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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: VI**
Branch: Mechanical Engineering — **Duration: 3 hrs.**
Course Code: 22ME6PCHTR / 20ME6DCFHT — **Max Marks: 100**
Course: Heat Transfer / 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. The Heat Mass Transfer Date hand book and steam tables are 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.

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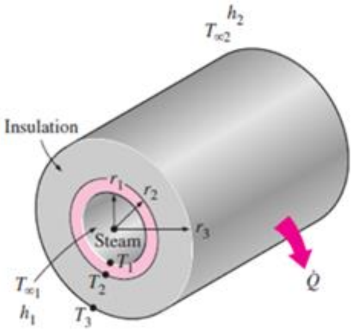
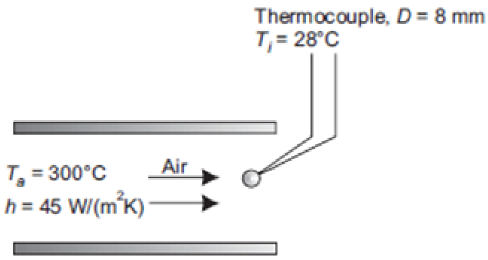
		UNIT - I	*CO*	*PO*	Marks
1	a)	Explain three principle differences between thermodynamics and heat transfer	*CO1*	*PO1*	**03**
	b)	Obtain a general solution for the temperature distribution inside the spherical shell under steady state and 1D conditions.	*CO2*	*PO1*	**07**
	c)	Steam at T_1 = 320°C flows in a cast iron pipe (k = 80 W/m °C) whose inner and outer diameters are D_1 = 5 cm and D_2 = 5.5 cm, respectively, as shown in Fig. 1. The pipe is covered with 3-cm-thick glass wool insulation with k = 0.05 W/m · °C. Heat is lost to the surroundings at T_2 = 5°C by natural convection and radiation, with a combined heat transfer coefficient of h_2 = 18 W/m^2 · °C. Taking the heat transfer coefficient inside the pipe to be h_1 = 60 W/m^2 °C, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation. From critical thickness context write your comment on its insulation thickness.	*CO2*	*PO2*	**10**
		OR			
2	a)	What is 'Lumped system analyses'? Write the temperature distribution equation and deduce it in terms of Biot and Fourier number.	*CO3*	*PO1*	**05**

		b)	A steel ball of 5 cm diameter initially at a uniform temperature of 450°C is suddenly placed in an environment at 100°C as shown in Fig.1. Heat transfer coefficient h, between the steel ball and the fluid is 10 W/(m^{2}K). For steel, c_p = 0.46 kJ/ kg K, ρ = 7800 kg/m^3, k = 35 W/(m K). Calculate the time required for the ball to reach a temperature of 150°C. Also, find the rate of cooling after 1 hr.  Fig.1  Fig.1	CO3	PO2	**10**
		c)	A 2-kW resistance heater wire whose thermal conductivity is k = 15 W/m °C has a diameter of D = 4 mm and a length of L = 0.5 m, is used to boil water. If the outer surface temperature of the resistance wire is Ts = 105°C, determine the temperature at the centre of the wire.	CO3	PO2	**05**
			UNIT - II			
	3	a)	Explain briefly the concept of velocity and thermal boundary layer for the flow over the flat plate using appropriate relations.	CO4	PO1	**04**
		b)	Derive the Blasius solution for boundary layer thickness 'δ' as a function of Re_x and x for the laminar flow over a flat plate. Consider the governing momentum equation is, $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \vartheta\frac{\partial^2 u}{\partial y^2}$	CO4	PO1	**10**
		c)	Air at 30°C flows over a flat plate, 0.4 m wide and 0.75 m long with a velocity of 20 m/s. Determine the heat flow rate from the surface of the plate assuming that the flow is parallel to the 0.75 m side. Plate is maintained at 90°C. Take average properties of air at 60°C: ρ = 1.06 kg/m^3, Cp = 1.008 kJ/kgK, α = 18.97×10^{-6} m^2/s, Pr = 0.708, k = 0.0285 W/mK	CO4	PO2	**06**
			OR			

