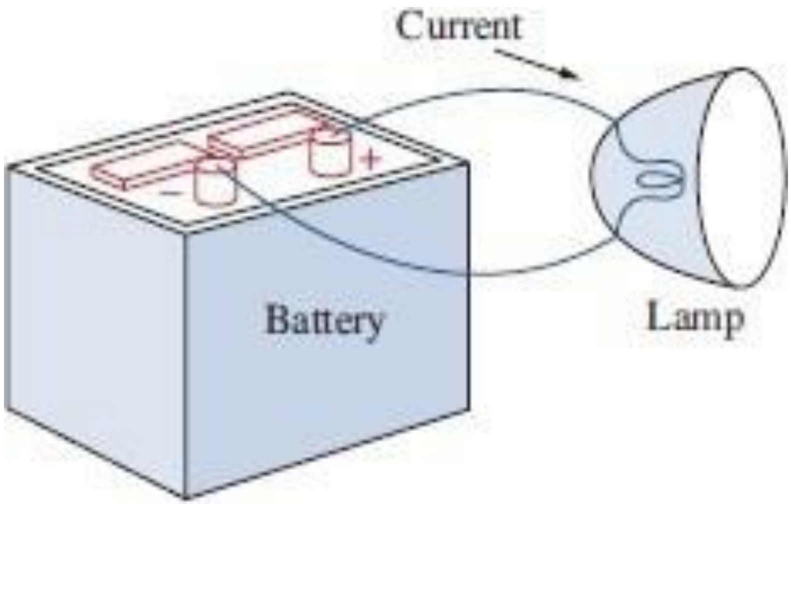
Introduction

Electric circuit theory and electromagnetic theory are the two fundamental theories upon which all branches of electrical engineering are built. Many branches of electrical engineering, such as power, electric machines, control, electronics, communications, and instrumentation, are based on electric circuit theory. Therefore, the basic electric circuit theory course is the most important course for an electrical engineering student, and always an excellent starting point for a beginning student in electrical engineering education. Circuit theory is also valuable to students specializing in other branches of the physical sciences because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and topology involved.

electric circuit : is an interconnection of electrical elements.

A simple electric circuit is shown in Fig below It consists of three basic elements: a battery, a lamp, and connecting wires. Such a simple circuit can exist by itself; it has several applications, such as a flashlight, a search light, and so forth.



Systems of Units:-

Table below shows the SI prefixes and their symbols

TABLE 1.1

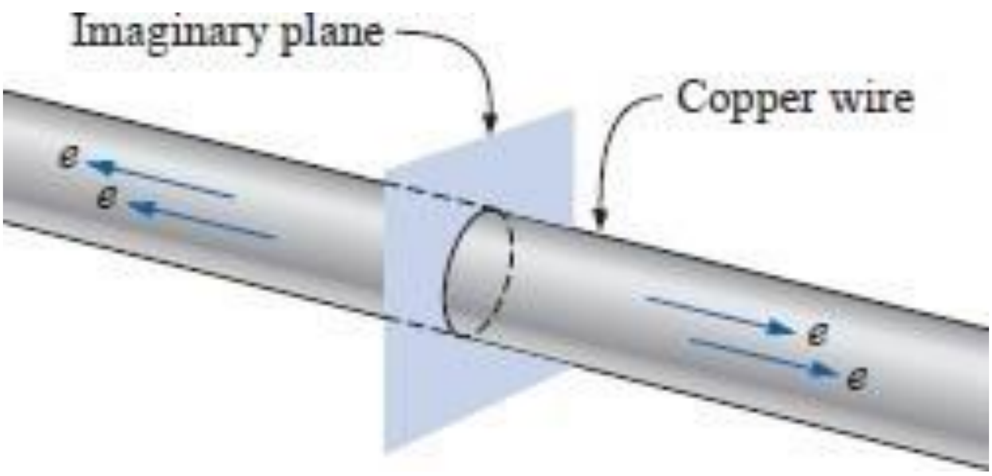
Six basic SI units and one derived unit relevant to this text.

Quantity	Basic unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Charge	coulomb	C

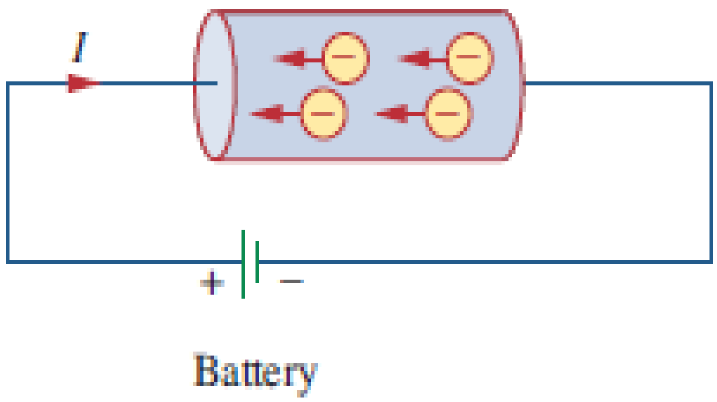
Current and Voltage

1. CURRENT

Consider a short length of copper wire cut with an imaginary perpendicular plane, producing the circular cross section shown in Fig below At room temperature with no external forces applied, there exists within the copper wire the random motion of free electrons created by the thermal energy that the electrons gain from the surrounding medium. When atoms lose their free electrons, they acquire a net positive charge and are referred to as positive ions. The free electrons are able to move within these positive ions and leave the general area of the parent atom, while the positive ions only oscillate in a mean fixed position. For this reason .



