 Phys 2426 2017-09-19 Lec 5

HW1-10

Gauss's Law in spherical symmetry

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

Q_{enc} = charge inside our radius

If we are @ r and Ball has R, and r is smaller:

$$Q_{enc} = \frac{r^3}{R^3} Q$$

HW1-15

$$\Delta V = -\int \vec{E} \cdot d\vec{l} = -\vec{E}_{avg} \cdot \Delta\vec{l}$$

If E is in only the x-direction

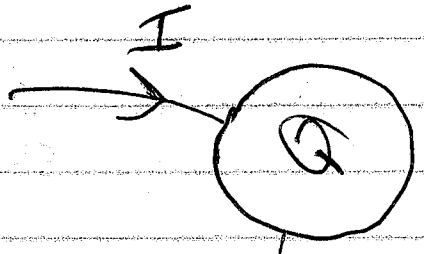
$$\Delta V = -E_x \Delta X \qquad \text{then } \Delta U = q_0 \Delta V$$

For general uniform E:
"Dot product"

$$-\vec{E} \cdot d\vec{l} = -E\,dl\cos\theta$$
$$= -E_x dx - E_y dy - E_z dz$$

Current is flow of charge,

$$I = \frac{dQ}{dt}$$



⊕ current flowing in makes Q more ⊕.

Recall, all Q made of smaller q's.

Protons: $Q = N_p(+e)$
Electrons: $Q = N_e(-e)$
Combination: $Q = (N_p - N_e)e$

Change charge: $\Delta Q = (\Delta N_p - \Delta N_e)e$

If we want $\Delta Q = ⊕$: ΔN_p is ⊕
or ΔN_e is ⊖

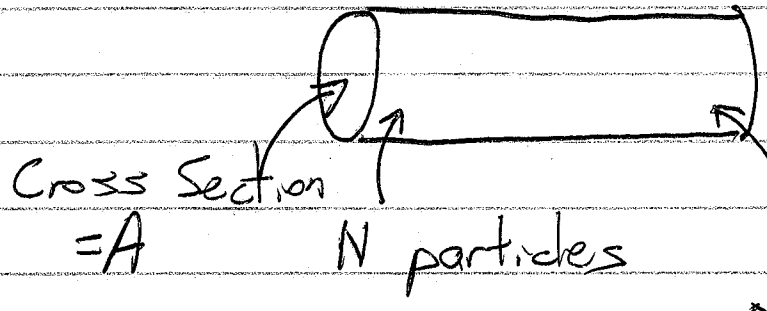
Increasing ⊕ charge caused by:
Adding ⊕
Removing ⊖
} Both are $I = ⊕$ flowing in.

When electrons form a current, they move opposite to I.

$$Q = Nq \rightarrow \frac{dQ}{dt} = \frac{dN}{dt}q$$

Drift Velocity

$$I = \frac{dQ}{dt} = q\frac{dN}{dt}$$



$\Delta Q = \rho A l$

$\therefore l = \frac{\Delta Q}{\rho A}$

$$\text{Velocity} = v = \frac{l}{\Delta t} = \frac{\Delta Q}{\rho A \Delta t} = \frac{I}{\rho A}$$

What is ρ? Density of movable charges

$$\rho = ne$$

n ← # density

Ex: Copper has $\sim 10^{28}$ electrons/m^3

$$\rho = \left(\frac{10^{28}}{m^3}\right)(1.6\times10^{-19}\ C) = -1.6\times10^{9}\ C/m^3$$

For a 1.0 A wire w/ radius 1 mm:

$I = vpA$

$$v = \frac{I}{\rho A} = \frac{(1.0\ C/s)}{(-1.6\times10^{9}\ C/m^3)(\pi(0.001\ m)^2)}$$

$$= -0.0002\ m/s = -0.2\ mm/s$$

We cannot build up Q more than ~nC.
But we often have I ~ 1.0 C/s.
All electrical systems have looping paths called circuits.

Sources - motivate current
Battery, Power Supply
EMF, Generator
Wall Outlet

Loads - use electrical energy
Resistors, Heaters
Light Bulb
Motor
Battery being Charged

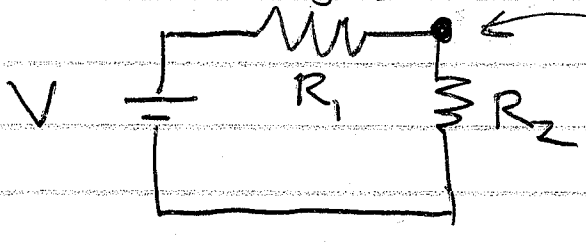
Power = Energy / Time

Resistors

$V = IR$ $\quad P = VI$

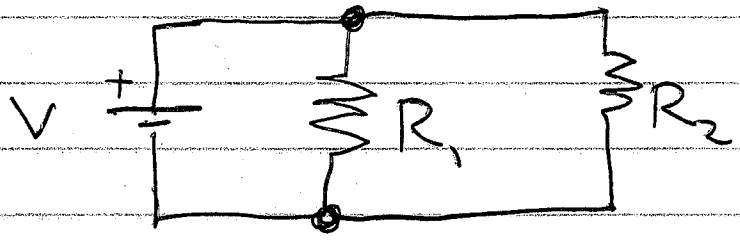
Effort = Result - Difficulty

Series - Current has no choice where to go.
Look for (or Build) a junction connecting two things.



single junction connects R_1 & R_2 (no branch)

Parallel - Current splits & rejoins.
Each bit of charge chooses a branch.



Two junctions connect R_1 & R_2