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

III B.Tech. II Semester Regular Examinations, April/May -2013

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) What are the mechanisms of heat transfer? How are they distinguished from each other?
   b) A 10cm diameter copper ball is to be heated from 100^0C to an average temperature of 150^0C in 30 minutes. Taking the average density and specific heat of copper in this temperature range to be $\rho = 8950\frac{kg}{m^3}$ and $C_p = 0.395\frac{kJ}{kg.^0C}$ respectively, determine the total amount of heat transfer to the copper ball, the average rate of heat transfer to the ball and the average heat flux.

2. a) How does transient heat transfer differ from steady heat transfer? How does one dimensional heat transfer differ from two dimensional heat transfers?
   b) Consider a large 3 cm thick stainless steel plate whose thermal conductivity is $15.1W/m.^0C$, in which heat is generated uniformly at a rate of $5x10^5$ W/m^3. Both sides of the plate are exposed to an environment at 30^0C with a heat transfer coefficient of $60W/m^{20}C$. Explain where in the plate the highest and the lowest temperatures will occur and determine their values.

3. a).What is Fourier, Biot numbers? What is the physical significance of these numbers?
   b) A solid steel, 160 mm long cylinder with a 80mm diameter initially at 800^0C is cooled in a medium which is at a constant temperature of 30^0 C. The surface heat transfer coefficient is $120W/m^2K$. Determine the centerline temperature at the mid point of length 30 minutes after cooling is initiated. The physical properties of the steel are: α=$0.022m^2/h$, k=23.5W/m K.

4. a) What is dimensional analysis? What are the uses of dimensional analysis?
   b) It is required to estimate the heat transfer from a cylinder 50mm diameter and of surface temperature 140^0C when kept in cross flow of air at a velocity of 4m/sec and temperature 20^0C. For this purpose, scale model experiments are performed using a 0.2 scale model with the same surface and air temperature but different velocities. The results obtained from experiments on the model are: velocity of air 2, 5, 10, 20m/sec and Heat transfer coefficient 39.5, 71.2, 106.5, $165.3W/m^2K$ respectively. Calculate the heat transfer coefficient and the rate of heat transfer per meter length of actual cylinder.

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

5. a) Derive an expression for turbulent boundary layer thickness over a flat plate.

   b) The velocity profile for laminar boundary is $\frac{u}{U} = 2\frac{y}{\delta} - \frac{y^2}{\delta^2}$ find the thickness of boundary layer at the end of the plate 1.5m long and 1m wide when placed in water flowing with a velocity of 0.12m/sec. Calculate the value of coefficient of drag also. μ for water is 0.001N-s/m^2.

6. a) Explain briefly the physical mechanism of boiling. Differentiate between the mechanism of film wise and drop wise condensation.

   b) A wire of 1.2 mm diameter and 200 mm length is submerged horizontally in water at 7bar. The wire carries a current of 135A with an applied voltage of 2.18V. If the surface of the wire is maintained at 200^0C, calculate the heat flux and the boiling heat transfer coefficient.

7. a) What does a cross flow heat exchanger differ from a counter flow one? What is the difference between mixed and un-mixed fluids in cross flow?

   b) Air at 2kg/s and 27^0C and a stream of water at 1.5 kg/s and 60^0C each enter a heat exchanger. Evaluate the exit temperatures if area is 12 m^2, U=185W/m^2K when exchanger is parallel flow, the exchanger is counter flow ($T_{h\ out}$=54^0C) the exchanger is cross flow, one stream mixed and the exchanger is cross flow neither stream mixed. ($T_{h\ out}$=53.62^0C).

8. a) Define radiation heat transfer. State and explain Wien's displacement law.

   b) A thin copper sphere with its internal surface highly oxidized, has a diameter of 20cm. How small a hole must be made in the sphere to make an opening that will have an absorptivity of 0.9?

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

III B.Tech. II Semester Regular Examinations, April/May -2013

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) Define thermal conductivity and explain its significance in heat transfer.
   b) The roof of an electrically heated home is 6 m long, 8m wide and 0.25 m thick and is made of a flat layer of concrete whose thermal conductivity is 0.8 W/m.^{0}C. The temperatures of the inner and outer surfaces of the roof one night are measured to be 15^{0}C and 40C respectively, for a period of 10hours. Determine the rate of heat loss through the roof that night.

