

(4)

OR

- a) Consider the flow between parallel plates (1m width \times 1m length) spaced 6mm apart. Calculate the compactness (m^2/m^3) of the surface exposed to the flow between parallel plates. Now suppose that straight plain fins of 0.05 mm thickness are installed between parallel plates and spaced on 1-mm centers. Calculate the compactness for this plate-fin surface.
- b) Define effectiveness concept for double pipe heat exchanger with all four possible cases. Co-Current flow, hot fluid minimal, Co-Current flow, cold fluid minimal, Counter-Current flow, hot fluid minimal, Counter-Current flow, cold fluid minimal.

Total No. of Questions

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MECM-104

M.E./M.Tech., I Semester

Examination, December 2014

Advanced Heat Transfer

Time : Three Hours

Maximum Marks : 70

Note: All questions carry equal marks, draw neat sketch and assume suitable data wherever you required.

1. a) Derive the one-dimensional heat-conduction equation.
- b) A 6.0-cm-diameter pipe whose surface temperature is maintained at 210°C passes through the center of a concrete slab 45 cm thick. The outer surface temperatures of the slab are maintained at 15°C . Using the flux plot, estimate the heat loss from the pipe per unit length.

OR

- a) What is the main assumption in the separation-of-variables method for solving Laplace's equation?
- b) A 2.5-m-diameter sphere contains a mixture of ice and water at 0°C and is buried in a semi-infinite medium having a thermal conductivity of $0.2 \text{ W/m}^\circ\text{C}$. The top surface of the medium is isothermal at 30°C and the sphere centerline is at a depth of 8.5 m. Calculate the heat lost by the sphere.

2. a) What is the basic procedure in setting up a numerical solution to a two-dimensional conduction problem?
- b) What is meant by a lumped capacity? What are the physical assumptions necessary for a lumped-capacity unsteady-state analysis to apply?

OR

- a) What initial conditions are imposed on the transient solutions in a long cylinder suddenly exposed to convection?
- b) Describe how one-dimensional transient solutions may be used for solution of two and three-dimensional problems.
3. a) What is the Dittus-Boelter equation? When does it apply?
- b) A semi-infinite slab of copper is exposed to a constant heat flux at the surface of 0.5 MW/m^2 . Assume that the slab is in a vacuum, so that there is no convection at the surface. What is the surface temperature after 5 min if the initial temperature of the slab is 20°C ? What is the temperature at a distance of 15 cm from the surface after 5 min?

OR

- a) Explain Shape-factor algebra for open ends of cylinders.
- b) Water at an average temperature of 300 K flows at 0.7 kg/s in a 2.5 cm-diameter tube 6 m long. The pressure drop is measured as 2 kPa. A constant heat flux is imposed, and the average wall temperature is 55°C . Estimate the exit temperature of the water.

4. a) Discuss electrical analogy when more than two nodes are involved in heat exchange.
- b) Three parallel black walls, 1 m wide form an equilateral triangle. One wall is held at 400 K, one is at 300 K, and the third is insulated. Find $Q \text{ W/m}$ and the temperature of the third wall.

OR

- a) A small diameter heater is centered in a large cylindrical radiation shield. Discuss the relative importance of the emittance of the shield during specular and diffuse radiation.
- b) Two parallel disks, 50 cm in diameter, are separated by a distance of 12.5 cm and enclosed by a large room at 300 K. One disk is maintained at a constant temperature of 800°C and has an emissivity of $\epsilon = 0.8$. The other disk is perfectly insulated and has an emissivity of $\epsilon = 0.1$. Calculate the net radiant energy lost by the disk maintained at 800°C .

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5. a) Explain why the temperature boundary layer grows much more rapidly than the velocity boundary layer in liquid metals.
- b) Water at the rate of 68 kg/min is heated from 35 to 75°C by oil having a specific heat of $1.9 \text{ kJ/kg}^\circ\text{C}$. The fluids are used in a shell-and-tube exchanger with the water making one shell pass and the oil making two tube passes and the oil enters the exchanger at 110°C and leaves at 75°C . The overall heat-transfer coefficient is $320 \text{ W/m}^2^\circ\text{C}$. Calculate the heat-exchanger area.