Current Electricity

①

Electric Current: "Rate of flow of charge through a cross-sectional area"

$$I = \frac{Q}{t} \quad ; \quad Q \longrightarrow \text{Charge (Coulomb)}, \quad t \longrightarrow \text{time (Seconds)}$$

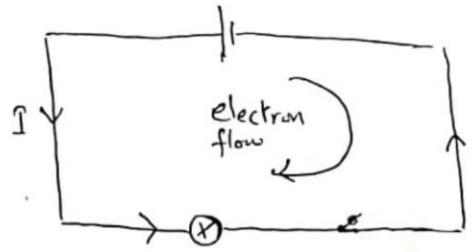
- SI unit → Ampere (A) or $C\,S^{-1}$

Example: If 5 μC charge flows through a part of wire in 3 ms. What will be amount of electric current?

Sol:

$$I = \frac{Q}{t} \qquad \frac{5 \times 10^{-6} C}{3 \times 10^{-3} s} = 1.7\,mA$$

Conventional Current: "The current that flows from positive to negative terminal of battery" (It is assumed due to flow of positive charges.



Measurement of Current: We use ammeter (A) to measure the current. It is connected in Series with the part of circuit whose current is to be measured.

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Electromotive force (e.m.f)

" It is work done by the battery in driving unit charge around a complete circuit"

$$E = \frac{W}{Q}$$

SI unit ⟶ Volt (V) or JC^{-1}

Potential Difference (p.d.)

" P.d. across a circuit component is work done in order to drive a unit charge e. through that component"

$$V = \frac{W}{Q}$$

SI unit ⟶ Volt (V) or JC^{-1}.

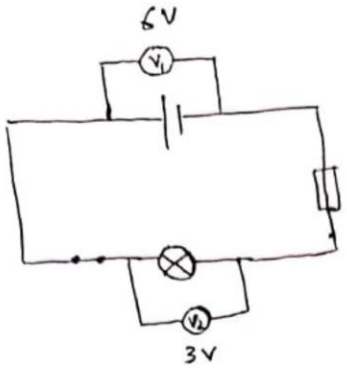
Despite having same formula and SI unit there are some significant differences between e.m.f and p.d.

- e.m.f is referred to the voltage of battery and potential difference is of individual circuit component.
- e.m.f is energy converted from non-electric to electric form where potential difference is refers to energy from electric to non-electric form.

→ We use voltmeter to measure potential difference or e.m.f.

→ Voltmeter is always connected in parallel across battery or circuit component

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In this diagram $V_1 = 6V$ is e.m.f and $V_2 = 3V$ is potential difference.

Ohm's Law

"Current passing through a conductor is directly proportional to the potential difference across it, Provided that physical conditions remains constant"

$$V \propto I$$

or $$V = IR$$

The constant of proportionality R is the resistance.

"It is the property of a conductor due to which it resists the flow of electric current"

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

It is ratio of potential difference to electric current. unit of resistance is ohm (Ω)

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Resistor

It is used to create resistance. We use resistors to control the flow of electric current.

There are two types of resistors:

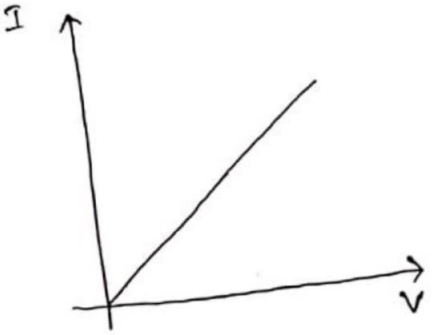
Fixed Resistor: "Resistor with constant resistance"

Symbol: 

Variable Resistor: "Resistor whose resistance can be changed". It is also called rheostat

Symbol: 

Ohmic Conductors "The conductors that obey Ohm's Law" (resistance remains constant over a wide range of p.d. and current)



" Gradient of this graph is constant i.e

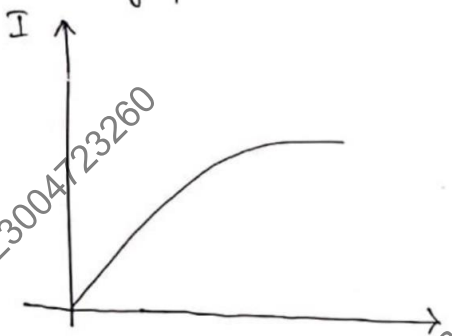
$\frac{1}{R}$ = Constant

This means R = Constant"

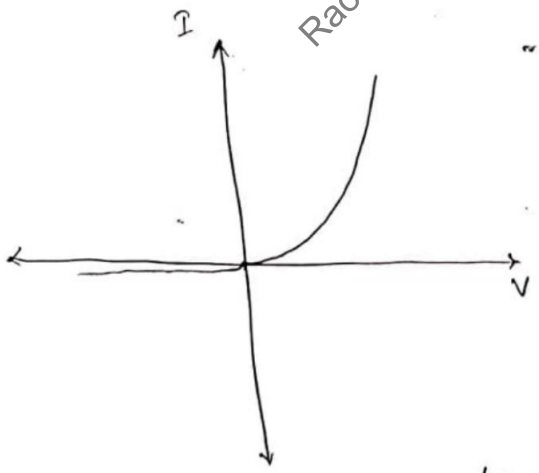
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Non-ohmic Conductors

For most of electrical devices we use in our daily life, the resistance does not remain constant as it it greatly affected by temperature and other physical conditions. These devices do not obey ohm's Law and we call them Non-ohmic Conductors.
I-V graph is not straight line.

