AMERICAN UNIVERSITY OF BEIRUT
FACULTY of ENGINEERING
DEPARTMENT of MECHANICAL ENGINEERING
BEIRUT-Lebanon

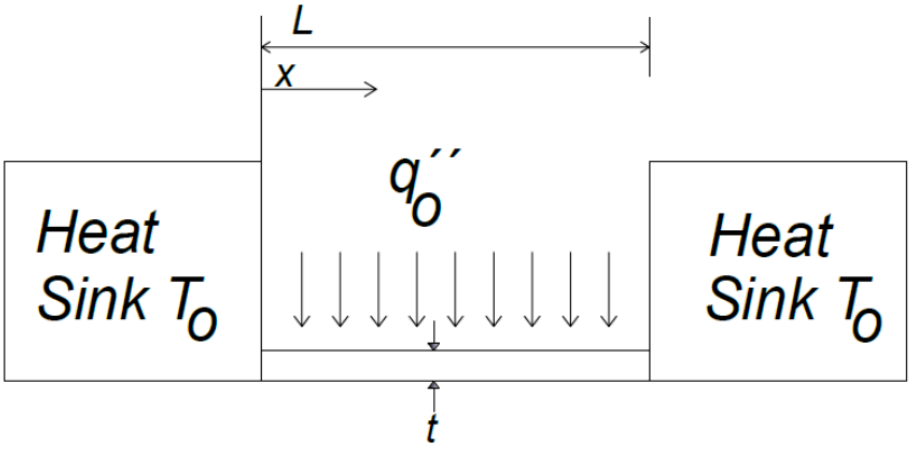
Heat Transfer (Exam 1)

1- (40%) In a pharmaceutical plant a copper pipe (k_c = 400 W/m°C) with inner diameter of 20 mm and wall thickness of 2.5 mm is used for carrying liquid oxygen to a storage tank. The liquid oxygen flowing in the pipe has an average temperature of -200 °C and a convective heat transfer coefficient of 120 W/m^2.°C. The condition surrounding the pipe has an ambient temperature of 20 °C and a combined heat transfer coefficient of 20 W/m^2.°C. If the dew point is 10 °C, determine the thickness of the insulation (k_i = 0.05 W/m°C) around the copper pipe to avoid condensation on the outer surface. Assume thermal contact resistance is negligible

2- (30%) A thin flat plate of length L, thickness t, and width W >>L is thermally joined to two large heat sinks that are maintained at a temperature of T_o. The bottom of the plate is well insulated, while the net heat flux to the top surface of the plate is known to have a uniform value of q_o''.

(a) Derive the differential equation that determines the steady state temperature distribution T(x) in the plate.

(b) Solve the foregoing equation for the temperature distribution, and obtain an expression of the rate of the heat transfer from the plate to the heat sinks.



3- A very long copper fin having a diameter of 5 cm and a base temperature of 20 °C is subjected to different air streams having a convective heat transfer coefficient of 50 $W/m^2.°C$: in the first one meter section of the fin, the air temperature T_∞ is 40 °C while in the remaining section of the fin the air temperature is at 25 °C. The two convective air streams are separated by a non-conducting wall and the fin protrudes the wall that is characterized by a negligible thickness. Determine the following:

a) The temperature of the fin at the end of the one meter section, the location where the fin protrudes inside the non-conducting wall.

b) Find the total amount of heat transported by the fin.