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

Autonomous Institute Affiliated to VTU

February 2025 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 23AS4PCHMT / 22AS4PCHMT **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.

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 an 3D heat conduction equation in cartesian co-ordinates. Obtain Laplace, Poisson and Diffusion equations from the 3-D plane wall equation.	*CO1*	*PO 2*	**10**
	b)	A steel rod (k = 30 W/m°C), 10mm in diameter and 50mm long, with an insulated end, is to be used as a spine. It is exposed to surroundings with a temperature of 65°C and a heat transfer coefficient of 50 W/m^2°C. The temperature of the base of the fin is 98°C. Determine: (i) The fin efficiency, (ii) The temperature at the edge of the spine, and (iii) The heat dissipation.	*CO2*	*PO3*	**10**
		OR			
2	a)	Calculate the critical radius of insulation for asbestos [k = 0.17 W/m°C] surrounding a pipe and exposed to room air at 20°C with h=3.0 W/m^2°C. Calculate the heat loss from 200°C, 5cm diameter pipe when covered with the critical radius of insulation and without insulation.	*CO3*	*PO2*	**10**
	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**

			UNIT - II			
	3	a)	Give the physical significance of: (i) Fourier number and (ii) Biot number	*CO1*	*PO1*	**5**
		b)	A ball of 60mm diameter at 600^oC is suddenly immersed in controlled medium at 100^oC. Calculate the time required for the ball to obtain a temperature of 150^oC. Assume: ρ =800 kg/m^3, C_p=500 J/kg-K, k = 40 W/m- K and h = 20 W/m^2 K for the ball.	*CO2*	*PO3*	**5**
		c)	A long aluminum cylinder 5.0 cm in diameter and initially at 200°C is suddenly exposed to a convection environment at 70°C and *h*=525 W/m^2 °C. Calculate the temperature at a radius of 1.25 cm and the heat lost per unit length 1 min after the cylinder is exposed to the environment.	*CO2*	*PO2*	**10**
			OR			
	4	a)	A 5 cm thick iron plate [K = 60 W/ (m°C), Cp = 460 J/kg °C), ρ = 7850 kg/m^3 and α = 1.6 x 10-5 m2/s] is initially at T_i = 225°C. Suddenly, both surfaces are exposed to an ambient at T_∞ = 25°C with a heat transfer co-efficient h = 500 W/m^2°C). Calculate the center temperature at t = 2 min after the start of the cooling. Calculate the temp at the depth 1.0 cm from the surface at t = 2 min after the start of the cooling. Calculate the energy removed from the plate per square meter during this time.	*CO2*	*PO3*	**10**
		b)	Derive an expression for temperature distribution for a lumped system analysis. List out the various assumption made.	*CO2*	*PO3*	**10**
			UNIT III			
	5	a)	Air at 27°C and 1 atm flows over a flat plate at a speed of 2 m/s. Calculate the boundary layer thickness of 20cm and 40cm from the leading edge of the plate. The viscosity of air is at 27°C is $1.85x10^{-5}$ kg/m.s. Assume unit depth in the z-direction.	*CO3*	*PO2*	**10**
		b)	Assuming a man represented as a cylinder of 30 cm diameter and length 1.7m. surface temperature of 37°C. Calculate the heat he would lose at temperature of 20°C.	*CO3*	*PO2*	**10**
			OR			
	6	a)	Explain the velocity boundary layer and thermal boundary layer over a flat plate.	*CO1*	*PO1*	**10**
		b)	A vertical flat plate 4m high is maintained at a constant temperature of 60°C and exposed to atmospheric air at 10°C. Calculate the free convection heat lost by the plate if the plate is 10m wide.	*CO3*	*PO2*	**10**
			UNIT - IV			
	7	a)	Explain the following i) Radiosity ii) Shape factor	*CO1*	*PO1*	**6**
		b)	It is desired to calculate the net radiation heat exchange between			**6**

			the floor of a furnace 4m x 2m and a side wall 3m x 2m. The emissivity of the floor material is 0.63 and that of the side wall material is 0.2. If the temperature of the floor and side wall are 600°C and 400°C. Calculate the net heat exchange between them.			
		c)	Two very large parallel planes with emissivity 0.3 and 0.8 exchange heat. Find the percentage reduction in heat transfer when a polished-aluminum radiation shield （ε =0. 04） is placed between them.	*CO3*	*PO2*	**8**
			OR			
	8	a)	Two parallel plates, 4 m^2 area each are placed with a gap of 5 mm separating them. One plate has a temperature of 800 K, emissivity 0.6, while other plate has a temperature of 300 K, emissivity 0.9. Find the net energy exchanged between them suppose if polished sheet of emissivity 0.1 on both side is centrally placed between the plates, what will be the temperature of the sheet? How much would the heat transfer be altered?	*CO3*	*PO2*	**10**
		b)	Explain the following: (use necessary sketch) i) Total emissive power ii) Radiosity iii) Black body iv) Kirchoff's law	*CO1*	*PO1*	**10**
			UNIT - V			
	9	a)	A counter flow double pipe heat exchanger is used to heat 0.7 kg/s of water from 35 to 90° C with an oil flow rate of 0.95 kg/s. The oil has a specific heat of 2100 J/kg°C and enters the heat exchangers at a temperature of 175°C. The overall heat transfer coefficient is 425 W/m^2 °C. Calculate the area of heat exchanger and analyze the flow for parallel flow heat exchanger for the same values.	*CO3*	*PO2*	**8**
		b)	Explain the pool boiling curve for water.	*CO1*	*PO1*	**8**
		c)	Differentiate between boiling and condensation	*CO1*	*PO1*	**4**
			OR			
	10	a)	Differentiate between film wise and drop wise condensation.	*CO1*	*PO1*	**6**
		b)	Saturated steam at 65°C condenses on a vertical tube with an outer diameter of 25mm, which is maintained at 35°C. Determine the length of tube needed, if the condensate flow needed is 6 x 10^{-3} kg/s.			**6**
		c)	In a food processing plant, a brine solution is heated from 8°C to 14°C in a double-pipe heat exchanger by water entering at 55°C and leaving at 40°C at the rate of 0.18 kg/s. If the overall heat transfer coefficient is 800 W/(m^2 K), determine the area of heat exchanger required (i) for a parallel flow arrangement, and (ii) for a counter flow arrangement. Take cp for water = 4.18 kJ/(kg K).	*CO3*	*PO2*	**8**

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