

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(END SEMESTER EXAMINATION)**

CLASS: BTECH  
BRANCH: PIE

SEMESTER: III  
SESSION: MO/2025

SUBJECT: ME24221 THERMAL AND FLUID ENGINEERING

TIME: 3 Hours

FULL MARKS: 50

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

- |  |      | CO | BL  |
|--|------|----|-----|
| Q.1(a) How would you interpret work done and temperature changes in context to the path as well as point functions?  | [5]  | 1  | 1   |
| Q.1(b) It is required to melt 5 tonnes/h of iron from a charge at 15°C to molten metal at 1650°C. The melting point is 1535°C, and the latent heat is 270 kJ/kg. The specific heat in the solid state is 0.502 and in the liquid state (29.93/atomic weight) kJ/kg·K. If an electric furnace has 70% efficiency, find the kW rating needed. If the density in the molten state is 6900 kg/m <sup>3</sup> and the bath volume is three times the hourly melting rate, find the dimensions of the cylindrical furnace if the length to the diameter ratio is 2. The atomic weight of iron is 56. | [5]  | 1  | 1,2 |
| Q.2(a) A turbo compressor delivers 2.33 m <sup>3</sup> /s at 0.276 MPa, 43°C which is heated at this pressure to 430°C and finally expanded in a turbine which delivers 1860 kW. During the expansion, there is a heat transfer of 0.09 MJ/s to the surroundings. Calculate the turbine exhaust temperature if changes in kinetic and potential energy are negligible.   | [5]  | 2  | 1-3 |
| Q.2(b) A cyclic heat engine operates between a source temperature of 800°C and a sink temperature of 30°C. What is the least rate of heat rejection per kW net output of the engine?   | [5]  | 2  | 1-3 |
| Q.3(a) Define conduction, convection, and radiation clearly, providing examples.   | [5]  | 3  | 2   |
| Q.3(b) A thin silicon chip and an 8-mm-thick aluminum substrate are separated by a 0.02-mm-thick epoxy joint. The chip and substrate are each 10 mm on a side, and their exposed surfaces are cooled by air, which is at a temperature of 25°C and provides a convection coefficient of 100 W/m <sup>2</sup> ·K. If the chip dissipates 104 W/m <sup>2</sup> under normal conditions, will it operate below a maximum allowable temperature of 85°C?   | [5]  | 3  | 1-3 |
| Q.4 Consider the two-dimensional, steady, incompressible flow through the plane converging channel shown in Fig. 1. The velocity on the horizontal centerline (x-axis) is given by $\vec{V} = V_1[1 + (x/L)]\hat{i}$ . Find an expression for the acceleration of a particle moving along the centerline using (a) the Eulerian approach and (b) the Lagrangian approach. Evaluate the acceleration when the particle is at the beginning and at the end of the channel.   | [10] | 4  | 1-4 |

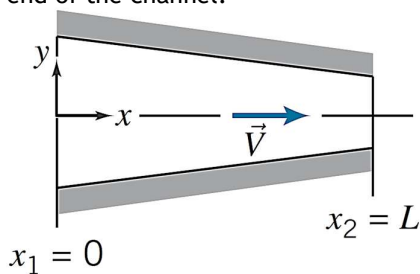


Fig. 1

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|---|-----|---|-----|
| Q.5(a) Derive an expression for Euler's equation in a streamline coordinate system.   | [5] | 5 | 1,2 |
| Q.5(b) Derive Bernoulli's equation from Euler's equation. Also, state the assumptions made while deriving Bernoulli's equation. | [5] | 5 | 1,2 |