KADI SARVA VISHWVIDHYALAYA

B.E.(Mecha/Auto Engineering) Semester: V Examination [Nov/2016]

Subject Code:ME505 / AE505 Subject Name: Heat & Mass Transfer

Date: 19/11/2016 Time:10:30 P.M.-01:30 P.M. Total Marks: 70

Instructions:

1. Attempt all questions as directed and answer each section in separate main answer sheets.
2. Figures to the right indicate full marks.
3. Make suitable assumptions.
4. Indicate Clearly , the option you attempt along with its respective question number.
5. Use the last page of main supplementary for rough work.
6. Use of scientific calculator is permitted.
7. Please don't write anything on this question paper except your Enrollment and ID Number.
8. Please keep your Identity Cards and Hall Tickets on your desk during the examination.
9. Please follow all the instructions provided by authorized university and institute personnel.

SECTION - I

Q. 1 Total: 15

A. Define and distinguish between (i) steady state, and (ii) unsteady state of heat transfer. 05

B. Explain the mechanism of thermal conduction in gases, liquids and solids. Discuss the effect of temperature on thermal conductivity. 05

C. Establish the general differential equation in Cartesian co-ordinates for three-dimensional unsteady heat conduction by considering an infinitesimal volume element. ~~Deduce there from the conduction equation for the following cases~~. 05

OR

C. Write some examples to illustrate the importance of heat transfer in various fields of engineering. 05

Q. 2 Total :10

A. Explain the term "critical thickness of insulation" with reference to insulation of hollow cylinders and spheres with outside convection. Sketch the variation of total resistance against insulation thickness in case of hollow cylinder. 05

B. A pipe carrying steam at 230°C has an internal diameter of 12 cm and the pipe thickness is 7.5 mm. The conductivity of the pipe material is 49 W/m K the convective heat transfer coefficient on the inside is 85 W/m^2K. The pipe is insulated by two layers of insulation one of 5 cm thickness of conductivity 0.15 W/m K and over it another 5 cm thickness of conductivity 0.48 W/m K. The outside is exposed to air at 35°C with a convection coefficient of 18 W/m^2K. Determine the heat loss for 5 m length. Also determine the interface temperatures and the overall heat transfer coefficient based on inside and outside areas. 05

OR

Q. 2 Total :10

A. Explain the concept of log mean area in the case of heat conduction in hollow cylinders. 05

B.	Two insulating materials A and B in powder form with thermal conductivities of 0.004 and 0.03 W/m K were purchased for use over a sphere of 0.4 m dia. Material A is to form the first layer of a thickness of 4 cm and B is to form the next layer to 5 cm thickness. During the installation, by mistake material B was applied first using up all the material and material A was applied over it. Investigate whether the thermal resistance will change.	05

Q. 3 Total: 10

A.	Derive expressions for temperature distribution and heat dissipation in a straight fin of circular profile for the infinitely long fin.	05
B.	A plate fin of 8 mm thickness of 60 mm length is used on a wall at 200°C. The convection coefficient is 25 W/m^2K. The conductivity is 210 W/m K. (i) If the surroundings is at 35°C, determine the heat flow. (ii) if the same fin is split into 4 mm thick fins determine the total heat flow. Short fin end insulated condition can be used or chart can also be used. Consider 1 m width of fin.	05

OR

Q. 3 Total: 10

A.	List the parameters that influence the use of Lumped capacity model in unsteady heat conduction.	05
B.	A thermocouple is formed by soldering end-to-end wires of 0.5 mm diameter. The thermal diffusivity of the material is 5.3 × 10–6 m2/s. The conductivity of the material is 19.1 W/m K. The probe initially at 30°C is placed in a fluid at 600°C to measure the temperature of the fluid. If the convective heat transfer coefficient between the wire and the fluid is 85 W/m^2K, determine the time constant for the probe and also the time taken for it to read 598°C.	05

SECTION - II

Q. 4 Total: 15

A.	State Kirchhoff's law of heat radiation and indicate its uses.	05
B.	Define the terms "absorptivity", "reflectivity" and "transmissivity". For a black surface what are the values of each.	05
C.	Define and explain the concept "shape factor" in radidation heat exchange.	05

OR

C.	The energy received from the sun at the earths atmosphere has been measured as 1353 W/m^2. The diameter of the earth = 1.29 × 107 m. Diameter of the sun = 1.39 × 109 m. Mean distance = 1.5 × 1011 m. Estimate the emissive power of the sun and the surface temperature assuming it to be black. Assuming that the source of energy for the earth is from the sun and earth to be black, estimate the temperature of the earth.	05

