Indian Maritime University

(A Central University, Govt of India)

End Semester Examinations – December 2025

Programme Name: B Tech (ME)

Semester: V

Subject Code: UG11T4509

Subject Name: HEAT TRANSFER & MARINE HEAT EXCHANGERS

Date: 24.12.2025	Max Marks: 70
Duration: 03 Hrs	Pass Marks: 35

General Instructions

(i) All Sections (A, B & C) are to be attempted.

(ii) Scientific calculators are required

(iii) Symbols used have their standard meanings if not specified

(iv) Heat and mass transfer data book can be used

Section A

Ten MCQs/Fill in the Blanks of 01 Mark each – Choose the correct answer as applicable.

1. In conduction, heat is transferred due to:
   a. Movement of fluid particles
   b. Molecular collisions and lattice vibrations
   c. Radiation of energy through space
   d. Mass transfer between surfaces

2. In MLTΘ system, the dimension of thermal conductivity is
   a) $ML^{-1}T^{-1}\Theta^{-1}$ b) $MLT^{-1}\Theta^{-1}$
   c) $ML\,T^{-3}\Theta^{-1}$ d) $MLT^{-2}\Theta^{-1}$

3. Grashof number is defined as
   a) $\frac{g\beta L(T_W - T_\infty)}{\vartheta}$ b) $\frac{g\beta L^3(T_W - T_\infty)}{\vartheta^2}$
   c) $\frac{g\beta L^2(T_W - T_\infty)}{\vartheta^2}$ d) $\frac{g\beta L^3(T_W - T_\infty)}{\vartheta^3}$

4. The Nusselt number represents:

a. Ratio of momentum diffusivity to thermal diffusivity

b. Dimensionless temperature gradient at the surface

c. Ratio of conductive and convective temperature gradients at the wall

d. Ratio of viscous to inertial forces

5. The Stefan–Boltzmann law is applicable to:

a. Opaque solids only b. Transparent gases only

c. Ideal blackbodies d. Any surface at room temperature

6. Two bodies at the same temperature but with different emissivities will:

a. Emit the same radiant energy b. Emit no energy

c. Emit different amounts of radiant energy d. Absorb all incident energy

7. The emissivity of a surface is the ratio of:

a. Ratio of energy emitted by a gray body to that of a blackbody at the same temperature

b. Energy absorbed to energy reflected

c. Energy emitted to energy absorbed

d. Reflected to incident energy

8. Compared to parallel flow heat exchanger, the LMTD of a counter flow heat exchanger is

a. more b. less c. same d. none of the above

9. For $C_{min}/C_{max} = 0$, the effectiveness is given by the expression

a. $e = 1 - \exp(NTU)$ b. $e = \exp(NTU) - 1$

c. $e = 1 + \exp(-NTU)$ d. $e = 1 - \exp(-NTU)$

10. The main function of a baffle in a shell-and-tube heat exchanger is to:

a. Support the tubes and direct fluid flow for better heat transfer

b. Prevent mixing of hot and cold fluids

c. Reduce the shell diameter

d. Increase the thermal conductivity

Section B

Five Questions of 02 Marks each

11. Explain the term fin efficiency and fin effectiveness?
12. Define Prandtl number?
13. Explain Kirchhoff's law of radiation?
14. A steel rod (k = 45 W/mK) of length 2 m and cross-section 0.01 m^2 has its ends maintained at 100°C and 25°C. Calculate the rate of heat conduction.
15. Explain the concepts of velocity and thermal boundary layer in convection heat transfer?

Section C

Seven Questions of 10 Marks each of which any 05 questions to be answered.

16. a. Explain about the laws governing conduction, convection and radiation heat transfer.

    b. A Solar flat plate collector of surface area 4 m^2 receives solar radiation of 2000 watts. Neglecting radiation loss from the surface. Calculate the surface temperature of the plate. If surrounding air is at 20 ^{0}C and convective heat transfer coefficient, which is 5 W/m^2K

    (5 + 5 marks)

17. A stainless steel fin with thermal conductivity of 20 W/mK has a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300 °C. The ambient temperature is 50 °C and the heat transfer coefficient is 10 W/m^2K. The fin tip is insulated. Determine

    a. the rate of heat dissipation from the fin,

    b. the temperature at the fin tip,

    c. the rate of heat transfer from the wall area covered by the fin was not used and

    d. the heat transfer rate from the same fin geometry if the stainless steel fin is replaced by a fictitious fin with infinite thermal conductivity.

    (10 marks)

18. Explain TEMA construction standards for heat exchanger with shell and tube type heat exchanger. What is the scope of these standards?

    (10 marks)

19. a. Derive LMTD for counter flow heat exchanger.

b. Explain evaporator and condenser type heat exchanger with diagram?

(5 + 5 marks)

20. a. Discuss the role of heat exchangers in marine systems.

b. Explain the phenomenon of natural convection. What are the factors influencing the natural convection heat transfer?

(5+5 marks)

21. In a heat exchanger hot fluid enters at 180^0C and leaves at 118^0C. The cold fluid enters at 99^0C and leaves at 119^0C. Find the LMTD and effectiveness in the following heat exchangers: a. counter flow, and b. cross flow both fluid unmixed (10 marks)

22. a. State and explain Wein's displacement law and its significance

b. A black body of $0.2m^2$ area is at a temperature of 1000 K. Calculate the total energy emitted by it, the intensity of radiation along a direction 60^0 to normal and the wavelength of maximum monochromatic emissive power.

(4+6 marks)