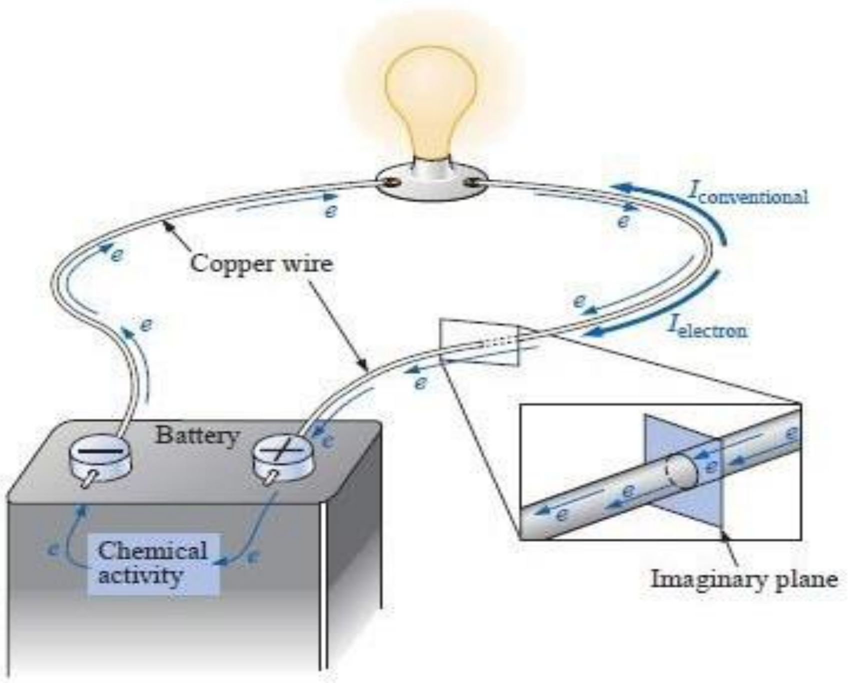
The free electron
is the charge carrier in a copper wire or any other solid conductor of electricity.
Electric current
is the time rate of change of charge, measured in amperes (A).
or
The flow of charge (electrons) in a conductor.



Electric current due to flow

of electronic charge in a conductor

Let us now connect copper wire between two battery terminals and a light bulb, as shown in Fig below, to create the simplest of electric circuits.
The battery, at the expense of chemical energy, places a net positive charge at one terminal and a net negative charge on the other. The instant the final connection is made, the free electrons (of negative charge) will drift toward the positive terminal, while the positive ions left behind in the copper wire will simply oscillate in a mean fixed position. The negative terminal is a “supply” of electrons to be drawn from when the electrons of the copper wire drift toward the positive terminal.



A coulomb (C) of charge was defined as the total charge associated with **6.242 ×10^{18}** electrons. The charge associated with one electron can then be determined from :

$$\textbf{Charge/electron} = Q_e = \frac{1\,\text{C}}{6.242 \times 10^{18}} = 1.6 \times 10^{-19}\,\text{C}$$

The current in amperes can now be calculated using the following equation :

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

I = amperes (A)
Q = coulombs (C)
t = seconds (s)

Through algebraic manipulations, the other two quantities can be determined as follows :

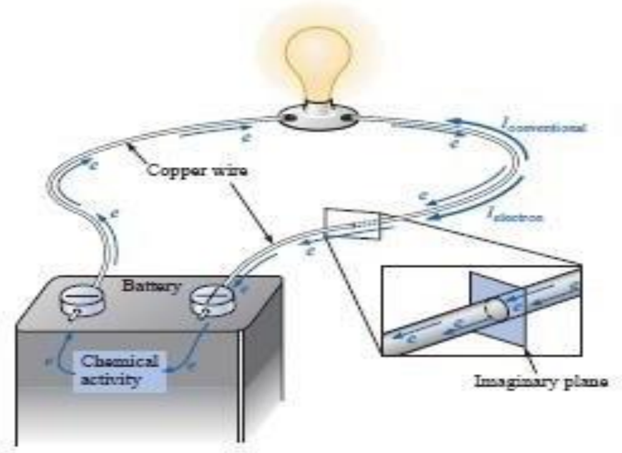
$$Q = It \qquad \text{(coulombs, C)}$$

$$t = \frac{Q}{I} \qquad \text{(seconds, s)}$$

EXAMPLE : The charge flowing through the imaginary surface of Fig below is 0.16 C every 64 ms. Determine the current in ampere?

