INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Chemical Engineering

End-Spring Semester Examination, 2015-2016

Subject: **Advanced Heat Transfer** *Subject No.*: **CH 61014**

Time: **3 Hrs** **No. of Students: 94** *Full Marks*: **50**

Instructions:

1. **Use a SINGLE answer script for both the parts.**
2. All questions are compulsory.
3. Clearly write your Name, Roll No., Subject Name, Subject Number on the Answer Book.
4. Feel free to assume any missing data with proper justifications.
5. Please try to answer all the questions of each part together. **Also, all sub parts of each question MUST be answered together.**

PART - A

1. Define a Diffuse Emitter. Define Spectral Hemispherical Emissive Power and obtain it's expression for a Diffuse Emitter. What are the essential properties of a black body? (1+1+2+1=5)
2. What is the mechanism of Bubble formation in Nucleate Boiling? Comment on the size of the rising bubbles. What is the significance of **Leidenfrost** Point? (2+1+1=4)
3. Derive an expression for the thickness of the Condensing layer (**δ**) at a distance **y** from the leading edge of a cold vertical wall, on which saturated vapor is condensing. Assume a linear temperature profile along the depth of the layer. Consider all assumptions of the Boundary Layer to be valid within the condensing layer. (9)
4. Starting from the Boussinisq Approximated momentum transport equation, discuss qualitatively the possible velocity profiles in a Vertical Natural Convective Boundary Layer. (7)

PART - B

5. Consider the cross section of a long rectangular bar as shown in Fig. 1 below. Internal energy is generated in the bar at a constant rate $\dot{q}$ per unit volume. q_1'' and q_2'' are given constant heat fluxes out of and into the bar at $x = a$ and $x = b$, respectively. The surfaces at $x = 0$ and $y = 0$ are perfectly insulated. The thermal conductivity of the material of the bar is constant. Find the relationship between q_1'', q_2'' and $\dot{q}$ so that the temperature distribution $T(x, y)$ can attain steady state. **[5]**

(Please Turn Over)

6. Consider a long solid cylinder of circular cross section with a radius r_0. The surface of the cylinder at $r = r_0$ is held at an arbitrary temperature $f(\phi)$. There are no internal energy sources or sinks, and the thermo-physical properties of the material of the cylinder can be assumed to be constant. Determine the steady state temperature distribution $T(r,\phi)$ in the cylinder using **separation of variables**. **[7]**

7. Consider a plane wall of thickness L as shown in Fig. 2 below. This is initially kept at a temperature $T_i(x)$. The internal energy is generated in this wall at a rate of $\dot{q}(x,t)$ per unit volume for times $t \geq 0$. Also, heat is dissipated by convection from the surfaces at $x = 0$ and $x = L$ into a surrounding medium whose temperature T_∞ varies with time. The thermo-physical properties may be assumed to be constant and the heat transfer coefficients h_1 and h_2 are very large. Determine the unsteady-state temperature distribution $T(x,t)$ in the wall using **method of integral transforms**. **[7]**

8. Consider steady state heat conduction in a long square slab $(2L \times 2L)$ as shown in Fig. 3 below. The internal energy is generated in the slab at a constant rate of $\dot{q}$ per unit volume. All four sides are maintained at temperature T_∞. The thermal conductivity of the material of the slab is constant.
(a) Write down the governing energy equation and the boundary conditions for the system in non-dimensional forms. **[2]**
(b) Using **central difference approximation**, write down the finite-difference forms of the governing equation and the boundary conditions. **`[1+2]**
(c) How will you handle the corner points? **[1]**

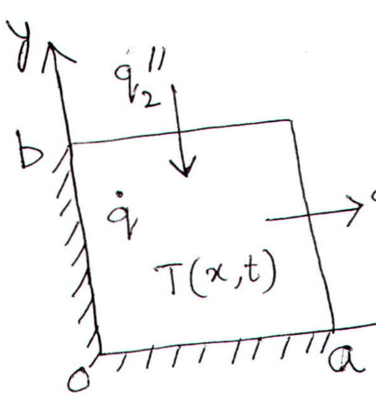

Fig. 1

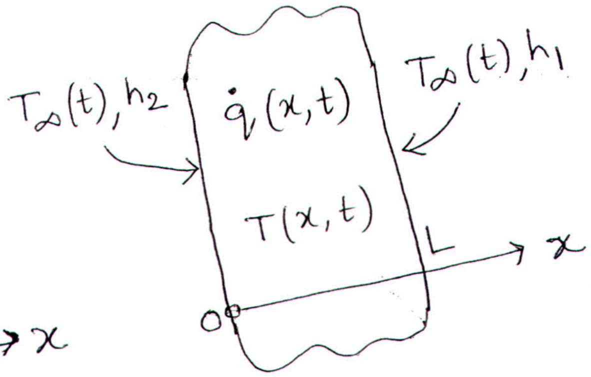

Fig. 2

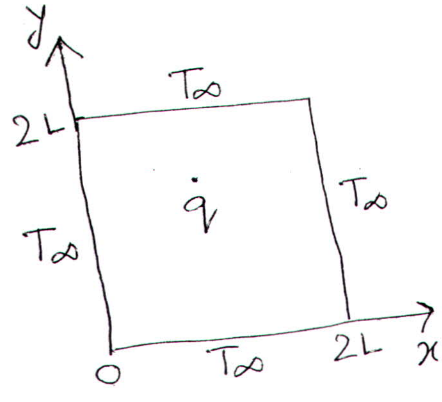

Fig. 3