U.S.N.										

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

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

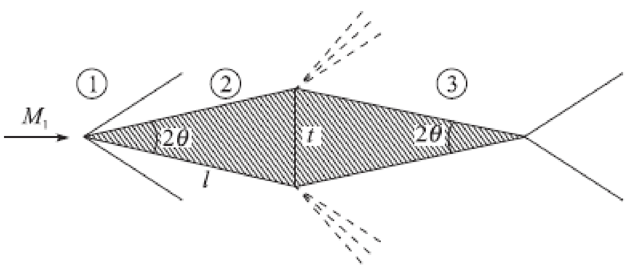
Programme: B.E. **Semester: V**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 23AS5PCAAD **Max Marks: 100**
Course: Advanced Aerodynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use gas tables and assume standard data wherever needed

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.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Define isothermal and isentropic process. Calculate isothermal and isentropic compressibility for air at a pressure of 0.5 atm. Compare the results between the two processes and comment your inferences.	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	PO2	**10**
		OR			
2	a)	Define isothermal process and adiabatic process. Furthermore, 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 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**
		UNIT - II			
3	a)	During the entry of the Apollo space vehicle into the Earth's atmosphere, the Mach number at a given point on the trajectory was M = 38 and the atmosphere temperature was 270 K. Calculate the temperature at the stagnation point of the vehicle, assuming a calorically perfect gas with $\gamma = 1.4$. Do you think this is an accurate	CO2	PO2	**10**

			calculation? If not, why? If not, is your answer an overestimate or underestimate?			
		b)	Define a normal shock wave and explain how the flow properties like Mach number, temperature, pressure and density vary across the shock wave. Also show that total temperature across the normal shock is constant while the total pressure decreases.	CO2	PO1	**10**
			OR			
	4	a)	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**
		b)	Derive Prandtl relation and thereby prove that Mach number downstream the normal shock is always subsonic.	CO2	PO1	**10**
			UNIT - III			
	5	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_I = 0.3, p_1= 1 atm, and T_I = 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**
			OR			
	6	a)	Air enters a constant area duct at M_1 = 0.2, p_1 = 1 atm and T_1 = 273 K. Inside the duct, the heat added per unit mass is q = 1.0×10^6 J/kg. Calculate the flow properties M_2, p_2, T_2, ρ_2, T_{02}, and p_{02} at the exit of the duct. Also calculate how much heat per unit mass must be added to choke the flow?	CO2	PO2	**10**
		b)	What is Fanno curve. 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? Identify the maximum entropy and maximum temperature on the curve.	CO2	PO1	**10**

			UNIT - IV			
	7	a)	A supersonic wind tunnel is designed to produce Mach 2.5 flow in the test section with standard sea level conditions. Calculate the exit area ratio and reservoir conditions necessary to achieve these design conditions (at standard sea level conditions, p_e = 1 atm and T_e = 288 K).	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 considered to be a minimum area region.	CO2	PO1	**10**
			OR			
	8	a)	A symmetric diamond aerofoil as shown in the figure, has side length of 1 m and maximum thickness 150 mm, which is placed at zero angle of attack is subjected to a Mach number of 1.6 and a freestream pressure of 50 kPa. Determine the drag coefficient using shock-expansion theory. 	CO2	PO2	**10**
		b)	What are expansion waves and derive the governing differential equation for Prandtl-Meyer flow.	CO2	PO1	**10**
			UNIT - V			
	9	a)	Derive Euler's equation for irrotational inviscid flow with no body forces.	CO3	PO1	**10**
		b)	What are hypersonic flows and what are the salient features of hypersonic flows.	CO3	PO1	**10**
			OR			
	10	a)	Assuming the flow to be steady, inviscid and irrotational, derive Euler's equation with no body forces.	CO3	PO1	**10**
		b)	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**

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