Code No: R05320306 **Set No. 1**

III B.Tech II Semester Regular Examinations, Apr/May 2008
HEAT TRANSFER
(Common to Mechanical Engineering and Automobile Engineering)
Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Derive steady state general heat conduction equation without heat generation in spherical systems.
   (b) State and explain the mode of conduction heat transfer. [10+6]

2. (a) Sketch various types of fin configurations?
   (b) Aluminum fins of rectangular profile are attached on a plane wall with 5 mm spacing. The fins have thickness 1 mm, length = 10 mm and the normal conductivity K = 200 W/mk. The wall is maintained at a temperature of 200^0C and the fins dissipate heat by convection into ambient air at 40^0C, with heat transfer coefficient = 50 W/m^2k. Find the heat loss. [6+10]

3. (a) What are Biot and Fourier numbers? Explain their physical significance.
   (b) A slab of Aluminum 10cm thick is originally at a temperature of 500^0C. It is suddenly immersed in a liquid at 100^0C resulting it a heat transfer coefficient of 1200 W/m^2k. Determine the temperature at the centerline and the surface 1 min after the immersion. Also the total thermal energy removal per unit area slab during this period. The properties of aluminum for the given condition are: $\alpha = 8.4 \times 10^{-5}$m^2 /s, K=215 W/mk, ρ = 2700 kg/m^3, C_p= 0.9 kJ/kg. [6+10]

4. (a) Water at 50^0C enters a 1.5cm diameter and 3m long tube with a velocity of 1m/s. The tube wall is maintained at a constant temperature of 90^0C. Calculate the heat transfer coefficient and the total amount of heat transferred if the exit water temperature is 64^0C.
   (b) What is Reynolds analogy? Describe the relation between fluid friction and heat transfer. [8+8]

5. (a) Explain the terms 'hydrodynamic boundary layer' and 'thermal boundary layer', how are these thickness related to Prandtl number.
   (b) Compute the coefficient of heat transfer from a vertical plate of height 2 m to the surrounding still air at 20^oC when the plate is maintained at 100^oC. Use the following relation
   $Nu_L = 0.15(Gr_L Pr_L)^n \ (Pr/Pr_s)^{0.25}$.
   Where all fluid properties except Prs (Pr at surface) are taken at the ambient temperature. [6+10]

6. (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^oC, what is the rate at which steam is condensed per unit length of the tubes? [6+10]

7. (a) How are exit fluid temperatures determined with the help of ε -NTU method?

   (b) When one of the two fluids undergoes phase change, show that the effectiveness values for both parallel flow and counter flow heat exchangers are equal and given by
   $\varepsilon = 1$ exp(- NTU). [4+12]

8. (a) Explain the terms absorptivity, reflectivity and transmissivity.

   (b) Fused quartz transmits 90% of the incident thermal radiation between 0.2 and 4 μ. 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^oC
      ii. 550^oC
      iii. 250^oC
      iv. 70^oC. [6+10]

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Code No: R05320306 **Set No. 2**

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HEAT TRANSFER
(Common to Mechanical Engineering and Automobile Engineering)
Time: 3 hours **Max Marks: 80**
Answer any FIVE Questions
All Questions carry equal marks
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1. (a) State and explain Newton's law of heat convection.
   (b) A refrigerator stands in room where the air temperature is 20 ^{0}C. The surface temperature on the outer side of the refrigerator is 16 ^{0}C, the sides are 30 mm thick having a thermal conductivity of 0.1 W/mK. The heat transfer coefficient on the outer side is 10 W/m^2 K . Assuming one dimensional conduction through the sides, calculate the net heat flow and the surface temperature inside the refrigerator. [4+12]
2. (a) A plate 20 mm thick and 100 mm wide is used to heat a fluid at 30^{0}C. The heat generation rate inside the plate is 7×10^6 W/m^3. Determine the heat transfer coefficient to maintain the temperature of the plate below180^0 C. Given K = 26 W/m^{0}C.
   (b) Explain the following:
      i. Efficiency of fin.
      ii. Effectiveness of fin. [10+6]
3. (a) On a hot summer's day a concrete high way reach a temperature of 55^{0}C. Suppose that a stream of water is directed on the high way so that the surface temperature is suddenly lowered to 35^{0}C. How long will it take to cool the concrete to 45^{0}C at a depth of 5cm from the surface?
   (b) A solid steel, 160mm long cylinder with a 80mm diameter initially at 800^{0}C, is cooled in a medium which is at a constant temperature of 30^{0}C. The surface heat transfer coefficient is 120 W/m^{2}k. Determine the centre line temperature at the midpoint of length 30 minuets after cooling is initiated. Take α= 0.022 m^2 /hr, k=23.5 W/mk. [8+8]
4. (a) Define the local and average skin friction (drag) coefficient for a flat smooth plate at zero incidence.
   (b) A thin flat plate has been placed longitudinally in a steam of air at 20^{0}C and while flows with undisturbed velocity of 7.5 m/s. The surface of plate is maintained at a uniform temperature of 120^{0}C.
      i. calculate the heat transfer coefficient 0.8m from the leading edge of the plate,
      ii. Also calculate the rate of heat transfer from one side of the plate to the air over the first 0.8 m length. Assume unit width of the plate. [8+8]

