Roll No: --------------------------

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: M.TECH CFD | **Semester – I**
Subject (Course):Advanced Heat and Mass Transfer | **Max. Marks : 100**
Course Code :ASEG 7003 | **Duration : 3 Hrs**
No. of page/s:02
Note: Heat and Mass Transfer Data Book need to be provided

Section A: Answer all the question given below (4 x 5 = 20 Marks)

1. Describe *thermal Diffusivity* and *Newton's law of cooling*.
2. Explain about radiation phenomena and about radiations patterns using wavelength.
3. What is the importance of Critical insulation thickness; write the expression for the plane wall?
4. What is the momentum equation for the laminar boundary layer on a flat plate? What assumptions are involved in the direction of this equation?

Section B: Answer the following Questions given below (4×10=40 Marks)

5. A steel ball of 12 mm diameter are annealed by heating to 1150 K then slowly cooling to 400 K in an air environment for which free stream temperature is 350 K and convective heat transfer coefficient is 20 W/m^2 K. Assuming the properties of the steel to be k= 40 W/m.K and density is 7800 kg/m^3 and c=600 J/kg K. Estimate the time required for the cooling process
6. A long wire of diameter D=1 mm is submerged in an oil bath of temperature 25^0C. The wire has an electrical resistance per unit length of $R`_e$=0.01 Ω/m. If a current of I= 100 A flows through the wire and the convection coefficient is h=500 W/m^2. K. What is the steady state temperature of the wire? From the time the current is applied, how long does it takes for the wire to reach a temperature that is with in 1^0 C of the steady state value? The properties of the wire are ρ=8000 kg/m^3, c=500J/kg.k, and k=20 W/m.K

7. Derive the expression for unsteady heat conduction in semi-infinite medium and neglect the special variation of temperature in lumped analysis?

8. The flow of oil in a journal bearing can be approximated as parallel flow between two large plates with one plate moving and other plate stationary. Consider two large large isothermal plates separated by 2mm thick oil film. The upper plate moves at a constant velocity of 12 m/s. while the lower plate is stationary. Both plates are maintained at 20^0. (a). Obtain relations for the velocity and temperature distribution in the oil. Determine the maximum temperature in the oil and the heat flux from the oil to each plate.

Section C: Answer All the following Questions given below (2×20=40 Marks)

9. (a). A 5-cm-diameter steel pipe is covered with a 1-cm layer of insulating material having $k = 0.22$ W/m.^{0}C followed by a 3-cm-thick layer of another insulating material having $k = 0.06$ W/m ^{0}C. The entire assembly is exposed to a convection surrounding condition of $h = 60$ W/ m^2 ^{0}C and $T\infty = 15$ ^{0}C. The outside surface temperature of the steel pipe is 400 ^{0}C. Calculate the heat lost by the pipe-insulation assembly for a pipe length of 20 m. Express in Watts.

(b). A cold storage room has walls made of 0.23 , of brick on the outside, 0.08 m of plastic foam, and finally 1.5 cm of wood on the inside. The outside and inside air temperatures are 22^0 C and -2^0C respectively. If the inside and outside heat transfer coefficients are respectively 29 and 12 W/m^2 K, and the thermal conductivity of brick, foam, and wood are 0.98, 0.02, and 0.17 W/mK respectively, determine (a). The rate of heat removed by refrigeration if the total wall area is 90 m^2, and (b) the temperature of the inside surface of the brick?

10. Derive steady state heat conduction equation using Cartesian coordinate system; also express one dimensional heat flow with heat generation?

(OR)

11. Derive an expression for the temperature distribution in a plane wall in which distributed heat sources vary according to the linear relation.

$$\dot{q} = \dot{q}_w[1 + \beta(T - T_w)]$$

Where $\dot{q}w$ is a constant and equal to the heat generated per unit volume at the wall temperature Tw. Both sides of the plate are maintained at Tw, and the plate thickness is $2L$.

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Section A: Answer all the question given below (4 x 5 = 20 Marks)

1. Consider a sphere and a cylinder of equal volume made of copper. Both the sphere and the cylinder are initially at the same temperature and are exposed to convection in the same environment. Which do you think will cool faster, the cylinder or the sphere? Why?

2. What is the basic procedure in setting up a numerical solution to a two-dimensional conduction problem? How one-dimensional transient solutions may be used for solution of two and three-dimensional problems.

3. Define thermal conductivity and Discuss the mechanism of thermal conduction in gases and solids, Name some good conductors of heat; some poor conductors?

