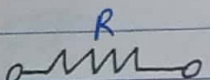
Introduction:

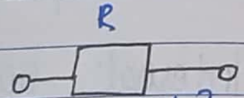
(a): Resistor:

The instrument that opposes the flow of current.

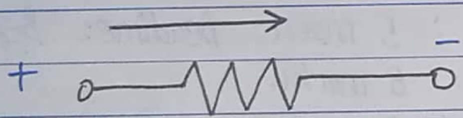
Symbols:



{American symbol}

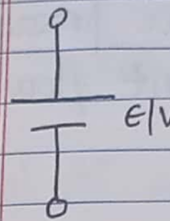


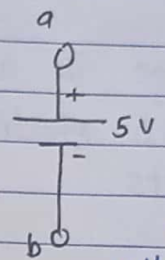
{European symbol.}



current entering point = positive polarity
current exiting point = negative polarity.

(b): Capacitor:

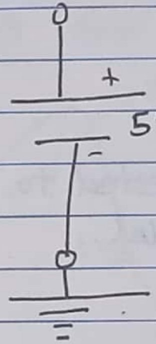




ie, $V_{ab} = 5V$

⇓

double subscript means voltage at point A w.r.t. b.



ie, $V_a = V_a - V_b = 5\ V.$

⇓

single subscript means voltage at point A w.r.t ground.

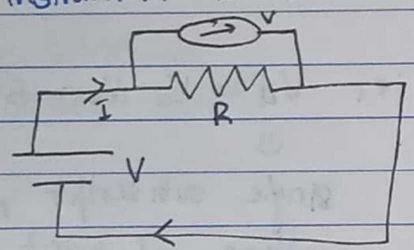
(X): Note:

i) In series, current is not distributed
ii) In parallel, voltage remains same and current is distributed.

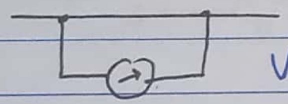
Terms Used in Electric Current:

a) Voltage: voltage is an electric pressure due to which electric current flows in the circuits.

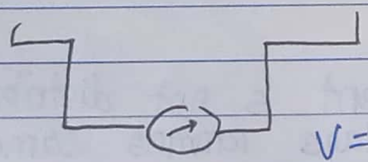
Symbol: V
unit: volts.
Instrument to measure: Voltmeter



⇒ connected to parallel.



$V = 0$.



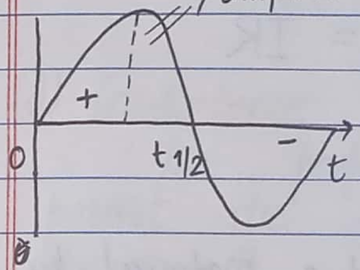
$V = V_{max}$
gives maximum voltage.

It can also be defined as potential difference between any two points.

- Types:

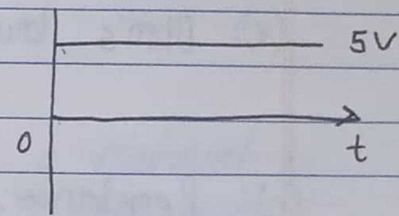
a) AC voltage:

changes amplitude with time



b) DC voltage.

- no change in amplitude with time.



(b): Current:

The rate of flow of ~~current~~ change of electron is called electric current.

ie,

Continuous flow of electrons in an electric current.

Mathematically, $I = \frac{q}{t} = \frac{\text{charge}}{\text{time}}$

Unit: Ampere (A)
Instrument to measure: Ammeter
{connected in series}

⇒ To measure current:
- must be closed path.
- least resistance path must be approach. {ohm's law}

(*): Ohm's law: $V = IR$

(c): Resistance:

The property of a material by which it opposes the flow of electric current throughout it.

Symbol: R
Unit: Ohm.

⇒ factors affecting resistance:

i): $R \propto l$ (length) —(i)
ii) $R \propto \frac{1}{A}$ (area). —(ii)

Combining (i) and (ii), we get.

$$R = \rho \frac{l}{A}$$

$\therefore \rho = RA/l$

Rho is constant called resistivity of material.
Unit: Ωm.

(d) Conductance:

The property of a material to permit the flow of electric current through it.

OR,

It is the reciprocal of resistance.

$G = \frac{1}{R} = \frac{A}{\rho l}$ Unit: $(\Omega)^{-1}$

Now, σ (conductivity) $= \frac{1}{\rho}$

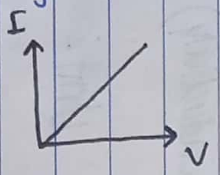
Unit: Simen (S).

