Basic Electrical Engg.
ES/EE/T101B

- **DC Network Theorems**
- **AC fundamentals**
- **Electromagnetism**
- **Magnetically coupled circuits**
- **Three -phase A.C. circuits**
- **Non-sinusoidal periodic waves**
- **Electrostatics**
- **Electrical Machines**

Course outcomes (CO)

After successful completion of this course, the students would be able to:

CO1	**Describe** fundamental theorems of electrostatics, electromagnetics and electrical circuits
CO2	**Describe** the operating principles of different ac and dc electrical machines and systems
CO3	**Apply** fundamental concepts of various electrical quantities related to single phase and 3 phase alternating current systems
CO4	**Solve** numerical problems on electrostatics, electromagnetics and electrical circuits and systems

DC circuits & circuit elements

- ILO – Day1
  - Classify electric circuits & circuit elements
  - Describe passive circuit elements
    - Resistance
    - Inductance
    - Capacitance

DC Networks

- Electrical Network
  - Electrical network is a collection of different electrical elements and components connected in such a way that they perform a specific function.

- Electrical circuit
  - Electrical circuit is obtained when the electrical network is closed so that a current can flow through the network.

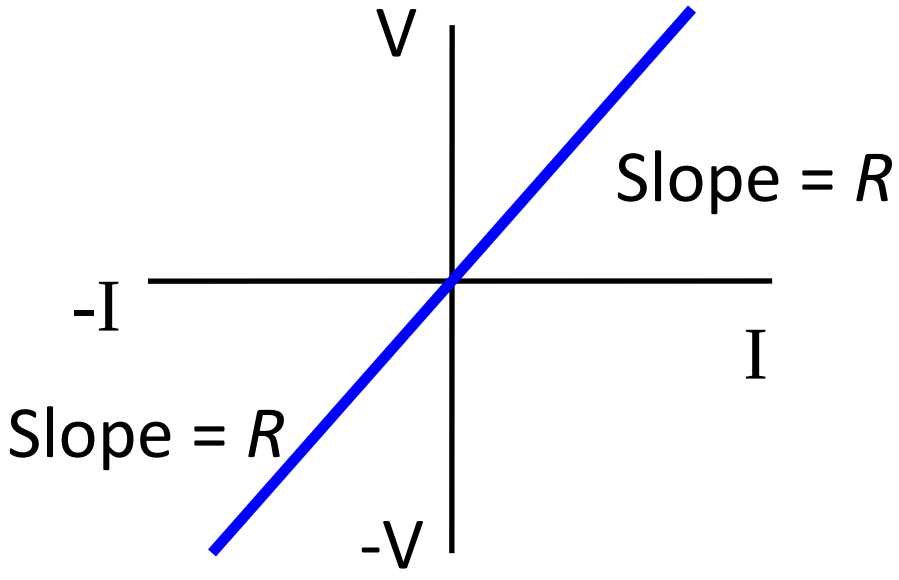
Electrical circuits classification

- Linear and non-linear circuit
- Active and Passive circuit
- Bilateral and Unilateral circuit

Linear and non-linear circuit element

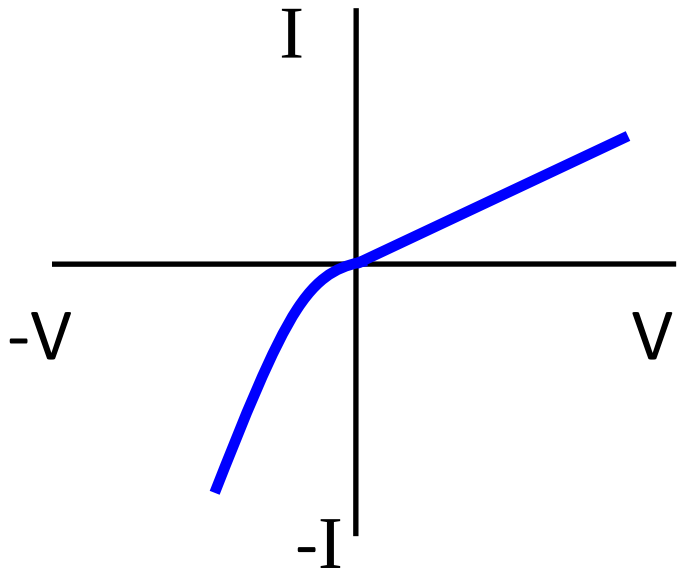
- A **Linear circuit element** is one for which the input vs. output characteristic is a straight line.
- For example, a resistor is a linear element for which the voltage vs. current relationship is linear over its entire operating range.

