Exam.Code:0942
Sub. Code: 33875

2056
B.E. (Mechanical Engineering)
Sixth Semester
MEC-604: Heat Transfer

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt <u>five</u> questions in all, including Question No. I which is compulsory and selecting two questions from each Part.

x-x-x

1 a Explain with examples the three modes of heat transfer. 10
b Discuss a few commonly used types of fins.
c Write short notes on hydrodynamic and thermal boundary layers.
d Differentiate between nucleate boiling and film boiling.
e Define: absorptivity, reflectivity and transmissivity

Part -A

2 Derive a 3-dimensional general conduction equation in cylindrical co-ordinates for a homogeneous material. Deduce therefrom an expression for unidirectional unsteady state system when heat is generated within it at the rate of q_g per m^3 of the material. 10

3 a Hot gases at 980°C flow past the upper surface of the blade of a gas turbine and the lower surface is cooled by air bled off the compressor. The convective heat transfer coefficient at the upper and lower surfaces are estimated to be 2830 and 1415 W/m^2-deg respectively. The blade material has a thermal conductivity of 11.6. W/m-deg. If metallurgical considerations limit the blade temperature at 870°C, workout the temperature of the cooling air. Consider the blade as a flat plate 0.115 cm thick and presume that steady state conditions have been reached. 5

b Define the concept of the 'critical thickness of insulation' for curved surfaces. For a thin cylinder with an initial radius r_i, let an insulation layer with thermal conductivity k be applied until it reaches an outer radius r_o. Given an ambient convective heat transfer coefficient h_o, prove that the maximum radial heat transfer rate occurs exactly when the outer radius satisfies the condition $r_o = k/h_o$. Neglect any heat loss from the ends of the cylinder. 5

4 a Derive an expression for the heat dissipation rate and the temperature distribution for a longitudinal fin of uniform cross-section, assuming that the fin loses heat from its tip by convection to the surrounding fluid 7

b What are the influences of (a) fin length and (b) fin thickness on the efficiency of a fin? 3

Part-B

5 a Discuss the concepts of Velocity and Thermal Boundary Layers. Explain their physical significance and how the Prandtl Number relates the two. 5

b Discuss in detail the various regimes in boiling and explain the condition for the growth of Bubbles. 5

6 a In a parallel-flow heat exchanger, engine oil is cooled from 150°C to 80°C. The cooling medium is water, which enters the system at 25°C and exits at 60°C. Calculate the heat exchanger's effectiveness and its Number of Transfer Units 7

Contd.....P/2

(NTU). Furthermore, assuming the flow rates and inlet temperatures stay constant, determine the minimum possible exit temperature for the oil if the exchanger's length were increased indefinitely.

b State and explain Planck's law relating to thermal radiation and temperature of a radiating body. 3

7 a A thermos flask consists of a double-walled vessel with an evacuated internal space designed to minimize heat transfer. To further reduce energy loss, the internal surfaces are silver-plated, resulting in an emissivity of 0.025 for each surface. Given that the bottle's contents are at 375 K and the surrounding ambient air is at 300 K, determine the rate of heat loss from the flask. Additionally, calculate the necessary thickness of cork (with a thermal conductivity of k = 0.03 W/m·K required to provide an equivalent level of insulation. 5

b Derive a general relation for the radiation shape factor in case of radiation between two surfaces. 5

x-x-x