B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

01845

Term-End Examination

December, 2014

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours   *Maximum Marks : 70*

Note : *Answer any* **seven** *questions. All questions carry equal marks. Use of calculator is permitted.*

1. (a)   What is Heat Transfer ? Explain the process of "Convection Heat Transfer".   5

    (b)   The quantity of radiation received by Earth from the Sun is 1·4 kW/m^2 (Solar Constant). Assuming that Sun is an ideal radiator, calculate the surface temperature of the Sun. The ratio of the radius of Earth's orbit to the radius of the Sun is 216.   5

2. (a)   Derive a relation for critical thickness of insulation for a cylinder.   6

(b) Explain the conduction, convection and radiation of heat transfer. *4*

3. (a) Using Buckingham π-theorem show that, the free convection heat transfer, $Nu = BGr^a Pr^b$. *8*

(b) Define drag coefficient and drag force. *2*

4. (a) It was found during a test in which water flowed with a velocity of 2·44 m/s through a tube (with 2·54 cm inner-diameter and 6·08 m long), that the heat lost due to friction was 1·22 m of water. Estimate the surface heat transfer coefficient based on Reynolds analogy. (Take, $\rho = 998$ kg/m^3 and $c_p = 4·187$ kJ/kgK.) *5*

(b) Explain the following : *5*

(i) Laminar flow and Turbulent flow

(iii) Thermal Boundary Layer and Hydrodynamic Boundary Layer

5. (a) Briefly explain the terms Surface Absorption, Reflection and Transmission. *5*

(b) Two infinitely long parallel plates of widths $x = 12$ cm and $y = 6$ cm are located at a distance $z = 7$ cm apart as shown below. Determine the view factor F_{12}. *5*
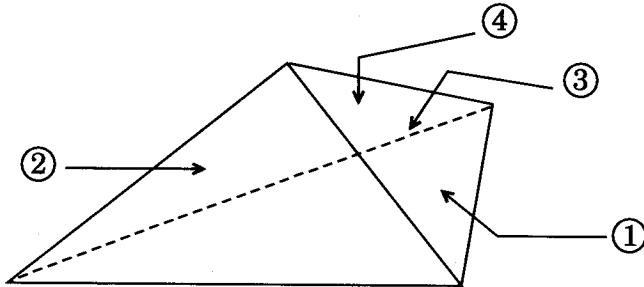
6. (a) What is Fick's Law ? Explain. *5*

(b) What is the physical significance of Lewis number ? *2*

(c) What is the major difference between Laminar and Turbulent mass transfer ? *3*

7. Calculate the maximum rate of absorption of O_2 in a fermenter from air bubbles at 1 atm. Absolute pressure having diameters of 100 µm at 37°C into water having a zero concentration of dissolved O_2. The solubility of O_2 from air in water at 37°C is $2\cdot26 \times 10^{-7}$ g mol O_2/m^3 liquid or $2\cdot26 \times 10^{-4}$ kg mol O_2/m^3. The diffusivity of O_2 in water at 37°C is $3\cdot25 \times 10^{-9}$ m^2/s. Agitation is used to produce the air bubbles. *10*

8. (a) Define Effectiveness of a heat exchanger. Also explain the rating and sizing problem for a heat exchanger. *6*

(b) A counterflow shell and tube heat exchanger is used to heat water at a rate of m = 0·8 kg/s from $T_i = 20°C$ to $T_0 = 80°C$, with hot oil entering at $120°C$ and leaving at $85°C$. The overall heat transfer coefficient is $U = 125$ W/(m^2 . °C). Calculate the heat transfer area required. *4*

9. (a) Discuss Film condensation in detail. *5*

(b) Describe the surface condenser with neat diagram. *5*

10. (a) What are the different types of Evaporators ? Explain any one of them with neat diagram. *5*

(b) What are the different separation processes ? Explain the difference between absorption and adsorption. *3*

(c) State Gibbs' Phase Rule. *2*

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