HEAT AND MASS TRANSFER

Department of Mechanical Engineering – SEAS

SRM UNIVERSITY A.P

Registration Number: _____

Name: _____

Branch & Section: _____

SRM UNIVERSITY AP
Andhra Pradesh

SRM UNIVERSITY – AP, ANDHRA PRADESH

End Term Examination, May 2025

[Question Paper ID: **009037]**

Subject Title	: HEAT AND MASS TRANSFER	**Subject Code**	: MCE 305
Batch	: 2022	**Max Marks**	: 75
Degree	: B.Tech.	**Duration**	: 3 hours
Branch	: ME	**QP Set**	: ---

Instructions:

Read the instructions provided for every question properly before attempting the answer.

Scientific calculators are permitted

Make suitable assumptions if required and necessary

	Part A: (5 x 06 = 30 Marks) Answer Any Five questions only (5 × 6 Marks = 30 Marks) Answer **any 5** Questions	**Marks**	**BL**	**CO**
1.	Explain the terms thermal diffusivity, thermal conductivity and its significance in conduction heat transfer mechanism?	**6**	**1**	**1,2**
2.	Consider an electrical copper wire of radius (r_1). This has to be insulated with foam of certain thickness (r_2). Derive the condition for maximum heat transfer from the copper wire ?	**6**	**2**	**1,2**
3.	Explain about fins and their applications with examples?	**6**	**2**	**1,4**
4.	Explain the concept of thermal boundary layer formed over a flat plate and define the convection heat transfer coefficient near the surface?	**6**	**2**	**2,3**
5.	Explain about classification of heat exchangers their applications and fouling phenomena in heat exchangers ?	**6**	**1**	**2,3**
6.	Explain about spectral distribution and directional distribution feature of radiation heat transfer ?	**6**	**2**	**1,2**
7.	Explain about film condensation over a surface ?	**6**	**1**	**2,4**
8.	State the Fick's Law of diffusion and explain the two common types of boundary conditions in mass transfer?	**6**	**1**	**1,2**

	PART B: (3 x 15 = 45 Marks): Answer Any Three questions only (3 × 15 Marks = 45 Marks) Answer **any 3** Questions	**Marks**	**BL**	**CO**
9.	Consider a solid body in earth's atmosphere undergoing energy exchange. Derive the 3D heat conduction equation for a heterogeneous, isotropic material in cartesian coordinate system with appropriate assumptions ?	**15**	**2**	**1,2**
10.	A thermocouple junction, which may be approximated as a sphere, is to be used for temperature measurement in a gas stream. The convection coefficient between the junction surface and the gas is h = 400 W/m^{2}K, and the junction thermo-physical properties are : k = 20 W/m K, C_p = 400 J/kg K, and ρ = 8500 kg/m^3 Determine the junction diameter needed for the thermocouple to have a time constant of 1second. If the junction is at 25°C and is placed in a gas stream that is at 200°C, how long will it take for the junction to reach 199°C? You may use the following relations:	**15**	**2**	**1,2**

$Time\ constant: \tau_t = \frac{\rho V C_p}{h\, A_s}$

$where\ V - Volume;\ \rho - Density;\ A_s - surface\ area;$

$h - convective\ heat\ transfer\ coefficient$

$Bi = \frac{hL_c}{k}\ where\ L_c - Characteristic\ length;\ k - Thermal\ conductivity$

Temperature distribution: $\frac{T(t) - T_\infty}{T_i - T_\infty} = e^{\left[-t\left(\frac{hA_s}{\rho V C_p}\right)\right]}$

		15	**15**	**3**	**3,4**

11. Draw a schematic of fluid flow over a flat plate which needs to be analysed using Order of magnitude analysis. Consider 2D steady state flow with negligible body forces situation over the flat plate and obtain the significant terms in Continuity and Momentum equations?
You may use the governing equations provided below:

15	**15**	**3**	**2,3**

Continuity equation: $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

Momentum equation: X-direction

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\mu}{\rho}\left[\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right]$$

Momentum equation: Y-direction

$$u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\mu}{\rho}\left[\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right]$$

12. A hot pipe carrying high energy fluid passes through a room with air at 20°C. The pipe is 6m long 80mm diameter and its surface is at 90°C. Determine the rate of heat loss by natural convection only?
You may use the relations & fluid property data as follows:
Fluid properties given are at mean film temperature

15	**15**	**3**	**3,4**

Kinematic viscosity: $\vartheta = 1.8437 \times 10^{-5}\ \frac{m^2}{s}$

Thermal conductivity: : $k = 0.28169\ \frac{W}{mK}$

Prandtl number: : $Pr = 0.70982$

Rayleigh number: $Ra = \frac{g\,\beta\,(T_s - T_\infty)\,L_c^3}{\vartheta^2}$

Nusselt number: $Nu = \left\{0.6 + \frac{0.387}{\left[1+(0.559/Pr)^{9/16}\right]^{8/27}}\right\}^2$

15	**15**	**2**	**2,3**

13. Derive the expression for LMTD (Logarithmic Mean Temperature Difference) for a parallel flow heat exchanger?

15	**15**	**1**	**3,4**

14. Draw the Nukiyama pool boiling curve for water at a pressure of 1 bar.
Explain the following regimes only:
i) Nucleate boiling
ii) Transition boiling
iii) Film boiling ?

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