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**B. TECH.**
**(SEM V) THEORY EXAMINATION 2018-19**
**HEAT AND MASS TRANSFER**

***Time: 3 Hours*** ***Total Marks: 70***

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

**SECTION A**

**1. Attempt *all* questions in brief.** **2×7 = 14**

a. Define three different modes of heat transfer. Give a practical example where all three modes are occurring simultaneously.
b. What do you mean by the term thermal conductivity? Why good electrical conductor materials are also good heat conductors?
c. What do you understand by overall heat transfer coefficient?
d. Write down the significance of critical radius of insulation.
e. State the assumptions made in lumped heat capacity method for analysis of transient heat conduction problems.
f. Define Nusselt number and Prandtl number.
g. Explain black body, white body, gray body and opaque body.

**SECTION B**

**2. Attempt any *three* of the following:** **7 × 3 = 21**

a. A gas filled tube has 2mm inner diameter and 25cm long, the gas is heated by an electrical wire of diameter 50 microns located along the axis of the tube, the current and voltage drop across the heating element are 0.5A and 4V respectively. If the temperature of wire is 175°C and inside tube wall temperature is 150°C respectively. Find the thermal conductivity of the gas filling the tube.
b. Derive the expression for temperature distribution and heat dissipation in a straight fin of rectangular profile when fin is of infinite length.
c. Explain the physical mechanism of free convection with the help of example and neat sketch. Discuss the significance of various dimensionless numbers with respect to natural convection.
d. Define the following terms: Total emissivity, Monochromatic emissive power and Monochromatic emissivity.
e. Differentiate between dropwise and filmwise condensation. Which type has higher heat transfer film coefficient and why?

**SECTION C**

**3. Attempt any *one* part of the following:** **7 × 1 = 7**

a. Derive the 3-D steady state generalized heat conduction equation (without internal heat generation) in Cartesian coordinate system. Write the assumptions used.

b. An exterior wall of a house may be approximated by a 0.1m layer of common brick (k = 0.7 W/m°C) followed by a 0.04m layer of gypsum plaster (k = 0.48 W/m°C). What thickness of loosely packed rock wool insulation (k = 0.065 W/m°C) should be added to reduce the heat loss (or gain) through the wall by 80 percent?

**4. Attempt any *one* part of the following:** **7 × 1 = 7**

a. A steel rod (k = 32 W/m°C), 12mm in diameter and 60mm long, with an insulated end, is to be used as spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/m²°C. The temperature at the base of fin is 95°C. Determine:
   i. The fin efficiency

ii. The temperature at the edge of the spine
iii. The heat dissipation

b A steel ball of 12mm diameter is annealed by heating to 800°C and then slowly cooled to 127°C in air at 50°C. The heat transfer coefficient, h = 20 W/m²°C. Calculate the time required for air cooling process. The properties of steel are k = 45 W/m°C, ρ = 7830 kg/m³ and c = 600 J/kg-K.

**5. Attempt any *one* part of the following: 7 × 1 = 7**

a. Air at atmospheric pressure and 200°C flows over a flat plate with a velocity of 5 m/s. The plate is 15mm wide and is maintained at a temperature of 120°C. Calculate the thickness of hydrodynamic and thermal boundary layers and the local heat transfer coefficient at a distance of 0.5m from the leading edge. Assume that flow is on one side of the plate.

b Define the following terms with expression:
i. Boundary layer thickness
ii. Displacement thickness
iii. Momentum thickness
iv. Energy thickness

**6. Attempt any *one* part of the following: 7 × 1 = 7**

a. The large parallel plates with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction when a polished aluminium shield of emissivity 0.04 is placed between them. Use the method of electrical analogy.

b. Derive the following relation for the radiant heat exchange between two gray surfaces:

$$(Q_{12})_{net} = \frac{A_1\,\sigma\,(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1} + \frac{1}{\bar{F}_{1-2}} + \left(\frac{1-\varepsilon_2}{\varepsilon_2}\right)\frac{A_1}{A_2}}$$

**7. Attempt any *one* part of the following: 7 × 1 = 7**

a. Steam at atmospheric pressure enters the shell of a surface condenser in which the water flows through a bundle of tubes of diameter 25mm at the rate of 0.05 kg/s. The inlet and outlet temperatures of water are 15°C and 70°C, respectively. The condensation of steam takes place on the outside surface of the tube. If the overall heat transfer coefficient is 230 W/m²°C, calculate the following, using NTU method:

i. The effectiveness of the heat exchanger
ii. The length of the tube
iii. The rate of steam condensation

Take latent heat of vapourisation at 100°C = 2257 kJ/kg

b. State Fick's law of diffusion. What are its limitations?