Ohm's Law: $V=IR$



Linear and non-linear circuit element

- On the other hand, the input vs. output relationship is not linear in case of **non-linear circuit elements**.
- For example in semiconductors, diodes, transistors etc. the voltage vs. current relationship is not a straight line over the entire operating range.



Active and Passive circuit elements

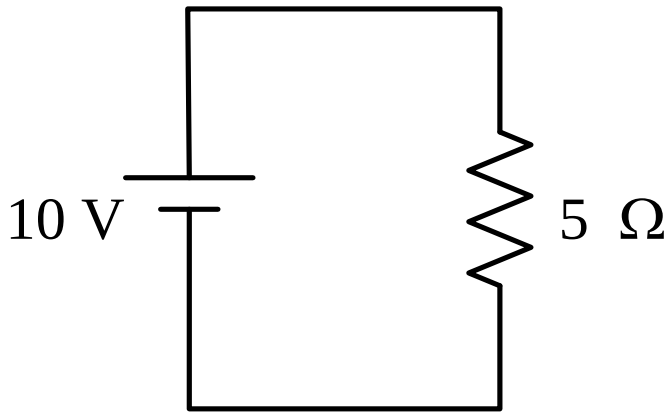
- **Active circuits** are those that have elements which have some energy source within them or can amplify a signal
  - for example a battery

- **Passive circuits** are those that have elements do not have any energy source in them, neither they can amplify any signal
  - examples are resistance, capacitance etc.

Bilateral and Unilateral circuit

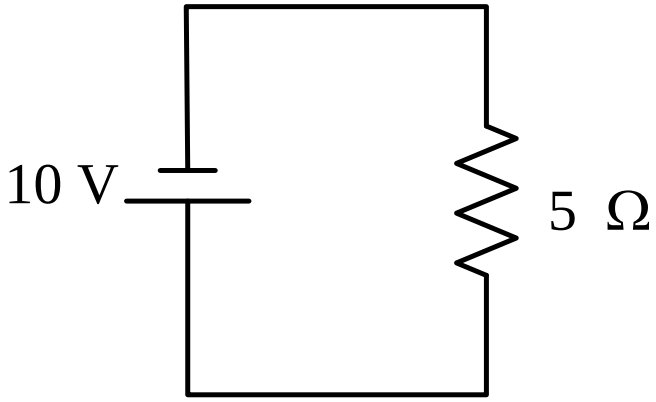
- **Bilateral circuits** are those whose performance does not change even when the supply source polarity is reversed.

Current ???



i = 10/5 = 2A

Current ???

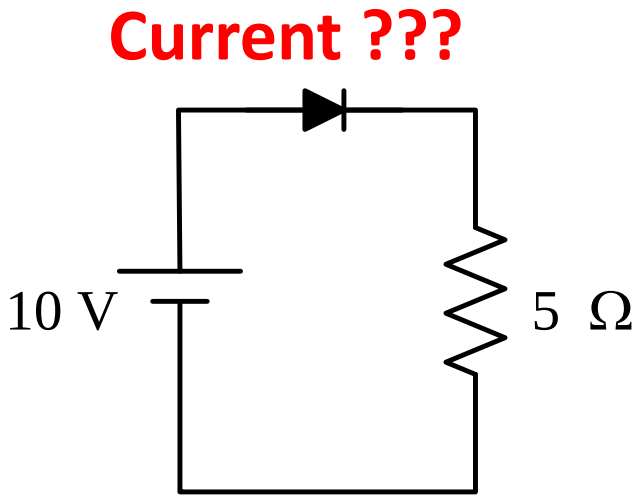


i = 10/5 = 2A

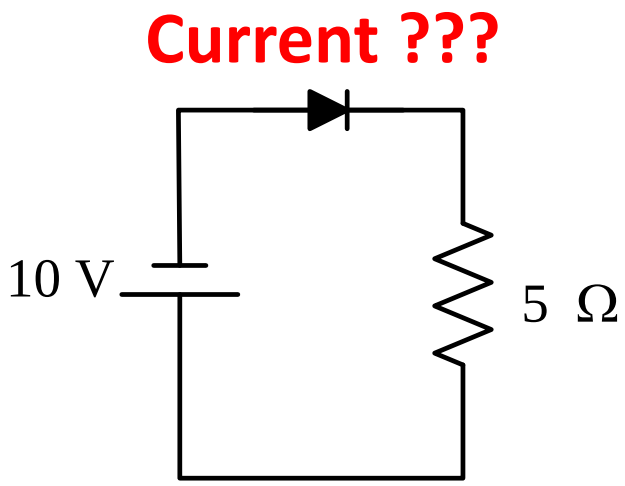
- Bilateral circuits mostly contain linear, passive elements in addition to the source.

