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Volume remains constant i.e., $A_1l_1 = A_2l_2$

After stretching length = l_2, area of cross-section = A_2,

radius = r_2, diameter = d_2 and resistance = $R_2 = \rho\frac{l_2}{A_2}$

Ratio of resistances before and after stretching

$$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \left(\frac{l_1}{l_2}\right)^2 = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^4 = \left(\frac{d_2}{d_1}\right)^4$$

(1) If length is given then $R \propto l^2 \Rightarrow \frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2$

(2) If radius is given then $R \propto \frac{1}{r^4} \Rightarrow \frac{R_1}{R_2} = \left(\frac{r_2}{r_1}\right)^4$

6. CURRENT DENSITY, CONDUCTANCE AND ELECTRIAL CONDUCTIVITY

6.1 Relation between J, σ and E

We know, $I = nAev_d = nAe\left(\frac{eE}{m}\tau\right) = \frac{nAe^2\tau E}{m}$

or $\frac{I}{A} = \frac{ne^2\tau E}{m}$ or $J = \frac{1}{\rho}E$

$\therefore$ $\boxed{J = \sigma E}$

1. **Insulators :** These are those materials whose electrical conducticity is either very very small or nil.

   Insulators do not conduct charges. When a small potential difference is applied across the two ends of an insulator, the current through the insulator is zero.

   Examples of insulators are glass, rubber, wood etc.

   Variation of R, ρ with T

2. **Conductors :** These are those materials whose electrical conductivity is very high

   Conductor conduct charges very easily. When a small potential difference is applied across the two ends of conductor, a strong current flows through the conductor. For super-conductor, the value of electrical conductivity is infinite and electrical resistivity is zero.

   Examples of conductors are all metals like copper, silver, aluminium, tungsten etc.

3. **Semiconductors :** These are those material whose electrical conductivity lies inbetween that of insulators and conductors.

   Semiconductors can conduct charges but not so easily as is in case of conductors. When a small potential difference is applied across the ends of a semiconductor, a weak current flows through semiconductor due to motion of electrons and holes.

   Examples of semiconductors are germanium, silicon etc.

   The value of elecrical resistance R increases with rise of temperature.

$$\alpha = \frac{R_t - R_0}{R_0 \times t} = \frac{\text{increase in resistance}}{\text{original resistance} \times \text{rise of temp.}}$$

Thus, temperature coefficient of resistance is defined as the increase in resistance per unit original resistance per degree celsium or kelvin rise of temperature.

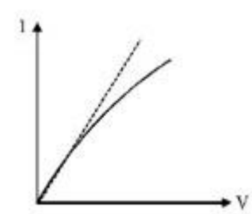
1. **For metals** like silver, copper, etc., the value of a is positive, therefore, resistance of a metal increases with rise in temperature. The unit of α is K^{-1} or $°C^{-1}$.
2. **For insulators and semiconductors α is negative,** therefore, the resistance decreases with rise in temperature.

6.2 Non-Ohmic Devices

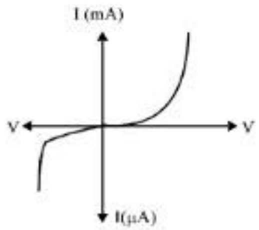
Those devices which do not obey Ohm's law are called non-ohmic devices. For example, vaccum tubes, semiconductor diode, liquid electrolyte, transistor etc.

For all **non-ohmic devices** (where there will be failure of Ohm's law), V–I graph has one or more of the following characteristics :

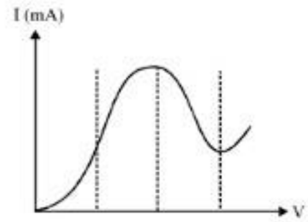
(a) The relation between V and I is **non-linear**, figure



(b) The relation between V and I **depends on the sign of V**. It means, if I is the current for a certain value of V, then reversing the direction of V, keeping its magnitude fixed, does not produce a current of same magnitude I, in the opposite direction, figure.



(c) The relation between V and I is **not unique**, i.e., there is more than one value of V for the same current I, figure.



7. COLOUR CODE FOR CARBON RESISTORS

The colour code for carbon resistance is given in the following table.

Colour code of carbon resistors

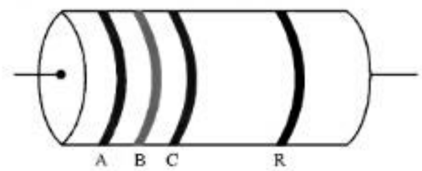
Colour	Letter as an Aid to memory	No.	Mulitplier	Colour	Tolerance
Black	B	0	10^0	Gold	5%
Brown	B	1	10^1	Silver	10%
Red	R	2	10^2	No colour	20%
Orange	O	3	10^3		
Yellow	Y	4	10^4		
Green		5	10^5		
Blue	B	6	10^6		
Violet	V	7	10^7		
Grey		8	10^8		
White	W	9	10^9		
Gold			10^{-1}		
Silver			10^{-2}		

To remember the value of colour coding used for carbon resistor, the following sentences are found to be of great help (where bold letters stand for colours).

B B ROY Green, **B**ritain **V**ery **G**ood **W**ife **Gold Silver.**

Way of finding the resistance of carbon resistor from its colour coding.

In the system of colour coding. Strips of different colours are given on the body of the resistor, figure. The colours on strips are noted from left to right.



(i) **Colour of the first stip A** from the end indicates the first significant figure of resistance in ohm.

(ii) **Colour of the second strip B** indicate the second significant figure of resistance in ohm.

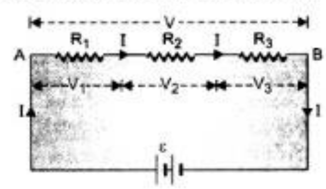
(iii) **The colour of the third strip C** indicates the multiplier, i.e., the number of zeros that will follow after the two significant figure.

(iv) **The colour of fourth strip R** indicates the tolerance limit of the resistance value of percentage accuracy of resistance.

8. COMBINATION OF RESISTORS

8.1 Resistances in Series

Resistors are said to be connected in series, if the same current is flowing through each resistor when some poential difference is applied across the combination.



1. Let V be the potential difference applied across A and B using the battery ε. In series combination, the same current (say I) will be passing through each resistance.
2. Let V_1, V_2, V_3 be the potential difference across R_1, R_2 and R_3 respectively. According to Ohm's law
   $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$
3. Here, $V = V_1 + V_2 + V_3 = IR_1 + IR_2 + IR_3 = I(R_1 + R_2 + R_3)$

Note :- Colour code of carbon resistors is in syllabus in session 2020-21.