ELECTRICAL CIRCUIT ELEMENTS

Linear

Eg: resistor, capacitor, inductor

→ Linear relationship between voltage and current



→ satisfies homogeneity and additive property

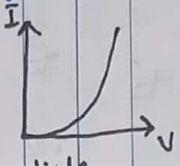
ie, $x(t) \rightarrow$ linear element $\rightarrow y(t)$

$kx(t) \rightarrow$ linear element $\rightarrow ky(t)$

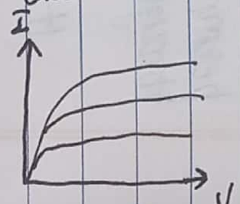
Non-linear

Eg: diode, {exponential} transistor {exponential, parabolic}

→ no linear relationship betn voltage and current.



diode



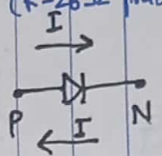
transistor

Unilateral

- current flow through only one direction

Eg: diode, transistor

(R = 0 ideally)
(R = 26 Ω practically)



R = ∞

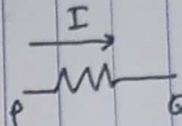
→ when current flows in opposite direction, it gives open circuit.

when current flows in same direction, it gives short circuit.

Bilateral.

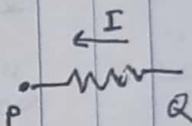
→ current flows through both direction.

Eg: resistor, capacitor



Here, Resistance = R.

Also,



Here, resistance = R.

Active elements.

→ they can generate energy.

Eg: transistor, OP-AMP {Operational Amplifier}

Passive element:

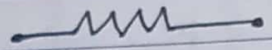
→ electric circuit element that doesn't generate power but instead dissipates, stores or releases it.

Eg: capacitor, ~~resistor~~ resistor, inductor.

(x): Types of Resistor:

i) Fixed Resistor:

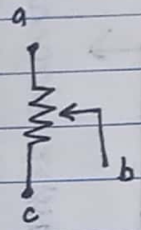
$R = 1k\Omega$



A resistor having a fixed, defined electrical resistance which is not adjustable.

<ii>: Variable Resistor:

A resistor ~~h~~ whose electrical resistance which is adjustable.



$R_{ab} = R_{ac} + R_{cb}$

Eg: Potentiometer.

Colour Coding of Resistor:

Colour coding of resistor gives information about the resistor through colour and set of bands in the resistor.

Information on resistor is obtained with the help of number-band scheme.

For resistors, the known band schemes are: 3-band scheme, 4-band scheme, 5-band scheme, 6-band scheme.

The band are always read from the end that has band closer together.

~~The four band~~

No. of bands	3	4	5	6
1st digit	1st value	1st value	1st value	1st value
2nd digit	2nd value	2nd value	2nd value	2nd value
3rd digit	Multiplier	Multiplier	3rd value.	3rd value
4th digit		Tolerance	Multiplier	Multiplier
5th digit			Tolerance.	Tolerance
6th digits				Temperature coefficient.

The 4-band scheme is the most common variation of band-scheme in resistor.

In 4-band scheme,

i) The first two band represents the first and second digits respectively. They are the actual first two numbers that define the numerical value of resistor.

ii) The third band determines the power of ten multiplier for the first two digits.

iii) The fourth band is the manufacture tolerance which is an indicator of the precision by which resistor was made.

*) Colour values:

a) Tolerance:

Brown = ± 1%.
Red = ± 2%.
Gold = ± 5%.
Silver = ± 10%.

b) Temperature coefficient:

Brown = 100 ppm
Red = 50 ppm
Orange = 15 ppm
Yellow = 25 ppm.

c) Colour number for resistance:

0 = black
1 = brown
2 = red
3 = orange
4 = yellow
5 = green
6 = blue
7 = violet
8 = gray
9 = white.

<Num. No. 1> ⇒ Numericals copy.

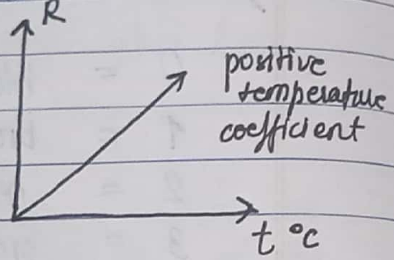
<Num. No. 2> ⇒ Numericals copy

Temperature Effects:

Temperature has a significant effect on the resistance of conductor, semi-conductor and insulators.

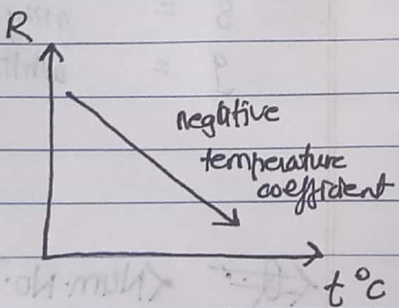
Conductor: For good conductor, an increase in temperature results in increase in resistance level.

Conductor have positive temperature coefficient.



Semi-conductor / Insulator: An increase in temperature results in decrease in resistance level for semi-conductor and insulator.

Semi-conductors and insulators have negative temperature coefficients.



