Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)
END SEMESTER EXAMINATIONS, DEC 2020

SUB: HYPERSONIC AEROTHERMODYNAMICS [AAE 4003]

REVISED CREDIT SYSTEM
(30/12/2020)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Data tables will be given.

1A. Write a short note on the importance of Hypersonic flow. **(2)**

1B. With the help of a neat diagram explain the characteristics of the physical effect of hypersonic flow. **(3)**

1C. For the velocity profile for laminar boundary layer flows given as $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4$ obtain an expression for boundary layer thickness, shear stress, the drag force on one side of the plate, and coefficient of drag in terms of Reynolds number. **(5)**

2A. What are the thin shock layer and Entropy layer? **(2)**

2B. Air approaches a symmetrical wedge angle 30^0 at a Mach number of 2. For the strong shock, determine the downstream Mach number and static temperature if the stagnation temperature upstream of the shock was found to be 450 K. **(3)**

2C. Derive the Hypersonic flow field small disturbance equations using the three-dimensional cartesian coordinate system. **(5)**

3A. A normal shock moves with velocity 750 m/s into stagnant air at 150 kPa and 200 K. Find the static temperature after the shock has passed and the velocity imparted to the fluid by the shock. **(2)**

3B. With the help of neat diagrams explain the concept of Hypersonic equivalence principle and blast wave theory. **(3)**

3C. Assuming the laminar flow over a flat plate at zero angle of attack in airflow at standard sea-level conditions. Also, assume the wall temperature is the adiabatic wall temperature "T_{aw}". Calculate and write the comments of the local shear stress on the plate using both the traditional method and the reference temperature method at the local 0.5m downstream from the leading edge when the free stream velocity is 3402 m/s. Take the following conditions: P_∞= 1.01 x 10^5 N/m^2 and T_∞ = 288 k. The chord length of the plate is 2 m. The planform area of the plate is 40 m^2. A standard sea-level conditions, μ_∞ = 1.7894 x 10^{-5} kg/(m)(s). **(5)**

4A.	During an experiment, a weak oblique shock angle 44^0 occurs and flow is observed to be deflected by 14^0 anti-clockwise. Further, the downstream temperature of the shock wave was found to be 300 K. Determine the Mach number and the stagnation temperature after the shock.	**(2)**
4B.	Derive the Hypersonic inviscid flow field equations applicable for high L/D hypersonic vehicle configurations.	**(3)**
4C.	Consider a Mach 10 blow down wind tunnel ingesting atmospheric air at standard conditions. Calculate the velocity, static temperature, and static pressure in the test section, along with the flux of stagnation enthalpy there. Compare the value of the stagnation enthalpy in this wind tunnel with the stagnation enthalpy around the X-43A at a maximum flight speed of Mach 10 at 40 km of altitude, and provide an explanation of the discrepancy.	**(5)**
5A.	A flow at Mach number 4 encounters a compression corner with a deflection angle of 20^0. The conditions downstream of the shock are such that a strong oblique shock wave occurs. Find the shock angle and the downstream Mach number.	**(2)**
5B.	Explain the concept of Newtonian theory and modified Newtonian theory with suitable equations.	**(3)**
5C.	With the help of a neat diagram explain clearly the hypersonic flow viscous shock layer interaction through parabolized Navier stokes equations.	**(5)**