Code No: RR320306 **Set No.1**

III B.Tech. II Semester Supplementary Examinations, November/December -2005
HEAT TRANSFER
(Mechanical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) What are boundary and initial conditions? How many boundary conditions are needed to solve a second order differential equation for heat conduction.
   (b) Derive the fourier heat conduction equation in Cartesian co-ordinates. [8+8]

2. (a) Define the overall heat transfer coefficient? Obtain the expression composite wall with three layer with convective conditions over the wall?
   (b) A wall consists of three layers of 0.2 m concreter, 0.08 m of fibre glass insulation and 0.015 m gypsum board (0.04 W/mK). The convective heat transfer coefficients at inside and outside surfaces are 15 and 45 W/m^{2}K respectively. The inside and outside surface temperatures are 25^{0}C and -10^{0}C respectively. Calculate the overall heat transfer coefficients for the wall and heat loss per unit area. [7+9]

3. (a) Explain the Buckingham's Π -Theorem for dimensional analysis.
   (b) What are repeating variables and how are they selected for dimensional analysis. [10+6]

4. (a) Sketch temperature and velocity profile of free convection of vertical wall.
   (b) Water at 20^{0}C was flowing over a plate of uniform heat flux of 9000 w/m^2. The flow velocity was 200 mm/s. The length of the plate was 1.3 m. Determine the temperature of the plate. [10+6]

5. (a) Assuming laminar film condensation, calculate the ratio of the heat transfer to a vertical tube to that for a horizontal tube of same diameter, D and length H. Briefly comment on the implications of this in the condenser design.
   (b) A vertical plate 0.4m wide and 1.2m high is maintained at 60^{0}C and exposed to saturated steam at 1 bar. Calculate the heat transfer and the total mass of steam condensed per hour. [10+6]

6. Calculate the shape factors for the configurations shown in the Figures 1.
   (a) Sphere of diameter d inside a cubical box of length l = d
   (b) end and side of circular tube of equal length and diameter.

7. Cold water at 1495 kg/hr enters at 25^{0}C through a parallel flow heat exchanger to cool 605kg/hr of hot water entering at 70^{0}C and leaving at 50^{0}C . Find the area

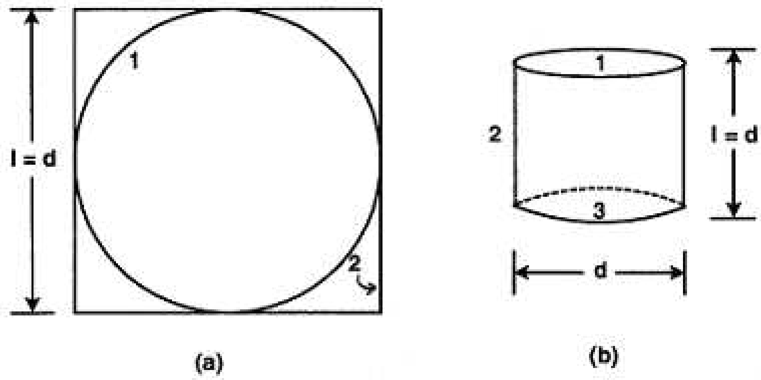

Figure 1:

of heat exchanger .the individual heat transfer coefficients on both sides are 1590 W/m^2-K.Use LMTD and NTU methods. Find also the exit temperature of cold and hot streams if the flow of hot water is doubled. Assume the individual heat transfer coefficient are proportional to 0.8 th power of flow rate. For water Cp = 4180 J/kg-K. [16]

8. (a) Define
   i. mass concentration and mass fraction.
   ii. molar concentration and molar fraction with relevant equations.

