Reg. No.										

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

II SEMESTER M.TECH (TSES)

END SEMESTER MAKE UP EXAMINATIONS, JUNE 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. Consider an infinite (in y & z directions) plane wall of thickness L. The wall is initially at temperature T_i. It is then suddenly exposed to convection on both surfaces with a fluid having temperature T_∞ and convective heat transfer coefficient h. Write the mathematical formulation of the problem. Is there any way to simplify the problem analysis? Which method you suggest for the solution? **3**

1B. Determine the temperature distribution in the wall as a function of time for the problem given in question 1A. **5**

1C. Steady state temperature distribution in a thick walled cylinder is given as follows; $T(r) = a\ln(r) + b$. Obtain the expression for temperature at $r_m = 0.5(r_i + r_o)$ in terms of T_i and T_o. **2**

2A. A short cylinder of radius R and length L is initially at a uniform temperature T_i. Its exterior surface temperature is suddenly changed to a new value T_∞. The differential equation and the boundary and initial conditions are given by:

$$\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial x} + \frac{\partial^2 T}{\partial z^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

$$T(r,\, z,\, 0) = T_i$$

$$T(R,\, z,\, t) = T_\infty$$

$$T(r,\, 0,\, t) = T_\infty$$

$$T(r,\, L,\, t) = T_\infty$$

Reduce the above problem to one-dimensional transients. **3**

2B. Write the governing equation and boundary conditions for the steady state heat conduction in the cross-section of the wall shown in Fig. 2B.

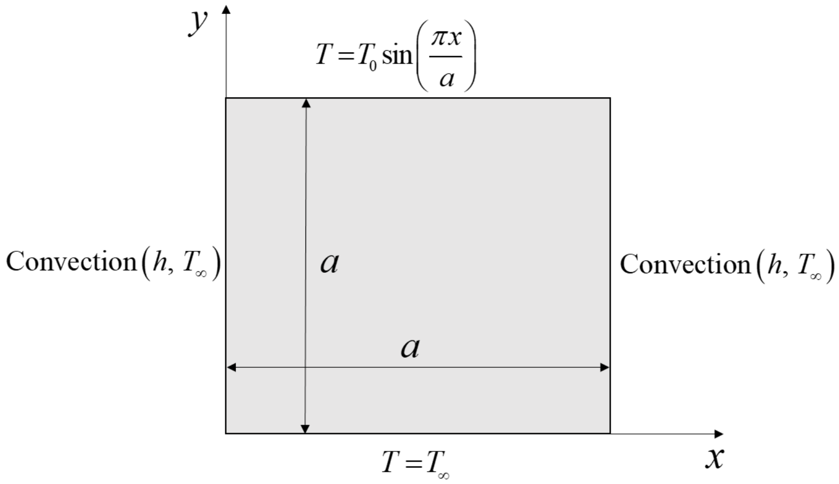

Fig. 2B

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

3A. What are the steps involved in the method of partial solutions? When can we use this method?

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3B. Obtain the fully developed velocity profile for laminar flow through elliptic cross section tube.

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3C. The fully developed velocity and temperature profiles for a circular tube of radius R with constant heat flux condition are as follows;

$$u(r) = 2V\left(1 - \left(\frac{r}{R}\right)^2\right), \qquad T(r) = T_s + \frac{2V}{\alpha}\left(\frac{dT_m}{dx}\right)\left(\frac{r^2}{4} - \frac{r^4}{16R^2} - \frac{3R^2}{16}\right)$$

Obtain the expression for mixed mean temperature. **4**

4A. Oil of viscosity $60\,\text{mPa.s}$ and $844\,\text{kg/m}^3$ enters a copper tube of $10\,\text{mm}$ diameter and $1\,\text{m}$ length at 50°C and leave at 40°C. The entire tube is immersed in large quantity of ice cold water. If the mass flow rate of the oil is $0.004\,\text{kg/s}$, calculate;

i. Hydrodynamic and thermal entry length
ii. Average Nusselt number at exit
iii. Surface heat flux at $x = 0.5\,\text{m}$, assuming $T_s = 0^\circ\text{C}$

Take $C_p = 20\,\text{kJ/kgK}$ and $\alpha = 8\times10^{-8}\,\text{m}^2/\text{s}$

Refer following table for the Nusselt numbers in the thermal entry length region.

$x^* = \frac{x}{R\,\text{Pe}}$	0	0.001	0.004	0.01	0.04	0.08	0.1	0.2
$Nu(x^*)$	∞	12.8	8.03	6.0	4.17	3.77	3.71	3.66

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4B. A double tube counter flow heat exchanger annulus region has $r_i = 30\,\text{mm}$ and $r_o = 50\,\text{mm}$. Determine the Nusselt number at the inner and outer tube surface, for $q_{si} = 2000\,\text{W/m}^2$ and $q_{so} = 1000\,\text{W/m}^2$. For what heat flux ratio, outer surface temperature matches mean temperature?

$r^* = \dfrac{r_i}{r_o}$	Nu_{ii}	Nu_{00}	ζ_i	ζ_0
0.6	5.912	5.099	0.473	0.2455

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4C. Write the governing equations for 2D turbulent boundary layer flow and heat transfer. **2**

5A. Explain the crossed-strings method of determining view factors between two infinitely long surfaces.

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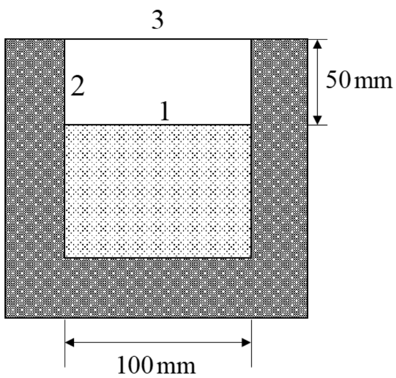
5B. What is the function of radiation shield? Prove that, when all emissivities are equal, radiation heat transfer rate is reduced by $(N+1)$ times by providing N number of radiation shields.

4

5C. A graphite block has a cylindrical cavity $100\,\text{mm}$ in diameter and serves as a crucible for laboratory experiments. The cavity is filled with melt at $600\,\text{K}$ up to $50\,\text{mm}$ below the opening. The surrounding temperature is $300\,\text{K}$ and the average temperature of the un-wet surface is $500\,\text{K}$. Estimate the rate of heat loss from the melt by radiation.



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