PHYSICS

OHM'S LAW

1. **George Simon Ohm (1787-1854)** German physicist, George Simon Ohm is famous for the law named after him. He arrived at the law by considering an analogy between thermal and electrical conduction. He also contributed to theory of sirens, interference of polarised light in crystals etc. Ohm, the practical unit of resistance, is named in his honour.

2. According to Ohm's law, **the electric current through a conductor is directly proportional to the potential difference across it, provided the physical conditions such as temperature and pressure remain unchanged.**

3. Let V be the potential difference applied across a conductor and I be the current flowing through it. According to Ohm's law,

$$V \propto I \text{ or}$$

$$V = RI$$

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

4. The SI unit of resistance is ohm. It is expressed by symbol **Ω** (read as omega) 1 ohm = 1 volt/1 ampere.

5. Most of the metals obey Ohm’s law and the relation between voltage and current is linear. Such resistors are called **ohmic**. Resistors which do not obey Ohm’s law are called **non-ohmic**. Devices such as vacuum diode, semiconductor diode, transistors show non ohmic character. For semiconductor diode, Ohm’s law does not hold good even for low values of voltage

Resistive circuits

6. Resistors are circuit elements that impede the passage of electric charge in agreement with Ohm's law, and are designed to have a specific resistance value R. In a schematic diagram the resistor is shown as a zig-zag symbol. An element (resistor or conductor) that behaves according to Ohm's law over some operating range is referred to as an ohmic device (or an ohmic resistor) because Ohm's law and a single value for the resistance suffice to describe the behavior of the device over that range.

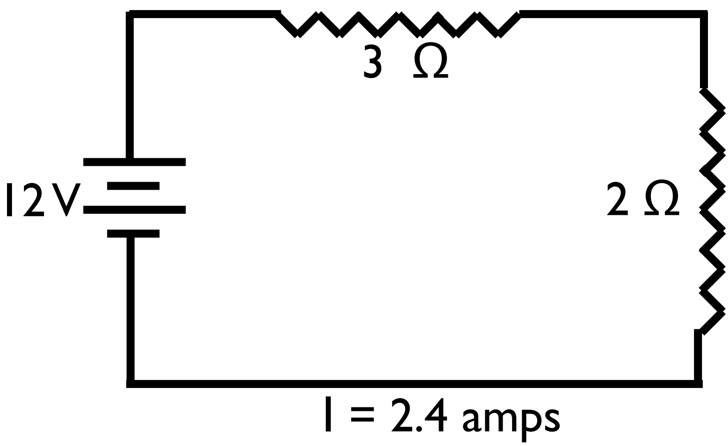
7. Ohm's law holds for circuits containing only resistive elements (no capacitances or inductances) for all forms of driving voltage or current, regardless of whether the driving voltage or current is constant DC or time-varying such as AC. At any instant of time Ohm's law is valid for such circuits.

8. Resistors which are in Series or in Parallel may be grouped together into a single "equivalent

resistance" in order to apply Ohm's law in analyzing the circuit.

Series Combination

9. You may connect many resistors in series by joining them end-to-end such that the same current passes through all the resistors. In Fig 1, two resistors of resistances R1 and R2 are connected in series. The combination is connected to a battery at the ends A and D. Suppose that current I flows through the series combination when it is connected to a battery of voltage V. Potential differences V1 and V2 develop across R1 and R2 , respectively.



Then V1 = I x R1 and V2 = I x R2.

But sum of V1 and V2 is equal to V, i.e.

$\Rightarrow$ $V = V1 + V2 = IR1 + IR2$

10. In the figure given,

$V = 12\ V$

$R_1 = 3\ \Omega$, $R_2 = 2\ \Omega$

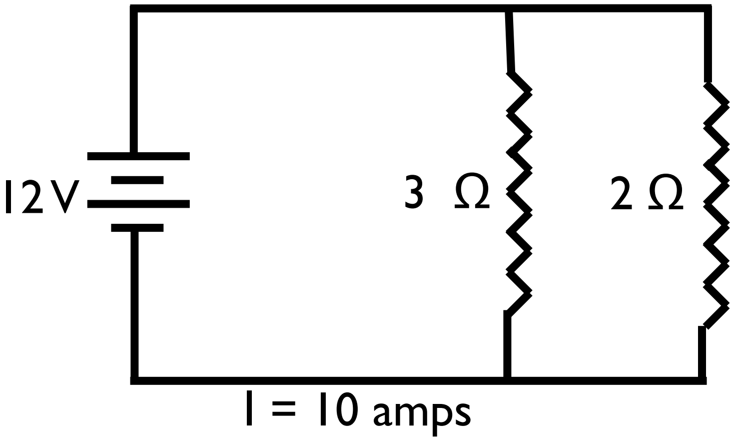
$R = R_1 + R_2 \Rightarrow 3 + 2 = 5\ \Omega$

$I = \frac{V}{R} \Rightarrow \frac{12}{5}\ v \Rightarrow 2.4$ Amps

11. That is, the equivalent resistance of a series combination of resistors is equal to the sum of individual resistances. If we wish to apply a voltage across a resistor (say electric lamp) less than that provided by the constant voltage supply source, we should connect another resistor (lamp) in series with it.

Parallel Combination

12. You may connect the resistors in parallel by joining their one end at one point and the other ends at another point. In parallel combination, **same potential difference exists across all resistors.** Fig. shows a parallel combination of two resistors R1 and R2. Let the combination be connected to a battery of voltage V and draw a current I from the source.



13. The main current divides into two parts. Let I1 and I2 be the currents flowing through resistors R1 and R2 , respectively. Then I1 = V/R1 and I2 = V/R2. The main current is the sum of I1 and I2. Therefore, we can write

$$\Rightarrow \quad I = I1 + I2 = \frac{V}{R1} + \frac{V}{R2}$$

If the equivalent resistance of combination is R, we write V = IR or I = V/R:

$$I = \frac{V}{R} = \frac{V}{R1} + \frac{V}{R2}$$

$$\therefore \quad \frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

14. In the figure given

Total resistance

$$\frac{1}{R} = \frac{1}{3} + \frac{1}{2}$$

$$\frac{1}{R} = \frac{2}{6} + \frac{3}{6}$$

$$R = \frac{6}{5} = 1.2$$

$$V = I \times R$$

$$12\,V = I \times \frac{6}{5}$$

$$I = \frac{12 \times 5}{6}$$

$$I = 10 \text{ amps}$$

15. Note that the equivalent resistance of parallel combination is smaller than the smallest individual resistance. You may easily see this fact by a simple electrical circuit having a resistor of 2 Ω connected across a 2V battery. It will draw a current of one ampere. When another resistor of 2 Ω is connected in parallel, it will also draw the same current. That is, total current drawn from the battery is 2A. Hence,

resistance of the circuit is halved. As we increase the number of resistors in parallel, the resistance of the circuit decreases and the current drawn from the battery goes on increasing.

16. This lesson introduced you to the basic Ohm's Law. There are other effects of temperature etc which we shall learn in following lessons.