Physics 142 - September 22, 2005

Electric Potential, capacitance electron-Volts

Last time:

Potential in Space abt point Charge -

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

Potential near series of discrete charges -

$$V_p = \sum_i \frac{kQ_i}{r_i}$$

Potential due to continuous charge distribution -

$$V_p = \int_{\text{distribution}} \frac{k\,dQ}{r}$$

Potential difference is path Independent

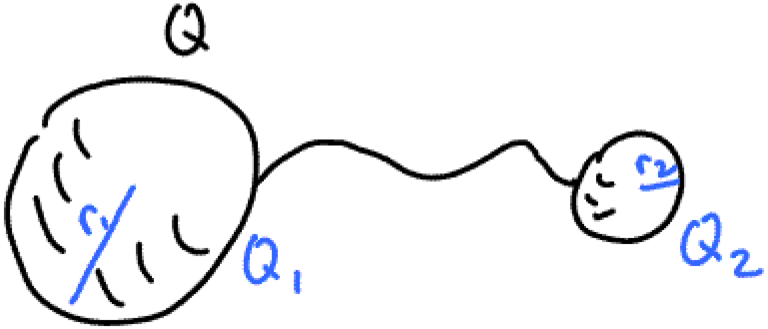
i.e. electric force is Conservative

$$\boxed{\vec{E} = -\vec{\nabla} V}$$

Game is to get $\vec{E}$
can do directly
might be easier to get
by calculating V and
then using $\vec{E} = -\vec{\nabla} V$

PRS problem

2 conducting
spheres. large one
w/ charge Q
Small one uncharged.



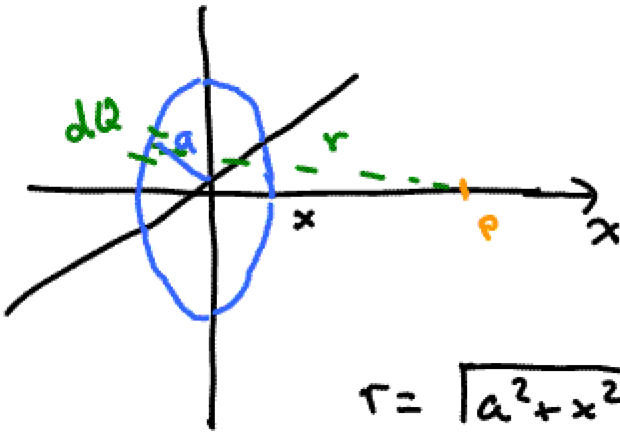
Spheres connected by a conducting wire.

How is Q divided between the spheres?

$$V_1 = \frac{kQ_1}{r_1} \qquad V_2 = \frac{kQ_2}{r_2}$$

$$\frac{kQ_1}{r_1} = \frac{kQ_2}{r_2} \qquad \frac{r_2}{r_1} = \frac{Q_2}{Q_1}$$

uniformly charged ring



V_P ? $\vec{E}_P$?

$dQ = \lambda ds$

$$V = \int \frac{k\,dQ}{r} = \frac{k\lambda}{\sqrt{x^2+a^2}} \int_0^{2\pi a} ds$$

$r = \sqrt{a^2+x^2}$

$= \text{const}$

$$V_P = \frac{k\lambda 2\pi a}{\sqrt{x^2+a^2}} = \frac{kQ}{\sqrt{x^2+a^2}}$$

$x \gg a \qquad V_P \rightarrow \dfrac{kQ}{x}$

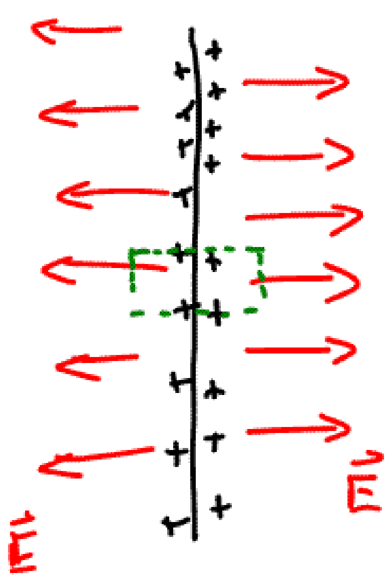
symmetry $\rightarrow$ $\vec{E}$ in $\hat{x}$ direction

