

BASIC ELECTRICAL ENGINEERING

Course Code: EE100



Dr. Pragnyashree Ray

Assistant Professor

Dept. of Electrical Engineering,

C. V. Raman Global University, Bhubaneswar, Odisha

watts up?



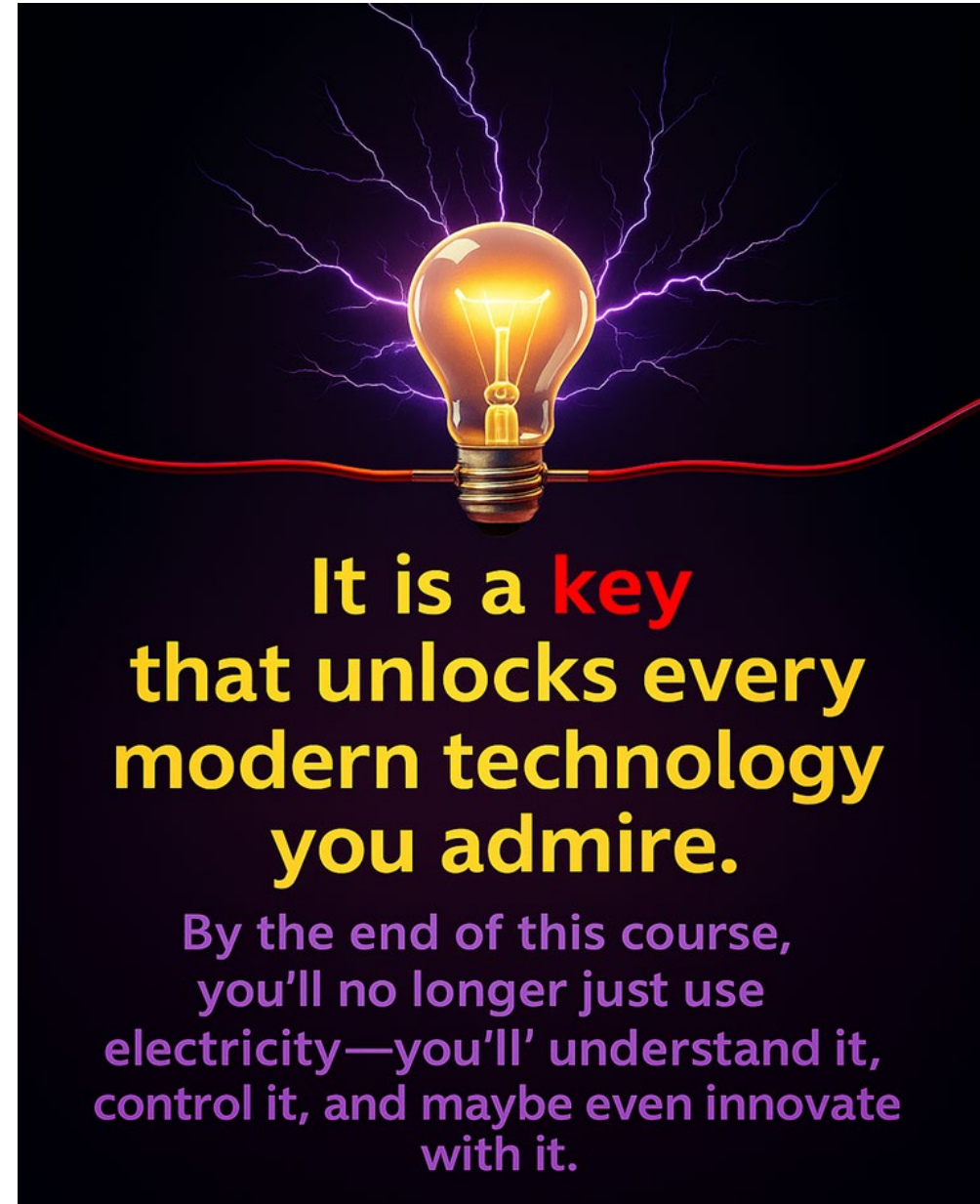
Why studying Basic Electrical Engineering?



Welcome to Basic Electrical Engineering:
the foundation that connects every **branch**,
every **invention**, and every **dream** of the
future.



Don't look at this
subject as a burden.



Vision and Mission of CGU

Vision

To emerge as a global leader in the arena of technical education commensurate with the dynamic global scenario for the benefit of mankind

Mission

- ❖ To provide State-of-art technical education in the undergraduate and postgraduate levels.
- ❖ To work collaboratively with technical Institutes/ Universities/Industries of National and International repute.
- ❖ To keep abreast with latest technological advancements.
- ❖ To enhance the R and D activities.

Vision and Mission of the Dept. of Electrical Engineering

Vision

To be a premier department known for its quality, cutting-edge research, and accomplished graduates

Mission

M1: To provide the best possible education facilities and to guide the students to become performing professionals in the international arena.

M2: To create a conducive atmosphere in which higher studies and research can thrive and prosper.

M3: To establish and maintain state-of-the-art research facilities for dissemination of knowledge in engineering and science.

M4: To render service to the industry and community through educational, technical, and entrepreneurial activities and innovations.

M5: To prepare a cadre of engineers and scientists to cater to the industrial development and economic growth of the country.

Course Objective

- ✓ Explain the concept of different basic circuit elements, sources, and basic laws for dc, single-phase and three-phase ac, and magnetic circuits
- ✓ Evaluation of different parameters in electrical circuits using basic circuit laws for dc, single-phase, and three-phase ac circuits
- ✓ Apply the concepts of magnetic circuits for different ac and dc machines
- ✓ Assess the working of different specialized motors
- ✓ Analyze the use of electric Measuring instruments, transmission, and distribution, and various switchgear components in the electrical supply system

Course Outcomes

CO-1 Understand the concept of basic circuit elements, sources, and basic laws for dc circuits and, the working principles of protective devices and personal safety measures

CO-2 Understand the circuit fundamentals for the single-phase and three-phase AC circuits magnetic circuits, and the working principles of different dc and ac machines

CO-3 Apply the circuit basic to calculate circuit parameters for dc, ac, and magnetic circuits.

CO-4 Apply the concept of magnetic circuits in understanding the basics of transformers and specialized machines.

CO-5 Understand the significance of different measuring instruments, basic concepts of power system transmission and distribution.

Syllabus

Module – 1 (10hrs.)

- **DC circuits:** Ohm's law and Kirchhoff's laws, analysis of series, parallel and series-parallel circuits excited by independent voltage sources. Mesh analysis, Nodal Analysis, Star-Delta and Delta-star conversion, Superposition theorem, Thevenin's and Norton's theorems, and maximum power transfer theorem.

Module – 2 (10hrs.)

- **Single-phase circuits:** Generation of sinusoidal voltage, frequency of generated voltage, average value, RMS value, form, and peak factors. Voltage and current relationship, with phasor diagrams, in R, L, and C circuits, j operators. Analysis of R-L, R-C, R-L-C Series circuits, series and parallel resonance, Real power, reactive power, apparent power, and Power factor. Measurement of power.
- **Three-phase circuits:** Generation of three-phase power, representation of the balanced star (3 wire and 4-wire system) and delta connected loads, the relation between phase and line values of voltage and current from phasor diagrams, advantages of three-phase systems.

Module – 3 (6 hrs.)

- **Basics of Magnetic Circuits and DC Machines:** Basics of Magnetic circuit, MMF, Flux, Reluctance calculations for simple magnetic cores, B-H curve, DC machines Construction, Principle of Operation, Basic Equations, and Applications

Module – 4 (8 hrs.)

- **Transformers:** Necessity of transformer, the principle of operation, Types, and construction of single-phase transformers, emf equation,
- **Three-phase induction Motors:** Concept of the rotating magnetic field, Principle of operation, constructional features of motor, types – squirrel cage and wound rotor, slip and problems on the slip, applications.
- **Specialized machines:** Principle of operation of BLDC motor, Stepper motor.

Module-5 (8 Hrs.)

- **Measuring Instrument:** Classification of instruments, principles, and essentials of an instrument, moving coil instruments, Permanent Magnet Moving Coil (PMMC) Instruments, Moving Iron Type instruments, and Dynamometer-Type Instruments. Ammeters and voltmeters Measurement of Power and Energy.
- **Power transmission and distribution:** Concept of power transmission and power distribution. Low voltage distribution system (400 V and 230 V) for domestic, commercial, and small-scale industries through block diagrams only.
- **Electrical Installations:** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries.

Text Books :

1. D.C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill Publication, 2009.
2. S. Salivahanan, R. Regaraj and G. R. Venkatakrishnan, “Basic Electrical, Electronics, and Measurement Engineering”, McGraw Hill Publication, 2009.
3. E. Hughes, Electrical and Electronics Technology, Pearson, 2010.

