U.S.N.										

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

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

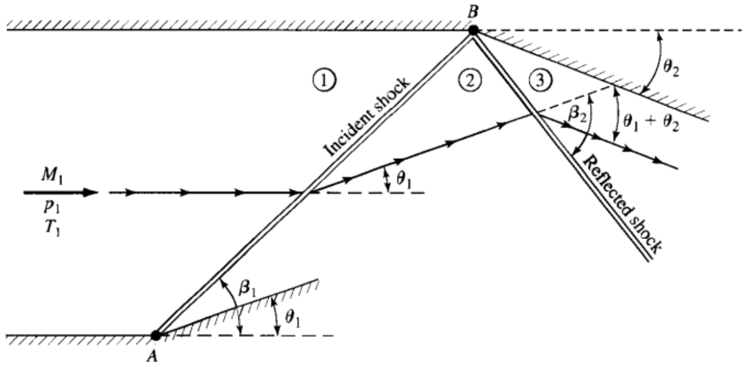
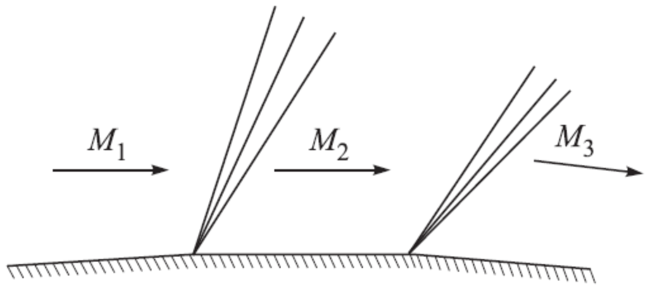
Programme: B.E. **Semester: V**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 20AE5DCAAD **Max Marks: 100**
Course: Advanced Aerodynamics

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)	Derive energy equation in integral form applying finite control volume approach.	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)	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	PO2	**10**
	b)	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	PO1	**10**
		UNIT - II			
3	a)	Explain the working principle of shock tube and draw the variation of pressure along the length of tube after the diaphragm is broken	CO2	PO2	**10**
	b)	Define a normal shock wave and explain how the flow properties like Mach number, temperature, pressure and density vary across	CO2	PO1	**10**

			the shock wave. Also show that total temperature across the normal shock is constant while the total pressure decreases.			
			OR			
	4	a)	Consider a normal shock wave propagating into stagnant air where the ambient temperature is 300 K. The pressure ratio across the shock is 10. Calculate the shock wave velocity, the velocity of the induced mass motion behind the shock wave, and the temperature ratio across the wave.	CO2	PO2	**10**
		b)	Derive expression for Hugoniot equation and comment on the effectiveness of shock compression when compared to isentropic compression when the flow starts from the same initial conditions of p1 and v1	CO2	PO1	**10**
			UNIT - III			
	5	a)	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**
		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 *(a)* $M_1 = 2.0$ *(b)* $M_2 = 0.2$	CO2	PO2	**10**
			OR			
	6	a)	Air is flowing through a pipe of 0.02-m inside diameter and 40-m length. The conditions at the exit of the pipe are $M_2 = 0.5$, $P_2 = 1$ atm, and T2 = 270 K. Assuming adiabatic, one-dimensional flow, with a local friction coefficient of 0.005, calculate M_1, p_1, and T_1 at the entrance to the pipe.	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)	Consider the geometry shown in Fig. Here a supersonic flow with Mach number, pressure, and temperature M_1, p_1, and T_1, respectively, is deflected through an angle θ_1 by a compression comer at point A on the lower wall, creating an oblique shock wave emanating from point A. This shock impinges on the upper wall at point B. Also precisely at point B the upper wall is bent downward through the angle θ_2. The incident shock is reflected at point B, creating a reflected shock which propagates downward	CO2	PO2	**10**

			and to the right in Fig. Consider a flow where M_1, = 3, p_1 = 1 atm, and T_1 = 300 K. Consider the geometry as sketched in Fig. where θ_1 = 14° and θ_2 = 10°. Calculate the Mach number, pressure, and temperature in region 3 behind the reflected shock wave. 			
		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)	Consider the isentropic subsonic-supersonic flow through a convergent-divergent nozzle. The reservoir pressure and temperature are 10 atm and 300 K, respectively. There are two locations in the nozzle where A/A* =6: one in the convergent section and the other in the divergent section. At each location, calculate M, p, T, and u.	CO2	PO2	**10**
		b)	A uniform supersonic flow at M_1=2, p_1=0.8 x $10^5 N/m^2$ 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**
			UNIT - V			
	9	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)	Using the small perturbation theory derive an expression for linearized pressure coefficient (C_p) in terms of perturbation velocity.	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)	Derive Crocco’s theorem at steady state	CO3	PO1	**10**

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