PHYS-101 Applied Physics

Credit Hours: 03 **Basic Electronics Solid State by B.L Therraja**

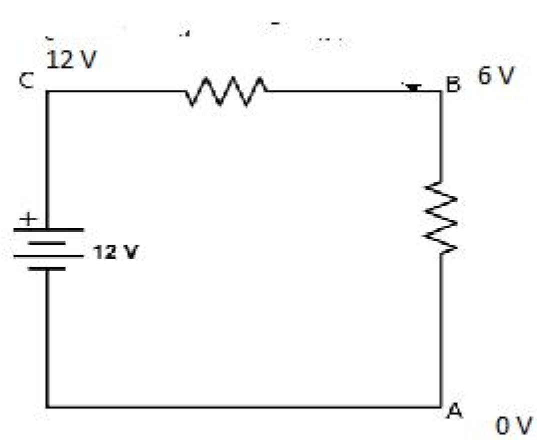
Course Content:

1. Zero Reference Level, Chassis Ground, Ohm's Law, Formula Variations of Ohm's Law, Graphical Representation of Ohm's Law, Linear Resistor, Non Linear Resistor, Cells in Series and Parallel.[Ch 1]
2. Resistive Circuits. [Ch 2]
3. Resistors (5.1-15), Inductors (5.19-21) Capacitors (5.35-48) .[Ch 5]
4. Energy Sources. [Ch 6]
5. Magnetism and electromagnetism [Ch 7].
6. Solid State. Atomic structure, Electron distribution of different atoms, Energy bands in solids, Bonds in solids, Conduction in solids, Conductors, Semiconductors and types of semiconductors, Insulators, Majority and Minority charge carriers, Mobile charge carriers and immobile ions, Drift current in good conductors. [Ch 12]
7. P-N Junction. Formation of depletion layer, Junction or barrier voltage, Forward biased P-N Junction, Forward V/I Characteristics, Reverse biased P-N Junction, Re-verse Saturation Current, Reverse V/I Characteristics, Junction breakdown, Junction Capacitance. [Ch 13]
8. Optoelectronics Devices. Spectral response of human eye, Light Emitting Diode (LED), Photo-emissive Devices, Photomultiplier Tube, Photovoltaic Devices, Bulk type Photoconductive cells, Photodiodes, P-N junction Photodiode, PIN Photodiode, and Avalanche Photodiode. [Ch 16]
9. DC Power Supplies. Unregulated and Regulated Power Supply, Steady and Pulsating DC Voltages, Rectifiers (17.5-17.8), Filters (17.9-17.2), Voltage Multipliers (17.24-17.30), Silicon Controlled Rectifier SCR (17.33-17.37) [Ch 17]
10. The Basic Transistor. Transistor Biasing, Transistor Circuit Configuration. [Ch 18]
11. Modulation and Demodulation. Carrier Waves, Modulation, Demodulation or Detection, Comparison between Amplitude Modulation (AM) and Frequency Modulation (FM). [Ch 30]
12. Integrated Circuits. Advantages of ICs and Drawbacks of ICs, Scale of Integration, Classification of ICs by function, Linear and Digital Integrated Circuits, IC Terminology, Fabrication of IC Components, Popular Application of ICs, Operational Amplifier. [Ch 31]
13. Fiber Optics. Structure of Optical Fibers, Classification of Optical Fibers, Fiber Characteristics, Choice of Wavelength, Optical Fiber cable, Application of Fiber Optic Communication. [Ch 38]

Zero Reference Level

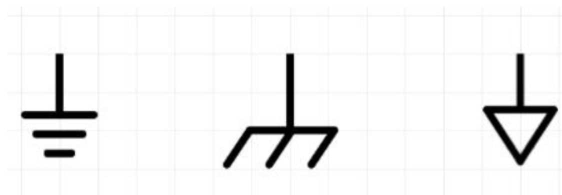
In electronic circuits, the measurement of the Voltage or Electro Motive Force can only be done with relative to a reference level or reference point. For example, when we say a Battery is of 3V means the difference in the Voltage or EMF of the positive terminal to the Zero Reference Level which is the negative terminal normally is 3V voltage as shown in the figure.

