**Chapter 31: Current and Resistance**

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## 31.1 Current and Current Density

Free electrons in an isolated metallic conductor are in random motion. On average, the number of electrons moving in all directions are equal. If a battery is connected to the conductor, an electric field is set up at every point of the conductor. This field will act on the electrons and give them a resultant motion in the direction . We say that an electric current is established if a net charge passes through any cross section of the conductor in time .

Regardless of the cross-section of the conductor, the current, the rate of flow of charge, remains constant in order to maintain the conservation of charge.

The electrons acquire a constant average drift speed, .

The current is a characteristic of a particular conductor, and is a macroscopic quantity. A related microscopic quantity is the current density, . It is a vector quantity and is a characteristic of a point inside the conductor. If current is distributed uniformly over the cross-sectional area of the conductor,

or

The vector is oriented to the direction that a positive charge carrier would move, so an electron moves in the direction .

A charge passes through a conductor in a given time , where is the number of conducting electrons per unit volume and is the volume.

so

Since , .

## 31.2 Resistance, Resistivity and Conductivity

Different conductors have a different characteristic property known as resistance, where

Related to resistance is resistivity, which is the characteristic of the material of the conductor.

Conductivity is the reciprocal of resistivity.

For a conductor of cross-sectional area , length and constant electric field and current density,

and

and

, and are macroscopic quantities characteristic to the body as a whole. The corresponding microscopic quantities are , and that have values at every point of a body.

and

## 31.3 Ohm’s Law

Ohm’s law states that the resistance for metallic conductors remains the same, given that the temperature remains constant. Some conductors however, do not follow this law and are known as non-ohmic conductors, such as transistors and vacuum tubes.