Register No.: ..... Name: .....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SIXTH SEMESTER B.TECH DEGREE EXAMINATION (S), AUGUST 2023
MECHANICAL ENGINEERING
(2020 SCHEME)

Course Code: **20MET302**

Course Name: **Heat and Mass Transfer**

Max. Marks: **100** **Duration: 3 Hours**

Use of Heat and Mass Transfer data book and Steam table are permitted

PART A

(Answer all questions. Each question carries 3 marks)

1. Discuss thermal contact resistance related to composite geometries
2. Explain Biot number. How it is used for classifying different bodies
3. Using Reynolds-Colburn analogy, prove that for laminar flow over a flat plate $Nu_{avg} = 0.664\ Re^{0.5}\ Pr^{0.333}$
4. Discuss any three non-dimensional numbers used in convection
5. Explain the effectiveness of a heat exchanger
6. Compare film wise and drop wise condensation
7. What is Wein's Displacement Law? Explain with the help of Planks distribution
8. Explain the concept of black body
9. Discuss the analogy between heat transfer and mass transfer
10. Discuss Fick's Law of diffusion

PART B

(Answer one full question from each module, each question carries 14marks)

MODULE I

11. a) Derive general heat conduction equation in Cartesian coordinates with relevant figure? Apply this equation for the design of two dimensional, unsteady heat conduction system without internal heat generation? (10)
    b) Discuss Fourier's law of heat conduction (4)

OR

12. a) A steel pipe with 50 mm outside diameter is designed such that it is covered with two layers of insulation. The inner layer is 7.5 mm thick and has K=0.3 W/mK & top layer is 25 mm thick and K=0.12 W/mK. Pipe wall is at 315 °C and outside temperature is 25°C. The outside convective heat transfer coefficient is 16 (9)

W/m²K. Determine the surface temperatures and heat loss per meter length for 10 minutes?

b) Explain lumped system analysis. Derive an expression for temperature distribution for a lumped body (5)

MODULE II

13. a) Explain the development of velocity and thermal boundary layers for an internal flow with relevant figures? (7)

b) A plate heater is designed such that its dimensions are 600 mm x 300 mm. Air at 25°C flows past heater at 2.5 m/s and is maintained at a uniform temperature at 95°C. Calculate the heat loss from the plate, if the air flows parallel to the 600 mm side? How would this heat loss be affected if the flow of air is made parallel to the 300 mm side? (7)

OR

14. a) Calculate the rate of free convection heat loss from a 30 cm diameter sphere maintained at 90°C and exposed to ambient air at 20°C? (8)

b) Explain the development of velocity and thermal boundary layers for an external flow with relevant figures? (6)

MODULE III

15. a) A double pipe counter flow heat exchanger is designed with water flows at the rate of 65 kg/min and is heated from 50°C to75°C by oil flowing through the tube. The specific heat of the oil is 1.780 kJ/kgK. The oil enters heat exchanger at 115°C and leaves at 75°C. The overall heat transfer co-efficient is 340 W/m²K. Assume tube diameter as 25 mm and using LMTD method, determine (9)

(i) Heat transfer rate
(ii) Heat exchanger area
(iii) Length of tube required

b) With the help of neat diagram explain the pool boiling process for water (5)

OR

16. a) Derive an expression for Log Mean Temperature Difference for a parallel flow heat exchanger. (8)

b) Discuss the classification of heat exchanger (6)

MODULE IV

17. a) Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures of 527°C and 127°C respectively. A radiation shield having emissivities of 0.05 on both sides is placed between them. Calculate (8)

(i) Heat transfer rate between them without shield.
(ii) Heat transfer rate between them with shield.

b) Two rectangular surfaces are perpendicular to each other with a common edge of 2 m. The horizontal plane is 2 m long and vertical plane is 3 m long. Vertical plane is at 1200 K and has an emissivity of 0.4. The horizontal plane is 291 K and has a emissivity of 0.3. Determine the net heat exchange between the planes? (6)

OR

18. a) Define shape factor. A sphere of diameter D is enclosed in another sphere of diameter 2D. Stating the reciprocity theorem, find the shape factor of the outer cylinder with respect to itself? (7)

b) Emissivities of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per square meter of the plates? If a polished aluminium shield (Є = 0.05) is placed between them. Find the percentage reduction in heat transfer? (7)

MODULE V

19. a) Explain steady state equi-molar counter diffusion? Show that the diffusion coefficient remains same in the process? (7)

b) A pan of 40 mm deep, is filled with water to a level of 20 mm and is exposed to dry air at 30°C. Calculate the molar flux of water. Take mass diffusivity as 0.25×10^{-4} m^2/s. (7)

OR

20. a) Dry air at 30°C and 1 atm flows over a wet flat plate 600 mm long at a velocity of 50 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion co-efficient of water vapour in air, $D = 0.26 \times 10^{-4}$ m^2/s (8)

b) Define Schmidt Number, Lewis Number and Sherwood Number? (6)

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