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

III B.Tech I Semester Examinations,May 2011
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

⋆⋆⋆⋆⋆

1. (a) Explain clearly the analogy between heat and electricity. 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]

2. (a) A vertical cylinder 30 cm high and 30 cm in diameter is maintained at a surface temperature of 43.3 ^0C while submerged in water at 10 ^0C. Calculate the heat lost form the surface area of the cylinder.
   (b) What is film temperature? Why the properties are evaluated at this temperature. [8+8]

3. (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]

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. [8+8]

5. (a) Derive the expression for the temperature distribution and heat conduction through a solid wall if material has thermal conductivity varies with temperature as K = $k_0(1+\alpha T)$. Assume the surface temperatures at T_1 and T_2.
   (b) Heat is generated at a constant rate of 4×10^8 W/m^3 in a copper rod (3.86 W/mK) of radius 5 mm. The rod is cooled by convection from its cylindrical surface into an ambient at 30^0C with a heat transfer coefficient of 2000 W/m^2K. Determine the surface temperature of the rod. [8+8]

6. (a) During a heat treatment process a spherical object of 5 cm diameter is cooled in one minute in an oil bath from 15^0C to 6^0C. If a cube made of the same material with a side of 50 mm is to be cooled between the same temperature limits, calculate the time required. Assume negligible internal thermal resistance.

(b) What is meant by a lumped capacity? What are the physical assumptions necessary for a lumped- capacity unsteady-state analysis to apply? [8+8]

7. (a) Air flowing through a long tube of 2.5 cm diameter at a flow rate of 30 m/s is heated from an entry temperature of 20^0C to an exit temperature of 40^0C, while the temperature of the tube is maintained at 50^0C. Estimate heat transfer coefficient between the air and the inner tube.

   (b) Show by dimensional analysis that data for forced convection may be correlated by an equation of the form N_u=f(R_e,P_r). [8+8]

8. (a) How does the log mean temperature difference for a heat exchanger differ from the arithmetic mean temperature difference? For specified inlet and outlet temperatures, which one of these two quantities is larger?

   (b) A shell-and-tube heat exchanger has condensing steam at 100 ^{0}C in the shell side with one shell pass. Two tube passes are used with air in the tubes entering at 10 ^{0}C. the total surface area of the exchangers is 30 m^2 and the overall heat-transfer coefficient may be taken as 150 W/m^2.K. If the effectiveness of the exchanger is 85 percent, what is the total heattransfer rate? [8+8]

⋆⋆⋆⋆⋆

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

III B.Tech I Semester Examinations,May 2011
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

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Deduce average heat transfer co-efficient equation in film condensation on a Vertical flat plate using Nusselt's theory.
   (b) Explain various regimes of pool boiling. [8+8]

2. A long steel cylinder 12cm in diameter and initially at 20 ^0C is placed into a furnace at 820 ^0C where the heat transfer coefficient, h=140 W/m^2.K. Calculate the time required for the axis temperature to reach 800 ^0C. calculate also.
   (a) the corresponding temperature at a radius of 4.8 cm at that time and
   (b) the heat energy absorbed by the cylinder during this period, given that the thermal diffusivity, $\alpha = 6.11 \times 10^{-6}$ m^2/s and the thermal conductivity, k=21 W/m.K. [16]

3. Identify the different modes of heat transfer in the following systems/ operations.
   (a) Steam raising in a steam boiler.
   (b) Air / water cooling of an I.C. engine cylinder.
   (c) Heat loss from a thermos flask.
   (d) Heating of water in a bucket with an immersion heater.
   (e) Heat transfer from a room heater.
   (f) Heat transfer in a refrigerator cabin. [16]

4. Hot oil is to be cooled by water in a one shell pass and eight tube passes heat exchanger. The tubes are thin walled and made of copper with an internal diameter of 14 mm. The length of each tube pass is 5 m and Uo = 310 W/m^{2}K. Water flows through the tubes at a rate of 0.2 kg/s and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enter at temperatures of 20^{O}C and 150^{O}C respectively. Determine the rate of heat transfer and the exit temperatures of the water and the oil [16]

