Code No: 07A5EC06 **R07** **Set No. 2**

III B.Tech I Semester Examinations,November 2010
HEAT TRANSFER
Common to Mechanical Engineering, Production Engineering, Automobile Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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Note: Use of Heat and Mass Transfer data book by Kothandaraman and Subrahmanyam is permissible.

1. (a) State and explain the different types of boundary conditions applied to heat conduction problems.
   (b) Give three applications of heat transfer that involve all the three modes of heat transfer. Explain each one in detail. [8+8]

2. (a) Explain the different modes of boiling when a fluid is forced through a heated tube.
   (b) Steam at 100^0C is being condensed on the outer surface of a horizontal tube of 3 m length and 50 mm outer diameter, while the tube surface is maintained at 90^0C. Determine the average heat transfer coefficient and the total rate of condensation over the tube surface. [6+10]

3. (a) What electrical current in amps is required to maintain a 0.076 mm diameter, 0.6 m long vertical wire at 400 K in an atmosphere of quiescent air at 300 K? The wire's resistance is 0.0118 ohms per meter. Assume that heat transfer takes place due to natural convection only.
   (b) Give merits and demerits of dimensional analysis and explain the significance. [8+8]

4. Two parallel discs of 1m diameter are situated 2m apart in surroundings at a temperature of 20 ^{0}C. The inner side of one disc has an emissivity of 0.5 and is maintained at 500 ^{O}C by electric resistance heating and the outer side of the disc is well insulated. The other disc is open to radiation on both sides and reaches an equilibrium temperature. Calculate this equilibrium temperature and the heat flow rate from the first disc, assuming heat transfer is entirely by radiation. [16]

5. A Counter flow heat exchanger consisting of two concentric flow passages is used for heating 1200 kg/hr of oil (specific heat=2.1kJ/kgK) from an initial temperature of 27 ^{0}C. The oil is flowing through the inner pipe and the convective heat transfer coefficient on the oil side is 750 W/m^2K. The inner and outer radii of the inner pipe are 12 mm and 15 mm and the thermal conductivity of the pipe materials is 350 W/mK. The oil is heated by hot water supplied at the rate of 400 kg/hr at the inlet temperature of 92 ^{O}C. The waterside heat transfer coefficient is 1470 W/ m^2K. The length of the heat exchanger is 9 m. What are the terminal temperatures of the two fluids? [16]

6. (a) Air at 35 ^0C flows across a cylinder of 50mm diameter at a velocity of 50m/s. the cylinder surface is maintained at 145^0C. Calculate the heat loss per unit length of the cylinder.

(b) Distinguish between laminar and turbulent flow in a physical sense. [8+8]

7. (a) A round rod of 10mm diameter and 300mm long is firmly fixed between two heat sources maintained at 125^0C. If the conductivity of the rod is 45 W/m-K and film heat transfer coefficient is 7 W/m^2 .K. Estimate the temperature at the middle of the rod and the heat loss from the rod per unit time.

   (b) Derive expressions for heat flow and temperature distribution for a rectangular fin of infinite length. [8+8]

8. A large aluminium plate of thickness 200 mm originally at a temperature of 530 ^0C is suddenly exposed to an environment at 30^0C. The convective heat transfer coefficient between the plate and the environment if 500 W/m^2 K. Determine with the help of Heisler charts, the temperature at a depth of 20 mm from one of the faces 225 seconds after the plate is exposed to the environment. Also calculate how much energy has been lost per unit area of the plate during this time? Take for aluminium, $\alpha = 8 \times 10^{-5}$ m^2/s and k = 200 W/m K. [16]

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Code No: 07A5EC06 **R07** **Set No. 4**

III B.Tech I Semester Examinations,November 2010
HEAT TRANSFER
Common to Mechanical Engineering, Production Engineering, Automobile Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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Note: Use of Heat and Mass Transfer data book by Kothandaraman and Subrahmanyam is permissible.

1. (a) Derive an expression for logarithmic mean temperature difference for the case of counter flow of heat exchanger.

   (b) A hot fluid enters a heat exchanger at a temperature of 200 ^0C at a flow rate of 2.8 kg/s (sp. heat 2.0 kJ/kg-K). It is cooled by another fluid with a mass flow rate of 0.7kg/sec (Sp.heat 0.4 kJ/kg-K). The overall heat transfer coefficient based on outside area of 20m^2 is 250W/m^2-K. Calculate the exit temperature of hot fluid when fluid when fluids are in parallel flow. [8+8]

2. (a) Explain clearly the analogy between heat and electricity in case heat conduction. What do you understand by the term over all heat transfer coefficient.

   (b) State and explain Fourier's law of conduction. What is the significance of negative sign in the equation. [8+8]

3. (a) A vertical pipe of 5 cm diameter carrying hot water is exposed to ambient air at 15 ^0C. If the outer surface of the pipe is at 65^0C, find the heat loss from one meter height of the pipe per hour.