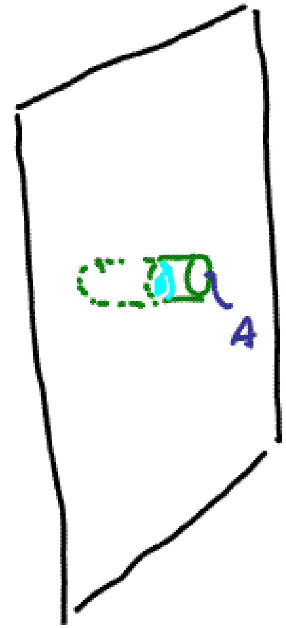
$$\vec{E}_P = -\frac{dV_P}{dx} = \frac{kQx}{(x^2+a^2)^{3/2}}\,\hat{x}$$

large x $\quad \vec{E}_P \rightarrow \dfrac{kQ}{x^2}\,\hat{x}$

Area chg density σ ∞ plane of charge

use E to get V

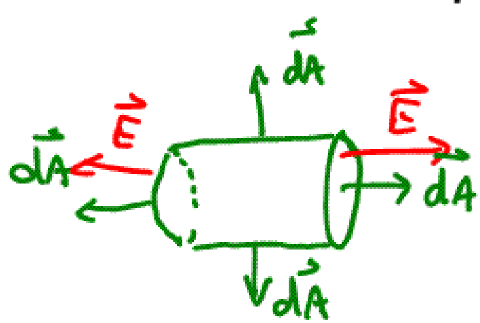




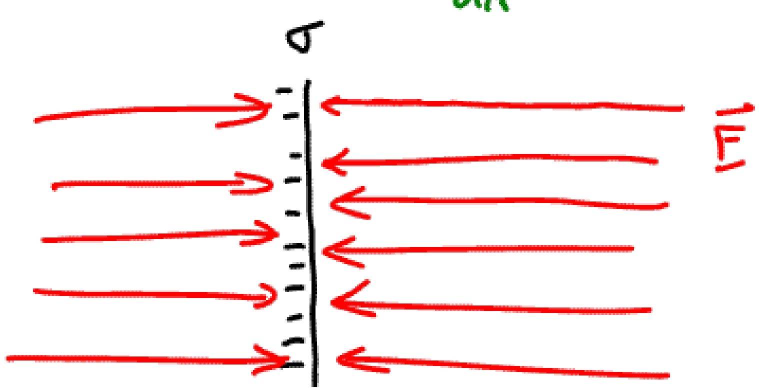
$$\int \vec{E}\cdot d\vec{A} = 2|E|A$$

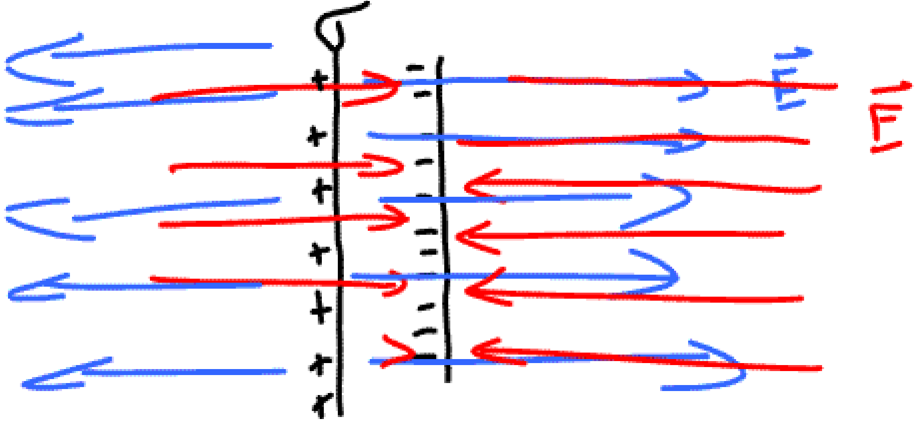
$$\frac{Q_{encl}}{\epsilon_0} = \frac{\sigma A}{\epsilon_0}$$

$$|E| = \frac{\sigma}{2\epsilon_0}$$

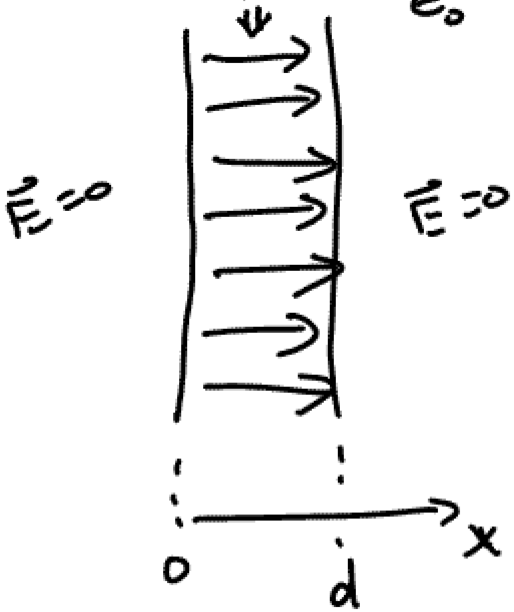


$$\int \vec{E}\cdot d\vec{A} = \underbrace{\cancel{\int_{cyl} \vec{E}\cdot d\vec{A}}}_{0} + \underbrace{\int_{endcap1} \vec{E}\cdot dA}_{|E|A} + \underbrace{\int_{Ec2} \vec{E}\cdot dA}_{|E|A}$$





