Heat and Mass Transfer VTU CBCS Question Paper Set 2018

USN | | | | | | | | | | | **10AU65**

Sixth Semester B.E. Degree Examination, June/July 2017
Heat and Mass Transfer

Time: 3 hrs.   Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Usage of HMT data hand book is permitted.***
3. ***Missing data; if any, may be assumed suitably.***

PART – A

1 a. Stating all the assumptions, derive 3-D heat conduction equation made in Cartesian co-ordinates. **(10 Marks)**

b. Steam at 350°C flowing in a pipe (K = 80 W/mk) 5 cm inner dia, 5.6 cm outer dia is covered with 3 cm thick insulation (K = 0.05 W/mK). Heat is lost to the surroundings at 5°C by natural convection (h_0 = 20 W/m^{2}K and h_i = 60 W/m^{2}K). Find

(i) Rate of heat loss from pipe per unit length.

(ii) Temperature drop across the pipe and insulation.

Draw net–work diagram. **(10 Marks)**

2 a. Derive an expression for the heat transfer from an extended rectangular surface of finite length with usual assumptions. **(10 Marks)**

b. A stainless steel fin (K = 20 W/mK) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300°C. The ambient temperature is 50°C and the heat transfer coefficient is 10 W/m^{2}K. The fin tip is insulated. Determine (i) The rate of heat dissipation from the fin (ii) The temperature at the fin tip (iii) The rate of heat transfer from the wall area covered by the fin if the fin was not used and (iv) the heat transfer rate from same fin geometry if the stainless steel fin is replaced by a fictitious fin with infinite thermal conductivity. **(10 Marks)**

3 a. Explain Biot and Fourier numbers. Show that $\frac{T - T_\infty}{T_0 - T_\infty} = e^{-B_i F_o}$ **(10 Marks)**

b. Steel ball bearings (K = 50W/mK, $\alpha = 1.3 \times 10^{-5}$ m^2/s) having a diameter of 40 mm are heated to a temperature of 650°C and then quenched in a tank of oil at 55°C. If the heat transfer coefficient between the ball bearings and oil is 300 W/m^{2}K, determine (i) duration of time the bearings must remain in oil to reach a temperature of 200°C (ii) The total amount of heat removed from each bearing during this time and (iii) The instantaneous heat transfer rate from the bearings when they are first immersed in oil and when they reach 200°C. **(10 Marks)**

4 a. Discuss the concepts of hydrodynamic and thermal boundary layers with neat sketches. **(06 Marks)**

b. Give physical significance of, (i) Grashoff number. (ii) Nusselt number (iii) Prandtl number. **(06 Marks)**

c. A fine wire having a diameter of 0.02 mm is maintained at a constant temperature of 54°C by an electric current. The wire is exposed to air at 1 atm and 0°C. Calculate the electric power necessary to maintain the wire temperature if the length is 50 cm. **(08 Marks)**

PART – B

5 a. Using dimensional analysis correlate the forced convection data: $Nu = C(Re^{m})(P_r)^{n}$. **(10 Marks)**

b. Air at 35°C flows across a cylinder of 50 mm diameter at a velocity of 50 m/s. The cylinder surface is maintained at 145°C. Find the heat loss per unit length. Properties at mean temperature are $\rho = 1\ \text{kg/m}^3$, $\mu = 20\times10^{-6}$ kg/ms, K = 0.0312 W/m°C, C_P = 1.0 KJ/kg°C. **(10 Marks)**

6 a. For a co-axial parallel flow heat exchanger, establish $\in = \dfrac{1-e^{-NTU(1+c)}}{1+c}$ with usual notation. **(10 Marks)**

b. Water is heated at a rate of 1.4 kg/s from 40°C to 70°C by an oil entering at 110°C and leaving at 60°C in a counter flow heat exchanger. If $U_0 = 350$ W/m^2 K. Calculate

(i) Mass flow rate of oil.
(ii) Surface area required and
(iii) Effectiveness of heat exchanger using NTU method.

