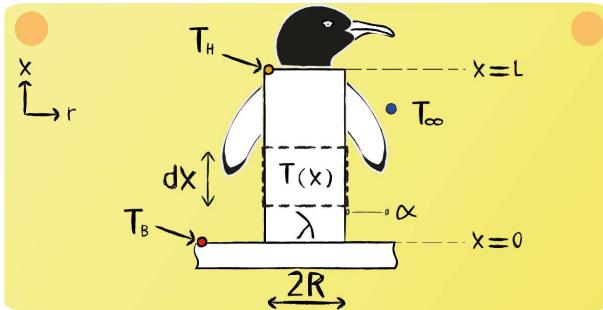


Lecture 11 - Question 7



Derive a homogeneous differential equation to describe the axial temperature distribution for the body of a penguin. Assume one-dimensional, steady-state heat transfer in the x -direction with no sources/sinks.

Homogenization:

$$\Theta = T(x) - T_\infty$$

$$m^2 = \frac{2\alpha}{\lambda R}$$

Energy balance:

$$\dot{Q}_{x,in} - \dot{Q}_{x,out} - \dot{Q}_{conv}(x) = 0$$

Since the heat transfer is characterized as steady-state, the sum of the in- and outgoing heat fluxes for the control volume should equal zero.

Heat fluxes:



$$\dot{Q}_{x,in} = -\lambda \cdot \pi R^2 \cdot \frac{\partial T}{\partial x} \rightarrow \dot{Q}_{x,in} = -\lambda \cdot \pi R^2 \cdot \frac{\partial \Theta}{\partial x}$$

$$\begin{aligned} \dot{Q}_{x,out} &= -\lambda \cdot \pi R^2 \cdot \frac{\partial T}{\partial x} + \frac{\partial \dot{Q}_{x,in}}{\partial x} \cdot dx \rightarrow \dot{Q}_{x,out} = \\ &\dot{Q}_{x,in} - \lambda \cdot \pi R^2 \cdot \frac{\partial^2 \Theta}{\partial x^2} dx \end{aligned}$$

$$\dot{Q}_{conv} = \alpha \cdot 2\pi R dx \cdot (T(x) - T_\infty) \rightarrow \dot{Q}_{conv} = \alpha \cdot 2\pi R dx \cdot \Theta$$

Boundary Conditions:

$$\Theta(x=0) = T_B - T_\infty$$

$$\Theta(x=L) = T_H - T_\infty$$

The first boundary condition results from the fact that $T(x=0) = T_B$ and the second one from the fact that $T(x=L) = T_H$.