**DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE**

**Regular/Supplementary Winter Examination – 2024**

**Course: B.Tech Branch : Mechanical Engineering and Allied**

**Subject Code & Name: (BTMC501) Heat Transfer Semester: V**

**Marks: 60 Date:06/02/2025 Duration: 3 Hr.**

***Instructions to the Students:***

1. *Each question carries 12 marks.*
2. *Question No. 1 will be compulsory and include objective-type questions.*
3. *Candidates are required to attempt any four questions from Question No. 2 to Question No. 6.*
4. *The level of question/expected answer as per OBE or the Course Outcome (CO) on which the question is based is mentioned in ( ) in front of the question.*
5. *Use of non-programmable scientific calculators is allowed.*
6. *Assume suitable data wherever necessary and mention it clearly.*

| | | | | | (Level /CO) | Marks |
|---|---|---|---|---|---|---|
| **Q. 1** | **Objective type questions. (Compulsory Question)** | | | | | **12** |
| 1 | Which of the following is true about Fourier's law of heat conduction? | | | | CO1 | 1 |
| | a It describes the rate of heat flow through a material. | b. It is only applicable to fluids. | c. It is used only for non-steady-state conditions. | d. It applies to heat transfer by convection. | | |
| 2 | In which of the following situations would heat conduction not occur? | | | | CO1 | 1 |
| | a. Between two solid bodies placed in cold water | b. Between a solid and a liquid placed in hot water. | c. Between two different phases of matter. | d. Between two liquids in a vacuum. | | |
| 3 | Which factor determines the effectiveness of insulation? | | | | CO2 | 1 |
| | a. Temperature difference | b. Material thickness. | c. Thermal conductivity | d. All of the above | | |
| 4 | In lumped heat transfer analysis, the temperature of an object changes with time according to: | | | | CO2 | 1 |
| | a. Newton's Law of Cooling. | b. Fourier's Law | c. Stefan-Boltzmann Law. | d. Carnot's Law. | | |
| 5 | In the case of a fin, the temperature distribution along its length is: | | | | CO3 | 1 |
| | a. Linear | b. Exponential | c. Parabolic | d. Constant | | |

| | | | | | | |
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| 6 | In a finned surface, the heat transfer rate increases with: | | | | CO3 | 1 |
| | a. Increasing the thickness of the fin. | b. Decreasing the surface area. | c. Increasing the convective heat transfer coefficient. | d. Decreasing the length of the fin. | | |
| 7 | For a fin with a high thermal conductivity, the fin efficiency is generally: | | | | CO3 | 1 |
| | a. Low | b. High | c. Zero | d. Variable | | |
| 8 | Which number characterizes the flow regime in boundary layers? | | | | CO4 | 1 |
| | a. Prandtl number | b. Reynolds number | c. Nusselt number | d. Froude number | | |
| 9 | In a heat exchanger, NTU stands for: | | | | CO5 | 1 |
| | a. Net Transfer Units | b. Number of Transfer Units | c. New Thermal Units | d. None of the above | | |
| 10 | A heat exchanger operates in parallel flow mode, and the temperature difference between the fluids is given by the logarithmic mean temperature difference (LMTD). If the fluids experience significant temperature change across the heat exchanger, how can the effectiveness of the heat exchanger be improved? | | | | CO5 | 1 |
| | a. By reducing the flow velocity of one of the fluids. | b. By increasing the flow rate of the hotter fluid. | c. By using a counter flow heat exchanger. | d. By decreasing the temperature difference between the two fluids. | | |
| 11 | The Stefan-Boltzmann Law states that the radiative heat flux from a black body is proportional to: | | | | CO6 | 1 |
| | a. $T^3$ | b. $T^2$ | c. $T^4$ | d. $T^1$ | | |
| 12 | The emissivity (ϵ\epsilonϵ) of a surface ranges between: | | | | CO6 | 1 |
| | a. 0 and 1 | b. 0 and ∞ | c. -1 and 1 | d. 0 and 100 | | |
| **Q. 2** | **Solve the following.** | | | | | **12** |
| **A)** | Derive an equation for heat transfer rate through a hollow cylinder by applying Fourier's Law of Heat Conduction. The hollow cylinder has a length, L, inner radius as 'ri' and outer radius as 'ro', inner and outer wall temperatures as Ti, and To. Thermal conductivity is represented as 'k'. | | | | CO1 | **6** |