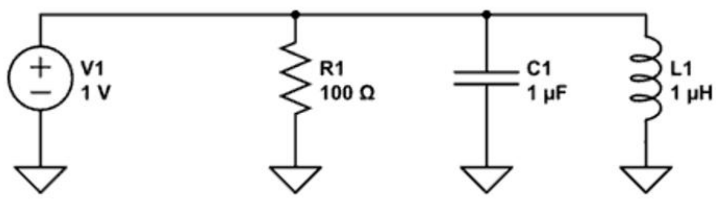
The following fig below show that the voltage at point C is 12 V, the voltage at point B is 6 V and at point A is 0V (ZRL).



Chassis Ground in Circuits:

It is a common practice to mount electronic components to a conducting metal sheet or a non-conducting plastic board with printed wires (Printed Circuit Board – PCB). When the chassis or PCB is used for building the circuit it is a common practice to regard the conducting body of the chassis or PCB as the common ground. The following symbols are used.





Chassis grounding makes the return of current easier and efficient, because chassis is a good conductor it provides a good path for the return of current from various components in a circuit. As the chassis is grounded so it is considered to be in Zero Reference Level and all voltage measurements in the circuit are done with respect to the chassis.

Voltage is defined as energy per unit of charge and is expressed as

$$V = \frac{W}{Q}$$

where V is voltage in volts (V), W is energy in joules (J), and Q is charge in coulombs (C). As a simple analogy, you can think of voltage as corresponding to the pressure difference created by a pump that causes water to flow through a pipe in a closed water system.

Volt: The Unit of Voltage

The unit of voltage is the **volt**, symbolized by V.

One volt is the potential difference (voltage) between two points when one joule of energy is used to move one coulomb of charge from one point to the other.

Example

If 50 J of energy are required to move10 C of charge, what is the voltage?

Solution

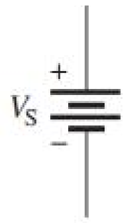
$$V = \frac{W}{Q} = \frac{50\text{ J}}{10\text{ C}} = \mathbf{5\ V}$$

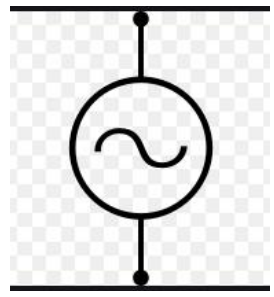
Voltage Source

There are two types of voltage sources, D.C and A.C. Battery is the D.C voltage source and generator is an A.C source.

A **voltage source** provides electrical energy or electromotive force (emf), more commonly known as voltage. Voltage is produced by means of chemical energy, light energy, and magnetic energy combined with mechanical motion.

D.C and A.C symbols





Problems

1. What is the voltage of the battery that uses 800 J of energy to move 40 C of charge through a resistor?

2. How much energy does a 12 V battery in your car use to move 2.5 C through the electric circuit?

1 C = 6.25 x 10^{18} no of electrons

Current

Voltage provides energy to electrons that allows them to move through a circuit. This movement of electrons is the current, which results in work being done in an electric circuit.

Electrical current is the rate of flow of charge.

Current in a conductive material is measured by the number of electrons (amount of charge) that flow past a point in a unit of time.

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

Ampere: The Unit of Current

Current is measured in a unit called the *ampere* or *amp* for short, symbolized by A.

One ampere (1 A) is the amount of current that exists when a number of electrons having a total charge of one coulomb (1 C) move through a given cross-sectional area in one second (1 s).

Example

Ten coulombs of charge flow past a given point in a wire in 2 s. What is the current in amperes?

Solution

$$I = \frac{Q}{t} = \frac{10\text{ C}}{2\text{ s}} = \mathbf{5\ A}$$

Problems

1. How long does it take 10 C to flow past a point if the current is 5 A?

2. How many coulombs pass a point in 0.1 s when the current is 1.5 A?

Resistance

Resistance is the opposition to flow of current, represented by R.