4. Why is the one-dimensional heat-flow assumption important in the analysis of fins? Define fin efficiency. Why is the insulated-tip solution important for the fin problems

Section B: Answer All the following Questions given below (4×10=40 Marks)

5. Consider the flow of fluid between two large parallel isothermal plates separated by a distance L. The upper plate is moving at a constant velocity of V and maintained at temperature T_0 while the lower plate is stationary and insulated. By simplifying and solving continuity, momentum and energy equation, Obtain the relations for the maximum temperature of fluid, the location where it occurs, and heat flux at the upper plate?

6. A 2.5 cm diameter pipe carrying condensing steam at 101 kPa passes through the centre of an infinite plate having a thickness of 5 cm and k=0.1 W/m. ºC. The plate is exposed to room air at 27ºC with a convection coefficient of h= 5.1 W/m^2.ºC on both sides and is sprayed with a flat black paint. Calculate the heat loss by the steam pipe per meter of length. Compare with the heat that would have been lost by a black steam pipe, not placed in the insulating slab.

7. A steel ball [c=0.46 kJ/kg.^{0}C, K=35 W/m.^{0}C] 5.0 cm in diameter and initially at a uniform temperature of 450^0 C is suddenly placed in a controlled environment in which the temperature is maintained at 100^0 C. The convection heat transfer coefficient is 10 W/m^2 ^{0}C. Calculate the time required for the ball to attain a temperature of 150^{0}C.

8. The temperature distribution across a wall 1 m thick at a certain instant of time is given as

$$T(x) = a + bx + cx^2$$

Where T is in degree Celsius and x is in meters while a=900^0 C, b= -300^0 C/m^3, and c=-50^{0}C/m^2. A uniform heat generation of 1000 W/m^3, is present in the wall of area 10 m^2 having the properties ρ=1600 kg/m^3, k=40 W/m.k and C_p= 4 kJ/kg.K

(i). Determine the rate of heat transfer entering the wall (x=0) and leaving the wall (x=1 m) the wall.

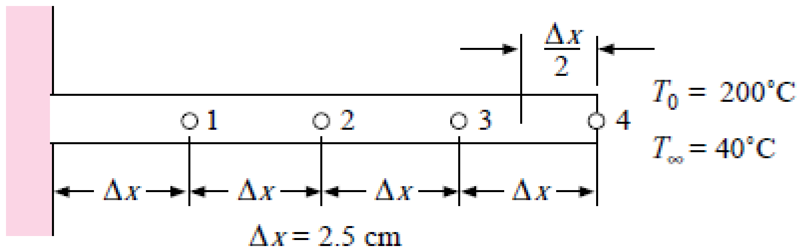
(ii). Rate of change of Energy storage in the wall, time rate of change at x=0, 0.25, 0.5 m.

Section C: Answer the following Questions given below (2×20=40 Marks)

9. (a). A circumferential fin of rectangular profile is constructed of 1 percent carbon steel and attached to a circular tube maintained at 150◦C. The diameter of the tube is 5 cm, and the length is also 5 cm with a thickness of 2 mm. The surrounding air is maintained at 20◦C and the convection heat-transfer coefficient may be taken as 100 W/m^2 ◦C. Calculate the heat lost from the fin (10 Marks)

(b). A small metal building is to be constructed of corrugated steel sheet walls with a total wall surface area of about 300m^2. The air conditioner consumes about 1kW of electricity for every 4kW of cooling supplied. Two wall constructions are to be compared on the basis of cooling costs. Assume that electricity costs $0.15/kWh. Determine the electrical energy savings of using 260mm of fiberglass batt insulation instead of 159mmof fiberglass insulation in the wall. Assume an overall temperature difference across the wall of 20◦C on a hot summer day in Texas. (10 Marks)

10. A steel rod [k =50W/m ^{0}C] 3mmin diameter and 10 cm long is initially at a uniform temperature of 200. At time zero it is suddenly immersed in a fluid having h=50W/m^2 ^{0}C and $T\infty$ =40 ^{0}C while one end is maintained at 200 ^{0}C. Determine the temperature distribution in the rod after 100 s. The properties of steel are ρ=7800 kg/m3 and c=0.47 kJ/kg ^{0}C.



(OR)

11. Starting with an energy balance on a disk volume element, derive the one-dimensional transient explicit finite difference equation for a general interior node for T(z,t) in a cylinder whose side surface is insulated for the case of constant thermal conductivity with information heat generation?