USN

21ME62

Sixth Semester B.E./B.Tech. Degree Examination, Dec.2025/Jan.2026
Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2.Use of Thermodynamics and Heat Transfer data handbook is permitted.
3.Any missing data may be suitably assumed.

Module-1

1 a. Explain the boundary conditions of I, II and III kinds. **(06 Marks)**

b. Explain briefly on the following :
(i) Thermal conductivity (ii) Thermal diffusivity **(04 Marks)**

c. Derive the general three-dimensional heat conduction equation in Cartesian coordinates and state the assumptions made. Write simplified form of 1-D heat conduction equation. **(10 Marks)**

OR

2 a. What is critical thickness of Insulation? Derive an expression for critical radius of insulation interms of thermal conductivity and heat transfer coefficient for cylinder. **(10 Marks)**

b. A wall of furnace is made up of inside layer of Silica brick 120 mm thick covered with a layer of Magnesite brick 240 mm thick. The temperatures at the inside surface of Silica brick wall and outside surface of Magnesite brick wall are 725°C and 110°C respectively. The contact thermal resistance between the two walls at the interface is 0.0035°C/w per unit wall area. If thermal conductivities of silica and magnesite bricks are 1.7 W/m °C and 5.8 W/m °C Calculate (i) The rate of heat loss per unit area of walls. (ii) The temperature drop at the interface. **(10 Marks)**

Module-2

3 a. Derive an expression for the temperature distribution and heat flow for a pin fin, when the tip of the fin is insulated. **(10 Marks)**

b. Aluminium fins of rectangular profile are attached to a plane wall with 5 mm spacing. The fins have thickness of 1 mm, length 10 mm and thermal conductivity 200 W/mK and the fins dissipate heat by convection into an ambient at 40°C with a surface heat transfer coefficient of 50 W/m^2K. Determine (i) The fin efficiency ii) The heat loss from the plane wall per m^2 of the wall surface. Neglect the heat loss from the fin tip.
Take : Width = 1 m and fin base temperature = T_0 = 200°C. **(10 Marks)**

OR

4 a. Derive an expression for temperature distribution through a body for lumped parameter analysis in terms of Biot number and Fourier number. **(10 Marks)**

b. A (50 cm × 50 cm) slab of 6.25 mm thick has a uniform temperature of 300°C. Its temperature is suddenly lowered to 36°C, calculate the time required for the plate to reach the temperature of 108°C.
Take : $\rho = 9000$ kg/m^3 , c = 0.38 KJ/kg °C
K = 370 W/m °C , h = 90 W/m^2 **(10 Marks)**

Module-3

5 a. Explain the boundary conditions applied in finite difference representation for one dimensional steady state heat conduction. **(08 Marks)**

b. Consider the steady state heat conduction in slab of thickness 'L', in which energy is generated at a constant rate of 'g' W/m^3. The boundary surface at x = 0 is maintained at a constant temperature T_0 , while the boundary surface at X = L, dissipates heat by convection with a heat transfer coefficient 'h' into an ambient temperature 'T_∞'. Dividing the region into 5 equal subregions, write the finite difference formulation of this heat conduction problem and find the temperature at nodal points. **(12 Marks)**

OR

6 a. What is Radiation View Factor? Explain briefly. **(04 Marks)**

b. Prove that emissive power of the black body in hemispherical enclosures is 'π' times of intensity of radiation. **(06 Marks)**

c. Two large parallel plates are at 1000 K and 600 K, determine the heat exchange per unit area for the following cases:
i) If the surfaces are black.
ii) If the hot one has an emissivity of 0.8 and colder one has 0.5.
iii) A large plate is inserted between these plates having emissivity of 0.2. **(10 Marks)**

Module-4

7 a. With neat sketch explain the following :
i) Velocity boundary layer ii) Thermal boundary layer **(10 Marks)**

b. Air at 30°C is flowing over a flat plate at a pressure of 0.01325 bar with velocity 5 m/s. The entire plate surface is maintained at a temperature of 70°C. Assuming transition occurs at a Reynolds number of 5×10^5, find the distance from the leading edge at which the flow in the boundary layer changes from laminar to turbulent. At that location find
i) Thickness of hydrodynamic boundary layer and thermal boundary layer.
ii) Local and average heat transfer coefficients. **(10 Marks)**

OR

8 a. Explain the significance of Reynolds number, Prandtl number, Nusselt number and Grasshof number with equations. **(10 Marks)**

b. A 5 cm diameter pipe carrying hot water is exposed to the ambient air at 15°C. If the outer surface of the pipe is at 65°C, find the rate of heat loss from 1 m pipe length when :
i) The pipe is horizontal ii) The pipe is vertical. **(10 Marks)**

Module-5

9 a. Briefly explain filmwise and dropwise condensation process. **(04 Marks)**

b. With a neat sketch, explain the different regimes of pool boiling. **(06 Marks)**

c. Air free saturated steam at a temperature of 65°C (P = 25.08 KPa) condenses on a vertical tube of 3 m long at the outer surface. The tube maintained at a uniform temperature of 35°C. Assuming film condensation, calculate the average heat transfer coefficient over the entire length of the surface. Also calculate the average heat transfer coefficient and rate of condensate flow for a horizontal tube of 2.5 cm outer diameter. Take : The data same as for a vertical tube. **(10 Marks)**

OR

10 a. Derive an expression for Logarithmic Mean Temperature Difference (LMTD) for counter flow heat exchanger. State the assumptions made. **(10 Marks)**

b. The product of 16.5 kg/s at 650°C (c_p = 3.55 KJ/kg °C) in a chemical plant are to be used to heat 20.5 kg/s of incoming fluid from 100°C (c_p = 4.2 KJ/kg °C). If overall heat transfer coefficient is 0.95 KW/m^2 °C and the installed heat transfer surface is 44 m^2, calculate the effectiveness and NTU for (i) Parallel flow arrangement (ii) Counter flow arrangement (iii) Heat transfer. **(10 Marks)**

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