Name:

Enrolment No:

UPES

End Semester Examination, May 2024

Program Name: B. Tech-Food Tech. and Bio-Medical Engineering **Semester : IV**

Course Name : Heat and Mass Transfer **Time : 03 hrs.**

Course Code : MECH2037 **Max. Marks: 100**

Nos. of page(s) : 02

Instructions: Attempt All Questions. One question from section B and C have an internal choice. Assume any missing data if required and mention it clearly.

SECTION A
(5Qx4M=20Marks)

S. No.	Statement of question	Marks	CO
Q1	Distinguish between natural and forced convection by taking suitable examples.	**4**	**CO1**
Q2	Explain the Fourier's Law of heat conduction.	**4**	**CO1**
Q3	Discuss Fick's law for mass transfer.	**4**	**CO2**
Q4	Explain the factors influencing the rate of absorption and absorption. Illustrate your answer with relevant examples from industrial processes.	**4**	**CO3**
Q5	What is Molecular Diffusivity? How it is important in determining the rate of mass transfer.	**4**	**CO4**

SECTION B
(4Qx10M= 40 Marks)

Q6	A composite cylinder is made of 6 mm thick layers each of two materials of thermal conductivities of 30 W/m°C and 45 W/m°C. The inside is exposed to a fluid at 500°C with a convection coefficient of 40 W/m^2 °C and the outside is exposed to air at 35°C with a convection coefficient of 25 W/m^{2}K. Determine the heat loss for a length of 2 m and the surface temperatures. Inside diameter is 20 mm.	**10**	**CO2**
Q7	Explain the mechanism of film condensation heat transfer on vertical surface.	**10**	**CO3**
Q8	Consider the flow of oil at 20°C in a 30-cm-diameter pipeline at an average velocity of 10 m/s. A 200-m-long section of the pipeline passes through icy waters of a lake at 0°C. Measurements indicate that the surface temperature of the pipe is very nearly 0°C. Disregarding the thermal resistance of the pipe material, determine (a) the temperature of the oil when the pipe leaves the lake, (b) the rate of heat transfer from the oil, and (c) the pumping power required to overcome the pressure losses and to maintain the flow of the oil in the pipe. (Take following properties:	**10**	**CO3**

<table>
<tr><td></td><td>density=888 kg/m^3, viscosity= 901*10^{-6} m^2/s, k=0.145 W/m^0C, specific heat= 1880 J/Kg^0C, Pr=10400.</td><td></td><td></td></tr>
<tr><td>Q9</td><td>Deduce mathematical formulation for three-dimensional heat conduction equation with internal heat generation in cylindrical coordinates.
OR
Deduce mathematical formulation for three-dimensional heat conduction equation with internal heat generation in spherical coordinates.</td><td>10</td><td>CO4</td></tr>
<tr><td colspan="4">SECTION-C
(2Qx20M=40 Marks)</td></tr>
<tr><td>Q10</td><td>Hot water at an average temperature of 90°C is flowing through a 15-m section of a cast iron pipe (k =52 W/m° C) whose inner and outer diameters are 4 cm and 4.6 cm, respectively. The outer surface of the pipe is exposed to the cold air at 10°C in the basement, with a heat transfer coefficient of 15 W/m^2°C. The heat transfer coefficient at the inner surface of the pipe is 120 W/m^2°C. Taking the walls of the basement to be at 10°C also, determine the rate of heat loss from the hot water. Also, determine the average velocity of the water in the pipe if the temperature of the water drops by 3°C as it passes through the basement.</td><td>20</td><td>CO3</td></tr>
<tr><td>Q11</td><td>An economizer in a boiler has flow of water inside the pipes and hot gases on the outside flowing across the pipes. The flow rate of gases is 2,000 tons/hr and the gases are cooled from 390°C to 200°C. The specific heat of the gas is 1005 J/kg K. Water is heated (under pressure) from 100°C to 220°C. Assuming an overall heat transfer coefficient of 35 W/m^2K, determine the area required. Assume that the air flow is mixed.
OR
Water flows at a velocity of 1 m/s through a pipe of 25 mm ID and 30 OD and 3 m length. Air at 30°C flows across the tube, with a velocity of 12 m/s. The inlet temperature of the water is 60°C. Determine the exit temperature. The thermal conductivity of the tube material is 47 W/m K.
<table>
<tr><th>Fluid</th><th>Density (kg/m^3)</th><th>Kinematic Viscosity (m^2/s)</th><th>Prandtl Number</th><th>Thermal Conductivity (W/m k)</th></tr>
<tr><td>Water</td><td>990</td><td>0.5675*10^{-6}</td><td>3.68</td><td>0.63965</td></tr>
<tr><td>Air</td><td>1.2</td><td>16.96*10^{-6}</td><td>0.699</td><td>0.02756</td></tr>
</table></td><td>20</td><td>CO4</td></tr>
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