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| **B)** | The inner surface of furnace wall is at 500 °C and outer surface is at 40 °C. Calculate the heat loss per $m^2$ area of the wall. If the thermal conductivity of the brick is 2.5 W/m °C and wall thickness is 150 mm. | CO1 | **6** |
| | | | |
| **Q.3** | **Solve the following.** | | **12** |
| **A)** | Write a short note on critical radius of insulation. Derive an equation for the critical radius of insulation for a cylinder. | CO2 | **6** |
| **B)** | An egg with a mean diameter of 30 mm is taken from a refrigerator at 5oC and heated in a pot using boiling water at atmospheric pressure. What will be the temperature of egg after 5 minutes? Use following properties of egg: Density = 1000 kg/m3, Specific heat = 2 kJ/kg.K, thermal conductivity = 10 W/m.K, Convective heat transfer coefficient = 40W/$m^2$K . Check the validity of lumped heat capacity approach. | CO2 | **6** |
| | | | |
| **Q. 4** | **Solve Any Two of the following.** | | **12** |
| **A)** | Explain the concept of hydrodynamic and thermal boundary layers with reference to flow over a flat heated plate. Sketch laminar and turbulent boundary layers for flow over a flat plate. Also, show velocity profiles in the two regions: a) at the entrance b) in the laminar region. Assume uniform velocity profile on the upstream side of the plate. | CO3 | **6** |
| **B)** | Explain the Role of the Nusselt Number in Forced Convection and How It is Related to the Heat Transfer Coefficient. | CO4 | **6** |
| **C)** | What is the Effect of Surface Roughness on Heat Transfer in Forced Convection? | CO4 | **6** |
| | | | |
| **Q.5** | **Solve Any Two of the following.** | | **12** |
| **A)** | In a double-pipe counter flow heat exchanger, oil flowing at 195 kg/min with a specific heat of 4200 J/kg·K is cooled from 90°C to 40°C by 140 kg/min of cooling water initially at 25°C. The overall heat transfer coefficient is given as 200 W/$m^2$·K, and the specific heat of the water is 6200 J/kg·K. Determine the following:<br>1. The Logarithmic Mean Temperature Difference (LMTD).<br>2. The required surface area of the heat exchanger. | CO5 | **6** |

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| **B)** | Explain the following terms:<br>(i) Heat Exchanger Effectiveness<br>(ii) NTU (Number of Transfer Units)<br>(iii) Fouling Factor of a Heat Exchanger<br>(iv) Overall Heat Transfer Coefficient | CO5 | **6** |
| **C)** | Explain & Sketch basic temperature distribution diagrams (temperature variation along the length) for the following heat exchanger configurations:<br>a) Parallel Flow Heat Exchanger b) Counter flow Heat Exchanger | CO5 | **6** |
| | | | |
| **Q. 6** | **Solve Any Two of the following.** | | **12** |
| **A)** | Explain the Concept of Radiation Heat Transfer. How Does It Differ from Conduction and Convection? | CO6 | **6** |
| **B)** | Explain the Concept of Radiation Shielding. How Can It Be Used to Minimize Heat Transfer in High-Temperature Applications? | CO6 | **6** |
| **C)** | State and Explain Planck's Law of Radiation. How Does It Relate to the Spectral Distribution of Radiation Emitted by a Body? | CO6 | **6** |
| | ***** End ***** | | |