Reg. No.

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH (TSES)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: ADVANCED HEAT TRANSFER [MME 5270]

REVISED CREDIT SYSTEM

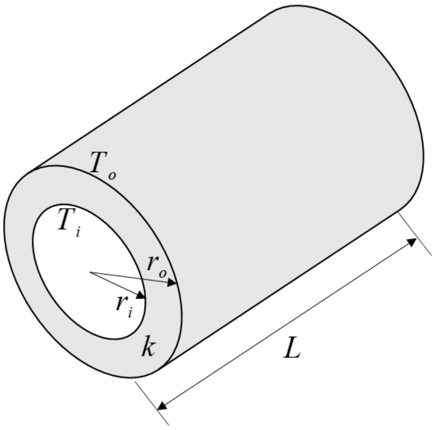
Time: 3 Hours | MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Use of Heat and Mass Transfer data book is permitted.

1A. What are the different types of boundary conditions we come across in conduction heat transfer? Give one example for each. **2**

1B. Steady state temperature distribution in a thick walled cylinder is given as follows; $T(r) = a\ln(r) + b$



Obtain the expression for heat transfer rate from a cylinder of length L. **3**

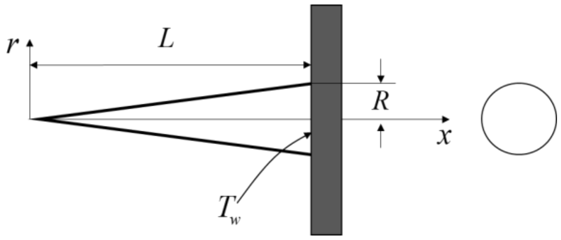
1C. A plane wall initially at uniform temperature T_i is suddenly exposed to different fluids on either sides at ambient temperature of T_∞. Heat capacity of one of the fluid is very high compared to the other. The mathematical formulation of the problem is as follows;

$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$ Initial condition: $T(x,0) = T_i$ and boundary conditions:

At $x = 0;\ T = T_\infty$ and at $x = L;\ -k\frac{\partial T}{\partial x} = h(T - T_\infty)$

Obtain the solution for $T(x, t)$ **5**

2A. A spine protruding from a wall at temperature T_w has the shape of a circular cone. The radius of the cone base is R. The spine comes to a point at its tip and its length is L. Derive the governing ordinary differential equation from basic principles. Assume that the temperature is uniform in the r-direction. **3**



2B. A massive wall of square cross section is heated by applying constant heat flux on one side and is exposed to convection on other three sides as shown in Fig. 2B. Model the steady state heat conduction in the cross-section of the wall mathematically. **2**

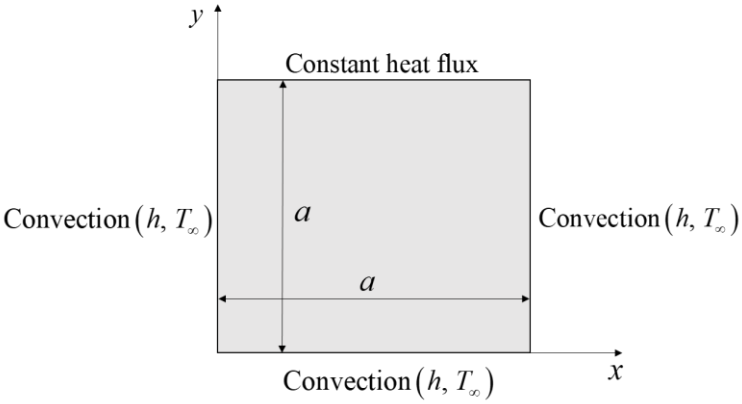


Fig. 2B

2C. Obtain the expression for the steady state temperature distribution in the square cross-section of the wall shown in Fig. 2B. **5**

3A. Explain the principle of superposition with an example. **3**

3B. The fully developed velocity profile for the laminar flow through a smooth circular tube of radius R is $u(r) = \frac{1}{4\mu}\frac{dp}{dx}\left(r^2 - R^2\right)$. Obtain the expression for average velocity. **2**

3C. For the fully developed laminar flow through a smooth circular tube, prove that friction coefficient $C_f = \frac{16}{\text{Re}}$. **4**

3D. Plot the variation of friction coefficient with the aspect ratio for the fully developed laminar flow through smooth rectangular cross-section tubes. **1**

4A. Discuss the concept of viscous and thermal boundary layer for laminar internal flows. **4**

4B. Nusselt number for the fully developed thermal and hydrodynamic boundary layer flow through a circular tube applied with peripherally varying heat flux $q_s = q_0(1 + b\cos\theta)$ is given by $\mathrm{Nu}(\theta) = \dfrac{1 + b\cos\theta}{\dfrac{11}{48} + \dfrac{b\cos\theta}{2}}$. Plot the variation of Nusselt number in the peripheral direction (θ). What is the surface temperature at $\theta = \pi$? **3**

4C. Consider a circular tube of diameter $60\,\mathrm{mm}$ carrying water at the rate of $0.01\,\mathrm{kg/s}$ with inlet temperature $20^\circ\mathrm{C}$. Find the length of the tube required to raise water temperature to $80^\circ\mathrm{C}$, when a heat flux of $2000\,\mathrm{W/m^2}$ is applied in the fully developed hydrodynamic boundary layer region. What is the surface temperature of the tube where water temperature is $80^\circ\mathrm{C}$? **3**

5A. What is the function of radiation shield? Prove that, when all emissivities are equal, radiation heat transfer rate is reduced by $(N+1)$ times by providing N number of radiation shields. **4**

5B. Discuss the additive and reciprocity properties of view factor. **2**

5C. Liquid nitrogen flows through $30\,\mathrm{mm}$ outer diameter tube, which is contained in an evacuated $50\,\mathrm{mm}$ inner diameter cylindrical shell. The nitrogen is at its normal boiling point of $77.4\,\mathrm{K}$ and the shell inner surface is at $260\,\mathrm{K}$. Emissivity of the both surfaces is 0.04. Estimate the heat gain by the nitrogen per meter length of tube if;

i. the surfaces are diffuse reflectors.
ii. the surfaces are specular reflectors.

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