CBCS SCHEME

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Sixth Semester B.E. Degree Examination, July/August 2022
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

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 10 mm thick. On the otherside of the heater the material has a thermal conductivity of 0.05 W/m°K and 25 mm thick. The convection heat transfer coefficient 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 dessipation for each square meter of the mattress is 5 kW. 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. **(14 Marks)**

OR

2 a. A furnace wall is made up of three layers of thickness 250 mm, 100 mm and 150 mm 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 coefficient of 25 W/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. **(10 Marks)**

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

Module-2

3 a. A thin rod of copper K = 100 W/m°C, 12.5 mm in diameter spans between two parallel plates 150 mm apart Air flows over the rod providing a heat transfer coefficient of 50 W/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. **(10 Marks)**

b. What is physical significance of critical thickness of insulation? Derive an expression for critical thickness of insulation for a sphere. **(10 Marks)**

OR

4 a. Derive an expression for temperature distribution under lumped system analysis in terms Biot and Fourier numbers. **(10 Marks)**

b. An egg with mean diameter of 40 mm 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 = 2 KJ/kg°C and h = 100 W/m^2°C. **(10 Marks)**

Module-3

5 a. Explain briefly with sketches:
(i) Velocity boundary layer thickness.
(ii) Thermal boundary layer thickness. **(10 Marks)**

b. A nuclear reactor with its core constructed of parallel vertical plates 2.2 m high and 1.4 m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960°C while the lowest allowable temperature of bismuth is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. For the convective coefficient the appropriate correlation is $N_a = 0.13(Gr.Pr)^{0.333}$. **(10 Marks)**

OR

6 a. Air at standard conditions of 760 mm Hg at 20°C flows over a flat plate at 3 m/sec. The plate is 50 cms × 25 cms. Find the heat lost per hour if air flow is parallel to 50 cms side of the plate. If 25 cms side is kept parallel to the air flow, what will be effect on heat transfer? Temperature of the plate is 100°C. **(10 Marks)**

b. With the help of dimensional analysis derive the expression which relates Reynolds number, Nusselt number and Prandtl number. **(10 Marks)**

Module-4

7 a. With assumptions determine L.M.T.D for parallel flow heat exchanger. **(10 Marks)**

b. In an open heart surgery under hypothermic conditions, the patients blood is cooled before the surgery and rewarmed afterwords. It is proposed that a concentric tube counter flow heat exchanger of length 0.5 m is to be used. For this purpose, with a thin walled inner tube having a diameter of 55 mm. 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 $U_o = 500$ W/m^{2}K, C_P of blood = 3.5 kJ/kgK, C_P of water = 4.183 kJ/kg.K. **(10 Marks)**

OR

8 a. Explain the different regimes of pool boiling using an appropriate boiling curve. Indicate CHF and Leiden Frast points on it. **(10 Marks)**

b. A vertical tube of 60 mm outside diameter and 1.2 m long is exposed to steam at atmospheric pressure. The outer and surface of the tube is maintained at a temperature of 50°C by circulating cold water through the tube. Calculate the following:

(i) The rate of heat transfer to the coolant.

(ii) The rate of condensation of steam. **(10 Marks)**

Module-5

9 a. State and explain :

(i) Kirchoff's law

(ii) Plank's law.

(iii) Wein's displacement law

(iv) Lambert's Cosine law

(10 Marks)

b. An enclosure measures 1.5m × 1.7m with a height of 2 m. 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. **(10 Marks)**

OR

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

b. Two large parallel plates, with emissivities 0.4 ($\in_1$) and 0.8($\in_2$) exchange heat by radiation. If a polished aluminium shield ($\in_3 = 0.05$) is placed between them, calculate the percentage reduction in heat transfer. **(10 Marks)**

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