Infered Absolute Temperature

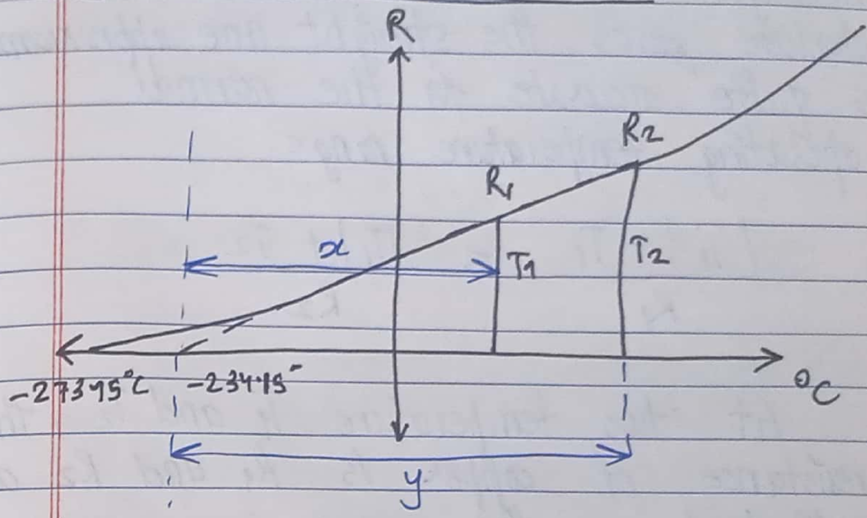


Fig: Effect of temperature ~~of~~ on resistance of copper.

The resistance increases almost linearly with increase in temperature. We have a method of determining the resistance at any temperature within operating limits.

An equation for this propose can be obtained by appriaxiamoting the curve by the straight dotted line that intersects the temperature scale at -234.5°C.

This -234.5°c is the inferred absolute temperature of copper.

Although the actual curve extends to absolute zero, the straight line approximation is quite accurate for the normal operating temperature range.

$$\frac{|T_1| + T_1}{R_1} = \frac{|T_1| + T_2}{R_2}.$$

At two temperature T_1 and T_2, the resistance of copper is R_1 and R_2 as indicated on the curve.

Using the property of similar triangles, mathematical relationship between these value of resistance at different temperature.

Let x = distance from $-234.5°C$ to T_1

y = distance from $-234.5°C$ to T_2.

From figure,

$$\frac{x}{R_1} = \frac{y}{R_2}$$

or, $$\frac{234.5° + T_1}{R_1} = \frac{234.5° + T_2}{R_2}.$$

Temperature Coefficient of Resistance:

The change in electrical resistance of a substance with respect to per degree change in temperature is called temperature coefficient of resistance.

$$\alpha_{20} = \frac{1}{|T_1| + 20°c}.$$

α_{20} = temperature coefficient of resistance at 20°C

R_{20} = resistance at 20°C.

So, resistance R_1 at temperature T_1 is obtained by,

$$R_1 = R_{20}\,[\,1 + \alpha_{20}\,(T_1 - 20°C)\,]$$

So,

$$\cancel{\alpha_0 = \frac{1}{|T_1| + 0°C}} \qquad \cancel{R_1 = R_0\,[\,1 + \alpha_0\,(T_1 - 0°C)\,]}$$

$|T_1|$ = infered absolute zero temperature of material.

$$\alpha_\theta = \frac{1}{|T_1| + \theta°C}$$

$$R = R_\theta \left[1 + \alpha_\theta \left(|T_1| - \theta°C \right) \right]$$

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~~We kn~~ Ohm's Law

In electric circuits, the effects we are trying to establish the flow of charge or current, the potential difference or voltage between two points is the cause ("pressure") and the opposition is the resistance encountered.

We know,

$$\text{Effect} = \frac{\text{Cause}}{\text{opposition}} \quad \text{— (i)}$$

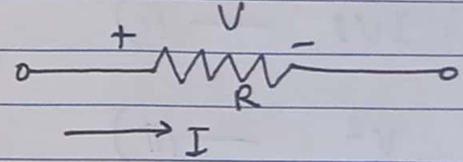
Thus,

$$\text{Current } (I) = \frac{\text{Potential difference } (V)}{\text{Resistance } (R)}$$

ie,

$$I = \frac{V}{R} \quad \text{— (ii)}$$

Eqn (ii) gives Ohm's law in honour of Georg Simon Ohm.



For any resistor, in any network, the direction of current through a resistor will define the polarity of the voltage drop across the resistor.

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Power :

The rate of doing work in an electric circuit is called electric power.

Unit = Watt (W).

Mathematically,

Power = Voltage × Current.

or, $P = IV$ — (i)

or, $P = \frac{V^2}{R}$ — (ii)

or, $P = I^2R$ — (iii)