   (b) List various parameters which influence natural convection heat transfer. Explain how each parameter influence the process. [8+8]

4. (a) Define fin efficiency and fin effectiveness.

   (b) What are the assumptions made in deriving an expression for finding temperature distribution along a circular fin.

   (c) A Thin rod of copper, K=110 W/m K, of 1.25 cm in diameter spans the distance between two parallel plates 15 cm apart. Air at 40^0C flows in the space between the plates providing h = 55 W/m^2 K. Temperature of the plates exceeds that of air by 40^0C. What is the temperature at the center of the rod? Also find the heat lost from the rod per hour. [4+4+8]

5. (a) Dry saturated steam at a pressure of 2.5 bar condenses on the surface of a vertical tube of height 1.5m. The tube surface temperature is 120 ^0C. Estimate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.3m from the upper end of the tube.

   (b) Show the various regimes in pool boiling and discuss the heat transfer mechanisms in each region in detail. [8+8]

6. (a) Explain for fluid flow along a flat plate.

i. Velocity distribution in hydrodynamic boundary layer
ii. Temperature distribution in thermal boundary layer.
iii. Variation of local heat transfer co-efficient along the flow.

(b) Water at 75^0C flows through a 0.005 m diameter tube with a velocity of 1m/s. If the tube wall temperature is 25^0C, make calculations for the heat transfer coefficient The thermo-physical properties of water are:
Thermal conductivity is 0.647 W/m.K; Viscosity is 1.977 kg/m. h
Density is 1000 kg/m^3; Specific heat 4.187 kJ/kg.K. [8+8]

7. An aluminium sphere of 0.1 m diameter and at a uniform temperature of 500^0C is suddenly exposed to an environment at 20^0C, with convection heat transfer coefficient 30 W/m^2 K. Calculate the temperature of the sphere

(a) 100 s,
(b) 300 s, and
(c) 500 s after it is exposed to the environment. Justify any method you use for the analysis; take, for aluminium, k = 200 W/m K,ρ = 2700 kg/m^3, c_p = 0.9 kJ/kg K. [16]

8. (a) Explain the utility of radiation shields.
(b) Two large parallel planes having emissivities 0.3 and 0.5 are maintained at temperatures of 900 ^0C and 400^0C respectively. A radiation shield having an emissivity of 0.05 is placed between the two planes. Estimate:

i. Heat exchange per m^2 of area if the shield were not present
ii. Temperature of the shield, and
iii. Heat exchange per m^2 area when the shield is present. [8+8]

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Code No: 07A5EC06 **R07** **Set No. 1**

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Note: Use of Heat and Mass Transfer data book by Kothandaraman and Subrahmanyam is permissible.

1. (a) Define the terms:
   i. absorptivity
   ii. reflectivity and
   iii. transmissivity.

   (b) Differentiate between specular and diffuse reflections.

   (c) Derive Stefan-Boltzmanns law from Plank's Law. [16]

2. (a) Explain the mechanism of heat conduction in metals and insulators and also mention some of the situations where poor conductivity of air helps to restrict the heat transmission by conduction.

   (b) Sate and explain the laws governing the three modes of heat transfer. [8+8]

3. (a) Explain the Buckingham's π-Theorem for dimensional analysis. How is it applied to forced convection problems

   (b) What are repeating variables and how are they selected for dimensional analysis.

   (c) What do you understand by the hydrodynamic and thermal boundary layers. Illustrate with reference to flow over a flat heated flat plate. [16]

4. (a) The surface of human body may be approximated by a vertical cylinder 0.3 m in diameter and 2 m in height. Assuming the surface temperature to be 30^0C, determine the heat loss from a human body in a quiescent atmosphere of air at 20^0C. Use the appropriate correlation.

   (b) What is the significance of dimensionless numbers in natural convection heat transfer? Explain. [8+8]

5. (a) Write the advantages of NTU method over LMTD method.

   (b) Oil (C_p = 3.6 kJ/kg.K) at 100 ^{0}C flows at the rate of 30,000 kg/hr and enters into a parallel flow heat exchanger. The cooling water enters the heat exchangers at 10 ^{0}C at the rate of 50,000 kg/ hr. Heat transfer area is 10m^2 and U=1 kW/m^2K. Calculate the outlet temperatures of oil and maximum possible outlet temperature of water. [8+8]

6. A solid rod of radius R generates heat at a constant rate of q_o W/m^3, while the outer surface of the rod is maintained at constant temperature T_2. Develop an

expression for one dimensional radial steady state temperature distribution and the heat flux. Hence determine the centre temperature and the heat flux at the outer surface for radius when R=1cm, q_o=2 × 10^8 W/m^3, K = 20 W/m K and T_2 = $100^0 C$ [16]

