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

Autonomous Institute Affiliated to VTU

October 2023 Semester End Main Examinations

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

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of heat transfer data handbook is permitted.

UNIT - I

1	a)	With suitable examples, explain the various modes of heat transfer and its law governing equation.		**8**
	b)	The average forced convective heat transfer coefficient for a hot fluid flowing over a cold surface is 200 W/(m^2°C). The fluid temperature upstream of the cold surface is 100°C, and the surface is held at 20°C. Determine the heat transfer rate per unit surface area from the fluid to the surface.		**6**
	c)	Compare Thermodynamics and Heat transfer analysis.		**6**

UNIT - II

2	a)	Derive an expression for 3D heat conduction equation for a Cartesian co-ordinates.		**10**
	b)	A furnace wall is made of inside silica brick (k = 1.6 W/mK) outside magnesia brick (k = 4.8 W/mK) 10 cm thick each. If the inner and outer surfaces are exposed to fluid temperature of 820°C and 120°C respectively. Find the heat flow through the wall per m^2 per hour. Assume a contact resistance of 0.002 m^2 K/W. Determine the rate of heat transfer and draw the temperature profile through the composite wall. The inside and outside heat transfer coefficients are 35 W/m^2K and 12 W/m^2 K respectively.		**10**

OR

3	a)	Steel ball bearing k = 50 W/mK, $\alpha = 1.3 \times 10^{-5}$ m^2/s having a dia of 40 mm are heated to a temperature of 650°C and then quenched in a tank of oil at 55°C. If the heat transfer coefficient between the ball bearing and oil is 300 W/m2K. Determine i) duration of time the bearings must remain in oil to reach a temperature of 200°C ii) the total amount of heat removed from each bearing during this time iii) the instantaneous heat transfer rate from the bearings when they are first immersed in oil and when they reach 200°C.		**10**

b) Define critical thickness and derive an expression for critical radius of insulation for sphere. **10**

UNIT - III

4 a) Using Buckingham's theorem, obtain the relationship between various non-dimensional numbers for free convection heat transfer **10**

b) An approximate expression for the velocity profile for a laminar boundary layer flow along a flat plate is given by, **10**

$\left(\frac{U(x,y)}{U_\infty}\right) = 2\frac{y}{\delta(x)} - 2\left(\frac{y}{\delta(x)}\right)^3 + \left(\frac{y}{\delta(x)}\right)^4$ Where boundary layer thickness,

$\delta(x) = 5.83\ \frac{x}{Re_x^{1/2}}$. i) Develop an expression for local drag coefficient C_x. Also ii) develop an expression for average drag coefficient C_m over a distance x = L.

OR

5 a) Explain the velocity boundary layer and thermal boundary layer over a flat plate with a neat sketch. **6**

b) Highlight the significance of Nusselt's number and Prandtl number **4**

c) Air at atmospheric pressure and 200°C flows over a plate and maintained at 120°C. The velocity is 5 m/s. The plate is 15 mm wide. Calculate the thickness of hydrodynamic and thermal boundary layer and local heat transfer coefficient at distance 0.5 m from leading edge. **10**

UNIT - IV

6 a) Calculate the net radiation heat exchange per meter square area for 2 large parallel planes at the temperature 427°C and 27°C. Take ε for hot and cold plates as 0.9 and 0.6 respectively. If a polished Al sheet is placed with ε= 0.04. Find the percentage reduction in heat transfer. **10**

b) In a food processing plant, a brine solution is heated from 8°C to 14°C in a double-pipe heat exchanger by water entering at 55°C and leaving at 40°C at the rate of 0.18 kg/s. If the overall heat transfer coefficient is 800 W/(m^2 K), determine the area of heat exchanger required (i) for a parallel flow arrangement, and (ii) for a counter flow arrangement. Take cp for water = 4.18 kJ/(kg K). **10**

UNIT - V

7 a) A vertical square plate 30 cm x 30 cm is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and the mass of steam condensate per hour. **10**

b) Explain the different boiling regimes with a neat sketch. **10**

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