2. a) Explain the importance of insulated tip solution for the fins used in practice.
   b) Consider a 2 m high and 0.7m wide bronze plate whose thickness is 0.1 m one side of the plate is maintained at a constant temperature of 600K while the other side is maintained at 400K. The thermal conductivity of the bronze plate can be assumed to vary linearly in that temperature range as $k(T)=K_0(1+\beta T)$, where k_0=38 W/m-K and $\beta=9.21\times10^{-4}K^{-1}$. Disregarding the edge effects and assuming steady one-dimensional heat transfer, determine the rate of heat conduction through the plate.

3. a) Define a semi-infinite body. What is an error function? Explain its significance in a semi-infinite body in transient state.
   b) The initial uniform temperature of a large mass of material (α=0.42m^2/hour) is 120^{0}C. The surface is suddenly exposed to and held permanently at 6^{0}C. Calculate the time required for the temperature gradient at the surface to reach 400^{0}C/m.

4. a) What are the dimensionless numbers? Describe the Rayleigh's method for dimensional analysis.
   b) The pressure difference **Δp** in a pipe of diameter, **D** and length, **l** due to turbulent flow depends on the velocity, **V**, viscosity, **μ**, density, **ρ** and roughness, **k**. Using Buckingham's π-theorem obtain an expression for **Δp**.

5. a) Discuss the significance of bulk temperature in case of fully developed laminar flow in a tube.
   b) If velocity distribution in laminar boundary layer over a flat plate is assumed to be given by second order polynomial $u = a+by+cy^2$, determine its form using the necessary boundary conditions.

6. a) What is burnout point? Derive the Nusselt theory of laminar flow film condensation on a vertical plate.
   b) A nickel wire of 1mm diameter and 400mm long, carrying current is submerged in a water bath which is open to atmospheric pressure. Calculate the voltage at the burnout point if at this point the wire carries a current of 190A.

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

7. a) State Planck's law. Define Lambert's law of radiation.
   b) Explain the meaning of the term geometric factor in relation to heat exchange by radiation. Derive an expression for the geometric factor F_{11} for the inside surface of a black hemispherical cavity of radius R with respect to itself.

8. a) Can you have a cross flow heat exchanger in which both flows are mixed? Discuss.
   b) Consider a counter flow heat exchanger that must cool 3000kg/h of mercury from 150^0F to 128^0F. The coolant is 100kg/h of water, supplied at 70^0F. If U is 300W/m2K, complete the design by determining reasonable value for the area and the exit water temperature. Area is $0.147m^2$.

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

III B.Tech. II Semester Regular Examinations, April/May -2013
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 general heat conduction equation in Cartesian coordinates.
   b) A 1m^3 rigid tank contains hydrogen at 250 kPa and 420K. The gas is now cooled until its temperature drops to 300K. Determine the final pressure in the tank and the amount of heat transfer from the tank.

2. a) Why is the assumption of one dimensional heat flow made in the analysis of fins.
   b) Consider a spherical container of inner radius 8cm, outer radius 10cm and thermal conductivity 45 W/m.^{0}C. The inner and outer surfaces of the container are maintained at constant temperatures of 200^{0}C and 80^{0}C respectively, as a result of some chemical reactions occurring inside. Obtain a general relation for the temperature distribution inside the shell under steady condition and determine the rate of heat loss from the container.

3. a) What is lumped capacity? What are the assumptions for lumped capacity analysis?
   b) An aluminum sphere weighing 5.5kg and initially at a temperature of 290^0 C is suddenly immersed in a fluid at 15^{0}C. The convective heat transfer coefficient is 58W/m^{2}K. Estimate the time required to cool the aluminum to 95^{0}C, using the lumped capacity method of analysis.

4. a) State the Buckingham's π theorem. Explain the various parameters used in the forced convection. Using dimensional analysis obtain an expression for Nusselt number in terms of Reynolds and Prandtl numbers.
   b) Derive an expression for the velocity profile for fully developed laminar flow between two parallel plates a distance L apart. Also obtain an expression for the friction
   factor.

