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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B E	**Semester: IV**
Branch: Aerospace Engineering	**Duration: 3 hrs.**
Course Code: 19AE4DCAHT	**Max Marks: 100**
Course: Aero-Heat & Mass Transfer	**Date: 20.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Heat Transfer Data Hand Book is permitted.

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Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

UNIT - I

1 a) With a suitable example explain the modes of heat transfer with corresponding governing laws. **8**

b) A wire 1.5 mm in dia and 150 mm long is submerged in water at atmospheric pressure. An electric current is passed through the wire and is increased until the water boils at 100°C. Under the condition if convective heat transfer co-efficient is 4500 W/m^2°C. Find how much electric power must be supplied to the wire to maintain the wire to maintain the wire surface at 120°C? **7**

c) Explain the Fick's law of diffusion. **5**

UNIT - II

2 a) What do you mean by critical thickness of insulation? Derive an expression for critical thickness of insulation for a cylinder. **8**

b) A plane wall of a refrigerated van is made of 1.5 mm steel sheet (ks = 25 W/mK) at the outer surface, 10 mm plywood (kp = 0.05 W/mK) at the inner surface and 20 mm glass wool (kg = 0.01 W/mK) in between the outer and inner surfaces. The temperature of the cold environment inside the van is -15°C, while the outside surface is exposed to a surrounding ambient at 24°C. The average values of convective heat transfer coefficients at the inner and outer surfaces of the wall are 12 W/m^{2}K and 20 W/m^{2}K respectively. The surface area of the wall is 0.75 m^2. Determine the **8**

i) individual components of the thermal resistance to heat flow
ii) the rate of heat flow through the wall
iii) the temperatures at
a. the outer surface of the wall
b. the interface between steel sheet and glass wool
c. the interface between glass wool and plywood and
d. the inner surface of the wall.

c) Write a note on thermal diffusivity. **4**

OR

3 a) A turbine blade 60 mm long with sectional area 4.5 x 10^{-4} m^2 and perimeter 0.12 m is of stainless steel (k = 15 W/m-K). The temperature at the blade root is 480°C. The blade is exposed to a hot gas at 870°C and the surface heat transfer co-efficient is 400 W/m^2-K and neglecting the heat transfer at the blade tip. Determine the temperatures at the locations 10 mm, 20 mm, 30 mm, 40 mm, 50 mm and 60 mm on the turbine blade from the root and draw the temperature distribution on the turbine blade. **8**

b) A 5 cm thick iron plate [K = 60 W/ (m°C), Cp = 460 J/kg °C), ρ = 7850 kg/m^3 and α = 1.6 x 10^{-5} m^2/s] is initially at Ti = 225°C. Suddenly, both surfaces are exposed to an ambient at T∞ = 25°C with a heat transfer co-efficient h = 500 W/m^2°C). Calculate the center temperature at t = 2 min after the start of the cooling. Calculate the temp at the depth 1.0 cm from the surface at t = 2 min after the start of the cooling. Calculate the energy removed from the plate per square meter during this time. **8**

c) Explain the Biot number and Fourier number. **4**

UNIT - III

4 a) Using Buckingham π theorem, Obtain the relationship between various non-dimensional numbers for free convection heat transfer. **8**

b) The velocity profile u(x,y) for the boundary layer flow over a flat plate is given by $\left(\frac{U(x,y)}{U_\infty}\right) = \frac{3}{2}\left(\frac{y}{\delta(x)}\right) - \frac{1}{2}\left(\frac{y}{\delta(x)}\right)^3$; Where the boundary layer thickness is $\delta(x) = \sqrt{\frac{280\, \nu x}{13\, u_\infty}}$; **8**

i) Develop an expression for the local drag coefficient

ii) Develop an expression for the average drag coefficient C_m over a distance x = L from the leading edge of the plate.

c) With a neat sketch highlight the hydrodynamic entrance length and fully developed flow. **4**

OR

5 a) Explain the following **10**

i) Nusselt number
ii) Prandtl number
iii) Grashoff number
iv) Stanton number

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b) In a wind tunnel, 15ºC air at 5 m/s flows over a flat plate (1 m x 0.8 m) that is aligned parallel to the flow directions. The plate temperatue is 35 ºC. One of the sides of the plate is arranged to be a parallel to the flow direction, such that the heat transfer is less. Estimate (i) the rate of heat transfer from the plate from one side (top surface) and (ii) the initial rate of cooling (dT/dt) (ºC /h) if the mass of the plate is 5 kg and the specific heat of the plate is 875 J/kg K (iii) if the air flow is turned off, compute the heat flow rate from the upper surface of the plate in still air at 15 ºC (iv) what is the percentage change in the heat flow rate? **10**

UNIT - IV

6 a) Two parallel plates, 4 m^2 area each are placed with a gap of 5 mm separating them. One plate has a temperature of 800 K, emissivity 0.6, while other plate has a temperature of 300 K, emissivity 0.9. Find the net energy exchanged between them suppose if polished sheet of emissivity 0.1 on both side is centrally placed between the plates, what will be the temperature of the sheet ? How much would the heat transfer be altered ? **10**

b) A cross flow heat exchanger in which both fluids are unmixed is used to heat water with an engine oil. Water enters at 30°C and leaves at 25°C at a rate of 1.5 kg/s while the engine oil with Cp = 2.3 kJ/kg K enters at 120°C with a mass flow rate of 3.5 kg/s. The heat transfer surface area is 30 m^2. Calculate the overall heat transfer coefficient using LMTD method. **10**

UNIT - V

7 a) Sketch and explain the regimes of pool boiling. **8**

b) Saturated steam at 65°C condenses on a vertical tube with an outer diameter of 25mm, which is maintained at 35°C. Determine the length of tube needed, if the condensate flow needed is 6 x 10^{-3} kg/s. **8**

c) What do you mean by ablative heating? **4**

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