Ref. No.: Ex/ME(M2)/PC/B/T/214/2023

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION, 2023

HEAT TRANSFER

Time: Three hours **Full Marks 100**

	All parts of the same question must be answered together. Assume any unfurnished data suitably	
	Group I	
	Answer any ten questions	
1 (a)	Define overall heat transfer coefficient?	
(b)	What is critical thickness of insulation? Explain its significance?	
(c)	Distinguish between fin effectiveness and fin efficiency?	
(d)	How is the thermal boundary layer thickness defined for flow over a flat plate?	
(e)	Illustrate the thermal and hydrodynamic boundary layer in a low Prandtl number fluid flow over a flat plate.	
(f)	Explain the physical significance of Grashof number.	
(g)	Define bulk mean temperature? Explain its significance?	
(h)	What is monochromatic hemispherical emissivity?	
(i)	What is view factor? Explain its significance?	
(j)	What is emissive power of a black body?	
(k)	What is fouling factor in heat exchangers?	
(l)	Define log mean temperature difference (LMTD)? Explain its significance?	10 x 2 = 20
	Group II	
	Answer any four questions	
2 (a)	Derive the one-dimensional heat conduction equation of an isotropic stationary solid in cylindrical coordinates. Derive the expression for critical radius of insulation for cylinder.	10
(b)	Consider steady state 1-D heat flow in a plate of 20 mm thickness with a uniform heat generation of 80 MW/m^3. The left and right faces are kept at constant temperature of 160 °C and 120 °C respectively. The plate has constant thermal	10

[Turn over

Ref. No.: Ex/ME(M2)/PC/B/T/214/2023

	conductivity with k= 200 W/mK. Find the location of maximum temperature within the plate from its left face. Determine the maximum temperature within the plate.	
3.(a)	What is Biot number? Explain its physical significance.	5
(b)	Write the condition for the lumped system analysis. Determine the steady-state temperature in a slab of thickness L, initially at a uniform temperature of T_0. For time t>0, heat is supplied to the slab from one of its boundary surfaces at a constant rate of g w/m^2, while heat is dissipated by convection from the other boundary surface into a medium at uniform temperature T_a with a heat transfer coefficient h. Assume a lumped system model based on the Fourier's law of heat conduction. Also, calculate the heat transfer rate through the constant cross-sectional area of A.	15
4. (a)	Consider steady, laminar boundary type flow of a high Prandtl number (Pr >>1) fluid over a flat plate of length L. The free stream velocity and temperature are U_∞ and T_∞ respectively. The plate is maintained at a uniform temperature of T_w. Show the following by the method of scale analysis: $$\frac{\delta}{L} \sim Re_L^{-1/2}$$ $$\frac{\delta_T}{L} \sim Re_L^{-1/2}\, Pr^{-1/3}$$ $$Nu_L \sim Re_L^{1/2}\, Pr^{1/3}$$	15
(b)	Describe the thermally fully developed condition for internal flows.	5
5. (a)	Define spectral intensity of blackbody and spectral emissive power of a black body. Derive the relation between them.	10
(b)	Define transmissivity, absorptivity and reflectivity and state how they are related.	5
(c)	Derive the shape factor of two elemental surfaces. What is reciprocity relation in this connection?	5
6.(a)	Define effectiveness and NTU for a heat exchanger. When is effectiveness-*NTU* method preferred for calculation of a heat exchanger?	5

Ref. No.: Ex/ME(M2)/PC/B/T/214/2023

(b)	Derive the expression for LMTD of a parallel flow heat exchanger.	10
(c)	Write down the governing equations for natural convection over a vertical flat plate if the plate temperature is greater than the surrounding fluid temperature.	5
7.(a)	What is radiosity? Define surface and space resistances for heat exchange due to radiation.	5
(b)	Show that the net radiant heat transfer between two infinitely large parallel plates at T_1 and T_2 temperature respectively, separated by n shield is $$Q_{1-2} = \frac{1}{n+1}\frac{\sigma A\,(T_1^4 - T_2^4)}{2/_{\epsilon} - 1}$$	15