CBCS SCHEME

USN | | | | | | | | | | |

17ME63

Sixth Semester B.E. Degree Examination, Feb./Mar. 2022
Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of heat transfer data hand book is permitted.

Module-1

1 a. Explain:
i) Thermal conductivity
ii) Convective heat transfer coefficient
iii) Thermal diffusivity. **(06 Marks)**

b. Describe the three types of boundary conditions. **(06 Marks)**

c. A furnace wall comprises three layers; 13.5m thick layer of fire brick (K = 1.2W/mK), 7.5cm thick of insulating brick (K = 0.14W/mK) at the middle and 11.5cm thick outside layer of red brick (K = 0.85W/mK). The furnace operates at 870°C and the outside of the composite wall is maintained at 40°C by the circulation of air. Neglecting contact resistance between the layers, find the rate of heat loss from the furnace and the wall interface temperatures. The wall measures area of $10m^2$. **(08 Marks)**

OR

2 a. Explain the basic laws governing conduction, convection and radiation heat transfer. **(06 Marks)**

b. Stating clearly the assumptions made, derive the three dimensional general heat conduction equation in Cartesian coordinates. **(07 Marks)**

c. Compute the heat loss per square meter of a furnace wall 25cm thick, whose inner and outer surfaces are maintained at temperatures 400°C and 40°C respectively. The variation of thermal conductivity of furnace wall material with temperature is given by the relation.
$K = 0.002T - 10^{-6}T^2$
Where 'K' is in W/mK and T is in °C. **(07 Marks)**

Module-2

3 a. Define critical thickness of insulation. Derive an expression for critical radius of pipe. **(06 Marks)**

b. Derive an expression for temperature distribution for heat flow through a straight rectangular fin, whose are end is attached to the heat source and the other end is insulated. **(06 Marks)**

c. An aluminium (K = 204W/mK) rod 20mm in diameter and 200mm long protrudes from a wall which is maintained at 300°C. The end of the rod is insulated and the surface of the rod is exposed to air at 30°C. The convection heat transfer coefficient between the rod's surface and air is $10W/m^2K$. Calculate the heat lost by the rod. Also calculate the temperature of rod at a distance of 100mm from the wall. **(08 Marks)**

OR

4 a. Write a note on:
   i) Heisler charts
   ii) Numerical analysis of heat conduction. **(08 Marks)**

b. Derive an expression for the temperature history of a cooling body with negligible internal resistance. State the assumptions made. **(07 Marks)**

c. A carbon steel (K = 54W/mK, ρ = 7833kg/m^2, C_p = 0.465kJ/kg K) ball of 100mm diameter which is initially at a uniform temperature of 625°C is suddenly immersed in a large quantity of oil at 25°C. If the convection heat transfer coefficient between the steel ball and oil in 10W/m^{2}K, determine the time required for the ball to attain a temperature of 100°C. **(05 Marks)**

Module-3

5 a. Explain the following:
   i) Velocity boundary layer
   ii) Thermal boundary layer
   iii) Nusselt number
   iv) Prandtl number. **(10 Marks)**

b. Assuming that a man can be represented by a cylinder 30cm is diameter and 1.7m high with a surface temperature of 30°C. Calculate the heat he would loose while standing is a 36km/hr wind at 10°C. Use the relation Nu = 0.027 $(R_e)^{0.8}$ $(P_r)^{1/3}$. **(10 Marks)**

OR

6 a. Define and mention physical the significance of
   i) Reynold's number
   ii) Grashoff number. **(06 Marks)**

b. A hot square plate 40cm × 40cm at 100°C is exposed to atmospheric air at 20°C. Make calculations for the heat loss for both surfaces of the plate i) If the plate is kept vertical ii) If plate is kept horizontal. Use the following relations:
   Nu = 0.125 (Gr. Pr)$^{0.33}$ for vertical position plate and
   Nu = 0.72 (Gr. Pr)$^{0.25}$ for upper surface
   = 0.35 (Gr. Pr)$^{0.25}$ for lower surface.
   Take the properties of air at the mean temperature. **(14 Marks)**

Module-4

7 a. Distinguish between:
   i) Black body and grey body
   ii) Radiosity and irradiation. **(06 Marks)**

b. Derive an expression for the rate of heat transfer when the radiation shield is introduced between two parallel plates. **(06 Marks)**

c. Two large parallel planes are at 1000K and 600K. Determine the heat exchange per unit area i) If the plane surfaces are black ii) If the hot plane has an emissivity 0.8 and the cooler plane has emissivity 0.5 iii) if a large plate is inserted between these two plates, the larger plate having an emissivity of 0.2. The two plates are having emissivity 0.8 and 0.5 respectively as before. **(08 Marks)**

OR

8 a. State and explain:
 i) Kirchoff's law
 ii) Stefan Boltzman law
 iii) Planck's law
 iv) Wein's displacement law. **(10 Marks)**

b. Two large parallel plates maintained at 800°C and 300°C. The emissivities are 0.3 and 0.5 respectively. A polished aluminium shield of emissivity 0.05 is placed between these plates. Determine:
 i) The temperature of the shield
 ii) Radiation heat exchange per square meter without shield
 iii) Radiation heat exchange per square meter with shield
 iv) The percentage reduction in heat transfer. **(10 Marks)**

Module-5

9 a. Derive an expression for effectiveness of counter flow heat exchanger in terms of NTU and heat capacity ratio. **(10 Marks)**

b. A double pipe counter flow heat exchanger is used to cool oil from 80°C to 50°C by water entering at 25°C. The mean flow rate of oil is 10,000kg/hr and the mean flow rate of water is 8000kg/hr. Determine the heat exchange area for an overall heat transfer coefficient of $300 W/m^2K$. Take C_p value for oil as 2.095 kJ/kg K and for water as 4.18kJ/kg K. **(10 Marks)**

OR

10 a. Sketch and explain various regimes of pool boiling. **(06 Marks)**

b. Distinguish between, filmwise and dropwise condensation. **(04 Marks)**

c. Engine oil is to be cooled from 80°C to 50°C by using a single pass counter flow concentric tube heat exchanger with cooling water available at 20°C. Water flows inside a tube with inside diameter of 25mm, at a rate of 0.08kg/s and oil flows through annulus at a rate of 0.16kg/s. The heat transfer coefficients for the water side and oil side are respectively 1000 and $80 W/m^2K$. Neglecting tube wall resistance, calculate the tube length required. Take C_p for water = 4180J/kg K and for oil, 2090J/kgK. The fouling factors for both water and oil side are $0.00018 m^2K/W$. **(10 Marks)**

* * * * *