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

Autonomous Institute Affiliated to VTU

July 2023 Semester End Main Examinations

Programme: B.E. **Semester: VI**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 20ME6DCFHT / 16ME5DCFHT **Max Marks: 100**
Course: Fundamentals of Heat Transfer **Date: 14.07.2023**

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.

		UNIT - I	CO	PO	Marks
1	a)	Name and explain briefly various modes of heat transfer.	CO1	PO1	**06**
	b)	Derive an expression for general three-dimensional heat conduction equation in Cartesian coordinates and reduce to Laplace equation.	CO2	PO1	**08**
	c)	Steam at 350°C flowing in a pipe (k=80 W/m K) of 5 cm inner diameter and 5.6 cm outer diameter is covered with 3 cm thick insulation of k=0.05 W/m K. Heat is lost to the surroundings at 5 cm by natural convection and radiation, the combined h being 20 W/m^2 K. Taking the heat transfer coefficient inside the pipe as 60 W/m^2 K. Determine: i) the rate of heat loss from the steam per unit length of the pipe, and ii) the temperature drop across the pipe and the insulation.	CO2	PO2	**06**
		OR			
2	a)	Under what circumstances from the heat transfer point of view, will the use finned wall be better? Derive the heat transfer equation for a rectangular fin with infinitely long boundary conditions.	CO2	PO1	**08**
	b)	The longitudinal fins 12 (k=75 W/m K) in number are attached to the cylindrical surface. The length of the fin is 25 mm with 0.75 mm thickness. The fins run along the length of the cylinder. The dimension of cylinder are 50 mm diameter and 1 m length. The cylinder is maintained at 150°C and ambient conditions are 40°C with 23 W/m^2 K. Determine the total rate of heat transfer from fins, and percentage increase in heat transfer due to fins.	CO2	PO1	**06**
	c)	A 120 mm diameter apple (ρ=990 kg/m^3; c_p=4170 J/kg °C; k=0.58 W/m °C) approximately spherical in shape is taken from a 25°C environment is placed in a refrigerator where temperature is 6°C and average convective heat transfer coefficient over the apple surface is 12.8 W/m^2 °C. Determine the temperature at the centre of the apple after a period of 2 hours.	CO2	PO2	**06**

			UNIT - II			
	3	a)	Explain the concept of velocity and thermal boundary layer, if the fluid is flowing over the flat plate.	*CO4*	*PO2*	**06**
		b)	Define the following: i) Reynolds number, ii) Prandtle number, and iii) Nusselt number. Explain their importance in convective heat transfer	*CO4*	*PO1*	**06**
		c)	Air at 20°C, and at a pressure of 1bar is flowing over flat plate at a velocity of 3 m/s. If the plate is 280 mm wide and at 56°C. Calculate the following quantities at x = 280 mm. i) Boundary layer thickness, ii) Local friction coefficient, iii) Average friction coefficient, iv) Shear stress due to friction, v) Thermal boundary layer thickness, vi) Local heat transfer coefficient, vii) Average heat transfer coefficient, and viii) Total drag force	*CO4*	*PO2*	**08**
			OR			
	4	a)	Derive an expression for Momentum equation for hydrodynamic boundary layer by considering the laminar flow over a flat plate.	*CO4*	*PO1*	**08**
		b)	In a certain glass making process, a square plate of glass 1 m^2 and 3 mm thick heated uniformly to 90°C is cooled by air at 20°C flowing over the both sides parallel to the plate at 2 m/s. Calculate the initial rate cooling the plate. Neglect temperature gradient in the glass plate and consider only forced convection. Take for glass : ρ=2500 kg/m^3; c_p=0.67 kJ/kg K Take the following properties of air at mean temperature: ρ=1.076 kg/m^3; c_p=1008 J/kg K; k=0.0286 W/m °C and μ=19.8×10^{-6} N-s/m^2.	*CO4*	*PO2*	**06**
		c)	800 kg/h of cream cheese at 15°C is pumped through a tube 100 mm in diameter 1.75 m long and maintained at 95°C. Calculate: i) The temperature of cheese leaving the heated section, ii) The rate of heat transfer from the tube to the cheese. Use the following correlation for laminar flow inside a tube: $\overline{Nu}=3.65+\frac{0.067\left[\left(\frac{D}{L}\right)Re\ Pr\right]}{1+0.04\left[\left(\frac{D}{L}\right)Re\ Pr\right]^{1/3}}$ Thermo-physical properties of cheese are: ρ=1150 kg/m^3; c_p=2.75 kJ/kg °C; k=0.42 W/m °C and μ=22.5 kg/m-s.	*CO4*	*PO2*	**06**
			UNIT - III			
	5	a)	Discuss briefly what are the difference between free convection and forced convection	*CO4*	*PO1*	**04**
		b)	Find the convective heat loss from a radiator 0.6 m wide and 1.2 m high maintained at a temperature 90° C in a room at 14° C. Treat the radiator as vertical plate	*CO4*	*PO2*	**08**

		c)	A steam pipe 10 cm diameter maintained at 170°C is exposed to air at 30°C. The length of the pipe is 2 m and is kept horizontal. Find the heat lost by the pipe per bar	*CO4*	*PO2*	**08**
			UNIT - IV			
	6	a)	State and explain followings: i) Kirchhoff's law, ii) Wein's displacement law iii) Plank's law of Radiation, and iv) Radiation shape factor and v) Radiation shield.	*CO6*	*PO1*	**08**
		b)	Define radiation intensity? Prove that intensity of radiation is given $\boldsymbol{I_b} = \frac{E_b}{\pi}$	*CO6*	*PO1*	**06**
		c)	Consider two large parallel plates, one at 1000 K with emissivity 0.8 and other is at 300 K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity as 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiationshield.	*CO6*	*PO2*	**06**
			UNIT - V			
	7	a)	What is heat exchanger? Discuss the following parameters with respect to heat exchanger analysis: i) Fouling factor, and ii) NTU method.	*CO5*	*PO1*	**06**
		b)	Derive an expression for logarithmic mean temperature difference for counter-flow heat exchanger.	*CO5*	*PO1*	**06**
		c)	Hot oil is to be cooled by water in a one-shell-pass and eight-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 K. 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. Take the specific heats of water and oil to be 4.18 kJ/kg° C and 2.13 kJ/kg °C, respectively.	*CO5*	*PO2*	**08**

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