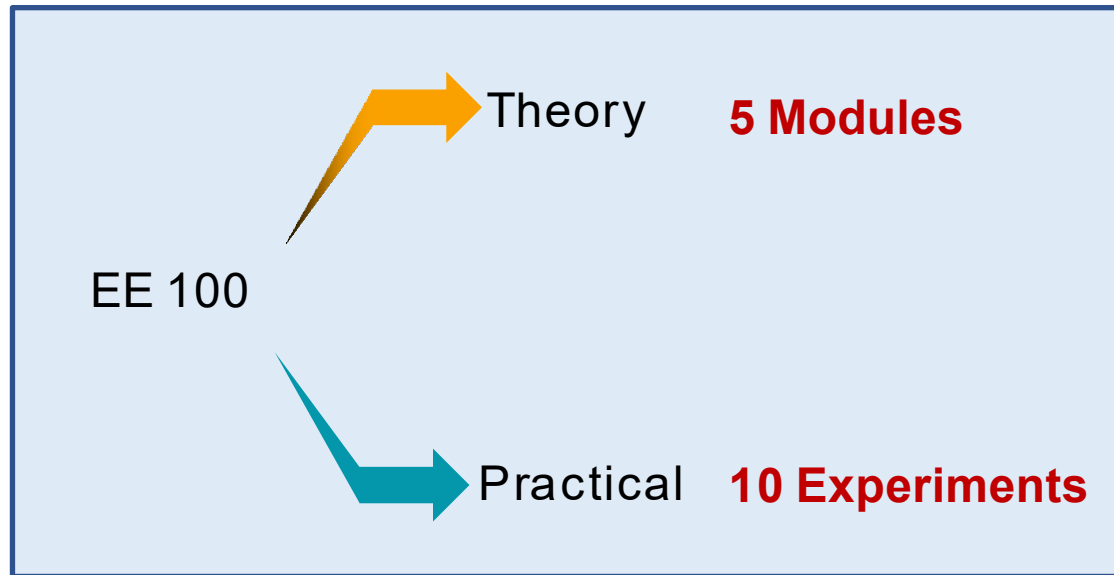
Reference Books :

1. T.K. Nagsarkar & M.S. Sukhija, “Basic Electrical & Electronics Engineering”, Oxford, 2nd Edition 2011.
2. V.D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India Publication, 1989.
3. D.P. Kothari and I. J. Nagrath, “Basic Electrical & Electronics Engineering”, Tata McGraw Hill Publication, 2010

Open Sources:

1. Dr. Nagendra Krishnapura, “Basic Electrical Circuits”, NPTEL - IIT Madras.
<https://nptel.ac.in/courses/108/106/108106172/>
2. Prof. Mahesh B. Patil, “Basic Electronics”, NPTEL – IIT Bombay.
<https://nptel.ac.in/courses/108/101/108101091/>

Evaluation Scheme



Category	Assessment Marks	Weightage Marks
Assignment	50	10
Quiz	40	10
Attendance	10	10
Mid Sem	20	20
End Sem	100	50
Total		100

Module 1

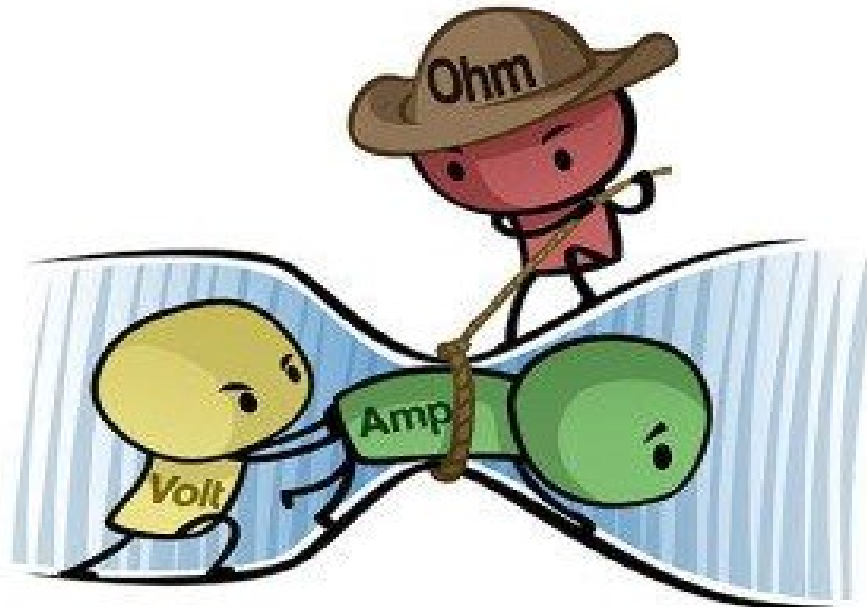
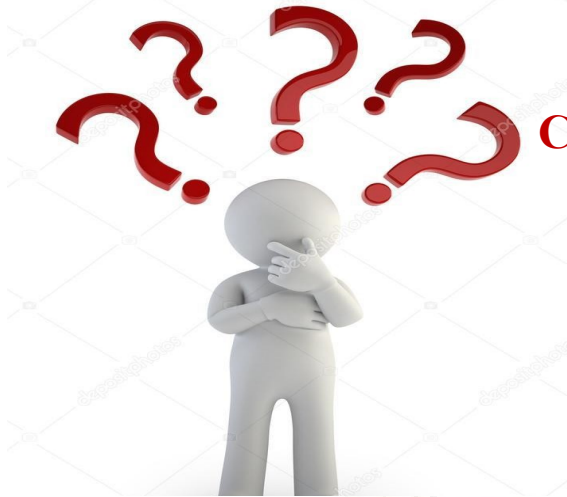
DC circuits

Basic Circuit Elements and Sources

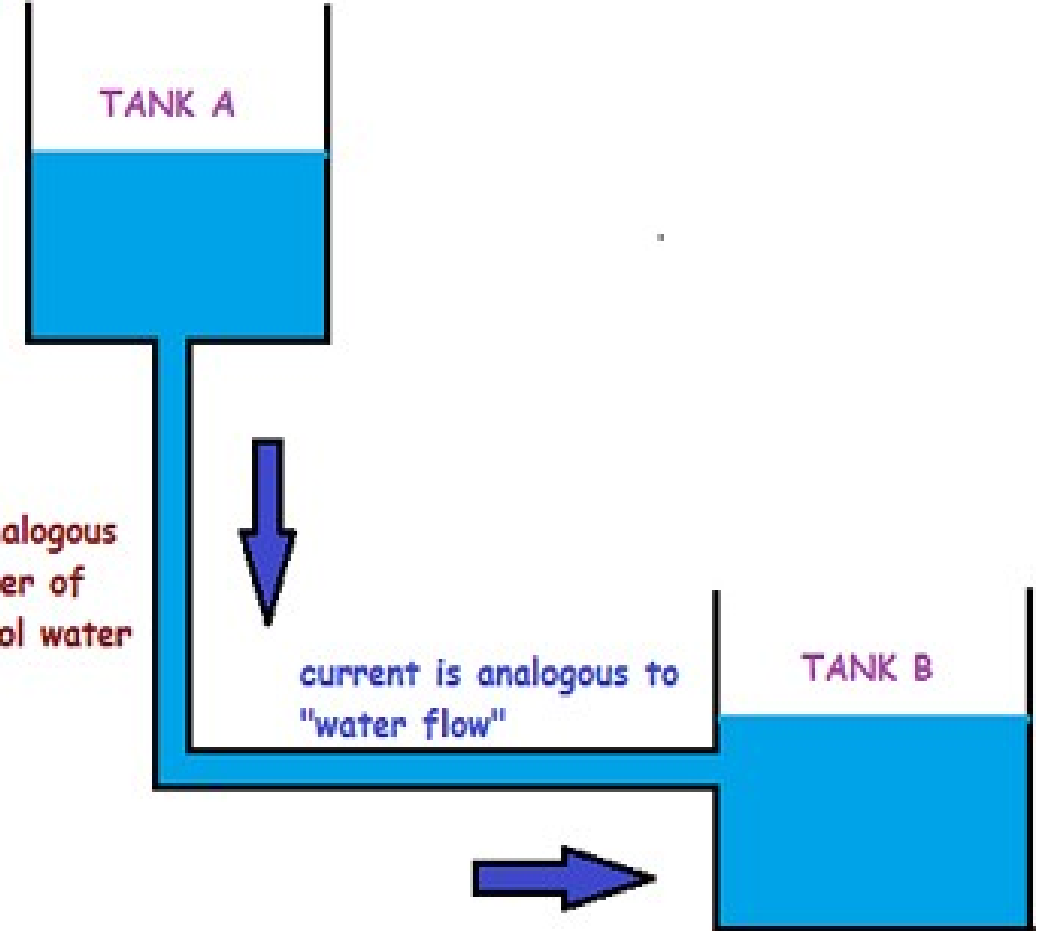
Resistance

Voltage

Current



voltage is analogous to pressure in the tank forcing the water to flow from tank A to tank B



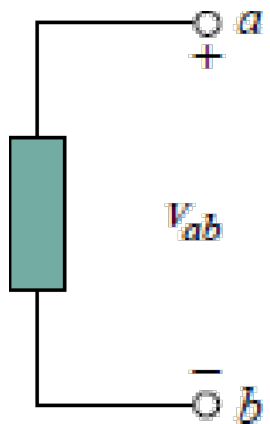
resistance is analogous to small diameter of pipe that control water

current is analogous to "water flow"

Basic Circuit Elements and Sources

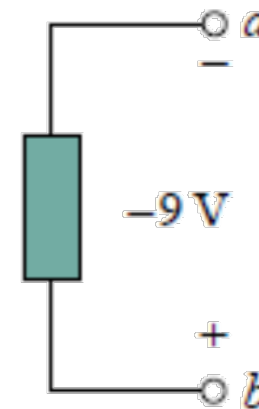
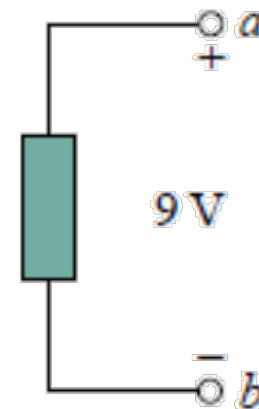
Voltage

Voltage (or potential difference) is the energy required to move a unit charge through an element, measured in volts (V).



