CBCS SCHEME

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18MR61

Sixth Semester B.E. Degree Examination, June/July 2024
Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Explain the modes of heat transfer with its governing laws. **(09 Marks)**

b. A square plate heater (15cm × 15cm) is inserted between two slabs. Slab A is 2cm thick (K = 50W/mK) and slab B is 1cm thick (K = 0.2W/mK). The outside heat transfer coefficient on both the sides of A and B are $200W/m^2K$ and $50W/m^2K$ respectively. Temperature of surrounding air is 25°C. If the rating of heater is 1kW, then find:
i) Maximum temperature in the system.
ii) Outer surface temperature of two slabs. **(11 Marks)**

OR

2 a. Derive the general three dimensional heat conduction equation in Cartesian coordinates. **(07 Marks)**

b. What is critical thickness of insulation? Derive an expression for critical thickness of insulation for the cylinder. **(06 Marks)**

c. A composite wall consist of a 10cm layer of building brick (K = 0.7W/mK) and 3cm thick plaster (K = 0.5W/mK). What thickness of rock wool insulation material (K = 0.08W/mK) should be added to reduce the heat loss through the wall by 70% insulated. **(07 Marks)**

Module-2

3 a. Derive an expression of temperature distribution and heat transfer for short fin with its end is insulated. **(10 Marks)**

b. A rod (K = 200W/mK) 10mm in diameter and 5cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 30°C with convective heat transfer coefficient of $100W/m^2K$. Assuming other end insulated determine.
i) The temperature of the rod at 25mm distance from the end at 100°C.
ii) Heat dissipation rate from the surface of the rod.
iii) Efficiency and effectiveness of rod. **(10 Marks)**

OR

4 a. Derive an expression of temperature distribution and instantaneous heat transfer for lumped system in terms of biot and fourier number. **(12 Marks)**

b. An aluminium sphere weighing 5.5kg and initially at a temperature of 290°C is suddenly immersed in a fluid at 15°C. The convective heat transfer coefficient is $58W/m^2K$. Estimate time required to cool the aluminium to 95°C. Using the lumped capacitance method of analysis for aluminium $\rho = 2700kg/m^3$, c = 900J/kgK, K = 205W/mK. **(08 Marks)**

Module-3

5 a. Using Buckingham's π-theorem, obtain the relationship between various non-dimensional numbers for free convection heat transfer. **(10 Marks)**

b. Air at atmospheric pressure and 200°C flows over a plate with a velocity of 5m/s. The plate is 15mm wide and is maintained at a temperature of 120°C. Calculate: i) The thickness of hydrodynamic and thermal boundary layer ii) Local heat transfer coefficient at a distance of 0.5cm from the loading edge. Assume that flow is on one side of the plate. **(10 Marks)**

OR

6 a. Define following and give expression for
i) Reynolds number ii) Nusselt number iii) Prandtl number iv) Grashoff number. **(08 Marks)**

b. With neat sketch, explain the hydrodynamic boundary layer for flow over a flat plate. **(06 Marks)**

c. A cylindrical body of 300mm diameter and 1.6m height 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 $\rho = 1.025 kg/m^3$, $C_p = 0.96 kJ/kg°C$, $\gamma = 15.06 \times 10^{-6} m^2/s$, $K = 0.02477 W/m°C$ and $\beta = \frac{1}{298} K^{-1}$. Assume $Nu = 0.12(Gr.Pr)^{1/3}$. **(06 Marks)**

Module-4

7 a. Derive an expression for LMTD of a parallel flow heat exchanger. State the assumption. **(10 Marks)**

b. Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350°C. The mass flow of steam is 800kg/min. The gas enters the heat exchanger at 650°C and mass flow rate is 1350kg/min. If the tubes are 30mm diameter and 3m long, determine the number of tube required. Neglect the resistance offered by metallic tubes. Use following data:
For steam : $T_{sat} = 180°C$ (at 10bar); $C_{P_S} = 2.71 kJ/kg°C$; $h = 600 W/m^2°C$
For gas : $C_{pg} = 1 kJ/kg°C$; $hg = 250 W/m^2°C$. **(10 Marks)**

OR

8 a. Explain :
i) Filmwise condensation and dropwise condensation
ii) Regimes of pool boiling. **(12 Marks)**

b. A vertical plate 30cm × 30cm is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate: i) heat transfer ii) mass of steam condensed iii) film thickness at bottom of plate. **(08 Marks)**

Module-5

9 a. Explain:
i) Stefan boltzman law
ii) Kirchoff's law
iii) Planks law
iv) Weins displacement law
v) Radiation shield. **(10 Marks)**

b. Calculate the net radiant heat energy per m^2 area for two large parallel plates at a temperature of 427°C and 27°C respectively. $\in$(hotplate) = 0.9 and $\in$(cold plate) = 0.6. If polished aluminium shield is placed between them, find the percentage reduction in the heat transfer $\in$(shield) = 0.4. **(10 Marks)**

OR

10 a. For a black body enclosed in a hemispherical space show that emissive power of body is π times the intensity of radiation. **(08 Marks)**

b. Explain : i) Concept of black body ii) Shape factor in radiation. **(06 Marks)**

c. An electric heating system is inserted in ceiling of a room 5m × 5m × 2.5m. The temperature of the ceiling is 315K. Whereas under equilibrium conditions the walls are at 295K. If the floor is non sensitive to radiation and emissivities of the ceiling and walls are 0.75 and 0.65 respectively. Calculate the radiant heat loss from the ceiling of wall. **(06 Marks)**

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