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Subject Code:- **AME0501**

Roll. No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech

SEM: V - THEORY EXAMINATION (2023 - 2024)

Subject: Heat and Mass Transfer

Time: 3 Hours **Max. Marks: 100**

General Instructions:

IMP: *Verify that you have received the question paper with the correct course, code, branch etc.*

1. *This Question paper comprises of* ***three Sections -A, B, & C.*** *It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.*

2. *Maximum marks for each question are indicated on right -hand side of each question.*

3. *Illustrate your answers with neat sketches wherever necessary.*

4. *Assume suitable data if necessary.*

5. *Preferably, write the answers in sequential order.*

6. *No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.*

SECTION-A 20

1. Attempt all parts:-

1-a. A plane wall is 25 cm thick with an area of 1 m^2, and has a thermal conductivity of 0.5 W/mK. If a temperature difference of 60°C is imposed across it, what is the heat flow? (CO1) 1

(a) 120W

(b) 140W

(c) 160W

(d) 180W

1-b. Which one of the following expresses the thermal diffusivity of a substance in terms of thermal conductivity (k), mass density (ρ) and specific heat (c)? (CO1) 1

(a) k2ρc

(b) 1/ρkc

(c) k/ρc

(d) ρc

1-c. From a metallic wall at 100°C, a metallic rod protrudes to the ambient air. The temperatures at the tip will be minimum when the rod is made of: (CO2) 1

(a) Aluminium

(b) Steel

(c) Copper

(d) Silver

1-d. Which one of the following is correct? The effectiveness of a fin will be maximum in an environment with (CO2) 1

(a) Free convection
(b) Forced convection
(c) Radiation
(d) Convection and radiation

1-e. If velocity of water inside a smooth tube is doubled, then turbulent flow heat transfer coefficient between the water and the tube will: (CO3) 1

(a) Remain unchanged
(b) Increase to double its value
(c) Increase but will not reach double its value
(d) Increase to more than double its value

1-f. Which one of the following numbers represents the ratio of kinematic viscosity to the thermal diffusivity? (CO3) 1

(a) Grashoff number
(b) Prandtl number
(c) Mach number
(d) Nusselt number

1-g. In radiative heat transfer, a gray surface is one (CO4) 1

(a) Which appears gray to the eye
(b) Whose emissivity is independent of wavelength
(c) Which has reflectivity equal to zero
(d) Which appears equally bright from all directions.

1-h. Fraction of radiative energy leaving one surface that strikes the other surface is called (CO4) 1

(a) Radiative flux
(b) Emissive power of the first surface
(c) View factor
(d) Re-radiation flux

1-i. Drop wise condensation usually occurs on (CO5) 1

(a) Glazed surface
(b) Smooth surface
(c) Oily surface
(d) Coated surface

1-j. In spite of large heat transfer coefficients in boiling liquids, fins are used advantageously when the entire surface is exposed to: (CO5) 1

(a) Nucleate boiling
(b) Film boiling

(c) Transition boiling

(d) All modes of boiling

2. Attempt all parts:-

2.a.	How does the heat transfer differ from the thermodynamics? (CO1)	2
2.b.	Define efficiency of the fin. (CO2)	2
2.c.	What is Convective heat transfer? (CO3)	2
2.d.	What is stefan boltzmann law? (CO4)	2
2.e.	Sketch temperature distribution graph for condensers & evaporators. (CO5)	2

