

Roll No:

**BTECH**  
**(SEM V) THEORY EXAMINATION 2023-24**  
**HEAT AND MASS TRANSFER**

TIME: 3 HRS

M.MARKS: 100

Note: Attempt all Sections. If you require any missing data, then choose suitably.

**SECTION A**

1. Attempt all questions in brief.

Qno	Questions	CO
(a)	Discuss the effect of temperature on thermal conductivity of metals. Write SI unit of thermal conductivity.	1
(b)	Discuss the concept of thermal resistance.	1
(c)	Define unsteady state heat conduction.	2
(d)	Define effectiveness of fin and efficiency of fin.	2
(e)	Differentiate between natural and forced convection.	3
(f)	Draw velocity boundary layer over a flat plate.	3
(g)	Describe any 4 rules used in determination of radiation shape factor.	4
(h)	Explain black body and gray body.	4
(i)	Define Fouling factor used in analysis of heat exchanger.	5
(j)	What are the various modes of mass transfer?	5

**SECTION B**

2. Attempt any three of the following:

Qno	Questions	CO
(a)	Derive a general heat conduction equation for Cartesian (rectangular) coordinates	1
(b)	State the assumptions made in Lumped Parametric analysis. For transient heat conduction, derive the following- $\theta/\theta_i = \exp(-Bi.Fo)$ where $\theta = T - T_a$	2
(c)	Explain Reynolds analogy and colburn analogy. Obtain the expression for Nusselt Number for turbulent flow over flat plate using colburn analogy.	3
(d)	State and prove the reciprocity theorem used to determine shape factor.	4
(e)	Illustrate the following- i) Fick's Law of Mass diffusion. ii) Film-wise and drop-wise condensation.	5

**SECTION C**

3. Attempt any one part of the following:

Qno	Questions	CO
(a)	Derive the expression for critical radius of insulation for a cylinder. A 10 mm cable is to be laid in atmosphere of 20°C with outside heat transfer coefficient 8.5 W/m <sup>2</sup> °C. The surface temperature is likely to be 65°C due to heat generation. Will the rubber insulation (K=0.155 W/m <sup>2</sup> °C) be effective? If yes, determine the maximum effective thickness of insulation for maximum heat transfer rate.	1
(b)	Obtain the expression for steady state one dimensional heat transfer rate without heat generation through a hollow cylinder. A stainless steel tube (Ks=19W/mK) of 2 cm internal diameter 5 cm outer diameter is insulated with 3 cm thick asbestos (Ks=0.2 W/mK). If the temperature difference between the innermost and outermost surfaces is 600°C. Determine the heat transfer rate per unit length.	1

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4. Attempt any one part of the following: 10x1=10
- |     |   |   |
|-----|---|---|
| (a) | Derive the expression for temperature distribution for fin insulated at tip.  | 2 |
| (b) | The aluminium square fins (0.5 mm x 0.5 mm) of 10 mm length are provided on a surface of semiconductor device to carry 1 Watts of energy generated by electronic device. The temperature at surface of device should not exceed 80°C, when surrounding temperature is 40°C. Determine the number of fins required to carry out this duty. Neglect the heat loss from end of fins. $K_{\text{aluminium}} = 200 \text{ W/m}^\circ\text{C}$ and $h = 15 \text{ W/m}^2\text{ }^\circ\text{C}$ | 2 |
5. Attempt any one part of the following: 10x1=10
- |     |   |   |
|-----|---|---|
| (a) | Explain the following dimensionless numbers- Nusselt Number, Grashoff Number, Prandtl Number, and Stanton Number.   | 3 |
| (b) | Estimate The coefficient of heat transfer from a vertical plate (height and width=2m x 2m ) to the surrounding air at 25°C. The plate surface temperature is 150°C, Also calculate the rate of heat transfer from the plate. For air assume the kinematic viscosity as $16 \times 10^{-6} \text{ m}^2/\text{s}$ . The properties of air at film temperature are density $0.972 \text{ Kg/m}^3$ , $C_p = 1.0059 \text{ KJ/KgK}$ , $K = 3.13 \text{ W/mK}$ , $Pr = 0.69$ . The constant C and n in Nusselt number are 0.15 and 1/3. | 3 |
6. Attempt any one part of the following: 10x1=10
- |     |   |   |
|-----|---|---|
| (a) | Two large plates at temperatures 1000 K and 500 K have emissivity of 0.5 and 0.7 respectively. A radiation shield having emissivity 0.1 on both sides is placed between the plates. Determine the percentage reduction in heat transfer rate. | 4 |
| (b) | Explain the following - Kirchhoff's Law of radiation, Steffan Boltzmann's law of radiation, absorptivity, reflectivity and transmissibility of a surface.   | 4 |
7. Attempt any one part of the following: 10x1=10
- |     |   |   |
|-----|---|---|
| (a) | Derive an expression for effectiveness of a heat exchanger by NTU method for parallel flow.   | 5 |
| (b) | i) Draw boiling curve and also name regimes of pool boiling.<br>ii) A counter flow heat exchanger is used to cool 50000 Kg/hr of a liquid from 65°C to 40°C using 40000 Kg/hr of water at 10°C Determine the surface area of heat exchanger required.<br>Take $C_{p(\text{liquid})} = 3700 \text{ J/KgK}$ , $C_{p(\text{water})} = 4180 \text{ J/KgK}$ , Overall heat transfer coefficient as $580 \text{ W/m}^2\text{K}$ . | 5 |