جامعة الملك عبدالعزيز
KING ABDULAZIZ UNIVERSITY

PHYS 202

Ch. 6

Current and Resistance

Chapter 6

Chapter Six

Current and Resistance

- ***Electric Current***
- ***Current Density***
- ***Resistance and Resistivity***
- ***Ohm's Law***
- ***Power, Semiconductors, Superconductors***

Electric Current

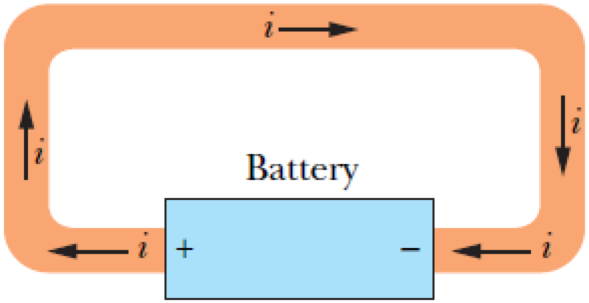
Electric Current

- Electric current i in a conductor is defined by

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

where dq is the amount of positive charge that passes in time dt.

- Direction is taken as the direction of positive charge carriers move.



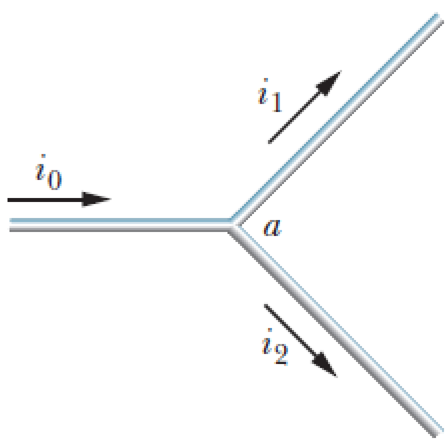
- The SI unit of electric current is Ampere (A).

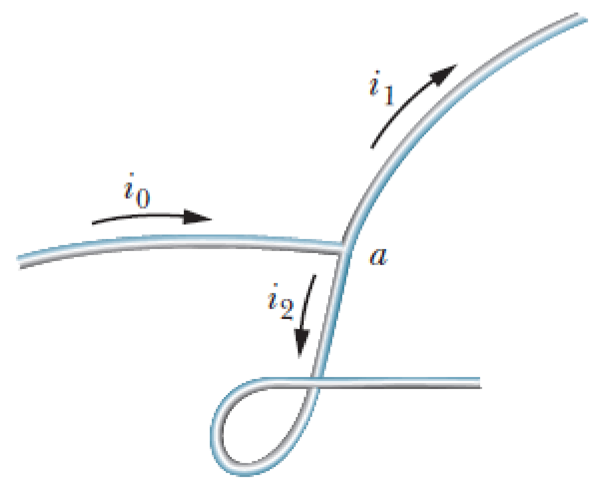
Electric Current

The Directions of Currents

- The current into the junction must equal the current out (charge is conserved).

$$i_0 = i_1 + i_2$$





Current Density

Current Density

- The current is related to current density by this relation

$$i = \int \vec{J} \cdot d\vec{A}$$

where $d\vec{A}$ is a vector perpendicular to a surface element of area dA.

- For uniform current, current density is given by:

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

where A is the total area of the surface.

Current Density

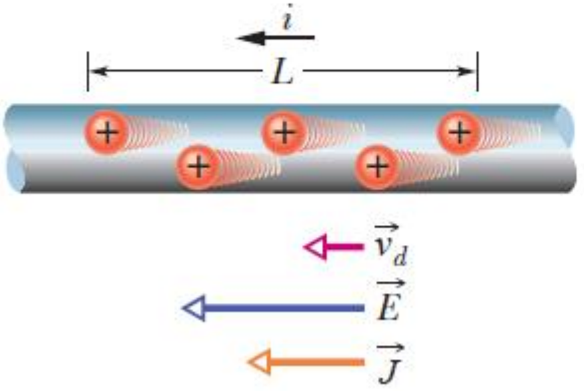
Drift Speed

- When an electric field $\vec{E}$ is established in a conductor, the charge carriers (positive) acquire a drift speed v_d in the direction of $\vec{E}$.

- The velocity $\vec{v}_d$ is related to the current density by:

$$\vec{J} = (ne)\vec{v}_d$$

where ne is the carrier charge density



Current Density

Example 1:

A cylindrical wire of radius 10 mm has a current of 2 A. The current density in the wire is:

Solution:

(A)

(A) $6.4 \times 10^3\ \mathrm{A/m^2}$
(B) $5.7 \times 10^3\ \mathrm{A/m^2}$
(C) $4.4 \times 10^3\ \mathrm{A/m^2}$
(D) $3.2 \times 10^3\ \mathrm{A/m^2}$

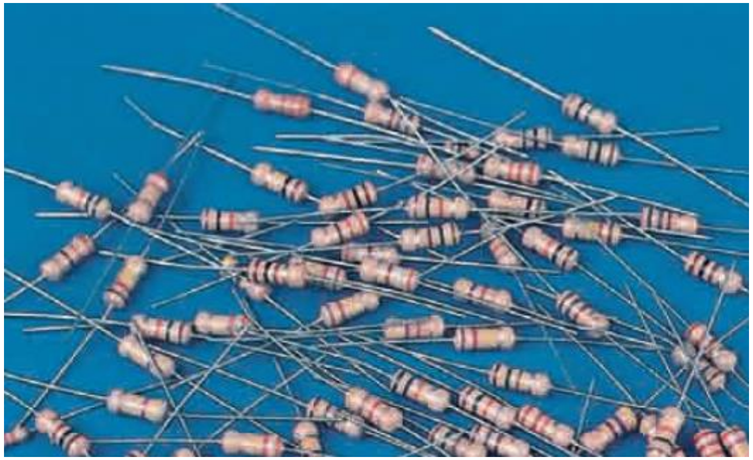
Resistance and Resistivity

Resistance and Resistivity

- The resistance R of a conductor is defined as

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

where V is the potential difference across the conductor and i is the current.



