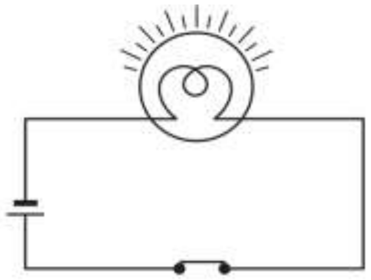
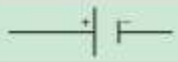
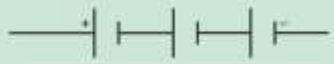
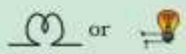
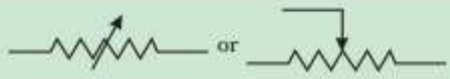
Components of an electric circuit and their symbols

- It is convenient to represent electric components by symbols.
- Using these, an electric circuit can be represented by a circuit diagram.



A simple Circuit Diagram

Sl. No.	Components	Symbols
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	
8	A resistor of resistance *R*	
9	Variable resistance or rheostat	
10	Ammeter	
11	Voltmeter	

Ohms law

- In 1827, a German physicist Georg Simon Ohm (1787-1854) found out the relationship between the current I, flowing in a metallic wire and the potential difference across its terminals.
- He stated that the **electric current flowing through a metallic wire is directly proportional to the potential difference V**, across its ends provided its temperature remains the same. This is called Ohm's law.

$$V \propto I$$

$$\text{or} \quad V/I = \text{constant} = R$$

$$\text{or} \quad V = IR$$

- R is a constant for the given metallic wire at a given temperature and is called its **resistance**.
- It is the property of a conductor to resist the flow of charges through it.
- Its SI unit is ohm, represented by the Greek letter **Ω**.
- According to Ohm's law, **R = V/I**.
- If the potential difference across the two ends of a conductor is 1 V and the current through it is 1 A, then the resistance R, of the conductor is 1 Ω.
- **Ohm's law holds true for semiconductors**, but **for a wide variety of materials (such as metals) the resistance is fixed and does not depend on the amount of current or the amount of voltage**.

Resistance

- The electrons, not completely free to move within a conductor. They are restrained by the attraction of the atoms among which they move. Thus, motion of electrons through a conductor is retarded by its resistance.
- A component of a given size that offers a low resistance is a good conductor.
- A conductor having some appreciable resistance is called a resistor.
- A component of identical size that offers a higher resistance is a poor conductor.
- An insulator of the same size offers even higher resistance.
- Resistance of the conductor depends

a) on its length (greater the length, greater is the resistance, and greater is the transmission loss),

b) on its area of cross-section (greater the cross-section, lesser is the resistance), and

c) on the nature of its material.

- Precise measurements have shown that resistance of a uniform metallic conductor is directly proportional to its length (l) and inversely proportional to the area of cross-section (A).
- The **metals and alloys** have very **low resistivity.** They are good conductors of electricity.

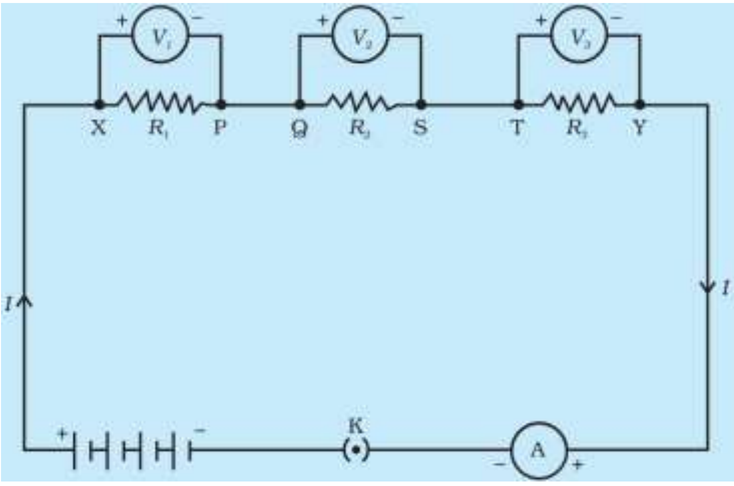
- **The resistivity of an alloy is generally higher than that of its constituent metals.**
- **Alloys do not oxidise (burn) readily at high temperatures**. For this reason, they are commonly used in electrical heating devices, like electric iron, toasters etc.
- **Tungsten** is used almost exclusively for filaments of electric bulbs, whereas copper and aluminium are generally used for electrical transmission lines.
- Insulators like rubber and glass have resistivity.
- Both the resistance and resistivity of a material vary with temperature.

