CBCS SCHEME

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15AE53

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: **1.** ***Answer any FIVE full questions, choosing ONE full question from each module.***
2. ***Use of HMT data handbook is permitted.***

Module-1

1 a. With a neat sketch, briefly explain Fick's law of diffusion. **(08 Marks)**
b. Differentiate Heat Transfer and Mass Transfer. **(04 Marks)**
c. Explain: (i) Thermal conductivity (ii) Thermal diffusivity **(04 Marks)**

OR

2 a. Describe various modes of Mass Transfer with an example. **(08 Marks)**
b. Discuss in detail radiation and convection. **(08 Marks)**

Module-2

3 a. Derive general 3D heat conduction equation in Cartesian coordinates. **(08 Marks)**
b. Obtain an expression for temperature distribution of a Fin with insulated end. **(08 Marks)**

OR

4 a. Derive an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment of heat conduction problem. **(08 Marks)**
b. A 15 mm diameter mild steel sphere having thermal conductivity 42 W/m°C is exposed to cooling airflow at 20°C resulting in the convective coefficient h = 120 W/m^2°C. Determine:
(i) Time required to cool the sphere from 550°C to 90°C.
(ii) Instantaneous heat transfer rate 2 minutes after the start of cooling.
(iii) Total energy transferred from the sphere during the first 2 minutes.
For mild steel take ρ = 7850 kg/m^3, c = 475 J/kg°C and α = 0.045 m^2/h. **(08 Marks)**

Module-3

5 a. Using dimensional analysis derive an expression relating Nusselt number, Prandtl number and Grashoff number for natural convection. **(08 Marks)**
b. The water is heated in a tank by dipping a plate of 30 cm × 30 cm size. The temperature of plate surface is maintained at 140°C. Assuming the temperature of surrounding water at 20°C. Find out the heat lost from the plate per hour. **(08 Marks)**

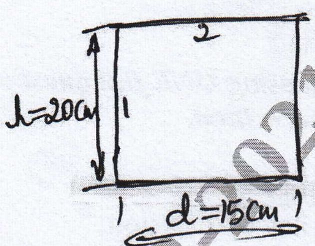
OR

6 a. Air at atmospheric pressure and 40°C flow with a velocity of U = 5 m/s over a 2m long flat plate where surface is kept at a uniform temperature of 120°C. Determine the average heat transfer coefficient over the 2m length of the plate. Also find out the rate of heat transfer between the plate and the air per 1m width of the plate. **(08 Marks)**
b. Water is heated while flowing through a 1.5 cm × 3.5 cm rectangular tube at a velocity of 1.2 m/s. The entering water temperature is 40°C and tube wall is maintained at 85°C. Determine the length of the tube required to raise the temperature of water by 35°C. Take properties of water as ρ = 985.5 kg/m^3, K = 0.653 W/mK, $\gamma = 0.517 \times 10^{-6}$ m^2/s, C_p = 4.19 kJ/kgK. **(08 Marks)**

Module-4

7 a. Explain: (i) Kirchoff's law (ii) Planck's law **(06 Marks)**

b. Derive expressions for shape factors of the cavities (each enclosed on its surface with a flat surface) shown in Fig.Q7(b)(i) and (ii).



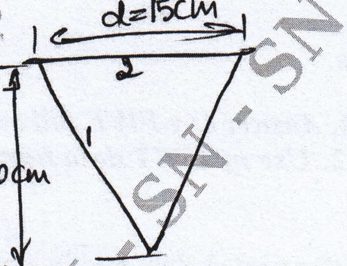


Fig.Q7(b)(i) Cylindrical Cavity Fig.Q7(b)(ii) Conical cavity **(10 Marks)**

OR

8 a. Obtain an expression for effectiveness and NTU for a Parallel Flow Heat Exchanger. **(08 Marks)**

b. Exhaust gases flowing through a heat exchanger at the rate of 30 kg/min are cooled from 300°C to 85°C by water initially at 10°C. Specific heat of gases may be taken as 1.13 kJ/kg and overall heat transfer coefficient is 502.3 kJ/m^2hrK. If water flow rate is 25 kg/min. Calculate the surface area needed for (i) Parallel flow (ii) Counter flow **(08 Marks)**

Module-5

9 a. Briefly explain various cooling methods for reducing aerodynamic heating of hypersonic vehicles. **(08 Marks)**

b. Discuss various cooling methods for Rocket Thrust Chamber. **(08 Marks)**

OR

10 a. Derive species conservation equation for a central volume in space. **(10 Marks)**

b. Calculate the diffusion coefficient for NH_3 in air at 27°C temperature and atmospheric pressure. Take:

(i) Molecular weight and volume of NH_3 17 and 26.43 cm^3/gm mole.

(ii) Molecular weight and volume of air 29 and 30.6 cm^3/gm mole **(06 Marks)**

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