5. A power amplifier is mounted vertically in air at 25^oC. The case is made of anodized aluminium with a surface area of about 3800 mm^2 and a height of 40 mm. Determine

   (a) The heat transfer coefficient for natural convection cooling with a case temperature of 125^oC.

   (b) The rate of total heat dissipation

   (c) What is the percentage of total heat that is lost by natural convection? Properties of air at 75^oC are $\nu = 2.06 \times 10^{-5} m^2/s$, Pr = 0.697 and K = 0.0299 W/mK. [16]

6. (a) Distinguish between nucleate and film boiling.

   (b) A heated 30 × 30 cm square copper plate, serves as the bottom for a pan of water at 1 atm. Pressure. The temperature of the plate is maintained at 119^oC. Estimate the heat transferred per hour by the plate. [6+10]

7. (a) Explain, how are the heat exchangers classified?

   (b) Calculate the overall coefficient of heat transfer between water and oil if the water flows through a copper tube of 180mm inside diameter and 15mm thick while the oil flows through the annulus formed by this pipe and an outer concentric pipe. The thermal conductivity of the tube wall is 349 W/m K and the fouling factors on the oil and water side are 0.00086 m^2K / W and 0.000344 m^2K / W respectively. The oil and water side heat transfer coefficients can be taken as 1280 and 4650 W/m^2K respectively. [6+10]

8. (a) What is the shape factor with respect to itself if the surface is concave, convex or flat?

   (b) Show that for two infinite parallel gray planes exchanging radiant energy, the mean emissivity is given by $\left[1/\left(\frac{1}{\varepsilon 1} + \frac{1}{\varepsilon 2} - 1\right)\right]$. [6+10]

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Code No: R05320306 **Set No. 3**

III B.Tech II Semester Regular Examinations, Apr/May 2008

HEAT TRANSFER

(Common to Mechanical Engineering and Automobile Engineering)

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

Answer any FIVE Questions

All Questions carry equal marks

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1. (a) Derive steady state general heat conduction equation without heat generation in spherical systems.
   (b) State and explain the mode of conduction heat transfer. [10+6]

2. (a) A plate 20 mm thick and 100 mm wide is used to heat a fluid at 30^0C. The heat generation rate inside the plate is 7×10^6 W/m^3. Determine the heat transfer coefficient to maintain the temperature of the plate below180^0 C. Given K = 26 W/m^{0}C.
   (b) Explain the following:
      i. Efficiency of fin.
      ii. Effectiveness of fin. [10+6]

3. (a) On a hot summer's day a concrete high way reach a temperature of 55^0C. Suppose that a stream of water is directed on the high way so that the surface temperature is suddenly lowered to 35^0C. How long will it take to cool the concrete to 45^0C at a depth of 5cm from the surface?
   (b) A solid steel, 160mm long cylinder with a 80mm diameter initially at 800^0C, is cooled in a medium which is at a constant temperature of 30^0C. The surface heat transfer coefficient is 120 W/m^{2}k. Determine the centre line temperature at the midpoint of length 30 minuets after cooling is initiated. Take α= 0.022 m^2 /hr, k=23.5 W/mk. [8+8]

4. (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) Under forced flow conditions how does the prandtl number affect relative thickness of thermal Boundary layer and velocity Boundary layer. Show that the velocity and temperature distributions within the Boundary layer are going to be similar in nature. [8+8]