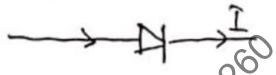


"I-V graph of a filament lamp. It gains more heat energy and resistance increases"



"I-V graph of a diode. It is used to allow one-way flow of current. It is used as rectifier (a device converts A.C. to D.C.)"

* Diode a is either reverse biased or forward biased. When it is forward, large current will flow which means resistance will be low. When it is reverse, almost no current flows which means it will have high resistance when reverse biased.

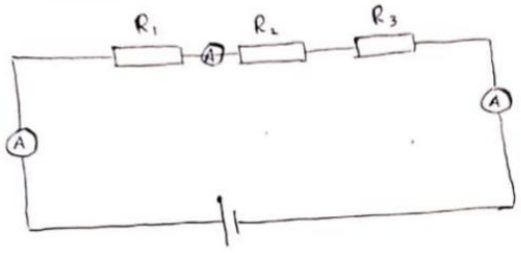


(forward biased)

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Combinations of resistors

Series Combination



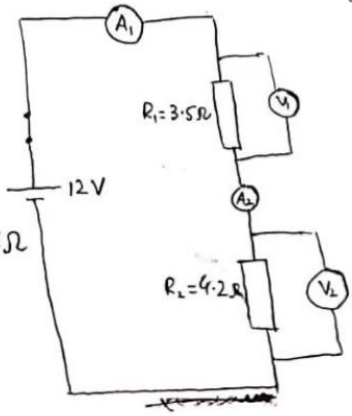
Properties

- all resistors are connected side by side with a single wire
- Current flowing through each resistor is same
- Potential difference divides higher the resistance, higher the voltage. $V = V_1 + V_2 + V_3$
- Combined resistance in Series Combination:

$$R = R_1 + R_2 + R_3 + \cdots$$

Example

The diagram shows a circuit, Calculate value of A_1, A_2 and V_1, V_2



Solution

Combined resistance:

$R = 3.5 + 4.2 = 7.7\Omega$

$$I = \frac{V}{R} = \frac{12}{7.7} = 1.6\ A$$

Since current is same in Series Combination; So $A_1 = A_2 = 1.6A$

Now

$V_1 = IR_1$

$= 1.6 \times 3.5$

$= 5.6\ V$

$V_2 = IR_2$

$= 1.6 \times 4.2$

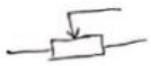
$V_2 = 6.7\ V$

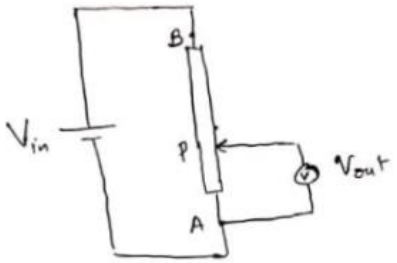
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Potentiometer

It is a potential divider having a large resistor with three terminals

Symbol · 



$$V_{out} = \frac{V_{in} \times R_{PA}}{R_{AP} + R_{PB}}$$

· Note that if resistance R_2 (connected to V_{out}) increases output voltage will increase.

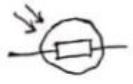
Thermistor

A device whose resistance decreases as temperature increases

- used in fire alarm
- Symbol 

Light Dependent Resistor (LDR)

A device whose resistance decreases as light intensity increases

- used in street lamps
- Symbol 

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Sources of electrical Energy

- **Solar Power**

  Advantages: High efficiency in daylight, renewable, clean energy

  Disadvantages: Low efficiency at night or in cloud cover, high cost, requires large land area for installation

- **Hydroelectric Power**

  Advantages: Highly efficient, easily manageable as water can be controlled, renewable, clean energy

  Disadvantages: Dams require large land, disrupt ecosystem, Silting in large dams

- **Wind Power**

  Advantages: Highly effective in windy areas, renewable, clean energy

  Disadvantages: costly, land occupied, harms birds

- **Nuclear Power**: Highly efficient,

  Disadvantages: Harmful nuclear waste, costly, Contaminates water
  Non-renewable

- **Fossil Feuls**

  Advantages: available all round the globe

  Disadvantages: Non-renewable, pollution

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Dangers of Electricity

- Damaged Insulation
- overheating of cables
- Damp environment

Safety Devices

- **Circuit Breaker**: It contains electromagnet, turns off when current exceeds the limit and saves appliances
- **Fuse**: It consists of a wire that blows off (breaks) when large current flows. Its disadvantage is that it it to be replaced. Fuse limit should be slightly above desired amount of current.
  - It should be connected to live wire
- **Switches**: It is used to turn on and off the circuit. It should be connected to live wire.
- **Live Wire**: The wire which supplies current
- **Neutral Wire**: It provides return path of current
- **Earth Wire**: used to Earth the current if live wire touches the device/appliance

Three pin-plug: It contains live, neutral and earth wire

Double Insulation: It insulates the wires internally, and it saves the casing.

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