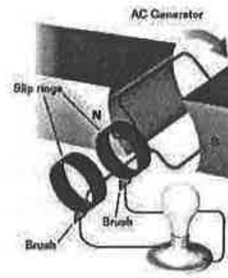
Alternating Current (AC):

current which alternates its direction of flow

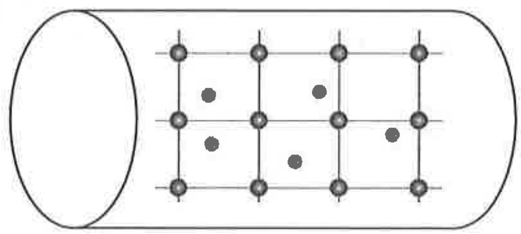



Nikola Tesla


George Westinghouse

Source of AC: AC generators
currents ⇒ homes + businesses

Model for the structure of a metal conductor (like a wire or filament)

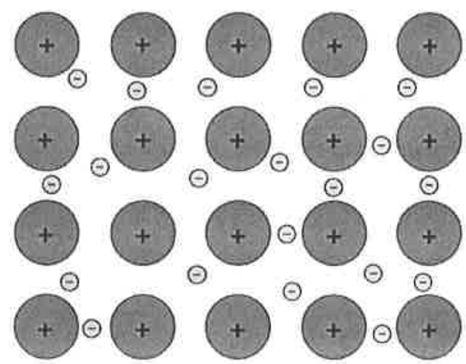


a) positive lattice ions fixed in place

b) freely moving conduction electrons that carry charge

Without an applied potential difference . . . electrons move randomly

When a potential difference is applied across the conductor . . .

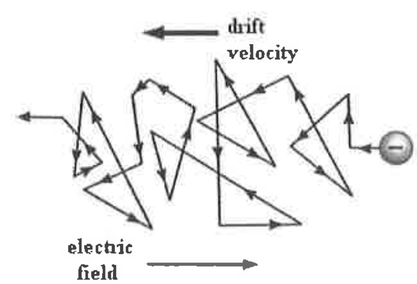


a) an electric field is set up in the conductor,

b) conduction electrons accelerate to the positive terminal

c) and collide with lattice ions thus transferring energy to them.

drift speed: net speed of conduction of electrons

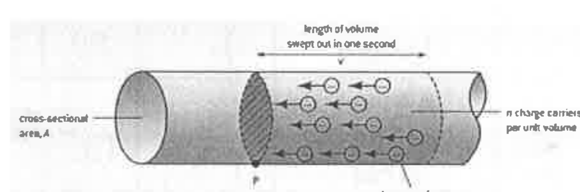


7. Compare the instantaneous speed of the conduction electrons with their drift speed.

high Instantaneous speed – 10^6 m/s

low Drift speed – one meter/hour (copper wire)

Drift Speed formula



A = cross-sectional area q = charge v = drift speed

n = charge density = number of charge carriers per unit volume (per 1 m^3 of volume)

$$I = nAvq$$

Derivation

In the figure above, charge carriers, each with chare q, move past point P with a speed v.

a) In one second, the volume of charge carriers passing P is equal to Volume = area x length = $A \cdot l$

$D = \frac{m}{V}$ b) The total number of charge carriers in this volume is (density) nAl

c) The total charge of the charge carriers in this volume is $qnAl$

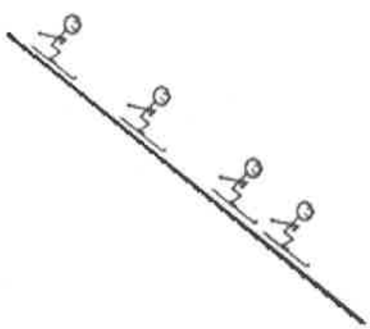
d) Therefore, the current is $I = \frac{qnA \cdot l}{t} = qnAv$

$I = \frac{q}{t}$

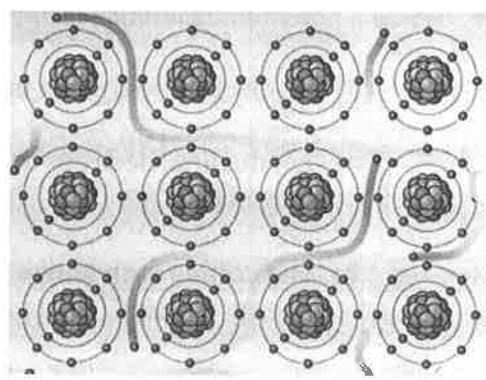
8. A copper wire of diameter 0.65 mm carries a current of 0.25 A. There are 8.5 x 10^{28} charge carriers in each cubic meter of copper. Calculate the drift speed of the charge carriers.