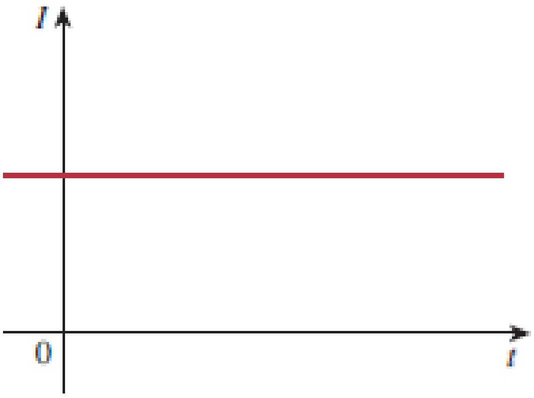
Solution :

$$I = \frac{Q}{t} = \frac{0.16\ \text{C}}{64 \times 10^{-3}\ \text{s}} = \frac{160 \times 10^{-3}\ \text{C}}{64 \times 10^{-3}\ \text{s}} = 2.50\ \text{A}$$

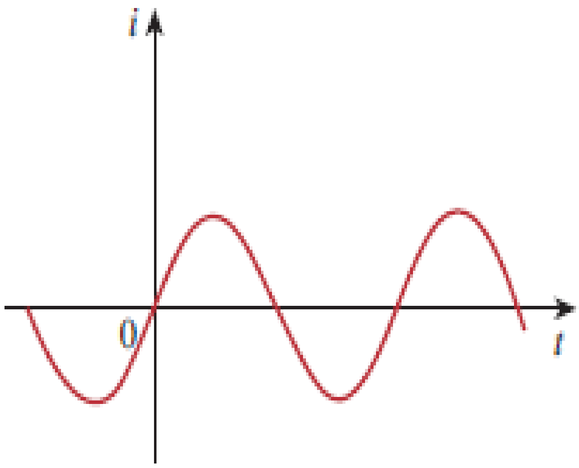


The way we define current as (I) suggest that current need not be a constant-valued function, there can be several types of current; that is, charge can vary with time in several ways. If the current does not change with time, but remains constant, we call it a direct current (dc).

A direct current (dc) is a current that remains constant with time.



Alternating current (ac) is a current that varies sinusoidally with time.



By convention the symbol I is used to represent such a constant current. A time-varying current is represented by the symbol i.

2. VOLTAGE

The flow of charge described in the previous section is established by an external "pressure" derived from the energy that a mass has by virtue of its position: potential energy.

Energy, by definition, is the capacity to do work.

it has a measure of potential energy expressed in joules (J) that is determined by :

$$W \text{ (potential energy)} = mgh \qquad \text{(joules, J)}$$

Where **g** is the gravitational acceleration (9.754 m/s2). This mass now has the "potential" to do work such as crush an object placed on the reference plane.

a **potential difference** or voltage is always measured between two points in the system. Changing either point may change the potential difference between the two points under investigation.

In general, the potential difference between two points is determined By.

$$V = \frac{W}{Q} \qquad \text{(volts)}$$

Through algebraic manipulations, we have:

$$W = QV \qquad \text{(joules)}$$

$$Q = \frac{W}{V} \qquad \text{(coulombs)}$$

EXAMPLE : Find the potential difference between two points in an electrical system if 60 J of energy are expended by a charge of 20 C between these two points.

Solution:

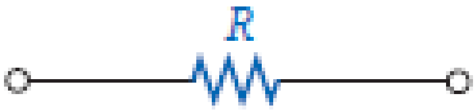
$$V = \frac{W}{Q} = \frac{60\ \text{J}}{20\ \text{C}} = \mathbf{3\ V}$$

Notation plays a very important role in the analysis of electrical and electronic systems. To distinguish between sources of voltage (batteries and the like) and losses in potential across dissipative elements, the following notation will be used :
E for voltage sources (volts)
V for voltage drops (volts)

dc Voltage Sources
Dc voltage sources can be divided into three broad categories :
(1) batteries (chemical action) .
(2) generators (electromechanical) .
(3) power supplies (rectification) .

Resistance
The flow of charge through any material encounters an opposing force. This opposition, due to the collisions between electrons and between electrons and

other atoms in the material, which converts electrical energy into another form of energy such as heat, is called the resistance of the material. The unit of measurement of resistance is the ohm, for which the symbol is Ω, the capital Greek letter omega. The circuit symbol for resistance appears in
Fig below with the graphic abbreviation for resistance (R).



Then
The Resistance R of an element denotes its ability to resist the flow of electric current; it is measured in ohms (Ω).
The resistance of any material with a uniform cross-sectional area is determined by the following four factors:

1. Material
2. Length
3. Cross-sectional area
4. Temperature

At a fixed temperature of 20°C (room temperature), the resistance is related to the other three factors by :

$$R = \rho \frac{l}{A} \qquad \text{(ohms, } \Omega\text{)}$$

where **ρ** is a characteristic of the material called the resistivity, **L** is the length of the sample, and **A** is the cross-sectional area of the sample.