Assignment 1 (ME346-S3)

August 7, 2023

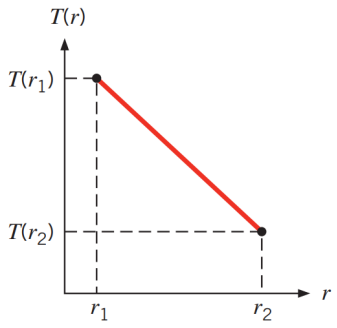
- Each question carries 20 marks.
- Make suitable assumptions if necessary.

1. Consider a plane wall made of an inhomogeneous material of varying thermal conductivity. The thermal conductivity varies along the thickness of the wall according to the relation $k = ax + b$, where a and b are constants. Assuming steady-state, one-dimensional heat conduction:
   (a) Given that the heat flux in the material is constant, determine an expression for the temperature gradient along the thickness direction.
   (b) If the wall surface at $x = 0$ is at a temperature T_0, determine an expression for the temperature distribution along the thickness direction.

2. A 100 mm thick plane wall has a steady-state temperature distribution $T(°\text{C}) = a + bx^2$, where $a = 150$ °C, $b = -1000$ °C/m^2, and the thickness variable x is in meters. Assume one-dimensional heat conduction in the wall. If the wall has a thermal conductivity of 45 W/m-K, calculate the following:
   (a) Heat generation rate $\dot{q}$ in the wall.
   (b) Heat fluxes at the two wall surfaces.

3. Derive the heat diffusion equation in spherical coordinates, beginning with a differential control volume.

4. Consider a spherical shell with inner radius r_1 and outer radius r_2. For one-dimensional, steady-state conduction (and no internal heat generation), under what condition is the following linear temperature distribution possible? Justify your answer.



5. Consider a radial wall with inner radius r_i and outer radius r_o. The steady-state temperature distribution in the wall is given as: $T(r) = C_1 \ln\left(\frac{r}{r_0}\right) + C_2$.
   (a) Determine if the wall is cylindrical or spherical.
   (b) Determine how the heat flux and heat rate vary with the wall radius.