Lecture 3 : Voltage, Ground, Power, Power Sources

Learning Objectives:

1. **Define resistance, resistors**
2. **Define Ohm's Law**
3. **Use ohms law to compute voltage and current.**

1. Electrical Elements:

An **electrical circuit** is made up of **electrical elements.** Initially we will look at circuits made up of circuit elements shown below. The circuit symbol of the elements is also shown.

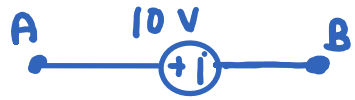
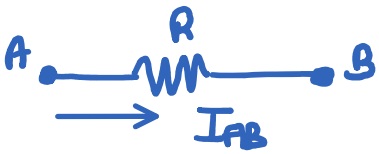
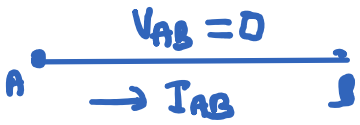
1. **Ideal Voltage Source:**		$V_{AB} = V_A - V_B = 10\,V$
2. **Ideal Current Source:**		$I_{AB} = 2mA$
3. **Wires (ideal conductor)**		$V_{AB} = 0\,V$
4. **Resistor:**		$V_{AB} = I_{AB}R$

Fig 3.1: Electrical elements and their symbols.

In the previous lecture we looked at ideal voltage and current sources. We now take a look at wires and resistors.

1.1 Wires:

Wires are represented by unbroken lines as shown in Fig. 3.1 above. Wires are assumed to be ideal conductors, i.e, the voltage difference between two point on a wire is zero. Two points in a circuit that are connected by a wire are said to be **shorted** together.

Circuit symbol of wire: 

1.2 Resistor: A resistor is an electrical element that has resistance. Resistance can be seen as the voltage ("effort") required to push current through the electrical element. Resistance of element is given by the following expression,

$$R = \frac{\rho l}{A}, \text{ where,}$$

$\rho =$ Resistivity of the material, $l =$ length, $A =$ cross $-$ sectional area.

Resistivity can also be seen as the property of a material to "resist" the flow of current.

2. Ohm's Law:

Ohm's law captures the relationship between voltage across a resistor and current through it. Ohm's law can have the following two forms,

2.1 Ohm's Law (1) -

$$V_{AB} = I_{AB} R$$

2.2 Ohm's Law (2) -

$$V_{AB} = -I_{BA} R$$

To determine if we need to include a negative sign, look at the subscripts of voltage and current. If the **subscripts** are in the **same order**, then there is **no** negative sign.

Some observations that we may make based on Ohm's law are:

1. **Low** Resistance, $R \Rightarrow$ **Small** voltage causes large current $\left(I = \frac{V}{R}\right)$.
2. **Large** Resistance, $R \Rightarrow$ **Large** voltage without much current flow.

I-V Curves:

$I - V$ curves capture the relationship between the current and voltage. For a **resistance** $I - V$ curve is a **straight line.** The inverse of the slope of the straight line represents the resistance. The smaller the slope higher the resistance.

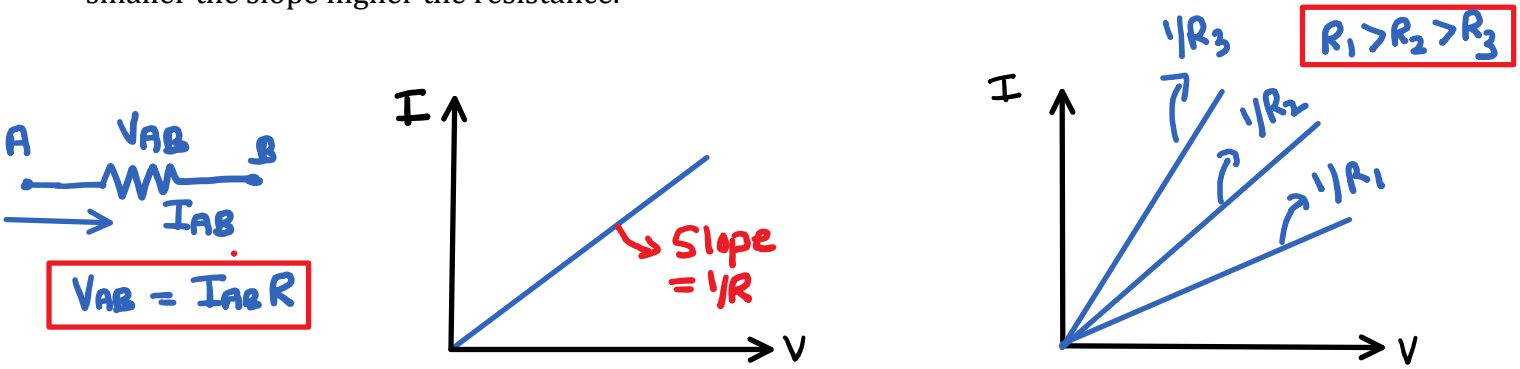
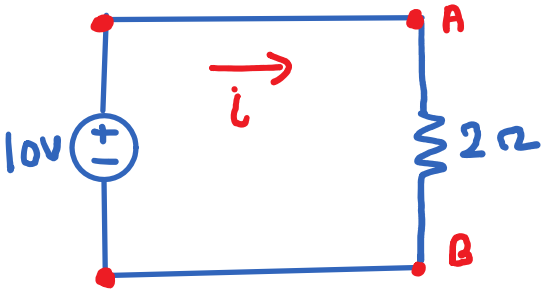