5. A hot gas at 573 K flows through a long metal pipe of 0.1m OD and 0.003m thick. From the stand point of safety and of reducing heat loss from the pipe, mineral wool insulation (k=0.052 W/m K) is wrapped around so that the exposed surface of the insulation is at a temperature of 323 K. Calculate the thickness of insulation required to achieve this temperature if h_i=29 W/m^2K, h_o=11.6 W/m^2K and the surrounding air temperature in 298 K. Also calculate the corresponding heat transfer rate per unit length.

   [16]

6. (a) Explain the Reynold's Analogy in forced convection.

   (b) Water flows inside a smooth tube at a mean flow velocity of 3.0 m/s. The tube diameter is 25mm and constant heat flux condition is maintained at the tube wall such that the tube temperature is always 20^0C above the water temperature. The water enters the tube at 30^0C and leaves at 50^0C. Calculate the tube length necessary to accomplish the indicated heating. [8+8]

7. (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]

8. (a) What is the criterion for transition from laminar to turbulent boundary layer in free convection on a vertical flat plate.

   (b) Estimate The electrical power required to maintain a vertical heater surface at 130^0C in ambient air at 20^0C. The plate is 15 cm high and 10 cm wide. Consider equivalent radiation heat transfer coefficient as 8.5 W/m^2K. [8+8]

⋆⋆⋆⋆⋆

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

III B.Tech I Semester Examinations,May 2011
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

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Large vertical plate 4.0 m high is maintained at 60 ^0C and exposed to atmospheric air at 10 ^0C. Calculate the heat transfer if the plate is 10 m wide.
   (b) What is natural convection? What force causes natural convection currents? [8+8]

2. (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 hydrodynamics and thermal boundary layers. Illustrate with reference to flow over a flat heated plate. [16]

3. (a) Explain the terms absorptivity, reflectivity and transmissivity.
   (b) Fused quartz transmits 90% of the incident thermal radiation between 0.2 and 4 μm. Suppose a certain heat source is viewed through the quartz window, what heat flux in Watts will be transmitted through the material from black body radiation sources at:
      i. 800 ^{0}C
      ii. 550 ^{0}C [8+8]

4. The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of horizontal pipes through which cooling water circulates. The outer diameter of the pipes is 2 cm, and the outer surfaces of the pipes are maintained at 30 ^{0}C. Determine
   (a) the rate of heat transfer to the cooling water circulating in the pipes and
   (b) the rate of condensation of steam per unit length of a horizontal pipe. [16]

5. (a) Write the Fourier rate equation for heat transfer by conduction. Give the physical significance of each term.
   (b) Determine the steady heat transfer per unit area through a 3.8 cm thick homogeneous slab with its two faces maintained at uniform temperatures of 35^0C and 25^0C. The thermal conductivity of wall material is 1.9×10^{-4} kW/m-K. [8+8]

6. (a) In a gas to liquid heat exchanger, why are fins provided on gas side? Explain.

(b) Determine the overall heat transfer coefficient based on the outer area of a 3.81 cm O.D. and 3.175 cm I.D. brass tube (k = 103.8 W/m.K) if the heat transfer coefficients for flow inside and outside the tube are 2270 and 2840 W/m^2K respectively and the unit fouling resistances at inside and outside are $R_{fi} = R_{fo} = 0.0088 m^2$ K/W [8+8]

7. 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]

8. (a) Derive an expression for temperature distribution in a slab when T_1 and T_2 are its surface temperatures. Assume that the thermal conductivity of the slab varies with temperature $k = k_0(1+\alpha T)$

