MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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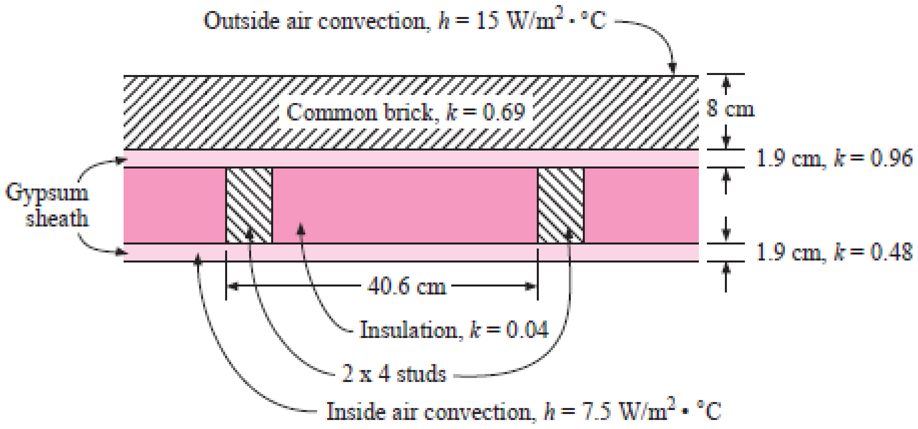
FOURTH SEMESTER B. TECH GRADE IMPROVEMENT/MAKEUP EXAMINATIONS AUG' 2021

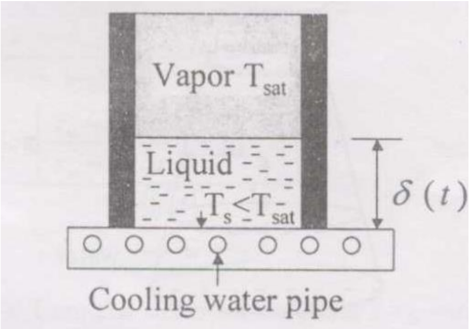
SUBJECT: PRINCIPLES OF HEAT AND MASS TRANSFER OPERATIONS [BIO 2254]

Date of Exam: **06-08-2021** Time of Exam: **9:00-12:00 PM** Max. Marks: **40**

Instructions to Candidates:

- Answer any FOUR full questions & missing data may be suitable assumed.
- Data handbook can be referred for any missing data/formula

1A.	Compute the Overall heat transfer coefficient and resistance of the wall shown. You can take unit depth of the wall, The 2x4 studes have the dimension of 4.13 x 9.21 cm and the material thermal conductivity of 0.1 W/m ^{0}C. Ref: J P Holman, Heat Transfer. 	**6**
1B.	A 3.0 cm diameter SS bars 10 cm long have ground surfaces and are exposed to air with a surface roughness of about 1µm. If the surface are pressed together with a pressure of 50 atm and the two bar combination is exposed tos an overll temperature difference of 100^{0}C, calculate the axial heat flow and the temperature drop across the contact surface. You may assume that contact resistance of the air gap is reciprocal of convective heat transfer coefficient of air in the gap. ($1/h_c = 5.28 \times 10^{-4}$ m^2 ^{0}C/W).	**4**
2A	Water flows at 50^{0}C inside a 2.5 cm inside diameter tube such that h_i=3500 W/m^2 ^{0}C. The tube has a wall thickness of 0.8mm with a thermal conductivity of 16 W/m ^{0}C. The outside of the tube loses heat by free convection with h_0=7.6 W/m^2 ^{0}C. Calculat ethe overall het transfer coefficient and the heat loss per unit length to surrounding air at 20^{0}C.	**5**
2B.	Water enters a thin walled tube L=1m, D=3mm at an inlet temperature of 97^{0}C and mass flow rate of 0.015 kg/s. The tube wall is maintained at a constant temperature of 27^{0}C. Given the following data for water; Density=1000 kg/m^3, viscosity = 489x10^{-6}Ns/m^2, specific heat=4184J/KgK, Inside heat transfer coefficient = 12978 W/m^{2}K. Compute the Reynold number and outlet temperaure of water.	**5**