SECTION-B 30

3. Answer any five of the following:-

3-a.	The walls of a house, 4 m high, 5 m wide and 0.3 m thick are made from brick with thermal conductivity of 0.9 W/m.K. The temperature of air inside the house is 20°C and outside air is at –10°C. There is a heat transfer coefficient of 10 $W/m^2.K$ on the inside wall and 30 $W/m^2.K$ on the outside wall. Calculate the inside and outside wall temperatures, heat flux and total heat transfer rate through the wall. [CO1]	6
3-b.	Simplify the three dimensional heat conduction equation in Cartesian coordinates to obtain one dimensional steady state heat conduction with heat generation and constant thermal conductivity.[CO1]	6
3-c.	A long brass rod (k = 104 W/mK), 25 mm in diameter is heated by inserting its one end into a furnace, while remaining portion is projected into an ambient at 25°C. During steady state, the measurements of temperature at two points 10 cm apart reveal 155°C and 101°C respectively. Calculate the effective heat transfer coefficient. (CO2)	6
3-d.	Derive the heat dissipation equation through pin fin with insulated end.[CO2]	6
3.e.	Discuss the concept of thermal boundary layer in case of flow over the flat plate. How it differs from Hydrodynamic boundary layer? (CO3)	6
3.f.	A thermocouple is used to measure the temperature of a hot gas flowing in a tube maintained at 100°C. The thermocouple indicates a temperature of 500°C. If the emissivity of thermocouple junction is 0.5 and the convective heat transfer coefficient is 250 $W/m^2.K$, determine the actual temperature of the gas.(CO4)	6
3.g.	What are the limitations of LMTD method? How is ε-NTU method superior to LMTD method? (CO5)	6

SECTION-C 50

4. Answer any one of the following:-

4-a.	Derive general heat conduction equation in cylindrical coordinates and mention the assumptions for this derivation. (CO1)	10
4-b.	A hollow steel sphere (k = 10 W/m.K) has an inside radius of 10 cm and outside radius of 20 cm. The inside surface is maintained at a uniform temperature of 230°C, while its outside surface dissipates heat by convection with h = 20	10

$W/m^2.K$, into an ambient air at 30°C. Calculate the thickness of asbestos insulation (k=0.5 W/m.K) required to reduce the heat loss by 50%. [CO1]

5. Answer any <u>one</u> of the following:-

5-a. Derive the heat transfer equation of infinitely long fin. (CO2) 10

5-b. The handle of a saucepan, 30 cm long and 2 cm in diameter is partially immersed in boiling water at 100°C. The average unit conductance over the handle surface is 7.35 $W/m^2.K$ in the kitchen air at 24°C. The cook is likely to grasp the last 10 cm of the handle and hence, the temperature of this portion should not exceed 32°C. What should be the material conductivity of handle ? The handle may be treated as a fin of insulated tip. (CO2) 10

6. Answer any <u>one</u> of the following:-

6-a. Explain Reynolds Colburn analogy for turbulent flow over a flat plate. (CO3) 10

6-b. Atmospheric air at 400 K flows with a velocity of 4 m/s along a flat plate, 1 m long, maintained at an uniform temperature of 300 K. The average heat transfer coefficient is estimated to be 7.75 $W/m^2.K$. Using Reynolds Colburn analogy, calculate the drag force exerted on the plate per metre width. (CO3) 10

7. Answer any <u>one</u> of the following:-

7-a. Derive the expression for net radiation heat exchange between two parallel infinite planes. (CO4) 10

7-b. Two parallel, infinite gray surfaces are maintained at temperature of 127°C and 227°C respectively. If the temperature of the hot surface is increased to 327°C. By what factor is the net radiation exchange per unit area increased? Assume the emissivities of colder and hotter surfaces to be 0.9 and 0.7, respectively. (CO4) 10

8. Answer any <u>one</u> of the following:-

8-a. Derive an expression for effectiveness in terms of NTU and capacity rate ratio (C) for parallel flow. (CO5) 10

8-b. A heat exchanger is required to cool 55,000 kg/h of alcohol from 66°C to 40°C using 40,000 kg/h of water entering at 5°C. Calculate (i) exit temperature of water, (ii) heat transfer rate, (iii) surface area required for (a) parallel flow type, (b) counter flow type of heat exchanger. Take overall heat transfer coefficient U = 580 $W/m^2.K$ Cp (alcohol) = 3760 J/kg.K Cp (water) = 4180 J/kg.K. (CO5) 10