Office hrs today: 9^{50}_{AM} - 11^{50}_{AM}
tomorrow: 2^{50} PM - 3^{50} PM
Wed: 9^{50} AM - 11^{50} AM
Th: 2^{50} PM - 4^{30} PM

* Opportunity 2 → Next Monday 11/23
* HW4 due this Friday, 11/20!

<u>Today</u>: Current, Voltage, Resistance, Resistivity (ρ)

resistance ↓

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

L ← length of wire

A ← cross sectional area

ρ ↑ material property

$$\rho - \rho_0 = \rho \alpha (T - T_0)$$

α ← temperature coefficient)

T_0 ← initial temperature (K)

?K = 273 + celsius.

ρ_0 ↑ initial resistivity

σ

Conductivity = ease at which charge moves through given material.

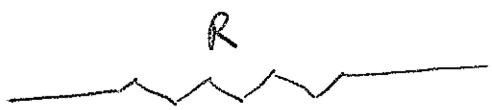
$$\sigma^e = \frac{1}{\rho} = \frac{1}{\text{resistivity}} = \text{conductivity}.$$

$$\text{Current} = I = \frac{dq}{dt} \qquad 1A = \frac{C}{s}$$

(Amps = A)

$$\text{Current density} = J = \frac{\text{current}}{\text{Area}}$$

$$I_{net} = \int J \cdot dA \qquad J = \text{may be non-uniform}$$



$$P = I^2 R = \frac{V^2}{R} = IV$$

Joule Heating ⟶ rate at which energy is dissipated across a resistor.

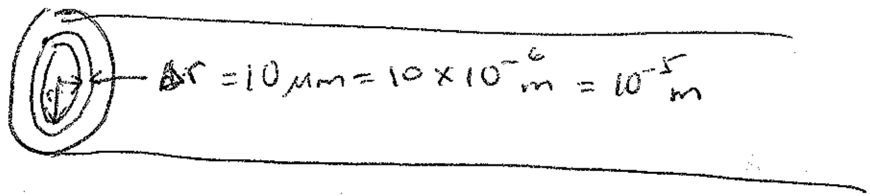
Ohm's Law: $V = IR \Rightarrow I = \frac{V}{R}$

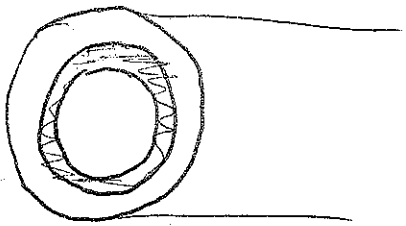
Example 26-11.) $J(r) = Br$

$B = 2 \times 10^5 \; A/m^3$

$R = 2\,mm = 2 \times 10^{-3}\,m$

How much current is contained within a the width of a thin ring concentric with the wire if ring has a radial width of $10\,\mu m$ and is at a radial distance of 1.2 mm





$r = 1.2\,mm = 1.2 \times 10^{-3}\,m$ $\qquad$ $R = 2 \times 10^{-3}\,m$

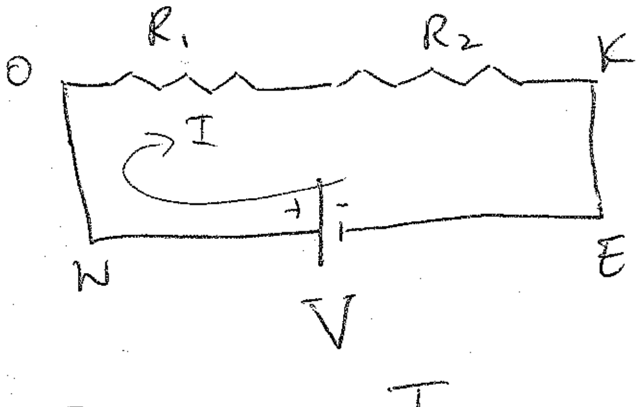
$I = \int J\,dA \qquad A = \pi r^2 \Rightarrow dA = 2\pi r\,dr$

$$I = \int_{1.2\times10^{-3}\,m}^{1.2\times10^{-3}+10^{-5}} (Br)\cdot 2\pi r\,dr = 2\pi B \int_{1.2\times10^{-3}}^{1.2\times10^{-3}+10^{-5}} r^2\,dr$$

$$I = 2\pi B \frac{r^3}{3}\Bigg|_{1.2\times10^{-3}}^{1.2\times10^{-3}+10^{-5}} = 18.1\,\mu A$$

$J = J(r) \Rightarrow$ current density non-uniform!

Series



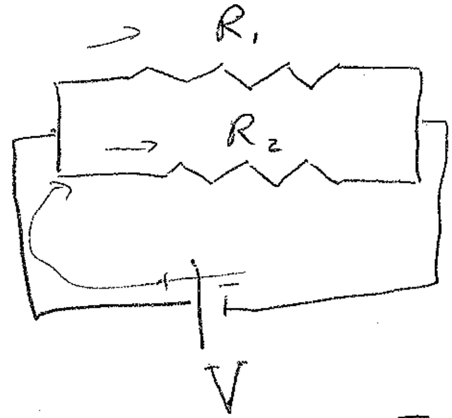
$I_1 = I_2 = I_{net}$

Loop EWOKE:

$V - V_1 - V_2 = 0$

$V = V_1 + V_2$

Parallel



$I_{net} = I_1 + I_2$

$V = V_1 = V_2$

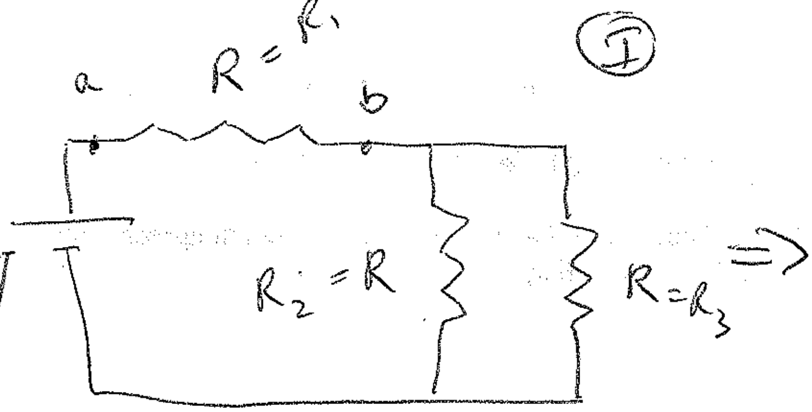
$$\frac{1}{R_{net}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$I = \frac{V}{R} \Rightarrow R = \frac{V}{I} \leftarrow$$

aside: $Q = VC \Rightarrow C = \frac{Q}{V} \leftarrow$

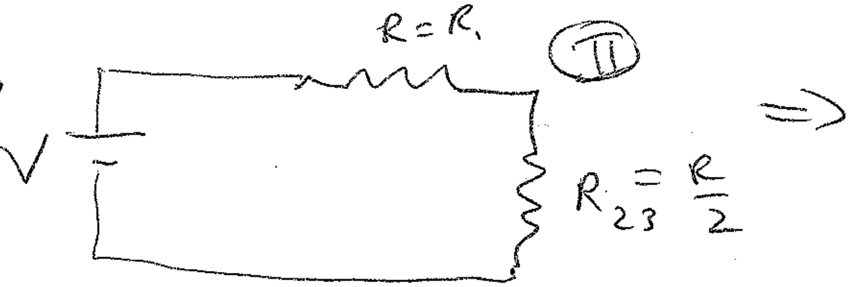
$R_{net} = R_1 + R_2$

Example:



R_2, R_3 parallel $\Rightarrow$

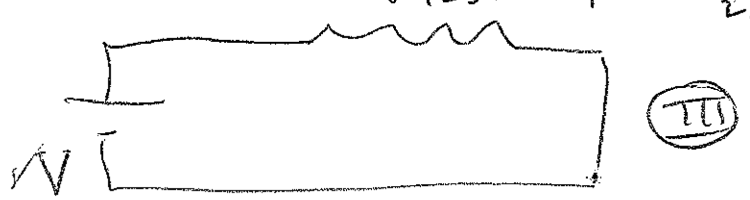
$$\frac{1}{R_{23}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$$



$$R_{23} = \frac{R}{2}$$

$$R_{123} = R_1 + R_{23} = \frac{3R}{2} \checkmark$$

R_1, R_{23} Series



$$I_{net} = \frac{V}{R_{123}} = \frac{V}{\frac{3R}{2}} = \frac{2}{3}\frac{V}{R} \checkmark$$

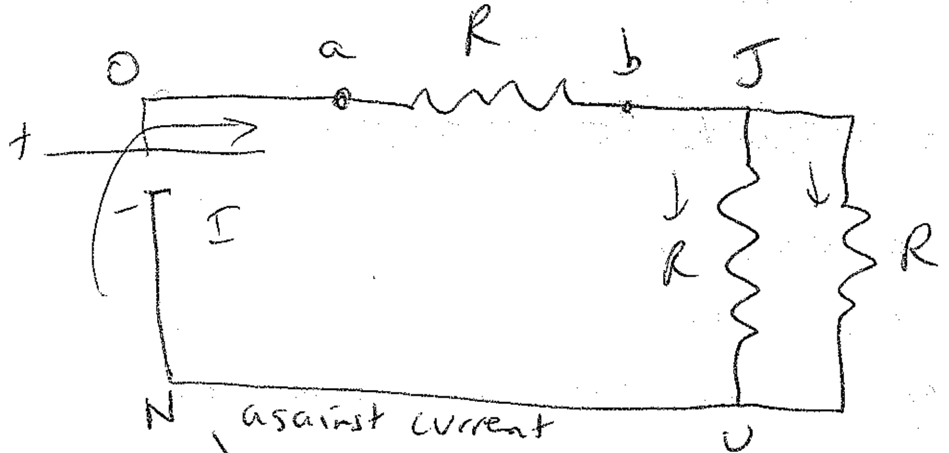
For pic II: $I_1 = I_{23} = I_{123} = I_{net} = \frac{2}{3}\frac{V}{R}$

$$V_1 = I_1 R_1 = \frac{2}{3}\frac{V}{R} \cdot R = \frac{2}{3}V$$

$$V_{23} = I_{23} R_{23} = \frac{2}{3}\frac{V}{R} \cdot \frac{R}{2} = \frac{V}{3}$$

pic I: R_2, R_3 parallel: $V_2 = V_3 = V_{23} = \frac{V}{3}$

$$I_2 = \frac{V_2}{R_2} = \frac{V/3}{R} = \frac{1}{3}\frac{V}{R} \qquad I_3 = \frac{1}{3}\frac{V}{R}$$



against current

$$V_{ab} = +I_1 R_1 = \frac{2}{3}\frac{V}{R}\cdot R = \frac{2}{3}V$$

(a: end, b: start)

Loop bJUNOa: $-I_2 R_2 + V = V_{ab}$

$$-\frac{1}{3}\frac{V}{R}R + V = \frac{2}{3}V \quad ✓$$