Ohm: The Unit of Resistance

Resistance, *R*, is expressed in the unit of ohms, which is symbolized by the Greek letter omega (Ω).

One ohm (1 Ω) of resistance exists when there is one ampere (1 A) of current in a material with one volt (1 V) applied across the material.

Ohm's Law

Georg Ohm found that, at a constant temperature, the electrical current flowing through a fixed linear resistance is directly proportional to the voltage applied across it, and also inversely proportional to the resistance. This relationship between the Voltage, Current and Resistance forms the basis of **Ohms Law** and is shown below.

Ohms Law Relationship

$$Current, (I) = \frac{Voltage, (V)}{Resistance, (R)} \ in \ Amperes, (A)$$

By knowing any two values of the Voltage, Current or Resistance quantities we can use **Ohms Law** to find the third missing value. **Ohms Law** is used extensively in electronics formulas and calculations so it is "very important to understand and accurately remember these formulas".

To find the Voltage, (V)

V = I x R   V (volts) = I (amps) x R (Ω)

To find the Current, (I)

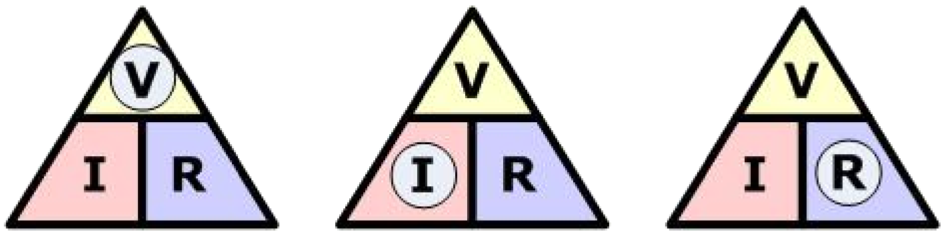
I = V ÷ R   I (amps) = V (volts) ÷ R (Ω)

To find the Resistance, (R)

R = V ÷ I   R (Ω) = V (volts) ÷ I (amps)

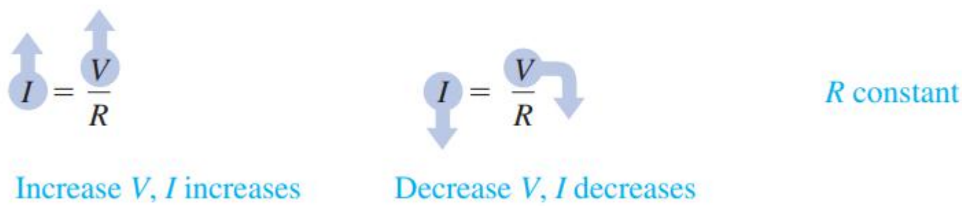
The three quantities of V, I and R have been superimposed into a triangle (affectionately called the **Ohms Law Triangle**) giving voltage at the top with current and resistance below. This arrangement represents the actual position of each quantity within the Ohms law formulas. Ohms Law Triangle

Transposing the standard Ohms Law equation above will give us the following combinations of the same equation:

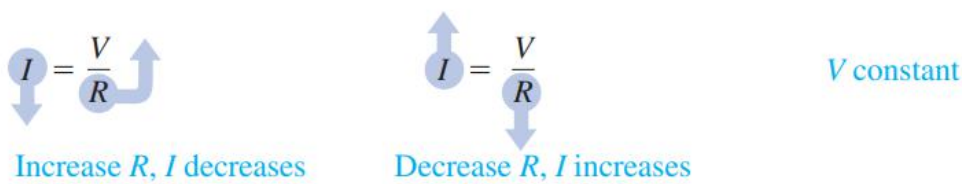


$$V = I \times R \qquad I = \frac{V}{R} \qquad R = \frac{V}{I}$$

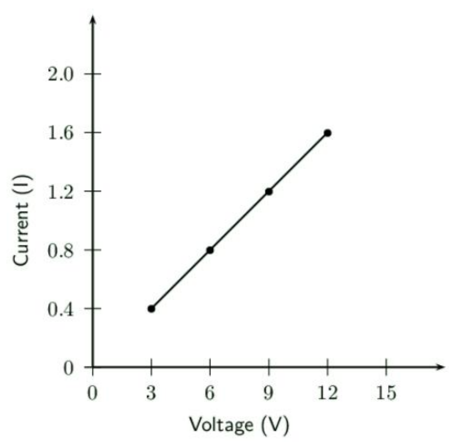
For a constant resistance, if the voltage applied to a circuit is increased, the current will increase; and if the voltage is decreased, the current will decrease.



