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

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**

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

Course Code: 23AS6PEHAD **Max Marks: 100**

Course: Hypersonic Aerothermodynamics

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

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 the one-dimensional continuity equation for inviscid, steady flow with no body force.	*CO1*	*PO2*	**10**
	b)		Derive the relation between total pressure and static pressure in isentropic flow.	*CO1*	*PO2*	**10**
			OR			
2	a)		(i) Define compressible flow. Show that the total temperature is constant across the stationary normal shock wave. (ii) Discuss with a neat sketch the different flow regimes behind the bow shock.	*CO1*	*PO2*	**10**
	b)		Derive the one-dimensional momentum equation for inviscid, steady flow with no body force.	*CO1*	*PO2*	**10**
			UNIT - II			
3	a)		Define hypersonic flow. Demonstrate five major characteristics of hypersonic flow.	*CO1*	*PO1*	**10**
	b)		Consider a flat plate exposed to hypersonic flow at some angle of attack. According to the Newtonian theory, calculate the aerodynamic forces and lift to drag ratio.	*CO1*	*PO2*	**10**
			OR			
4	a)		(i) Demonstrate "Modified Newtonian Law" as a local surface inclination method in order to find out the coefficient of pressure over a hypersonic body locally. (ii) Under which condition, the "Modified Newtonian Law" will be reduced to the "Straight Newtonian Law" of local surface inclination. (iii) Why does the method accurately predict the surface pressure near the stagnation point or near the nose of a hypersonic blunt body?	*CO1*	*PO2*	**15**

		b)	At very high Mach numbers, show that the coefficient of pressure, $C_p = \left(\frac{4}{\gamma+1}\right)\sin^2\beta$. β is the shock angle, and γ is the ratio of specific heats.	*CO1*	*PO2*	**05**
			UNIT - III			
	5		Derive hypersonic small-disturbance equations. With the help of hypersonic small disturbance equations, show that the hypersonic flow is inherently nonlinear.	*CO1*	*PO2*	**20**
			OR			
	6	a)	Derive the Hypersonic Boundary Layer Equations from the Navier-Stokes Equations (particularly continuity and momentum equations). Write down the assumptions that you need to consider in deriving the Hypersonic Boundary layer equations.	*CO1*	*PO2*	**15**
		b)	How are the Hypersonic Boundary layer equations different from the Supersonic/Subsonic Boundary layer equations?	*CO1*	*PO2*	**05**
			UNIT - IV			
	7	a)	(i) Write down the real gas equation. Under which conditions does a gas behave like a real gas? (ii) Describe the gas from the microscopic point of view.	*CO2*	*PO1*	**10**
		b)	With an appropriate diagram, discuss the velocity-altitude map for reentry vehicles.	*CO2*	*PO1*	**10**
			OR			
	8	a)	(i) Discuss the nature of high-temperature flows. (ii) Demonstrate with an appropriate sketch the undesirable effect of atmospheric entry of reentry vehicles.	*CO2*	*PO1*	**10**
		b)	Describe the procedure for calculating the equilibrium composition of a chemically reacting gas.	*CO2*	*PO1*	**10**
			UNIT - V			
	9	a)	Write down the working principle of the Hypersonic Wind Tunnel and Hypersonic Shock Tunnel. State the advantages and disadvantages associated with the Hypersonic Wind Tunnel and Hypersonic Shock Tunnel.	*CO3*	*PO1*	**10**
		b)	Demonstrate Shock and Boundary Layer Interactions with the appropriate sketch. How the Shock and Boundary Layer Interactions inside the Hypersonic intake influence the flow phenomena.	*CO3*	*PO1*	**10**
			OR			
	10	a)	Demonstrate the working principle of Schlieren flow and Shadowgraph flow visualizations.	*CO3*	*PO1*	**14**
		b)	Describe the working principle of Piezo-electric and Piezo-resistive devices.	*CO3*	*PO1*	**06**

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