Electric Current

The Electric current is defined as the rate of flow of electric charge through any crosssection of wire or conductor. It is denoted by (I). Thus if charge (q) flows in a wire in time then,

$$I \text{ (electric current)} = \frac{\text{Total charge flowing (q)}}{\text{Time taken (t)}}$$

$$I = q / t$$

If n be the number of electron crossing any section of wire in time t. Then the quantization of charge q is written as

$$q = ne$$

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

where I = ectric, current,
e=charge of one electron.
& The Value of $e = 1.6X10^{-19}C$.

Units of Electric Current: The S.I. unit of electric current is *Ampere (A). The electric current through a wire is called one Ampere (1 A), if one coulomb (1 C) of charge flow through the wire in one second.*

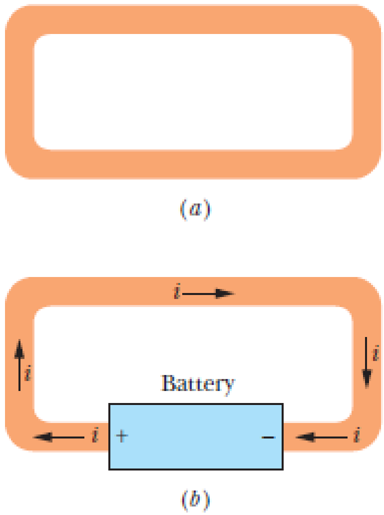
$$1 \text{ Ampere (A)} = \frac{1 \text{ Coulomb (C)}}{1 \text{ Second (S)}} = 1\ CS^{-1}$$

We say that 1 Ampere current constitute of 6.25×10^{18} electrons.

Direction: The direction of current is conventionally taken as the direction opposite to the direction of flow of electron.

A current arrow is drawn in the direction in which positive charge carriers would move, even if the actual charge carriers are negative and move in the opposite direction.

We can use this convention because in *most* situations, the assumed motion of positive charge carriers in one direction has the same effect as the actual motion of negative charge carriers in the opposite direction. (When the effect is not the same, we shall drop the convention and describe the actual motion.)

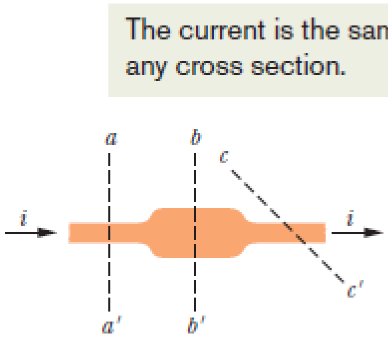


(*a*) A loop of copper in electrostatic equilibrium. The entire loop is at a single potential, and the electric field is zero at all points inside the copper. (*b*) Adding a battery imposes an electric potential difference between the ends of the loop that are connected to the terminals of the battery. The battery thus produces an electric field within the loop, from terminal to terminal, and the field causes charges to move around the loop. This movement of charges is a current i.

Types of Electric Current:

1. *Electronic:* The free electrons (conduction electrons) in an isolated length of copper wire are in random motion at speeds of the order of 106 m/s. If you pass a hypothetical plane through such a wire, conduction electrons pass through it *in both directions* at the rate of many billions per second—but there is *no net transport* of charge and thus *no current* through the wire. However, if you connect the ends of the wire to a battery, you slightly bias the flow in one direction, with the result that there now is a net transport of charge and thus an electric current through the wire.

2. *Conventional:* The flow of water through a garden hose represents the directed flow of positive charge (the protons in the water molecules) at a rate of perhaps several million coulombs per second. There is no net transport of charge, however, because there is a parallel flow of negative charge (the electrons in the water molecules) of exactly the same amount moving in exactly the same direction.



The current i through the conductor has the same value at planes *aa'*, *bb*', and *cc*'.

Electric Current As Seen Different In Other Field

Examples of electric currents abound and involve many professions. Meteorologists are concerned with lightning and with the less dramatic slow flow of charge through the atmosphere. Biologists, physiologists, and engineers working in medical technology are concerned with the nerve currents that control muscles and especially with how those currents can be re-established after spinal cord injuries. Electrical engineers are concerned with countless electrical systems, such as power systems, lightning protection systems, information storage systems, and music systems. Space engineers monitor and study the flow of charged particles from our Sun because that flow can wipe out telecommunication systems in orbit and even power transmission systems on the ground. In addition to such scholarly work, almost every aspect of daily life now depends on information carried by electric currents, from stock trades to ATM transfers and from video entertainment to social networking.

Current Density

Sometimes we are interested in the current i in a particular conductor. At other times we take a localized view and study the flow of charge through a cross section of the conductor at a particular point. To describe this flow, we can use the **current density J,** which has the same direction as the velocity of the moving charges if they are positive and the opposite direction if they are negative. For each element of the cross section, the magnitude ***J*** is equal to the current per unit area through that element. We can write the amount of current through the element as **J**.dĀ where dĀ is the area vector of the element, perpendicular to the element. The total current through the surface is then

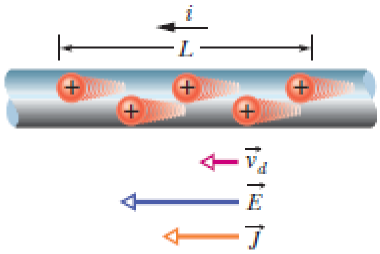
$$i = \int \vec{J} \cdot d\vec{A}.$$

If the current is uniform across the surface and parallel to then is also uniform and parallel to dĀ. Then above equation becomes

$$i = \int J\, dA = J \int dA = JA,$$

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

where A is the total area of the surface. From above equations, we see that the ***SI unit for current density is the ampere per square meter (A/m^2).***



Positive charge carriers drift at speed *vd* in the direction of the applied electric Ē field. By convention, the direction of the current density **J** and the sense of the current arrow are drawn in that same direction.