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

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY 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 (Answer any 5 questions)	
1 (a)	Determine heat transfer rate through a solid cylinder of radius R and length L subject to maintain a constant temperature T_o at the outer lateral surface for constant thermal conductivity of solid k, constant heat transfer coefficient h, constant volumetric heat generation $q^{\cdot}_g$ and one-dimensional steady state heat transfer. Also draw the temperature distribution as a function of radial coordinate.	20
2 (a)	Derive an expression for the temperature distribution and rate of heat transfer from a fin of uniform cross section with insulated tip.	10
(b)	A 4-mm-diameter and 10-cm-long aluminum fin (k = 237 W/m·K) is attached to a surface. If the heat transfer coefficient is 12 W/m²·K, determine the percent error in the rate of heat transfer from the fin when the infinitely long fin assumption is used instead of the adiabatic fin tip assumption.	10
3.(a)	Derive an expression for instantaneous temperature and heat transfer rate for a body subjected to heating or cooling in terms of Biot and Fourier number.	10
(b)	The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as a 1.2-mm-diameter sphere. The properties of the junction are k = 35 W/m·K, ρ = 8500 kg/m³, and cp = 320 J/kg·K, and the heat transfer coefficient between the junction and the gas is h = 90 W/m²·K. Determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference.	10

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4. (a)	Consider the flow of mercury (a liquid metal) in a tube. How will the hydrodynamic and thermal entry lengths compare if the flow is laminar?	5
(b)	Consider steady, laminar boundary type flow of a low Prandtl number (Pr <<1) fluid over a flat plate. 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: $$\frac{\delta}{L} \sim Re_L^{-1/2}$$ $$\frac{\delta_T}{L} \sim Re_L^{-1/2}\, Pr^{-1/2}$$ $$Nu_L \sim Re_L^{1/2}\, Pr^{1/2}$$	15
5. (a)	Define the following: i) Black body and Opaque body ii) Stefan Boltzman Law iii) Wein's displacement law iv) Plank's Law	8
(b)	Calculate the net radiant heat exchange per unit area for two parallel plates at temperatures of 427°C and 27°C respectively. ε (hot plate) is 0.9 and ε (cold plate) is 0.6. A polished aluminum shield is placed between them, find the percentage reduction in heat transfer. ε (Shield) is 0.4	12
6.(a)	Derive the expression for LMTD of a parallel heat exchanger.	10
(b)	In a counter flow double pipe heat exchanger, water is heated from 25°C to 65°C by oil with specific heat of 1.45 kJ/kg K and mass flow rate of 0.9 kg/s. The oil is cooled from 230°C to 160°C. If overall Heat transfer coefficient is 420 W/m^2 °C. Calculate following: a) The rate of heat transfer b) The mass flow rate of water, and c) The surface area of heat exchanger.	10
7.(a)	Explain the concept of black body and gray body.	6
(b)	Derive an expression for critical thickness of insulation for a cylinder. Discuss the design aspects for providing insulation scheme for cable wires and steam pipes.	14