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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

Sixth Semester, B.E. - Mechanical Engineering

Semester End Examination; June - 2016

Heat and Mass Transfer

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Use of HMTDHB is allowed.
iii) Missing data (if any) may be suitably assumed.

UNIT - I

1 a.	Briefly explain the mechanism of convection heat transfer with suitable sketch.	6
b.	Mention the significance of thermal conductivity and thermal diffusivity.	4
c.	The solar radiation incident on the outside surface of an aluminium shading device is 1000 W/m^2. Aluminium absorbs 12% of the incident solar radiation and dissipates it by convection from back surface and by combined convection and radiation from the outer surface. The emissivity of aluminium is 0.1 and the convection heat transfer coefficient for both the surfaces is 15 W/m^2-ºK. The ambient temperature may be taken as 20ºC. Determine the temperature of the shading device.	7
d.	Mention the different types of boundary conditions used for conduction problems.	3
2 a.	Derive an expression for critical thickness of insulation for a sphere and mention its significances.	6
b.	Derive the general equation for temperature distribution for a straight fin of uniform thickness.	6
c.	The superheated steam is flowing through a tube of 95 mm diameter. The temperature of the steam is measured by putting an iron well of 15 mm diameter for the thermometer. The steam has a temperature of 320ºC. The flow velocity of the steam is 20 m/s. Find out the length of the well which gives maximum 1.5% error in temperature measurement. Heat transfer coefficient between steam and thermometer is 80 W/m^2-ºK, thickness of well wall (δ) is 1 mm thick steel for which thermal conductivity is 45 W/m-ºK. Tube wall temperature is 120ºC.	8

UNIT - II

3 a.	The brickwork of a furnace is built up of a layer of fireclay brick with a K = $0.84(1+0.695\times10^{-3}\,T)$. The brickwork is 250 mm thick. Determine the loss of heat from one square meter of brickwork surface and the wall surface temperatures, if the temperature of the gas in the furnace is 1200ºC and the room temperature 30ºC and the local heat transfer coefficient from the hot gas to brickwork is 30 W/m^2-ºK and the local heat transfer coefficient from brickwork to surrounding is 10 W/m^2-ºK.	10

b. Determine the temperature distribution in an infinite slab of thickness 2L in which heat is generated at a uniform rate of q''' W/m^3 and both the faces of the slab are in contact with a fluid maintained at a uniform temperature of T_fºC. Assume the surface heat transfer coefficient to be h W/m^2-ºK. 10

4 a. A 36 mm diameter egg approximately spherical in shape is initially at 25ºC. To boil to the consumers taste, it needs to be placed for 225 seconds in a sauce pan of boiling water at 100ºC. For how long should a similar egg for the same consumer be boiled when taken from a refrigerator at a temperature of 5ºC? Thermo physical properties of egg are K = 2.5 W/m-ºK, ρ = 1250 kg/m^2, C = 2200 J/kg-ºK. The heat transfer coefficient for the shell water interface may be taken as 280 W/m^2-ºK. Compare the centre temperature attained with that by treating the egg as a lumped heat capacity system. 10

b. Derive an expression for temperature distribution in transient heat conduction for $Bi < 0.1$. 6

c. Briefly explain the usefulness of Heisler charts. 4

UNIT - III

5 a. With a schematic diagram explain the thermal boundary layer for a fluid flowing over a flat plate. 6

b. Briefly explain the Reynolds-Colburn analogy. 6

c. Air at atmospheric pressure and temperature of 300ºK flows with a velocity of 1.5 m/s along the plate. Determine the distance from the leading edge of the plate where transition begins from laminar to turbulent. Calculate the drag force acting per width of the plate over the distance from $x = 0$ to where the transition starts. 8

6 a. With the help of a schematic diagram explain the mechanism of free convection for a vertical wall when it is hot and cold. 8

b. Water at 30ºC with a mass flow rate of 2 kg/s enters a circular tube of 25 mm inner diameter whose wall is maintained at a uniform temperature of 90ºC. Calculate the length of the tube required to heat the water to 70ºC. 8

c. What is the significance of the following dimensionless number :

(i) Grashoff number (ii) Prandtl number. 4

UNIT - IV

7 a. State the following laws of radiation :

i) Planck's law ii) Wien's displacement law iii) Kirchhoff's law. 6

b. The temperature of black surface of 0.2 m^2 area is 540ºC. Calculate :

(i) The total rate of energy emission

(ii) The intensity of normal radiation

(iii) The wave length of maximum monochromatic emissive power. 4

Contd…3

c. The distance of the sun from the earth is $150x10^6$ km. If the radius of the sun is $0.7x10^6$ km and its temperature is 6200ºK, estimate approximately the mean temperature of the earth. Assume that the rate of radiation transfer from the sun to the earth is equal to the rate of radiant transfer from the earth to the outer space which is at 0ºK. Consider the earth and the sun as black. 10

8 a. Define shape factor. Mention its important properties. 4

b. Derive an expression for radiation heat exchange between two parallel infinite gray surfaces. 8

c. Two large parallel plates are at 800ºK and 600ºK have emissivities of 0.5 and 0.8 respectively. A radiation shield having emissivity of 0.1 on the surface facing 800ºK plate and 0.05 on the surface facing 600°K is placed between the plates. Calculate the heat transfer rate per m^2 with and without the shield. Also calculate the temperature of the shield. 8

UNIT - V

9 a. Derive an expression for effectiveness-NTU relation for a parallel-flow heat exchanger. 10

b. A shell and tube heat exchanger is to be designed for heating water from 25ºC to 50ºC with the help of steam condensing at 1 atmospheric pressure. The water flows through the tubes (25 mm I.O., 29 mm O.D. and 4 m long) and the steam condenses on the outside. Calculate the number of tubes required if the water flow rate is 500 kg/min and the individual coefficients of heat transfer on the steam and water side are 5000 and 750 W/m^2-ºK. Neglect all other resistances. 10

10 a. Differentiate between film wise and drop wise condensation. 4

b. With a schematic diagram explain briefly the pool boiling regimes. 8

c. Air free saturated steam at 65ºC condenses on the surface of a vertical tube of O.D. 25 mm. The tube is maintained at a uniform temperature of 35ºC. Calculate the length of the tube required to have a condensate flow rate of 6 x 10^{-3} kg/s. Given h_{fg} = $2346x10^3$J/kg. 8

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