For a constant voltage, if the resistance in a circuit is increased, the current will decrease; and if the resistance is decreased, the current will increase.



Graphical representation of Ohm's law

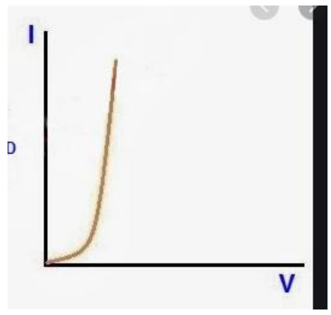


Linear and Non-linear resistors

Linear resistors, one whose value remain same i.e. it does not depend on applied voltage. The voltage and current (I-V) characteristics of such a resistor is a straight line.it means the current and voltage are directly proportional.

For non-linear resistors voltage and current (V-I) characteristics is not a straight line. The voltage and current values vary depending upon other factors like temperature and light, but they may not be linear. Tungsten filament bulb is the example.

Graphical Representation of non-linear resistors.



EXAMPLE 1

Using the Ohm's law formula in Equation 1, verify that the current through a 10 Ω resistor increases when the voltage is increased from 5 V to 20 V.

Solution For $V = 5\text{ V}$,

$$I = \frac{V}{R} = \frac{5\text{ V}}{10\ \Omega} = \mathbf{0.5\text{ A}}$$

For $V = 20\text{ V}$,

$$I = \frac{V}{R} = \frac{20\text{ V}}{10\ \Omega} = \mathbf{2\text{ A}}$$

EXAMPLE 2

Use the Ohm's law formula in Equation 2 to calculate the voltage across a 100 Ω resistor when the current is 2 A.

Solution

$$V = IR = (2\text{ A})(100\ \Omega) = \mathbf{200\text{ V}}$$

EXAMPLE 3

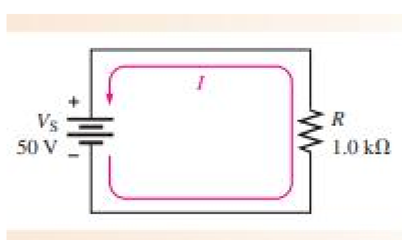
Use the Ohm's law formula in Equation 3 to calculate the resistance of a rear window defroster grid in a certain vehicle. When it is connected to 12.6 V, it draws 15.0 A from the battery. What is the resistance of the defroster grid?

Solution

$$R = \frac{V}{I} = \frac{12.6\text{ V}}{15.0\text{ A}} = \mathbf{840\text{ m}\Omega}$$

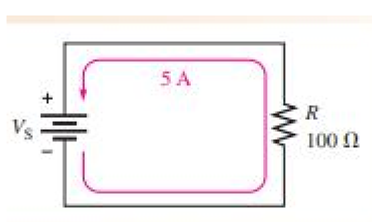
Problem; 1

Calculate the current in milliamperes for following circuit.



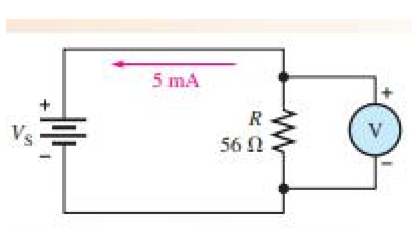
Problem; 2

How much voltage is required to produced 5 A of current?



Problem; 3

How much voltage measured across the resistor in following fig.



