Q- An aluminum rod has a resistance of 1.234 Ω at 20.0°C. Calculate the resistance of the rod at 120°C by accounting for the changes in both the resistivity and its dimensions. (Resistivity of aluminum at 20^0C is $2.75*10^{-8}$ Ωm, temperature coefficient of resistivity is $4.4*10^{-3}/^0$C and the coefficient of linear expansion of aluminum is $\alpha = 23*10^{-6}/^0$C)

As the temperature coefficient of resistivity if the increase in the resistivity per unit resistivity per degree increase in temperature we may write it as

$$\rho_{coeff} = \frac{\Delta\rho}{\rho*\Delta\theta}$$

Or $\Delta\rho = \rho * \rho_{coeff} * \Delta\theta$

Hence increase in resistivity of aluminum with increase in temperature by (120 – 20) = 100^0C will be

$$\Delta\rho = \rho*4.4*10^{-3}*100 = 0.44\ \rho$$

Hence resistivity at 120^0C will be

$$\rho' = \rho + 0.44\ \rho = 1.44\ \rho$$

Let the length of the rod is L and area of cross section be A at 20^0C than resistance of the rod at 20^0C will be

$R = \rho*L/A = 1.234\Omega$ ------------------- (1)

Now the coefficient of linear expansion of the aluminum is $\alpha = 23*10^{-6}/^0$C
The new length will be $L + L*\alpha*100 = L\ (1.0023)$

As the coefficient of thermal expansion of area $\beta = 2\alpha$, the new area of cross section will be
$A + A*2\ \alpha*100 = A\ (1.0046)$

Hence the resistance of the rod at 120^0C will be

$$R' = 1.44\rho*L*1.0023/(A*1.0046)$$

Or $R' = (\rho L/A)*1.44*1.0023/1.0046$

Or $R' = 1.234*1.4367 = 1.7729\ \Omega$.