C_P of water = 4.187 KJ/kgK; C_p of oil = 1.9 KJ/kgK. **(10 Marks)**

7 a. With a neat sketch, explain regimes of pool boiling. **(10 Marks)**

b. Saturated steam at 110°C condenses on the outside of a bank of 64 horizontal tubes 25 mm outer diameter. 1 m long arranged in a 8×8 square array. Calculate the rate of condensation if the tube surface is maintained at 100°C. The properties of saturated water at 105°C are ρ = 954.7 kg/m^3, K = 0.684 W/m^2 K, $\mu = 271\times10^{-6}$ kg/ms, h_{fg} = 2243.7 kJ/kg. **(10 Marks)**

8 a. Explain

(i) Stefan-Boltzmann law
(ii) Kirchoff's law.
(iii) Planck's law.
(iv) Weins-displacement law.
(v) Radiation shield. **(10 Marks)**

b. Two very large parallel planes with emissivities 0.3 and 0.8 exchange radiative energy. Determine the percentage reduction in radiative energy transfer when a polished aluminium radiation shield ($\varepsilon = 0.04$) is placed between them. Draw network diagram. **(10 Marks)**

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10AU65

Sixth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Heat Transfer data handbook can be referred.***

PART – A

1 a. What are the basic laws of conduction, convection and radiation? Explain. **(06 Marks)**

b. Arrange the thermal conductivities of the following in the decreasing order at room temperature:
(i) Copper (ii) Silver (iii) Gold (iv) Diamond **(04 Marks)**

c. A large window glass 0.5 cm thick $\left(K = 0.78\frac{W}{m.k}\right)$ is exposed to warm air at 25°C, over its inner surface, with convection co-efficient of $15\frac{W}{m^2-K}$. The outside air is at -15^0C with convection coefficient of $50\frac{W}{m^2-K}$. Determine the heat transfer rate and temperatures at the inner and outer surface of the glass. **(10 Marks)**

2 a. Derive a mathematical expression for critical radius of insulation for a hollow cylinder. **(06 Marks)**

b. A copper pipe carrying a refrigerent at –20°C is 10 mm in outer diameter and is exposed to the ambient at 25°C with convective coefficient of $50\frac{W}{m^2-K}$. It is proposed to apply an insulation material having thermal conductivity of $0.5\frac{W}{m-K}$. Determine the critical thickness of insulation. Also, calculate heat losses for 2.5 mm, 7.5 mm and 15 mm thick layer of insulation for 1 m length of pipe and comment. **(10 Marks)**

c. Derive relations to find fin efficiency and fin effectiveness of a infinitely long fin of uniform cross section. **(04 Marks)**

3 a. Derive the mathematical expression to find the temperature distribution in a lumped system in the form given below with usual notations:
$$\frac{\theta}{\theta_i} = e^{-B_i F_G}.$$ **(08 Marks)**

b. An aluminium tube, 20 cm long with inner and outer radii as 5 cm and 6 cm respectively, is quenched from 500°C to 30°C in a large reservoir of water at 10°C. Below 100°C, the heat transfer coefficient is $1500\frac{W}{m^2-K}$ and above 100°C its value is $500\frac{W}{m^2-K}$. The thermophysical properties of aluminium are $\rho = 2700$ kg/m³, $K = 210\frac{W}{m-K}$, $C = 900$ J/kg-K.
Neglecting the internal thermal resistance, calculate the quenching time. **(12 Marks)**

4 a. Draw laminar and turbulent boundary layers for flow over a flat plate. On this sketch, show the following: laminar boundary layer region, transition region, turbulent boundary layer region, viscous sublayer, buffer layer, velocity profile in the laminar region and velocity profile in the turbulent region. **(08 Marks)**

b. Water flows at 20°C with a mass flow rate 8 kg/s through a diffuser having 3 cm diameter at the entrance and 7.0 cm at the end. Calculate the velocity and Reynolds number at the inlet and outlet of the diffuses. **(06 Marks)**

c. A fan provides air speed upto 50 m/s in a low speed wind tunnel with atmospheric air at 27°C. If this wind tunnel is used to study the boundary layer behavior over a flat plate upto $R_e = 10^8$, what should be the minimum plate length? At what distance from the leading edge transition would occur, if $R_{e_{C_L}} = 5\times10^5$? **(06 Marks)**

