Code No: R32033 **R10** **Set No: 1**

III B.Tech. II Semester Supplementary Examinations, January -2014

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 Hours **Max Marks: 75**

Answer any FIVE Questions

All Questions carry equal marks

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Heat and Mass Transfer data book is allowed

1. (a) Derive the expression for the temperature distribution and the rate of heat transfer for a hollow cylinder.
   (b) A composite wall is made up three layers of thickness 25 cm, 10 cm and 15 cm of material A, B and C respectively. The thermal conductivities of A and B are 1.7 W/m °K and 9.5 W/m °K respectively. The outside surface is exposed to air at 20 °C with convection coefficient of 15 W/m² °K and the inside is exposed to gases at 1200 °C with a convection coefficient of 28 W/m² °K and the inside surface is at 1080 °C. Determine the unknown thermal conductivity of layer made up of material C. (6+9)

2. Explain the following (5x3 = 15)
   (i) Electrical analogy.
   (ii) Fin, efficiency and effectiveness of the fin.
   (iii) Thermal resistance.
   (iv) Critical thickness.
   (v) One dimensional heat conduction.

3. (a) Discuss the significance of critical radius.
   (b) One end of very long aluminum rod is connected to a wall at 140 °C, while the other end protrudes into a room whose air temperature is 15 °C. The rod is 3 mm in diameter and the heat transfer coefficient between the rod surface and the environment its 300W/m² °C. Find out the total heat dissipated by the rod taking its thermal conductivity as 150 W/m °C. (6+9)

4. (a) A 10 cm diameter cylindrical bar heated in the furnace to a temperature of 200^0C is allowed to cool in an environment with convection coefficient of 150 W/m^2 ^{0}K and temperature of 40^0 C determine the,
   (i) The time required to cool the centre of the bar to 50^0C
   (ii) Temperature of the surface at this instant. For the material of the bar, K = 50 W/m K and thermal diffusivity 2 x 10^{-5} m^2/sec.
   (b) The Biot number during a heat transfer between a sphere and its surroundings is found to be 0.02. Would you prefer lumped system analysis or transient temperature charts when determining the centre temperature of the sphere? Why? (7+8)

5. (a) What is meant by bulk mean temperature? Where do you use it?
   (b) How do you possess pressure drop for flow through a pipe?
   (c)Atmosphere air at 30^0C flows over a flat plate of (3x1) m^2 maintained at 70^0C with a velocity of 10m/s. Calculate the distance from the leading edge at which transition occurs. Find the thickness of the hydrodynamic boundary layer and thermal boundary layer at 0.5m from the edge. (4+4+7)

6. (a) Derive the expression for condensing heat transfer coefficient for a vertical plate under laminar conditions.
   (b) Water at 100 °C is boiled with the help of Ni-Cr heating wire having surface area $5x10^{-2}$ m^2 immersed in it and maintained at 114.3 °C. Calculate the heat flux and rate of evaporation. Assume nucleate flux and rate of evaporation. Assume nucleate boiling and the constant for water Ni-Cr as 0.013 boiling and the constant for water Ni-Cr as 0.013. (7+8)

7. (a) In a counter flow double pipe heat exchanger water is heated from 40 ºC to 80 ºC with oil entering at 105 ºC and leaving at 70 ºC. Taking the overall heat transfer coefficient as 300 W/m² ºK and the water flow rate as 0.1Kg/s. Calculate the heat exchanger area.
   (b) Derive the relationship between effectiveness and number of transfer units for a parallel flow heat exchanger. (8+7)

8. (a) Distinguish between black color and radiation black bodies.
   (b) State Lambert's cosine law and its significance.
   (c) A 3mm thick glass window transmits 90 percent of the radiation between λ= 0.3 & 3μm and is essentially opaque for other wave lengths. Determine the rate of radiation through a 2mx2m glass window from a black body source at 5000 °K. (4+4+7)

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Code No: R32033 **R10** **Set No: 2**

III B.Tech. II Semester Supplementary Examinations, January -2014

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 Hours **Max Marks: 75**

Answer any FIVE Questions

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Heat and Mass Transfer data book is allowed

