U.S.N

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; August - 2023

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**			
1 a.	Define critical thickness of insulation? Write the equation for critical thickness of insulation for sphere.	2	L1	CO1	PO1
b.	Define Biot number. Mention its Significance.	2	L1	CO2	PO1
c.	Define thermal conductivity and heat transfer co-efficient.	2	L1	CO3	PO1
d.	Define black and white body.	2	L1	CO4	PO1
e.	Explain any two factors which affecting the nucleate boiling.	2	L1	CO5	PO1
	II : PART - B	**90**			
	UNIT - I	**18**			
2 a.	With neat sketch, derive the expression for general heat conduction equation in Cartesian co-ordinate system.	9	L2	CO1	PO1
b.	Find the heat flow rate through the composite wall as shown in Figure 2(b). Assume one dimensional flow. Take K_A= 150 W/m°C, K_B= 30 W/m°C, K_C= 65 W/m°C and K_D= 50 W/m°C	9	L3	CO1	PO2

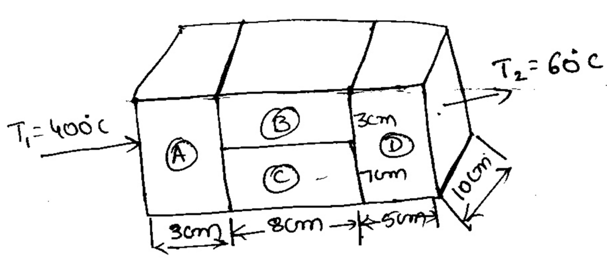

Figure 2(b)

c.	A fin 5 mm thick and 45 mm long has its base on a plane plate which is maintained at 125°C. The ambient temperature is 25°C. The conductivity of fin material is 55 W/m°C and heat transfer co-efficient is 145 W/m°C. Determine; i) Temperature at the end of the fin ii) Temperature at the middle of the fin iii) Heat dissipated by the fin (per meter width)	9	L3	CO1	PO2
	UNIT - II	**18**			
3 a.	Derive an expression for temperature distribution for a solid having infinite thermal conductivity (lumped system).	9	L2	CO2	PO1
b.	The rate of heat generation in a slab of thickness 160 mm (k = 180 W/m°C) is 1.2×10^6 W/m^3. If the temperature of each of the surface of solid is 120°C, Determine: i) The temperature at the mid and quarter plane ii) Heat flow rate at the mid and quarter plane	9	L3	CO2	PO2
c.	A 60 mm thick large steel plate (k = 42.6 W/m°C, α= 0.043 m$^{2/}$h) initially at 440°C is suddenly exposed on both sides to an environment with convective heat transfer coefficient 235 W/m$^{2°}$C and temperature 50°C. Determine center line temperature and temperature inside the plane is 15 mm from the mid plane after 4.3 minutes.	9	L3	CO2	PO2
	UNIT - III	**18**			
4 a.	For natural convection heat transfer using dimensional analysis, prove that Nu = ϕ(Pr)(Gr).	9	L2	CO3	PO1
b.	A cylindrical body of 300 mm diameter and 1.6 m high is maintained at a constant temperature of 36.5°C. The surrounding temperature is 13.5°C. Find out the amount of heat to be generated by the body per hour, if ρ =1.025 KG/m^3, C_p = 0.96 kJ/Kg°C, γ = 15.06×10^{-6}m^2/s, k = 0.0892 kj/m-h°C and $\beta = \frac{1}{290}$ K^1. Assume Nu = 0.12 (Gr.Pr)$^{1/3}$	9	L3	CO3	PO2
c.	In a certain glass making process a square plate of glass 1 m^2 area and 3 mm thick heated uniformly to 90°C is cooled by air at 20°C flowing over both sides parallel to plate at 2 m/s. Calculate the heat flow both sides of the plate.	9	L3	CO3	PO2

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		Marks	Level	CO	PO
	UNIT - IV	**18**			
5 a.	State and explain the following: i) Shape factor ii) Wein's displacement law iii) Kirchhoff's law	9	L2	CO4	PO1
b.	Assume the sum (diameter = 1.4×10^{9} m) as a black body having a surface temperature of 5750 K and at a mean distance of 15×10^{10} m from the earth (diameter = 12.8×10^{6}m). Estimate the following: i) The total energy emitted by the sun ii) The emission received per m^2 just outside the atmosphere of the earth iii) The total energy received by the earth if no radiation is blocked by the atmosphere of the earth	9	L3	CO4	PO2
c.	Consider two large parallel plates one at T_1 =727°C with emissivity ε_1= 0.8 and other at T_2 = 227°C with emissivity ε_2 = 0.4. An aluminium radiation shield with an emissivity ε_s = 0.05 on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield. Take $\sigma = 5.67\times10^{-8}$ W/m^2K^4.	9	L3	CO4	PO2
	UNIT - V	**18**			
6 a.	With usual notations, derive the various regimes of saturated pool boiling.	9	L2	CO5	PO1
b.	With neat sketch, explain the various regimes of saturated pool boiling.	9	L3	CO5	PO2
c.	In a counter flow double pipe heat exchanger, water is heated from 25°C to 65°c by oil with a specific heat of 1.45 kJ/Kg-K and mass flow rate of 0.9 kg/s. The oil is cooled from 230°C to 160°C. If the overall heat transfer co-efficient is 420 W/m^2°C, calculate the following: i) The rate of heat transfer ii) The mass flow rate of water iii) The surface area of the heat exchanger	9	L3	CO5	PO2

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