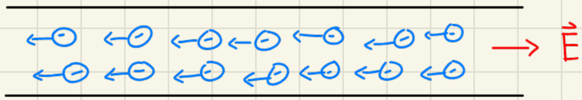
Current and resistance

- Consider a wire carrying electron with a constant electric Field $\vec{E}$ Pointing along the wire

- Since $\vec{F}_e = q\vec{E}$ each charge Feels a constant net Force opposing the direction of electric Feild



- Presume charges accelerates until they collide with something within the wire at which Point the Velocity could go any direction (and thus Velocity is zero)

- Define τ as Free time between collisions (or in other words the time between each collision)

τ = (greek symbol tow)

- Drift Velocity (V_d)
  - the V_d is termed drift Velocity it gives a measurement of an average speed of each charge

• recall the electric current is the amount of charge that passes per unit time

- hence:

$$I = qV_d \left(\frac{\#\text{ of charge}}{\text{unit length of wire}}\right)$$

• For a wire of cross-sectional area A:

$$I = qV_d N A$$

• q is a constant number equal to 1.6×10^{-19} C

- Where n is the number the number density (number of conducting charge per unit charge) the "n" can be calculated using unit conversion method or demensional analysis

• current density
- notice our current depended directely on cross-sectional area A

$$J = \frac{I}{A} = NV_d q$$

$$J = Nq\vec{V}_d$$

• combining this result with our previous equation for drift velocity that gives us

$$\sigma = \frac{nq^2 \tau}{m}$$

• conductivity
- this σ is termed conductivity
- conductivity means how good something is at conducting electricty for exampl copper is a good conducter

- notice σ depends only on intensive properties of the material
- Since τ is temperture related so is σ

- temperture increases the Frequency of collisions τ decreases and so does σ for a typical conducter

- resistivity

- the inverse of conductivity is resistivity is termed resistivity

$$\rho = \frac{1}{\sigma} = \frac{m}{n q^2 \tau}$$

that is not the letter p but greek letter rho

good conducters have big σ and small ρ, while good insulators have big ρ and small σ

- how does ohms law connect to this?

- this statement:

current density

electric Field

$$\vec{J} = \sigma \vec{E}$$

conductivity

is equaivalent to ohms law

$$\Delta V = IR$$

For:

length on material

resistance

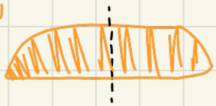
$$R = \frac{L}{\sigma A}$$

conductity

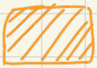
cross sectional area

• to understand what cross sectional area is imagine you you cut a loaf of bread what ever shape you have that will be the cross sectional area if you had a square then you would do length times width

loaf of bread



you cut it half



• if you look in the cut half you will see a square shape the cross sectional area is length times width

• Semiconducters

- a semiconducter is a material which can behave more like conducters (small ρ) or insulator (large ρ) depending on factors like ambient temperture

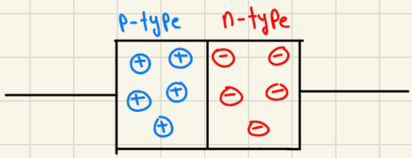
- unlike conducters where ρ typically increases with increasing temperture most semi-conducters exhibit opposing behavior with ρ increasing and temperture decreasing or vise versa

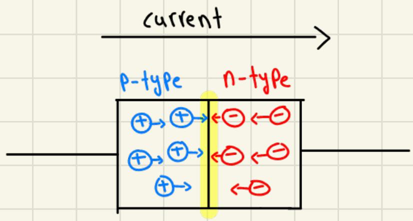
• Semiconducter material comes in two types

• diode

1) n-type, where the current is carried primarly by moving electrons just as they are in metals

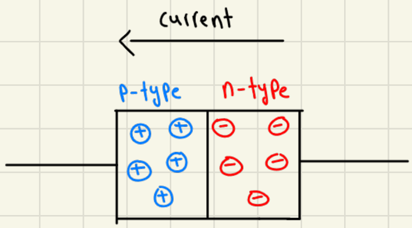
2) in p-type, the current is carried by moving "holes" these holes are places where electrons are supposed to be but aren't so you have a bunch of protons





When you send current through this diode the Positive Follows the current while the negitive turns away From it

- When the Negitive and Positive meet they release energy



again the Positive is Following the charge and the negitive is running away From it

here No energy is being released