BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION SP/2024)

CLASS: B.TECH **SEMESTER : IV**
BRANCH: MECHANICAL **SESSION : SP/2024**

SUBJECT: ME213 THERMO-FLUID ENGINEERING

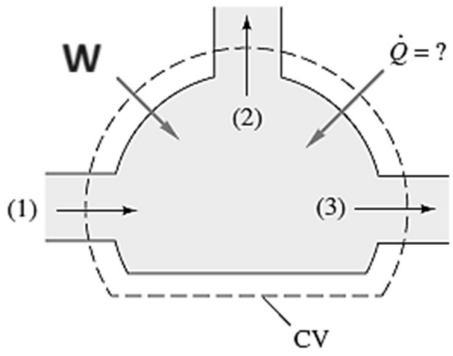
TIME: 02 Hours **FULL MARKS: 25**

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.

			CO	BL
Q.1	Using vector notation, prove that $\nabla \cdot \left(\nabla \vec{U}\right)^T = \nabla(\nabla . \vec{U})$, where $\vec{U}$ is a vector and if $\vec{U} = U_{ij}\hat{e}_i\hat{e}_j$, then its transpose is $\vec{U}^T = U_{ji}\hat{e}_i\hat{e}_j = U_{ij}\hat{e}_j\hat{e}_i$. Hint: expand both the LHS and RHS to expanded form	[5]	1	1-3
Q.2	State and derive the equation defining conservation of angular momentum in integral analysis of fluid motion, starting from Newton's 2nd law and using RTT. Define the physical significance of each term.	[5]	1	1-2
Q.3	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	[5]	1	1-5

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 '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.4	Derive the equation of conservation of mass in differential form for fluid flow in the 3D rectangular cartesian coordinate. Also state the generalized coordinate independent vectorial form of the equation, and the reduced form for steady compressible flow, and incompressible flow.	[5]	2	1-2
Q.5	Define streamlines and state its characteristics. What is/are the utility of 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]	2	1-3

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