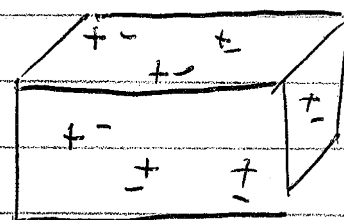
① Phys 1402 2017-09-12 Lec 3

Equation Sheet posted w/ Lecture Notes
HW1 on WebAssign due Wed 9/20 night

Conductors & Insulators

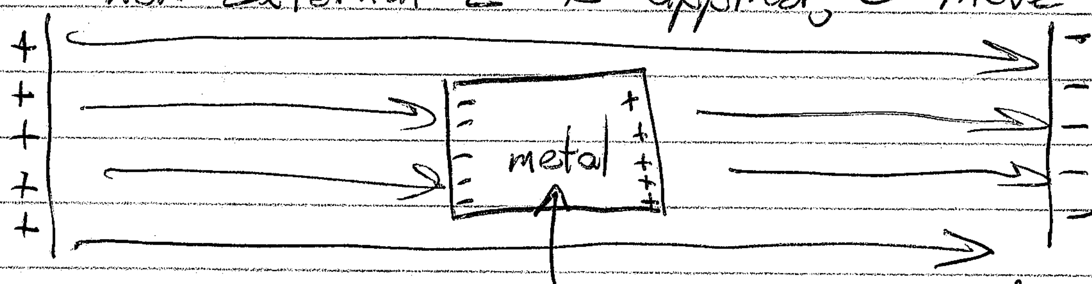
All materials made of ⊕ & ⊖



⊕ are stationary in solids.
⊖ depend on material

Insulators: ⊖ basically held in place
Small E → "stretched" like wall near balloon
Large E → Breaks chemical bonds

Conductors: Some ⊖ are mobile
When external E is applied, ⊖ move to cancel.



E = 0 in conductor

How much charge gathers?

$$E = 4\pi k \sigma$$

E outside metal ↑ ; $\sigma = Q/A$; k: $9\times10^9 \ Nm^2/C^2$

②

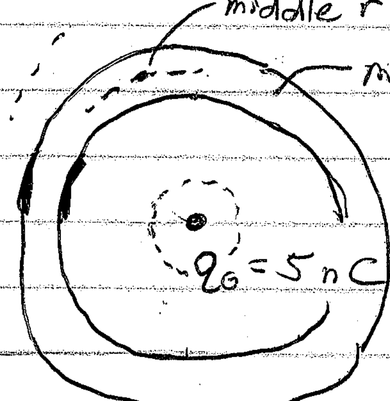
Gauss's Law: Symmetry helps

When the setup is spherically symmetric, E looks a lot like that of point charge.

$$E = \frac{k Q_{enc}}{r^2}$$

r = dist from symmetry center

Q_{enc} = charge "enclosed" by sphere of radius r



$R_{in} = 0.25$ m

$R_{out} = 0.3$ m

Net Charge of -8 nC on shell.

For small r (less than 0.25 m):

$Q_{enc} = 5\,nC$

$$E = \frac{k(5\,nC)}{r^2}$$ ($\times 10^{-9}$)

For "middle" r (In metal of shell)

$E = 0$

$Q_{enc} = 5\,nC + Q_{inner} = 0$

$Q_{inner} = -5\,nC$ on inner surface.

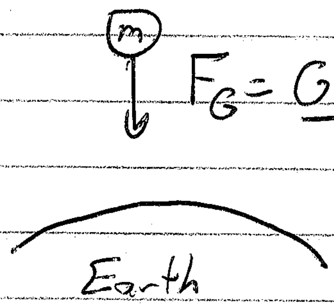
For large r (more than 0.3 m)

$Q_{enc} = 5\,nC - 8\,nC$

$= -3\,nC$

$$E = \frac{k(-3\,nC)}{r^2}$$ (inward)

Why does a ball fall?



$$F_G = \frac{GmM}{r^2}$$

Attracted to mass

$$F_g = mg$$

Pulled by grav field (g)