Q. 5 Total: 10

A.	Distinguish between filmwise and dropwise condensation.	05
B.	Describe the various regimes of boiling with neat sketch.	05

OR

Q. 5 Total: 10

A.	State the essential differences in the development of boundary layer in flow over surfaces and flow through ducts.	05

B.	Explain the advantages and limitations of dimensional analysis method used in convection studies.	05

Q. 6 Total: 10

A.	Distinguish between recuperative and regenerative heat exchangers.	05
B.	Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is 10 kg/s. The specific heat of the oil is 2200 J/kg K. The overall heat transfer coefficient U = 300 W/m^2 K. Compare the area required for a counter flow exchanger.	05

OR

Q. 6 Total: 10

A.	Distinguish between diffusion mass transfer and convective mass transfer.	05
B.	State and explain the Fick's law of diffusion and compare it with Fourier's law of heat conduction.	05

KADI SARVA VISHWVIDHYALAYA

B.E.(Mechanical Engineering) Semester: V Examination [Dec/2015]

Subject Code:ME/AE 505 Subject Name: Heat & Mass Transfer

Date: 28/11/2015 Time:10:00 A.M.-01:00 P.M. Total Marks: 70

Instructions:

1. Attempt all questions as directed and answer each section in separate main answer sheets.
2. Figures to the right indicate full marks.
3. Make suitable assumptions.
4. Indicate Clearly , the option you attempt along with its respective question number.
5. Use the last page of main supplementary for rough work.
6. Use of scientific calculator is permitted.
7. Please don't write anything on this question paper except your Enrollment and ID Number.
8. Please keep your Identity Cards and Hall Tickets on your desk during the examination.
9. Please follow all the instructions provided by authorized university and institute personnel.

SECTION - I

Q. 1 **Total: 15**

A. Explain the mechanism of thermal conduction in gases, liquids and solids. Discuss the effect of temperature on thermal conductivity. **05**

B. Derive the general heat conduction equation in Cartesian co-ordinates for isotropic materials. **05**

C. A 8 mm thick metal plate, having thermal conductivity (k=98.6 W/mk) is exposed to vapour at 100 ^{o} C on one side and cooling water at 30 °C on opposite side. The heat transfer co-eeficients are h_i=14200 W/m^{2}K on vapour side and h_o=2325 W/m^{2}K on the water side. Determine the rate of heat transfer, drop in temperature of each side of plate. **05**

OR

C. In an air conditioned room, the wall of the house measures 2 m x 6 m. It consists of 1 cm thick wood paneling of thermal conductivity 0.06 W/mK and 20 cm thick concrete wall having the thermal conductivity of 1.2 W/mK. The inside temperature is 40°C Find the gain of heat transfer rate by the room and the temperature at interface of wood and concrete wall. **05**

Q. 2 **Total :10**

A. What do you understand by critical radius of insulation ? Derive an expression for critical radius of insulation in case of cylinders. State its physical significance. **05**

B. Two large aluminium plate (k=240 W/mK) each 5 cm thick with certain roughness are placed in contact under atmospheric pressure in air having the thermal contact resistance of 2.75 x 10^{-4} m^{2}K/W. The temperature at the **05**

outside surfaces are 500°C and 400°C. Calculate:

(a) The heat flux
(b) The temperature drop due to contact resistance and
(c) The contact temperatures.

OR

Q. 2 **Total :10**

A. Differentiate between steady state and transient heat conduction. Also state the assumptions made in lumped heat capacity method for analysis of transient heat conduction. **05**

B. An average human body modelled as a 30 cm diameter, 160 cm long cylinder has 72 % water by mass, so that its properties may be taken as those of water at room temperature: density= 1000 kg/m^3, specific heat=4180 J/kg K and thermal conductivity= 6 W/mK. A person is found dead at 5:00 A.M. in a room the temperature of which is 20° C. The temperature of the body is measured to be 25° C when found, and the heat transfer coefficient is estimated to be 8 W/m^{2}K.Assuming the body temperature of a living man is 37° C , estimate the time of death of the above person. Also estimate its Biot number and state whether the body can be analysed based on lumped heat capacity method. **05**

Q. 3 **Total: 10**

A. Why fins are used ? State some of its application **05**

B. A copper rod 30 mm in diameter extends from a wall at 150°C The surrounding air is at 20°C. Assuming k=400 W/mK for copper and h=10 W/m^{2}K for convection, Find: **05**

(a) Heat loss from rod assuming it to be infinitely long.
(b) The minimum length of rod in order to consider it as infinitely long fin.