Cells

Cells generate electricity and also derives chemical reactions. One or more electrochemical cells are batteries. Every cell has two terminals namely:

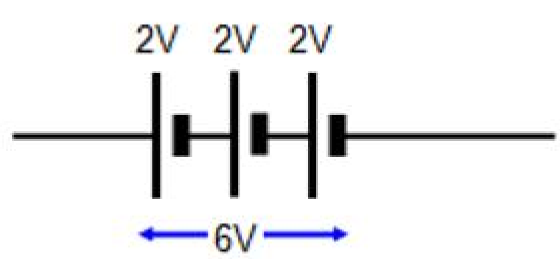
1. ***Anode:*** Anode is the terminal from where the current flows in from out i.e. it provides an incoming channel for the current to enter the circuit or the device. The positive terminal is anode.
2. ***Cathode:*** Cathode is the terminal from where the current flows out i.e. it provides an outgoing current flow from the circuit or the device. The negative terminal is cathode.

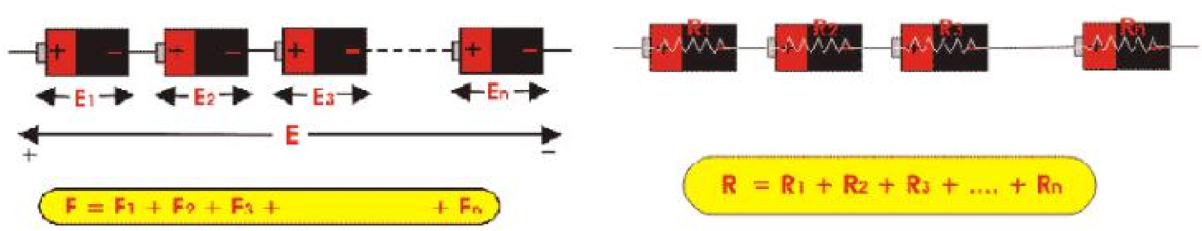
There are two simplest ways for cell connectivity are as follows:

1. ***Series Connection*** ***2. Parallel Connection:***

Cells in Series Connection

In series, cells are joined end to end so that the same current flows through each cell. In case if the cells are connected in series the emf of the battery is connected to the sum of the emf of the individual cells. Suppose we have multiple cells and they are arranged in such a way that the positive terminal of one cell is connected to the negative terminal of the another and then again the negative terminal is connected to the positive terminal and so on, then we can that the cell is connected in series. The current delivering capacity of the series combination does not exceed that of the single cell. Hence in series combination of cells is employed when higher voltage is required.



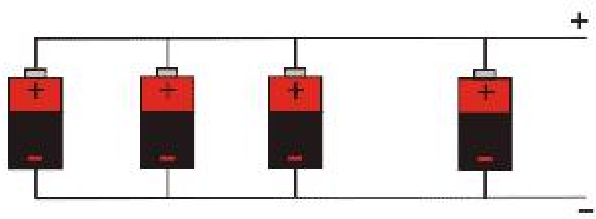
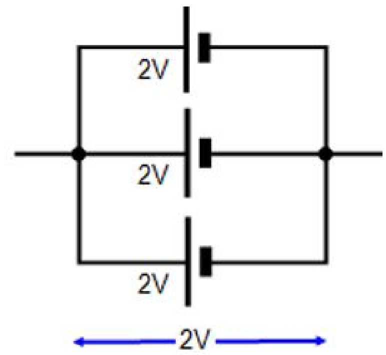


Equivalent EMF/Resistance of Cells in Series

If E is the overall emf of the battery combined with *n* number cells and E_1, E_2, E_3, E_n are the emfs of individual cells. Then $E_1 + E_2 + E_3 + \ldots\ldots E_n$

Cells in Parallel Connection

Cells are in parallel combination if the current is divided among various cells. In a parallel combination, all the positive terminal are connected together and all the negative terminal are connected together. Such a combination is used when more current is required. In this case the total current is equal to sum of currents of all cells.

If  

emf of each cell is identical, then the emf of the battery combined by n numbers of cells connected in parallel, is equal to the emf of each cell. The resultant internal resistance of the combination is,

$$\left(\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+\dots\dots\dots\dots+\frac{1}{r_n}\right)^{-1}$$