PVP 20

Code: 20ME3501

III B.Tech - I Semester – Regular / Supplementary Examinations NOVEMBER 2024

HEAT TRANSFER

(MECHANICAL ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This paper contains questions from 5 units of Syllabus. Each unit carries 14 marks and have an internal choice of Questions.
2. All parts of Question must be answered in one place.

BL – Blooms Level CO – Course Outcome

			BL	CO	Max. Marks
UNIT-I					
1	Derive the heat conduction equation in spherical coordinates.		L2	CO1	14 M
OR					
2	a)	A flat plate of area 0.5 m² is maintained at a constant temperature of 120°C. It is exposed to air at a temperature of 25°C with a heat transfer coefficient of 25 W/m²·K. Calculate the rate of heat loss from the plate to the air due to convection. If the plate's temperature is increased to 150°C, what will be the new rate of heat loss?	L2	CO1	6 M
	b)	What are the modes of heat transfer and also write their laws?	L2	CO1	8 M
UNIT-II					
3	a)	What does steady state heat conduction with variable thermal conductivity mean? Explain with an example.	L2	CO1	3 M

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<tr><td></td><td>b)</td><td>Explain the significance of boundary conditions in extended surface heat transfer problems.</td><td>L2</td><td>CO1</td><td>3 M</td></tr>
<tr><td></td><td>c)</td><td>A homogeneous hollow sphere with an inner radius of 0.05 m and an outer radius of 0.1 m is initially at a uniform temperature of 200°C. The inner surface is suddenly exposed to water at 30°C with a convective heat transfer coefficient of 100 W/m²·K, while the outer surface is insulated. Calculate the temperature at the inner surface after 15 minutes. Take thermal conductivity as 30 W/m·K, density as 7800 kg/m³ and specific heat as 500 J/kg·K.</td><td>L3</td><td>CO2</td><td>8 M</td></tr>
<tr><td colspan="6">OR</td></tr>
<tr><td>4</td><td>a)</td><td>Explain periodic heat transfer with applications.</td><td>L2</td><td>CO1</td><td>6 M</td></tr>
<tr><td></td><td>b)</td><td>A composite slab is made of two homogeneous layers of different materials, each with a thickness of 0.1 m. The slab is initially at a uniform temperature of 100°C and is suddenly exposed to air at 20°C on one side with a convective heat transfer coefficient of 25 W/m²·K. The other side is insulated. Calculate (i) the temperature at the interface between the two layers after 10 minutes. (ii) the temperature at a point 0.05m from the exposed surface after 10 minutes.
Take the following thermo physical properties,
<table>
<tr><th>Property</th><th>Material 1</th><th>Material 2</th></tr>
<tr><td>Thermal Conductivity (k) (W/m·K)</td><td>1.0</td><td>2.0</td></tr>
<tr><td>Density (ρ) (kg/m³)</td><td>2400</td><td>2600</td></tr>
<tr><td>Specific Heat (c) (J/kg·K)</td><td>880</td><td>900</td></tr>
</table></td><td>L3</td><td>CO2</td><td>8 M</td></tr>
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UNIT-III					
5	a)	What are the key conditions that determine whether a flow will be laminar or turbulent? Discuss the role of Reynolds number in defining the flow regime.	L2	CO1	4 M
	b)	A vertical plate 0.75 meters high is maintained at a constant temperature of 60°C and is exposed to air at 15°C. The plate is large enough in width that edge effects can be ignored. Determine the average convection heat transfer coefficient along the height of the plate.	L3	CO2	10 M
OR					
6	a)	Explain the significance of non-dimensional numbers and what is Buckingham Pi theorem.	L2	CO1	7 M
	b)	Air at 25°C flows over a flat plate at a velocity of 10 m/s. The surface of the plate is maintained at a constant temperature of 50°C. The length of the plate in the direction of flow is 1 meter. Calculate the average convection heat transfer coefficient along the length of the plate.	L3	CO2	7 M
UNIT-IV					
7	a)	What are various regimes in pool boiling?	L2	CO3	7 M
	b)	In a counterflow double-pipe heat exchanger, hot water enters at 150°C and exits at 85°C. Cold water enters at 25°C and is heated to 70°C. The mass flow rate of the hot water is 0.6 kg/s, and the specific heat of the hot water is 4.18 kJ/kg·K. The overall heat transfer coefficient is 500 $W/m^2 \cdot K$. Determine the following: (i) The rate of heat transfer in the heat exchanger. (ii) The mass flow rate of cold water.	L3	CO3	7 M

OR					
8	a)	Derive the expression for LMTD (Logarithmic Mean Temperature Difference) for a parallel flow heat exchanger.	L3	CO3	8 M
	b)	A stainless steel pot with a flat bottom of diameter 30 cm is used to boil water at atmospheric pressure. The pot is heated from below using an electric heating element, and the bottom surface of the pot is maintained at a uniform temperature of 105°C. Calculate the rate of water boiling if the latent heat of vaporization of water is 2260 kJ/kg.	L3	CO3	6 M
UNIT-V					
9	a)	What is shape factor and how does it affect the heat exchange between two bodies?	L2	CO1	4 M
	b)	A gray sphere of radius 0.5 meters is located inside a large cavity. The cavity has a temperature of 500°C, and the sphere's surface temperature is 400°C. If the emissivity of the sphere is 0.8, calculate the net radiative heat exchange between the sphere and the cavity. Assume the shape factor and support your assumption.	L4	CO4	10 M
OR					
10	a)	What are radiation shields and explain their uses in thermal management?	L2	CO1	4 M
	b)	What is a black body, comment on its radiation and emissivity?	L2	CO4	3 M
	c)	A gray body with an emissivity of 0.7 is placed in a room where the walls are at 350 K and the body is at 500 K. Calculate the rate of heat exchange between the gray body and the walls if the surface area of the body is 2 m^2.	L4	CO4	7 M