CBCS SCHEME

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18ME63

Sixth Semester B.E./B.Tech. Degree Examination, Dec.2025/Jan.2026
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 book is permitted.***

Module-1

1 a. Briefly explain the three modes of heat transfer. **(06 Marks)**

b. Define critical thickness of insulation. Derive an expression for critical thickness of insulation for a sphere. **(06 Marks)**

c. A 100 mm outside dia pipe carrying steam at a temperature of 195ºC is lagged to 200 mm diameter with magnesium and further lagged with laminated asbestos to 250 mm diameter. The entire pipe is further protected by a lays of canvas. If the temperature under the canvas is 20ºC, find the mass of steam condensed in 8 hours on a 100 meter length of pipe. Take Thermal conductive magnesia is 0.07 W/m K and the thermal conductivity of asbestos as 0.082 W/m K. Neglect, thermal resistance of the pipe material and also contact resistance between the layers. The latent heat and stream is 1951kJ/Kg at 195ºC. Also find the intermediate temperature between the two layers. **(08 Marks)**

OR

2 a. Derive the general three dimension heat conduction equations in Cartesian coordinates. State the assumption made. **(06 Marks)**

b. Derive an expression for steady state heat flow through a wall of thickness 'L' and thermal conductivity K varies as $K = K_0(1 + \beta T)$, whose faces are maintained at temperatures T_1 and T_2 where K_0 and β are constants and T is temperature. There is no internal heat generation. **(05 Marks)**

c. A furnace wall consists of three layers. The inner layer of 10 cm thickness is made of fire brick (K = 1.04W/mK) the intermediate layer of 25 cm thickness is made of (K = 0.69 W/mK) masonry brick followed by a 5 cm thick concrete wall (K = 1.37 W/mK). When the surfaces is in operation, the combustion products inside the furnace are at 1000ºC, while the atmospheric air is at 25ºC, the convection heat transfer coefficients at the inner and outer surfaces of the wall are 50 W/m^2 K and 15 Wm^2K respectively. Neglect the contact resistance between layers. Determine : i) the rate of heat transfer per unit area from hot gas to the air ii) the temperature at the inner, interface between the layers and the outer surface of the furnace. Draw the temperature profile for heat flow through furnace wall. **(09 Marks)**

Module-2

3 a. Define effectiveness and efficiency of Fin. What are the applications of fin. **(04 Marks)**

b. Derive an expression for the temperature distribution in a pin-fin when are end is attached to a heat source at temperature T_i and the other end of fin is insulated. Fin surface is exposed to ambient at temperature T_f and heat transfer coefficient h. Also obtain an relation for heat flow along the fin. **(08 Marks)**

c. A square rod of side 12 mm made of low carbon steel protrudes into air at 35ºC from a furnace wall at 200ºC. The convection heat transfer coefficient is 22 W/m^2 K and the thermal conductivity of rod material is 51.9 W/m K. Determine the location (in distance) from the wall at which the temperature as rod will be 60ºC. When :
   i) The rod end is infinitely long
   ii) The length of the rod is 159 mm and the end of the rod protruded to air is insulated. **(08 Marks)**

OR

4 a. Write a short note on Heisler charts for transient heat flow. **(04 Marks)**

b. Derive an expression for temperature distribution with time 't' and heat flow for a solid body of surface area 'A' volume 'V' density ρ specific heat C_p initially at temperature T_i heated in an environment at temperature T_f and heat transfer coefficient 'h' Neglect internal temperature gradients with in the body (is lumped heat system). **(07 Marks)**

c. A 12 mm diameter mild steel sphere (K = 42.5W/mK) is exposed to cooling air flow at 27ºC, resulting in the heat transfer coefficient of 114 W/m^2 K). Determine :
i) the rime required to cool the sphere from 540ºC to 95ºC ii) instantaneous heat transfer rate 2 minutes after the start of cooling iii) total energy transfered from the sphere during the first 2 minutes. The properties of M.S are, density = 7850 Kg/m^3, Specific heat = 475 J/Kg K. **(09 Marks)**

Module-3

5 a. State and explain the following laws of thermal radiators
i) Stefan – Boltzman law of radiation ii) Kirchoff's law iii) Plank's law. **(09 Marks)**

b. Emissivity of two large parallel plates maintained at 800º and 300ºC are 0.3 and 0.5 respectively. Find the net radiant heat exchanger per square meter for these plates. **(04 Marks)**

c. A pipe carrying steam having an outside diameter of 20 cm runs in a large room and is exposed to air at a temperature of 30ºC. The pipe surface temperature is 400ºC. Calculate the loss of heat to surrounding per meter length of pipe due to thermal radiation. The emissivity of the pipe surface is 0.8. What would be the loss of heat due to radiation if the pipe is enclosed in a 40 cm diameter brick conduct of emissivity 0.917. **(07 Marks)**