5. (a) The boundary layer thickness for a free convection process is more than in the case of forced convection process. Why?
   (b) A plate of size 20 cm × 30 cm is used as a water heater in a process plant. The temperature of water is 20^oC while the heater plate is maintained at a temperature of 120^oC. Determine the heat transfer rate by free convection when 20 cm side of the heater is kept vertical. [4+12]

6. Saturated steam at atmospheric pressure condenses on a horizontal copper tube of 25 mm inner diameter and 29 mm outer diameter through water flows at the rate of 25 kg/min entering at 30^oC and leaving at 70^oC. Making necessary assumptions, calculate

   (a) The condensing heat transfer coefficient

   (b) The inside heat transfer coefficient

   (c) The length of the tube. [16]

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

   (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/mK) 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 $R_{fi} = R_{fo} = 0.0088 m^2K/W$. [4+12]

8. (a) What is the shape factor with respect to itself if the surface is concave, convex or flat?

   (b) Show that for two infinite parallel gray planes exchanging radiant energy, the mean emissivity is given by $\left[{}^1/\left(\frac{1}{\varepsilon 1} + \frac{1}{\varepsilon 2} - 1\right)\right]$. [6+10]

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Code No: R05320306 **Set No. 4**

III B.Tech II Semester Regular Examinations, Apr/May 2008
HEAT TRANSFER
(Common to Mechanical Engineering and Automobile Engineering)
Time: 3 hours **Max Marks: 80**
Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Derive general differential heat conduction equation in cylindrical co-ordinate system.
   (b) Describe the mechanism of conduction, convection and radiation. [10+6]

2. (a) A plate 20 mm thick and 100 mm wide is used to heat a fluid at 30^0C. The heat generation rate inside the plate is 7×10^6 W/m^3. Determine the heat transfer coefficient to maintain the temperature of the plate below180^0 C. Given K = 26 W/m^{0}C.
   (b) Explain the following:
      i. Efficiency of fin.
      ii. Effectiveness of fin. [10+6]

3. (a) What are Biot and Fourier numbers? Explain their physical significance.
   (b) A slab of Aluminum 10cm thick is originally at a temperature of 500^0C. It is suddenly immersed in a liquid at 100^0C resulting it a heat transfer coefficient of 1200 W/m^{2}k. Determine the temperature at the centerline and the surface 1 min after the immersion. Also the total thermal energy removal per unit area slab during this period. The properties of aluminum for the given condition are: $\alpha = 8.4 \times 10^{-5}$m^2 /s, K=215 W/mk, ρ = 2700 kg/m^3, C_p= 0.9 kJ/kg. [6+10]

4. (a) Discuss the advantages and limitations of dimensional analysis.
   (b) Neglecting viscous dissipation, the convection heat transfer coefficient is anticipated to depend upon the following parameters:–
   Fluid viscosity μ, fluid density ρ, fluid thermal conductivity K, fluid specific heart C_p, flow velocity v, and significant length L. Considering mass, length, time and temperature as the significant dimensions, set up a suitable correction in terms of non-dimensional numbers for the heat flow. Use Buckingham - π method of analysis. [6+10]

5. (a) The heat transfer coefficient is less in natural convection compared to forced convection. Why?
   (b) A square plate 0.5 m × 0.5 m with one surface insulated and the surface is maintained at a uniform temperature of 385 K, which is placed in quiescent air at atmospheric pressure and 315 K. Calculate the average heat transfer coefficient for natural convection when the plate is vertical. [4+12]

6. Air free saturated steam at 65^oC condenses on the outer surface of a 25 mm outer diameter 3m long vertical tube maintained at a uniform temperature of 35^oC by flow of cooling water through the tube. Assuming film condensation and 20% in excess of Nusselt's value calculate the average heat transfer coefficient over the entire length of the tube and the rate of condensate flow at the bottom of the tube. Confirm that the flow is laminar. [16]

7. 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 $U_o = 310$ 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^oC and 150^oC respectively. Determine the rate of heat transfer and the exit temperatures of the water and the oil. [16]

8. (a) State and prove Kirchoff's law of radiation.
   (b) Why is Planck's law the basic law of thermal radiation? Explain graphically how E_b, λ, and T are related. [8+8]

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