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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Mechanical Engineering

Semester End Examination; July / Aug. - 2022

Heat and Mass Transfer

Time: 3 hrs *Max. Marks: 100*

Course Outcomes

The Students will be able to:

CO1: Understand fundamentals of three heat transfer modes and formulate governing differential equation to solve problems of one-dimensional steady state conduction heat transfer problems, with focus on fin design.

CO2: Solve one dimensional steady state and transient heat conduction problems considering heat generation and variable thermal conductivity.

CO3: Understand the concepts of convection heat transfer and solve related problems using both analytical and empirical approaches.

CO4: Demonstrate fundamentals of radiation heat transfer problems..

CO5: Apply the heat transfer basics to design heat exchanger and understand the concept of condensation and boiling of liquids.

***Note:** **I) PART - A** is compulsory. **Two** marks for each question.*

***II) PART - B**: Answer any **Two** sub questions (from a, b, c) for Maximum of **18 marks** from each unit.*

***III)** Use of data hand book is permitted.*

Q. No.	Questions	Marks	BLs	COs	POs
	I : PART - A	**10**			
I a.	Define thermal diffusivity and what is its physical significance?	2	L1	CO1	PO1
b.	What is lumped system analysis? When is it applicable?	2	L1	CO2	PO1
c.	Define radiation shield and mention its applications.	2	L1	CO3	PO1
d.	Define; i) Thermal conductivity and ii) Heat transfer coefficient.	2	L1	CO4	PO1
e.	Give applications of boiling and condensation.	2	L1	CO5	PO1
	II : PART - B	**90**			
	UNIT - I	**18**			
1 a.	Define critical thickness of insulation and derive expression for critical thickness of insulation for cylinder.	9	L2	CO1	PO1
b.	The wall of a house in a cold region consists of three layers, an outer brick work 20 cm thick, an inner wooden panel 1.4 cm thick and intermediate layer made of an insulating material 10 cm thick. The inside and outside temperature of the composite wall 28°C and −12°C respectively. The thermal conductivity of brick and wood are 0.7 W/mK and 0.18 W/mK respectively. If the layer of insulation has thermal conductivity of 0.023 W/mK. Find: i) The heat loss per unit area of the wall ii) Overall heat transfer co-efficient	9	L3	CO1	PO2

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c.	The aluminium square fins (0.6 × 0.6 mm), 12 mm long are provided on the surface of a semiconductor electronic device to carry 2 W of energy generated. The temperature at the surface of the device should not exceed 85°C, when the surrounding is at 35°C. Given K = 200 W/mK, h = 15 W/m^2K. Determine number of fins required to carry out the above duty. Neglect the heat loss from end of fin.	9	L3	CO1	PO2
	UNIT - II	**18**			
2 a.	Obtain an expression for instantaneous heat transfer and total heat transfer using lumped heat analysis for unsteady state heat transfer from a body exposure to the surroundings.	9	L2	CO2	PO1
b.	Aluminium sphere weighing 6 kg and initially at a temperature of 420°C is suddenly immersed in a fluid at 18°C. The convective heat transfer co-efficient is 45 W/m^2K. Estimate the time required to cool the sphere to 120°C. Also find the total heat flow from the sphere to surroundings when it cools from 300°C to 120°C. [for aluminium ρ = 2700 Kg/m^3 , C_p= 900 J/kgK, K = 200 W/mK]	9	L3	CO2	PO2
c.	In a production facility, large brass plates of 4 cm thickness that are initially at a uniform temperature of 20°C are heated by passing through an oven that as maintained at 500°C. The plates remain in the oven for a period of 7 minutes, the combined heat transfer co-efficient h = 120 W/m^2K. Determine the surface temperature of the plates when they come out of oven. Calculate using both lumped and heisler chart.	9	L3	CO2	PO2
	UNIT - III	**18**			
3 a.	Using dimensional analysis show that for free convective heat transfer $Nu = B\, Gr^a\, Pr^b$.	9	L2	CO4	PO1
b.	A vertical plate 4 m high and 6 m wide is maintained at 60°C and exposed to atmosphere air at 10°C. Calculate the heat transfer from both sides of the plate. For air at 35°C, take K = 0.027 W/mK, $\gamma = 16.5\times10^{-6}$ m^2/s, P_r = 0.7.	9	L3	CO3	PO2
c.	Air at 30°C flows with a velocity of 10m/s along a flat plate 4 m long is maintained at a uniform temperature of 130°C. Assuming critical Reynolds number of 2×10^5 and width of the plate is 1 m, determine; i) Heat flux at trailing edge of plate ii) Heat transfer from laminar portion of plate	9	L3	CO3	PO2

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		Marks	BT	CO	PO
	UNIT - IV	**18**			
4 a.	Define: i) Stefan Boltzmann Law ii) Weins displacement Law iii) Radiation shield iv) Radiosity v) Kirchhoff's Law	9	L2	CO4	PO1
b.	Two large parallel plates having emissivity of 0.3 and 0.6 are maintained at a temperature of 900°C and 250°C. A radiation shield having an emissivity of 0.05 on both sides is placed between two plates. Calculate: i) Heat transfer without shield ii) Heat transfer with shield. iii) Percentage reduction in the heat transfer due to shield. iv) Temperature of the shield.	9	L3	CO3	PO2
c.	Prove that monochromatic emissive power of a black body is maximum when T_{max} = 2900 μK.	9	L2	CO4	PO1
	UNIT - V	**18**			
5 a.	Derive an expression for LMTD of parallel flow heat exchanger.	9	L2	CO4	PO1
b.	Saturated steam at 140°C is condensing on the outer surface of a single pass heat exchanger. The overall heat transfer co-efficient is 1500 W/m^{2}K. Determine the surface area of the heat exchanger required to heat 2000 kg/h of water from 20°C and 45°C. Also determine the route of condensation of steam in kg/h. Assume latent heat is 2145 kJ/kg.	9	L3	CO3	PO2
c.	Define mass transfer co-efficient. State Fick's law and what are its limitations?	9	L2	CO4	PO1

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