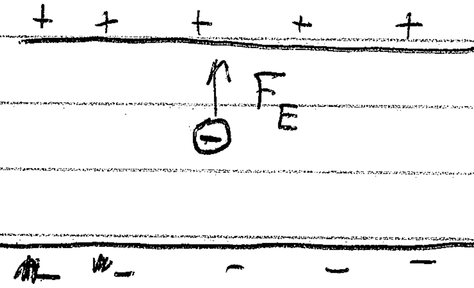
High h = High PE

$$PE = mgh$$

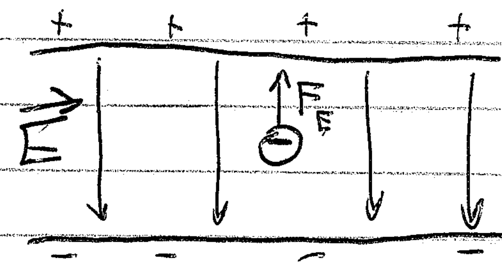
Low h = Low PE

Seeks Low PE

Why does a ⊖ move?



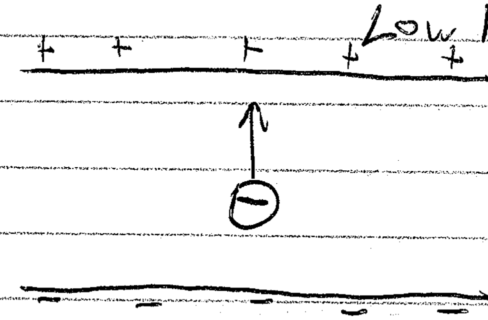
Attract to ⊕, repel from ⊖



Pulled opposite dir of $\vec{E}$

$$\vec{F} = q_0 \vec{E}$$

Low PE



High PE

For the ⊖, being near ⊕ is low PE.

Force points away from high PE, toward low PE

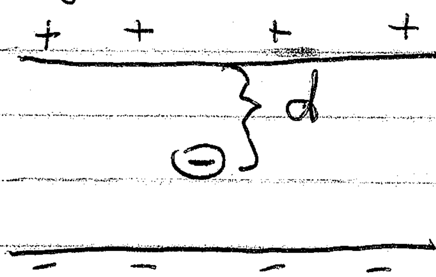
Grav field points away from high height toward low height

$\vec{F_g} = m\vec{g}$ All m are ⊕, $\vec{F_g}$, $\vec{g}$ down

$PE_g = mgh$

Elec Field points away from high V toward low V

$\vec{F_E} = q_o\vec{E}$



$PE_E = q_o E d$

(Work = $F_{avg}\,\Delta x$)

Electric Potential is Energy per unit charge.

$PE_E = q_o V$ $V = \frac{PE_E}{q_o}$

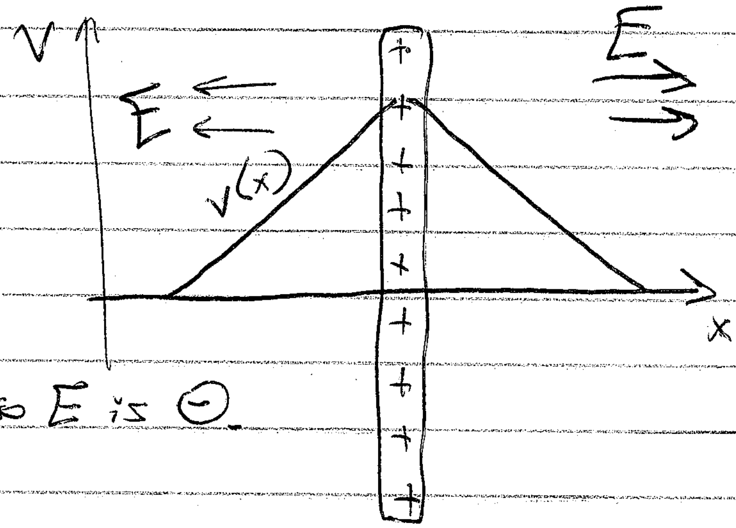
4 Different names for V:

- Electric Potential (not P.E.)
- Potential Difference
- Electromotive Force (EMF or $\mathcal{E}$)
- Voltage

All measured in volts (V).

Relationship between E and V

$$E = \frac{-\Delta V}{\Delta x}$$



On left, slope is ⊕, so E is ⊖

"E points left"

On right, slope is ⊖, so E is ⊕ and points right.

Ex: 500 V potential difference between plates 1.5 cm apart.

$$E = \frac{-\Delta V}{\Delta x} = \frac{500\ V}{0.015\ m} = 33300\ \frac{V}{m}$$

(Note: Less than a million, no spark)