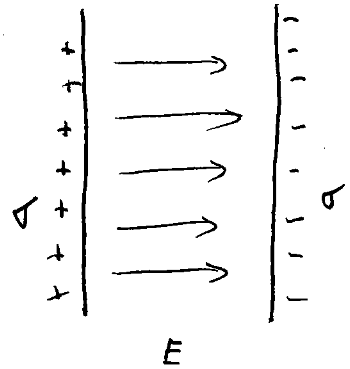
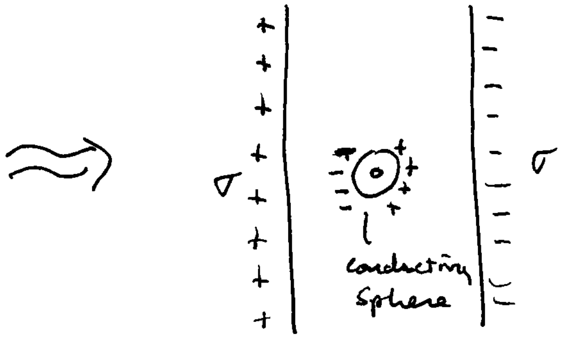
Dielectrics - insulator - charges do NOT flow freely

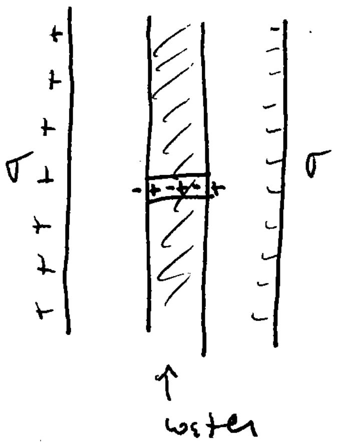
Polar vs. nonpolar

can become polarized





Force between plates (E field) increased due to induced charges

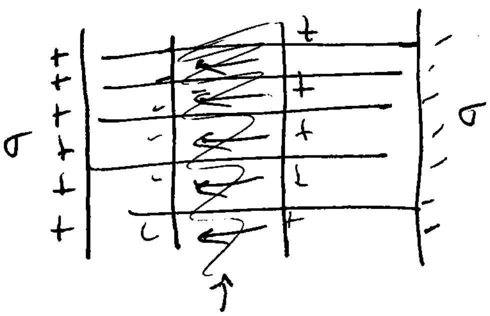


dipoles line up ... get induced surface charge

Again E at plates increased slightly

(Less than if had placed conductor)

But inside dielectric



E is reduced

So, can reduce E between plates by filling w/ dielectric

So

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

reduced by $K \equiv$ dielectric constant ≥ 1

Water $K = 80.4$

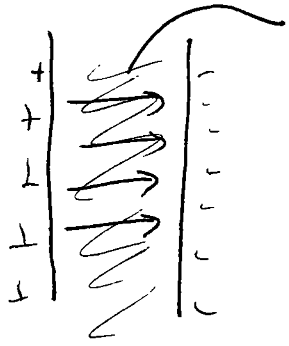
Air $K = 1.00054$

Vacuum $K \equiv 1$

Oil $K = 4.5$

Fields are affected by Medium

effect is medium-dependent



$$E = \frac{\sigma}{\kappa \epsilon_0}$$

$$dV = -\vec{E}\cdot d\vec{s}$$

$$|\Delta V| = V_{\text{between plates}} = \frac{\sigma}{\kappa\epsilon_0} d = \frac{Q}{A}\frac{d}{\kappa\epsilon_0}$$

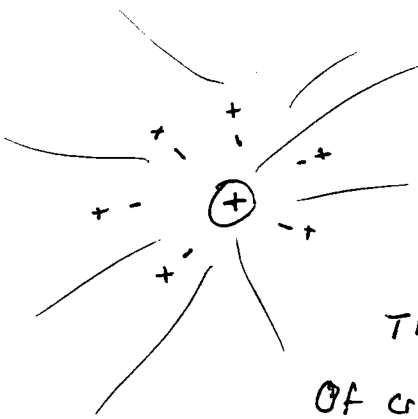
Earlier, w/ no dielectric

$Q = CV$ $\quad$ C was $\frac{\epsilon_0 A}{d}$

Now $\quad C = \frac{\kappa \epsilon_0 A}{d}$

capacitance is increased!