PART – B

5 a. Define the following, and explain,
(i) Reynolds number (ii) Prandtl number (iii) Grash of number (iv) Nusselt number
(v) Stantow number. **(10 Marks)**

b. Atmospheric pressure at a hill station is 83.4 kPa. Air at this pressure and 20°C flows with a velocity of 8 m/s over a $1.5\text{m}\times6.0\text{m}$ flat plate whose temperature is 134°C. Determine the rate of heat transfer from the plate if air flows parallel to (i) 6 m long side, and (ii) 1.5 m side. **(10 Marks)**

6 a. Derive a mathematical expression to find the log mean temperature difference for a parallel flow heat exchanger. Stating all the assumptions. **(10 Marks)**

b. Water enters the tubes of a small single-pass head exchanger at 20°C and leaves at 40°C. On the shell side, 25 kg/min of steam condenses at 60°C. Calculate the overall heat transfer coefficient and the required flow rate of water, if the area of the heat exchanger is 12 m^2.
h_{fg} of water at 60°C = 2358.7 kJ/kg.
C of water = 4174 J/kg.K **(10 Marks)**

7 a. Draw the typical boiling curve for saturated water at 1 atmosphere depicting all the boiling regimes, and explain the following (i) nucleate boiling and (ii) film boiling. **(10 Marks)**

b. Water is boiled at a rate of 30 kg/h on a copper pan, 30 cm in diameter, at atmospheric pressure. Estimate the temperature of bottom surface of the paw assuming nucleate boiling conditions. Also determine the peak heat flux. **(10 Marks)**

8 a. Define the following in relation to thermal radiation:
(i) blackbody (ii) Emissive power (iii) Absorptivity (jv) Irradiation **(08 Marks)**

b. Calculate the following quantities for an industrial furnace (blackbody) emitting radiation at 2650°C.
(i) Spectral emissive power at $\lambda = 1.2\ \mu$m.
(ii) Wavelength at which the emissive power is maximum.
(iii) Maximum spectral emissive power.
(iv) Total emissive power.
(v) Total emissive power of the furnace, if it is treated as non-black body with an emissivity of 0.9. **(12 Marks)**

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10AU65

Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART - A

1 a. Derive 3 – D heat conduction equation stating all the assumptions made in Cartesian co-ordinates Reduce the general conduction equation to Fourier – Biot equation, Poisson equation, Diffusion equation and Laplace equation. **(10 Marks)**

b. In an attempt to reduce the energy loss from a 2cm outer diameter pipe line with hot water, a plumber decides to insulate the line with 1cm thick insulation having K = 0.1W/mK. The entire metal tube can be considered to remain at a uniform temperature of 70^0C. The line is surrounded by air at 15^0C for which heat transfer coefficient is 6.5W/m^2K. Find the critical thickness of insulation and also justify the plumber's decision. **(10 Marks)**

2 a. Find the temperature distribution and heat transfer for a rectangular cross section fin of infinite length. State all the assumptions. **(10 Marks)**

b. One end of a long rod, 3cm in diameter is inserted into a furnace with outer end projecting into outside air. Once steady state is reached, the temperature of the rod are measured at two points 15cm apart and are found to be 140^0C and 100^0C. The atmospheric air temperature is 30^0C and convective heat transfer coefficient is 20W/m^2K. Calculate the thermal conductivity of the rod. State all assumptions made. **(10 Marks)**

3 a. For a lumped system, find the temperature distribution and heat transfer with usual notations. **(10 Marks)**

b. It is proposed to quench steel balls of a bearing 1cm in diameter, initially at 400^0C. These are placed in a cold chamber maintained at -20^0C. The steel balls pass through the chamber on a conveyor belt. Optimum bearing production requires that 75% of initial thermal energy content of the balls above -15^0C be removed. How long the balls should be placed on the conveyor belt? **(10 Marks)**

4 a. Define the following and mention their significances :
i) Reynold's number ii) Prandtl number iii) Grashof number
iv) Nusselt number v) Stanton number. **(10 Marks)**

b. A circular disc heater 0.2m in diameter is exposed to ambient air at 25^0C. One surface of the disc is insulated and the other surface is maintained at 130^0C. Calculate the amount of heat transferred from the disc when it is i) horizontal with hot surface facing up ii) horizontal with hot surface facing down. **(10 Marks)**

