ELECTRIC CHARGE EXISTS & IS A FUNDAMENTAL CHARACTERISTIC OF FUNDAMENTAL PARTICLES - CHARGES WITH THE SAME SIGN REPEL EACH OTHER & THOSE WITH OPPOSITE SIGNS ATTRACT.

COULOMB'S LAW $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} = \frac{k q_1 q_2}{r^2}$

$k = 8.99 \times 10^9 \ N\text{-}m^2/C^2$

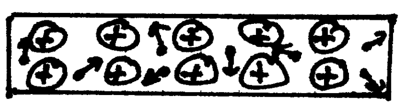
$q_{e^-} = 1.6 \times 10^{-19} C$

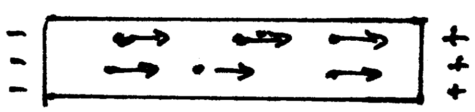
1 Coulomb = CHARGE TRANSFERRED OVER A CROSS SECTION OF WIRE in 1 SEC FOR A CURRENT FLOW OF 1 AMPERE

CHARGE PASSING in 1 SEC } $i = \frac{dq}{dt}$

ELECTRICAL CONDUCTORS

⊕ + NUCLEI
– – electrons



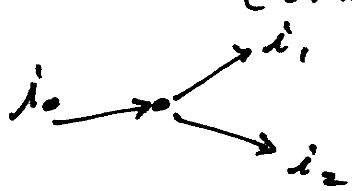


$i = \frac{dq}{dt}$ $q = \int i\,dt$

FOR ANY JUNCTION

$i_{in} = \sum i_{OUT}$

CURRENT CONSERVATION

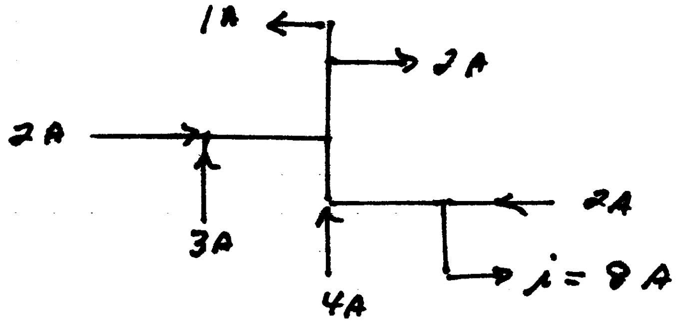


$i_0 = i_1 + i_2$

CHARGE IS CONSERVED

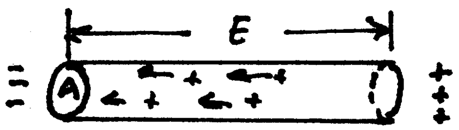
EXAMPLE I

CALCULATE i



CURRENT DENSITY

$E = \frac{\vec{F}}{q}$



$J = \frac{i}{A}$

$\leftarrow v_d$

$\leftarrow \vec{E} = \frac{\vec{F}}{q}$

$\leftarrow J = \frac{i}{A} = n e v_d$

n - # of CHG CARRIERS/VOL

e - CHG / CARRIER

v_d - DRIFT VELOCITY OF THE CARRIERS

EXAMPLE II A BEAM OF DOUBLY CHARGED + IONS CONSISTS OF 2×10^8 IONS/CC WHICH MOVE AT 10^5 m/s

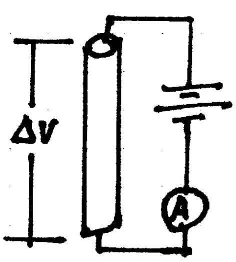
a) CALCULATE J $J = n e v_d$ (CURRENT/AREA)

$$J = \left(2 \times 10^8 \frac{\text{PARTICLES}}{cc} \times \frac{1\ cc}{10^{-6}\ m^3}\right)\left(2(1.6 \times 10^{-19} C)\right)\left(1.0 \times 10^5 \frac{m}{s}\right)$$

(2 ↑ DOUBLY CHARGED)

