Answer on Question #53458-Physics-Electric Circuits

How the formula of resistance changes in different conditions like:

1 when mass, resistance, density of material of which wire is made and resistivity of the wire is given and we have to find diameter and length of the wire.

2 when length, diameter and resistance of wire are given and we have to find resistivity of the material of wire.

3 when resistance of wire is given and length is increased to twice its original length. and we have to calculate new resistance.

4 when a wire is stretched to reduce its diameter to half its original value and we have to find new resistance of wire.

5 when resistance of wire is given and the wire is stretched so that its length becomes 3 times. Assuming that there is no change in density on stretching and we have to calculate the resistance of new wire.

Solution

The formula of resistance is

$$R = \rho \frac{l}{\frac{\pi d^2}{4}},$$

where R is resistance, ρ is resistivity, l is length, d is diameter.

1. We know

$$\frac{l}{\frac{\pi d^2}{4}} = \frac{R}{\rho},$$

$$\frac{\pi d^2}{4} l = V = \frac{m}{D}.$$

Thus,

$$\left(\frac{\pi d^2}{4}\right)^2 = \frac{\frac{m}{D}}{\frac{R}{\rho}} = \frac{m\rho}{DR} \to d = \sqrt{\frac{4}{\pi}\sqrt{\frac{m\rho}{DR}}}.$$

$$l^2 = \frac{R}{\rho}\frac{m}{D} \to l = \sqrt{\frac{Rm}{\rho D}}.$$

2. Resistivity of the material of wire is

$$\rho = \frac{\pi R d^2}{4l}.$$

3. The resistance of wire is directly proportional to its length. So,

$$R' = R\frac{l'}{l} = 2R.$$

4. We know that $R \sim d^{-2}$. Thus,

$$R' = R\left(\frac{d}{d'}\right)^2 = 4R.$$

5. We assume that $D = const, V = \frac{\pi d^2}{4} l = const$.

Thus,

$$d' = d\sqrt{\frac{l}{l'}} = \frac{d}{\sqrt{3}}.$$

The resistance of new wire is

$$R' = \rho \frac{l'}{\frac{\pi d'^2}{4}} = \rho \frac{3l}{\frac{\pi d^2}{3 \cdot 4}} = 9R.$$