Answer on Question 59045, Physics, Electric Circuits

Question:

A wire with resistance of 8.0 Ω is drawn out through a die so that its new length is three times its original length. Find the resistance of the longer wire assuming that the resistivity and density of the material are unaffected by the drawing process.

a) 72 Ω

b) 60 Ω

c) 80 Ω

d) 45 Ω

Solution:

The resistance R of the wire of length l and cross-sectional area A is given by the formula:

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

here, ρ is the constant called the resistivity and is a characteristic of the material from which the wire is made.

Then, we can write the resistances of the wire before and after it is drawn out through a die (from the initial conditions of the task, we know that the resistivity of the material is unaffected by the drawing process, thus ρ will be the same for both resistances):

$$R_1 = \rho \frac{l_1}{A_1}, \qquad (1)$$

$$R_2 = \rho \frac{l_2}{A_2}. \qquad (2)$$

It is obviously, that we can find the resistance of the wire after it is drawn out through a die from the ratio of the resistances. So, let's divide equation (1) by equation (2):

$$\frac{R_2}{R_1} = \frac{l_2}{l_1}\frac{A_1}{A_2} \quad (3)$$

Also, from the initial conditions of the task, we know that the density of the material is unaffected by the drawing process. If the density of the wire is constant, then the volume of the wire is also constant. We can find the volume of the wire from the formula:

$$V = Al = const,$$

here, A is the cross-sectional area of the wire, l is the length of the wire.

Then, according to this formula, we can write:

$$A_1 l_1 = A_2 l_2.$$

And we know, that the new length of the wire is three times its original length ($l_2 = 3l_1$).

So, this formula gives us the opportunity to express A_1 in terms of A_2:

$$A_1 l_1 = 3l_1 A_2,$$

$$A_1 = 3A_2.$$

Finally, from the equation (3) we can calculate the resistance of the wire after it is drawn out through a die:

$$R_2 = R_1 \frac{l_2}{l_1}\frac{A_1}{A_2} = R_1 \frac{3l_1 \cdot 3A_2}{l_1 \cdot A_2} = 9R_1 = 9 \cdot 8.0\ \Omega = 72.0\ \Omega.$$

Answer:

a) 72 Ω