$\vec{E} = \sigma/\epsilon_0$

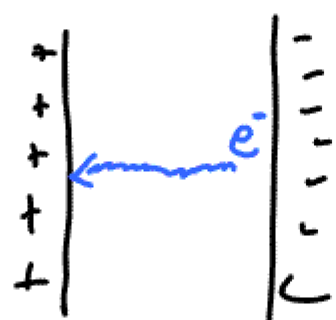


from 0 – d

$$V_{\text{bet plates}} = -\int \vec{E}\cdot d\vec{s} = -|E|d$$

$$\Delta V_{\text{bet plates}} = |E|d = \frac{\sigma d}{\epsilon_0}$$

$\Delta V = 1$ Volt



how much energy does it gain

electron-Volt $\equiv$ eV

$$\text{Potential diff} = \frac{\text{Work}}{\text{Charge}} = \frac{\text{Joule}}{\text{Coul}} \equiv \text{Volt}$$

e^- gains 1eV of energy

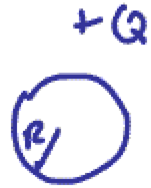
$$\text{Work} \sim \text{energy} = (\Delta V)|q|$$

$$1\,eV = (1|e|)(1\text{ Volt}) = (1.6\times 10^{-19}\text{ Coul})(1\text{ Volt})$$
$$= 1.6\times 10^{-19}\text{ Joules}$$

$$E = Mc^2$$

$$eV \qquad M = eV/c^2 \qquad M_{proton} = 938\ MeV/c^2$$

Sometimes people are informal or working in System of units w/ $c=1$ and Mass $\sim$ eV



$$V_+ = \frac{kQ}{R}$$

$$V_- = \frac{-kQ}{R}$$

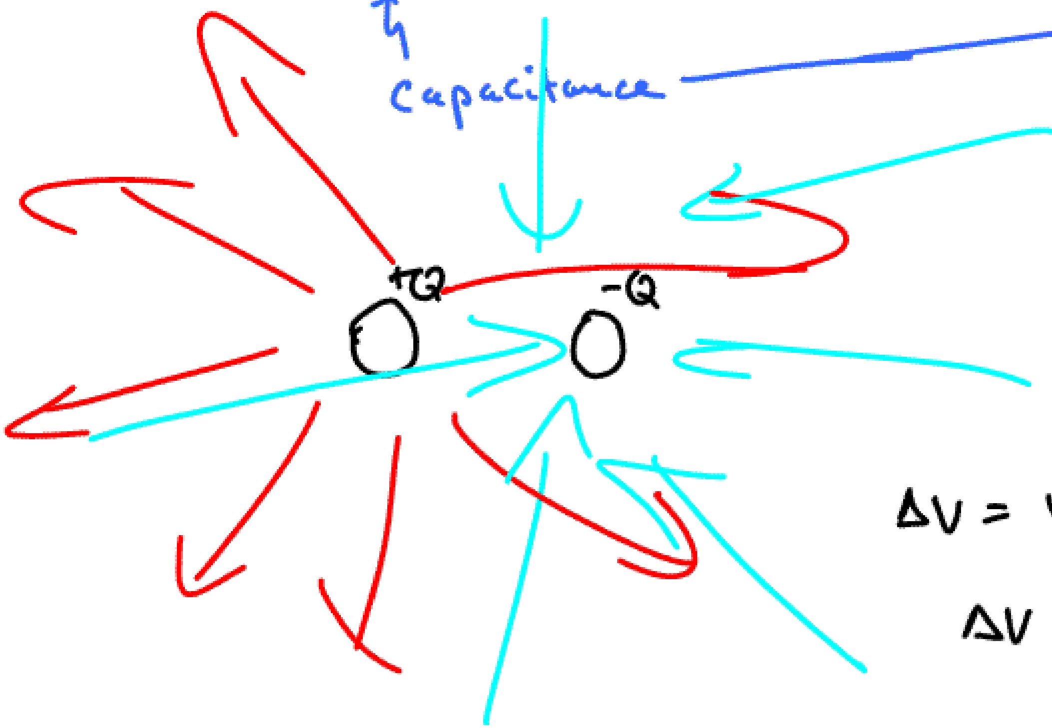
$V_+ \propto Q$

$V_+ = C_+ Q$

$V_- \propto Q$

$V_- = C_- Q$

capacitance



$|V_{syst}| < |V_{\pm}|$

$\Delta V = V_+ - V_-$

ΔV reduced

$$C = \frac{Q}{\Delta V}$$

$$Q = CV$$

Capacitance

$\equiv$ Geometry