CBCS Scheme

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15AU62

Sixth Semester B.E. Degree Examination, June/July 2018
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing one full question from each module.
2. Use of Heat transfer data hand book and steam tables are permitted.

Module-1

1 a. Explain the boundary condition of 1st, 2nd and 3rd kind. **(06 Marks)**

b. An electrical resistance of mattress type is inserted in between two slabs of different materials on a panel heater. On one side, the material has a thermal conductivity of 0.174 W/m°K and 10mm thick. On the other side of the heater the material has a thermal conductivity of 0.05W/m°k and 25mm thick. The convection heat transfer co-efficient from the thinner and thickner slabs are 23.26 and 11.63 W/m^2°K. The temperature of the surrounding air on both the sides is 15°C. If the energy dissipation for each square meter of the mattress is 5kW. Neglecting edge effects. Find: i) The square temperature of the slab; ii) The temperature of the mattress assuming it to be the same as the inner surface of the slabs. **(10 Marks)**

OR

2 a. Determine one dimensional conduction equation for cylindrical coordinates starting from 3-dimensional equation. **(10 Marks)**

b. A furnace wall is made up of three layers of thickness 250mm, 100mm and 150mm with thermal conductivities of 1.65, K and 9.2 W/m°C respectively. The inside is exposed to gases at 1250°C with a convection co-efficient of 25W/m^{2}C and the inside surface is at 1100°C. The outside surface is exposed to air at 25°C with convection coefficient of 12 W/m^2°C. Determine:

i) The unknown thermal conductivity K.

ii) The overall heat transfer coefficient. **(06 Marks)**

Module-2

3 a. What is physical significance of critical thickness of insulation? Derive an expression for critical thickness of insulation for a sphere. **(08 Marks)**

b. A thin rod of copper K = 100W/m°C, 12.5 mm in diameter spans between two parallel plates 150mm apart. Air flows over the rod providing a heat transfer coefficient of 50W/m^2°C. The surface temperature of the plate exceeds the air by 40°C. Determine: i) The excess temperature at the centre of the rod over that of air and ii) Heat lost from the rod in watts. **(08 Marks)**

OR

4 a. Derive an expression for temperature distribution under lumped system analysis in terms Biot and Fourier numbers. **(08 Marks)**

b. An egg with mean diameter of 40mm and initially at 20°C is placed in a boiling water pan for 4 mins and found to be boiled to the consumers taste for how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5°C. Take the following properties for egg, K = 10 W/m°C, ρ = 1200 kg/m^3, C_p = 2kJ/kg°C and h = 100 W/m^2°C. **(08 Marks)**

Module-3

5 a. Explain briefly with sketches: i) Velocity boundary layer thickness ii) Thermal boundary layer thickness. (08 Marks)

b. A 15cm outer diameter steel pipe lies 2m vertically and 8m horizontally in a large room with an ambient temperature of 30°C. If the pipe surface is at 250°C and the emissivity of steel is 0.60, calculate the total rate of heat loss from the pipe to the atmosphere. Properties of air at 140°C are ρ = 0.854 kg/m^3. C_p = 1.01 kJ/kg K, K = 0.035 W/mK, P_r = 0.684 and $\gamma = 27.8 \times 10^{-6}$ m^2/s. (08 Marks)

OR

6 a. With the help of dimensional analysis, derive expression for the Reynolds number, Prandtl number and Nusselt number. (08 Marks)

b. A liquid metal flows at the rate of 4 kg/s through a constant heat flux 6cm inner diameter tube in a nuclear reactor. The fluid at 200°C is to be heated with the tube wall 40°C above the fluid temperature. Determine the length of the tube required for 25°C rise in bulk fluid temperature, using the following properties $\rho = 7.7 \times 10^3$ kg/m^3, $\gamma = 8 \times 10^{-8}$ m^2/s C_p = 130 J/kg°C, K = 12 W/m K and P_r = 0.011. (08 Marks)

Module-4

7 a. With assumptions determine L.M.T.D. for parallel flow heat exchanger. (08 Marks)

b. In an open heart surgery under hypothermic conditions. The patients blood is cooled before the surgery and rewarmed afterwards. It is proposed that a concentric tube counter flow heat exchanger of length 0.5m is to be used. For this purpose, with a thin walled inner tube having a diameter of 55mm. If water at 60°C and 0.1 kg/s is used to heat blood entering the exchanger at 18°C and 0.05 kg/s. What is the temperature of the blood leaving the exchanger and the heat flow rate. Take U_0 = 500W/m^{2}K, C_p of blood = 3.5 kJ/kgK, C_p of water = 4.183 kJ/kg K. (08 Marks)

OR

8 a. Clearly explain the regions of pool boiling with neat sketch. (08 Marks)

b. Saturated steam at 110°C condenser on the outside of a bank of 64 horizontal tubes 25mm outer diameter 1m long arranged in a 8 x 8 square array. Calculate the rate of condensation if the tube surface is maintained at 100°C. The properties of saturated water at 105°C are ρ = 954.7 kg/m^3, K = 0.684 W/m^{2}K, $\mu = 271 \times 10^{-6}$ kg/ms and h_{fg} = 2243.7 kJ/kg. (08 Marks)

Module-5

9 a. State and explain: i) Kirchhoff's law; ii) Plank's law; iii) Wein's displacement law iv) Lambert's cosine law. (08 Marks)

b. An enclosure measures 1.5m × 1.7m with a height of 2m. The walls and ceiling are maintained at 250°C and the floor at 130°C. The walls and ceiling have an emissivity of 0.82 and the floor 0.7. Determine the net radiation to the floor. (08 Marks)

OR

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

b. Two large parallel plates with emissivity 0.5 each are maintained at different temperature and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. (08 Marks)

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