MASTER OF MECH ENGG. EXAMINATION 2019
Second Semester
Subj: CONVECTION HEAT TRANSFER

Time: Three hours **Full Marks: 100**

Answer **question No. 1 (Compulsory)**
and **any four questions** from the rest

NB: Assume any data, if not furnished, consistent with the problem.

1. a)Define the significance of Prandtl Number in convective heat transfer. Provide examples where Pr is very high and very low.
   b) Name five factors which change the transition to turbulence. In each case mention whether critical Re increases or decreases.
   c) Discuss the differences between Biot Number and Nusselt number.
   d) The temperature profile at a particular location on the surface of a plate is prescribed by the expression $(T-T_s)/(T_\infty - T_s) = \sin(\pi y/0.015)$. Derive an expression for convective heat transfer coefficient at this location.
   e) Explain why characteristics length of a slot jet is taken 2 times the jet width?

5+5+4+3+3

2. a) Show that coefficient of volumetric thermal expansion is 1/T for an ideal gas.
   b) Sketch the velocity and temperature profiles in the boundary layer for a vertical flat plate under natural convection.
   c) A nuclear reactor of vertical parallel plates 2.25 m high and 1.5 m wide is surrounded by liquid bismuth. The maximum temperatures of vertical walls and liquid bismuth are 975^0 and 325^0 C respectively. Estimate maximum possible heat dissipation rate from both sides of each plate using the relationship Nu= 0.13 $(GrPr)^{1/3}$. The thermo-physical properties for bismuth are
   $\mu = 3.12$ kg/m-hr, $\rho = 10,000$ kg/m^3, $c_p = 150.7$ J/kgK, k = 13.02 W/mK
   d) Show that limiting value of Nu is 1 for two horizontal plates maintained at constant temperatures, T_u and T_l for upper and lower walls respectively

3+3+11+3

3. a) Derive the expression for velocity profile and skin friction coefficient for fully developed parabolic flow in a circular duct.
   b) Temperature values at 10 intervals were found to be 10.9,10.7,10.6,10.2, 10.1, 10, 9.8, 9.6, 9.5,9.4, 9.2. Find out the value of $\overline{T'^2}$

15+5

4. a) Explain the basic features of turbulence
   b) State the limitations of k-ε model. How turbulent viscosity is expressed in this class of model?
   c) Write down the expressions for Reynolds stress terms. Define turbulent viscosity and turbulent Prandtl Number.

7+5+8

5. A ball of ice, 4 cm in diameter at 0^0 C is suspended in a dry air steam at 25^0C flowing at a velocity of 2m/s. Find out the initial melting rate of the ice? How much time would be needed for melting of 50% ice. A relevant correlation for flow around a sphere is

$$Nu= 2+ [0.4Re^{1/2} + 0.06Re^{2/3}] Pr^{0.4}$$

The thermo-physical properties of fluid are viscosity of 1.69×10^{-5} kg/ms , specific heat 1.005 kJ/, thermal conductivity 0.02792 W/ mK. Ice has a density of 920 kg/m^3 and latent heat of melting 334 kJ/kg.

20

6. a) Draw the boiling curve and label different important points and regimes. Discuss the importance of critical heat flux.
   b) The bottom of a copper pan has 0.3 m diameter and maintained at 118 ^{0} C. Estimate the power required to boil water in this pan and the rate of evaporation due to boiling. . Given: Pr= 1.76, h_{fg} = 2257kJ/kg, $\sigma = 58.9 \times 10^{-5}$ N/m, $\mu = 279 \times 10^{-6}$ N.s/m^2. Value of $C_{s,f}$= .0130 and n = 1.0.

10+10

7. a)Air flows with 6m/s velocity through a duct of rectangular cross section measuring 40 x 80 cm. Determine heat loss per meter length of duct if the temperature difference between duct wall and environment is 30 K. The thermo-physical properties is SI units are
   $\mu = 1.895 \times 10^{-5}$, C_P = 1007, K = 0.02625

   b) Water flows through a tube with diameter of 25 mm. At a location of 3m from inlet, water velocity is 3 m/s and the temperature is 280 ^{0} C. the surface temperature is 250^0 C. Estimate the local heat transfer coefficient at this location and rate of heat transfer.
   The thermo-physical properties is SI units are
   $\mu = 9.356 \times 10^{-4}$, C_P = 5278, K = 0.5803
   c) Explain simultaneously developing boundary layer in ducts and discuss the heat transfer behavior.

8+6+6