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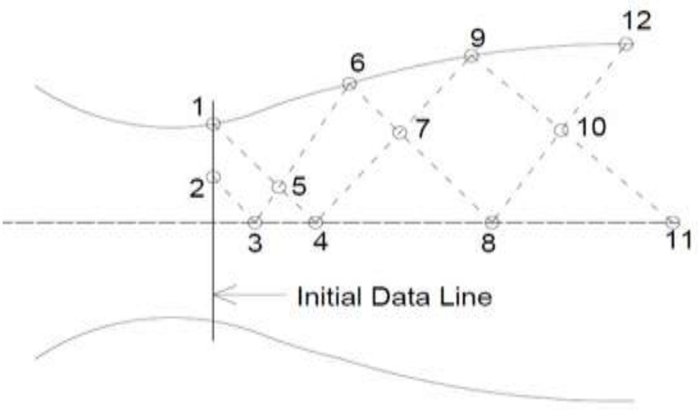
MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)
END SEMESTER EXAMINATIONS, MAY 2024

HIGH SPEED AERODYNAMICS [AAE 4083]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 06 May 2024** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

Q.NO	Questions	M	CLO	AHEP LO	BTL
1A.	Consider the following figure -1 and determine the velocity at point 8 by considering two different cases through Method of Characteristics  Figure - 1 Given parameters are : M_1=1.2, M_2=1.2, T_1=400K, θ_1=2 deg, θ_2=1 deg, (suitably assume if any value is missing) - Case -1 When θ_6=15 deg Case -2 When θ_6=20 deg Identify which case provides the highest velocity at point 8	(05)	CO2	1, 2, 4	5
1B.	Explain the conditions and procedures to obtain hypersonic small disturbance equations	(03)	CO2	1, 2	3
1C.	Define self-similar solutions and mention how it is different compared to the hypersonic boundary layer theory	(02)	CO1	1, 2	2

2A.	Consider a flat plate at angle of attack 10^0 with M=11 at standard atmospheric conditions. Calculate the lift and the drag of the plate by using a) Exact oblique shock relations b) Modified Newtonian c) Straight Newtonian d) Compare the above three results	**(05)**	**CO3**	**1, 2, 4**	**3**
2B.	Evaluate the following types of hypersonic wind tunnels with diagram a) Gas dynamic laser b) Shock tunnel c) Arc tunnel	**(03)**	**CO4**	**3, 4, 5, 12**	**3**
2C.	Identify the parameters, which influence the transitions Reynolds number in viscous hypersonic flows.	**(02)**	**CO2**	**1, 2**	**2**
3A.	Consider a flat plate at zero angle of attack in an airflow at standard sea level conditions. The chord length of the plate is 1.8m and platform area is $32m^2$. Assume the wall temperature is the adiabatic wall temperature (T_{aw}) a laminar flow over the surface and the total friction drag is caused by shear stress acting on both the top and bottom surfaces. If then calculate: a) The local shear stress on the plate at the location of 0.3m from the leading edge when the free stream velocity is 3010 m/s. ($C_f(Re)^{0.5}$= 0.46) b) The skin friction drag for the whole plate c) The local heat- transfer rate at the quarter-chord location (assume with a constant wall temperature (T_W=500K)($C_H(Re)^{0.5}$=0.28)	**(05)**	**CO5**	**1, 2, 4**	**4**
3B.	Explain shock expansion prediction method and also mention why it is more accurate for hypersonic flow	**(03)**	**CO3**	**1, 2, 4**	**3**
3C.	Explain the procedures of shooting technique in hypersonic self-similar solutions	**(02)**	**CO5**	**1, 2, 4**	**3**
4A.	Consider a flat plate at zero angle of attack in an airflow at standard sea level conditions and the chord length of the plate is 2m with $42m^2$ planform area. Calculate the shear stress by using reference temperature method. Assume (T_w=T_{aw}=6280K, T_e=T_∞, M_e=M_∞, u_e=4500m/s).	**(05)**	**CO5**	**1, 2, 4**	**4**
4B.	Evaluate the accuracy level hypersonic prediction methods like Newtonian, Modified Newtonian and Newtonian-Buseman. Also, make conclusion about which method is preferable for a blunt nose shape body.	**(03)**	**CO3**	**1, 2, 4**	**3**
4C.	What is the application of recovery factor in heat transfer calculations in viscous hypersonic flow?	**(02)**	**CO2**	**1, 2**	**3**

5A.	Elaborate with diagrams the shock-shock interactions and the shock wave – boundary layer interactions in viscous hypersonic flows	**(05)**	**CO5**	**3, 4**	**4**
5B.	Analyze the difference between strong and weak interactions in hypersonic viscous interactions.	**(03)**	**CO2**	**1, 2, 4**	**4**
5C.	Explain how the nose radius influence the aerodynamic heating on the surface of a hypersonic vehicle	**(02)**	**CO5**	**1, 2, 4**	**3**