Bilateral and Unilateral circuit

- **Unilateral circuits** are those whose performance varies when the supply source polarity is reversed.



i = 10/5 = 2A



i = 0

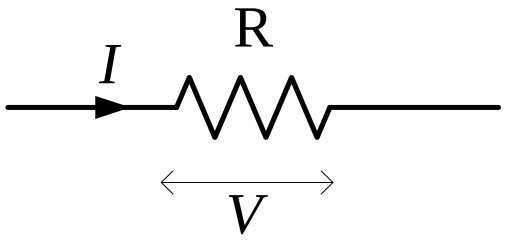
- Unilateral circuits contain non-linear elements in addition to other linear elements, and also sometimes active elements as well in addition to the source.

Passive circuit elements

- Resistance (R)
- Inductance (L)
- Capacitance (C)

Resistance

- Electrical resistance is the property of a material by virtue of which it opposes the flow of electrons through the material.
- Thus, resistance restricts the flow of electric current through a material.
- Mathematically, resistance is defined as the ratio of voltage across it, to the current flowing through it:

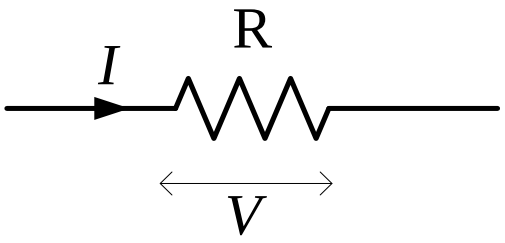


$$R = \frac{V}{I}$$

- The unit of resistance (R) is “ohm” (Ω)

Resistance

- When an electric current flows through any conductor material, heat is generated due to collision of the free moving electrons with the atoms of the material.
- **Power** absorbed by the resistance:



$$P = V \times I = (IR) \times I = \boxed{I^2 R} \quad \text{Watt}$$

$$P = V \times I = V \times \frac{V}{R} = \boxed{\frac{V^2}{R}} \quad \text{Watt}$$

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

Resistance

- The total **energy** absorbed by the resistance in the form of heat is then expressed as:

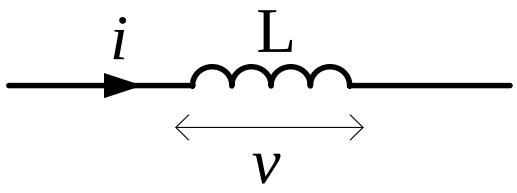
$$W = \int_0^t P\,dt = P\int_0^t dt = Pt = I^2Rt = \frac{V^2}{R}t \quad \text{Joule}$$

Energy = Power × Time

Inductance

- Inductance is the property of a material by virtue of which is opposes any **change** of electric current passing through it.

- Mathematically, inductance is defined as the ratio of voltage across it, to the rate of change of current through it:

