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

Autonomous Institute Affiliated to VTU

October 2024 Supplementary Examinations

Programme: B.E. **Semester: IV**

Branch: Aerospace Engineering **Duration: 3 hrs.**

Course Code: 23AS4PCHMT **Max Marks: 100**

Course: Heat & Mass 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 transfer data handbook is permitted to use.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Write the boundary conditions of first, second and third kind with suitable sketches.	*CO1*	*PO1*	**6**
	b)	A plane wall of a refrigerated van is made of 1.5 mm steel sheet (K_s = 25 W/mK at the outer surface, 10 mm plywood (K_p =0.05 W/mK) at the inner surface and 20 mm glass wool (K_g =0.01 W/mK) in between the outer and inner surfaces. The temperature of the cold environment inside the van is -15°C, while the outside surface is exposed to a surrounding ambient at 24°C. The average values of convective heat transfer coefficients at the inner and outer surfaces of the wall are 12 W/m^{2}K and 20 W/m^{2}K respectively. The surface area of the wall is 0.75 m^2. Determine i) the individual components of the thermal resistance to heat flow ii) the rate of heat flow through the wall iii) the temperature at the interfaces and outer walls. Write the composite wall and electric circuit.	*CO2*	*PO3*	**10**
	c)	What do you mean by thermal contact resistance?	*CO1*	*PO1*	**4**
		OR			
2	a)	Derive an expression for critical radius of insulation for sphere. Draw the heat transfer and resistance variation with radius.	*CO1*	*PO2*	**7**
	b)	Derive an expression for 3D heat conduction equation in Cartesian co-ordinates. Also write the heat conduction equation in terms of Laplace equation and Poissons equation.	*CO1*	*PO2*	**8**
	c)	To measure the effective thermal conductivity of an opaque honeycomb material for an aircraft wall. A spherical shell of inner radius 26 cm and outer radius 34 cm was constructed and a 100 W electric light bulb placed in the center. At steady state, the temperatures of the inner and outer surfaces were measured to be 339 and 311 K respectively. What is the effective conductivity of the material?	*CO3*	*PO2*	**5**

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 - II			
	3	a)	Derive an expression for temperature distribution for a lumped system analysis.	*CO2*	*PO1*	**7**
		b)	Write a short note on Biot number & Fourier number.	*CO1*	*PO1*	**5**
		c)	A large aluminium plate of thickness 200 mm originally at a temperature of 530°C is suddenly exposed to an environment at 30°C. The convective heat transfer coefficient between the plate and the environment is 500 W/(m^2 K). Determine the temperature at a depth of 20 mm from one of the faces 225 seconds after the plate is exposed to the environment. Also calculate how much energy has been lost per unit area of the plate during this time? Take for aluminium, $a = 8 \times 10^{-5}$ m^2/s and k = 200 W/(m K).	*CO2*	*PO3*	**8**
			UNIT - III			
	4	a)	Explain the development of boundary layer over a flat plate with different zones.	*CO1*	*PO1*	**6**
		b)	Explain the significance of Prandtl number and Grassoff's number.	*CO1*	*PO1*	**4**
		c)	Nuclear reactor is constructed of parallel vertical plate 2.2 m high and 1.4 m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of plate surface is limited to 900°C. While minimum temperature is 300°C. Calculate maximum temperature distribution on both sides of plate.	*CO3*	*PO2*	**10**
			OR			
	5	a)	Using Buckingham's theorem, obtain the relationship between various non-dimensional numbers for free convection heat transfer.	*CO3*	*PO2*	**10**
		b)	Air at atmospheric pressure and 200°C flows over a plate and maintained at 120°C. The velocity is 5m/s. The plate is 15mm wide. Calculate the thickness of hydro and thermal boundary layer and local heat transfer coefficient at distance 0.5m from leading edge.	*CO2*	*PO3*	**10**
			UNIT - IV			
	6	a)	What is shape factor? Write the properties of shape factors.	*CO1*	*PO1*	**6**
		b)	Hot coffee at 70°C is contained in a cylindrical vacuum bottle with a height of 25 cm. The coffee container consists of an inner bottle centered within an outer casing that is at 2°C. The space between the inner bottle and the casing is evacuated, and the walls are coated with aluminium to minimize radiative heat loss. There is negligible heat transfer at the ends of the container. In a new	*CO3*	*PO2*	**7**

			vacuum bottle, the emissivity of all surfaces is 0.05, but in an older container, the finish becomes dull and the emissivity rises to 0.25. Calculate the rate heat loss from the coffee for both a new and an old vacuum bottle. Comment on the output results.			
		c)	Calculate the net radiation heat exchange per meter square area for 2 large parallel planes at the temperature 427°C and 27°C. Take emissivity for hot and cold plates as 0.9 and 0.6 respectively. If a polished aluminium sheet is placed with emissivity 0.04. Find the percentage reduction in heat transfer.	*CO2*	*PO1*	**7**
			UNIT - V			
	7	a)	A cross-flow heat exchanger with both fluids unmixed is used to heat water [Cp = 4.18 kJ/(kg K)] from 50°C to 90°C, flowing at the rate of 1.0 kg/s. Determine the overall heat transfer coefficient if the hot engine oil [cp = 1.9 kJ/(kg K)] flowing at the rate of 3 kg/s enters at 100°C. The heat transfer area is 20 m^2.	*CO3*	*PO2*	**8**
		b)	Explain the pool boiling curve with a neat sketch and highlighting the different regimes.	*CO1*	*PO1*	**7**
		c)	A vertical tube of 60 mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 30°C by circulating cold water through the tube. Calculate the following i) the rate of heat transfer to the coolant ii) the rate of condensation of steam	*CO4*	*PO3*	**5**

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