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

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Mechanical Engineering

Semester End Examination; June - 2017

Heat and Mass Transfer

Time: 3 hrs Max. Marks: 100

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. Explain the three types of boundary conditions. 6

b. Derive a general heat conduction equation in rectangular coordinate system. 8

c. A plain wall of thickness '*L*' and constant thermal properties is initially at a uniform temperature 'T_i'. Suddenly the surface at x = L is subjected to heating by hot gases at T_∞ with heat transfer coefficient '*h*'. The other surface at x = 0 is kept insulated. Write the mathematical formulation for 1-D, transient temperatures distribution in the wall. 6

2 a. Derive an expression for critical thickness of insulation of a cylinder. 6

b. Define efficiency and effectiveness of fins. 4

c. An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k = 0.7 W/m°C) followed by a 0.04 m layer of gupsum plaster (k = 0.48 W/m°C), what thickness of glass wool insulation (k=0.065 W/m°C) should be added to reduce the heat loss through the wall by 80 percent? 10

UNIT – II

3 a. Derive an expression for temperature distribution through a plane wall with uniform heat generation when both the surface have the same temperature and also find the maximum temperatures. 10

b. An electric current of 34,000 A flows along a flat steel plate 12.5 mm thick and 100 mm wide. The temp at one surface is 82° C and other is 95° C. Find the temp distribution and the value and position of maximum temperature. Take $\rho = 12\text{x}10^{-8}\ \Omega/\text{m}$ and $\text{K} = 52.4$ W/m°K. 10

4 a. Derive an expression of temperatures distribution in lumped parameter analysis. 10

b. Steel ball bearing (K = 50 W/m°K, $\propto = 1.3\times10^{-5}$ m^2/s) having dia of 40 mm, initially at a temperature of 650° C and suddenly quenched in a oil bath at 55° C. If the heat transfers coefficient is 300 W/m^2K.

Determine; (i) Time taken for bearing to reach the temp at 200°C

(ii) Instantaneous heat transfer when bearing at 200°C

(iii) Total heat transfer during this time period. 10

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UNIT - III

5 a. With reference to fluid flow over a flat plate, discuss the concept of velocity and thermal boundary layer, with necessary sketches. 10

b. A vertical pipe 15 cm outer dia, 1m long, has a surface tempt of 90°C.

(i) If the surrounding air is at 30° C. What is the rate of heat loss by free convection per meter length of pipe? 10

(ii) If the pipe is inclined to vertical at an able of 30°, what is the heat loss/meter length?

6 a. With the help of dimensional analysis derive relation for the Reynolds number, Prandtal number and Nusselt number. 10

b. Air at –20°C, 30 m/s, flows over a sphere of dia 25 mm, which is maintained at 80°C. Calculate the heat loss from sphere. 10

UNIT - IV

7 a. Explain briefly the following laws:

(i) Stefan Boltzmann law (ii) Kirchhoff's law (iii) Planck's law 10

(iv) Wien's displacement law (v) Lambert's Cosine law.

b. Two large parallel plates are at 1000° K and 800° K. Determine the heat exchange per unit area, when (i) the surface are black, (ii) the hot surface has an emissivity of 0.9 and cold surface has a emissivity of 0.6, iii) A large plate of emissivity of 0.1 is inserted between them. 10

8 a. Explain the concept of black body. 4

b. Prove that Emissive power of a black body in a hemispherical enclosure is π times the intensity of radiation. 8

c. The temperature of a black surface 0.2 m^2 in area is 540°C. Calculate

(i) The total rate of energy emission (ii) The intensity of normal radiation 8

(iii) The wavelength of maximum monochromatic emissive power.

UNIT – V

9 a. Derive an expression for LMTD of parallel flow heat exchanger. 10

b. Oil at 100° C (C_p = 3.6 kJ/kgK) flows at a rate of 30,000 kg/hr and enters a parallel flow heat exchanger cooling water (C_p = 4.2 kJ/kgK) enters at 10° C at the rate of 50,000 kg/hr. The heat transfer area is 10 m^2 and u = 1000 W/m^2K. Calculate outlet temp of oil and water. 10

10 a. With a neat sketch, explain the regimes of pool boiling. 8

b. State and explain Fick's law of diffusion. 4

c. Dry saturated steam at atmospheric pressure condenses on a vertical tube of dia 5 cm and length 1.5 m. If the surface is maintained at 80°C, determine the heat transfer rate and the mass of steam condensed per hour. 8

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