B. MECHANICAL 2ND YEAR 1ST SEMESTER SUPPLE EXAMINATION, 2017

SUBJECT: HEAT TRANSFER

Time: Three hours | Full Marks: 100

Answer any *five* questions
All questions carry equal marks

1.	a) The inside and outside surfaces of a hollow cylinder $(r_i \le r \le r_0)$, at $r = r_i$ and $r = r_0$ are maintained at uniform temperature T_1 and T_2, respectively. The thermal conductivity of the cylinder material is a constant. Derive the governing equation for conducting heat in the hollow cylinder in the radial direction under steady state condition. Solve for the temperature distribution in the cylinder wall and develop an expression of total heat flow rate through the cylinder per unit length. Write also a relation for the conductive resistance of heat flow in the above case.	12
	(b) Derive an expression of critical radius of insulation of a sphere of radius r_i. Thermal conductivity of insulating material is k and heat transfer coefficient between the outer surface and ambient is h. Plot the conductive and convective resistance and total resistance as a function of insulation radius.	8
2.	Consider a longitudinal fin subject to an insulated boundary condition at the tip and a constant base temperature. The heat is dissipated from the fin surface to the surrounding fluid due to convection only. If the heat conduction in the fin takes only in the length direction, derive the energy equation of the fin. Solve for the temperature variation along the length of the fin and determine the heat transfer rate and fin effectiveness. Assume suitable notations for thermophysical and geometrical parameters.	20
3.	a) A tiny solid body of thermal conductivity k, density ρ, and specific heat cp is initially at a temperature Ti. The body is suddenly immersed in a large pool of liquid at temperature T_∞ (T_∞ <Ti) and convective heat transfer coefficient h. Considering a 'lumped approach', estimate the temperature of the body as a function of time. Explain the role of Biot Number in the 'lumped approach'.	12
	b) The two ends of a slab are at Temperature T_1 and T_2, respectively. The slab generates volumetric heat at a uniform rate q_g W/m^3. The thermal conductivity of the slab is constant. Under steady state and one-dimensional heat flow, determine the temperature distribution in the slab.	8
4.	Two infinite parallel plates are separated with a very small distance H. An incompressible and Newtonian fluid having viscosity μ, specific heat c_p, and thermal conductivity k is filled up in between two plates. The upper plate is moving with a uniform velocity U whereas the lower plate is stationary. Under steady state, the lower and upper plates are maintained at constant temperature T_0 and T_1, respectively. Determine the maximum	20

	temperature in the fluid between the plates.	
5.	(a) Derive the LMTD for the parallel flow heat exchanger for a known design parameter. Why the heat exchange rate in the counter flow heat exchanger is higher than that in other flow heat exchanger?	12
	(b) What is LMTD correction factor? When is it required to be determined?	4
	(c) Define effectiveness of a heat exchanger. When is the NTU method used in connection with heat exchanger calculations?	4
6.	(a) Write the boundary layer equations for Newtonian fluid flow due to buoyancy effect. Write the physical significance of Grashof number.	5
	(b) Write a parameter which indicates the nature of convection (free or forced). How this parameter can be derived?	10
	(c) Using scale analysis, derive the boundary layer thickness as a function of Reynolds number for the flow of a very low Prandtl number fluid over a flat plate under forced convection situation.	5
7.	(a) Derive the radiation view factor between two infinitesimally small surfaces. What is view factor algebra? What is surface resistance for radiation heat transfer?	10
	(b) How radiation heat exchange between two surfaces can be reduced? Establish it mathematically.	6
	(c) Using electrical analogy, draw a net sketch of thermal resistances for the radiation heat exchange in a three zone enclosure.	4