1. (a) Explain the different modes of heat transfer with appropriate expressions.
   (b) A composite wall consists of 10 cm thick layer of building brick, k = 0.7 W/m ºK and 3 cm thick plaster, k = 0.5 W/m ºK. An insulating material of k = 0.08 W/m ºK is to be added to reduce the heat transfer through the wall by 40%. Find its thickness. (7+8)

2. (a) A furnace wall is made of 14 cm. thick inside layer of fire brick (k =1.2 W/m ºC), 8 cm. Thick middle layer of insulating brick (k = 0.15 W/m ºC) and 12 cm thick outside layer of red brick (k = 0.85 W/m ºC). The furnace operates at 870 ºC and it is anticipated that the outside of this composite wall can be maintained at 400 ºC by circulation of air. Assuming the close bonding of layer at their interfaces, find the rate of heat loss from the furnace and the wall interface temperature. The wall measures 5 m x 2 m.
   (b) Derive an expression for critical radius of insulation for a hollow cylinder. (10+5)

3. (a) Define semi infinite body.
   (b)Derive the expression for temperature variation in a semi-infinite body without any surface resistance.
   (c) In a quenching process, a copper plate of 3 mm thick is heated up to 350^0C and then suddenly it is dipped a 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 plate dimensions may be taken as length 40 cm and width 30 cm. Take properties of copper as c = 380 J/kg K, ρ = 8800 kg/m^3, k = 385W/m °K.
   (3+4+8)

4. (a) What do you understand by the hydrodynamic and thermal boundary layers. Illustrate with reference to flow over a flat heated plate.
   (b)Explain the circumstances under which natural convection occurs. Use the principle of dimensional analysis to establish a relation between Nusselt number, Grashoff number and Prandtl number. (7+8)

5. (a) Explain Reynolds analogy and cal burn analogy.
   (b).Air at a temperature of 30^0C flows over a flat plate of length 1m and width 2m with a velocity of 3m/s. Determine the direction of air i.e, along its length or width that will create maximum drag force. (7+8)

6. Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan on top of a heating unit. The inner surface of the bottom of the pan is maintained at l08º C. If the diameter of the bottom of the pan is 30 cm, determine (15)
   (a) The rate of heat transfer to the water and,
   (b) The rate of evaporation of water.

Following properties are known and the following correlation may be used

σ =0.0589 N/m h_{fg} = 2257000 K/kg C_{sf} = 0.0130, p_l = 857.9 kg/m^3, $\mu_{1=}$0.282x 10^{-3} kg/m.s, n=1.0 ρ_v = 0.6 kg/m^3, Pr =1.75, C_{pl} = 4211 J/kg °C.

$$q = \mu_l h_{fg} \left[\frac{g(\rho_l - \rho_v)}{\sigma}\right]^{1/2} \left[\frac{C_{pl}(T_s - T_{sat})}{C_{sf} h_{fg} \mathrm{Pr}_l^n}\right]^3$$

7. (a) Define the LMTD and obtain an expression for LMTD for parallel flow heat exchanger.
   (b) Water to water heat exchanger of a counter flow arrangement has heating surface area of 2m². Mass flow rates of hot and cold fluids are 2000 kg/hr and 1500 kg/hr respectively. Temperatures of hot and cold fluids at inlet are 85 ºC and 25 ºC respectively. Determine the amount of heat transferred from hot to cold water and their temperatures at the exit if the overall heat transfer coefficient U = 1400 W/m² ºK. (6+9)

8.(a) Using the definition of radiosity and irradiation prove that the radiation heat exchange between two grey bodies is given by the relation:

$$Q_{net} = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{A_1\ \varepsilon_1} + \frac{1}{A_1F_{1-2}} + \frac{-\varepsilon_2}{A_2\varepsilon_2}}$$

(b) A surface at 100 °K with emissivity of 0.10 is protected from a radiation flux of 1250W/m² by a shield with emissivity of 0.05. Determine the percentage cut off and the shield temperature' Assume shape factor as 1. (7+8)

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Code No: R32033 **R10** **Set No: 3**

III B.Tech. II Semester Supplementary Examinations, January -2014

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 Hours **Max Marks: 75**

Answer any FIVE Questions

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Heat and Mass Transfer data book is allowed

