U.S.N.										

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

Autonomous Institute Affiliated to VTU

July 2024 Semester End Main Examinations

Programme: B.E.
Branch: Aerospace Engineering
Course Code: 22AS5PCAAD
Course: ADVANCED AERODYNAMICS

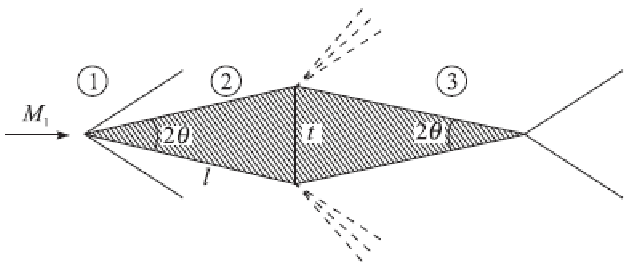
Semester: V
Duration: 3 hrs.
Max Marks: 100

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. ISA Tables, Airfoil data, Gas Tables are Permitted to be used.

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)	What is the difference between adiabatic and isentropic process? A reversible process changes the state of a system from state A to state B. Alternatively, an irreversible process can also bring about the same change in state. What is the change in entropy in both cases? State the reason.	*CO 1*	*PO 1*	**4**
	b)	A pressure vessel that has a volume of 10 m^3 is used to store high-pressure air for operating a supersonic wind tunnel. If the air pressure and temperature inside the vessel are 20 atm and 300 K, respectively, what is the mass of air stored in the vessel and total internal energy of the gas stored in the vessel?	*CO 1*	*PO 2*	**8**
	c)	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)	*CO 1*	*PO 2*	**8**
		UNIT - II			
2	a)	Derive Prandtl's relation and thereby prove that Mach number downstream the normal shock is always subsonic.	*CO 2*	*PO 1*	**6**
	b)	Consider a Pitot static tube mounted on the nose of an experimental airplane. A Pitot tube measures the total pressure at the tip of the probe (hence sometimes called the Pitot pressure), and a Pitot static tube combines this with a simultaneous measurement of the free-stream static pressure. The Pitot and free-stream static measurements are given below for three different flight conditions. Calculate the free-stream Mach number at which the airplane is flying for each of the three different conditions: a. Pitot pressure = 1.22 x 10^5 N/m^2, static pressure = 1.01 x 10^5 N/m^2 b. Pitot pressure = 7222 lb/ft^2, static pressure = 2116 lb/ft^2 c. Pitot pressure = 13107 lb/ft^2, static pressure = 1020 $1b/ft^2$	*CO 2*	*PO 2*	**10**

		c)	Prove why total temperature remains constant across normal shock wave while the total pressure decreases.	*CO 2*	*PO 1*	**4**
			OR			
	3	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. 1. Determine the velocity immediately downstream from the shock. 2. Determine the pressure change across the shock. 3. Calculate the corresponding pressure change for a frictionless, shockless deceleration between the same speeds and temperatures.	*CO 2*	*PO 2*	**10**
		b)	Consider the compression of air by means of (a) shock compression and (b) isentropic compression. Starting from the same initial conditions of p_l and v_l, plot to scale the pv diagrams for both compression processes on the same graph. From the comparison, what can you say about the effectiveness of shock versus isentropic compression?	*CO 2*	*PO 1*	**6**
		c)	Prove why total temperature remains constant across normal shock wave while the total pressure decreases.	*CO 2*	*PO 2*	**4**
			UNIT - III			
	4	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?	*CO 3*	*PO 2*	**10**
		b)	With neat sketch, explain what is Fanno curve on T-s diagram and identify the maximum entropy point on the curve. When friction is increased in the system, how does the downstream properties change for supersonic and subsonic upstream conditions.	*CO 3*	*PO 1*	**5**
		c)	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.	*CO 3*	*PO 1*	**5**
			UNIT - IV			
	5	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)	*CO 2*	*PO 2*	**6**
		b)	What are expansion waves and derive the governing differential equation for Prandtl-Meyer flow	*CO 2*	*PO 1*	**6**
		c)	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	*CO 2*	*PO 2*	**8**

			locations in the nozzle where A/A* = 2: one in the convergent section and the other in the divergent section. At each location, calculate M, p, T, and u.			
			OR			
	6	a)	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.	*CO 2*	*PO 1*	**4**
		b)	A symmetric diamond airfoil as shown in the Fig.1, 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.  Fig.1: Diamond airfoil subjected to supersonic flow	*CO 3*	*PO 2*	**10**
		c)	Consider an infinitely thin flat plate at a 5^0 angle of attack in a Mach 2.6 free stream. i) Calculate the lift coefficient and drag coefficient. ii) How does the lift and drag coefficients change if the flat plate is placed at 0^0 angle of attack	*CO 3*	*PO 2*	**6**
			UNIT - V			
	7	a)	Using the small perturbation theory derive an expression for linearized pressure coefficient (C_p) in terms of perturbation velocity.	*CO 3*	*PO 1*	**8**
		b)	Derive an expression for Crocco's theorem assuming the steady state flow condition.	*CO 3*	*PO 1*	**6**
		c)	Assuming the flow to be steady, inviscid and irrotational, derive Euler's equation with no body forces.	*CO 3*	*PO 1*	**6**

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