav} = mgh$$

define potential to zero at ∞

LET $r_A \to \infty$



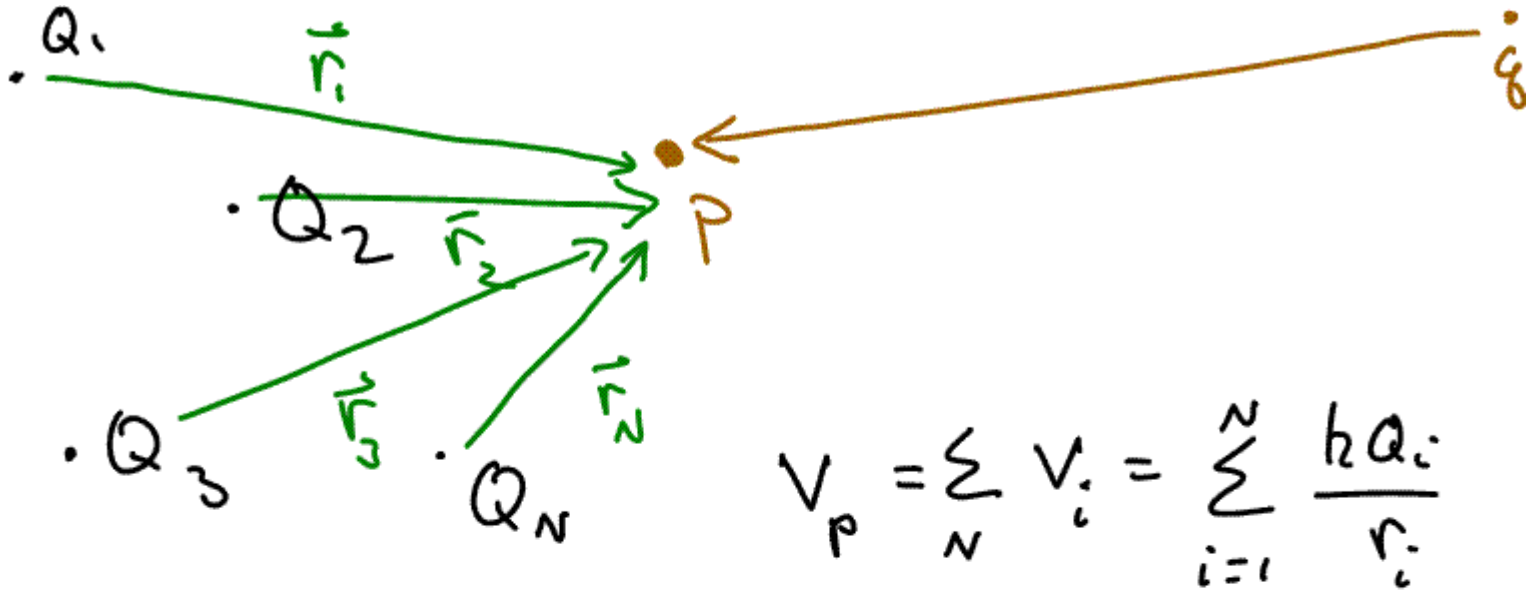
$$\frac{W}{q} = kQ\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