	Material	Resistivity (Ω m)
Conductors	Silver	1.60×10^{-8}
	Copper	1.62×10^{-8}
	Aluminium	2.63×10^{-8}
	Tungsten	5.20×10^{-8}
	Nickel	6.84×10^{-8}
	Iron	10.0×10^{-8}
	Chromium	12.9×10^{-8}
	Mercury	94.0×10^{-8}
	Manganese	1.84×10^{-6}
Alloys	Constantan (alloy of Cu and Ni)	49×10^{-6}
	Manganin (alloy of Cu, Mn and Ni)	44×10^{-6}
	Nichrome (alloy of Ni, Cr, Mn and Fe)	100×10^{-6}
Insulators	Glass	$10^{10} - 10^{14}$
	Hard rubber	$10^{13} - 10^{16}$
	Ebonite	$10^{15} - 10^{17}$
	Diamond	$10^{12} - 10^{13}$
	Paper (dry)	10^{12}

Resistor

- A resistor is an electrical component that implements electrical resistance as a circuit element.
- In electronic circuits, resistors are used to reduce current flow, adjust signal levels, etc.
- **Current through a resistor is inversely proportional to its resistance**. If the resistance is doubled the current gets halved.
- A component used to regulate current without changing the voltage source is called **variable resistance**.
- In an electric circuit, a device called **rheostat** is often used to change the resistance in the circuit.

Resistors in Series



- The potential difference V is equal to the sum of potential differences V1, V2, and V3.
- That is the total potential difference across a combination of resistors in series is equal to the sum of potential difference across the individual resistors.
- That is,

V = V1 + V2 + V3 = IR = IR1 + IR2 + IR3 = I (R1 + R2 + R3)

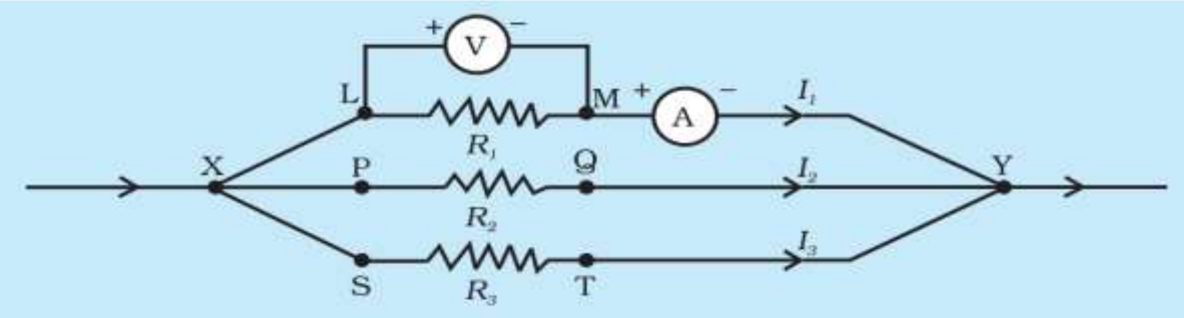
That is, **Rs = R1 + R2 + R3**

- We can conclude that when several resistors are joined in series, the resistance of the combination Rs equals the sum of their individual resistances, R1, R2, R3, and is thus greater than any individual resistance.

Disadvantages of series circuit

- In a series circuit the current is constant throughout the electric circuit. Thus, it is obviously impracticable to connect an electric bulb and an electric heater in series, because they need currents of widely different values to operate properly.
- Another major disadvantage of a series circuit is that when one component fails the circuit is broken and none of the components works.

Resistors in Parallel



- It is observed that the total current I, is equal to the sum of the separate currents through each branch of the combination.

I = I1 +12 +13 = V/R = V/R1 + V/R2 + V/R3 or **1/Rp = 1/R1 + 1/R2 + 1/R3**

- Thus, we may conclude that the reciprocal of the equivalent resistance of a group of resistances joined in parallel is equal to the sum of the reciprocals of the individual resistances.
- That is, **the total resistance in a parallel circuit is decreased**.
- Parallel circuits are helpful when each gadget has different resistance and requires different current to operate properly.

Electric power

- Electric power is the rate of consumption of energy = Voltage x Electric Current.

$$P = VI = (IR)\ I = I^2R = V^2 / R$$

- The SI unit of electric power is **watt (W)**. It is the power consumed by a device that carries 1 A of current when operated at a potential difference of 1 V. Thus, 1 W = 1 volt x 1 ampere = 1 V A.
- The unit 'watt' is very small. Therefore, we use a much larger unit called **kilowatt (1000 watts)**.
- Since energy is the product of **power and time**, the unit of electric energy is, therefore, **watt hour (Wh)**.
- One watt hour is the energy consumed when 1 watt of power is used for 1 hour.

- The commercial unit of electric energy is **kilowatt hour (kWh)**, commonly known as **unit**.
- **1 kW h = 1000 watt x 3600 second = 3.6 x 10^6 watt second = 3.6 x 10^6 joule (J)**

Questions

- Why is the tungsten used almost exclusively for filament of electric lamps?
- Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?
- Why is the series arrangement not used for domestic circuits?
- Why are copper and aluminium wires usually employed for electricity transmission?

1.2 Chemical Effects of Electric Current

- The passage of an electric current through a conducting liquid causes chemical reactions.
- The resulting effects are called chemical effects of currents.
- British chemist, William Nicholson (1753-1815), had shown that if electrodes were immersed in water, and a current was passed, bubbles of oxygen and hydrogen were produced.
- Oxygen bubbles formed on the electrode connected to the positive terminal of the battery and hydrogen bubbles formed on the other electrode.
- The passage of an electric current through a conducting solution causes chemical reactions.
- As a result, bubbles of a gas may be formed on the electrodes.
- Deposits of metal may be seen on electrodes.
- Changes of colour of solutions may occur.
- The reaction would depend on what solution and electrodes are used.