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

Total Number of Pages: 02

Course: B.Tech/IDD
Sub_Code: MEPC3002

5th Semester Regular Examination: 2025-26
SUBJECT: Heat Transfer
BRANCH(S): MECH, ME
Time: 3 Hours
Max Marks: 100
Q.Code: U207

Answer Question No.1 (Part-I) 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) Define thermal diffusivity. Mention its physical significance.
b) Define the convective heat transfer coefficient. Mention the parameters it depends on.
c) What is thermal conductivity? Does it depend on temperature?
d) State the governing differential equation for a straight fin without heat generation.
e) Define Biot number. Highlight its physical significance.
f) In a liquid-to-gas heat exchanger, fins are usually placed on the gas side. Why?
g) Define any one non-dimensional number used for free convection.
h) What is emissive power? How is it different from emissivity?
i) Define radiosity and irradiation.
j) Differentiate between pool boiling and forced boiling.

Part-II

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

a) Discuss the concept of thermal resistance for conduction, convection, and radiation using electrical analogy.
b) Explain how combined convection and radiation heat transfer from a surface is evaluated.
c) What is the critical radius of insulation? Why does critical insulation radius apply mainly to cylinders and spheres?
d) Define fin efficiency and fin effectiveness. Establish the relation between them.
e) Discuss lumped heat capacity analysis and derive the transient temperature expression.
f) Define the non-dimensional numbers: Reynolds number, Prandtl number and Nusselt number. Mention the significance of each in fluid flow and heat transfer analysis.
g) Consider a person standing in a breezy room at 20^0C. Determine the total rate of heat transfer from this person if the exposed surface area and the average outer surface temperature of the person are 1.6 m^2 and 30^0C respectively, and the convective heat transfer coefficient is 6 W/m^2 ^{0}C. Consider the emissivity of the person to be 0.95.

h) Discuss the importance of boundary conditions and initial conditions in estimating heat transfer through fins. Mention the boundary conditions for fin with insulate tip.

i) A radiation shield (ε = 0.1) is placed between two plates (ε = 0.6). Determine the factor by which heat transfer is reduced.

j) Explain Wien's displacement law.

k) With a neat figure, explain the pool boiling curve, its different regimes.

l) Discuss the meaning of heat exchanger effectiveness and derive its relation with NTU.

Part-III

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

Q3 **a)** Derive the general heat conduction equation in Cartesian coordinates from the energy balance. **(8)**

b) The insulation boards for air conditioning purpose comprises three layers. A 12cm thick layer of grass (K = 0.022 w/m k) is sandwiched between 3cm thick layer of plywood (K = 0.15 w/m k) on each side. The bonding is achieved with glue which does not offer any resistance to heat flow. If the side surfaces of the boards are maintained at 40^0C and 20^0C temperature, determine heat flux. How would the heat flux be affected if instead of glue the three piece are fastened by four steel bolts (K= 40 W/ m k) of 1.2 cm diameter at the corners? **(8)**

Q4 **a)** Derive the temperature distribution and heat transfer for a fin of infinite length. **(8)**

b) A small electric heating application uses wire of 2 mm diameter with 0.8 mm thick insulation with k = 0.12 w/m ^{0}C. The heat transfer coefficient on the insulated surface is 35^0C. Determine the critical thickness of insulation in this case and the percentage change in the heat transfer rate, if the critical thickness is used. Assume that temperature difference between the surface of wire and surrounding air remains unchanged. **(8)**

Q5 **a)** A person is found dead at 7 PM in a room where the ambient temperature is 15^0C. The temperature of the body is measured to be 25 ^{0}C when found. The heat transfer coefficient is estimated to be 8 W/m^2 ^{0}C. Modelling the body as a cylinder of diameter 30 cm and a length of 1.75 m long, estimate the time of death of that person. Consider K = 0.62 W/m ^{0}C, ρ = 996 kg/m^3, and C_p = 4180 J/kg ^{0}C. **(8)**

b) A horizontal flat plate (50 cm × 30 cm) is maintained at 100^0C. Air velocity is 5 m/s and temperature is 25^0C. Calculate the heat transfer from the plate if 50 cm side is parallel to flow of air. What will be the effect if 30 cm side is parallel to flow of air? Consider: K = 0.02 W/m ^{0}C, Pr = 0.7, and v (kinematic viscosity) = 20 × 10^{-6} m^2/s. **(8)**

Use correlation:

$$Nu = 0.664 (\mathrm{Re})^{1/2} (\mathrm{Pr})^{1/3}$$

Q6 **a)** Explain the characteristics and spectral behavior of black body, gray body and real body. **(8)**

b) Hot oil enters a counter-flow heat exchanger at 180°C and leaves at 120°C. Cold water enters at 25°C and leaves at 75°C. Mass flow rate of oil = 1.2 kg/s, Cp_oil = 2200 J/kg·K. Estimate: (i) Heat transfer rate. (ii) Heat-transfer area if U = 350 W/m²·K. **(8)**