Model Question Paper (CBCS)

15ME63

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Sixth Semester B.E. Degree (CBCS) Examination

Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing one full question from each module.
Use of Heat and Mass Transfer Data handbook is allowed

Important Note: 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.

		MODULE – I	
1	**a**	Derive 3-dimensional unsteady state heat conduction equation with heat generation, in Cartesian co-ordinate system for an isotropic material.	(08 Marks)
	b	A square plate heater 15cm x 15cm is inserted between two slabs. Slab A is 2cm thick (k = 50W/m-K) and Slab B is 1cm thick (k = 0.2W/m-K). The outside heat transfer coefficients on side A and side B are 200W/m²-K and 50W/m²-K respectively. The temperature of surrounding air is 25°C. If rating of heater is 1kW, find (a) Maximum temperature in the system, and (b) outer surface temperature of the two slabs.	(08 Marks)
		OR	
2	**a**	Derive an expression for temperature distribution for 1-dimensional slab with varying thermal conductivity. Assume the variation of thermal conductivity of slab as $k = k_0 (1+\beta t)$.	(08 Marks)
	b	A 3 mm diameter and 5m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is k = 0.15 W/m-K. Electrical measurements indicate that a current of 10 A passes through the wire and there is a voltage drop of 8 V along the wire. If the insulated wire is exposed to a medium at T_∞ = 30°C with a heat transfer coefficient of h = 12 W/m²-K, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also state with reason, whether doubling the thickness of the plastic cover will increase or decrease heat transfer.	(08 Marks)
		MODULE – II	
3	**a**	Define critical thickness of insulation. Derive an expression for critical thickness of insulation of a cylinder.	(08 Marks)
	b	A turbine blade made of stainless steel (k = 29 W/m-°C) is 60 mm long, 500 mm² cross-sectional area and 120 mm perimeter. The temperature of the root of the blade is 480°C and it is exposed to products of combustion passing through the turbine at 820°C. If the heat transfer coefficient between the blade and the combustion gases is 320 W/m²-C, determine (i) The temperature at the middle of the blade; (ii) the rate of heat flow from the blade. Assume the blade as short fin which is uninsulated.	(08 Marks)
		OR	
4	**a**	In a quench hardening process, steel rods (ρ = 7832 kg/m³, C_p = 434 J/kg-K, and k = 63.9 W/m-K) are heated in a furnace to 850°C and then cooled in a water bath to an average temperature of 95°C. The water bath has a uniform temperature of 40°C and convection heat transfer coefficient of 450 W/m²-K. If the steel rods have a diameter of 50 mm and a length of 2 m, determine (a) the time required to cool a steel rod from 850°C to 95°C in the water bath, considering only lateral surface area, and lateral surface area and cross-sectional area of the steel rod, and (b) the total amount of heat transferred to water during the quenching of a single rod.	(08 Marks)

	b	What are Heisler and Grober charts? Explain their significance in solving transient convection problems.	(08Marks)
		MODULE – III	
5	a	How do numerical solution methods differ from analytical ones? What are the advantages and disadvantages of numerical methods over analytical methods?	(08 Marks)
	b	For one dimensional unsteady state conduction equation without heat generation, obtain finite difference expression using FTCS method and discuss the stability criteria.	(08 Marks)
		OR	
6	a	State and explain: (i) Planck's law, (ii) Kirchoff's law, (iii) Wein's displacement law.	(06 Marks)
	b	Calculate the net radiant heat exchange per m² area for two large parallel plates at temperature of 427°C and 27°C respectively. Emissivity for hot plate is 0.9 and for cold plate is 0.6. If polished Aluminum shield is placed between them, find the percentage reduction in the heat transfer. Assume emissivity for shield as 0.4.	(10 Marks)
		MODULE – IV	
7	a	Define velocity and thermal boundary layer. Explain its physical significance.	(08 Marks)
	b	In an effort to increase the removal of heat from a hot surface at 120°C, a cylindrical pin fin (k_f = 237 W/m-K) with diameter of 5 mm is attached to the hot surface. Air at 20°C and 1 atmospheric pressure is flowing across the pin fin with a velocity of 10 m/s. Determine the maximum possible rate of heat transfer from the pin fin. Evaluate the properties at 70°C.	
		OR	
8	a	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 0.15m³/s. The duct is observed to be nearly isothermal at 60°C. Determine the exit temperature of the air.	(08 Marks)
	b	Consider a 0.6 m x 0.6 m thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection. If the emissivity of the surface is 1.0, calculate the heat loss by radiation. Also calculate the percentage of heat loss by convection.	
		MODULE –V	
9	a	Derive an expression for LMTD of double pipe, parallel flow heat exchanger.	(08 Marks)
	b	A counter flow double pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2kg/s. The heating is to be accomplished by geothermal water available at 170°C at a mass flow rate of 2kg/s. The inner tube is thin walled and has a diameter of 1.5cm. If the overall heat transfer coefficient of the heat exchanger is 640W/m²-K, determine the length of the heat exchanger required to achieve the desired heating. Use ε-NTU method.	(08 Marks)
		OR	
10	a	Draw the boiling curve of water at 1 atmospheric pressure and discuss the different regimes of boiling.	(08 Marks)
	b	What is heat pipe? Write the applications of heat pipe. With reference to heat pipe, explain entrainment and wicking.	(08 Marks)