7. An iron beam of rectangular cross-section of size 300 mm × 200 mm is used in the construction of a building. Initially, the beam is at a uniform temperature of 30^0C. Due to an accidental fire, the beam is suddenly exposed to hot gases at $730^0 C$, with a convection heat transfer coefficient of 100 W/m^2 K. Determine the time required for the center plane of the beam to reach a temperature of $310^0 C$. (Take thermal conductivity of the beam k = 73 W/m K and thermal diffusivity of the beam α = 2.034 x 10-5 m^2/s; use Heisler chart.) [16]

8. (a) Steam at 100^0C is being condensed on the outer surface of a horizontal tube of 3 m length and 50 mm outer diameter, while the tube surface is maintained at 90^0C. Determine the average heat transfer coefficient and the total rate of condensation over the tube surface.

   (b) Explain about heat transfer in boiling. Why the boiling heat transfer coefficients are very high. Explain. [10+6]

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Code No: 07A5EC06 **R07** **Set No. 3**

III B.Tech I Semester Examinations,November 2010
HEAT TRANSFER
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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Define irradiation and radiosity.
   (b) What does radiation shape factor mean?
   (c) Two parallel black plates 0.5m × 1.0m are separated by 0.5m distance. One plate is at 1100 ^0C and the other at 600 ^0C. What is the net radiant heat exchange between the two plates? [5+5+6]

2. (a) A vertical cylinder 1.8 m high and 7.5 cm in diameter is maintained at a temperature of 93^0C in an atmospheric air of 30 ^0C. Calculate the heat lost by free convection from this cylinder.
   (b) In which mode of heat transfer is the convection heat transfer coefficient usually higher, natural convection or forced convection? Why? [8+8]

3. A cylinder nickel-steel billet of 0.1 m diameter and 0.5 m length, initially at 800^0C, is suddenly dropped in a large vessel containing oil at 30^0C. The convection heat transfer coefficient between the billet and the oil is 20 W/m^2 K. Calculate the time required for the billet to reach a temperature of 250^0C. Take for nickel-steel, k = 20 W/m K, ρ = 8000 kg/m^3, c_p = 0.45kJ/kg K. [16]

4. (a) Differentiate between pool boiling and flow boiling.
   (b) A heated brass plate at 160^0C is submerged horizontally in water at a pressure corresponding to a saturation temperature of 120^0C. What is the heat transfer per unit area? Calculate also the heat transfer coefficient in boiling. [6+10]

5. (a) How are heat exchangers classified and sketch the temperature distribution in fluids in condensers and evaporators?
   (b) Steam is condensed in a single pass condenser at a pressure of 0.5 bar. The condenser consists of 100 thin walled tubes of 2.5 cm nominal diameter and 2m length. The cooling water enters and leaves at a temperature of 10^0C and 50^0C with a mean velocity of 2 m/Sec. The condensing heat transfer coefficient is 5 KW/m^2- K. Find
      (i) Overall heat transfer coefficient for heat exchanger
      (ii) Condensation rate of steam
      (iii) Mean temperature of metal at the center of condenser length. [6+10]

6. (a) Explain the mechanism of heat conduction in gases, liquids and solids. Discuss the effect of temperature on thermal conductivity.
   (b) A flat wall is exposed to an environmental temperature of 38^0C. The wall is covered with a layer of insulation 2.5 cm thick whose thermal conductivity is 1.4 W/m.^{0}K, and the temperature of the wall on the inside of the insulation is 315^0C. The wall loses heat to the environment by convection. Compute the

value of the convection heat transfer coefficient which must be maintained on the outer surface of the insulation to ensure that the outer-surface temperature does not exceed 41^0C. [8+8]

7. (a) An insulating glass window is constructed of two 5-mm glass plates separated by an air layer having a thickness of 4 mm. The air layer may be considered stagnant so that pure conduction is involved. The convection coefficients for the inner and outer surfaces are 12 and 50 W/m^2. K, respectively. Calculate the overall heat-transfer coefficient for this arrangement, Repeat the calculation for a single glass plate 5 mm thick.

   (b) A very long copper rod of k=372 W/m-K of 2.5 cm in diameter has one end maintained at 90^0C. The rod is exposed to a fluid whose temperature is 40^0C. The heat-transfer coefficient is 3.5 W/m^2-K^0C. How much heat is lost by the rod? [8+8]

8. (a) Discuss the physical significance of the following in heat transfer
      i. Reynold's number
      ii. Nusself number
      iii. Prandtl Number.

   (b) For heating water from 20^0C to 60^0C by an electrically heated tube resulting in a constant heat flux of 10 kW/m^2 is proposed. The mass flow rate is to be such that Re_D=2000, and consequently the flow must remain laminar. The tube inside diameter is 25mm. The flow is fully developed (velocity profile). Determine the length of tube required. [8+8]

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