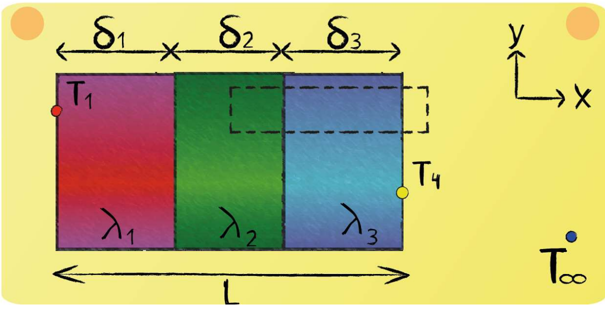
Lecture 7 - Question 8



Give the energy balance and the numerical value for the heat fluxes [W]. Assume one-dimensional steady-state heat transfer. Take $\delta_1 = \delta_2 = \delta_3 = 0.01\ m$, $\lambda_1 = \lambda_2 = \lambda_3 = 0.01\ W/mK$, $A = 1\ m^2$, $T_1 = 103\ K$, $T_4 = 100\ K$ and $T_\infty = 0\ K$

Energy balance:

$$\dot{Q}_{cond} - \dot{Q}_{conv} = 0$$

Since the type of heat transfer is steady-state, the in- and outgoing heat fluxes of the control volume should equal each other.

Heat fluxes:

$$\dot{Q}_{cond} = \frac{T_1 - T_4}{\frac{\delta_1}{\lambda_1 A} + \frac{\delta_2}{\lambda_2 A} + \frac{\delta_3}{\lambda_3 A}} = \frac{3}{1+1+1} = 1\ W$$

$$\dot{Q}_{conv} = \dot{Q}_{cond} = \frac{T_1 - T_4}{\frac{\delta_1}{\lambda_1 A} + \frac{\delta_2}{\lambda_2 A} + \frac{\delta_3}{\lambda_3 A}} = \frac{3}{1+1+1} = 1\ W\$$$

The heat flux entering the control volume has first been conducted through the plate and will then be transferred by convection. For that reason the ingoing heat flux can be described as $\dot{Q}_{in} = \dot{Q}_{cond}$ and the outgoing heat flux as $\dot{Q}_{out} = \dot{Q}_{conv}$ The conductive heat transfer can be described as: $\dot{Q}_{cond} = \frac{\text{Temperature difference inside the body}}{\text{Conductive thermal resistance inside the body}}$.