PART - B

5 a. Using Buckingham π – theorem, establish $\pi_3 = f(\pi_1, \pi_2)$ with usual notations for forced convection. **(10 Marks)**

b. Air at 1 atm, 40^0C flows with a velocity 8m/s along a flat plate 3m long, which is maintained at a uniform temperature of 100^0C, calculate the local heat transfer coefficient (h_x) at the end of the plate and also average head transfer coefficient over the entire length of the plate, given $R_{e_{cr}} = 2\times10^5$. **(10 Marks)**

6 a. For a co-axial parallel flow heat exchanger, establish

$$\in = \frac{1 - e^{-NTU(1+c)}}{1+c}$$ with usual notation. **(10 Marks)**

b. A shell and tube condenser is constructed with 2.5cm OD. Single pass horizontal tube with steam condensing at 54^0C, the cooling water enters the tube at 18^0C at a flow rate of 0.7kg/s for tube and leaves at 36^0C. The overall heat transfer coefficient based on outer surface of the tube is 3509W/m^2 K. Calculate the tube length and heat transfer rate by NTD method. **(10 Marks)**

7 a. Draw the typical boiling curve for water and show all the boiling regimes, natural convection boiling, nucleate boiling, transition boiling and film boiling. Explain. **(10 Marks)**

b. An electric wire of 1.5mm diameter and 20cm length is laid horizontally and submerged in water at 1 atm/pressure. The current flowing through the wire is 40 amps while the voltage drop is 16V. Calculate the heat flux, heat transfer coefficient and excess temperature. Use appropriate correlation.

[$h = 1.54 \left(\frac{Q}{A}\right)^{3/4} = 5.58\ (\Delta J_e)^3$]. **(10 Marks)**

8 a. Define the following : i) Black body ii) Emissive power iii) Irradiation iv) Gray body v) Diffuse and specular reflections. **(10 Marks)**

b. Two large parallel planes with emissivity 0.6 are at 900K and 300K. A radiation shield with on side polished and having emissivity of 0.05 and the other side with emissivity 0.4 is proposed. Which side of the shield must face the hotter plane in order to keep the temperature of shield minimum? Justify your answer. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, Dec.2016/Jan.2017

Heat & Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Heat transfer data book and steam tables are permitted.***

PART – A

1 a. State assumptions and derive general 3 – dimensional heat conduction equation in Cartesian coordinates. **(08 Marks)**

b. State the laws governing three basic modes of heat transfer. **(06 Marks)**

c. A long hollow cylinder (k = 50 w/m.k) has an inner radius of 10cm and outer radius of 20cm. The inner surface is heated uniformly at constant rate of 1.16×10^5 W/m^2 and outer surface is maintained at 30°C. Calculate the temperature of inner surface. **(06 Marks)**

2 a. Derive an expression for temperature distribution and rate of heat transfer in plane wall with proper assumptions. **(10 Marks)**

b. A very long rod, 25mm in diameter, has one end maintained at 100°C. The surface of rod is exposed to ambient air at 25°C with convective coefficient of 10W/m^2.k.

i) What are heat losses form rods, constructed of pure copper (K = 398W/m.k) and stainless steel (k = 14W/m.k)? Also write the remarks.

ii) Estimate how long the rods must be, to be, considered infinite. **(10 Marks)**

3 a. A titanium alloy blade of an axial compressor for which K = 25 W/m.k, ρ = 4500kg/m^3 and C = 520J/kg.k is initially at 60°C. The effective thickness of the blade is 10mm and it is exposed to gas stream at 600°C, the blade experiences a heat transfer coefficient of 500W/m^2. k. Use low Biot number approximation to estimate the temperature of blade after 1, 5, 20 and100 seconds. **(10 Marks)**

b. Define Biot number and Fourier number? Write their physical significances. **(04 Marks)**

c. What are heisler charts? Explain their significances in solving transient conduction problem. **(06 Marks)**