The **voltage** (v_{ab}) between two points a and b in an electric circuit is the energy (or work) needed to move a unit charge from a to b ;
Mathematically:

$$v_{ab} = \frac{dW}{dq}$$



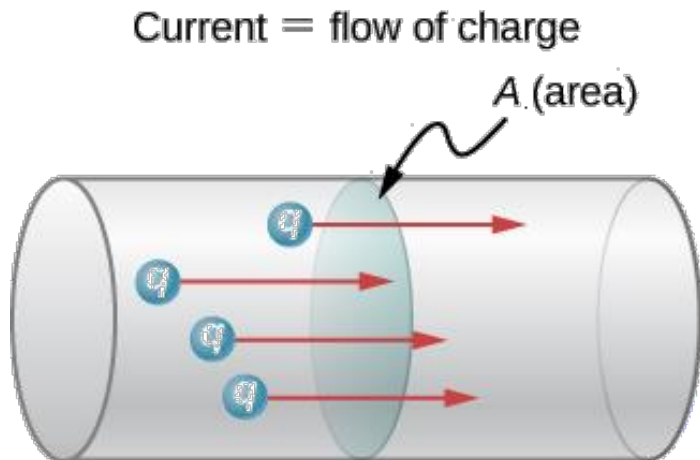
$$v_{ab} = -v_{ba}$$

Note: In a circuit, voltage is often defined relative to “ground”

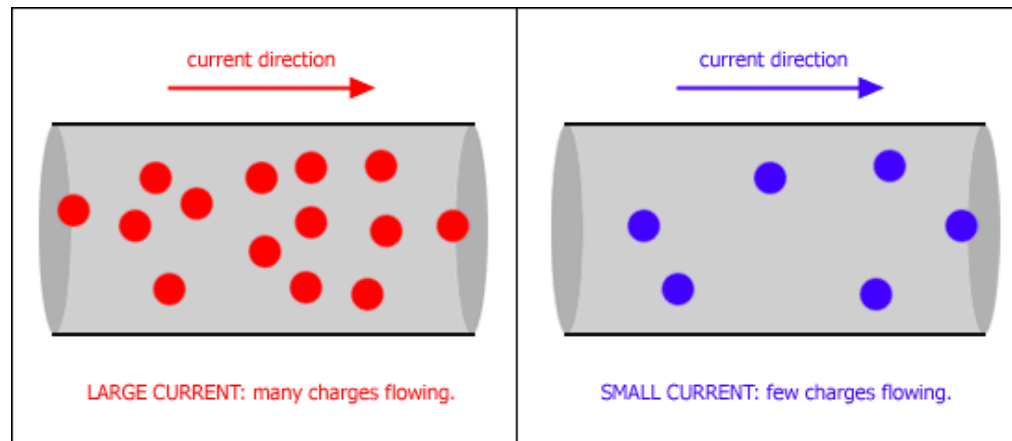
Basic Circuit Elements and Sources

Electric Current

Electric current is the time rate of change of charge, measured in amperes (A).



$$i = \frac{dq}{dt}$$



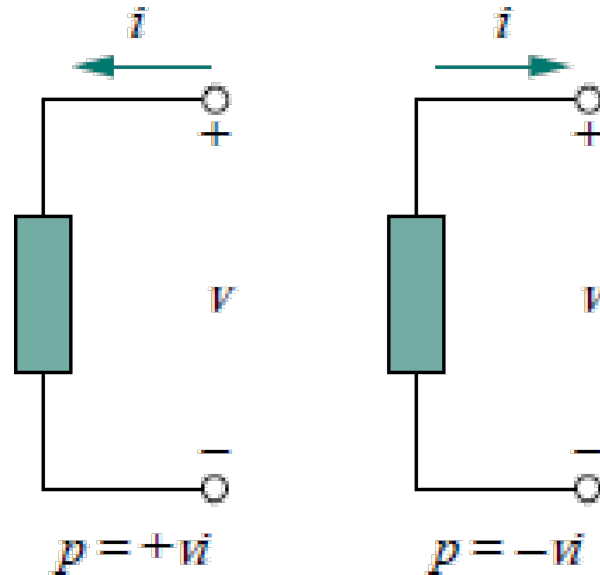
Basic Circuit Elements and Sources

Power is the rate of change of energy, measured in watts (W)

$$p = \frac{dw}{dt}$$

$$p = \frac{dw}{dq} * \frac{dq}{dt}$$

$$p = vi = i^2 R = \frac{v^2}{R}$$



Power is positive :

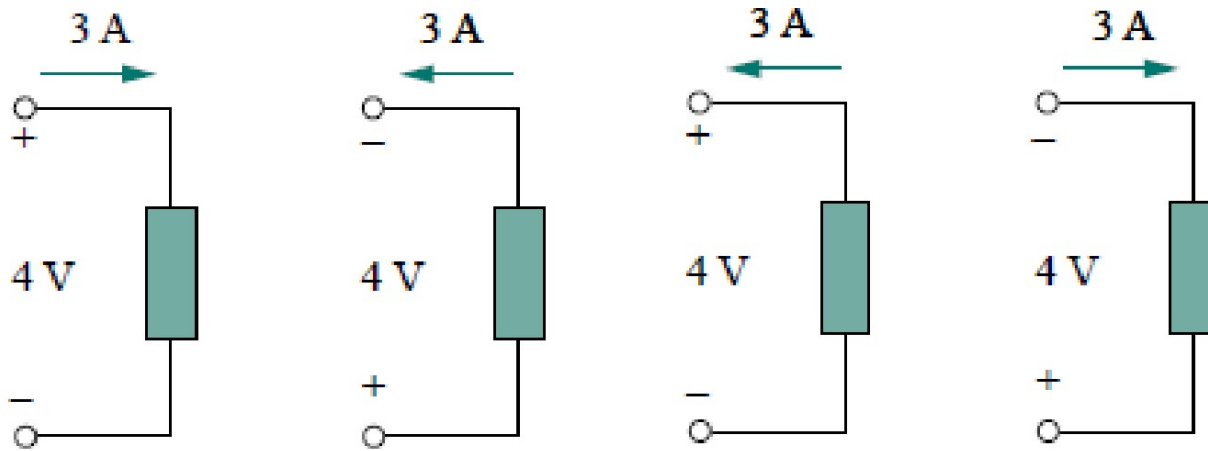
Power is being delivered to or absorbed by the element.

Power is negative:

Power is being supplied by the element.

Passive sign convention is satisfied when the current enters through the positive terminal of an element and $p = +vi$. If the current enters through the negative terminal, $p = -vi$.

Basic Circuit Elements and Sources



$$p = 4 \times 3 = 12 \text{ W}, \quad 4 \times 3 = 12 \text{ W}, \quad 4 \times (-3) = -12 \text{ W}, \quad 4 \times (-3) = -12 \text{ W}.$$

Energy

Energy is the capacity to do work, measured in joules (J)

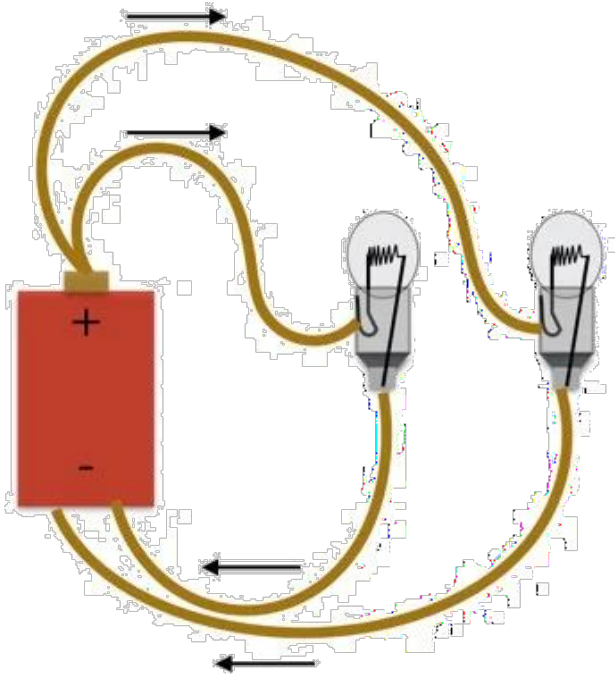
$$\text{Electrical Energy} = \text{Power} \times \text{Time}$$

The electric power utility companies measure energy in watt-hours (Wh)

$$1 \text{ Wh} = 3,600 \text{ J}$$

Basic Circuit Elements and Sources

Circuit Elements



An Electric circuit is an interconnection of various elements in which there is at least one closed path in which current can flow.

