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

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SECOND SEMESTER M.TECH DEGREE EXAMINATION (Regular), JULY 2022

(2021 Scheme)

Course Code: **21MD206-E**

Course Name: **Design of Heat and Mass transport systems**

Max. Marks: **60** **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. How electrical analogy is applied in the design of heat transfer systems?
2. Explain Biot number. How it is used for classifying different bodies?
3. Discuss any three non-dimensional numbers used in the design of convection systems?
4. Explain heat pipe. Also discuss the design condition for the operation of heat pipe?
5. Explain any two laws governing radiation heat transfer?
6. What is shape factor related to radiation heat transport?
7. State and explain the governing law for diffusion mass transfer?
8. Define Schmidt Number, Lewis Number and Sherwood Number?

PART B

(Answer one full question from each module, each question carries 6 marks)

MODULE I

9. Derive general heat conduction equation in cylindrical coordinates with relevant figure? Apply this equation for the design of two dimensional, steady heat conduction system with internal heat generation? (6)

OR

10. A carbon steel rod of length 50 cm and diameter 10 mm (K = 40 W/mK) is designed such that its base is at a temperature of 500 °C and ambient temperature 28°C. The film coefficient is 10 W/m²K. Assuming the tip is perfectly insulated, determine the (6)

i) Heat transfer rate from the fin
ii) Fin efficiency
iii) Temperature of the fin at 10 cm from the base

iv) Fin effectiveness

MODULE II

11. Derive an expression for temperature profile of a lumped body & plot the profile. (6)

OR

12. An aluminium sphere of mass 5.5 kg and initially at a temperature of 290°C is suddenly immersed in a fluid at 15°C with heat transfer co efficient 58 W/m^2K. Estimate the time required to cool the aluminium to 95°C for aluminium take ρ = 2700 kg/m^3, C = 900 J/kg K, k = 205 W/mK. (6)

MODULE III

13. A vertical pipe is designed to have a diameter of 80 mm and 2 m height. The pipe is maintained at a constant temperature of 120°C. the pipe is surrounded by still atmospheric air at 30°C. Find heat lost by the vertical pipe? (6)

OR

14. Using Buckingham-π theorem, Show that the Nusselt number varies as a function of Reynolds number and Prandtl number in forced convection systems? (6)

MODULE IV

15. Water at the rate of 4 kg/s is heated from 35°C to 55°C in a shell and tube heat exchanger. On the shell side one pass is assumed with water as the heating fluid and at a mass flow rate of 1.9 kg/s, and entering the heat exchanger at 95°C. The overall heat transfer coefficient is 1420 W/m^2K and the average water velocity in the 2 cm diameter tubes is 0.4m/s. Because of space limitations, the tube length must not exceed 3.1 m. Determine the number of tube passes, the number of tubes per pass and the length of the tubes, keeping in mind the design constraints? (6)

OR

16. A parallel flow heat exchanger is designed for cooling 4.2 kg/min of hot liquid of specific heat 3.5 kJ/kg K at 130°C. A cooling water of specific heat 4.18 kJ/kg K is used for cooling purpose of a temperature of 15°C. The mass flow rate of cooling water is 17 kg/min. Determine the following. (6)
    - (i) Outlet temperature of liquid
    - (ii) Outlet temperature of water
    - (iii) Effectiveness of heat exchanger

MODULE V

17. Show that the relation for radiation heat exchange between two gray surfaces is (6)

$$(Q_{12})_{net} = \frac{A_1\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1} + \frac{1}{\bar{F}_{1-2}} + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2}}$$

OR

18. Emissivity's 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 (6)

a polished aluminium shield (Є = 0.05) is placed between them. Find the percentage of reduction in heat transfer?

MODULE VI

19. 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, $D = 0.26 \times 10^{-4}$ m2/s (6)

OR

20. Explain isothermal evaporation of gas through a stagnant gas film? Derive the relation for mass flux of the diffusing component? (6)

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