- The SI unit of resistance is the ohm (Ω), 1 Ω = 1 V/A.

Electric Current

Example 2:

A 4 Ω resistor is connected to a potential of 12 V. the current passing through the resistor is:

Solution:

(C)

(A) 1 A
(B) 2 A
(C) 3 A
(D) 4 A

Resistance and Resistivity

➢ The resistivity ρ and the conductivity σ of a material can be related by:

$$\sigma = \frac{1}{\rho} \qquad \rho = \frac{E}{J}$$

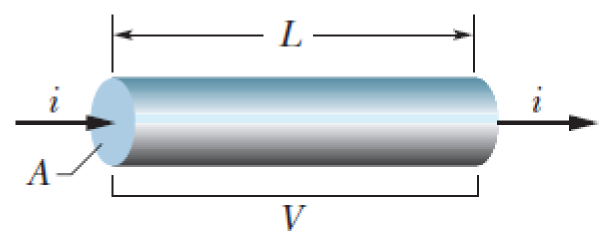
where E is the electric field and J is current density.

Calculating Resistance from Resistivity

➢ The resistance R of a conducting wire of length L and uniform cross section is:

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

where A is the cross sectional area.



Resistance and Resistivity

Example 3:

A wire of length 5 cm and cross-sectional area 2 mm^2 is connected to a potential of 12 V. If the current passing through the wire is 2 A, the resistivity of the wire is:

Solution:

(B)

(A) 1.7×10^{-4} Ω.m
(B) 2.4×10^{-4} Ω.m
(C) 3.5×10^{-4} Ω.m
(D) 4.2×10^{-4} Ω.m

Resistance and Resistivity

Example 4:

The electric field inside a cylindrical wire of radius 1.2 mm is 0.1 V/m. If the current in the wire is measured to be 16 A, the conductivity of the wire is:

Solution:

(C)

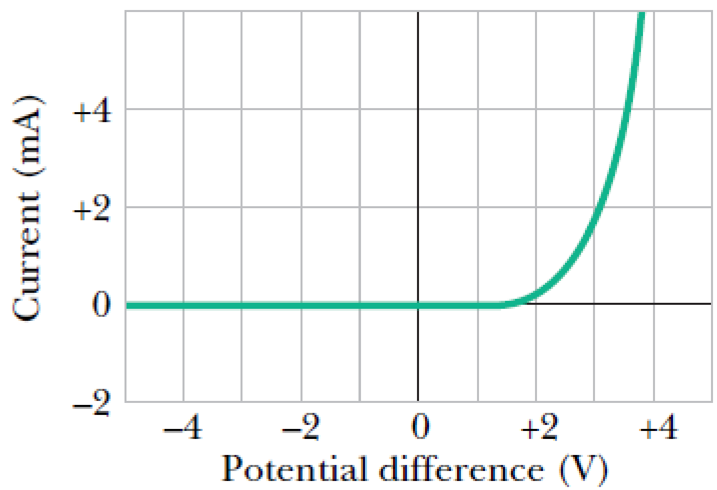
(A) 1.72×10^{7} $(\Omega.m)^{-1}$
(B) 2.43×10^{7} $(\Omega.m)^{-1}$
(C) 3.54×10^{7} $(\Omega.m)^{-1}$
(D) 4.27×10^{7} $(\Omega.m)^{-1}$

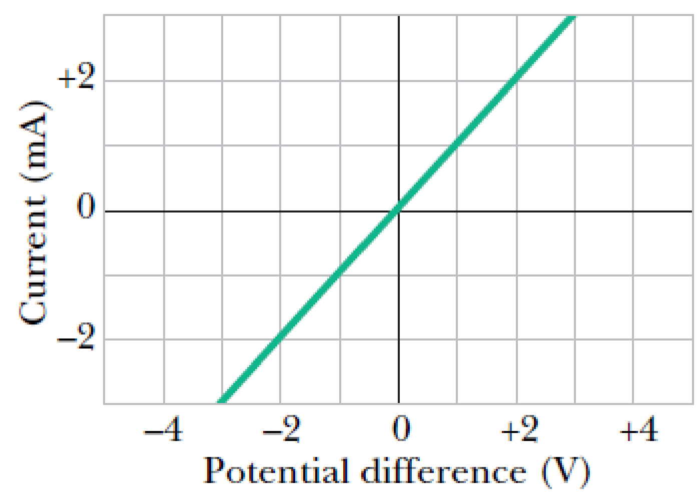
Ohm's Law

Ohm's Law

- A given device obeys Ohm's law if its resistance *R* independent of the applied potential difference *V* and defined as:

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





Power, Semicond's, Supercond's

Power in Electric Circuits

- The power P, or rate of energy transfer, in an electric device with potential difference V across is defied as:

$$P = iV$$

- For resistor device the power for the electrical energy dissipation due to resistance can be written as:

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

- The unit of power is Watt, (W): 1 W = 1 V. A

Power, Semicond's, Supercond's

Example 5:

The power for the dissipation through a 5 Ω resistor is 3.2 W. The potential difference across the resistor is:

Solution:

(D)

(A) 1 V
(B) 2 V
(C) 3 V
(D) 4 V