$= 6.4$ Amps/m^2

RESISTANCE & RESISTIVITY



$R = \frac{\Delta V}{i}$

↑

PROPERTY OF THE MATERIAL AS WELL AS THE GEOMETRY

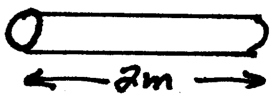
$\rho = \frac{\vec{E}}{\vec{J}}$

$R = \frac{\Delta V}{i}$ & $\rho = \frac{E}{J}$ BUT $E = \frac{\Delta V}{L}$

$$\rho = \frac{\Delta V}{LJ} = \frac{\Delta V}{L(i/A)} = \left(\frac{\Delta V}{i}\right)\frac{A}{L} = R\frac{A}{L}$$

$$\rho = R\frac{A}{L} \quad \text{OR} \quad R = \frac{\rho L}{A}$$

EXAMPLE III DETERMINE ρ



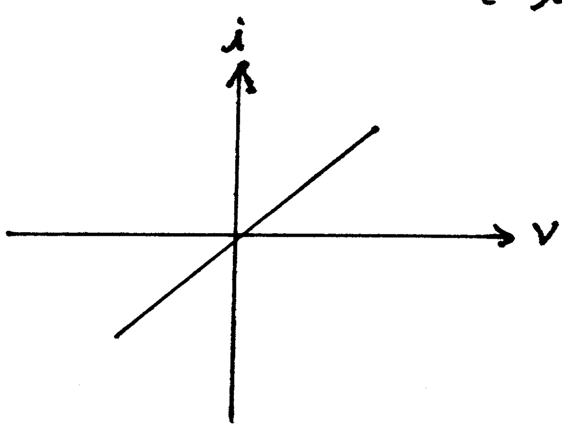
$d = 1mm$ $R = 50\ m\Omega$

$$\rho = \frac{RA}{L} = \frac{(50\times10^{-3})\left(\frac{\pi}{4}\left(1mm \times \frac{cm}{10mm} \times \frac{m}{100cm}\right)^2\right)}{2mm}$$

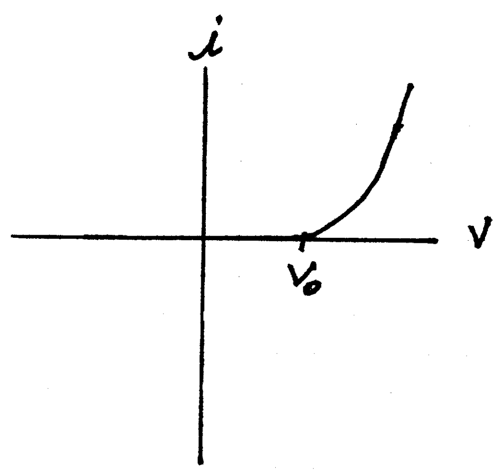
$\rho = 19.6\times10^{-9}\ \Omega\text{-}m$

OHM'S LAW

$E = iR$



METALS

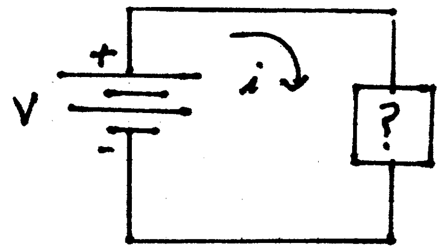


SEMI CONDUCTORS

A CONDUCTING MATERIAL (METALS FOR EXAMPLE) OBEY $V = iR$ WHEN THE ρ IS independent OF THE MAGNITUDE & DIRECTION OF V

$i = \frac{dq}{dt}$

$V = iR$



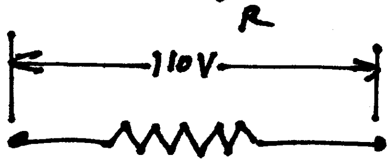
ELECTRICAL DEVICE

$U \rightarrow$ ELECTRIC P.E. $\qquad dU = dq\,V = \underbrace{i\,dt}_{q}\,V$

POWER $\rightarrow$ $\frac{\text{ENERGY TRANSFER}}{\text{TIME}} \rightarrow \frac{dU}{dt} = P = iV = i(iR) = i^2R$

$$P = Vi = i^2R = \frac{V^2}{R}$$

EXAMPLE IV



SPACE HEATER
$R = 14\,\Omega$

a) find the rate at which electrical energy is transferred into heat

$$P = \frac{V^2}{R} = \frac{120^2}{14} = 1\ \text{kW}$$

b) AT 5¢/kW-HR FIND THE ELECTRICAL COST FOR 5 HRS.

$$1\ \text{kW} \times 5\ \text{HRS} \times \frac{\$.05}{\text{kW-HR}} = 25¢$$