# CBCS SCHEME

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**18AU62**

## Sixth Semester B.E. Degree Examination, June/July 2023
## 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. Use of HMT data handbook is permitted.***



### Module-1

1 a. Derive the three dimensional heat conduction equation in Cartesian coordinates. **(10 Marks)**

b. A reactor's wall of 320 mm thick is made up of an inner layer of fire brick (k = 0.84 W/m°C) covered with a layer of insulation (k = 0.16 W/m°C). The reactor operates at a temperature of 1325°C and the ambient temperature is 25°C.
(i) Determine the thickness of firebrick and insulation.
(ii) Calculate the heat loss assuming the insulating material has a maximum temperature of 1200°C. **(10 Marks)**

**OR**

2 a. Derive the temperature distribution and heat conduction equation for Hollow sphere. **(10 Marks)**

b. A standard cast iron pipe (ID = 50 mm and OD = 55 mm) is insulated with 85% magnesium insulation (K = 0.02 W/m°C). Temperature at the interface between pipe and insulation is 300°C. The allowable heat loss through the pipe is 600 W/m. The temperature of outside surface of insulation must not exceed 100°C for safety. Determine :
(i) Minimum thickness of insulation
(ii) Temperature of inside surface of pipe assuming its conductivity as 20 $W/m^2{}°C$. **(10 Marks)**

### Module-2

3 a. Obtain an expression for temperature distribution and heat flow through a fin of uniform cross section with insulated end. **(10 Marks)**

b. A rod (K = 200 W/mK) 10 mm in diameter and 5 cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 30°C with convective heat transfer coefficient of 100 $W/m^2K$. Assuming other end insulated, determine:
(i) The temperature of the rod at 25 mm distance from the end at 100°C
(ii) Heat dissipation rate
(iii) Efficiency of fin **(10 Marks)**

**OR**

4 a. Derive an expression for instantaneous heat transfer and total heat transfer using lumped heat analysis for unsteady state heat transfer from a body to surroundings. **(10 Marks)**

b. A 50 cm × 50 cm copper slab 6.25 mm 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. Take $\rho$ = 9000 $kg/m^3$, C = 0.38 kJ/kg°C, K = 370 W/m°C and h = 90 $W/m^2{}°C$. **(10 Marks)**

## Module-3

5 a. Explain the significance of :
(i) Reynolds number (ii) Prandtl number (iii) Grashoff number
(iv) Stanton number (v) Nusselt number **(10 Marks)**

b. Air at atmosphere pressure of 40°C flows with a velocity of V = 5 m/s over a 2m long flat plate whose surface is kept at a uniform temperature of 120°C. Determine the average heat transfer coefficient over the 2 m length of the plate (Air at 1 atm and 80°C, $\nu = 2.107 \times 10^{-5}$ m$^2$/s, K = 0.03025 W/mK, Pr = 0.6965). **(10 Marks)**

**OR**

6 a. Explain the following briefly with sketches:
(i) Boundary layer thickness
(ii) Thermal boundary layer thickness **(10 Marks)**

b. Using dimensional analysis show that for free convection heat transfer $Nu = C\,Gr^m\,Pr^n$ with usual notations. **(10 Marks)**

## Module-4

7 a. Derive the expression for LMTD of a parallel flow heat exchanger. **(10 Marks)**

b. A counter flow heat exchanger is employed to cool 0.55 kg/s (Cp = 2.45 kJ/kg°C) of oil from 115°C to 40°C by the use of water. The inlet and outlet temperatures of cooling water are 15°C and 75°C respectively. The overall heat transfer coefficient is expected to be 1450 W/m$^2$°C using NTU method. Calculate the following:
(i) The mass flow rate of water
(ii) Effectiveness of heat exchanger
(iii) Surface area required **(10 Marks)**

**OR**

8 a. With a neat sketch, explain the different regimes of pool boiling. **(10 Marks)**

b. A vertical plate 350 mm high and 420 mm wide at 40°C is exposed to saturated steam at 1 atm. Calculate the following:
(i) Film thickness at the bottom of the plate
(ii) Average heat transfer coefficient
(iii) Total heat transfer **(10 Marks)**

## Module-5

9 a. Explain: (i) Stefan-Boltzman law (ii) Wein's displacement law (iii) Radiation shield
(iv) Radiosity (v) Black body **(10 Marks)**

b. Two large parallel plates having emissivity of 0.8 and 0.4 maintained at a temperature of 727°C and 227°C. A radiation shield having an emissivity of 0.05 on both sides is placed between the two plates. Calculate the percentage reduction in heat transfer rate due to shield. **(10 Marks)**

**OR**

10 a. Prove that total emissive power of a diffuse surface is equal to $\pi$ times the intensity of radiation. **(10 Marks)**

b. Two concentric spheres 210 mm and 300 mm in diameter are used to store liquid air (–153°C) in a room at 27°C. The space between the spheres is evaluated and surfaces of the spheres are highly polished as $\in = 0.03$. Find the rate of evaporation of liquid air per hour. **(10 Marks)**

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