Roll No. | | | | | | | | | | |

ANNA UNIVERSITY (UNIVERSITY DEPARTMENTS)

B.E. / B. Tech / B. Arch (Full Time) - END SEMESTER EXAMINATIONS, APRIL / MAY 2024

B.E. MECHANICAL ENGINEERING
Semester - VI
ME 5651 HEAT AND MASS TRANSFER
(Regulation 2019)

Time: 3hrs

Max. Marks: 100

CO 1	Understanding the steady and transient heat conduction.
CO 2	Comprehending the principles of convective heat transfer
CO 3	Outlining the facets of heat transfer for designing a heat exchanger
CO 4	Inferring the fundamental concepts of radiation heat transfer.
CO 5	Analyzing the relation between heat and mass transfer

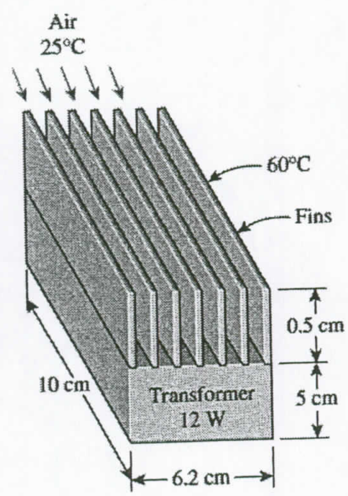
BL – Bloom's Taxonomy Levels
(L1 - Remembering, L2 - Understanding, L3 - Applying, L4 - Analysing, L5 - Evaluating, L6 - Creating)

PART- A (10 x 2 = 20 Marks)
(Answer all Questions)

Q. No	Questions	Marks	CO	BL
1	A 3 mm wire of thermal conductivity 19 W/mK at a steady heat generation of 500 MW/m^3. Determine the center temperature if the outside temperature is maintained at 25°C	2	1	L3
2	What is lumped system analysis? When is it applicable?	2	1	L1
3	State the relation between the thermal and velocity boundary layer.	2	2	L1
4	Define critical Reynolds number. What is its typical value for flow over a flat plate and flow through a pipe?	2	2	L2
5	What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop?	2	3	L2
6	What is the Leidenfrost effect of hot water and the science behind the Leidenfrost effect?	2	3	L2
7	Define: Radiosity and Irradiation.	2	4	L1
8	State Wien's displacement law.	2	4	L1
9	State Fick's law of diffusion. What are its limitations?	2	5	L1
10	What are the three types of mass transport?	2	5	L2

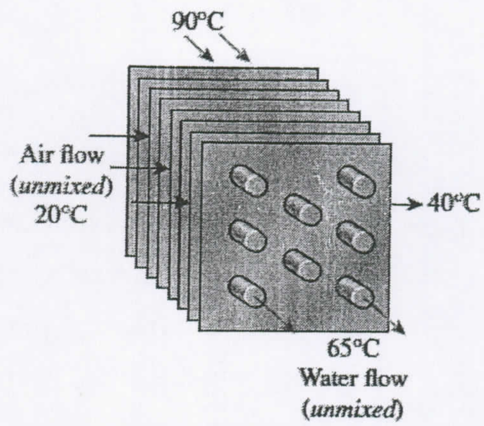
PART- B (5 x 13 = 65 Marks)

Q. No	Questions	Marks	CO	BL
11 (a)	Derive the Heat conduction equation in cylindrical coordinates.	13	1	L3
	OR			
11 (b)	A heater of 150 mm X 150 mm size and 800 W rating is placed between two slabs A and B. Slab A is 18 mm thick with k = 55 W/mK. Slab B is 10 mm thick with k = 0.2 W/mK. Convective heat transfer coefficients on outside surface of slab A and B are 200 W/m^2K and 45 W/m^2K respectively. If ambient temperature is 27^oC, calculate maximum temperature of the system and outside surface temperature of both slabs.	13	1	L4
12 (a)	A transformer that is 10 cm long, 6.2 cm wide, and 5 cm high is to be cooled by attaching a 10 cm x 6.2 cm wide polished aluminum heat sink (emissivity = 0.03) to its top surface. The heat sink has seven fins, which are 5 mm high, 2 mm thick, and 10 cm long. A fan blows air at 25^o C parallel to the passages between the fins. The heat sink is to dissipate 12 W of heat and the base temperature of the heat sink is not to exceed 60^o C. Assuming the fins and the base plate to be nearly isothermal and the radiation heat transfer to be negligible, determine the minimum free-stream velocity the fan needs to supply to avoid overheating. Assume the flow is laminar over the entire finned surface of the transformer.	13	2	L4