4 a. Using Buckingham's π theorem, obtain relationship between Nu, Pr and Gr, bor natural convection heat transfer. **(12 Marks)**

b. The velocity distribution in the boundary layer is given by ; $\frac{u}{U}=\frac{y}{\delta}$, where 'u' is the velocity at a distance 'y' from the plate and u = U at y = δ, δ being boundary layer thickness. Find : i) the displacement thickness ii) Momentum thickness iii) the energy thickness and iv) the value of $\frac{\delta^*}{\theta}$ **(08 Marks)**

PART – B

5 a. Explain the following briefly with sketches :
i) Boundary layer thickness ii) Thermal boundary layer thickness. **(12 Marks)**

b. The efficiency (η) of a fan depends on density (ρ) the dynamic viscosity (μ) of the fluid, the angular velocity (ω), diameter (D) of the rotor and discharge (Q). Expresses (η) in terms of dimensionless parameters. **(08 Marks)**

6 a. A heat exchanger is required to cool 55000kg/hr of alcohol from 66°C to 40°C using 40,000kg/hr of water entering at 5°C. Calculate :
   i) Exit temperature of water
   ii) Heat transfer rate
   iii) Surface area required for parallel flow type and counter flow type. **(08 Marks)**

b. Derive an expression for effectiveness of parallel flow heat exchange by 'NTU' method with proper assumption. **(12 Marks)**

7 a. Distinguish between nucleate boiling and film boiling with neat sketch. **(06 Marks)**

b. Determine the rate of heat loss by radiation from a steel tube of outside diameter 70mm and 3m long at a temperature of 227°C. If the tube is located with in a square brick conduit of 0.3m side and at 27°C. Take ε (steel) = 0.79 and ε (brick) = 0.93. **(10 Marks)**

c. State and explain fick's law of diffusion. **(04 Marks)**

8 a. With reference to thermal radiation, explain the following terms :
   i) Black body and gray body
   ii) Specular and diffuse surface
   iii) Plank's law and weins displacement law
   iv) Radiosity and irradiation
   v) View factor and Radiation shield. **(10 Marks)**

b. A steam condenser consist of 16 tubes arranged in 4×4 array, water flows through the tube at 65°C while steam condenses at 75°C over the tube surface. Find the rate of condensation if,
   i) Tube are horizontal
   ii) Tubes are vertical.

Take latent heat of steam as 2300kJ/kg and properties of water at 70°C.

$\rho = 977.8$ kg/m^3

$K_f = 0.668$ W/m.k

$\beta = 5.7 \times 10^{-3}$

$C_p = 4.187$ kJ/kg.k

$\upsilon = 0.415 \times 10^{-6}$ m^2/s

L = 1.2m, D = 25mm. **(10 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2015
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of heat transfer data hand book is permitted.

PART – A

1 a. State the modes of heat transfer with governing laws and equations. **(09 Marks)**
b. Discuss with an example heat transfer in combined mode. **(05 Marks)**
c. With sketches, write the mathematical representation of boundary condition 2^{nd} kind and 3^{rd} kind for 1-D heat conduction in rectangular coordinates. **(06 Marks)**

2 a. Derive an expression for the critical radius for the insulation of a cylinder. **(08 Marks)**
b. Fins, 12 in number with tips insulated, having thermal conductivity 75 W/m-K and 0.75 mm thickness protrude 25 mm from a cylindrical surface of 50mm diameter and 1 m length placed in an atmosphere of 40°C. If the cylinder surface is maintained at 150°C and the heat transfer coefficient is 23 W/m^{2}K, calculate:
i) The rate of heat transfer by fins.
ii) The percentage increase in heat transfer due to fins.
iii) The temperature at the centre of the fins and
iv) The fin efficiency
v) The fin effectiveness. **(12 Marks)**

3 a. What is lumped system analysis? When is it applicable? What is the physical significance of Biot number? **(06 Marks)**
b. A solid iron rod [K = 60 W/m-K, ρ = 7280 kg/m^3, c_p = 410 J/kg K and $\alpha = 2 \times 10^{-5}$ m^2/s] of 6cm diameter, initially at temperature 800°C is suddenly dropped into an oil bath at 50°C. The heat transfer coefficient between the fluid and the surface is 400 W/m^{2}K. Using the transient temperature chars, determine:
i) The centerline temperature 10 min after immersion in the fluid.
ii) The temperature at a depth of 2cm from the surface 10 min after immersion in the fluid.
iii) The energy removed from the rod during this period. **(14 Marks)**

