U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**

Branch: Aerospace Engineering **Duration: 3 hrs.**

Course Code: 23AS5PCAAD / 22AS5PCAAD **Max Marks: 100**

Course: ADVANCED AERODYNAMICS

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

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Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

			CO	*PO*	**Marks**
		UNIT - I			
1	a)	Derive the Bernoulli's equation for a 1D isentropic compressible flow. Write down the observations, comparing it with the incompressible flow Bernoulli's equation?	CO1	PO1	**10**
	b)	Derive an expression for speed of sound assuming one dimensional flow. Calculate speed of sound in air at standard sea level conditions (p = 1 atm, T = 288.8 K)	CO1	PO1	**10**
		OR			
2	a)	In an experiment air flows through a variable area duct. The pressure and temperature at the entrance are recorded as 200 kPa and 420 K respectively. The stagnation enthalpy of air is 800 kJ/kgK. During the experiment, the pressure sensor at the exit incurred damage an there was loss of data from the sensor. If the exit temperature is recorded as 350 K and the stagnation pressure at the exit is 500 kPa, calculate the exit pressure (in kPa) from theoretical relations assuming the flow in the duct to be adiabatic.	CO1	PO2	**10**
	b)	Derive the energy equation for the isentropic compressible flow relating the pressure, density and the velocity. Compare it with an incompressible Bernoulli's equation?	CO1	PO1	**10**
		UNIT - II			
3	a)	What are the properties of normal shock and how does the flow properties vary across the normal shock? Prove that shock is formed only when the upstream Mach number is supersonic	CO2	PO1	**10**
	b)	(i) Explain the behavior moving shock wave. (ii) A normal shock wave is standing in the test section of a supersonic wind tunnel. Upstream of the wave, M_1 = 3, p_1, = 0.5	CO2	PO2	**10**

			atm, and T_1 = 200 K. Find M_2, p_2, T_2. and u_2 downstream of the wave.			
			OR			
	4	a)	Derive Prandtl relation and thereby prove that Mach number downstream the normal shock is always subsonic.	CO2	PO2	**10**
		b)	Air approaches a normal shock with T_1 = 18° C, p_1 = 101 kPa (abs), and V_1 = 766 m/s. The temperature immediately downstream from the shock is T_2 = 551 K. i. Determine the velocity immediately downstream from the shock. ii. Determine the pressure change across the shock. iii. Calculate the corresponding pressure change for a frictionless, shockless deceleration between the same speeds and temperatures.	CO2	PO2	**10**
			UNIT - III			
	5	a)	With neat sketch, explain what is Fanno curve on T-s diagram. What is the effect of friction on downstream properties for supersonic and subsonic upstream conditions?	CO3	PO1	**10**
		b)	Consider air entering a heated duct at p_1 = 1 atm and T_1 = 288 K. Ignore the effect of friction. Calculate the amount of heat per unit mass (in joules per kilogram) necessary to choke the flow at the exit of the duct, as well as the pressure and temperature at the duct exit, for an inlet Mach number of i) M_1 = 2.0 ii) M_2 = 0.2	CO2	PO2	**10**
			OR			
	6	a)	Consider the flow of air through a pipe of inside diameter = 0.15 m and length = 30 m. The inlet flow conditions are M_1 = 0.3, p_1= 1 atm, and T_1 = 273 K. Assuming f = const = 0.005, calculate the flow conditions at the exit, M_2, p_2, T_2, and ρ_2. Also, what is the length of the duct required to choke the flow?	CO2	PO2	**10**
		b)	With neat sketch, explain what is Rayleigh curve on T-s diagram and identify the maximum temperature and maximum entropy point on the curve. When heat is added to the system, how does the downstream properties change for supersonic and subsonic upstream conditions.	CO2	PO1	**10**
			UNIT - IV			
	7	a)	What are expansion waves and derive the governing differential equation for Prandtl-Meyer flow.	CO2	PO1	**10**
		b)	Consider the isentropic subsonic-supersonic flow through a convergent-divergent nozzle. The reservoir pressure and temperature are 8 atm and 400 K, respectively. There are two locations in the nozzle where A/A* = 2: one in the convergent	CO2	PO2	**10**

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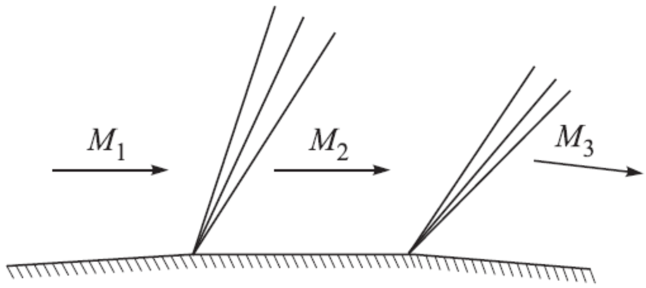
			section and the other in the divergent section. At each location, calculate M. p, T, and u.			
			OR			
	8	a)	A uniform supersonic flow at M_1=2, p_1=0.8 x 10^5N/m^2 and temperature 270 K expands through two convex corners of 10^0 each as shown in Fig. Determine the downstream Mach number M_3, p_2, T_2 and the angle of second fan.  Fig: Expansion waves at multiple corners	CO2	PO2	**10**
		b)	Derive a relationship between area of varying duct and velocity in differential form. Explain why throat in convergent divergent nozzle is a minimum area region.	CO2	PO1	**10**
			UNIT - V			
	9	a)	Derive Crocco's theorem at steady state.	CO3	PO1	**10**
		b)	Derive Euler's equation for irrotational inviscid flow with no body forces.	CO3	PO1	**10**
			OR			
	10	a)	Provide the steps for general procedure for the solution of irrotational, isentropic flow fields for the velocity potential equation of compressible flows.	CO3	PO1	**10**
		b)	What are hypersonic flows and what are the salient features of hypersonic flows.	CO3	PO1	**10**

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