CBCS SCHEME

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17AE53

Fifth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions, choosing ONE full question from each module.***

Module-1

1 a. With suitable examples, explain mode of heat transfer. **(06 Marks)**

b. Elaborate the following terms :
- i) Thermal conductivity
- ii) Fourier law and heat conduction
- iii) Thermal conductivity
- iv) Fick's first law of diffusion
- v) Analogy between heat transfer and mass transfer

(10 Marks)

c. With suitable mathematical equations, explain continuity equation and energy equation. **(04 Marks)**

OR

2 a. Explain the following terms :
- i) Velocity boundary layer
- ii) Thermal boundary layer

(10 Marks)

b. Elaborate three different types of boundary conditions. **(10 Marks)**

Module-2

3 a. Stating clearly the assumption mode. Derive the three dimensions general heat conductor equation in Cartesian coordinates. **(10 Marks)**

b. A wall is constructed of several layers. The first layer consists of masonry brick (K= 0.66W/mk) 25cm thick. The second layer of 2.5cm thick mortar (k = 0.7w/mk). The third layer of 10cm thick limestone (k = 0 .66w/mk) and finally 1.25cm thick plaster (k = 0.7w/mk). The heat transfer coefficient on the interior and exterior of the wall fluid layer are 5.8w/m^2k and 11.6w/m^2k respectively. Find :
- i) Overall heat transfer coefficient from the air at the interior to the air at the exterior on the wall
- ii) The overall thermal resistance per m^2
- iii) The rate of heat transfer per m^2 if the interior of the room is at 26°C, while the outside air is at a temperature of -7°C
- iv) The temperature at the junction between the mortar and the limestone. **(10 Marks)**

OR

4 a. Derive an expression for heat transfer distribution for along fin. **(10 Marks)**

b. A cylinder 1m long and 5cm in diameter is placed in an atmosphere if 45°C. It is provided with ten longitudinal straight fins having thermal conductivity of 120W/mk. The fins are portending 1.25cm form the cylinder surface and the thickness of each fin is 0.75mm. The heat transfer coefficient between the cylinder and surrounding air is 17W/m^2k. The surface temperature of the cylinder is 150°C. Calculate :
- i) The rate of heat transfer
- ii) The temperature at the tip of the fin **(10 Marks)**

Module-3

5 a. Using Buckingham's π theorem. Show the velocity through a circular orifice is given by $V = \sqrt{2gH\phi}\left[\frac{D}{H}, \frac{\mu}{\rho vH}\right]$, where H is head causing flow, D is the diameter of orifice, μ is the mass density and g is the acceleration due to gravity. **(10 Marks)**

b. A 5cm diameter pipe carrying hot water is exposed to the ambient air at 15°C. If the outer surface of the pipe is at 65°C. Find the rate of heat loss from 1m pipe length when,
   i) The pipe is horizontal
   ii) The pipe is vertical **(10 Marks)**

OR

6 a. Elaborate the significance of following dimensionless numbers.
i) Nusselt's number ii) Reynolds's number iii) Prandtl number iv) Grashoff number **(08 Marks)**

b. Air at 20°C is flowing over a flat plate 28cm × 28cm at a velocity of 3m/s. The surface temperature of the plate is 60°C. Calculate the following at 28cm from the leading edge.
   i) Hydrodynamic and thermal boundary layer thickness
   ii) Local friction coefficient
   iii) Average friction coefficient
   iv) Local and average convective heat transfer coefficients
   v) Rate of heat transfer by convection **(12 Marks)**

Module-4

7 a. State and explain Weins displacement law Plank's law and Kirchoff's law. **(06 Marks)**

b. With suitable mathematical equation, explain radiation shape factor. **(04 Marks)**

c. Two large parallel planes are not 1000K and 600K. Determine the heat exchange per unit area :
   i) If the surfaces are black
   ii) If the not one has an emissivity of 0.8 and the cooler one 0.5
   iii) If a large plate is inverted between these two, the plate having an emissivity of 0.2. What is the temperature of this large plate and also find the percentage reduction in heat transfer with this large plate. **(10 Marks)**

OR

8 a. Derive an expression for effectiveness of a parallel flow heat exchanger. **(10 Marks)**

b. A heat exchanger is required to cool 55000 Kg/hr of alcohol from 66°C to 40°C using 40000Kg/hr if water entering at 5°C. Calculate the surface area required for
i) Parallel flow type ii) Counter flow type
Take overall heat transfer coefficient, U = 580W/m^{2}K $C_{p\ alcohol}$ = 3760J/Kg K, $C_{p\ water}$ = 4180J/Kg K **(10 Marks)**

Module-5

9 a. What causes aerodynamic heating in rockets and missiler? Explain its effect on performance of high speed vehicles. **(08 Marks)**

b. Explain the phenomenon of ablation and its mechanism. Also elaborate its importance in aerospace application. **(12 Marks)**

OR

10 a. Elaborate types of mass transfer phenomenon. Also with suitable equation explain mass transfer coefficient. **(12 Marks)**

b. Explain the following terms : i) Diffusion coefficient ii) Mass concentration
iii) Mass fraction iv) Mole fraction. **(08 Marks)**