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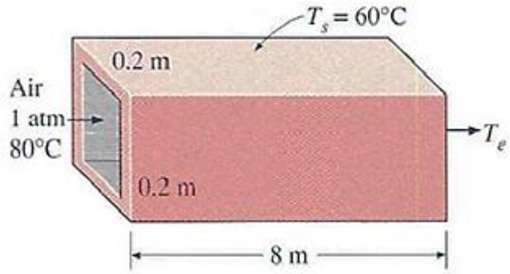
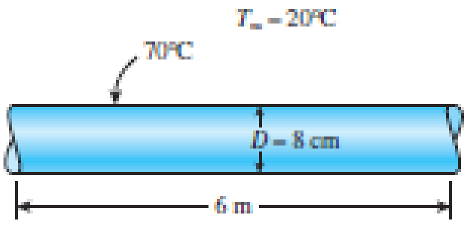
	4	a)	Draw the velocity and temperature curves for the fully developed flow inside the tube.	*CO4*	*PO1*	**03**
		b)	For a fully developed flow, derive the velocity distribution equation and obtain the mean and maximum velocity relations.	*CO4*	*PO1*	**07**
		c)	Hot air at atmospheric pressure and 80 °C enters an 8 m long uninsulated square duct of cross section 0.2 m x 0.2 m that passes through the attic of a house at a rate of 0.15 m^3/s (Fig. 2). The duct is observed to be nearly isothermal at 60°C. Determine the exit temperature of the air and the rate of heat loss from the duct to the attic space.  Fig. 2	*CO4*	*PO2*	**10**
			UNIT - III			
	5	a)	Write the momentum and energy equations for the laminar free convection flow over vertical plate. Draw the temperature and velocity profiles and discuss the characteristics.	*CO4*	*PO1*	**06**
		b)	What is Grashoff number? With its expression and discuss the significance.	*CO4*	*PO1*	**04**
		c)	A 6 m long section of an 8 cm diameter horizontal hot water pipe shown in Fig.3. passes through a large room whose temperature is 20°C. If the outer surface temperature of the pipe is 70°C, determine the rate of heat loss from the pipe by natural convection.  Fig.3.	*CO4*	*PO2*	**10**
			OR			
	6	a)	Define the term volume expansion coefficient and show for an ideal gas it is equal to, $\beta_{ideal\ gas} = \frac{1}{T}$	*CO4*	*PO1*	**04**
		b)	Derive the momentum equation for the free convection for the flow over a vertical flat plate.	*CO4*	*PO1*	**08**
		c)	Two concentric spheres of diameters D_i = 20 cm and D_o = 30 cm are separated by air at 1 atm. pressure. The surface temperatures of the two spheres enclosing the air are T_i = 320 K and T_o = 280 K, respectively. Determine the rate of heat transfer from the inner sphere to the outer sphere by natural convection.	*CO4*	*PO2*	**08**

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			UNIT - IV			
	7	a)	State the Wien's displacement law and Planck's law. Using them show that, $(\lambda T)_{max} = constant$ where, λ is the wave length and T is the absolute temperature of the black body.	*CO6*	*PO1*	**10**
		b)	In a three thin-walled, long, circular cylinders 1, 2 and 3, of diameters 15 cm, 25 cm and 35 cm, respectively, are arranged concentrically as shown in Fig. 4. Temperature of cylinder 1 is 80 K and that of cylinder 3 is 300 K. Emissivity's of cylinders 1, 2 and 3 are 0.05, 0.1 and 0.2, respectively. Assuming that there is vacuum inside the annular spaces, determine the steady state temperature attained by cylinder 2.	*CO6*	*PO2*	**10**

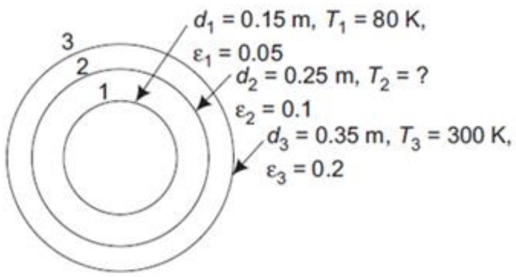

Fig. 4

			OR			
	8	a)	Discuss the following rules related to the radiation heat transfer between the surfaces. i) Reciprocity; ii) Summation; iii) Superposition; iv) Symmetry	*CO6*	*PO1*	**08**
		b)	Define the terms: i) Radiosity and ii) View factor.	*CO6*	*PO1*	**04**
		c)	Derive the general expression for view factor.	*CO6*	*PO1*	**10**
			UNIT - V			
	9	a)	Draw the temperature variation curve for hot and colder fluids for condenser and evaporators.	*CO5*	*PO1*	**02**
		b)	Derive and show that the effectiveness for parallel flow condenser is, $\epsilon = 1 - \exp\left\{-\frac{UA}{C_{min}}\right\}$.	*CO5*	*PO1*	**10**
		c)	Hot oil is to be cooled by water in a 1-shell-pass and 8-tube-passes heat exchanger. The tubes are thin-walled and are made of copper with an internal diameter of 1.4 cm. The length of each tube pass in the heat exchanger is 5 m, and the overall heat transfer coefficient is 310 W/m^2 · °C. Water flows through the tubes at a rate of 0.2 kg/s, and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enter at temperatures of 20°C and 150°C, respectively. Determine the rate of heat transfer in the heat exchanger and the outlet temperatures of the water and the oil.	*CO5*	*PO2*	**08**
			OR			
	10	a)	What is heat exchanger? Classify them.	*CO5*	*PO1*	**05**

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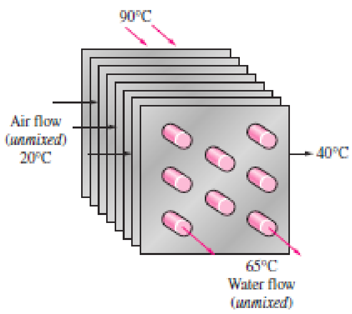
		b)	Define the terms with appropriate mathematical correlations; i) Overall heat transfer coefficient, ii) Fouling factor, iii) Correction factor, iv) Effectiveness.	*CO5*	*PO1*	**08**
		c)	A test is conducted to determine the overall heat transfer coefficient in an automotive radiation that is compact cross flow water to air heat exchanger with both fluids (air and water) un mixed (Fig. 5). The radiator has 40 tubes of internal diameter 0.5 cm and length 65 cm in a closely spaced plate finned matrix. Hot water enters the tubes at 90°C at rate of 0.6 kg/s and leaves at 65°C. Air flows across radiator through the interfin spaces and is heated from 20°C to 40°C. Determine the overall heat transfer coefficient of this radiator based on the inner surface area of the tubes.  Fig. 5.	*CO5*	*PO2*	**07**

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