5. a) Derive an energy equation for thermal boundary layer over a flat plate.
   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 the displacement thickness, the momentum thickness, the energy thickness and the ration of the momentum thickness to the displacement thickness.

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6. a) Discuss briefly the various regimes in boiling heat transfer.
   b) Water is boiled at the rate of 25kg/hour in a polished copper pan, 280mm in diameter at atmospheric pressure. Assuming nucleate boiling conditions, calculate the temperature of the bottom surface of the pan.

7. a) What are the fouling factors? Explain their effect in heat exchanger design
   b) Steam in the condenser of a power plant is to be condensed at a temperature of 30^0C with cooling water from a nearby lake, which enters the tubes of the condenser at 14^0C and leaves at 22^0C. The surface area of the tubes is $45m^2$ and the overall heat transfer coefficient is $2100W/m^2.^0C$. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser.

8. a) What is a black body? How does it differ from a gray body?
   b) An industrial furnace in the form of a black body and emitting radiation at 2500^0C. Calculate the monochromatic emissive power at 1.2μm length, wavelength at which the emission is maximum, maximum emissive power and total emissive power.

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

III B.Tech. II Semester Regular Examinations, April/May -2013

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 general heat conduction equation in cylindrical coordinates.
   b) A rigid tank contains 20 lbm of air at 50 psi and 80^0F. The air is now heated until its Pressure is doubled. Determine the volume of the tank and the amount of heat transfer.

2. a) Explain the importance of insulated tip insulation for the fins used in practice
   b) A composite fin consists of a cylindrical rod 3mm diameter and 100mm length of one material, uniformly covered with another material forming outer diameter 10mm and length 100mm. k(inner material)= 15W/m^{0}C;k(outer material)= 45W/m^{0}C. h(surface heat transfer coefficient) = 12W/m$^{2\,0}$C.
   (i) Determine the effectiveness of the composite fin. Assume no temperature gradient along the radial direction and end is insulated for the composite fin.
   (ii) Also find out the expression for the efficiency of this fin and its value for the given data.

3. a) What is meant by transient heat conduction? Explain the significance of Heisler's charts in solving transient conduction problems.
   b) A single cylinder (α=0.044m2/hour for cylinder material) two stroke I.C engine operates at 1400rpm. Calculate the depth where the temperature wave due to variation of cylinder temperature is damped to 2% of its surface value.

4. a) Describe the Rayleigh's method for dimensional analysis. Show by dimensional analysis for free convection, Nu=φ(Re.Pr).
   b) Find an expression for the drag force on smooth sphere of diameter D, moving with a uniform velocity V in a fluid having density ρ and dynamic viscosity μ.

5. a) Derive momentum equation for hydrodynamic boundary layer over a flat plate.
   b) The velocity distribution in the boundary layer is given by $\frac{u}{U}=\frac{3}{2}\frac{y}{\delta}-\frac{1}{2}\frac{y^2}{\delta^2}$, δ being the boundary layer thickness. Calculate the ratio of displacement thickness to boundary layer thickness and the ratio of momentum thickness to boundary layer thickness.

6. a) Write a brief note on heat transfer during boiling and condensation.
   b) Water at atmospheric pressure is to be boiled in polished copper pan. The diameter of the pan is 350mm and is kept at 115^0C. Calculate the power of the burner, rate of evaporation and critical heat flux for these two conditions.

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7. a) Classify heat exchangers according to flow type and explain the characteristic of each type.
   b) A counter flow double pipe heat exchanger is to heat water from 20^0C to 80^0C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160^0C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5cm. If the overall heat transfer coefficient of the heat exchanger is 640 $W/m^2.^0C$, determine the length of the exchanger required to achieve the desired heating.

8. a) State Stefan-Boltzmann law. State and prove Kirchoff's law of radiation.
   b) The effective temperature of a body having an area of 1.02 m^2 is 527^0C. Calculate the total rate of energy emission, the intensity of normal radiation and the wavelength of maximum monochromatic emissive power.

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