INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Department of Chemical Engineering

End-Spring Semester Examination, 2012-2013

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

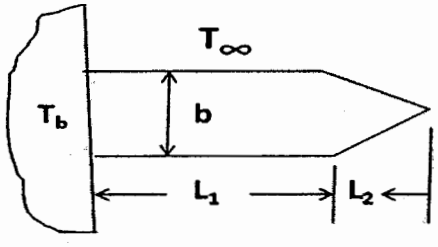
***Date*: 15.04.2013 (AN)** ***Time*: 3 Hrs** **No. of Students: 85** ***Full Marks*: 50**

***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. Fell 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 questions MUST be together.**
6. Be Precise with your answers. Long, redundant answers can potentially fetch zero!

PART A

1. Consider a fin of geometry shown below. The fin base is at constant temperature T_b and the fin tip may be considered as insulated. The ambient is at temperature T_∞. It may be assumed that the perimeter of the triangular portion is 2W, where W is the width of the fin. Develop an expression for the temperature profile along the length of the fin.



Note: You do not have to solve for the arbitrary constants, but you must provide the system of equations that would yield the arbitrary constants. **[10]**

2. Consider a hollow sphere with inner radius as a and outer radius as b. The sphere is initially at temperature $T_i(r)$. The surfaces at $r = a$ and $r = b$ are kept at temperatures $T_1(t)$ and $T_2(t)$, respectively, for times $t \geq 0$. We wish to find the unsteady-state temperature distribution, $T(r,t)$, in the spherical shell.

(a) Assuming constant thermo-physical properties, write down the governing heat conduction equation (spherical coordinate system) and all boundary/initial conditions. **[2]**

(b) Define a new temperature function $\theta(r,t) = rT(r,t)$ and reformulate the problem. The problem is now transformed to rectangular coordinate system. **[1]**

(c) Apply a change of variable, r = x + a, to the equations you obtained in step (b) and solve by using **Fourier Transforms.** [7]

3. Consider a fin of uniform cross-section so long that the tip temperature is practically equal to the ambient temperature. If we increase the cross-sectional area of the fin by 10%, keeping all other parameters unchanged, by what percent will the heat flow from the body into the fin increase? [5]

PART B

4. (a) What is **Benard** Convection Cell? When can they appear in boiling? (1+1)

   (b) Please mention the mechanism of bubble nucleation and detachment in boiling. (2)

   (c) One observes a series of bubbles rising from the same point on the heated surface in Nucleate boiling. Would you expect the same in Film boiling also? (1)

   (d) Please discuss why over some zone one observed drop in heat flux with increase in temperature. (2)

   (e) What is the fundamental difference boiling and evaporation? (1)

   (f) Discuss qualitatively the role of liquid surface tension and viscosity on boiling heat transfer [no expression needed]. (2)

   (g) What is "Flow" boiling? (1) **[11]**

5. Derive and expression for temperature profile within a turbulent thermal boundary layer over a hot horizontal plate in Waal co-ordinates. ($\mathbf{T^+}$)
   You can use the following equations:

$$\bar{u}\frac{\partial \bar{u}}{\partial x} + \bar{v}\frac{\partial \bar{u}}{\partial y} = \frac{\partial}{\partial y}\left[(\gamma + \epsilon)\frac{\partial \bar{u}}{\partial y}\right]$$

$$\bar{u}\frac{\partial \bar{T}}{\partial x} + \bar{v}\frac{\partial \bar{T}}{\partial y} = \frac{\partial}{\partial y}\left[(\alpha + \epsilon_H)\frac{\partial \bar{T}}{\partial y}\right]$$

   Any other assumption must be clearly stated. (8) **[8]**

6. (a) What is a diffuse emitter? (1)

   (b) What is the general trend in shift of spectral intensity of radiative emission with increase in temperature? (1)

   (c) Discuss, if radiation is a surface phenomena or a volume phenomena? (1)

   (d) For a condensing laminar film on a vertical surface, draw and explain the qualitative velocity profile in the vapor phase adjacent to the condensing layer. (2)

   (e) How will the velocity profile look if the surrounding temperature is identical to the saturation temperature and why? (1) **[6]**

All the Best! ☺