   (b) A steam pipe (k=50 W/m-K) of inside and out side diameters 100mm and 110mm is carrying steam at 250^0C. The ambient temperature is 30 ^0C. The convective heat transfer coefficients at inside and out side of the pipe are 25 W/m^2-K and 8 W/m^2-K respectively.

      i. Find out the rate of heat transfer per unit length of the pipe.
      ii. Find out whether it is possible to reduce the heat transfer by providing an insulation of thermal conductivity 0.06 W/m^2-K
      iii. Find out the thickness of insulation layer required to reduce the heat transfer by 50%. [8+8]

⋆⋆⋆⋆⋆

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

III B.Tech I Semester Examinations,May 2011
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

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Using Buckingham Π - Theorem obtain relation for natural convection in terms of dimensionless numbers.
   (b) A hot square plate of 75cm × 75cm at 120^0C is exposed to atmospheric air at 40 ^0C. Find the heat lost from both surfaces of the plate if it is kept in
      i. Vertical position and
      ii. Horizontal position. [8+8]

2. (a) State and prove reciprocity theorem as applied to radiation shape factors.
   (b) Two concentric cylinders having diameters of 10cm and 20 cm have a length of 20cm. Calculate the shape factor between the open ends of the cylinders. [8+8]

3. (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 ^{0}C 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]

4. (a) State the Newton's law of cooling. Discuss whether convective heat transfer coefficient is a material property.
   (b) A temperature difference of 845^0C is impressed across a fiberglass layer of 13 cm thickness. The thermal conductivity of the fiberglass is 0.035 W/m K. Compute the heat transferred through the material per hour per unit area. [8+8]

5. In quenching process a copper plate of 3mm thickness is heated up to 350^{0}C and is suddenly dipped into water bath and cooled to 25 ^0C Calculate the time required for the plate to reach the temperature of 50 ^0C. the heat transfer coefficient on the surface of the plate is 28 W/m^2-K. The length and width of the plates are 40cm and 30cm respectively. The properties of copper are as follows: specific heat=380.9 J/Kg-K, density 8800 kg/m^3 and thermal conductivity 385 W/m-K. 16]

6. Hot air at the mass flow rate of 0.08 Kg/s flows through an uninsulated sheet metal duct of 20cm diameter. The inlet temperature of air is 100 ^0C. The air

gets cooled in its passage due to cold outside air at a distance of 4m, the inside air temperature is 80 ^0C. The temperature of ambient is 6 ^0C and the outside heat transfer coefficient is 6 W/m^2-K. Calculate the following.

(a) The heat loss from duct over its 4m length.

(b) the heat flux and duct surface temperature at the length of 4m.

The properties of air can be assumed as ρ = 0.972 Kg/m^3. C_p=1.009 kJ/Kg-K, K=3.127 × 10^{-2} W/m-K, α =22.1 × $10^{-6}m^2$/s.

P_r=0.69 μ =22.14 × 10^{-6} kg/m-s. [8+8]

7. (a) A 0.5cm thick and 4cm long fin has its base on a plane plate which is maintained at 110^{0}C. The ambient air temperature is 20^{0}C. The conductivity of the fin material is 60 W/m-K and the heat transfer coefficient h= 150 W/m^2 K Determine. Assume that the tip of the fin is insulated.

   i. Temperature at the end of the fin
   ii. Temperature at the middle of the fin
   iii. Total heat dissipated by the fin.

   (b) Derive an expression for the temperature distribution in a short fin with convection taking place at the tip. [8+8]

8. (a) Explain the conditions under which dropwise condensation can take place. Why does the rate of heat transfer in drop-wise condensation many times larger than in film-wise condensation?

   (b) A steam condenser consists of 100 tubes, each 1.27mm in diameter are arranged in a square array. If the tubes are exposed to dry steam at atmospheric pressure and the tube surface temperature is maintained at 98^{o}C, what is the rate at which steam is condensed per unit length of the tubes? [8+8]

⋆⋆⋆⋆⋆