Active elements: Capable of supplying energy to a circuit

Voltage sources

Current sources

Generators (such as alternators, DC generators, PV)

Passive elements: It is an electronic component which can only receive energy, which it can either dissipate, absorb or store

Resistors

Inductors

Capacitors

Ohm's Law

According to Ohm's law, the potential difference across any two points on a conductor is directly proportional to the current flowing through it, provided the physical conditions, viz., material length, cross-sectional area and temperature of the conductor remain constant.

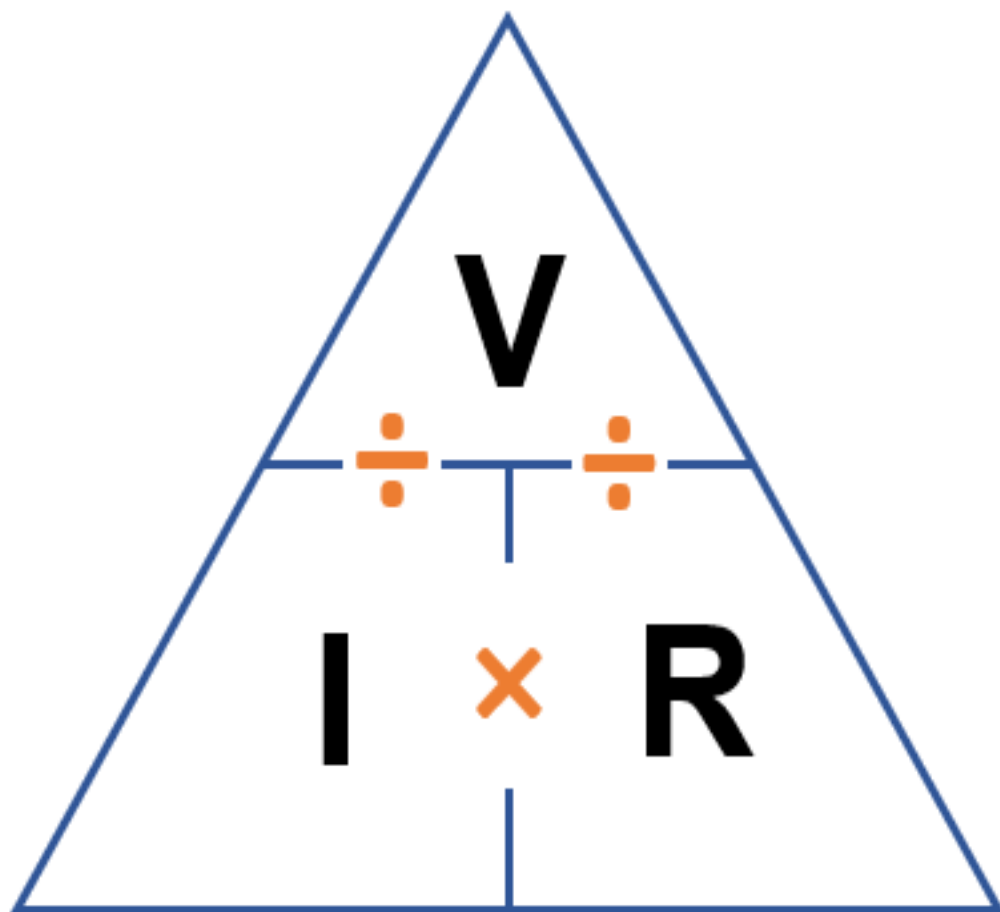
$$V \propto I$$

$$V = R I$$

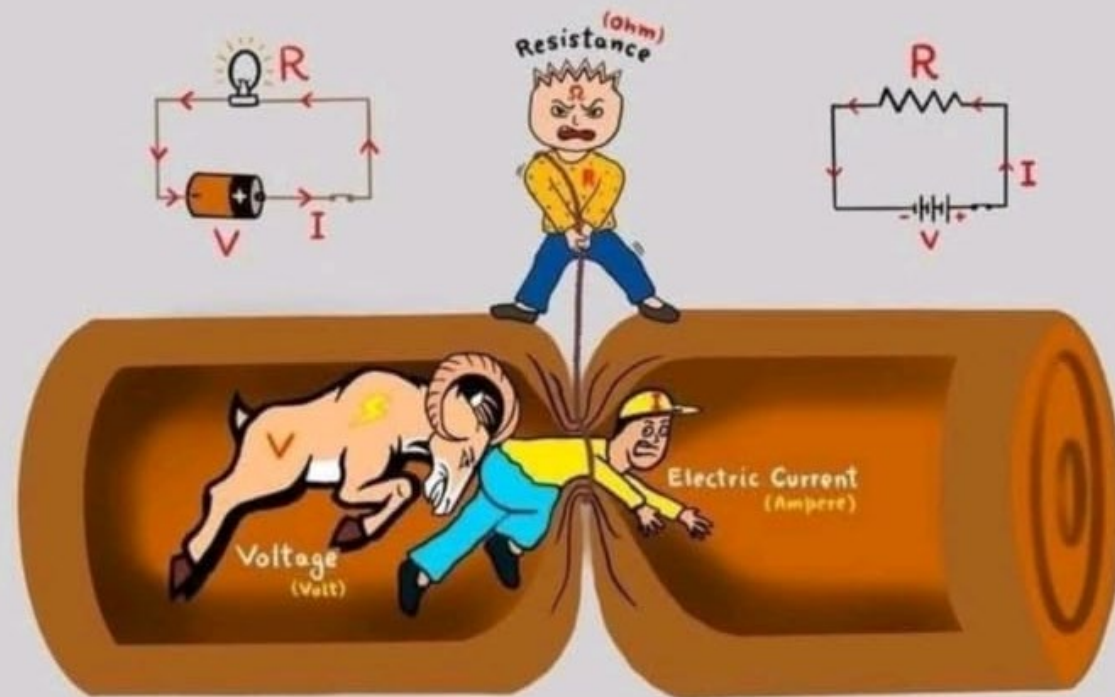
where R is the resistance between two points of the conductor.

Limitations

1. Ohm's law does not apply to nonmetallic conductors. For example, for silicon carbide, the relationship is given by $V = KI^m$ where K and m are constants and m is less than unity.
2. Ohm's law also does not apply to nonlinear devices such as zener diodes, voltage regulator tubes, etc.
3. Ohm's law is true for metal conductors at constant temperature. If the temperature changes, the law is not applicable.



How does voltage ⚡ and resistance affect the current flow?



