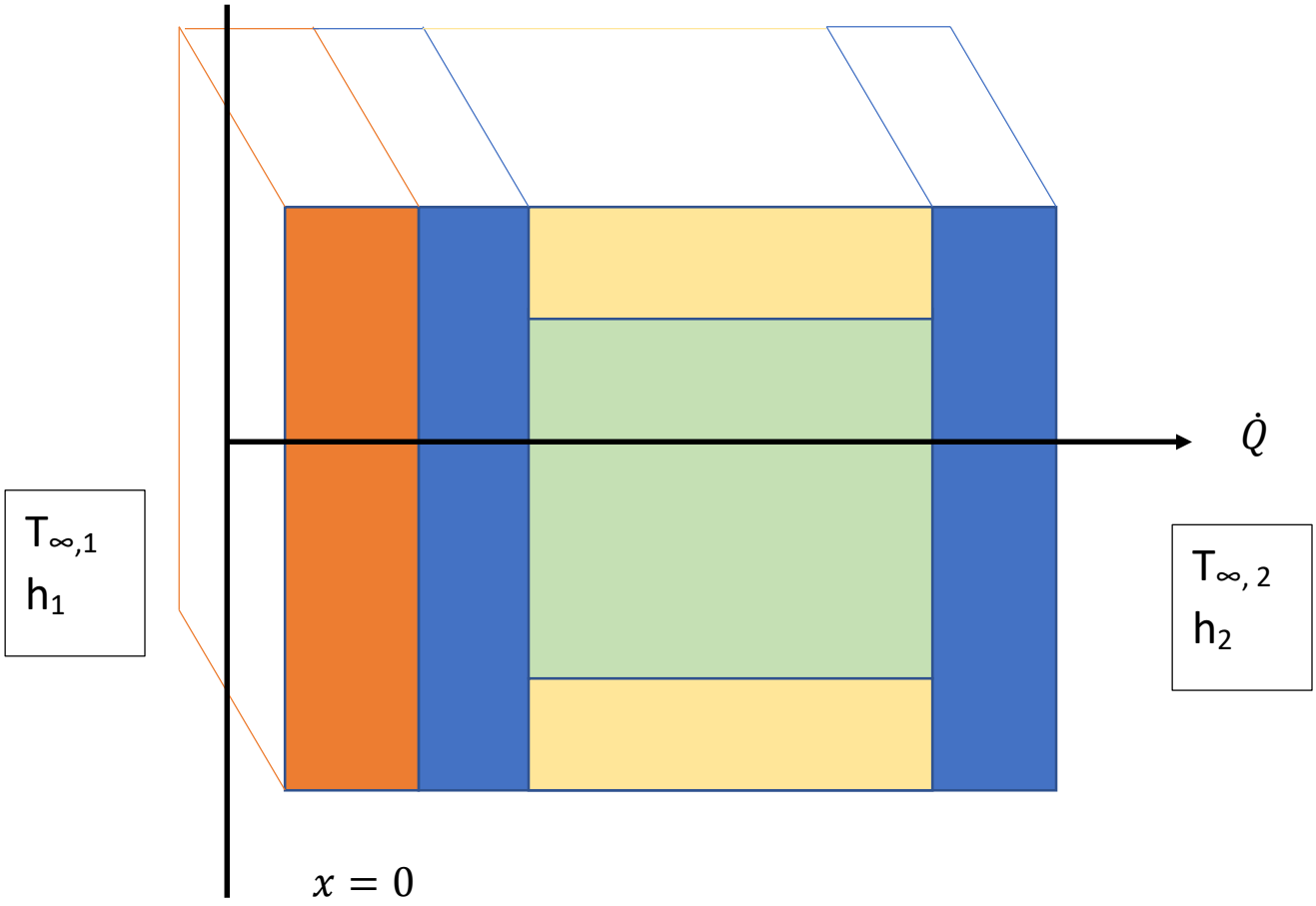
ME 345 – HTx Spring 2022 Conduction Take-Home Exam

Problem 1 – Composite Wall

You have a wall that is made up of many pieces (each with 0.33 m^2 area) with the cross-section shown in the figure below:



Calculate the following:

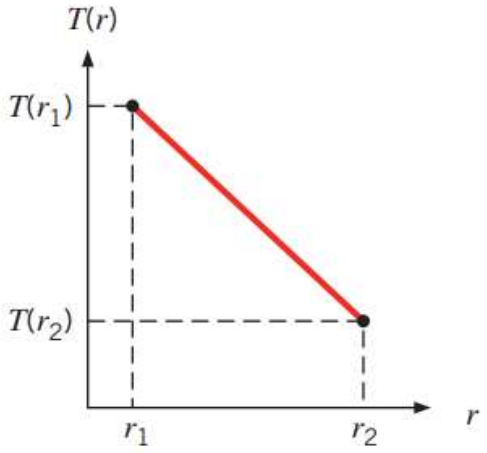
a) Using the thermal resistance model, calculate R_{total} [°C/W] through one section of wall.
b) Calculate the heat rate [W] through one section of wall if $T_{infinity,1}$ = 22 °C and $T_{infinity,2}$ = -4 °C.
c) If the entire wall has a surface area of 4 m x 6 m, calculate the heat rate [W] through the whole wall.

Additional Problem 1 Information

- The convection coefficient on the left side is 10 W/(m^2 °C)
- The orange section has a thickness in the x-direction of 0.02 m, a thermal conductivity of 0.026 W/m-°C, and an area of 0.33 m^2.
- Each blue section has a thickness in the x-direction of 0.02 m, a thermal conductivity of 0.22 W/m-°C, and an area of 0.33 m^2.
- Each yellow section has a thickness in the x-direction of 0.18 m, a thermal conductivity of 0.22 W/m-°C, and an area of 0.015 m^2.
- The green section has a thickness in the x-direction of 0.18 m, a thermal conductivity of 0.72 W/m-°C, and an area of 0.30 m^2.
- The convection coefficient on the right side is 20 W/(m^2 °C)

Problem 2 – Cylindrical Conduction

You have 1D SS conduction without heat generation through a cylindrical shell with inner and outer radius of r_1 and r_2. If the temperature profile through the wall was linear (as in the figure to the right), what conditions would be necessary for that to occur?
Use the heat equation in cylindrical coordinates to justify your answer(s).



Problem 3 – Cylindrical Heat Transfer

Problem 5 from Homework 5 gave you a lot of trouble. For this exam I want you to rework problem 5, only this time you are going to **ignore radiation heat transfer**. (See HW5 for picture and details)

Perform the following:

a) Compute the heat loss per length of pipe (q') as a function of of the insulation thickness ($r_2 - r_1$), where r_2 varies from 0.06 to 0.20 [m].
b) Compute the outer surface temperature ($T_{s,2}$) as a function of of the insulation thickness ($r_2 - r_1$), where r_2 varies from 0.06 to 0.20 [m].
c) Imagine you're working for a company that is trying to reduce heat loss from this pipe. Based on your above calculations, give a recommendation for the insulation thickness and justify your recommendation (in a few sentences).