Exercise 7.1

Consider a large vertical plate with a uniform surface temperature of $130°C$ suspended in quiescent air at $25°C$ and at atmospheric pressure.

a) Estimate the boundary layer thickness at a location $0.25m$ measured from the lower edge

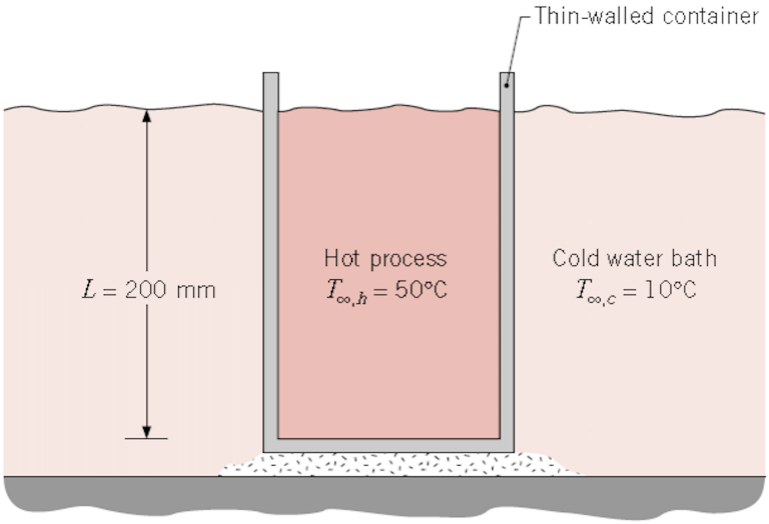
b) What is the maximum velocity in the boundary layer at this location and at what position in the boundary layer does the maximum occur?

c) Using the similarity solution result determine the heat transfer coefficient $0.25m$ from the lower edge

d) At what location on the plate measured from the lower edge will the boundary layer become turbulent?

Exercise 7.2

A thin walled container with a hot process fluid at $50°C$ is placed in quiescent cold water bath at $10°C$. Heat transfer at the inner and outer surfaces of the container may be approximated by free convection from a vertical plate. Determine the overall heat transfer coefficient between the hot process fluid and the cold water bath. Assume the properties of the hot process fluid are those of water.



Note: Estimate the temperature of the wall as the average between the hot and cold fluid temperatures. Estimate the physical properties of the hot and cold films at 310K and 295K respectively (how does this compare to the exact average temperature for each film?).

Exercise 7.3

It is desired to estimate the effectiveness of a horizontal straight fin of rectangular cross section when applied to a surface operating at $45°C$ in an environment for which the surroundings and ambient air are at $25°C$. The fin is to be fabricated from aluminum alloy $(2024 - T6)$ with an anodized finish $(\epsilon = 0.82)$ and is $2mm$ thick and $100mm$ long.

a) Considering only free convection from the fin surface and estimating an average heat transfer coefficient, determine the effectiveness of the fin. *Hint 1*: be careful to pick the correct tip boundary condition for the fin; *Hint 2*: the convection coefficient for the entire fin can be obtained as the average of the natural convection coefficient on the top and bottom surfaces of the fin. *Hint 3*: Assume $w \gg L$ and that the characteristic length is $L_c \approx \frac{L}{2}$.

b) Estimate the effectiveness of the fin including the influence of radiation exchange with the surroundings.[difficult question]

Note: **Properties:** Aluminum alloy 2024-T6 $(T \approx (45 + 25)/2 = 35°\text{C} \approx 300\text{K})$, k = 177 W/m · K; $\epsilon = 0.82$;

Exercise 7.4 FOR REVISION

Consider a vertical single-pane window of equal width and height ($W = L = 1m$). The interior surface is exposed to the air and walls of a room, which are each at $18°C$. Under cold ambient conditions for which a thin layer of frost has formed on the inner surface, what is the heat loss though the window? Do NOT neglect radiative heat transfer. The frost might be assumed to have an emissivity $\epsilon = 0.9$.

In addition, comment on the following aspects:

a) During incipience of frost formation, where would you expect the frost to begin developing on the window? In other words, which part of the window is coldest?

b) How would your analysis be affected by a frost layer whose thickness is not negligible?