CBCS SCHEME

USN 18ME63

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 handbook is permitted.
3. Missing data can be assumed suitably.

Module-1

1 a. Explain initial and boundary conditions for heat transfer analysis. **(06 Marks)**

b. Write a general conduction equation in Cartesian and cylindrical co-ordinates. With a sketch identity the areas of heat transfer. **(06 Marks)**

c. Develop mathematical formulation of one dimensional, steady state heat conduction for hollow cylinder with constant 'K'. The heat is supplied to cylinder at inner surface at radius $r = r_1$ at a rate of 'q' w/m^2 and heat is lost by connection from the surface at radius $r = r_2$ into ambient temp T_∞. With heat transfer co-efficient h. **(08 Marks)**

OR

2 a. Derive an expression for heat transfer through composite slab. State the assumptions made. **(10 Marks)**

b. A furnace wall is made up of inside silica brick (K = 1.856W/m^2-K) and outside magnesia brick (K = 5.568W/m^2-K) each 10mm thick. If inner and outer surface temperature of wall are 820°C and 120°C, find the heat transfer through the plane wall per sq. m area. Take the constant resistance of 1.722×10^{-3} m^2-c/w. Also find the intermediate temperatures and show the temperature profile. **(10 Marks)**

Module-2

3 a. Derive an expression for temperature distribution for a long fin. State the assumptions made. **(10 Marks)**

b. A stainless steel spoon (K = 15.1W/m^2-K) partially immersed in a boiling water at 95°C in a kitchen at 25°C. The handle of the spoon has a cross-section (0.2cm × 1cm) and it extends 18cm in air from the free surface of the water. If the HTC on the exposed surface of the spoon is 15W/m^2-K, calculate the temperature difference across the spoon handle. State the assumptions made. Formulate the problem with a sketch. **(10 Marks)**

OR

4 a. Identify the conditions under which the lumper parameter concept is applied. With standard notations derive an expression for temperature distribution through the body. **(10 Marks)**

b. A (40cm × 40cm) copper slab, 5mm thick is at a uniform temperature of 250°C suddenly exposed to convective environment at 30°C with hTC of 90W/m^2-K. The slab is cooled upto 90°C. Estimate the time of cooling. Take the properties of material ρ = 9000 kg/m^3, sp. heat C = 0.38 kJ/kg-K and thermal conductivity K = 370W/m-K. **(10 Marks)**

Module-3

5 a. What are the limitations of analytical solutions used in Engineering problems? Discuss the advantages of numerical methods over analytical methods. **(08 Marks)**

b. In a large uranium plate of thickness L = 4cm and K = 28W/m-K, heat is generated uniformly at a constant rate of $5 \times 10^6 W/m^3$. One side of plate is at 0°C while the other side is subjected to convection at T_∞ = 30°C with HTC, h = $45W/m^2$-K. Considering three equally spaced nodes in the medium, two at the boundaries and one at the middle, estimate the exposed surface temperature of the plate under steady state conditions using finite difference approach. **(12 Marks)**

OR

6 a. State and explain weins displacement law, Plank's low and Kirchoff's law. **(10 Marks)**

b. Write a brief note on radiation shape factor. **(04 Marks)**

c. Determine the heat lost by radiation per metre length of 8cm diameter pipe at 300°C if
   i) Located large room with a red brick wall at a temperature of 27°C.
   ii) Enclosed in a 16cm diameter red brick conduit at a temperature of 27°C. Take emissivity $\in$ (steel pipe) = 0.79 and $\in$ (brick conduit) = 0.93. **(06 Marks)**

Module-4

7 a. With a neat diagram, explain the Boundary layer developed over the flat plate and define hydrodynamic, thermal boundary layer, and critical Reynolds number. **(10 Marks)**

b. Air at free stream properties Ta = 40°C, velocity = 8m/s approaches the rectangular plate, 3m length. The plate surface temperature is maintained at 100°C. Calculate local HTC at the end of the plate, average HTC for the entire length of the plate, take critical Reynold's number $R_{ec} = 2 \times 10^5$. The properties of air at mean fluid temperature can be noted as $\rho = 1.029 kg/m^3$, K = 0.02966W/m-K, Prandtl number P_r = 0.694 and kinematic viscosity $\delta = 20.02 \times 10^{-6} m^2/s$. **(10 Marks)**

OR

8 a. With the help of dimensional analysis obtain an co-relations for natural convection process. Explain the significance of any two π-terms related to above. **(10 Marks)**

b. A vertical pipe 5cm diameter carrying a hot water is exposed to ambient air at 15°C. If the outer surface of the pipe is 65°C find the heat loss from one metre height of pipe per hour. Take the properties of air as $\rho = 1.128 kg/m^3$, $\delta = 16.96 \times 10^{-6} m^2/s$, $\mu = 19.1 \times 10^{-6}$ N-s/m^2, K = 0.027 W/m-K, P_r = 0.710. **(10 Marks)**

Module-5

9 a. Classify the Heat Exchangers. Derive an expression for Log Mean Temperature Difference (LMTD) for counter flow heat exchanger. **(10 Marks)**

b. The following data refers to oil cooler of the form tubular heat exchanger. Where oil is cooled by a large pool of stagnant water. The temperature of stagnant water is 20°C. Inlet and outlet temperature of oil are 80°C and 30°C. The inner diameter and the length of the tube are 20mm and 3m respectively. Specific heat and specific gravity of oil 2.5kJ/kg-K and 0.85. The average velocity of oil is 0.55m/s. Calculate the overall HTC based on inside surface area of the tube. **(10 Marks)**

OR

10 a. Explain with a neat sketch the Regimes of Pool Boiling process. **(10 Marks)**

b. One Hundred tubes of 12mm in diameter are arranged in a square array and are exposed to steam at atmospheric pressure. Calculate the mass of steam condensed per unit length of tube if the tube wall temperature is maintained at 98°C. Take the properties of water film at mean temperature. $\rho = 960 kg/m^3$, $\mu = 282 \times 10^{-6}$ N-s/m^2, K = 0.61 W/m-K. h_{fg} (Latent heat) = 2255kJ/kg. **(10 Marks)**

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