B.E. MECHANICAL ENGINEERING SECOND YEAR SECOND SEMESTER (Old) – 2017

Subject: HEAT TRANSFER

Time: Three hours **Full Marks: 100**

Answer any five questions
All questions carry equal marks

1 (a)	What is the physical mechanism for the convection mode of heat transfer? Why thermal conductivity of gases always increases with the temperature?	8
(b)	Determine heat transfer rate through a solid cylinder of radius R and length L subject to maintain a constant temperature T_0 at the outer lateral surface for constant thermal conductivity of solid k, constant heat transfer coefficient h, constant volumetric heat generation q_g, and one-dimensional steady state heat flow. Also draw the temperature distribution as a function of radial coordinate.	12
2 (a)	When the lump system of analysis is possible?	3
(b)	When the knowledge of critical thickness of insulation is essential? Write the steps to determine the critical radius of insulation for a cylindrical body. For an analytical establishment, what assumptions are to be required?	10
(c)	When fins are attached to a primary surface for the enhancement of heat transfer? Define fin efficiency and fin effectiveness.	7
3	Consider a hollow sphere under the convection boundary condition at both the inner and outer surfaces. The temperature and the convective heat transfer coefficient at the inner and outer convective environments are (T_1, h_1) and (T_1, h_1), respectively. It is assumed that the heat conduction in the solid is in the redial direction only. There is no heat generation within the solid. Under steady state, determine the heat transfer rate through this hollow sphere for a linear variation of the thermal conductivity with the temperature, $k = k_0(1+\alpha T)$, where T is the local temperature of the sphere. For the aforementioned problem, select suitable notations of the geometric parameters of the object.	20
4 (a)	Write the energy equation in Cartesian coordinates for a differential movable control volume in the flow field. Also write the physical significance of different terms of this equation.	8
(b)	Derive the energy integral equation for the fluid of $Pr << 1$ for the flow over a flat plate subject to laminar flow and forced convection.	12
5.	Two infinite parallel plates are separated with a very small distance H. An incompressible fluid having viscosity μ, specific heat cp, and thermal conductivity k, is filled up in between two plates. The upper plate is moving with a uniform velocity U whereas the lower one is stationary. Under steady state, the upper plate is maintained at a constant temperature T_h and the lower plate temperature is at T_0. Determine the maximum	20

	temperature in the fluid between the two plates.	
6 (a)	Why counter flow heat exchangers are mostly found in practical applications? What is NTU? When NTU is adopted for the design of a heat exchanger?	8
(b)	Derive the effectiveness of heat exchangers for a counter flow heat exchanger as given below: $$\varepsilon = \frac{1-\exp[-N(1-C)]}{1-C\exp[-N(1-C)]}$$ where, $N \equiv NTU = U_m A/C_{\min}$ and $C = C_{\min}/C_{\max}$	12
7 (a)	Write the boundary layer equations. Write the physical significance of Eckert number.	6
(b)	Write a parameter which indicates the nature of convection (free or forced).	4
(c)	Using scale analysis, derive the skin friction or drug coefficient as a function of Reynolds number in an order-of-magnitude sense for the flow over a flat plate under forced convection.	10
8 (a)	Write the physical significance of the radiation view factor between two surfaces. Write three properties of the view factor. What is surface resistance to radiation heat transfer?	8
(b)	Derive the radiation energy emitted by a black body at an absolute temperature T in all directions. Also write the above fact for the real surface.	12