OR

Q. 3 **Total: 10**

A. Discuss the concept of thermal boundary layer in case of flow over the plates. How does it differ from velocity boundary layer ? **05**

B. Air at 2 atm and 200°C is heated as it flows at a velocity of 12m/s through a tube with a diameter of 3 cm. A constant heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature all along the length of the tube. Calculate **05**

(a) The heat transfer per unit length of the tube.
(b) The increase in bulk temperature of air over a 4 m length of the tube.

Properties of air at 200°C are Pr=0.681, μ=2.57x10^{-5} kg/ms, k=0.0386 W/mK and C_p= 1.025 KJ/kg K. Use $Nu_d=0.023(Re_d)^{0.8}(Pr)^{0.4}$

SECTION - II

Q. 4 **Total: 15**

A. Define following terms: **05**
   (a) Total emissive power of a surface.
   (b) Black body
   (c) Grey body
   (d) Monochromatic emissive power
   (e) Emissivity

B. State and prove Wien's displacement law **05**

C. Cryogenic fluid flows through a tube 30 mm diameter which is concentric with a tube of 90 mm diameter. Surface emissivities of inner and outer tubes are 0.2 and 0.5 while respective temperatures are 100 K and 300 K. Find the heat gain by fluid. **05**

OR

C. A double-walled thermos flask may be assumed to be equivalent to two infinite parallel plates. The emissivities of wall are 0.3 and 0.7 respectively. Space between them is evacuated. Find the heat transfer rate by radiation through the flask if inside surface temperature is 90^0C and outside surface at 30^0C under steady state **05**

Q. 5 **Total: 10**

A. Give the classification of heat exchangers along with application. **05**

B. Engine oil flows into a double pipe counter flow heat exchanger at the rate of 0.4 kg/s. The inner tube has internal diameter of 2.0 cm and the inner diameter of the outer tube is 3.0 cm. The water flows in the inner tube at the rate of 0.6 kg/s with its inlet and exit temperatures as 30^0C and 60^0C respectively. The convective heat transfer coefficient on water side is 8000 W/m^2 K and on oil side of tube is 80 W/m^{2}K. The oil temperature at inlet is 160^0C. Neglecting the thickness of both the inner and outer tubes, find: **05**
   (a) Overall heat transfer coefficient
   (b) Heat transfer rate
   (c) Exit temperature of oil.

   Assume, C_{po}=2.25 KJ/kg K

OR

Q. 5 **Total: 10**

A. Show that if heat capacities of hot and cold fluids are equal in case of counter flow heat exchanger, then its LMTD is a indeterminate quantity and in such a case: $T_m=\Delta T_1=\Delta T_2$. **05**

B. In a double pipe parallel flow heat exchanger, the water is heated from 30^0C to 80^0C while flowing in the inner tube. The oil flows in the outer tube having the inlet and exit temperatures as 230^0C and 90^0C. In case the oil needs to be cooled up to the temperature equal to the exit temperature of water by increasing the length of the heat exchanger. Find the temperature of oil at exit. **05**

Q. 6		**Total: 10**
A.	Define and explain condensation. What are its types and state the difference between them?	*05*
B.	Discuss in details, the various regimes of pool boiling	*05*

OR

Q. 6		**Total: 10**
A.	State and explain the Fick's law of diffusion and compare it with Fourier's law of heat conduction.	*05*
B.	Calculate the diffusion coefficient of water vapour into air at atmospheric pressure and 27^0C . Assume, molecular volume as: V_{H2O}=18 cm^3/gm mole, M_{air}= 29.9 cm^3/gm mole and molecular weights: M_{H2o}=18, M_{air}=29	*05*

Our best wishes are always with you...

KADI SARVA VISHWAVIDYALAYA

BE SEMESTER 5th EXAMINATION NOVEMBER 2014

SUBJECT CODE: ME 505 SUBJECT NAME: HEAT AND MASS TRANSFER

DATE: 22/11/2014 TIME: 10.30 TO 01.30 TOTAL MARKS: 70

Instructions:

1. Answer each section in separate Answer Sheet.
2. Use of scientific calculator is permitted.
3. All questions are compulsory.
4. Indicate **clearly,** the options you attempted along with its respective question number.
5. Use the last page of main supplementary for rough work.
6. Assume suitable data if required.