$$= kQ\left(\frac{1}{r_B} - \frac{1}{\infty}\right)$$

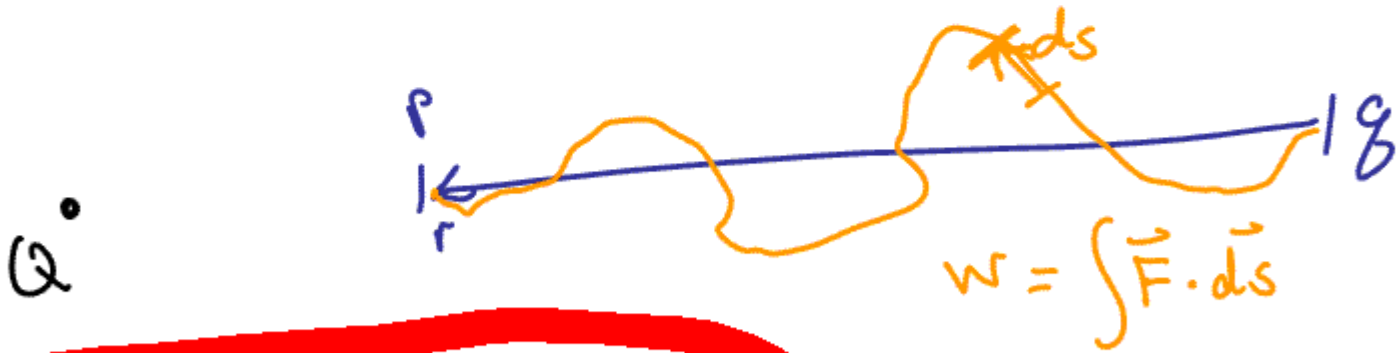
$$= kQ\left(\frac{1}{r_B} - 0\right)$$

$$V(r) = \frac{kQ}{r}$$

Potential of a point charge



$$V_P = \sum_N V_i = \sum_{i=1}^{N} \frac{kQ_i}{r_i}$$



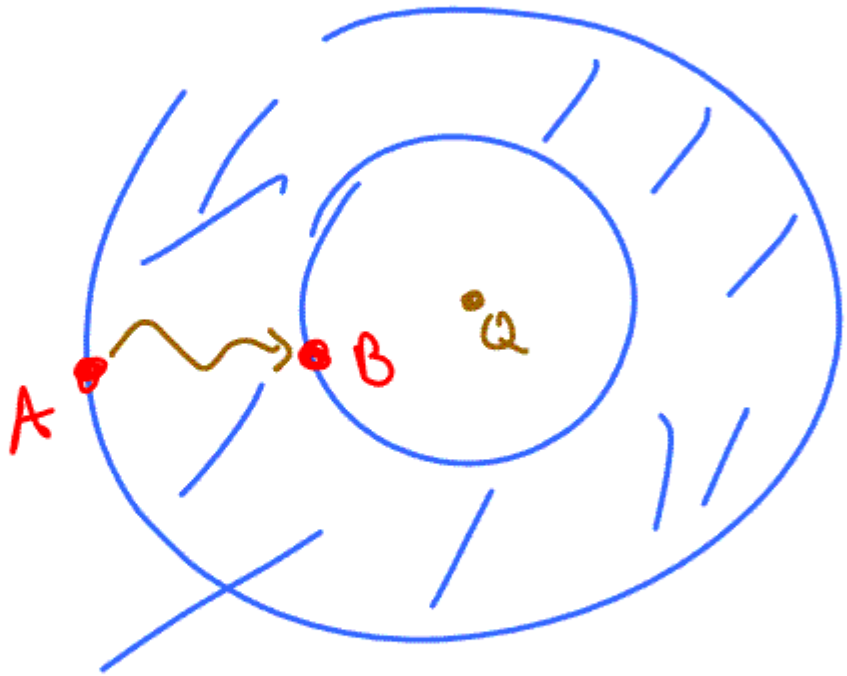
$$W = \int \vec{F} \cdot d\vec{s}$$

Electrostatics is Path Independent

Conservative Force

Potential only depends on position

Work = 0
due to $E = 0$



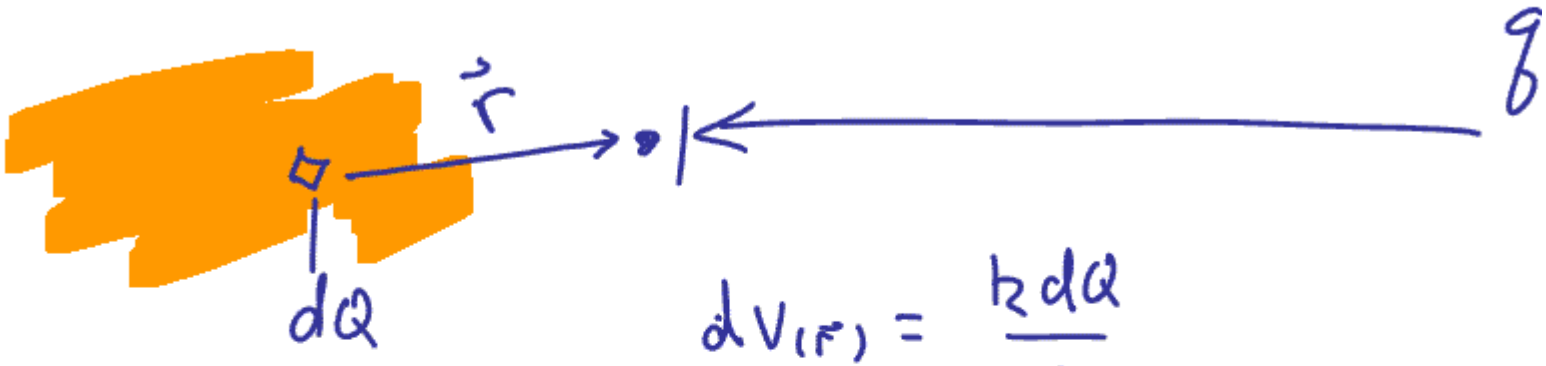
Conductor

$\vec{E} = 0$

Electrostatic

Conductor is all at one potential

Equipotential Surface



$$dV_{(r)} = \frac{k\,dQ}{r}$$

$$V_r = \int_{Vol} \frac{k\,dQ}{r} \qquad dQ \sim \rho\,dv$$

Potential is easier to calculate than $\vec{E}$

$$\vec{E} = \int_{Vol} \frac{k\,q\,dQ}{r^2}\,\hat{r}$$

$$V = \frac{W}{q} \qquad dV = \frac{dW}{q} = -\vec{E}\cdot d\vec{s} = -E_s\, ds$$

AND I can get E from V !

$$dV = -E_s\, ds$$

$$E_s = -\frac{dV}{ds}$$

$\vec{E}(x,y,z)$ $\quad V(x,y,z)$

$$E_x = -\frac{dV}{dx} \qquad E_y = -\frac{dV}{dy} \qquad E_z = -\frac{dV}{dz}$$

$$V \begin{matrix} x \\ y \\ z \\ r \end{matrix} = -\frac{dV}{ds} = E_s$$

$V(x,y,z)$

$\vec{A} = A_x\hat{i} + A_y\hat{j} + A_z\hat{k}$

$$E_x = -\frac{\partial V}{\partial x}$$

$$E_y = -\frac{\partial V}{\partial y}$$

$$E_z = -\frac{\partial V}{\partial z}$$

NOT For This Course

Just so you've seen it once

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

vector operator

$$\vec{\nabla} = \text{DEL} = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

$$\vec{E} = -\vec{\nabla}V = -\text{grad}(V)$$

Bottom Line:

The component of the electric field in a given direction is equal to the negative derivative of the potential (slope) with respect to that direction/variable

$$E_s = -\frac{dV}{ds} \qquad E_x = -\frac{dV}{dx}$$

$$E_y = -\frac{dV}{dy}$$

$$E_r = -\frac{dV}{dr}$$

V is a scalar.
Magnitude only! Can get from Energy Considerations
Thus often easy to calculate
Then get E by taking derivative