BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. 4th Semester (Aerospace Engineering) Final Examination, 2012
Sub. : **Introduction to Heat and Mass Transfer** Code : **AE 403**

Full Marks : 70 Answer any five questions. Time : 3 hrs.

1.a. Define the critical thickness of insulation.

b. Calculate the critical radius of insulation for asbestos ($k = 0.17$ W/m^{0}C) surrounding a pipe and exposed to room air at 20^{0}C with $h = 3.0$ W/m^2 ^{0}C. Calculate the heat loss from a 200^{0}C, 5.0 cm diameter pipe when covered with the critical radius of insulation and without insulation.

2.a. What is meant by a lumped capacity ? What are the physical assumption necessary for a lumped-capacity unsteady-state analysis to apply ?

b. A steel ball [specific heat (c) = 0.46 kJ/kg^{0}C; $k = 35$ W/m^{0}C] 5.0 cm in diameter and initially at a uniform temperature of 450^{0}C is suddenly placed in a controlled environment in which the temperature is maintained at 100^{0}C. The convection heat-transfer co-efficient is 10 W/m^2 ^{0}C. Calculate the time required for the ball to attain a temperature of 150^{0}C.

3.a. Using Planck's equation derive the Stefan-Boltzmann equation for emissive power of a black surface.

b. Prove that $E_{b\lambda}$ will be maximum when $\lambda_m T = 2900$ μ^0-K.

4.a. Derive an expression for the heat exchange by radiation between two black surface elements.

b. Calculate the shape factor $F_{1\text{-}2}$ between a small area A_1 and a parallel plane circular disc A_2. A_1 is located on the axis of the disc and the semi-vertex angle of the cone formed with the disc as base and A_1 as the vertex is α.

5.a. What is meant by a thermal boundary layer? Define the bulk temperature. How is it used?

b. An aircraft flies at an altitude where the temperature 60^{0}C and pressure is 0.08 atm. The air speed is 900 km/hr. The wing tank contains fuel at 20^{0}C, keeping the surface at this temperature. Assuming the effect of curvature to be small, determine the Reynold's number at the wing tip of wing is 3 m wide. Also determine the locations from the leading edge where $Re = 5 \times 10^5$. If $C_{fx} = 0.059 \times Re^{-0.2}$ determine the value of local heat transfer co-efficient. [At T_f = 20^{0}C and P = 0.08 atm. from. Table : $\rho = 1.395 \times 0.08$ kg/m^3; $\mu = 16.18 \times 10^{-6}$ N-S/m^2; x = 3 m; $k = 22.79 \times 10^{-3}$ W/mK; $P_r = 0.716$]

6.a. How is a modified Grashof number defined for a constant heat ~~of lux~~ flux condition on a vertical plate ?

b. A low speed wind tunnel is to be designed for tests up to $Re = 5 \times 10^5$ with air at 0.8 atm and 20^{0}C. The model length is restricted to 0.3 m. If the test section is 0.45 m^2, determine the mass flow required. Check whether the boundary layer on the wall will affect the test. The tunnel length is 1.5 m. [The properties are to be obtained at 20^{0}C; $\rho = 1.205$ kg/m^3; $\mu = 18.14 \times 10^{-6}$ N-S/m^2]

P.T.O.

7.a. When is the LMTD method most applicable to heat-exchanger calculation ?

b. Water at the rate of 68 kg/min is heated from 35 to 75^0C by an oil having a specific heat of 1.9 kJ/kg^{0}C. The fluids are used in a counterflow double-pipe heat exchanger and the oil enters the exchanger at 110^0C and leaves at 75^0C. The overall heat transfer co-efficient is 320 W/m^2 ^{0}C. Calculate the heat-exchanger area.

8.a. What advantage does the effectiveness - NTU method have over the LMTD method ?

b. A heat exchanger is used to heat an oil in the tubes (C = 1.9 kJ/kg^{0}C) from 15^0C to 85^0C. Blowing across the outside of the tubes is steam which enters at 130^0C and leaves at 110^0C with a mass-flow of 5.2 kg/s. The overall heat transfer co-efficient is 275 W/m^2 ^{0}C and C (sp. heat) for steam is 1.86 kJ/kg^{0}C. Calculate the surface area of the heat exchanger. [Take correction factor (F) = 0.97].