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Question Paper Code : R 40929

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2025.

Sixth/Eighth Semester

Mechanical Engineering

ME8693 – HEAT AND MASS TRANSFER

(Common to : Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define thermal diffusivity.
2. Write the physical significance of Biot and Fourier number.
3. Draw the hydrodynamic boundary layer for a flat plate.
4. What do you understand by free and forced convection?
5. Differentiate film wise and drop wise condensation.
6. What is fouling factor?
7. Write the significance of reflection along with types.
8. What do you mean by the term reciprocity theorem?
9. State Ficks law of diffusion?
10. Calculate the diffusion coefficient of ammonia in air at 20°C and 1 atm pressure.

PART B — (5 × 13 = 65 marks)

11. (a) Derive a relation to trace the maximum temperature in a plane wall in which the endothermic chemical reactions take place while one dimensional heat is being transferred by conduction mode alone step by step.

Or

- (b) A person puts a few apples into the freezer at -15°C to cool them quickly for guests who are about to arrive. Initially, the apples are at a uniform temperature of 20°C , and the heat transfer coefficient on the surfaces is $8 \text{ W/m}^2\text{C}$. Treating the apples as 9-cm-diameter spheres and taking their properties to $\rho = 840 \text{ kg/m}^3$, $C_p = 3.81 \text{ kJ/kg}^{\circ}\text{C}$, $K = 0.418 \text{ W/m}^{\circ}\text{C}$. and $\alpha = 1.3 \times 10^{-7} \text{ m}^2/\text{s}$. determine the center and surface temperatures of the apples in 1 h. Also determine the amount of heat transfer from each apple.
12. (a) Assuming a man as a cylinder of 40 cm diameter and 1.72 m high with a surface temperature of 37°C . Calculate the heat lost from its body, while standing in wind flowing at 20 km per hour at 17°C .

Or

- (b) Air at 2 atm and 200°C is heated as it flows through a tube with a diameter of 2.54 cm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant-heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature, all along the length of the tube.
13. (a) Water is to be cooled from 80°C to 50°C in a cross flow heat exchanger. Cooling is achieved by air which flows over the tubes, Flow rate of water is 0.14 kg/s . Flow rate of air is 0.60 kg/s . Inlet temperature of air is 28°C . The overall heat transfer coefficient for the system is $72 \text{ W/m}^2\text{K}$. Calculate Heat transfer area needed. Number of Transfer units and Effectiveness of heat exchanger.

Or

- (b) Derive effectiveness relation for a heat exchanger using parallel flow arrangement with neat sketch.
14. (a) Two thin radiation shields with emissivities of $\varepsilon_3 = 0.10$ and $\varepsilon_4 = 0.15$ on both sides are placed between two very large parallel plates which are maintained at uniform temperatures $T_1 = 600 \text{ K}$ and $T_2 = 300 \text{ K}$ and have emissivities $\varepsilon_1 = 0.6$ and $\varepsilon_2 = 0.7$, respectively. Determine the net rates of radiation heat transfer between the two plates with and without the shields per unit surface area of the plates and the temperatures of the radiation shields in steady operation.

Or

- (b) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C.
- (i) monochromatic emissive power at 1.2 μm length
 - (ii) wavelength at which the emission is maximum
 - (iii) maximum emissive power
 - (iv) total emissive power
15. (a) Air at 30°C temperature flows at 45 m/s past a wet flat plate 0.5 m long. Make calculations for the mass transfer coefficient of water vapour in air. Assume that the water vapour content of air initially is negligible and take the following thermos-physical properties of air:
- $D = 0.256 \times 10^{-4} \text{ m}^2/\text{s}$, $\mu = 1.86 \times 10^{-5} \text{ kg/ms}$, $C_p = 1.005 \text{ kJ/kg}^\circ\text{C}$,
 $\text{Pr} = 0.701$ and $\rho = 1.165 \text{ kg/m}^3$.

Or

- (b) Discuss about molecular diffusion, thermal diffusion, pressure diffusion and forced diffusion.

PART C — (1 × 15 = 15 marks)

16. (a) A solar collector consists of a horizontal copper tube of outer diameters 5 cm enclosed in a concentric thin glass tube of diameter 9 cm. Water is heated as it flows through the tube, and the annular space between the copper and the glass tubes is filled with air at 1 atm pressure. The emissivities of the tube surface and the glass cover are 0.85 and 0.9 respectively. During a clear day, the temperatures of the tube surface and the glass cover are measured to be 60°C and 40°C, respectively. Determine the rate of heat loss from the collector by natural convection and radiation per meter length of the tube.

Or

- (b) Explain the NTU method used in heat exchanger analysis.