   (b) State and explain Fick's law of diffusion. [8+8]

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Code No: RR320306 **Set No.2**

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HEAT TRANSFER
(Mechanical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. 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) Condensation of steam in a condenser.
   (d) Heat loss from a thermos flask.
   (e) Heating of water in a bucket with an immersion heater.
   (f) Heat transfer from a room heater.
   (g) Heating of earth surface by sun. [16]

2. (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 are 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^{2}K. Determine the surface temperature of the rod. [8+8]

3. (a) Give a general equation for the rate of heat transfer by convection.
   (b) List the various factors on which the value of this coefficient depends. [10+6]

4. (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 96^0C in an atmosphere of air at 20^0C. Estimate the local heat transfer co-efficient at a distance of 20 m from the lower edge and the average value over the 20 cm length. [6+10]

5. (a) Distinguish between filmwise and dropwise condensation. Which of the two gives a higher heat transfer coefficient? Why?
   (b) 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. [6+10]

6. (a) A black body is kept at a temperature of 1000k. Determine the fraction of thermal radiation emitted by the surface in the wavelength band 1.0 to 6.0μ.
   (b) Estimate the rate of solar radiation on a plate normal to the sun rays. Assume the sun to be a black body at a temperature of 5527^0C. The diameter of the sun is $1.39 \times 10^6 km$ and its distance from the earth is 1.5×10^8 km. [6+10]

7. (a) Derive an expression for effectiveness of a parallel flow heat exchanger using NTU method.
   (b) A hot gas at the rate of 16.2 Kg/Sec at 648^0C (Cp = 3.52 KJ/Kg-k) is used to heat 20.2 kg /sec of the incoming fluid from 100^0c (Cp = 4.2 KJ/Kg-K) in a heat exchanger . If the overall heat transfer Coefficient is 0.92 KW/m^2K for an effective area of 43.8 m^2, find the fluid outlet temperatures for counter flow and parallel flow arrangements. [8+8]

8. (a) Define the following non-dimensional numbers of mass transfer
      i. Prandtl number
      ii. Schmidt number
      iii. Lewis number.
   (b) Explain equimolal counter diffusion between the species A and B of a binary gas mixture. [9+7]

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

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1. Write down the general conduction equation of unsteady state of heat flow and with uniform heat generation for rectangular system of co-ordinates. Then transform this equation in
   (a) cylinderical and
   (b) spherical system of co- ordinates. [16]

2. Heat at the rate of 0.5 MW/m^3 is generated in a 50 mm thick wall having thermal conductivity 18 W/mK. One side of the wall exposed to environment at 50^{0}C with a heat transfer coefficient of 450 W/m^{2}K. Calculate the maximum temperature in the wall if the outer side of the wall is insulated? [16]

3. (a) Explain the advantage and limitations of dimensional analysis.
   (b) The coefficient of free convection at the surface of horizontal pipe may be computed from the relation:
   $N_u = \frac{hd}{k} = 0.053(P_r)^{0.5} * (P_r + 0.955)^{-0.25} * (G_r)^{0.25}$
   where, all the properties are evaluated at the surface temperature and coefficient of cubical expansions, = 1/T , T being the Absolute air temperature, use this relation to calculate the heat loss by natural convection per meter length from horizontal pipe of 15 cm diameter. The surface temperature of the pipe is 275^{0}C and the surroundings are at 17^{0}C.
   At the surface temperature of 275^{0}C, the thermo-physical property of air is:
   $P_r = 0.675$
   $\rho = 0.6445$ kg/m^3
   k = 3.81 * 10^{-2} kcal/m-hr-deg.
   $\mu = 2.91 \times 10^{-6} k_{gf} - s/m^2$ [16]

4. (a) Using a linear velocity profile $u/u_\alpha = y/\delta$, for flow over a flat plate, obtain an expression for the boundary layer thickness as a functions of x.
   (b) Air at 27^{0}C flows over a flat plate at a velocity of 2 m/s. The plate is heated over its entire length to a temperature of 60^{0}C. Calculate the heat transfer for the first 20 cm of the plate. [8+8]

5. (a) Distinguish between
      i. Subcooled boiling & Saturated boiling
      ii. Nucleate boiling & film boiling.

(b) Water at atmospheric pressure is boiled in a Kettle made of copper. The bottom of the Kettle is flat, 35 cm in diameter and maintained at a temperature of 115^0C by an electric heater. Calculate the rate of heat required to boil water. Also estimate the rate of evaporation of water from the Kettle. [4+12]

6. (a) Distinguish between a black body and grey body.