1. (a) A furnace is to be designed for a maximum wall temperature of 500 ºC. The hot gas temperature on one side of the wall is 1000 ºC and the air temperature on the other side is 30ºC. The values of *h* for hot side and cold side are 232.6 and 348.9 W/m² ºC respectively. Calculate the permissible thermal resistance per m² area of the metal wall. Explain briefly the concept of critical thickness of insulation and state any two applications of the same.
   (b). Explain,
   (i) Fourier's Law of heat conduction.
   (ii) Thermal diffusivity.
   (iii) Convective heat transfer. (9+6)

2. (a) Sketch the boundary layer development of a flow over a flat plate and explain the significance of the boundary layer.
   (b) Atmospheric air at 275 K and a free stream velocity of 20 m/s flows over a flat plate 1.5m long that is maintained at a uniform temperature of 325 K. Calculate the average heat transfer coefficient over the region where the boundary layer is laminar, the average heat transfer coefficient over the entire length of the plate and the total heat transfer rate from the plate to the air over the length 1.5 m and width 1 m. Assume transition occurs at Re = $2x10^5$. (5+10)

3. (a) A long aluminum cylinder 5.0 cm in diameter and initially at 200^0 is suddenly exposed to a convection environment at 70^0C and h=525 W/m² °K. Calculate the temperature at a radius of 1.25 cm, 1 min after the cylinder is exposed to the environment.
   (b) A 50 cm x 50 cm copper slab 6.25 mm thick has a uniform temperature of 100 °C. Its temperature is suddenly lowered to 36 °C. Calculate the time required for the plate to reach the temperature of 108 °C. Consider the heat transfer to occur by both side surface area of the plate. (Given that ρ = 9000 kg/m³, *cp* = 380W/ m °C, *h* =90W/m² °C). (7+8)

4. (a) Define turbulent Prandtl number. Discuss its significance convective heat transfer.
   (b) Distinguish between natural and forced convective heat transfers engine oil at 60^0C flow with a mean velocity of 0.15 m/s through a circular tube of 2.5cm dia. Calculate (i) Flow Reynolds number.(ii) Hydrodynamic entrance length (iii) friction factor (iv) pressure drop over a 100 m length of tube. (5+10)

5. (a) What is meant by bulk mean temperature? Where do you use it?
   (b) How do you possess pressure drop for flow through a pipe
   (c) Atmosphere air at 30^0C flows over a flat plate of (3x1) m^2 maintained at 70^0C with a velocity of 10m/s. Calculate the distance from the leading edge at which transition occurs. Find the thickness of the hydrodynamic boundary layer and thermal boundary layer at 0.5m from the edge. (4+4+7)

6. (a) How to promote drop-wise condensation? State some methods.
   (b) Saturated steam at atmospheric pressure and 100 condensers on a vertical plate of 1m height and 0.2m width. The surface temperature of the plate is maintained at 80^0C. Calculate (7+8)
   (i) The condensing heat transfer coefficient at 0.3m.
   (ii) The film thickness at 0.3m from top.
   (iii) The average heat transfer coefficient and
   (iv) The rate of steam condensation. Assume laminar flow.

7. (a) Define the heat capacity ratio.
   (b) Define the NTU and explain its significance.
   (c)Water flows through a stainless steel tube (k = 54 W/m K) of 1.3 cm inner diameter and 1.6 cm outer diameter and length 5 m with a velocity of 1.5 m/s. Water enters at 15^0C on the outer surface of tube steam condenser with a heat transfer coefficient of 12000W/m^2 K. Calculate the inside heat transfer coefficient and overall heat transfer coefficient based on outer surface. (4+4+7)

8. (a) Emissivity of two large parallel plates maintained at 800 °C and 300 °C are 0.5 and 0.6 respectively. Find the percentage reduction in heat transfer when a polished aluminum radiation shield of emissivity 0.05 is placed between them.
   (b) Define Lambert's cosine law, configuration factor, emissivity and emissive power (9+6)

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Code No: R32033 **R10** **Set No: 4**

III B.Tech. II Semester Supplementary Examinations, January -2014

HEAT TRANSFER

(Mechanical Engineering)

Time: 3 Hours **Max Marks: 75**

Answer any FIVE Questions

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Heat and Mass Transfer data book is allowed

1 (a). A furnace wall is made of 2 successive layers of insulating materials one of foamed fire clay (k= 0.279 + 0.000273T) w/m ^{0}C and red brick (k = 0.7 W/m^{0}C). The wall temperature inside the furnace wall is 1373 K and outside wall temperature is 323 K. If the thickness of insulating material being 12.5 cm of foam clay and 50 cm of red brick. Calculate the amount of heat lost from 100m^2 of furnace wall. Also calculate the temperature at interface layer.