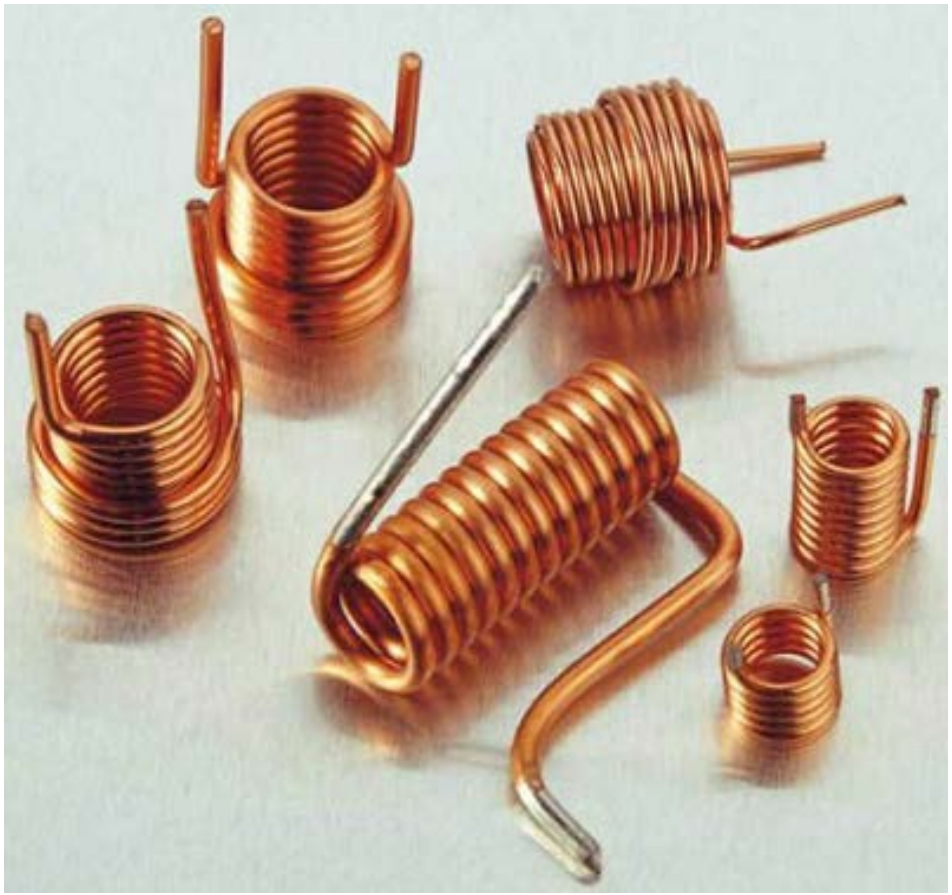


$$L = \frac{v}{\frac{di}{dt}} \qquad \Rightarrow v = L\frac{di}{dt}$$

- The unit of inductance (L) is “Henry” (H)

Inductance

- A conducting wire when twisted into a coil, it becomes a simple inductor.



Inductance

- The power absorbed by an inductor is given by:

$$P = v \times i = L\frac{di}{dt} \times i = \boxed{Li\frac{di}{dt}}$$

- Energy absorbed by the inductor will thus be given by:

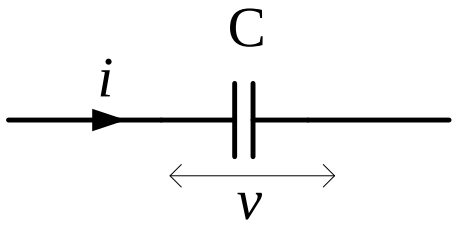
$$W = \int_0^t P dt = \int_0^t Li\frac{di}{dt}dt = \int_0^I Lidi = \boxed{\frac{1}{2}LI^2}$$

Capacitance

- Capacitance is the property of a material to store electrical charge within it.
- Mathematically, capacitance is defined as the ratio of time integral of current through it, to the voltage across it.
- Note that time integral of current is nothing but the charge:

$$\int i dt = q$$

- Thus, we can express capacitance of an object as:



$$C = \frac{\int i dt}{v} \quad \boxed{\Rightarrow C = \frac{q}{v}}$$

Capacitance

- Quantitatively, capacitance is a measure of charge (q) per unit voltage (v) that can be stored in an element.

$$C = \frac{q}{v} \qquad or,\ q = Cv \quad \therefore i = \frac{dq}{dt} = \frac{d(Cv)}{dt} \quad \Rightarrow \boxed{i = C\frac{dv}{dt}}$$

$$dv = \frac{1}{C} idt \quad \Rightarrow \int_0^V dv = \frac{1}{C}\int_0^t idt \quad \Rightarrow \boxed{V = \frac{1}{C}\int_0^t idt}$$

- The unit of capacitance (C) is “Farad” (F)

Capacitance

- Power absorbed by the capacitor during the charging process is given by:

$$P = v \times i = v \times C \frac{dv}{dt} = \boxed{Cv \frac{dv}{dt}}$$

- Energy stored by the capacitor will thus be given by:

$$W = \int_0^t P dt = \int_0^t Cv \frac{dv}{dt} dt = \int_0^V Cv dv = \boxed{\frac{1}{2} CV^2}$$