

BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(MID SEMESTER EXAMINATION)

CLASS: BTECH  
BRANCH: MECH

SEMESTER : V  
SESSION : MO/2025

SUBJECT: ME315 HEAT & MASS TRANSFER

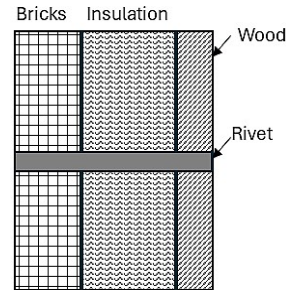
TIME: 02 Hours

FULL MARKS: 25

INSTRUCTIONS:

1. The question paper contains 5 questions each of 5 marks and total 25 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates

- Q.1 A composite insulating wall has three layers of material held together by 3 cm diameter aluminum rivet per 0.1 m<sup>2</sup> of surface ( $k_{al} = 204 \text{ W/m.K}$ ). The layers of material consist of 10 cm thick brick ( $k_{Brick} = 0.93 \text{ W/m.K}$ ) with hot surface at 200 °C, 1 cm thick wood ( $k_{wood} = 0.175 \text{ W/m.K}$ ) with cold surface at 10 °C. These two surfaces are interposed by third surface of insulating material ( $k_{insulation} = 0.12 \text{ W/m.K}$ ) 25 cm thick. Evaluate the percentage increase in heat transfer rate due to rivet.



[5] CO CO1 BL BTM

- Q.2(a) Explain the importance of critical insulation radius from engineering point of view. [2] CO1 BTL
- Q.2(b) A copper pipe carrying the refrigerant at -20 °C is 10 mm in outer diameter and is exposed to ambient at 25 °C with convective heat transfer coefficient of 50 W/m<sup>2</sup>.K. It is proposed to apply the insulation of material having thermal conductivity 0.5 W/m.K. Determine the critical thickness of insulation. Compare the heat loss at critical thickness and at 15 mm insulation thickness per meter length. [3] CO1 BTM
- Q.3(a) What is Biot number? Explain its physical significance in Lumped capacitance method. [2] CO1 BTL
- Q.3(b) In a heat treatment plant, the ball bearings 10 mm diameter are loaded on a conveyor belt. The belt passes through a furnace (inside temperature = 1000 °C,  $h = 200 \text{ W/m}^2.\text{K}$ ) along its length ( $L = 3 \text{ m}$ ). The balls are required to be heated from 30 °C to 250 °C, determine the velocity of the belt required. (Take  $\rho = 3000 \text{ kg/m}^3$ ,  $C = 0.5 \text{ kJ/kg.K}$ ,  $k = 50 \text{ W/m.K}$ ) [3] CO1 BTM
- Q.4 The handle of a ladle used for pouring molten metal at 327 °C is 30 cm long and is made of 2.5 cm x 1.5 cm mild steel bar stock ( $k = 43 \text{ W/m.K}$ ). In order to reduce the grip temperature it is proposed to make a hollow handle of mild steel plate 0.15 cm thick to the same rectangular shape. If the surface heat transfer coefficient is 14.5 W/m<sup>2</sup>.K and the ambient temperature is at 27 °C, estimate the reduction in the grip temperature. Neglect the heat transfer from inner surface of the hollow shape. [5] CO2 BTM
- Q.5(a) What is the difference between fin efficiency and effectiveness? A fin attached to a surface shows an effectiveness 0.9. Explain with reasonable cause the heat transfer has increased or decreased. [2] CO2 BTL
- Q.5(b) Explain the concept of black body. State and explain Kirchhoff's law of radiation. [3] CO2 BTL

:::::19/09/2025 :::::M