(b). Calculate the conduction shape factors for edges and corners. (9+6)

2 (a). Derive an equation for temperature distribution in a hollow sphere.

(b) Hot gas at a constant temperature of 400 ºC is contained in a spherical shell (2000mm internal diameter,50mm thick) made of steel. Mineral wool insulation (k = 0.06 W/m ºK) of thickness 100mm is wrapped all around it. Calculate the steady rate at which heat will flow out if the outside air is at a temperature of 30 ºC. HT Coefficient on the inner surface of the steel shell and on the outer surface of the insulation is 15W/m² ºK. (6+9)

3 (a) An aluminum rod (k =204 W/m ºK) 2 cm in diameter and 20 cm long protrudes from a wall which is maintained at 300°C. The end of the rod is insulated and the surface of the rod is exposed to air at 30°C. The heat transfer coefficient between the rod's surface and air is 10 W/m² °K. Calculate the heat lost by the rod and the temperature of the rod at a distance 2 of 10 cm from the wall.

(b) A large iron plate of 10 cm thickness and originally at 800 °C is suddenly exposed to an environment at 0 °C where the convection coefficient is 50 W/m² °K. Calculate the temperature at a depth of 4 cm from one of the faces 100 seconds after the plate is exposed to the environment. How much energy has been lost per unit area of the plate during this time? (7+8)

4 (a) Explain the physical significance of the dimensionless groups Prandtl number and Nusselt number.
(b) A nuclear reactor with its core constructed of parallel vertical plates 2.25m high and 1.5m wide has been designed on free convection heating of liquid Bismuth. Metallurgical considerations limit the maximum surface temperature of the plate to be 975^0C and the lowest allowable temperature of Bismuth is 325 ^{0}C. Estimate maximum possible heat dissipation from both sides of each plate. The appropriate correlation for convection coefficient is Nu = 0.13 (Gr.P r)0.33 where the different parameters are evaluated at mean film temperature.
Thermo-physical properties of Bismuth at mean film temperature are: (5+10)
Density 104 Kg/m^3 Thermal conductivity 13.02 W/M^{0}K
Specific heat 150.7 J/Kg^{0}K Viscosity is 3.12 Kg/m-hr.

5 (a)Distinguish free and forced convections with examples.
(b)A black plate(e=1) of dimensions 1mx1mx0.025m is maintained at its top a temperature of 227^0C.The top surface of the plate is exposed to environment at 27^0C and convective heat transfer coefficient between the plate and environment is 10 w/m^2 K Calculate the temperature at the bottom of the plate. Assume k for plate 60 w/mK. (6+9)

(Hint: $Q_{condu}=Q_{rad}+Q_{conv}$).

6 (a) Explain different types of boiling.
(b) Sixty-four tubes of 25mm diameter are arranged in a square array and are exposed to saturated steam at 100^0C.Calculate the rate of condensation of steam per hour if the tube surface is maintained at 90^0C. Take length of each tube as 1.5m. (7+8)

7 (a) In a counter-flow double pipe heat-exchanger; water is heated from 25 ºC to 65 ºC by an oil with a specific heat of 1.45 kJ/kg ºC and mass flow rate of 0.9 kg/s. The Oil is cooled from 230 ºC to 160 ºC. If the overall heat transfer coefficients 420 W/m² ºC calculate the following: (**i**) the rate of heat transfer, (**ii**) the mass flow rate of water, (**iii**) the surface area of the heat exchange.
(b) Explain about the following (9+6)
(i) Over all heat transfer coefficient.
(ii) Fouling factor.
(iii) Minimum fluid.

8 (a) Define emissivity, absorptivity and reflectivity
(b) Two parallel, infinite grey surfaces are maintained at temperature of 127 °C and 227 °C respectively. If the temperature of the hot surface is increased to 327 °C, by what factor is the net radiation exchange per unit area increased? Assume the emissivity of cold and hot surfaces to be 0.9 and 0.7 respectively. (6+9)

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