Ohm's Law:-

$$V = IR$$

Resistance of conductor

Electric current

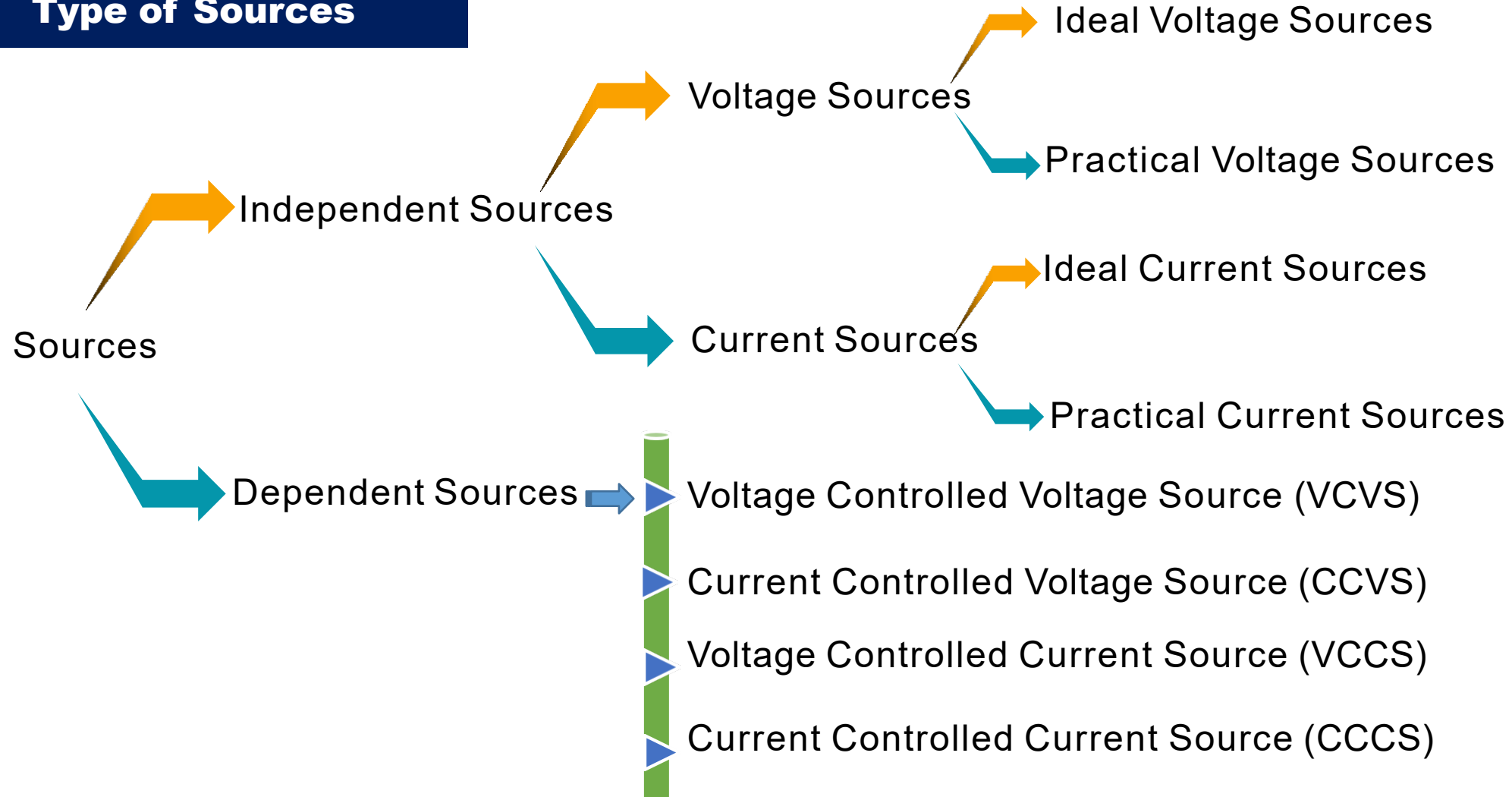
$$R = \frac{V}{I}$$

Constant at given temperature for a given resistor

$$\begin{aligned} \text{① } V &= I \times R \\ \text{② } I &= \frac{V}{R} \\ \text{③ } R &= \frac{V}{I} \end{aligned}$$

Basic Circuit Elements and Sources

Type of Sources



Basic Circuit Elements and Sources

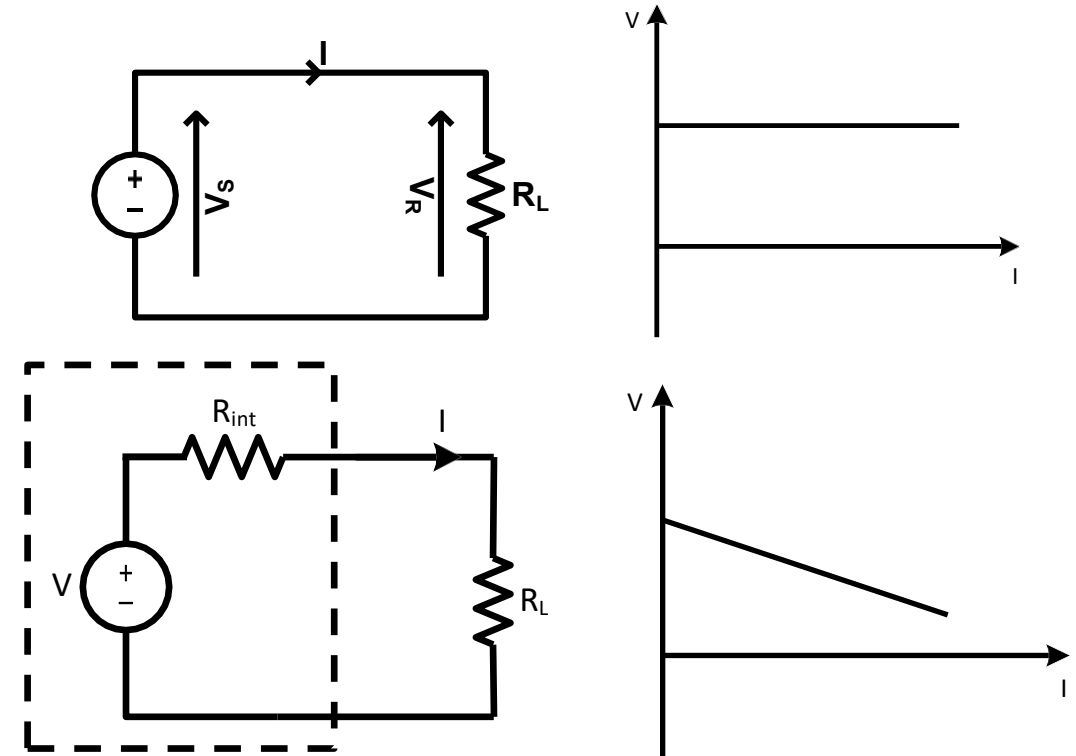
Independent Sources

An ideal independent source is an active element that provides a specified voltage or current that is completely independent of other circuit variables.

Voltage source

An **Ideal Voltage Source** is one that maintains a constant terminal voltage, no matter how much current is drawn from it.

A **Practical Voltage Source** has low but finite internal resistance (R_{int}) that causes its terminal voltage to decrease when load current is increased and *vice-versa*.



Basic Circuit Elements and Sources

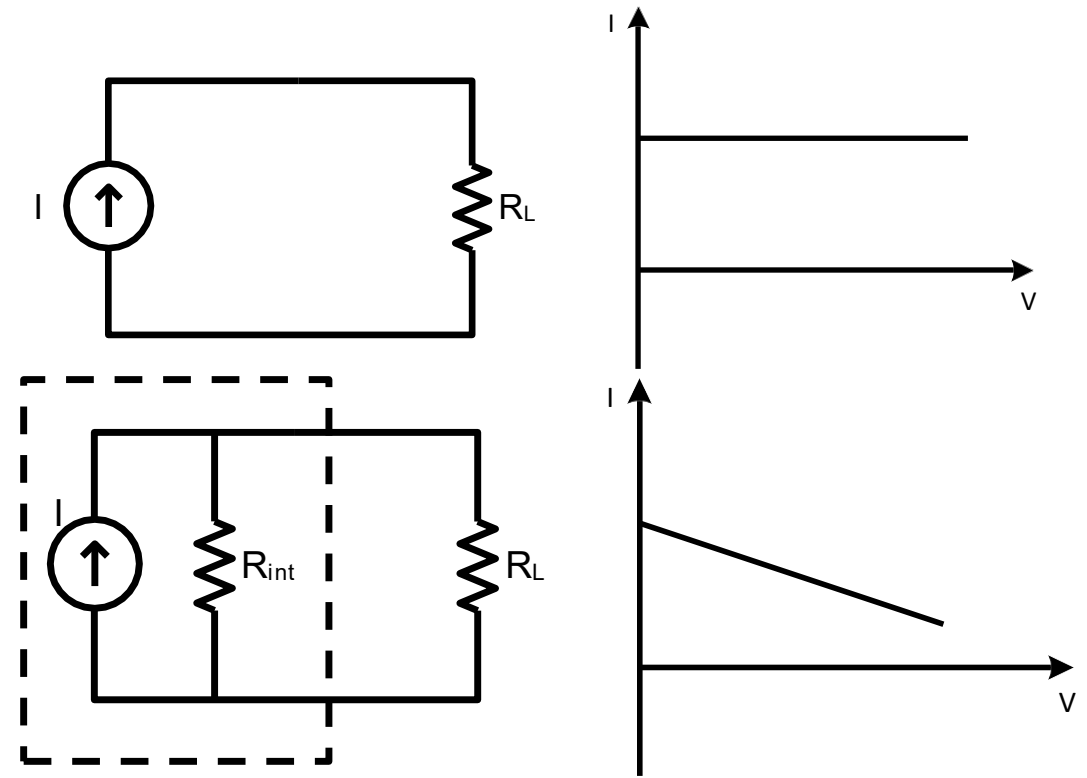
Independent Sources

An ideal independent source is an active element that provides a specified voltage or current that is completely independent of other circuit variables.

Current source

An **Ideal Current Source** is one which will supply the same current to any resistance (load) connected across its terminals.

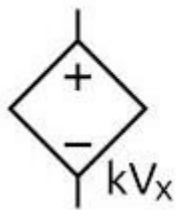
A **Practical Current Source** has high but finite internal resistance (R_{int}). Therefore, the load current will change as the value of load resistance changes.



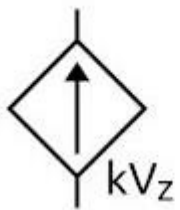
Basic Circuit Elements and Sources

Dependent Sources

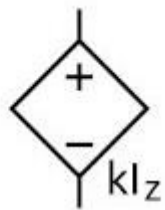
The special kind of sources in which the source voltage or current depends on some other quantity in the circuit which may be either a voltage or a current anywhere in the circuit are called Dependent sources or Controlled sources.



