Hall Ticket No | | | | | | | | | | | Question Paper Code: AMEC29

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal-500043, Hyderabad

B.Tech VI SEMESTER END EXAMINATIONS (REGULAR) - JULY 2023

Regulation: UG-20

HEAT TRANSFER

Time: 3 Hours MECHANICAL ENGINEERING **Max Marks: 70**

Answer ALL questions in Module I and II
Answer ONE out of two questions in Modules III, IV and V
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE – I

1. (a) Obtain the general differential heat conduction equation in cartesian coordinates.
[BL: Understand| CO: 1|Marks: 7]

   (b) A square silicon chip (K=150W/m.K) is of width w=5mm on a side and of thickness t=1mm. The chip is mounted in a substrate such that its side and back surfaces are insulated, while the front surface is exposed to a coolant. If 4W are being dissipated in circuits mounted to the back surface of the chip, what is the steady-state temperature difference between back and front surfaces? [BL: Apply| CO: 1|Marks: 7]

MODULE – II

2. (a) Develop an expression for the 1D heat conduction through a hollow cylinder from the general heat conduction equation. Assume steady state unidirectional heat flow in radial direction and no internal heat generation [BL: Understand| CO: 2|Marks: 7]

   (b) The inner and outer surfaces of a 5m × 6m brick wall of thickness 30 cm and thermal conductivity 0.69 W/m°C are maintained at temperatures of 20°C and 5°C, respectively. Determine the rate of heat transfer through the wall, in W. Calculate the percentage of change in rate of heat transfer if the thickness of the brick wall is increased to 50 cm rate. [BL: Apply| CO: 2|Marks: 7]

MODULE – III

3. (a) Show by dimensional analysis for free convection, Nusselts number is a function of Prandtl number and Grasshoff number. [BL: Understand| CO: 3|Marks: 7]

   (b) Determine the boundary layer thickness at a distance of 0.30M and 0.50 m from the leading edge of a 1 m deep flat plate when air at 300 K and 1 bar flows over the plate at a velocity of 300 m/min. Find the mass flow rate which enters the boundary layer between x =0.3 m and 0.5 m. The viscosity of air at 300 K is 1.85×10^{-5} kg/ms [BL: Apply| CO: 3|Marks: 7]

4. (a) Differentiate between mechanisms of heat transfer by free and forced convection. Mention some of the areas where these mechanisms are predominant. [BL: Understand| CO: 4|Marks: 7]

   (b) Find the heat transfer when air at 2 bar and 475 K flows at a velocity of 15 m/s through a 1 m long tube of diameter 50 mm. A constant heat flux condition is maintained and the wall temperature is kept at 30^0C above the air temperature, over the entire length of the tube.
[BL: Apply| CO: 4|Marks: 7]

MODULE – IV

5. (a) Enumerate the properties of black body and gray body. Distinguish thermal radiation from other types of radiation. [BL: Understand| CO: 5|Marks: 7]

   (b) Calculate the net radiant heat exchange per m^2 area for two large plates at temperatures of 427^0C and 27 °C respectively. Take $\epsilon = 0.9$ for hot plate and $\epsilon = 0.6$ for cold plate. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer ($\epsilon = 0.4$ for shield) [BL: Apply| CO: 5|Marks: 7]

6. (a) State and explain the Stefan-Boltzmann law of radiation heat transfer, giving the nomenclature involved in it. [BL: Understand| CO: 5|Marks: 7]

   (b) A steam pipe of outer diameter 20 cm and length 60 cm whose surface is at 200^0C passes through a room with a wall at 10^0C. Assuming the emissivity of the pipe as 0.8, determine the rate of heat loss from the pipe by radiation. [BL: Apply| CO: 5|Marks: 7]

MODULE – V

7. (a) How heat exchangers of classified? Determine an expression for LMTD in parallel flow heat exchangers. [BL: Understand| CO: 6|Marks: 7]

   (b) Hot oil is to be cooled in a double-tube counter-flow heat exchanger. The copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. Water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s. Taking the average temperatures of the water and the oil to be 45^0C and 80^0C, respectively, determine the overall heat transfer coefficient of this heat exchanger.
   [BL: Apply| CO: 6|Marks: 7]

8. (a) Explain briefly the various regimes of saturated pool boiling by drawing the diagram.
   [BL: Understand| CO: 6|Marks: 7]

   (b) In a double pipe heat exchanger, hot fluid with a specific heat of 2300 J/kg K enters at 380^0C and leaves at 300^0C, cold fluid enters at 25^0C and leaves at 210^0C . Calculate the heat exchanger area required for i) Parallel flow ii) Counter flow. Take overall heat transfer coefficient as $750W/m^2K$ and mass flow rate of hot fluid as 1 kg/s. [BL: Apply| CO: 6|Marks: 7]

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