Code No: 5221AQ **R15**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech II Semester Examinations, February - 2017

ADVANCED HEAT AND MASS TRANSFER

(Thermal Engineering)

Time: 3hrs **Max.Marks:75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

5 × 5 Marks = 25

1.a) What is meant by transient heat transfer? Mention some of the situations where transient conduction occurs. [5]

b) What are various methods of dimensional analysis? Express the heat transfer due to forced convection in terms of dimensionless number using Buckingham method. [5]

c) Explain the development of boundary layer over a cylinder. [5]

d) Explain how film wise condensation is different from drop wise condensation. [5]

e) Define Sherwood number, Lewis number and Schmidt number. Also explain the similarities between heat and mass transfer. [5]

PART - B

5 × 10 Marks = 50

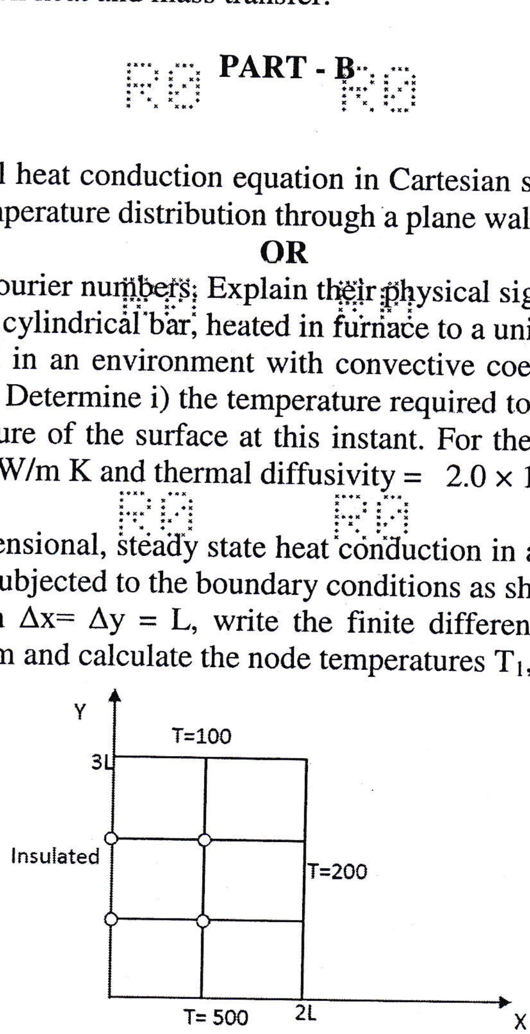
2. Derive the general heat conduction equation in Cartesian system and hence deduce the expression for temperature distribution through a plane wall. [10]

OR

3.a) Define Biot and Fourier numbers. Explain their physical significance.

b) A 10 cm diameter cylindrical bar, heated in furnace to a uniform temperature of 200^0 C, is allowed to cool in an environment with convective coefficient of 150 W/m^2 K and temperature 40^0C. Determine i) the temperature required to cool the centre of the bar to 60^0 C ii) temperature of the surface at this instant. For the material of the bar thermal conductivity = 50 W/m K and thermal diffusivity = 2.0×10^{-5} m^2/sec. [5+5]

4. Consider two dimensional, steady state heat conduction in a rectangular region of cross section 2L by 3L subjected to the boundary conditions as shown in the figure below. By using coarse mesh $\Delta x = \Delta y = L$, write the finite difference formulation of this heat conduction problem and calculate the node temperatures T_1, T_2, T_3 and T_4. [10]



OR

5.a) State the Buckingham's π theorem. Explain its usefulness in dimensional analysis.

b) The velocity distribution in the boundary layer of a flat plate is given by

$$u/u_\infty = \frac{3}{2}(y/\delta) - \frac{1}{2}(y/\delta)^2$$

Where all the symbols have their usual meaning. Use momentum integral equation to develop an expression for the boundary layer thickness. [5+5]

6.a) Define hydrodynamic and thermal entry lengths as referred to internal flows in circular tubes, with the help of appropriate sketches.

b) Water at 30^0C flowing at the rate of 0.015 kg/s enters a 3 cm diameter tube, which is maintained at 110^0C. Assuming the flow is fully developed determine the length of the tube required to heat the water up to 65^0C. Considering the entry length region, determine the average heat transfer coefficient. [5+5]

OR

7.a) Sketch the velocity boundary layer as referred to forced convection from an isothermal flat plate and explain the significance of various regimes in it.

b) Air at 27 ^{0}C temperature and 1 atm. pressure, flows across a spherical vessel of 1.2 cm diameter at a free stream velocity of 4 m/sec, while the surface of the spherical vessel is maintained at 77 ^{0} C temperature throughout, with the help of a small electric heater kept inside it. Find the rate of convection heat loss from the vessel into the air. [5+5]

8.a) How is the velocity field developed in front of a vertical plate which is maintained at a temperature i) higher and ii) lower than the surrounding fluid.

b) A vertical wall at a uniform temperature of 180^0C is exposed to quiescent atmospheric air at 30^0C. The wall is of height 3.5 m and width 2 m. Calculate the net rate of convection heat transfer from both sides of the wall into the atmospheric air. [5+5]

OR

9.a) Discuss the various regimes of boiling heat transfer. Explain about critical heat flux in nucleate boiling.

b) A 1.0 mm diameter and 150 mm long wire is submerged horizontally in water at 7 bar pressure. The wire has a steady state applied voltage drop of 2.1 V and a current of 131 A. Calculate the heat flux and boiling heat transfer coefficient if the surface of the wire is to be maintained at 180 ^{0} C. [5+5]

10.a) What is a black body? Give examples of some surfaces, which do not appear black, but have high values of absorptivities.

b) Two concentric pipes, 20 cm and 30 cm in diameter, with the space between them evacuated are used to store liquid air (boiling point -150 ^{0} C) in room at 25 ^{0} C. The surface of both the pipes are flushed with aluminum for which emissivity = 0.03. Estimate the rate of heat flow by radiation to the air and the rate of its evaporation. Latent heat of vaporization of liquid air is 208 KJ/kg. [5+5]

OR

11.a) State Fick's law of diffusion. Show the similarity of this law to Fourier equation for conduction and Newton's equation for shear stress. Express Fick's law in terms of partial pressures for diffusion of component A into component B and of component B into component A.

b) A deep narrow tube open at the top contains toluene at the bottom. Air inside the tube is motionless while at the top toluene concentration is zero. The entire system is at 1 atm, 18.7 ^{0}C when D= 0.826 × 10^{-4} m^2/sec. The saturated vapour pressure of toluene at liquid surface is 0.026 atm. Determine the rate of evaporation of toluene per unit area if the distance from the liquid surface to the top is 1.524 m. [5+5]

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