$A = \pi r^2$ $\quad V = \frac{I}{nAq}$ $\quad \frac{0.25A}{8.5\times10^{28}\, c/m^3\, (\pi(\frac{1}{2}\cdot .65\times10^{-3}m))^2\,(1.6\times10^{-19}C)} = 5.5\times10^{-5}\, m/s$

9. If the drift velocity is so small, why does the light bulb light as soon as the battery is connected?



Conduction electrons already in the filament start to move as soon as the electric field is set up in the circuit by the battery. It is these electrons, not the electrons from the battery, that collide with the lattice ions in the filament immediately and transfer enough energy to them to make the filament glow.

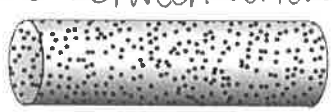


Resistance of a Wire

1. What is the cause of resistance in a wire? collisions between conduction electrons and lattice ions

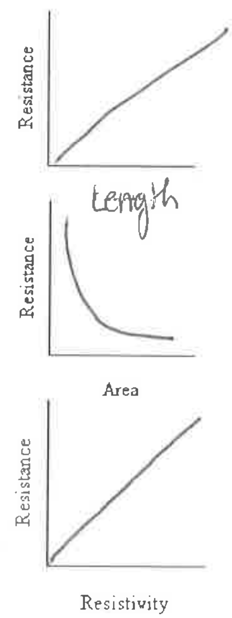
Symbol: R

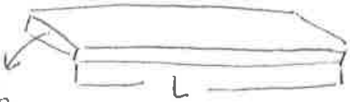
Unit: Ω ohm

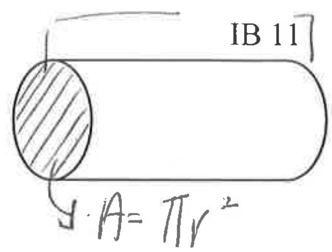


Factor	Symbol	Unit	Less Resistance	More Resistance	Relationship
Length	L	m	L_1	L_2	direct
Cross-sectional Area	A	m^2	A_1	A_2	inverse
Resistivity	ρ	Ω·m	Copper	Aluminum	direct
Temperature	T	K	T_1	T_2	—

usually higher temp = higher resistance







Formula for a conducting wire at a constant temperature . . . $R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$

2. What are the properties of wire that is the best conductor (has the least resistance)?

cold, short, wide

3. What are the properties of wire that is the worst conductor (has the most resistance)?

warm, long, thin

4. What material would you use to make a wire with the:

a) least resistance silver

b) most resistance rubber (or metal alloy nichrome)

5. What is the resistance of a copper wire 2.0 meters long with a cross-sectional area of 6.4×10^{-8} m^2?

$R = \frac{\rho L}{A} = \frac{1.68 \times 10^{-8}\,\Omega \cdot m \cdot 2.0\,m}{6.4 \times 10^{-8}\,m^2} = 0.525\,\Omega \rightarrow \boxed{0.53\,\Omega}$

~~6. a)~~ What is the resistance of a nichrome wire 12 meters long with a diameter of 2.7×10^{-4} meter?

b) If the diameter of the wire above is doubled, what is its resistance?

resistance would go down by a factor of four $R = \frac{\rho L}{\pi (2r)^2}$

Simple Circuits

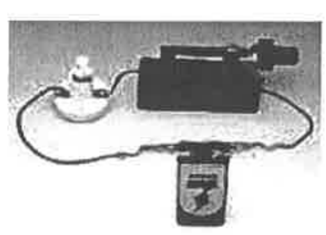
Schematic:

Draw a corresponding schematic diagram using appropriate *Circuit Symbols*.

Actual Circuit

Schematic Diagram of Circuit

Actual Circuit



Schematic Diagram of Circuit