3A	Consider a liquid stored in a container exposed to its saturated vapour at constant temperture of T_{sat}. The bottom surface of of the container is maintained at a constant temperature of T_S such that $T_S< T_{sat}$ while its side walls are insulated. The thermal conductivity k of th eliquid, latent heat of vaporization λ , density ρ are known. Assuming a linear temperature distribution in the liquid, prove that the expression for the growth of the liquid layer δ (t) due to condensation as a function of time t is given by (by energy balance for period of time t). $$(\delta(t))^2 = [\frac{2k(T_{sat} - T_s)t}{\rho\lambda}]$$ 	**6**
3B	Two paralle black plates 0.5x1.0m are separated by 0.5 m apart. One plate is maintained at 1000^0C and the other at 500^0C. What is the net radiation exchange, in W/m^2, between the two plates? F_{12} =0.285. The value of Stefan Boltzmann constant is 5.67x10^{-8} W/m^{2}K^4	**4**
4A	Two very large parallel plates with emissivities 0.8 exchange heat. Find the amount of reduction in heat transfer, in W/m^2,when another shield with same ϵ, is placed between them, T_1 =1000K and T_2 =500K.	**5**
4B	Vapour bubbles are formed in the nucleate boiling regime at a frequency of 10 bubbles per second per nucleation. There are 100 nucleations sites per m^2 of heating area. The latent heat of vaporization and the density of vapour under operating condition are 1000kJ/kg and 1 kg/m^3 respectively. The diameter of each bubble in 10^{-3}m. Assuming that the entire heat is used for vapor generation,compute the heat flux in W/m^{2}of heating area.	**5**
5A	Air at 20°C (ρ = 1.205 kg/m^3; v = 15.06 x 10-6 m^2/s; D = 4.166 x 10^{-5} m^2/s) flows over a tray (length = 320 mm, width = 420 mm) full of water with a velocity of 2.8 m/s. the total pressure of moving air is 1 atm and the partial pressure of water present in the air is 0.0068 bar. If the temperature on the water surface is 15°C, calculate the evaporation rate of water.	**5**
5B	Air is contained in a tyre tube of surface area 0.5 m^2 and wall thickness 10 mm. the pressure of air drops from 2.2 bar to 2.18 bar in a period of 6 days. The solubility of air in the rubber is 0.072 m^3 of air per m^3 of rubber at 1 bar. Determine the diffusivity of air in rubber at the operating temperature of 300 K if the volume of air in the tube is 0.028 m^3.	**5**

6A	Air at 20ºC, 40 % RH flows over a water surface at a velocity of 1.4 m/s; length parallel to flow is 200 mm. If average surface temperature is 16ºC, calculate the amount of water evaporated per hour/m^2 of the surface. Take: Partial pressure of water vapour at 20ºC and 40 % RH, P_{wa} = 0.011 bar, The vapour pressure at 16ºC and saturated, P_{ws} = 0.017 bar Viscosity of air = 16.38 x 10^{-6} kg/ms Density of air = 1.22 kg/m^3, and Diffusion coefficient; D = 0.256 x 10^{-4} m^2/s.	**5**
6B	Air at 1 atm, 25ºC, containing small quantities of iodine flows with a velocity of 5.18 m/s inside a 3.048 cm diameter tube. Determine the mass transfer coefficient for iodine transfer from the gas stream to the wall surface. If C_m is the mean concentrate of iodine in kmol/m^3 in the air stream, determine the rate of deposition of iodine on the tube surface where the iodine concentration is zero. Take v = 1.58 x 10^{-5} m^2/s; D = 0.826 x 10^{-5} m^2/s. Note: If flow is turbulent, i.e. 4000 ≤ Re ≤ 60,000, then Sh = 0.023 $Re^{0.83}$ $Sc^{0.33}$. If flow is laminar, i.e. Re ≤ 2100, then Sh = 1.62 $(Re\ Sc\ d/L)^{1/3}$.	**5**