

B.Tech III Year I Semester (R13) Supplementary Examinations June 2017

**HEAT TRANSFER**

(Mechanical Engineering)

Use of heat transfer data book and steam tables is permitted in the examination hall

Time: 3 hours

Max. Marks: 70

**PART – A**  
(Compulsory Question)

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- 1 Answer the following: (10 X 02 = 20 Marks)
- Mention different types of boundary conditions applied to heat conduction problems.
  - Explain the concept of driving potential applied to heat transfer problems.
  - What is lumped capacity?
  - Explain why Heisler chart cannot be used for the case of Biot number approaching zero.
  - What do you understand by thermal boundary layer?
  - Define Grashof number and explain its significance in free convection heat transfer.
  - What is the equation which is used to transfer heat from solid surface to liquid in the case of boiling?
  - Give two examples of direct contact heat exchanger.
  - Define intensity of radiation of a surface.
  - Define radiation shape factor.

**PART – B**  
(Answer all five units, 5 X 10 = 50 Marks)

**UNIT – I**

- 2 (a) Derive general heat conduction equation for isotropic material in cylindrical co-ordinates.  
(b) What do you mean by boundary and initial condition?

**OR**

- 3 (a) Derive expression for critical thickness of insulation for cylinder  
(b) A refrigerant at  $-40^{\circ}\text{C}$  flows in a copper pipe ( $k = 400 \text{ W/mK}$ ) of I.D. 10 mm and O.D. 14 mm. A 40 mm thick shell of thermocol ( $k = 0.03 \text{ W/mK}$ ) is put on the pipe to reduce losses. Estimate the heat leakage to the refrigerant per meter length of pipe, if the ambient air temperature is  $40^{\circ}\text{C}$ . Assume the internal and external heat transfer coefficients to be 500 and 5  $\text{W/mK}$  respectively. Calculate also the amount of refrigerant evaporated per hour taking its latent at  $-40^{\circ}\text{C}$  as 1390  $\text{kJ/kg}$ .

**UNIT – II**

- 4 (a) Give the values of characteristic dimensions (LC) used in lumped analysis for following cases:  
(i) Sphere. (ii) Cylinder. (iii) Plate.  
(b) A boiler furnace has the effective dimensions 4 m x 3 m x 3 m high. The walls are constructed from an inner firebrick wall 25 cm thick ( $k = 0.4 \text{ W/mK}$ ), a layer of ceramic blanket insulation ( $k = 0.2 \text{ W/mK}$ ), 8 cm thick and a steel protective layer ( $k = 54 \text{ W/mK}$ ) 2 mm thick. The inside temperature of the fire back layer was measured as  $600^{\circ}\text{C}$ . Determine the rate of heat loss through the vertical walls of the furnace. Also calculate the temperature drop across the steel layer.

**OR**

- 5 (a) A high pressure steam pipe of I.D. 21 cm and thickness 2 cm ( $k = 54 \text{ W/mK}$ ) carries steam at a temperature of  $450^{\circ}\text{C}$ . The pipe is covered with a layer of insulation 12 cm thick ( $k = 0.04 \text{ W/mK}$ ). Considering the resistance of steam to heat flow to be infinitesimally small, calculate the heat loss per meter length of pipe when the outer surface temperature of insulation is  $55^{\circ}\text{C}$ .  
(b) Derive the temperature distribution with negligible surface resistance.

## UNIT – III

- 6 (a) A plate at  $90^{\circ}\text{C}$  is located parallel to an air stream flowing at a speed of  $75\text{ m/s}$ . The temperature of air is  $0^{\circ}\text{C}$ . The plate is  $60\text{ cm}$  wide and  $45\text{ cm}$  long. Assuming a transition Reynolds number of  $4 \times 10^5$ , calculate the average heat transfer and friction coefficients for the laminar and turbulent region of the plate.
- (b) What is Reynolds analogy? Describe the relation between fluid friction and heat transfer.

OR

- 7 (a) Compare the variations of velocity, temperature and local heat transfer coefficient along a vertical plate for the plate under natural convection and forced convection.
- (b) A vertical plate is at  $96^{\circ}\text{C}$  in an atmosphere of air at  $20^{\circ}\text{C}$ . Estimate the local heat transfer coefficient at a distance of  $20\text{ cm}$  from the lower edge and the average value over  $20\text{ cm}$  length.

## UNIT – IV

- 8 (a) Discuss the flow regimes of forced convection boiling inside a tube.
- (b) A long electric wire of  $1\text{ mm}$  diameter carrying electric current dissipates  $4000\text{ W/m}$  and attains a surface temperature of  $125^{\circ}\text{C}$  when submerged in water at atmospheric pressure. Calculate the boiling heat transfer coefficient.

OR

- 9 (a) What is the method used for the determination of mean temperature differences across the heat exchanger ( $T_m$ )?
- (b) A counter flow concentric tube heat exchanger is used to cool engine oil ( $C = 2130\text{ J/kgK}$ ) from  $160^{\circ}\text{C}$  to  $60^{\circ}\text{C}$  with water, available at  $25^{\circ}\text{C}$  as the cooling medium. The flow rate of cooling water through the inner tube of  $0.5$  diameter is  $2\text{ kg/s}$  while the flow rate of oil through the outer annulus O.D =  $0.7\text{ m}$  is also  $2\text{ kg/s}$ . If the value of the overall heat transfer coefficient is  $250\text{ W/m}^2\text{K}$ , how long must the heat exchanger be to meet its cooling requirement?

## UNIT – V

- 10 (a) Using Planck's law, derive the expression for Stefan Boltzmann law.
- (b) Two large parallel planes are at  $1000\text{ K}$  and  $500\text{ K}$  respectively  $\epsilon_1 = 0.3$  and  $\epsilon_2 = 0.7$ . The planes are separated by a gray gaseous medium having  $\epsilon_m = 0.2$ .
- (i) What is the heat transfer rate between the two planes?
- (ii) What is the temperature of the gas?

OR

- 11 (a) Two square plates, each of  $5\text{ m}^2$  area, are separated by a gap of  $6\text{ mm}$ , one plate whose surface emissivity is  $0.7$ , is at a temperature of  $900\text{ K}$ . The other plate has surface emissivity of  $0.95$  and a temperature of  $300\text{ K}$ . Assuming the plates to be much larger than the gap, calculate the net radiation exchange between the plates.
- (b) State and prove reciprocal theorem apply to thermal radiation.

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