   (b) Prove that intensity of radiation is given by $I_b = E_b/\pi$

   (c) State and explain Kirchoff's identity? What are the condition's under which it is applicable. [4+6+6]

7. A multipass heat exchanger (two passes on shell side and four passes on the tube side) is designed for the cooling the oil . The oil is passed through the tubes and cooled from 134^0C to 53^0C. The cooling water passing through the shell enter at 14^0C and leaves at 32^0C . Find the heat transfer rate for the following data. h_I (oil) = 268 W/m^2-K ; h_0(water) = 962 W/m^2-K ; h(scale on water side) = 2832 W/m^2-K number of tubes per pass = 118.
   Length and outer diameter of each tube are 2m and 2.5cm thickness of tube = 1.6mm ; LMTD correction factor = 0.97 . Neglect the tube wall resistance. [16]

8. (a) Show the similarly of Fick's law of diffusion to Fourier equation for conduction.

   (b) Distinguish between thermal diffusion, pressure diffusion and forced diffusion. [8+8]

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1. (a) Write some examples to illustrate the importance of heat transfer in various fields of engineering.
   (b) A steam pipe is 7.5 cm external diameter and 30m long. It conveys 1000 kg. of steam per hour at a pressure of 2MN/m^2. The steam enters the pipe with a dryness faction of 0.98 and is to leave the other end of the pipe with the minimum dryness fraction of 0.96. This is to be accomplished by suitably lagging the pipe. The coefficient of thermal conductivity of flogging material is 0.19 W/m-K Determine the minimum thickness lagging required to meet the necessary conditions. Take the temperature of the outside surface of the lagging as 27^{0}C. Neglect the resistance of the pipe material and assume that there is no pressure drop across the pipe. [8+8]

2. (a) Define the term overall heat transfer coefficient? And explain its significance.
   (b) An aluminium fin (200 W/mK) of 3 mm thick and 75 mm long protrudes from a wall at 300^{0}C. The ambient temperature is 50^{0}C with heat transfer coefficient of 10 W/m^{2}K. Calculate the heat loss from the pin for unit depth of material. Also calculate its effectiveness and efficiency? [8+8]

3. (a) Describe the physical mechanism of convections. How is the convection heat transfer coefficient related to this mechanism?
   (b) A horizontal pipe 0.3048 m in diameter is maintained at a temperature of 250^0C in a room where the ambient air is at 15^{0}C, Calculate the free covection heat loss per meter of length. [8+8]

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

5. (a) Differentiate between pool boiling and flow boiling.
   (b) Show the various regimes in pool boiling and discuss the heat transfer mechanisms in each region in detail.
   (c) A heated brass plate at 160^{0}C is submerged horizontally in water at a pressure corresponding to a saturation temperature of 120^{0}C. What is the heat transfer per unit area? Calculate also the heat transfer coefficient in boiling. [4+6+6]

6. (a) Define the terms
      i. absorptivity

ii. reflectivity and
iii. transmissivity.

(b) Differentiate between specular and diffuse reflections.

(c) Derive Stefan-Boltzmann's law from Plank's law. [6+4+6]

7. (a) Derive an expression for logarithmic mean temperature difference for the case of parallel 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/Sec (sp.heat 2.0 kJ/kg-K) it is cooled by another fluid with a mass flow rate of 0.7 kg/sec (Sp.heat 0.4 kJ/kg-K). The overall heat transfer coefficient based on outside area of $20m^2$ is 250 W/m^2-K.Calculate the exit temperature of hot fluid when fluids are in parallel flow. [8+8]

8. Derive Stefan's equation for the rate of evaporation of water evaporation from the surface of a lake. State the assumption made . Find the diffusion rate of water from the bottom of test tube 1.5cm in diameter and 15 cm long into dry atmosphere air at 25^0C. Take diffusion co-efficient D=0.252 cm^2/sec. [16]

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