CBCS SCHEME

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17AE53

# Fifth Semester B.E. Degree Examination, July/August 2022
# Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

**Note: 1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
**2.** ***Heat transfer data handbook is permitted.***





## Module-1

1 a. Explain Fourier's law of conduction. **(06 Marks)**
b. Explain types of mass transfer with examples. **(08 Marks)**
c. Briefly explain Fick's law of diffusion. **(06 Marks)**

**OR**

2 a. Explain Newton's law of cooling and also the governing equation for convective heat transfer. **(08 Marks)**
b. Briefly explain Stefan Boltzmann law. **(08 Marks)**
c. Explain combined heat transfer mechanism. **(04 Marks)**

## Module-2

3 a. Derive the three dimensional general heat conduction equation in Cartesian coordinates and state the assumptions. **(10 Marks)**
b. A furnace wall consists of 25cm of fire brick 15cm of steel, 55mm layer of brick and a 3mm thick magnesia on the outside. If the inside surface temperature of the furnace is 1600°C and outside surface temperature is to be 80°C.Calculate the temperature between the layers and the heat loss per unit area of furnace wall K for fire brick is 1.28w/m°C. For steel is 69.77W/m°C, brick is 0.814W/m°C and magnesia is 0.0698W/m°C **(10 Marks)**

**OR**

4 a. Obtain temperature distribution equation for system with negligible internal resistance and hence obtain expression for total heat transfer through it in terms of Biot and Fourier number. **(10 Marks)**
b. A 50cm × 50cm copper slab 6.25mm thick has a uniform temperature of 300°C. Its temperature is suddenly lowered to 36°C. Calculate the time required for the plate to reach the temperature of 108°C. Assume ρ = 9000Kg/m$^3$, C = 0.38kJ/Kg°C. Take E = 370W/m°C, h = 90W/m°C. **(10 Marks)**



## Module-3

5 a. Obtain an empirical expression in terms of dimensional number for heat transfer coefficient in the case of forced convection heat transfer. **(10 Marks)**
b. Dry air at atmospheric pressure and 20°C is flowing with a velocity of 3m/s along the length of a long flat plate 0.3m wide maintained at 100°C. Calculate the following quantities at x = 0.3m. i) Boundary layer thickness ii) Average friction coefficient iii) Thickness of thermal boundary layer iv) Rate of heat transfer from the plate between x = 0 and x = x by convection. **(10 Marks)**

**OR**

6 a. Explain velocity boundary layer theory and thermal boundary layer theory with suitable figures. **(10 Marks)**

b. Explain the significance of following :
i) Grashoff number ii) Nusselt number iii) Prandtl number. **(06 Marks)**

c. A horizontal plate 1m × 0.8m is kept in a water tank with the water surface at 60°C providing heat to warm stagnant water at 20°C. Determine the value of convection heat transfer coefficient. **(04 Marks)**

## Module-4

7 a. Explain : i) Stefan Boltzman law ii) Black body. **(04 Marks)**

b. Obtain an expression for the rate of heat transfer when radiation shield is introduced between two parallel plates. **(08 Marks)**

c. Consider two large parallel plates, one at 1000K with emissivity 0.8 and other is at 300K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiation shield. **(08 Marks)**

**OR**

8 a. With assumptions, derive an expression for LMTD for a parallel flow heat exchanger. **(10 Marks)**

b. An oil cooler consists of straight tube of 2cm outer diameter and 1.5cm inner diameter, enclosed within a pipe and concentric with it. The external pipe is well insulated. The oil flows through the tube at 0.05Kg/s ($C_p$ = 2kJ/Kg K) and cooling fluid flows in the annulus in the opposite direction at the rate of 0.1Kg/s, ($C_p$ = 4.2kJ/Kg K) The oil enters the cooler at 180°C and leaves at 80°C, while cooling liquid enter the cooler at 30°C. Calculate the length of the pipe required if heat transfer coefficient from oil to the surface is 1720W/$m^2$ K and from metal surface to coolant is 3450W/$m^2$K. Neglect the resistance of the tube wall. **(10 Marks)**

## Module-5

9 a. Explain heat distribution in rocket thrust chamber. **(08 Marks)**

b. Explain ablative heat transfer. **(06 Marks)**

c. Explain aerodynamic heating in Aerospace engineering. **(06 Marks)**

**OR**

10 a. Briefly explain the species conversation equation. **(10 Marks)**

b. The flow rates of hot and cold fluids running through a parallel flow heat exchanger are 0.2 and 0.5 Kg/s respectively. The inlet temperature on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficient on both sides are 650W/$m^2$ K. Calculate the area of heat transfer (for hot and cold fluid) $C_p$ = 4.2kJ/Kg K. **(10 Marks)**

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