Q. No	Questions	Marks	CO	BL
	OR			
12 (b)	Nitrogen at a pressure of 0.1 atm flows over a flat plate with a free stream velocity of 8 m/s. The temperature of the gas is – 20°C. The plate temperature is 20°C.		2	L3
	(i) Determine the length for the flow to turn turbulent. Assume 5 × 105 as critical Reynolds number.	5		
	(ii) Determine the thickness of thermal and velocity boundary layers and the average convection coefficient for a plate length of 0.3 m. Properties are to be found at film temperature.	8		
13 (a) (i)	A test is conducted to determine the overall heat transfer	13	3	L4

coefficient in an automotive radiator that is a compact cross-flow water-to-air heat exchanger with both fluids (air and water) unmixed. The radiator has 40 tubes of internal diameter 0.5 cm and length 65 cm in a closely spaced plate-finned matrix. Hot water enters the tubes at 90° C at a rate of 0.6 kg/s and leaves at 65° C. Air flows across the radiator through the interfin spaces and is heated from 20° C to 40° C. Determine the overall heat transfer coefficient U_i of this radiator based on the inner surface area of the tubes.



OR

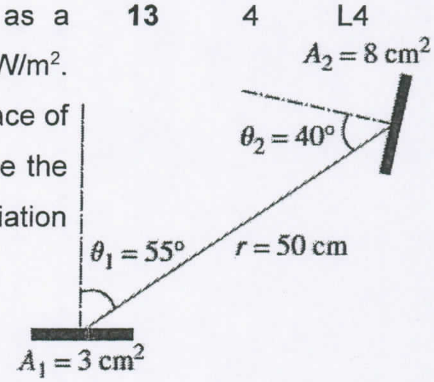
13 (b) Discuss briefly the pool boiling regimes of water at atmospheric pressure — **13** — 3 — L3

14 (a) The outlet header of a high-pressure steam superheater consists of a pipe (έ = 0.8) of diameter 27.5 cm. Its surface temperature is 500°C. Calculate the loss of heat per unit length by radiation if it is placed an enclosure at 30°C. — **6** — 4 — L3

If the header is now enveloped in a steel screen of diameter 32.5 cm and emissivity 0.7 and temperature of the screen is 240°C, find the reduction in heat by radiation due to the provision of this screen. — **7**

OR

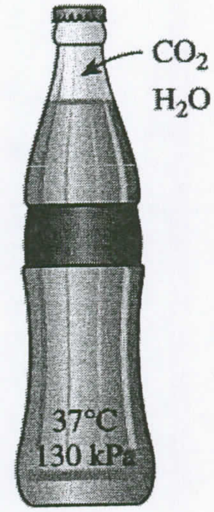
14 (b) A small surface of area A_1 = 3 cm^2 emits radiation as a blackbody with total emissive power of E_b = 5.67 3 10^4 W/m^2. Part of the radiation emitted by A_1 strikes another small surface of area A_2 = 8 cm^2 oriented as shown in the figure. Determine the rate at which radiation emitted by A_1 strikes A_2, and the irradiation on A_2. — **13** — 4 — L4



15 (a) Consider a carbonated drink in a bottle at 37°C and 130 kPa. Assuming the gas space above the liquid consists of a saturated mixture of CO_2 and water vapor and treating the drink as water, determine — 5 — L4

(i) the mole fraction of the water vapor in the CO_2 gas — **7**

(ii) the mass of dissolved CO_2 in a 200-ml drink. — **6**



OR

15 (b) The mole fraction of H_2 in a mixture of H_2 and O_2 is 0.4. If H_2 moves with a velocity of 1 m/s and O_2 is stationary. Find — 5 — L3

(i) mass and molar average velocities. — **6**

(ii) the mass and the molar fluxes across a surface which is (i) stationary (ii) moving with mass average velocity (iii) moving with molar average velocity. — **7**

PART- C (1 x 15 = 15 Marks)

(Q.No.16 is compulsory)

Q. No	Questions	Marks	CO	BL
16.	A steel rod (k = 30 W/m), 12 mm in diameter and 60 mm long, with an insulated end is to be used as spine. It is exposed to surrounding with a temperature of 60°C and heat transfer coefficient of 55 $W/m^2\,°C$. The temperature at the base is 100 °C. Determine :		2	L6
	(i) The fin effectiveness	4		
	(ii) The fin efficiency	4		
	(iii) The temperature at the edge of the spine	4		
	(iv) The heat dissipation.	3		