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

CLASS: B.TECH **SEMESTER : IV**
BRANCH: MECHANICAL **SESSION : SP/2025**

SUBJECT: ME213 THERMO-FLUID ENGINEERING

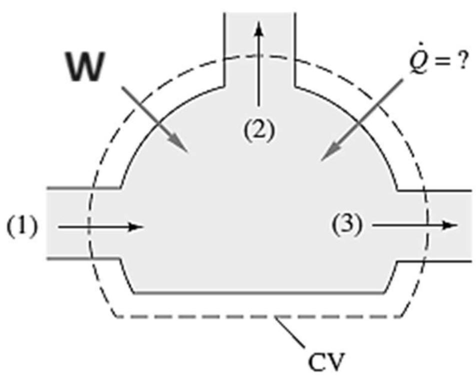
TIME: 3 Hours **FULL MARKS: 50**

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.

Q. No.	Question	Marks	CO	BL
Q.1(a)	What is the importance of the Reynold's Transport Theorem (RTT)? State the generalized form of RTT for a finite, fixed and non-deforming control volume. Using this, state the forms of RTT for mass and linear momentum conservation. How do these equations modify for a control volume moving linearly with a constant velocity?	[4]	1-2	1-2
Q.1(b)	A steady flow machine takes air at section 1 as shown in the figure and discharges it sections 2 and 3. The properties at each section are as follows	[6]	2-3	1-4

Section	A (m^2)	Q (m^3/s)	T (^oC)	Pressure (bar)	Z (m)
1	0.4	1	70	2	1
2	1	0.4	100	3	4
3	0.25	0.5	200	?	1.5

Work is provided to the machine at the rate of 0.1 MW. Find the absolute pressure 'p_3' and the heat transfer rate '$\dot{Q}$' going into the machine. Assume that air is an ideal gas with R = 287 J/kg·K and C_p = 1.005 kJ/kg-K.



Q. No.	Question	Marks	CO	BL
Q.2(a)	What are the advantages of defining and using stream functions in a 2D steady incompressible flow field? The stream function for an incompressible, two dimensional flow field is: $\psi = ay^2 - bx$, where a and b are constants. Is this an irrotational flow field? Explain.	[5]	1-2	1-3
Q.2(b)	It is observed that for certain type of fluid flow, stream function and potential function can be defined and both satisfy the Laplace Equation. What are the necessary limitations and advantages to such a flow behaviour? Derive the Bernoulli Equation for such flow situations, starting from Euler's equation of motion.	[5]	1-2	1-3
Q.3(a)	State the generalised equations of motion for fluid flow in x,y,z directions in 3D cartesian coordinates. Using the stress-strain rate correlation for viscous flows, deduce the Navier Stokes equation in 3D cartesian coordinates in x, y, z directions and in the vectorial notation. Are the N-S equations along with the continuity equation well-posed? Justify.	[4]	1-2	1-2

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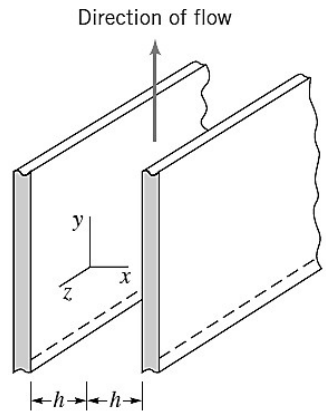
Q.3(b)	A viscous, incompressible fluid flows between the two infinitely long and wide, vertical, parallel plates separated by a distance of '2h', as shown in the figure. Determine, by use of the Navier–Stokes equations, an expression for the pressure gradient in the direction of flow, in terms of the mean flow velocity. Assume that the flow is laminar, steady, and uniform.	[6]	1-2	1-4



Q.4(a)	(i) Consider two systems that are at the same pressure as the environment. The first system 'A' is at the same temperature as the environment, whereas the second system 'B' is at a lower temperature than the environment. How would you compare the exergies of these two systems? Provide justification for the comparison. (ii) Consider an isolated system which has two components A and B thermally interacting with each other. During a certain process, there is a transfer of 5 kJ of energy from A to B, where A loses exergy of 5 kJ and B gains exergy of 10 kJ. Comment on the feasibility of the process with justification.	[4]	4-5	1-3
Q.4(b)	Steam enters an adiabatic turbine at 6 MPa, 600 °C, and 80 m/s and leaves at 50 kPa, 100 °C, and 140 m/s. If the power output of the turbine is 5 MW, determine (*a*) the mass flow rate of steam through the turbine, (b) the maximum power output, (c) exergy destruction and (d) the second-law efficiency of the turbine. Assume the surroundings to be at 25 °C. It is given that the enthalpy and entropy of steam at the turbine inlet are 3658.8 kJ/kg and 7.1693 kJ/kg.K, and that at the turbine exit are 2682.4 kJ/kg and 7.6953 kJ/kg.K respectively.	[6]	4-5	1-4
Q.5(a)	State the relation for velocity variation of a unidirectional steady frictionless compressible flow of an ideal gas through a duct of variable cross-sectional area. Discuss the resultant velocity variations in a converging duct, diverging duct and converging-diverging duct for subsonic and supersonic flows, with suitable sketch.	[4]	2	1-2
Q.5(b)	A converging duct having throat area equal to $1\text{x}10^{-4}$ m^2 passes air steadily from standard atmospheric conditions to a receiver pipe. Determine the mass flowrate through the duct if the receiver pressure is (a) 80 kPa, and (b) 40 kPa. Take ideal gas properties for air.	[6]	5	1-4

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