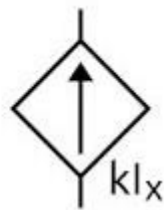
VCVS



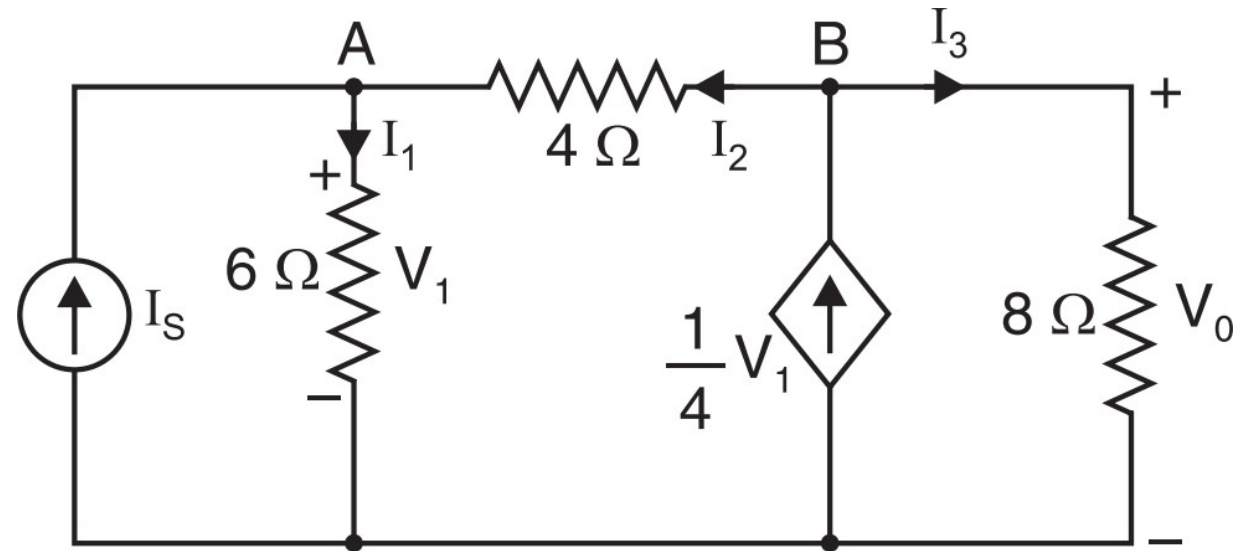
VCCS



CCVS

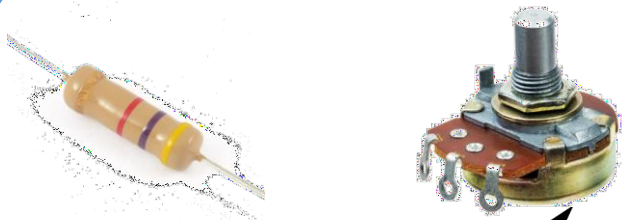


CCCS



Basic circuit elements

Resistor



$$V \propto I$$



$$V = IR$$

Power Drawn by Resistor

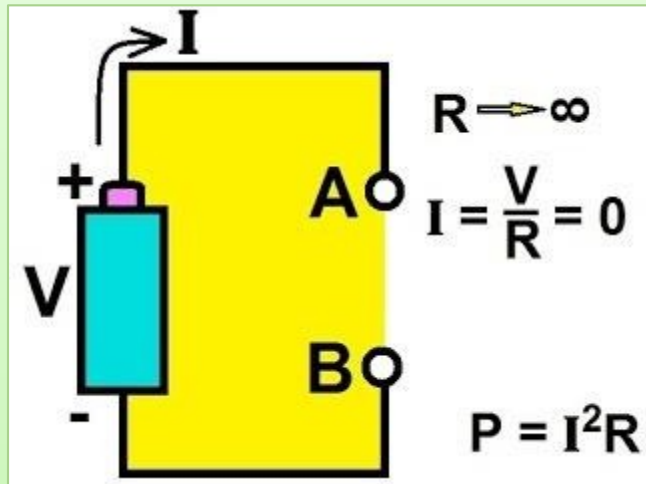
$$P = VI = I^2R = \frac{V^2}{R}$$

$$R = \frac{\rho l}{a} \Omega$$

- ♦ Resistance is that property of a circuit element which **opposes the flow of electric current** and in doing so converts electrical energy into heat energy.
- ♦ It is the **proportionality factor** in ohm's law relating voltage and current.
- ♦ The unit of electric resistance is the **ohm (Ω)**. One ohm is one volt per ampere.
- ♦ The resistance of an electrical conductor depends on 4 factors
 - the length of the conductor (l)
 - the cross-sectional area of the conductor (a)
 - the type of material (resistivity (ρ))
 - the temperature of the material
- ♦ Resistivity is a measure of the ease with which electrons can travel through a certain material. Unit is $\Omega\text{-m}$

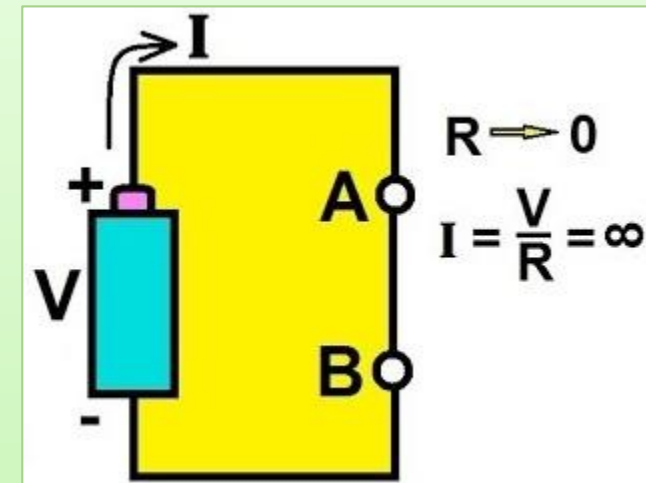
Concept of Open Circuit and Short Circuit

Open Circuit



An open circuit is a circuit element with resistance approaching infinity.

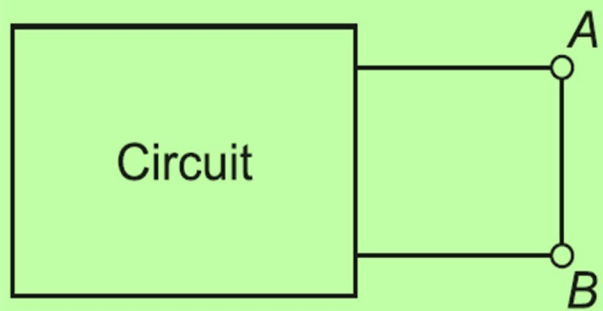
Short Circuit



A short circuit is a circuit element with resistance approaching zero.

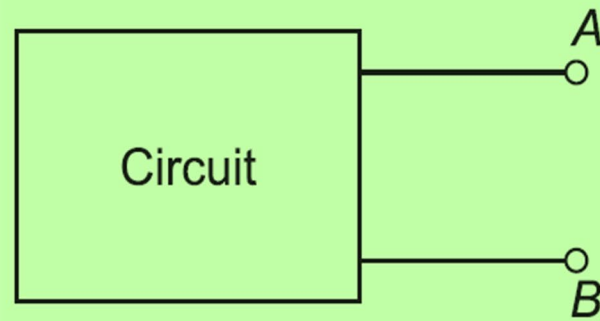
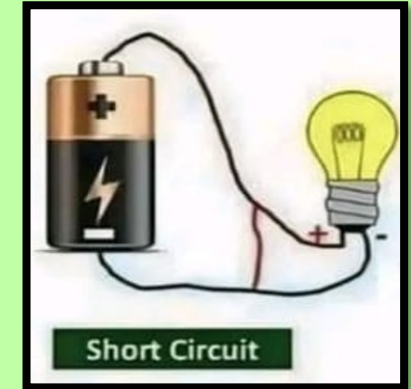
Concept of Open Circuit and Short Circuit

When two terminals of a circuit are connected by a wire, they are said to be short circuited. A short circuit has following features:



Short circuit

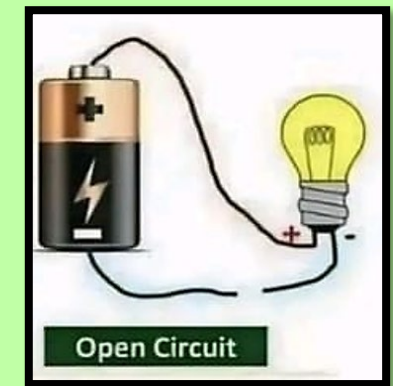
- (i) It has zero resistance.
- (ii) Current through it is very large.
- (iii) There is no voltage across it.



Open circuit

When two terminals of a circuit have no direct connection between them, they are said to be open circuited. An open circuit has the following features:

- (i) It has infinite resistance.
- (ii) Current through it is zero.
- (iii) The entire voltage appears across it.