4 a. Define the following dimensionless members. Also give their physical significance.
i) Prandtl number ii) Nusselt number. **(08 Marks)**
b. A horizontal pipe 0.3m in diameter is maintained at a temperature of 245°C in a room where the ambient air is at 15°C. Calculate the free convection heat loss per meter length of the pipe. Take the properties of air at the bulk mean temperature of 130°C as [K = 34.14×10^{-3} W/m-K, $\gamma = 26.63 \times 10^{-6}$ m^2/s and P_r = 0.685]. **(12 Marks)**

PART – B

5 a. Distinguish between hydrodynamic and thermal boundary layers with sketches. (08 Marks)

b. Air at 20°C and at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. The plate is 0.3m long and at 60°C. The properties of air at the bulk mean temperature of 40°C are [K = 0.02756 W/m-K, C_p = 1005 J/kg K, ρ = 1.128 kg/m^3, $\gamma = 19.96 \times 10^{-6}$ m^2/s and P_r = 0.699]. Calculate:

i) Velocity and thermal boundary layer thickness at 0.2m from the heading edge.
ii) Local and average friction coefficient.
iii) Average heat transfer coefficient.
iv) Rate of heat transfer by convection.
v) Total drag force on the plate per unit width. (12 Marks)

6 a. Briefly explain the classification of heat exchanger by flow management. (08 Marks)

b. A two-shell pass, four-tube pass heat exchanger has water on the shell side and brine on the tube side. Water is cooled from 18°C to 6°C with brine entering at -1°C and leaving at 3°C. The overall heat transfer coefficient is 600 W/m^2 K. Calculate the heat transfer are required for a design heat load of 24 kW. (12 Marks)

7 a. Sketch and explain boiling curve. (08 Marks)

b. Air free saturated steam at 85°C [P = 57.83 kPa] condenses on the outer surface of 225 horizontal tubes of 1.27 cm diameter in a 15-by-15 array. Tube surfaces are maintained at a uniform temperature of 75°C. Calculate the total condensation rate per 1m length of the tube bundle. The physical properties of water at T_f = 80°C are K = 0.688 W/m K, ρ_l = 974 kg/m^3, $\mu_l = 0.355 \times 10^{-3}$ kg/m-s, $h_{f_g} = 2309$ kJ/kg. (12 Marks)

8 a. State: i) Wein's displacement law; ii) Kirchoff's law; iii) Planck's law, also state their significances. (09 Marks)

b. Consider two large parallel plates; one at 1000K with emissivity 0.8 and the other is at 300K with emissivity 0.6. A radiation shield is placed between them. The shield has emissivity of 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate the percentage reduction in radiation heat transfer as a result of radiation shield. (11 Marks)

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Sixth Semester B.E. Degree Examination, June/July 2016
Heat & Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Heat transfer data book and steam tables are permitted.***

PART – A

1 a. Explain the basic equations for conduction, convection and radiation. **(06 Marks)**

b. Derive an expression for the heat flow rate through a hollow cylinder provided with two layers of insulation by taking into account of convective effects. **(06 Marks)**

c. A hollow sphere made up of steel having thermal conductivity of 45W/m°C. It is heated by means of a coil of resistance 100Ω which carries a current of 5amperes. The coil is located inside the hollow space at the centre. The outer surface area of the sphere is $0.2m^2$ and its mass is 32kg. Assuming the density of sphere material to be 8gm/cc, find the temperature difference between inner and outer surfaces. **(08 Marks)**

2 a. Explain critical insulation thickness. **(04 Marks)**

b. A brick wall of 5 m length, 3 m height and 250 mm thick has temperatures of 800°C and 20°C maintained on its bounding surfaces. Assuming that the thermal conductivity of the brick material is related to its temperature by the relation.

