

Indian Maritime University
(A Central University, Govt of India)

Sep/Oct'25 SE

Programme Name: B Tech (Marine Engineering)

Semester: V

Subject Code: UG11T4509

Subject Name: HEAT TRANSFER AND MARINE HEAT EXCHANGERS

Date: 16.10.2025

Max Marks: 70

Duration: 03 Hrs

Pass Marks: 35

General Instructions

- (i) All Sections (A, B & C) are to be attempted.
- (ii) Options, if any, are specified in respective section.
- (iii) Heat Transfer Data Handbook can be used.

Section A

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

1. The thermal conductivity of a damp brick is higher than that of dry brick, because
 - (a) the thermal conductivity of air is less than that of water.
 - (b) the heat transfer takes place in damp bricks by convection due to capillary motion of water within the porous material.
 - (c) both (a) and (b)
 - (d) none of the above

2. In natural convection heat transfer, the Nusselt number is a function of
 - (a) Re and Pr
 - (b) Re and Gr
 - (c) Gr and Pr
 - (d) Gr and Bi

3. When one of the fluid is condensing the best flow arrangement is
 - (a) counter flow
 - (b) parallel flow
 - (c) cross flow
 - (d) all are equal.

4. For buoyancy-induced fluid flow and heat transfer, this dimensionless number is significant

- (a) Reynolds number
- (b) Prandtl number
- (c) Grashof number
- (d) Nusselt number

5. Critical thickness of insulation for sphere is given by

- (a) $2k/h$
- (b) $4k/h$
- (c) k/h
- (d) $6k/h$

6. Why fins are provided on heat transferring surface?

- (a) To increase heat transfer area
- (b) To increase temperature gradient
- (c) To decrease heat transfer area
- (d) To decrease temperature gradient

7. The characteristic length for computing Grashof number in the case of a vertical cylinder is

- (a) the length of the cylinder
- (b) the diameter of the cylinder
- (c) the perimeter of the cylinder
- (d) the radius of the cylinder

8. Free convection dominates if

- (a) $Gr/Re^2 \ll 1$
- (b) $Gr/Re^2 \gg 1$
- (c) $Gr/Re^2 = 1$
- (d) $Gr.Pr/Re^2 \gg 1$

9. Most solids are _____ to radiation

- (a) highly absorptive
- (b) highly transmittive
- (c) opaque
- (d) highly reflective

10. The total emissive power from a radiating plane surface in any direction is directly proportional to the cosine of the angle of emission.

- (a) Wien's law
- (b) Kirchhoff's law
- (c) Stefan-Boltzmann law
- (d) Lambert's cosine law

Section B

Five Questions of 02 Marks each

11. What is the physical mechanism of heat conduction in a solid, a liquid, and a gas?
12. Differentiate natural and forced convection.
13. Draw temperature profiles of Parallel Flow and Counter Flow heat exchanger.
14. Define efficiency for a fin. Write the mathematical equation for the efficiency of an infinitely long fin.
15. Define Nusselt number and Critical Reynolds number.

Section C

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

16. Draw TEMA standard heat exchanger with channel and removable cover and single shell pass (AES) and mention at least 10 different parts of it.
17. A steam main 80mm inside diameter and 90mm outside diameter is lagged with two successive layers of insulation. The layer in contact with the pipe is 40mm asbestos and the asbestos layer is covered with 25mm thick magnesia insulation. The convective heat transfer coefficients for inside and outside surfaces are $227 \text{ W/m}^2\text{K}$ and $6.8 \text{ W/m}^2\text{K}$ respectively. If the steam temperature is 400°C and the ambient temperature is 30°C , calculate the steady state loss of heat from steam for 60m length of pipe. Also, work out the overall heat transfer coefficient based on inside and outside surfaces of lagged steam main. Thermal conductivities value of the pipe material, asbestos and magnesia insulation are 45 W/mK , 0.14 W/mK & 0.07 W/mK respectively.
18. Discuss the physical mechanism of natural convection with the help of a sketch.
19. A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s . The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s . The inner tube is thin-walled and has a diameter of 1.5 cm . If the overall heat transfer coefficient of the heat exchanger is $640 \text{ W/m}^2\text{K}$, determine the length of the heat exchanger required to achieve the desired heating.
20. A long rod 12 mm square section made of low carbon steel protrudes into air at 35°C from a furnace wall at 200°C . The convective heat transfer coefficient is estimated at $22 \text{ W/m}^2\text{K}$. The conductivity of the material is 51.9 W/mK . Determine the location from the wall at which the temperature will be 60°C . Also calculate the temperature at 80 mm from base. (5 + 5 Marks)
21. Consider a $0.6\text{-m} \times 0.6\text{-m}$ thin square plate in a room at 30°C . One side of the plate is maintained at a temperature of 90°C , while the other side is insulated.

Determine the rate of heat transfer from the plate by natural convection if the plate is (a) vertical, (b) horizontal with hot surface facing up. (5 + 5 Marks)

22. Briefly discuss the (a) velocity boundary layer and (b) thermal boundary layer. (5 +5 Marks)

TAM