Section 1

Q.1 (A) Derive three dimensional general conduction equation in Cartesian coordinates for a homogenous material. **05**

(B) A furnace wall is made up of three layers, 22 cm thick inside layer of fire brick, 7.5 cm thick middle layer of insulating brick and 11 cm thick outside layer of red brick. The furnace operates at 870^0 C and it is anticipated that the outside of this composite wall can be maintained at 40^0 C by the circulation of air. Assuming close bonding of layers 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 and the data on the thermal conductivities is: Fire brick k_1 = 1 W/m-deg, Insulating brick k_2 = 0.12 W/m-deg and Red brick k_3 = 0.75 W/m-deg. **05**

(C) What is meant by critical thickness of insulation? Derive an expression for critical radius of insulation for electrical wire. **05**

OR

(C) Derive the equation for thermal resistance for heat conduction in hollow spheres. **05**

Q.2 (A) Give general equation for the rate of heat transfer by convection and hence define the coefficient of heat transfer. List various factors on which its value depends. **05**

(B) Explain in brief the significance of: **05**

(a) Prandtl number
(b) Reynold number
(c) Nusselt number

OR

(A) Derive the energy equation for thermal boundary layer. **05**

(B) Explain natural or free convection. Using dimensional analysis show that for a natural convection. **05**

$$N_u = C \cdot (P_r)^n \cdot (G_r)^n$$

[P.T.O.]

Q.3 (A) From general form of energy equation for one dimensional heat dissipation from an extended surface, derive an expression for heat transfer for a fin having infinite length. **05**

(B) A steel rod (k= 30 W/m-deg) 1 cm in diameter and 5 cm long protrudes from a wall which is maintained at 100^0 C. the rod is insulated at its tip and is exposed to an environment with h = 50 W/m^2-deg and $t_a = 30^0$ C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation. **05**

OR

(A) Explain the phenomenon of film wise and drop wise condensation. **05**

(B) Write a short note on turbulent film condensation. **05**

Section 2

Q.4 (A) State and derive the Kirchoff's law for radiation. **05**

(B) Explain the terms related to heat exchanger: **05**
(i) NTU (ii) Effectiveness

(C) In a counter flow heat exchanger, oil (Cp = 3 kJ/kg K) at the rate of 1400 kg/hr is cooled from 100^0 C to 30^0 C by water that enters the exchanger at 20^0 C at the rate of 1300 kg/hr. Determine the heat exchanger area for an overall heat transfer coefficient of 3975 kJ/m^2-hr-K. **05**

OR

(C) Explain the terms absorptivity, reflectivity and transmissivity of radiant energy. How are they related to each other for a black body and an opaque body? **05**

Q.5 (A) Show that for a unit surface the intensity of normal radiation is $1/\pi$ times the emissive power. **05**

(B) Derive an equation of LMTD for counter flow heat exchanger. **05**

OR

(A) Write a short note on Radiation shields. **05**

(B) Explain in brief Stefan-Boltzmann law. **05**

Q.6 (A) State and explain Fick's law of diffusion. **05**

(B) Give classification of heat exchangers. **05**

OR

(A) Which is it better to arrange in a heat exchanger, parallel flow or counter flow? Why? **05**

(B) Water is available at the bottom of a well which is 2.5 m in diameter and 5 m deep. Estimate its diffusion rate into dry atmospheric air at 25°C. The diffusion coefficient may be taken as 0.0925 m^2/hr and the atmospheric pressure as 1.032 bar. Partial Pressure of water vapour at 25°C is 0.0317 bar. Universal gas constant = 8314 J/kg mole-K. **05**

******All the Best******

KADI SARVA VISHVAVIDHYALAYA
B.E. SEM V (ATKT) EXAM

Subject Code: ME-505 Subject Name: Heat and Mass Transfer

Date: 24/04/2015 Time: 10.30a.m.-1.30p.m. Total Marks: 70

Instructions:

1. Answer each section in separate Answer Sheet.
2. Use of Scientific calculator is permitted.
3. All questions are **compulsory.**
4. Indicate **clearly,** the options you attempt along with its respective question number.
5. Use the last page of main supplementary of **rough work.**

Section – I

Q 1 (A) Derive general Heat conduction equation in Cartesian coordinate system. **[5]**

(B) Derive an expression for heat dissipation in Rectangular Fin of Uniform cross section which is insulated at tip. **[5]**

