Chapter 27

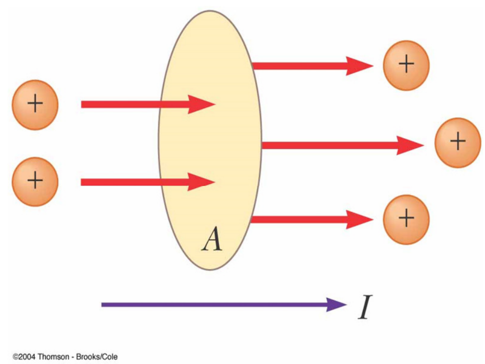
Current and Resistance

27-1 **Electric Current**

Consider a system of electric charges in motion. Whenever there is a net flow of charge through some region, a current is said to exist.

The current is the rate at which charge flows through this surface:

$$I = \frac{\Delta q}{\Delta t} \qquad (1\text{-}27)$$



- The unit of current is Ampere [A].

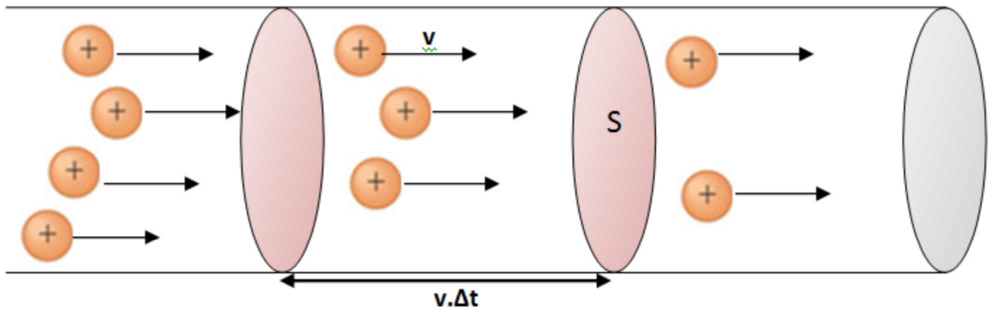
$$\frac{Coulomb}{\sec ond} = Ampere \ [C/s = A]$$

- That is, 1 A of current is equivalent to 1 C of charge passing through the surface area in 1 s.

- The direction of the current is defined as the direction of the flow of positive charge, which is opposite the direction of flow of electrons.

- It is common to refer to a moving charge (positive or negative) as a mobile charge carrier. For example, the mobile charge carriers in a metal are electrons

Microscopic View of Electric Current



The net motion of charge carriers is responsible for electric current. In an isolated conductor we know that there is no net motion of electric charge. However, there is quite a bit of motion of individual electrons due to their thermal energy. There is no net transfer of charge because the thermal motion is random and as many electrons that move to the left move to the right.

One can apply an electric field (or a potential) to cause a net transfer of charge. For example, a battery supplies the electric field (or potential difference) necessary for charge to move in an electric circuit.

It is interesting to figure out how fast the electrons that are responsible for current move in a conductor.

If n = number of charge carriers per volume then the total number charge, q, of the carriers in a length of wire *l* long with cross sectional area A is:

$$(2\text{-}27)\quad N = nV = n.(A.\Delta x) = n.(A.\Delta x).\frac{\Delta t}{\Delta t} = n.A.(\frac{\Delta x}{\Delta t}).\Delta t = n.A.\mathrm{v}_d.\Delta t$$

Then, the total charge can be written as:

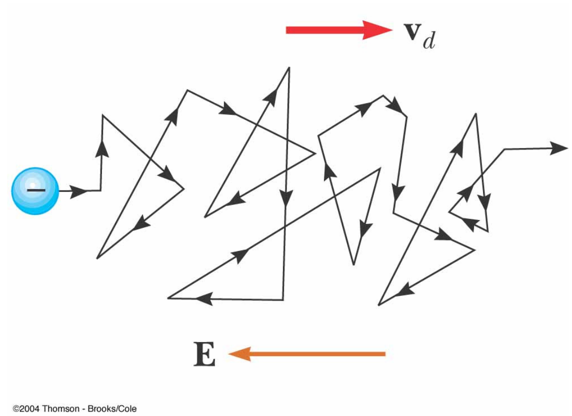
$$\Delta q = N.e \qquad (3\text{-}27)$$

Finally, we can give an expression of the electric current:

$$I = \frac{\Delta q}{\Delta t} = n \, \mathrm{v}_d e \; A$$

Where v_d is called the drift velocity which represents the average speed of the charge carriers.

(Carriers move in a zigzag fashion due to collision with atoms.)



Example 27-1

A copper wire in a typical residential building has a cross-sectional area of 3.31x 10^6 m^2. If it carries a current of 10.0 A, what is the drift speed of the electrons? Assume that each copper atom contributes one free electron to the current. The density of copper is 8.95 g/cm^3. (Atomic mass of cupper is 63.5 g/mol.)