OR

6 a. Explain clearly the application of Numerical method in solving the dimensional steady and unsteady conduction with any one type of boundary condition. **(10 Marks)**

b. Define i) Gray surface ii) Black body iii) Spectral emissive power as applied to thermal radiation. **(03 Marks)**

c. The surface of a double walled spherical vessel used for storing liquid oxygen are covered with a lays of silver having an emissivity of 0.03. The temperature of the outer surface of the inner wall is, -153ºC and the temperature of the inner surface of the outer wall is 27ºC. The sphere are 42 cm and 60 cm in diameter, with space between them is evaluated. Calculated the radiation heat transfer through the wall into the vessel and the rate evaporation of liquid oxygen/ hr if rate of vaporization is 220 kJ/Kg. **(07 Marks)**

Module-4

7 a. What is boundary layer? Explain in detail velocity and thermal boundary layers. **(06 Marks)**

b. Air flows over a heated plate at a velocity of 50m/s. The local skin friction coefficient at a point as a plate is 0.004. Estimate the local heat transfer coefficient at this point. Proposition of air are : $\rho = 0.88$ Kg/m^3, $\mu = 2.286 \times 10^{-5}$ Kg /ms, $C_p = 1.001$ kJ/Kg K, K = 0.035 W/mK,

Use the relation ; St. $P_r^{2/3} = \frac{C_{fx}}{2}$

Where, S_t = Stanton number, P_r = Prandtl number, C_{fx} = Friction coefficient. **(06 Marks)**

c. A steam pipe 50 mm diameter and 2.5 m long has been placed horizontal and exposed to still air at 25ºC. If the pipe wall temperature is 295ºC, determine the heat loss. Take the mean properties of air at 160ºC and use ; $N_u = 0.53\,(G_r.P_r)^{1/4}$ where N_u = Nusselt number, G_r = Groshoff number and P_r = Prandtl number. **(08 Marks)**

OR

8 a. Explain the significance following dimension numbers
   i) Prandtl number
   ii) Nusselt number
   iii) Reynolds's number **(06 Marks)**

b. A vertical pipe of 10 cm outer diameter at a surface temperature of 100ºC is in a room where the air is at 20ºC. The pipe is 3 m long. What is the rate of heat loss per meter length of the pipe? Use the relation: $N_u = 0.10(G_r.P_r)^{1/3}$. **(06 Marks)**

c. Water at 50ºC enters a tube of 15 mm diameter and 3 m long tube with a velocity of 1 m/s. The wall is maintained at a constant temperature of 90ºC. Calculate the heat transfer coefficient and the total amount of heat transferred if the exit water temperature is 70ºC.

Use the relation ; $N_u = 0.023,\ R_e^{0.8}\ P_r^{0.4}$,

Where R_e = Reynold's number, N_u = Nusselt number and P_r = Prandtl number. **(08 Marks)**

Module-5

9 a. Define the following as applied heat exchanges :
i) Overall heat transfer coefficient ii) Fouling factor iii) Effectiveness iv) N.T. U **(06 Marks)**

b. Derive an expression for the LMTD of a counter flow heat exchange. Mention the assumption made. **(08 Marks)**

c. An oil cooler for a large Diesel engine is to cool engine coil from 60ºC to 45ºC, using sea water at inlet temperature of 20ºC with a temperature rise of 15ºC. The design heat load is 140 kW and the mean overall heat transfer coefficient based on the outer surface area of the tubes is 70 W/m^{2}K. Calculate the heat transfer area for single pass :

i) Counter flow ii) Parallel flow arrangements. **(06 Marks)**

OR

10 a. Sketch the pool boiling curve for water and briefly explain the various regimes of boiling heat transfer. **(07 Marks)**

b. Writ short note on Filmwise and dropwise condensation. **(05 Marks)**

c. Oil at 100ºC (C_p = 3.6 kJ/Kg K) flows at a rate of 30,000 Kg/h and enters into a parallel flow heat exchanger. Cooling water enters the heat exchanger at 10ºC at the rate of 50,000 Kg/h. The heat transfer area is 10m^2, overall heat transfer coefficient is 1000 W/m^2 K, C_p of water = 4.2 kJ/Kg K. Determine :

i) Outlet temperature is oil and water

ii) Maximum possible outlet temperature of water. **(08 Marks)**

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