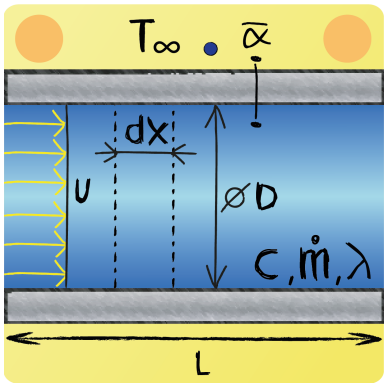
Lecture 7 Question 1

Consider a fluid flow through a cylindrical pipeline, as in the figure. It flows so slow that diffusion cannot be neglected. Which fluxes are applicable when deriving the energy balance for an infinitesimal element? Assume steady-state conditions without sources/sinks.



Energy balance for an infinitesimal element (including diffusive heat transfer without sources / sinks)

$$\dot{H}_{\mathrm{x,in}} - \dot{H}_{\mathrm{x,out}} + \dot{Q}_{\mathrm{x,in}} - \dot{Q}_{\mathrm{x,out}} - \dot{Q}_{\mathrm{conv}} = 0$$

Where:

$$\dot{H}_{\mathrm{x,in}} = \dot{m} \cdot c \cdot T(x)$$

$$\dot{H}_{\mathrm{x,out}} = \dot{m} \cdot c \cdot T + \frac{d}{dx}\left(\dot{m} \cdot c \cdot T\right) \cdot dx$$

$$\dot{Q}_{\mathrm{x,in}} = -\lambda \cdot \frac{\pi \cdot D^2}{4} \cdot \frac{dT}{dx}$$

$$\dot{Q}_{\mathrm{x,out}} = -\lambda \cdot \frac{\pi \cdot D^2}{4} \cdot \frac{dT}{dx} + \frac{d}{dx}\left(-\lambda \cdot \frac{\pi \cdot D^2}{4} \cdot \frac{dT}{dx}\right) \cdot dx$$

$$\dot{Q}_{\mathrm{conv}} = \alpha \cdot \pi \cdot D \cdot dx \cdot \left(T(x) - T_\infty\right)$$