~~Also~~ for a pt charge imbedded in dielectric



$$E \rightarrow \frac{1}{4\pi\kappa\epsilon_0}\frac{Q}{r^2}$$

$\epsilon_0 \nearrow \kappa\epsilon_0$

This is all I will say.

Of critical importance to biology + chemistry

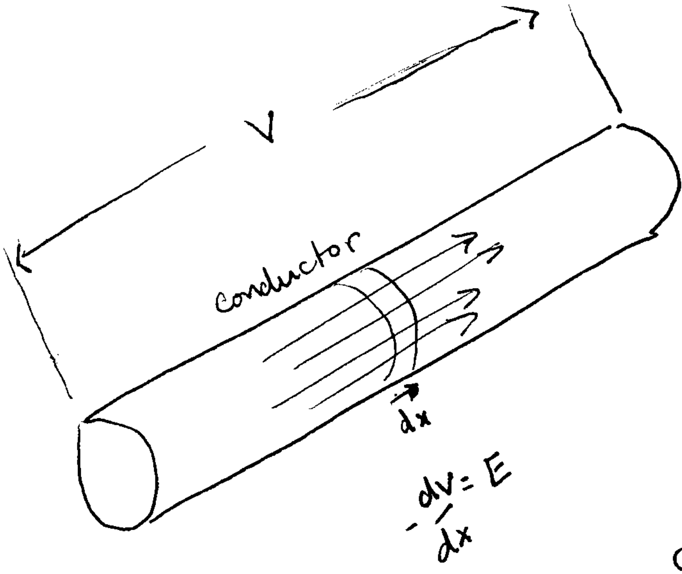
This is something you must deal w/ in real world

real solutions, real gasses, real cells, real expts.

This is the source of all sorts of impt optical effects!

~~However it isn't on the MCATS ∴ so I won't spend more lecture time on it.~~

Current and Circuits



Length Δx

use V in place of ΔV ≡ conventional way to simplify notation

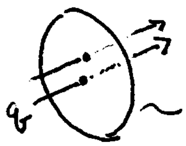
$\underline{E}$ for uniform wire

$$E = \frac{V}{L}$$

Charge flows

(Actually electrons but convention is "+"

Direction of "+" charge flow is +



~ x section of wire

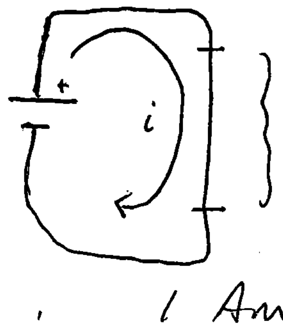
$$\frac{dq}{dt} \equiv \text{current } i$$

i is (+) in direction of + charge flow

~~If no other source~~

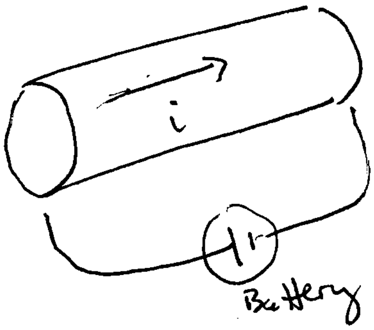
If little conductor section is isolated Then charge flows until field due to induced charges cancels initial imposed field

If not isolated but part of a circuit — charge goes around and around



} our length of wire

Current units: 1 Ampere = $\frac{1 \text{ Coulomb}}{1 \text{ Second}}$



charge is NOT continuously accelerated

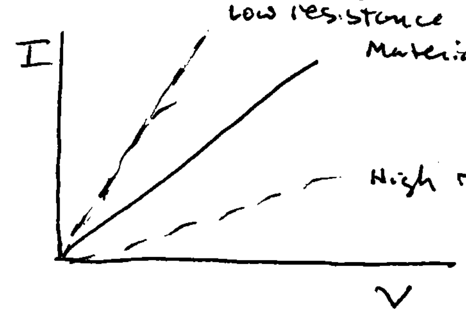
~~get a steady state equilibrium between i induced by $\vec{E}$ and lattice atoms~~

little collisions w/ atoms in the conductor lattice
Transfer energy from moving charges to the lattice (vibration + heat)

For given material get certain i for given V

For ohmic materials: $i \propto V$ or $V = iR$ (R = Resistance)

