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NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA

(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech.

SEM: V - THEORY EXAMINATION (2022 - 2023)

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. Thermal diffusivity of a substance is (CO1) 1

(a) Inversely proportional to thermal conductivity

(b) Directly proportional to thermal conductivity

(c) Directly proportional to the square of thermal conductivity

(d) Inversely proportional to the square of thermal conductivity

1-b. Upto the critical radius of insulation (CO1) 1

(a) Convection heat loss will be less than conduction heat loss

(b) Heat flux will decrease

(c) Added insulation will increase heat loss

(d) Added insulation will decrease heat loss

1-c. 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-d. The value of Biot number is very small (less than 0.01) when (CO2) 1

(a) The convective resistance of the fluid is negligible

(b) The conductive resistance of the fluid is negligible

(c) The conductive resistance of the solid is negligible

(d) None of these

1-e. For calculation of heat transfer by natural convection from a horizontal cylinder, what is the characteristic length in Grashof Number? (CO3) 1

(a) Diameter of the cylinder

(b) Length of the cylinder

(c) Circumference of the base of the cylinder

(d) Half the circumference of the base of the cylinder

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. 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-h. A radiation shield should (CO4) 1

(a) Have high transmissivity

(b) Absorb all the radiations

(c) Have high reflective power

(d) Partly absorb and partly transmit the incident radiation

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 condensers/boilers, heat capacity ratio is (CO5) 1

(a) Infinity

(b) Zero

(c) 1

(d) None

2. Attempt all parts:-

2.a. Explain about contact resistance. (CO1) 2

2.b. What is meant by transient heat conduction? (CO2) 2

2.c. State Newton's law of cooling. (CO3) 2

2.d. What benefits can be derived from a radiation shield and a reradiating surface? (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. A hot plate is exposed to an environment at 100°C. The temperature profile of the environment fluid is given as $T(°C) = 60 + 40\ y + 0.1\ y^2$. The thermal conductivity of the plate material is 40 W/m°C. Calculate the heat transfer coefficient. (CO1) 6

3-b. The wall of a furnace is constructed from 15 cm thick fire brick having constant thermal conductivity of 1.6 W/mK. The two sides of the wall are maintained at 1400 K and 1100 K, respectively. What is the rate of heat loss through the wall which is 50 cm × 3 m on a side? (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. What is lumped system analysis? What are the assumptions made in the lumped system analysis and when is it applicable? (CO2) 6

3.e. Air at 20°C and 1 atm, flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 60°C. Assuming unit depth in the z direction, calculate the heat transfer from the plate. Properties of the fluid are given as: $\rho = 1.128$ kg/m^3, $\mu = 1.906 \times 10^{-5}$ kg/m.s, Pr = 0.7, k = 0.02723 W/m·°C, c_p = 1.007 kJ/kg·°C. 6

$N_{uL} = Pr^{1/3}(0.037\ R_{eL}^{0.8} - 871)$ (CO3)

3.f. Define absorptivity, reflectivity and transmissivity. (CO4) 6

3.g. Discuss modes of condensation. What are the practical difficulties in retaining dropwise condensation on a surface? (CO5) 6

SECTION C 50

4. Answer any one of the following:-

4-a. Derive general heat conduction equation in Cartesian coordinates and mention the assumptions for this derivation. (CO1) 10

4-b. A furnace wall is made of three layers. First layer is of insulation (k = 0.6W/mK), 12 cm thick. Its face is exposed to gases at 870°C with convection coefficient of 110 W/m^2.K. It is covered with (backed with), a 10 cm thick layer of fire brick (k = 0.8 W/mK) with a contact resistance of 2.6×10^{-4} m^2.K/W between first and second layer. The third layer is a plate of 10 cm thickness (k = 4 W/mK) with a contact resistance between second and third layer of 1.5×10^{-4} m^2.K/W. The plate is exposed to air at 30°C with convection coefficient of 15 W/m^2.K. Determine the heat flow rate and overall heat transfer coefficient. (CO1) 10

5. Answer any one of the following:-

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

5-b. A high speed steel sphere of 15 mm in diameter initially at 680°C is exposed to a current of air at 30°C with convection coefficient of 140 W/m^2.K. Calculate : (i) Time required to cool the sphere to 100°C. Take properties of mild steel as : k = 43 W/m.K, $\rho = 7850$ kg/m^3, C = 474 J/kg.K, $\alpha = 0.045$ m^2/s. (CO2) 10

6. Answer any one of the following:-

6-a. 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

6-b. Derive the relation between local and average value of heat transfer coefficient? (CO3) 10

7. Answer any one 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 10

surfaces to be 0.9 and 0.7, respectively. (CO4)

8. Answer any one of the following:-

8-a.	Derive an expression for log mean temperature difference of parallel flow heat exchanger. (CO5)	10
8-b.	Explain pool boiling in detail with the help of boiling curve. (CO5)	10