Final Exam Winter 2025 - MEM 612

Show all steps and work for full credit.

Start: Monday 4pm EST, 3/17

End: Thursday 4pm EST, 3/20

16 points total

Problem 1

(5 pts)

Consider the vertical wall of an oven that is 0.6 meters tall. The surface temperature is 200 degC, the air temperature inside the oven is 80 degC at a pressure of 1 atm. Use air properties obtained at a mean temperature of 140 degC.

a) Draw a diagram indicating the boundary layer thickness profile over the height of the wall. Assuming natural convection dominates, which direction is the flow of air in the boundary layer?

b) Calculate the local heat transfer coefficient at the end of the wall.

c) Calculate the average heat transfer coefficient over the wall.

Problem 2

(4 pts)

Consider laminar flow through a circular pipe with inside radius R_0. The velocity is assumed to be constant, u(r) = U and the temperature profile is approximated as T(r) = a + br.

a) Determine the bulk temperature of the fluid (show steps and rationale)

b) Determine the Nusselt number (ignore the fact that Nu = 3.614 or 4.3 for physically realistic laminar forced convection cases with constant wall temperature or constant wall heat flux, since this problem has an arbitrarily determined linear temperature profile)

Problem 3

(4 pts)

Consider a concentric annulus (i.e. flow through a tube with a heated rod at the center). For a low Pr fluid such as liquid metal, one can assume a uniform velocity profile. Assume thermally fully developed flow with a constant heat flux boundary condition. The radius ratio is 0.7. The inner tube is heated and the outer tube is insulated.

a) Determine the hydraulic diameter in terms of the inner tube radius r_1 and outer tube radius r_2.

b) Determine the temperature profile within the annulus gap, T(r).

Problem 4

(3 pts)

Consider the Problem Set question that asked about a condensing film moving down a vertical wall that is initially at a given film thickness δ_0 and then the wall decreases in temperature.

Instead, now consider that the wall temperature increases from T_w to a temperature above T_{sat} (it will heat the condensing fluid, which will evaporate).

a) Draw what the boundary layer profile now looks like. The film thickness at the top is still δ_0

b) Determine an expression for the boundary layer profile $\delta(x)$, show all steps (start from the beginning of the derivation). Hint: what is h_{fg}?