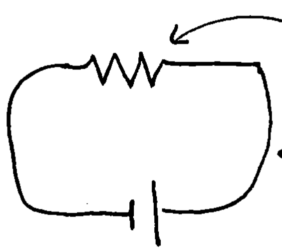
$1\,\Omega \equiv 1\ \frac{\text{Volt}}{\text{Ampere}}$ (ohm)

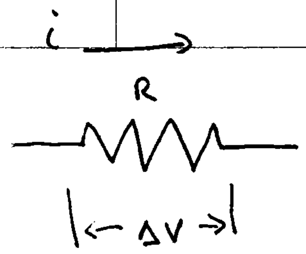


All materials have resistance except something called a "superconductor"

Except when explicitly said in problem - assume metal conductors - wires to have no/low resistance

Circuit Diagram

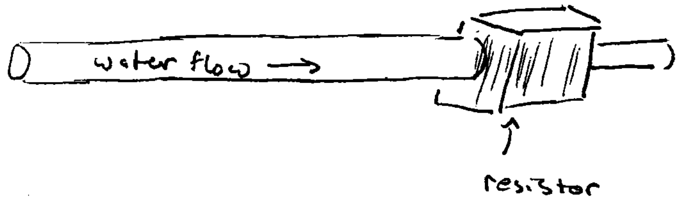


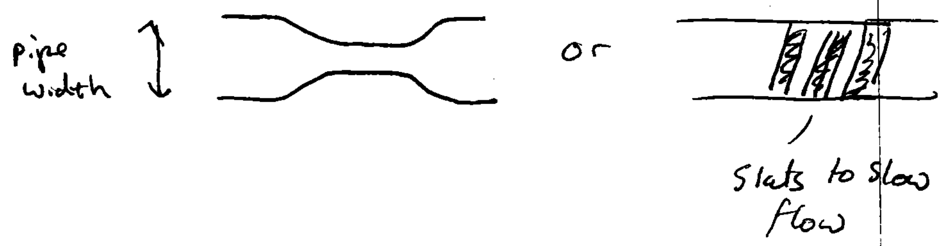


$\Delta V = V = iR$

V is said to be the "potential drop across the resistor"

useful analogy for circuits





$\frac{W}{q} = V$ across resistor

$W = qV$

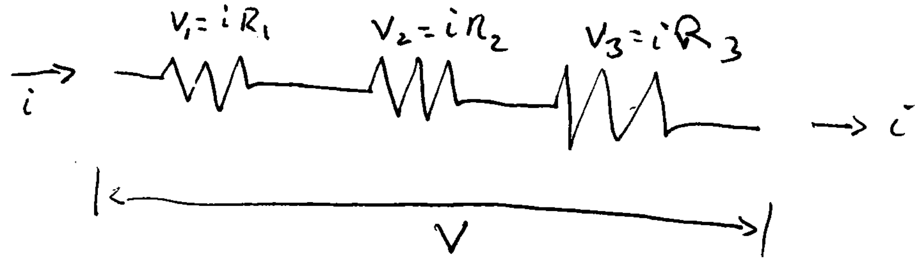
$\frac{dW}{dt} = \frac{dq}{dt} V \Rightarrow P = iV$

Power = (Current)(Voltage)

Power dissapated in resistor; Voltage across resistor

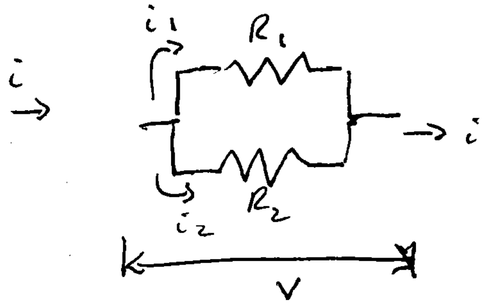
also $V = iR$ $\rightarrow$ $P = i^2 R$

Combinations of Resistors



$$V = V_1 + V_2 + V_3 = i\,(R_1 + R_2 + R_3)$$

Resistors in series: $R = R_1 + R_2 + R_3$



$$i = i_1 + i_2$$

$$V = iR$$

$$V = V_1 = i_1 R_1$$

$$V = V_2 = i_2 R_2$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

Resistors in Parallel ⟶

Batteries and EMF

Batteries + Generators : able to maintain

≡ Seats of electromotive force