Ref. No. **Ex/PG/ME/T/116H/2025**

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2025

Subject: Heat and Mass Transfer

Time: **3** hours

Full Marks: **100**

50 Marks for each Part

Use separate Answer Script for each Part

Part – I

Answer any two questions

1.	A cylindrical heat exchanger wall is an anisotropic material. Derive the general governing energy equation from the basic principle for conducting heat in this wall for the uniform velocity of the heat exchanger based on Fourier's law. How is the temperature response to find out?	25
2.	Overheating of an SI engine is possible to avoid by attaching a longitudinal rectangular fin, which can enhance the heat transfer from the engine to the surrounding medium due to convection and radiation. The engine's outer surface maintains a constant temperature. Heat flow in the fin only occurs in the length direction, and the convective heat transfer coefficient on the fin surfaces is assumed to be a constant. By choosing an appropriate coordinate from the tip, derive the above fin's equation for a constant thermal conductivity of fin material. Determine the fin's temperature distribution and heat transfer rate for the insulated tip, no heat generation, and steady-state circumstances. The above derivation can be done using a linearization of radiation energy transfer.	25
3. (a)	When is the radiation mode of heat exchange not neglected in heat transfer problems?	3
(b)	What are the fundamental laws associated with calculating radiation heat transfer?	3

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(c)	Explain mathematically that heat exchange due to radiation in a three-zone enclosure makes it difficult to choose the concept of electrical analogy.	12
(d)	What are the scale factors for expressing any differential equation in a general form?	3
(e)	Why is fin efficiency essential to know when enhancing heat transfer?	4

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Heat and Mass Transfer

(Part-2)

Marks of this part: 50

Answer this part in a separate answer script.

Answer any two questions.

1. Derive the energy equation in the following form:
$\rho \frac{De}{Dt} = -\hat{\nabla}.\hat{q} - p\ \hat{\nabla}.\hat{V} + \mu\phi + q'''$. Explain each terms. (25)

2. a) Derive the equations (continuity, momentum and energy equations) for boundary layer type flow over a flat plate. Show that longitudinal diffusion equations can be neglected and a single momentum equation is sufficient to solve the problem. (13)
b) Explain with neat sketch the developing and fully developed flow through a pipe. Develop a scale for hydrodynamic entrance length. (6+6)

3. Consider the natural convection over a vertical flat plate with constant wall temperature condition. Write down the momentum and energy equation along with the boundary conditions. Draw the temperature and velocity profile. Derive for Pr>1, the expression for Nusselt number using a scale analysis. (25)