$K = 1.00[1+0.001\ T]$ W/m°C

Calculate the average thermal conductivity, thermal resistance and heat loss from the wall. What will the temperature at 100mm distance from the wall surface at 800°C.? **(10 Marks)**

c. An electronic unit during operation generates an energy equal to 50 mill watts and the temperature at the surface of the unit is found to be 95°C. To increase the rate of heat transfer, the device is provided with aluminum fins of square cross section 0.5 mm × 0.5 mm of length 1cm. the temperature of the surrounding is 30°C. the heat transfer coefficient is $12.5 W/m^{2°}C$ and the thermal conductivity of aluminum is 175 W/m°C. Determine the number of fins required to dissipate the heat generated by the unit. Assume heat transfer from the end of fin is neglected. **(06 Marks)**

3 a. With neat sketch explain lumped system analysis show that $\frac{T - T_\infty}{T_o - T_\infty} = e^{-Bi\,Fo}$ and $Q = \rho v c_p (T_o - T_\infty)\,[e^{-Bi\,Fo} - 1]$ **(10 Marks)**

b. The average heat transfer coefficient for the flow of 100°C air over a flate plate is measured by observing the time history of a thick copper slab exposed to 100°C air. In one test run the initial temperature of the plate was 210°C and in 5 minutes the temperature becomes 170°C. Calculate the heat transfer coefficient in this case. **(05 Marks)**

c. An cron sphere K = 60W/m°C, C_p = 460 J/kg°C, ρ = 7850 kg/m^3 ; $\alpha = 1.6\times10^{-5}\ m^2/s$ of diameter 5cm is initially at a temperature of 225°C. Suddenly the surface of the sphere is exposed to an ambient air at 25°Cwith heat transfer coefficient $500 W/m^2 °C$. Calculate :

i) Centre temperature at t = 2min

ii) Temp at a depth of 1cm from the surface at t = 2min **(05 Marks)**

4 a. With the help of dimensional analysis, correlate the free convection data. (10 Marks)
b. Hot fluid at 300°C flows through a horizontal pipe of 30cm outside diameter and 90cm long. The pipe is exposed to an atmosphere maintained at 20°C. Determine the natural convection heat transfer. (10 Marks)

PART – B

5 a. Explain the significance of
   i) Reynolds's number
   ii) Prandtl number
   iii) Nusselt Number
   iv) Grashoff number
   v) Stanton number. (10 Marks)
b. Determine the rate of heat loss per hour from a wall of a building when the wind is flowing parallel to its surface with a speed of 2km/hr. The wall is 5m long and 3m high Temperature of the wall is 25°C and air temperature is 5°C. (10 Marks)

6 a. Derive an expression for LMTD of a parallel flow heat exchanger. (10 Marks)
b. Water enters a cross flow heat exchanger (both fluids unmixed) at 15°C and flows 7.5kg/s. It cools air (C_p = 1.005 kJ/kg°C) flowing at the rate of 10 kg/s with inlet temperature of 120°C. The overall heat transfer coefficient is 225 W/m^2°C and surface area of the heat exchanger is $240m^2$. Determine the total heat transfer rate and outlet temperatures using NTU method. (10 Marks)

7 a. With the help of boiling curve, explain various regimes of boiling. (08 Marks)
b. A vertical tube of 50 mm diameter and 2 m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 80°C by circulating water though the tubes. Determine the rate of heat transfer and condensate mass flow rate. (08 Marks)
c. Dry saturated steam at a pressure of 2.45 bar condenser on the surface of a vertical wall of tube of height 1 m. The tube surface temperature is 117°C. Estimate the thickness of the condensate film at a distance of 0.2 m from the upper end of the tube. (04 Marks)

8 a. With neat sketch explain the concept of black body. (06 Marks)
b. State and prove Kirchhoff's law of radiation. (06 Marks)
c. Two large parallel planes having emissivities 0.3 and 0.5 are maintained at temperature 800°C and 300°C respectively. A radiation shield having emissivity of 0.05 on both sides is placed between the two planes. Calculate ;
   i) Heat transfer per unit area without shield
   ii) Heat transfer per unit area with shield
   iii) Temperature of the shield. (08 Marks)

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