CHE312A: Homework 2

Instructions: Upload your original, legible and handwritten solution in pdf format, with the exact filename ⟨yourrollnumber⟩.pdf (e.g. 06302016.pdf). Include your name and roll number on the top of the first page. Include all necessary steps in detail, define all symbols and state all assumptions made in your solution.

1. Assuming steady state radial heat transfer across a spherical tank of inner diameter R_0 and outer diameter R_1, derive an expression for the rate of heat transfer across the tank in terms of its inner and outer surface temperatures $T_{s,0}$ and $T_{s,1}$, respectively. Rewrite this in terms of the thermal resistance due to conduction. The thermal conductivity is uniform throughout the tank. (1 points)

2. The spherical tank in the above problem stores a liquid at a temperature that is above the temperature of the air surrounding the tank. A mechanical engineer needs to decide whether adding a fibre glass insulation layer of thickness $R_2 - R_1$ enclosing the tank helps reducing the rate at which the temperature of the liquid in the tank drops. Provide an expression to the engineer to help her decide the minimum thickness of the insulation layer required to achieve this. (3 points)

3. Simplify the heat conduction equation for a steady state radial heat transfer across a spherical tank similar to that in the above problem, but including a term for uniform heat generation per unit volume of the tank material, $\dot{e}_{\text{gen}}$. Using the simplified heat conduction equation, derive an expression for the steady state temperature distribution along the radius of the tank in terms of known inner and outer surface temperatures. (2 points)

4. Heat is transferred from a liquid at 20 °C to air at 30 °C through a 1 m thick copper plate separating them. The convection heat transfer coefficients on the liquid and air sides are 20 $\text{W/m}^2\text{K}$ and 5 W/m^2, respectively. What is the rate of heat transfer per unit area of the thick copper plate? (1 points)

5. A thin copper sheet of length 30 cm, width 1 cm and height 3 mm is to be attached perpendicularly to the thick copper sheet in the above problem as an extended surface in order to enhance the rate of heat transfer. A physicist tells you that attaching the thin sheet such that it extends on the air side is better than attaching it on the liquid side. Quantify the physicist's statement by making reasonable assumptions. (3 points)

Information:

Material	Thermal conductivity k (W/m.K)
Glass	1
Brick	1.31
Concrete	0.8
Aluminium	237
Copper	401