Code No: R2032031 **R20** SET -1

III B. Tech II Semester Supplementary Examinations, December -2023
HEAT TRANSFER
(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

Answer any **FIVE** Questions **ONE** Question from **Each unit**
All Questions Carry Equal Marks
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UNIT-I

1. a) Derive the expression of general heat conduction equation in Cartesian coordinate system mentioning the assumptions made. [7M]
   b) A steel rod (k=30 W/mK), 1 cm in diameter and 5 cm long protrudes from a wall which is maintained at 100^0C. Assuming appropriate boundary condition at the tip, determine the temperature at the midway of the fin. The fin is dissipating heat into an ambient at 30^0C with a heat transfer coefficient of 50 W/m^2K. [7M]

(OR)

2. a) Derive the expression for the temperature distribution through a rectangular fin with insulated tip. Make necessary assumptions. [7M]
   b) The hot combustion gases at 150^0C flows through a hollow cylindrical pipe of 10 cm inner diameter and 12 cm outer diameter. The pipe is located in an ambient at 30^0C and the thermal conductivity of the pipe material is 200 W/mK. Neglecting the surface resistance, determine the temperature at a point halfway between the inner and outer surfaces. If there is heat generation in the pipe at the rate of $1X10^6$ W/m^3, what would be the temperature at the same location? [7M]

UNIT-II

3. a) Using the Dimensional Analysis, obtain the functional relationship for the variables affecting the forced convection. [7M]
   b) A 12 cm diameter cylindrical bar, initially at a uniform temperature of 40^0C, is placed in a medium at 650^0C with a convection coefficient of 22 W/m^2K. Determine the time required for the centre to reach 255^0C. What is the instantaneous heat transfer rate from the surface at this instant. Thermophysical properties of the material are: k= 20 W/mK, ρ = 580 kg/m^3 and C=1050 J/kg-K. [7M]

(OR)

4. a) A hollow sphere (k=30 W/mK) of inner radius 6 cm and outer radius 8 cm has a heat generation rate of $4X10^6$ W/m^3. The inner surface is insulated, while the heat is dissipated through the outer surface by convection, into an ambient at 100^0C, with a heat transfer coefficient of 300 W/m^2K. Determine the maximum temperature in the sphere. [7M]
   b) A mild steel sphere of 15 mm in diameter initially at 625^0C is exposed to a current of air at 25^0C, with a convection coefficient of 120 W/m^2K. Calculate, a) Time required to cool the sphere to 100^0C, (b) Initial cooling rate of the sphere and (c) Total energy transferred during first one minute. The thermo-physical properties of mild steel are, k=43 W/mK, α = 0.045 m^2/s, C=474 J/kg-K and ρ=7850 kg/m^3. [7M]

UNIT-III

5. a) Air at a temperature of 25^0C is blown across a flat plate at a mean velocity of 7.5 m/s. If the plate surface temperature is 575^0C, make calculations for the heat transferred per metre width from both sides of the plate over a distance of 20 cm from the leading edge. [7M]

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b) Air at atmospheric pressure and at 40^0Cis heated as it flows through a 30 cm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at 100^0C, determine the length of the tube needed to increase the air temperature by 20^0C. [7M]

(OR)

6. a) Calculate the rate of heat loss from a human body which may be considered as a vertical cylinder of 30 cm diameter and 175 cm high in still air at 15^0C. The skin temperature is 35^0C. [7M]

b) Air at 20^0C flows past a flat plate with a velocity of 4 m/s. The plate is of 1 m length and is maintained at a uniform temperature of 60^0C. Find the velocity and thermal boundary layer thickness at the trailing edge of the plate. Also, determine the amount of heat dissipated from the plate. [7M]

UNIT-IV

7. a) (i) Explain the types of condensation mechanisms with suitable examples. [7M]
(ii) Give the applications of pool boiling heat transfer.

b) A counter flow concentric tube heat exchanger is used to cool the lubricating oil of a large industrial gas engine. The oil flows through the tube at 0.19 kg/s (C=2.18 kJ/kgK), while the coolant water flows in the annulus in the opposite direction at a rate of 0.15 kg/s (C=4.18 kJ/kg-K). The oil enters the heat exchanger at 425 K and leaves at 345 K, while the coolant enters at 285 K. What should be the length of heat exchanger to perform this duty, if the heat transfer coefficient on oil side is 2250 W/m^2K and water side is 5650 W/m^2K. The tube has a mean diameter of 12.5 mmand conductive resistance of wall is negligible. [7M]

(OR)

8. a) (i) Give the classification of heat exchangers based on the flow direction. [7M]
(ii) Name the heat exchangers that are known as compact type heat exchanger.

b) A hear exchanger is to be designed to condense 8 kg/s of an organic liquid (T_{sat} = 80^0C; h_{fg} = 600 kJ/kg) with cooling water available at 15^0C and at a flow rate of 60 kg/s. The overall heat transfer coefficient is 480 W/m^2K. Determine, the number of tubes required if the tubes are to be 25 mm OD, 2 mm thickness and 4.58 m long. [7M]

UNIT-V

9. a) Obtain the relationship between the emissive power of a surface and its absorptivity. Make the necessary assumptions. [7M]

b) The top and bottom surfaces of a cylindrical furnace of 60 cm in diameter and 100 cm high are maintained at 1000K and 700K. Their respective emissivities are 0.8 and 0.7. Assuming cylindrical wall to be a refractory surface, compute the heat transfer from the top surface to the bottom surface. [7M]

(OR)

10. a) Obtain the shape factors between different surfaces of an equilateral triangle when it is placed in a closed enclosure. [5M]

b) Two parallel plates each of emissivity 0.8 are maintained at temperatures of 400K and 600K in an evacuated space. A screen of emissivity 0.05 is now introduced between these plates. Determine the temperature of the screen and also heat flux per unit area of the screen. [9M]