Fig. 3.2: $I - V$ Charateristics of a resistor

Examples:

Ex. 1 Find current *i* in the circuit shown below.

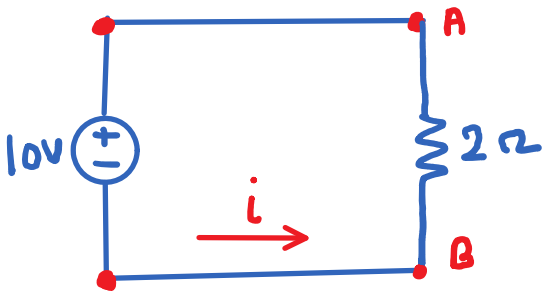


$$V_{AB} = 10\,V = i_{AB} R = i_{AB} \times 2$$

$$i = i_{AB} = \frac{V_{AB}}{R} = \frac{10}{2}$$

$$i = 5\,A$$

Ex 2 . Find current *i* in the circuit shown below.

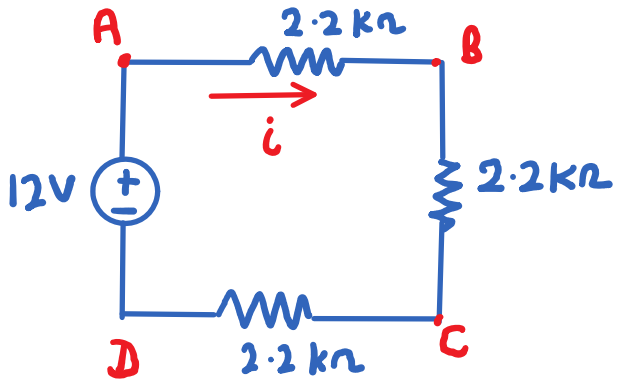


$$V_{AB} = 10\,V = i_{AB}R$$

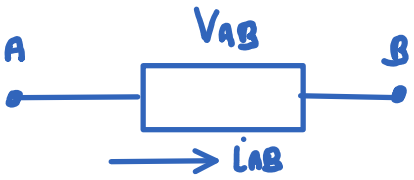
$$i = i_{BA} = \frac{V_{BA}}{R} = -\frac{V_{AB}}{R}$$

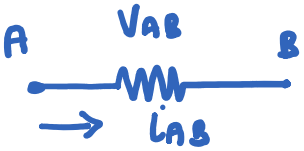
$$\boxed{i = -5\,A}$$

Ex 3 . Find current *i* and voltage V_{CB} in the circuit shown below.



3. Power:





As discussed earlier the power consumed by an electrical element is given by,

$$P = V_{AB} \times i_{AB}.$$

The voltage V_{AB} across a resistor is given by,

$$\boxed{V_{AB} = i_{AB} \times R.}$$

Hence the power consumed by a resistor is given by,

$$P = V_{AB}i_{AB} = i_{AB}Ri_{AB}$$

$$\boxed{P = i_{AB}^2 R} \quad \text{or} \quad \boxed{P = \frac{V_{AB}^2}{R}} \quad \text{Watts}$$