Registration No.: | | | | | | | | | | |

Total Number of Pages: 02

Course: IDD (B.Tech & M.Tech)
Sub_Code: RME5C003

5th Semester Regular/Back Examination: 2024-25
SUBJECT: Heat Transfer
BRANCH(S): MMEAM, MECH, ME
Time: 3 Hours
Max Marks: 100
Q.Code: R176

Answer Question No.1 (Part-1) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right-hand margin indicate marks.

Part-I

Q1 **Answer the following questions:** **(2 x 10)**

a) What are the basic laws used in deriving the heat conduction equation?
b) Write the vectorial form of Fourier's law of heat conduction equation.
c) For solving two-dimensional unsteady state heat conduction in a solid, how many initial and boundary conditions are required?
d) What is a fin or an extended surface? Where are they used?
e) Define fin efficiency and fin effectiveness.
f) What do you mean by velocity and thermal boundary layers on a flat plate?
g) Define Nusselt number and explain its physical significance.
h) Define Grashof number and explain its physical significance.
i) State Wien's displacement law.
j) Define Log Mean Temperature Difference for heat exchangers.

Part-II

Q2 **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) Derive the general heat conduction equation in Cartesian coordinates.
b) A plastic panel of area A = 0.09 m^2 and thickness L = 0.84 cm is found to conduct heat at the rate of 5 W at steady state with a temperature of 26° C on the left surface and a temperature of 24° C on the right surface. What is the thermal conductivity of the plastic at 25° C?
c) A steel pipe (k = 45.0 W/m. K) having a 5 cm outer diameter is covered with a 4.2 cm thick layer of magnesia (k = 0.07 W/m. K) which is in turn covered with a 2.4 cm layer of fiberglass insulation (k = 0.048 W/m. K). The pipe wall outside temperature is 370 K and the outside surface temperature of the fiberglass is 305 K. What is the interfacial temperature between the magnesia and the fiberglass?
d) Find the relation for the rate of heat flow through a single-layered plane wall composed of a material whose thermal conductivity varies as $k = k_o(1 + bT + cT^2)$.
e) Two long rods of the same diameter, one made of brass (k = 85 W/m.K) and the other made of copper (k = 375 W/m.K) have one of their ends inserted into a furnace. Both the rods are exposed to same environment. At a distance of 105 mm away from the furnace, the temperature of brass rod is 120°C. At what distance from the furnace, the same temperature would be reached in the copper rod?

f) A thin fin of length L has its two ends attached to two parallel walls which have temperatures T_1 and T_2. The fin loses heat by convection to the ambient air at T_∞. Obtain an analytical expression for the one-dimensional temperature distribution along the length of the fin.

g) It is better to use 10 fins of 5 cm length than 5 fins of 10 cm length. State and prove corrections of the statement. Take properties as follows:
Diameter of fin = 15 mm.
Thermal conductivity = 45 W/m K
Heat Transfer coefficient = 95 W/m^2 K

h) A vertical plate 0.5 m high and 1 m wide is maintained at uniform temperature of 124°C. It is exposed to ambient air at 30°C. Calculate the heat transfer rate from the plate. Take properties of air:

$\nu = 2.076 \times 10^{-5} \frac{m^2}{s}$, Pr=0.697, $k_{air} = 0.03 \ W/mK$

i) Air at 350 K and standard atmospheric pressure ($\nu = 2.076 \times 10^{-5} \ m^2/s$) flows along a smooth flat plate at 12 m/s. For laminar flow, at what length from the leading edge does the boundary layer thickness reach 0.5 cm?

j) Calculate the view factor between two opposite sides of a hollow cube, if view factor between two adjacent sides of it is 0.2.

k) Hot oil is used to heat water, flowing at the rate of 0.1 kg/s, from 40° C to 80° C in a counterflow double-pipe heat exchanger. For an overall heat transfer coefficient of 300 W/m^2. K, find the heat transfer area if the oil enters at 105°C and leaves at 70°C.

l) Derive an expression for log mean temperature difference of parallel flow heat exchanger. How this expression can be modified for counter flow heat exchanger.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 A furnace wall has the inside surface temperature of 1100° C, while the ambient air temperature is 25° C. The wall consists of 125 mm thick refractory bricks (k = 1.6 W/m K), 125 mm thick firebricks (k = 0.3 W/m K) and 12 mm thick plaster (k = 0.14 EW/m K). There is an air gap between refractory bricks and fire bricks which offers a thermal resistance of 0.16 K/W. The heat transfer coefficient on the outside wall to the air is 17 W/m^2 K. Determine (a) the rate of heat loss per unit area of wall surface, (b) the interface temperatures throughout the wall, and (c) the temperature of the outside surface of the wall. **(16)**

Q4 Derive expression for temperature distribution in a straight fin of rectangular profile for insulated tip. **(16)**

Q5 Assuming linear velocity and temperature profiles, carry out the integral analysis of the thermal boundary layer on an isothermal flat plate for Pr $\geq$ 1 and obtain an expression for the local Nusselt number as a function of Reynolds number and Prandtl number. For linear velocity profile: **(16)**

$(\delta/x) * (Re_x)^{1/2} = 3.46$

Q6 Derive expression for parallel flow and counter flow heat exchangers. **(16)**