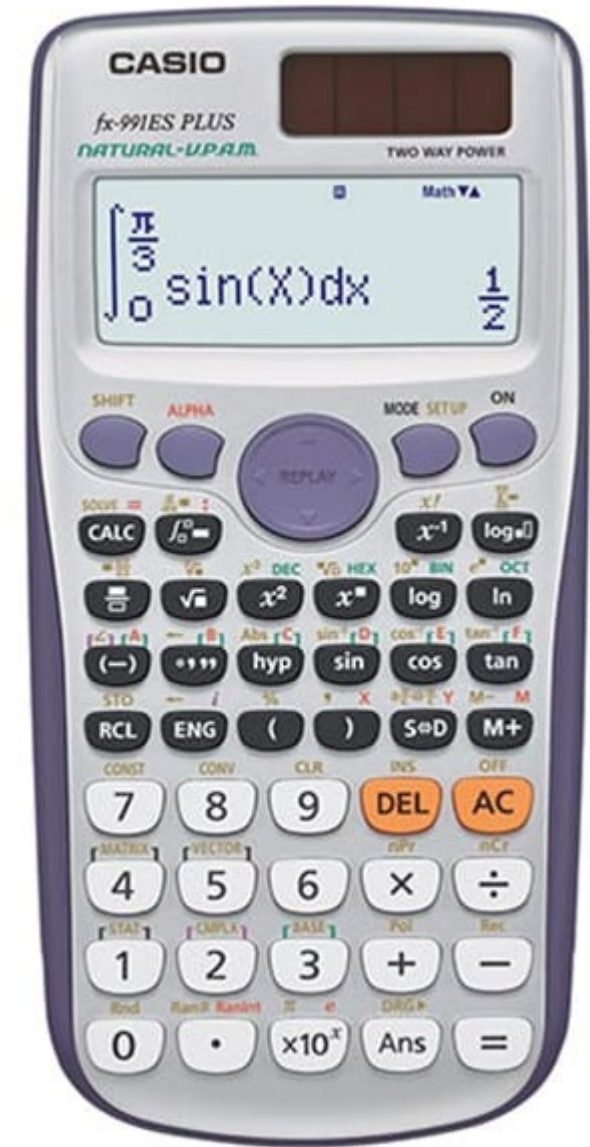
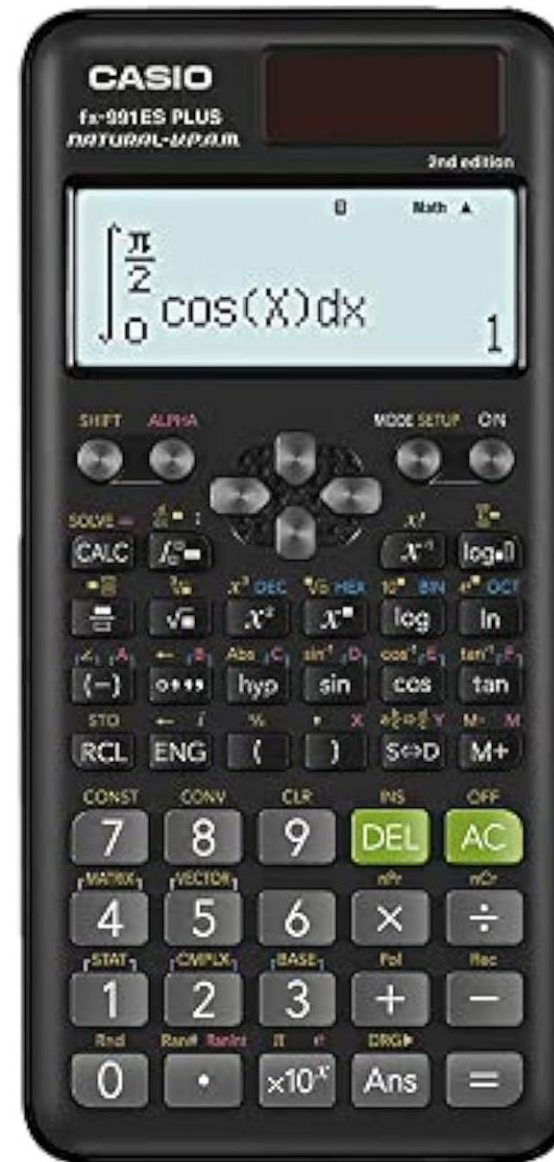


Calculator Suggestion/Advice:

REMEMBER: WITH GREAT
POWER COMES GREAT
CURRENT SQUARED
TIMES RESISTANCE.



OHM NEVER FORGOT HIS
DYING UNCLE'S ADVICE.



Numericals:



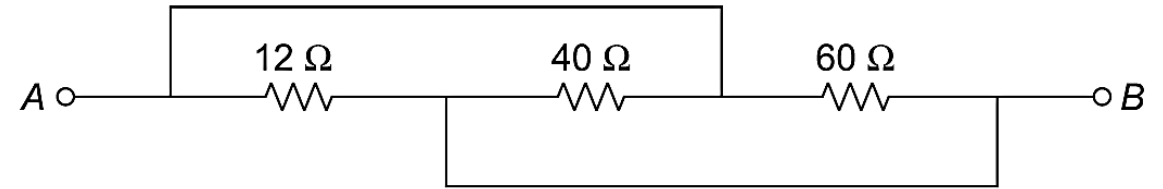
Studying Theory
in BEE



Solving Numerical
in BEE

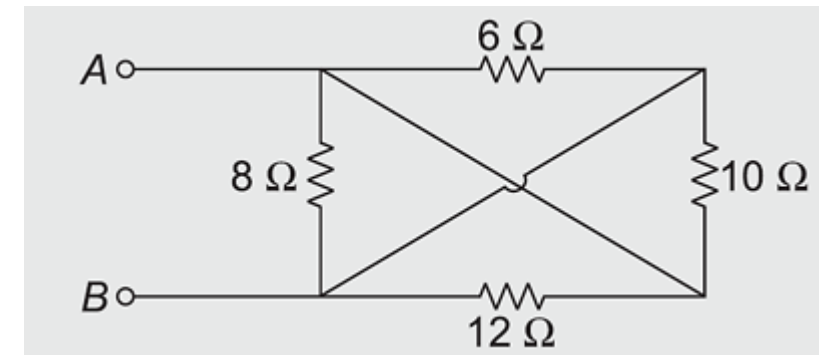
Q1:

Find the equivalent resistance between terminals A and B



Q2:

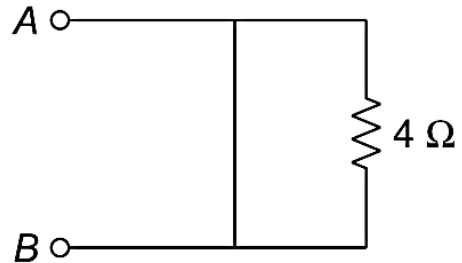
Find the equivalent resistance between terminals A and B



Numericals:

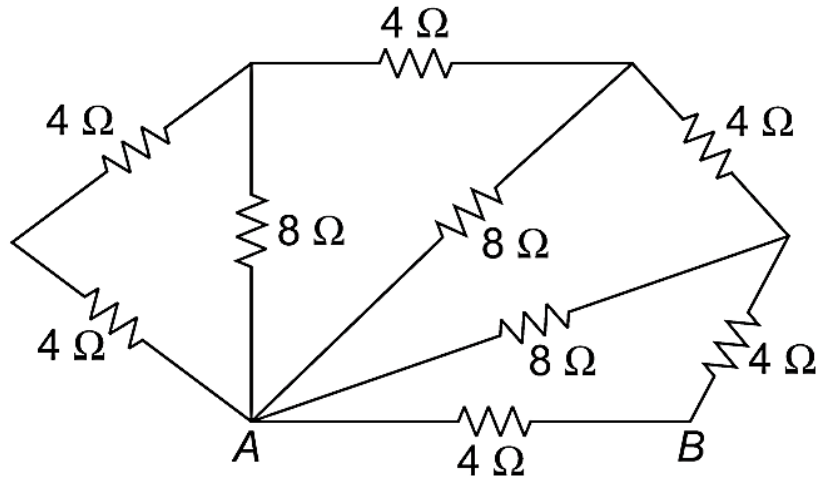
Q3:

Find the equivalent resistance between terminals A and B



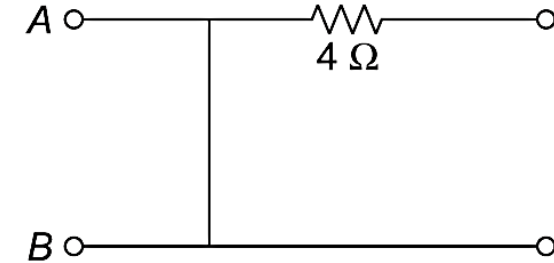
Q4:

Find the equivalent resistance between terminals A and B



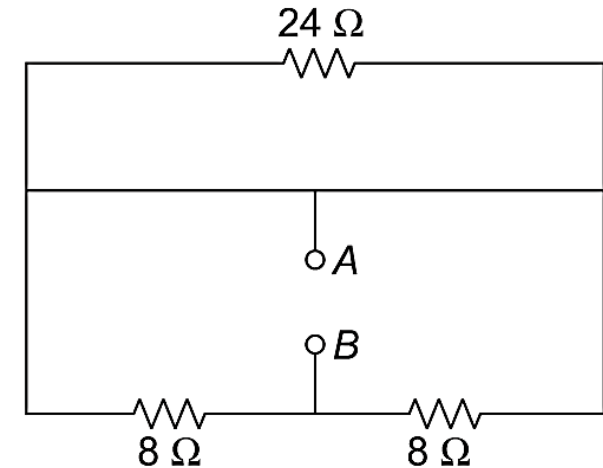
Q5:

Find the equivalent resistance between terminals A and B



Q6:

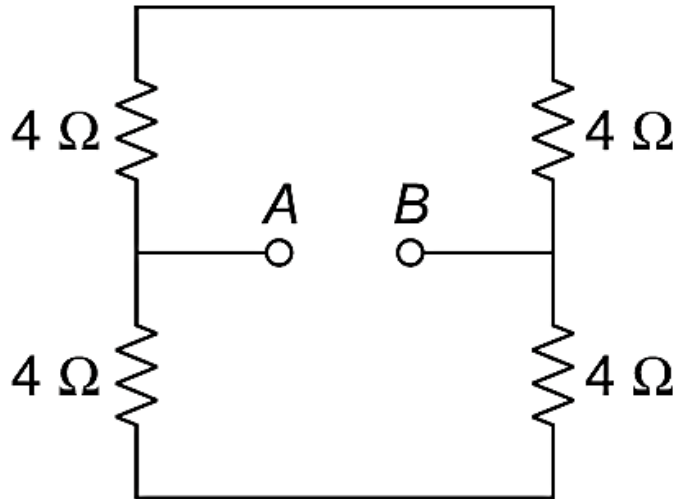
Find the equivalent resistance between terminals A and B



Numericals for Homework:

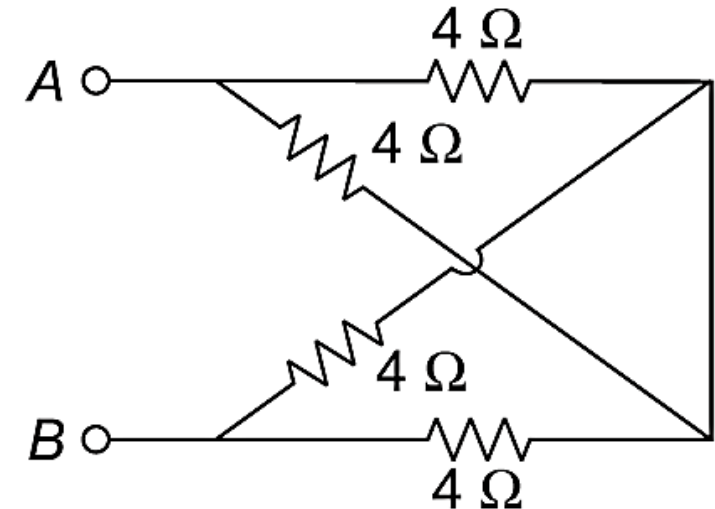
Q1:

Find the equivalent resistance between terminals A and B



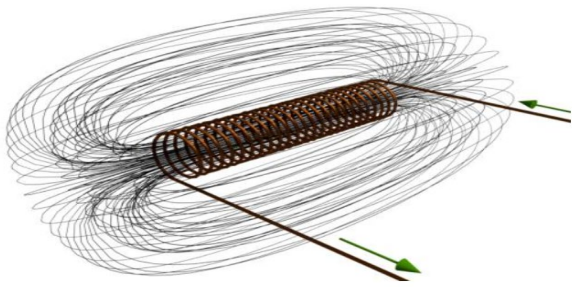
Q2:

Find the equivalent resistance between terminals A and B



Basic Circuit Elements:

Inductor



(a)



(b)

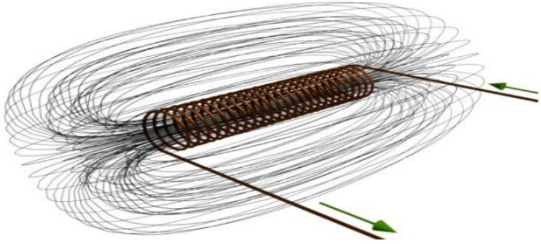
$$V_L = L * \frac{di}{dt}$$

- If a time-varying current flows through a coil there is an emf induced in it.
- The induced emf across the coil is directly proportional to the rate of change of current with respect to time.

$$V_L = L * \frac{di}{dt}$$

- Due to the property inducing emf, all types of electrical coil can be referred to as **inductors**.
- An **inductor** is an energy storage device that stores energy in the form of a magnetic field
- Inductor opposes any change in the amount of current flowing through it.

Inductor



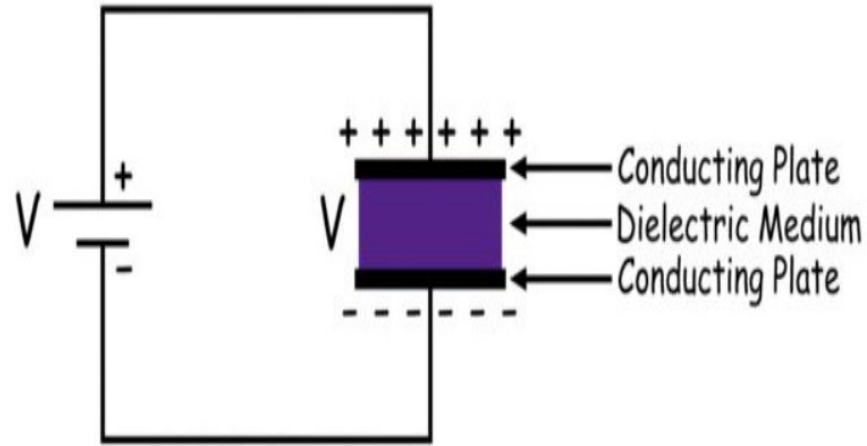
$$L = \mu \frac{AN^2}{l}$$

The inductance of an electrical conductor depends on **4** major factors

- It is directly proportional to the square of the number of turns.
- It is directly proportional to the area of cross section.
- It is inversely proportional to the length.
- It depends on the absolute permeability of the magnetic material

Basic Circuit Elements:

Capacitor



$$i_c = C * \frac{dv}{dt}$$

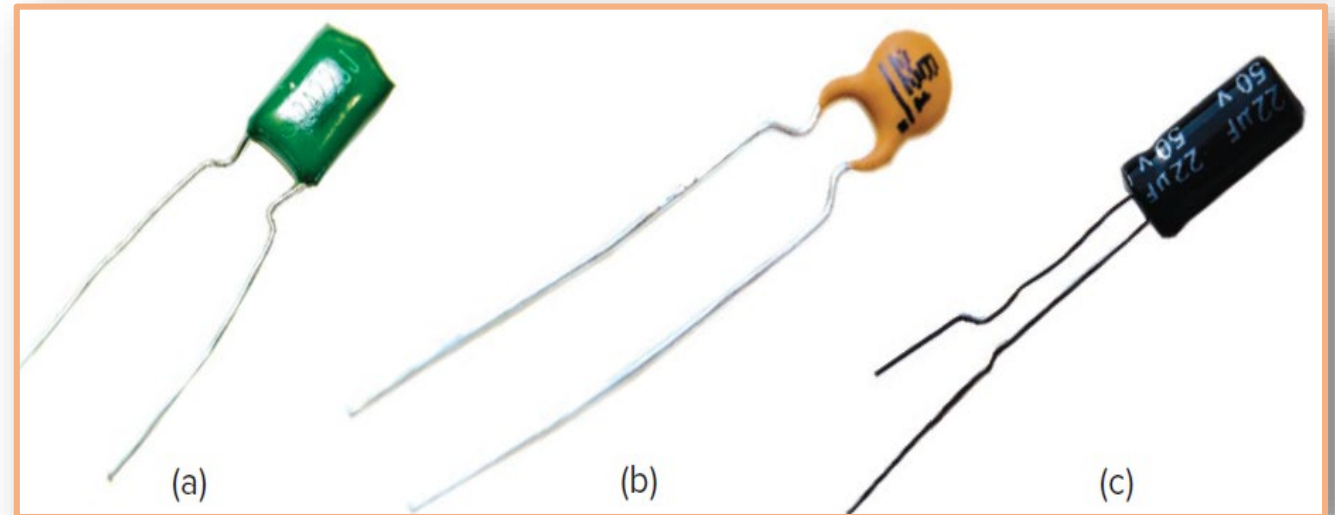
- ❖ A **capacitor** in an electrical circuit behaves as a charge storage device. It holds the electric charge when we apply a voltage across it, and it gives up the stored charge to the circuit as when required.
- ❖ The most basic construction of a capacitor consists of two parallel conductors (usually metallic plates) separated by a dielectric material.
- ❖ When we connect a voltage source across the capacitor, the conductor (capacitor plate) attached to the positive terminal of the source becomes positively charged, and the conductor (capacitor plate) connected to the negative terminal of the source becomes negatively charged.
- ❖ Because of the presence of dielectric in between the conductors, ideally, no charge can migrate from one plate to other.

Basic Circuit Elements:



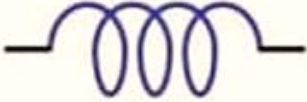
Capacitor

- The capacitance depends upon three physical factors, and these are the active area of the capacitor conductor (plates), the distance between the conductors (plates) and permittivity of the dielectric medium.
- Here, ϵ is permittivity of the dielectric medium, A is the active area of the plate and d is the perpendicular distance between the plates.

$$C = \frac{\epsilon A}{d}$$



Parallel and Series - Formulas

	Capacitor 	Resistor 	Inductor 
Series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$	$R = R_1 + R_2$	$L = L_1 + L_2$
Parallel	$C = C_1 + C_2$	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$
Fundamental Formula	$\Delta V = \frac{Q}{C}$	$\Delta V = IR$	$E_L = -L \frac{dI}{dt}$