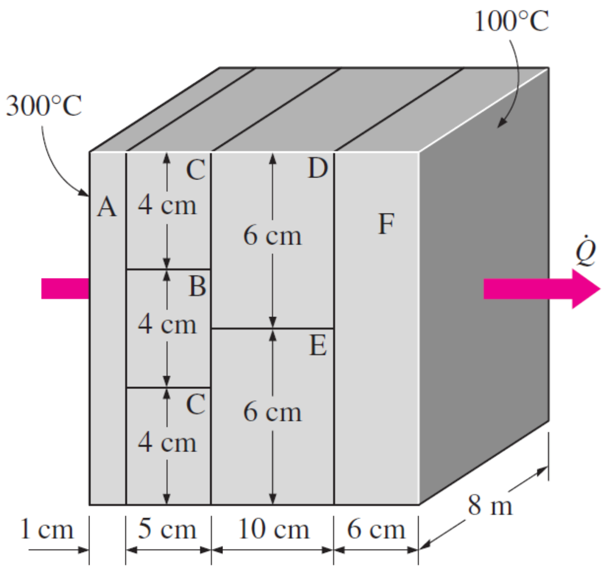
**Question 1**



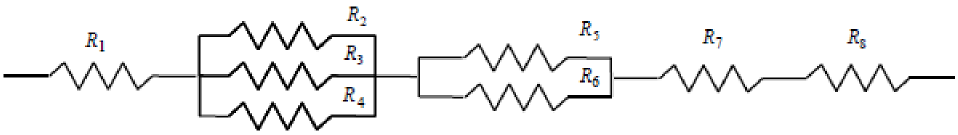

a) Consider a 5-m-high, 8-m-long, and 0.22-m-thick wall whose representative cross-section is as given in the figure. The thermal conductivities of various materials used, in W/m·°C, are $k_A$=$k_F$=2, $k_B$=8, $k_C$=20, $k_D$=15, and $k_E$=35. The left and right surfaces of the wall are maintained at uniform temperatures of 300°C and 100°C, respectively. Assuming heat transfer through the wall to be one-dimensional and the thermal contact resistance at the interfaces D-F and E-F is 0.00012 $m^2$·°C/W., determine

i. the rate of heat transfer (for a 0.12-m-high × 1-m-deep section), Watts
ii. the rate of heat transfer through the wall, Watts
iii. the temperature at the point where the sections *B*, *D*, and *E* meet, °C and
iv. the temperature drop across the section *F*, °C.

**Solution**

a)

i.




$$R_1 = R_A = \left(\frac{L}{kA}\right)_A = \frac{0.01}{(2)(0.12\times 1)} = 0.04°C/W$$

$$R_2 = R_4 = R_C = \left(\frac{L}{kA}\right)_C = \frac{0.05}{(20)(0.04\times 1)} = 0.06°C/W$$

$$R_3 = R_B = \left(\frac{L}{kA}\right)_B = \frac{0.05}{(8)(0.04\times 1)} = 0.16°C/W$$

$$R_5 = R_D = \left(\frac{L}{kA}\right)_D = \frac{0.1}{(15)(0.06\times 1)} = 0.11°C/W$$

$$R_6 = R_E = \left(\frac{L}{kA}\right)_D = \frac{0.1}{(35)(0.06\times 1)} = 0.05°C/W$$

$$R_7 = R_F = \left(\frac{L}{kA}\right)_F = \frac{0.06}{(2)(0.12\times 1)} = 0.25°C/W$$

$$R_8 = \frac{0.00012}{0.12} = 0.001°C/W$$

$$\frac{1}{R_{mid,1}} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{0.06} + \frac{1}{0.16} + \frac{1}{0.06} \Rightarrow R_{mid,1} = 0.025°C/W$$

$$\frac{1}{R_{mid,2}} = \frac{1}{R_5} + \frac{1}{R_6} = \frac{1}{0.11} + \frac{1}{0.05} \Rightarrow R_{mid,2} = 0.034°C/W$$

$$R_{total} = R_1 + R_{mid,1} + R_{mid,2} + R_7 + R_8$$

$$= 0.04 + 0.025 + 0.034 + 0.25 + 0.001 = 0.35°C/W$$

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{300-100}{0.35} = 571.43W$$

ii.

$$\dot{Q}_{total} = \dot{Q}\frac{\text{height}\times\text{length}}{A} = (571.43)\frac{5\times 8}{(0.12\times 1)} = 190476.67W$$

iii.

$$R_{total} = R_1 + R_{mid,1} = 0.04 + 0.025 = 0.065°C / W$$

$$\dot{Q} = \frac{T_1 - T}{R_{total}} \Rightarrow 571.43 = \frac{300 - T}{0.065} \Rightarrow T = 262.86°C$$

iv.

$$\dot{Q} = \frac{\Delta T}{R_F} \Rightarrow \Delta T = \dot{Q}R_F = 571 \times 0.25 = 142.75°C$$