(C) A heater of 150 mm × 150 mm size and 800 W rating is placed between two slabs A and B. Slab A is 18 mm thick with k = 55 W/m K. slab B is 10 mm thick with k = 0.2 W/m K. Convective heat transfer coefficients on outside surface of slab A and B are 200 W/m^2K and 45 W/m^2 K respectively. If ambient temperature is 27°C, calculate maximum temperature of the system. **[5]**

OR

(C) A furnace wall is made up of three layers of thickness 250 mm,100 mm and 150 mm with thermal conductivity of 1.65,K and 9.2 W/m^2 °C respectively .The inside is exposed to gases at 1250 °C with a convection coefficient of 25 W/m^2 °C and the inside surface is at 1100 °C,the outside surface is exposed to air at 25 °C with convection coefficient of 12 W/m^2 °C. Determine: **[5]**
(1)The unknown thermal conductivity k
(2)The overall heat transfer coefficient

Q 2 (A) State the general equation for the rate of heat transfer by convection and hence define the coefficient of heat transfer. What are the various factors on which the value of this coefficient depends? **[5]**

(B) Discuss the concept of thermal boundary layer in case of flow over the plates. How it differ from velocity boundary?. **[5]**

OR

Q 2 (A) A copper pipe is maintained at 50 °C. It is having dimension of 50 mm diameter and length1 m . It is placed in atmosphere, where air is having temperature of 30 °C and flowing at speed of 3m/s. Use the co-relation $Nu= 0.023 (Re)^{0.805}$ calculate the heat loss from the pipe. **[5]**

(B) State the relationship between Nusselt, Grashoff and Prandtl number in case of heat transfer by nature convection from a vertical plate . **[5]**

Q 3 (A) Derive momentum equation for hydrodynamic boundary layer over a flat plate. **[5]**

(B) A gas turbine blade made of stainless steel (k =32 W/m°C) is 70 mm long ,500 mm^2cross sectional area and 120 mm perimeter .The temperature of the root of blade is 500°C and it is exposed to the combustion product of the fuel passing from turbine at 830°C.If the film coefficient between the blade and the combustion gases is 300$W/m^2 \cdot °C$, [5]

Determine: (1) The temperature at the middle of blade
(2)The rate of heat flow from the blade

OR

Q 3 (A) Define absorptivity,reflectivity and transmissivity with respect to radiation heat transfer. [5]

(B) Enumerate the factors on which the rate of emission of radiation by body depends. [5]

Section - II

Q 4 (A) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. . [5]

(B) Explain emissivity and absorptivity of a surface. Also differentiate between black body and grey body. [5]

(C) 1. Explain Wein's displacement law of radiation. [5]
2. Explain Kirchoff's law of radiation.

OR

(C) Water at the rate of 4 kg/sec is heated from 40 °C to 55 °C in a shell and tube type heat exchanger. The water is to flow inside tubes of 2 cm diameter with an average velocity of 35cm/sec. Hot water is available at 100°C and at the rate of 2kg/sec.which is used as the heating medium in shell side. If the length of the tube is of 2m calculate the number of tube passes, the number of tube per pass and the length of the tubes for one shell pass, assuming Uo=1500 W/m^2 K. [5]

Q 5 (A) Determine net radiation heat transfer per $m^2$for two infinite parallel plates held at temperature of 800 K and 500 K respectively. Emissivities of hot and cold plates are 0.6 and 0.4 respectively. Now it is intended to reduce the heat transfer to 40% of original value by placing a radiation shied between the plates. Calculate the emissivity of the shield. [5]

(B) Explain the following terms [5]
1.Radiation
2.Thermal resistance
3.Thermal diffusivity
4.Thermal conductivity
5.Grey body

OR

Q 5 (A) Enumerate the factors on which the rate of emission of radiation by body depends. [5]

(B) What is black body? How does it differ from gray body? Give examples of each. [5]

Q 6 (A) Derive the relationship between the effectiveness and number transfer units for a counter flow heat exchangers. [5]

(B) A heat exchanger is to be designed to condense 8 kg/sec of an organic liquid (t_{sat}=80 °C,h_{fg}=600 Kj/kg)with cooling water available at 15 °C and at a flow rate of 60kg/sec.The overall heat transfer coefficient is 480 $W/m^2°C$ calculate: (a)the [5]

number of tube required .The tubes are to be of 25 mm outer diameter ,2 mm thickness and 4.85 m length.

OR

Q 6 (A) Explain and Sketch a shell and tube type heat exchanger. **[5]**

(B) Explain the following in detail: (draw neat sketch if required) **[5]**
1.Film wise and drop wise condensation
2.Fouling factors and over all heat transfer coefficient

----ALL THE BEST----