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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

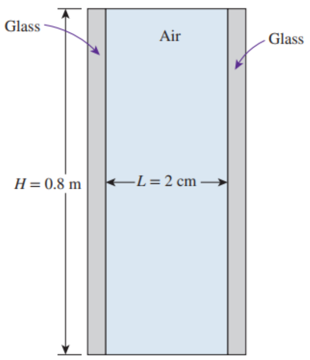
January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 16ME5DCFHT **Max Marks: 100**
Course: Fundamentals of Heat Transfer

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of Heat and mass Transfer Data book is permitted.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Derive the general 3-D heat conduction equation in Cartesian co-ordinate system and hence obtain Laplace and Poisson equation.	*CO1*	*PO1*	**08**
	b)	i) State the Fourier's law of heat conduction ii) Define 'Thermal Resistance' term.	*CO1*	*PO1*	**04**
	c)	The wall of a furnace is made up of inside layer of silica brick 120 mm thick covered with a layer of magnetite brick 240 mm thick. The temperature at the inside of the silica brick wall and the outside surface of magnetite brick wall are 725°C and 110°C respectively. The contact thermal resistance between the two walls at the interface is 0.0035°C/W per unit wall area. If the thermal conductivities of the silica and magnetite bricks are 1.7 W/m°C and 5.8 W/m°C, calculate: i) the rate of heat loss per unit area of walls, and ii) the temperature drop at the surface.	*CO1*	*PO2*	**08**
		OR			
2	a)	Define, 'Critical Radius' and derive the equation for critical thickness of insulation for a sphere.	*CO1*	*PO2*	**08**
	b)	Define Biot Number and mention its significance.	*CO1*	*PO2*	**02**
	c)	Two long rods of the same diameter, one made of brass (k = 85 W/m°C) and the other made of copper (k = 375 W/m°C) have one of their ends inserted into a furnace. Both the rods are exposed to same environment. At a distance of 105 mm away from the furnace, the temperature of brass rod is 120°C. At what distance from the furnace, the same temperature would be reached in the copper rod?	*CO1*	*PO2*	**10**
		UNIT - II			
3	a)	Explain the concept of velocity and thermal boundary layers over a flat plate.	*CO2*	*PO2*	**08**

		b)	Describe the significance of the Nusselt number, Reynolds number and Prandtl number.	*CO2*	*PO2*	**06**
		c)	Engine oil at 60°C flows over the upper surface of a 5 m long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate.	*CO2*	*PO2*	**06**
			OR			
	4	a)	Using dimensional analysis, derive an expression relating Nusselt number, Prandtl number and Grasshoff numbers for natural convection.	*CO2*	*PO2*	**10**
		b)	The vertical 0.8 m high, 2 m wide double-pane window shown in Fig. 1 consists of two sheets of glass separated by a 2 cm air gap at atmospheric pressure. If the glass surface temperatures across the air gap are measured to be 12°C and 2°C, determine the rate of heat transfer through the window.  Fig. 1	*CO2*	*PO2*	**10**
			UNIT - III			
	5	a)	With a neat sketch, explain the development of entrance and fully developed flow for both hydrodynamic and thermal gradients.	*CO3*	*PO1*	**10**
		b)	A surface condenser consists of 200 thin-walled circular tubes (each tube is 22.5 mm in diameter and 5 m long) arranged in parallel, through which water flows. If the mass flow rate of water through the tube bank is 160 kg/s and its inlet and outlet temperatures are to be 21°C and 29°C respectively, calculate the average heat transfer coefficient associated with the water.	*CO3*	*PO1*	**10**
			OR			
	6	a)	Compare the heat transfer coefficients under the following cases assuming that there is no change in the temperatures of the liquid and the tube wall and the flow through the tube is turbulent in character. Case 1: A two-fold increase in the diameter of the tube; the flow velocity if maintained constant by a change in the rate of liquid flow Case 2: Two-fold increase in the flow velocity, by varying the mass flow. Consider the standard general correlations.	*CO3*	*PO1*	**10**
		b)	hot air at atmospheric pressure and 80°C enters an 8 m long un-insulated square duct of cross section 0.2 m x 0.2 m and negligible thickness. The duct air passes through the attic of a house at a rate of 0.15 m^3/s. the duct surface is isothermal at 60°C. Determine the exit temperature of the air and the rate of heat loss from the duct to the attic space. assume fully-developed flow in the duct throughout.	*CO3*	*PO1*	**10**

			UNIT - IV			
	7	a)	Define the followings: i) Emissivity, ii) Kirchhoff's law, iii) Plank's law, iv) Wein's displacement law, and v) Stefan Boltzmann law.	*CO3*	*PO1*	**10**
		b)	Two large parallel plates with ε = 0.5 each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage of reduction in net radiation heat transfer.	*CO3*	*PO2*	**10**
			OR			
	8	a)	Prove that the emissive power of a black body in a hemispherical enclosure is 'π'times the intensity of radiation.	*CO4*	*PO2*	**10**
		b)	The radiation shape factor of a circular surface of a thin hallow cylinder of 10 cm diameter and 10 cm length is 0.1716. What is the shape factor of the curved surface of a cylinder with respect to itself?	*CO4*	*PO2*	**10**
			UNIT - V			
	9	a)	Derive an expression for 'Logarithmic Mean Temperature Difference (LMTD)' of a parallel flow heat exchanger.	*CO5*	*PO2*	**10**
		b)	A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m² K, determine the length of the heat exchanger required to achieve the desired heating. Take the specific heats of water and geothermal fluid to be 4.18 and 4.31 kJ/kg K, respectively.	*CO5*	*PO1*	**10**
			OR			
	10	a)	Derive an expression for LMTD for counter flow heat exchanger and state the assumptions made.	*CO5*	*PO1*	**10**
		b)	A counter flow heat exchanger is employed to cool 0.55 kg/s (C_p=2.45 kJ/kg°C) of oil from 115°C to 40°C by the use of water (C_p=4.186 kJ/kg°C). The inlet and outlet temperature of cooling water are 15°C and 75°C respectively. The overall heat transfer coefficient is expected to be 1450 W/m²°C. Using NTU method, calculate the following: i) The mass flow rate of water, ii) The effectiveness of the heat exchanger, and iii) The surface area required.	*CO5*	*PO2*	**10**

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