Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER– 2 • EXAMINATION – WINTER - 2023

Subject Code:3722113 Date: 06 Jan 2024

Subject Name:Advnaced Fluid Mechanics

Time:10:30 AM TO 01:00 PM Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive the Navier Stoke (NS) equation in Cartesian coordinates for incompressible 3D flow. State the NS equation in component form and vector form. Justify the presence of non-linearity in the NS equation. **07**

(b) Derive Bernoulli equation based on conservation of linear momentum. Re-write Bernoulli equation in terms of pressure and head, separately, and describe each term. State any two limitations of Bernoulli equation. **07**

Q.2 **(a)** Explain the effects of back pressure on the flow through a De-Laval nozzle with a neat diagram. **07**

(b) Derive the Prandtl Meyer equation for normal shock in terms of Mach number, as follows: **07**

$M^*_x \times M^*_y = 1$

OR

(b) Derive the governing differential equation of energy in Cartesian coordinates for incompressible 3D flow. Identify and define viscous dissipation function in the differential equation of energy. **07**

Q.3 **(a)** Fluid flow field is given by: $V = x^2y\,i + y^2z\,j - (2xyz + yz^2)\,k$. **07**

(i) Prove that this is a case of possible steady incompressible fluid flow.

(ii) Calculate velocity and acceleration at point (2, 1, 3).

(b) Explain the principle of superposition in irrotational regions of flow. Derive the stream function and velocity potential function for uniform stream. Plot the stream lines and equipotential lines for uniform stream. **07**

OR

Q.3 **(a)** Define and explain the following terms: (i) Eulerian method of fluid flow, (ii) Lagrangian method of fluid flow, (iii) Irrotational flow, (iv) Uniform flow, (v) Ideal fluid, (vi) Total acceleration, (vii) Stream line. **07**

(b) Derive the governing differential equation of disturbance (stability equation) based on stability theory of laminar flows, and then further derive the Orr-Sommerfeld equation. **07**

Q.4 **(a)** Define & explain the following terms: (i) Stagnation velocity, (ii) Subsonic flow, (iii) Sonic flow, (iv) Supersonic flow, (v) Stagnation enthalpy, (vi) Zone of silence, (vii) Shock strength. **07**

(b) Explain the mechanism of transition to turbulence. Explain the transition process in boundary layer flow for (i) flow over circular cylinder, (ii) flow over flat plate. **07**

OR

Q.4 **(a)** Derive Rankine Hugoniot equation for normal shock with usual notations. **07**

(b) State the assumption and derive the simplified Navier Stoke equations for creeping flow. Explain creeping flow past a sphere. **07**

Q.5	**(a)**	Describe characteristic nature of turbulent flow. Define: (i) Intensity of turbulence, (ii) Length scale of turbulence, (iii) Kinetic energy of turbulence.	**07**
	(b)	Explain velocity and thermal boundary layer over a flat plate. State boundary layer approximation and derive velocity boundary layer and thermal boundary layer equations from Navier Stoke equations and energy equation, respectively.	**07**

OR

Q.5	**(a)**	State assumptions for Fanno flow. Derive continuity equation, momentum equation and energy equations governing Fanno flow.	**07**
	(b)	Derive the Reynolds stress tensor from the Navier Stoke equations of turbulent flow.	**07**

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