Printed Pages – 6 Roll No. : .....

337654(37)

B. E. (Sixth Semester) Examination, ~~2020~~ APR-MAY 2022

(New Scheme)

(Mech. and Automobile Engg. Branch)

HEAT & MASS TRANSFER

Time Allowed : Three hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note : *Part (a) is compulsory from each question. Part (b), (c) and (d) from any two from each questions.*

Unit - I

1. (a) Distinguish between steady and unsteady state heat transfer. 2

(b) Derive an expression for three dimensional time

dependent heat conduction with internal heat generation and constant thermal conductivity in certesian coordinate system. Reduce it as. 7

(i) Poisson equation

(ii) Fourier equation

(iii) Laplace equation

(c) An exterior wall of house may be approximated by 10 cm layer of common brick ($k = 0{\cdot}75$ W/m-deg) followed by 4 cm layer of gypsum plaster ($k = 0{\cdot}5$ W/m-deg). What thickness of loosely packed rock wool insulation ($k = 0{\cdot}065$ W/m-deg) should be added to reduced the heat loss or gain through the wall by 75%? 7

(d) A furnace wall comprises three layers : 13·5 cm thick inside layer of fire brick, 7·5 cm thick middle layer of insulating brick and 11.5 cm thick outside layer of red brick. The furnace operates at 870°C and it is anticipated that the outside of this composite wall can be maintained at 40°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 × 2 m and the data on thermal conductivities is :

Fire brick k1 = 1·2 W/m-deg,

Insulating brick k2 = 0·14 W/m-deg,

Red brick k3 = 0·85 W/m-deg 7

Unit - II

2. (a) How does a fin enhance heat transfer at a surface? 2

(b) A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side and 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and convective heat transfer coefficient at surface is 90 W/m^{2}K. Calculate the heat dissipation rate from the rod. 7

(c) Derive equations of temperature distribution and heat dissipation for Fin insulated at tip. 7

(d) An egg with mean diameter of 4 cm and initially at 25 degree Celsius is placed in an open boiling water container for 4 minutes and found to be boiled at a particular level. For how long should a similar egg boil at the same level, when refrigerator temperature is 5 degree celsius? Use lumped parameter theory and assume following properties of egg :

$k = 12$ W/mK

$h = 125$ W/m^{2}K

$c = 2$ kJ/kg k

$\rho = 1250$ kg/m^3 7

Unit - III

3. (a) Explain free and forced convection. 2

(b) Derive an equation for free convection by use of dimensional analysis.

$$Nu = \phi(\text{Re}, \text{Pr})$$ 7

(c) A spherical heater of 20 cm diameter and at 60 degree centigrade is immersed in a tank of water at 20 degree centigrade. Determine the value of convective heat transfer coefficient. 7

(d) During test-run, air flows at 215 m/s velocity and 25 degree celsius temperature past a smooth thin model airfoil which can be idealized as a flat plate. If the chord length of the airfoil is 15 cm, find drag per unit width. The relevant physical properties of air are :

$p = 1{\cdot}82$ kg./m^3

$\nu = 15{\cdot}53 \times 10^{-6}$ m^2/s 7

Unit - IV

4. (a) State Fick's law of Diffusion. 2

(b) Discuss in detail the various regimes in boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling? 7

(c) Define the process of mass transfer and list some industrial applications where mass transfer is involved. 7

(d) Water flows normal to a polished 15 mm diameter copper tube at the rate of 3·5 m/s. The tube is maintained at 116 degree centigrade and film boiling occurs. Workout the boiling heat transfer coefficient. 7

Unit - V

5. (a) Define the term overall heat transfer coefficient. 2

(b) Derive logarithmic mean temperature difference (LMTD) for counter flow heat exchanger. 7

(c) An enclosure measure 1.5 m × 1.75 m with a height of 2 m. Under steady state equilibrium conditions, the walls and ceiling are maintained at

525 K and floor at 400K. Determine the net radiation to floor. 7

$\epsilon 1$ (emissivity of ceiling and walls) = 0·85

$\epsilon 2$ (emissivity of floor) = 0·75

(d) Show that effectiveness $\epsilon = \frac{NTU}{1+NTU}$ for counter flow heat exchanger. 7