

R13

Code No: 126EF

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year II Semester Examinations, July - 2023

HEAT TRANSFER
(Mechanical Engineering)

Time: 3 hours

Max. Marks: 75

- Note:** i) Question paper consists of Part A, Part B.
ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.
iii) In Part B, Answer any one question from each unit. Each question carries 10 marks and may have a, b as sub questions.

PART - A

(25 Marks)

- 1.a) What are the modes and mechanisms of the heat transfer? [2]
- b) Explain types of boundary conditions in detail. [3]
- c) Write short notes on efficiency and effectiveness of the fin. [2]
- d) What is critical radius of insulation? Discuss its significance. [3]
- e) What is dimensional analysis? What are the uses of dimensional analysis? [2]
- f) Discuss the physical significance of dimensionless numbers Nu, St, Gr. [3]
- g) What is radiation? Explain stefan's boltzman law. [2]
- h) Explain black body, white body, gray body and opaque body. [3]
- i) List out the applications of heat exchangers. [2]
- j) What is the LMTD correction factor? [3]

PART - B

(50 Marks)

2. Derive the general heat conduction equation in Spherical coordinate system. [10]

OR

- 3.a) Calculate the rate of heat transfer per unit area through a copper plate 45 mm thick, whose one surface is maintained at 350°C and the other face at 50°C. Take thermal conductivity of copper as 370 W/m°C.
- b) State and explain Fourier's law of conduction and also write its assumptions and features. [5+5]

- 4.a) In a quenching process, a copper plate of 3 mm thick is heated up to 350°C and then suddenly it is dipped a water bath and cooled to 25°C. Calculate the time required for the plate to reach the temperature of 500°C. The heat transfer coefficient on the surface of the plate is 28 W/m²K. The plate dimensions may be taken as length 40 cm and width 30 cm. Take properties of copper as $c = 380 \text{ J/kg K}$, $\rho = 8800 \text{ kg/m}^3$, $k = 385 \text{ W/m}^\circ\text{K}$.

- b) An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k 0.7 W/m°C) followed by a 0.04 m layer of gypsum plaster (k 0.48 W/m°C). What thickness of loosely packed rock wool insulation (k 0.065 W/m°C) should be added to reduce the heat loss or (gain) through the wall by 80 percent? [5+5]

OR

5.a) One end of a very long metal rod is connected to a wall at 150°C while the other end protrudes into a room whose air temperature is 20°C . The rod is 3mm in diameter and the heat transfer coefficient is $280\text{ W/m}^2\text{K}$. Estimate the total heat dissipated by the rod taking its thermal conductivity as 200 W/mK .

b) A wire of 6.5mm diameter at a temperature of 60°C is to be insulated by a material having $k=0.174\text{ W/m}^{\circ}\text{C}$. Convective heat transfer coefficient is $8.722\text{ W/m}^2\text{ }^{\circ}\text{C}$. The ambient temperature is 20°C . For maximum heat loss, what is the minimum thickness of insulation and heat loss per metre length? Also find percentage increase in the heat dissipation too. [5+5]

6.a) A square plate $0.2\text{ m} \times 0.2\text{ m}$ is suspended vertically in a quiescent atmospheric air at a temperature of 300K . The temperature of the plate is maintained at 400K . Determine the average heat transfer coefficient over the entire length of the plate.

b) Explain the concept of hydro dynamic entry length and thermal entry length of fully developed internal forced convection with a neat diagram. [5+5]

OR

7.a) Show by dimensional analysis for free convection, $\text{Nu} = f(\text{Pr}, \text{Gr})$.

b) Atmosphere air at 300°C flows over a flat plate of $(3 \times 1)\text{ m}^2$ maintained at 700°C with a velocity of 10 m/s . Calculate the distance from the leading edge at which transition occurs. Find the thickness of the hydrodynamic boundary layer and thermal boundary layer at 0.5 m from the edge. [5+5]

8.a) Explain the terms absorptivity, reflectivity and transmittivity.

b) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C

i) Monochromatic emissive power at $1.2\text{ }\mu\text{m}$ length,

ii) Wavelength at which the emission is maximum,

iii) Maximum emissive power,

iv) Total emissive power, and

v) Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.9. [3+7]

OR

9.a) Explain briefly the various regimes of saturated pool boiling curve of water.

b) Saturated steam at atmospheric pressure condenses on a vertical tube of diameter 5 cm and length 1.5 m, surface of the tube is maintained at 80°C . Determine the heat transfer rate. [5+5]

10.a) A double pipe parallel flow heat exchanger is employed in a food processing unit to heat the brine solution from -6.5°C to 12°C by means of water flowing at the rate of 540 kg/h . The water enters at 35°C and leaves at 20.5°C . If the overall heat transfer coefficient is $860\text{ W/m}^2\text{K}$, calculate the heat transfer area.

b) Define Effectiveness of heat exchanger, Heat capacity ratio, and Number of heat transfer units (NTU). [6+4]

OR

11.a) Derive an expression for LMTD in case of a parallel flow heat exchanger.

b) Give a comparison of parallel-flow and counter flow heat exchangers. Why are counter flow heat exchangers mostly used? [6+4]