Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2019

SUBJECT: HYPERSONIC AEROTHERMODYNAMICS [AAE 4003]

REVISED CREDIT SYSTEM
(26/11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Compressible flow chart will be provided

1A. What is numerical technique of Method of characteristics? Explain in detail with limiting characteristics, unit process, initial data line and limitations of method of characteristics and also write down the procedures to solve problem through equations. **(04)**

1B. Derive and explain the basic hypersonic expansion wave relation and conclude the merits and demerits of expansion waves on hypersonic bodies. **(04)**

1C. What are the basic differences in conventional hypersonic vehicles with surface reentry vehicles and explain their design features. **(02)**

2A. Define the followings: **(04)**

a) Mach Line
b) Viscous Interactions
c) Hypersonic Similarity
d) Nusselt number

2B. Derive and prove that the aerodynamic heating is inversely proportional to the radius of the body. **(04)**

2C. Write down advantages and disadvantages of wave rider **(02)**

3A. Write down the concepts of Newtonian-Busemann, tangent wedge, tangent cone and shock expansion methods. **(04)**

3B. Consider a flat plate at zero angle of attack in airflow at standard sea level conditions. The chord length of the plate is 2.5m and planform area is $30m^2$. Assume the wall temperature is the adiabatic wall temperature (T_{aw}) and assume it's a laminar flow over the surface and the total friction drag is caused by shear stress acting on both the top and bottom surfaces. Then Calculate:- **(04)**

a) the local shear stress on the plate at the location of 0.8m from the leading edge when the free stream velocity is 4082 m/s. ($C_f\sqrt{R_e}$= 0.4)

b) the skin friction drag for the whole plate
c) the local heat- transfer rate at the 0.5m location from leading edge (assume with a constant wall temperature (T_W=576K) ($C_H\sqrt{R_e} = 0.31$)
d) Compare the results from (a) and (c) and write the conclusion.

3C. Hypersonic boundary layer is thicker than subsonic & supersonic flows, explain why? Also how this thick boundary layer affects the aero dynamical properties of the flow over the entire body. **(02)**

4A. What are the uses of non-dimesionalized parameters in inviscid hypersonic flows? Prove with an example that in high speed hypersonic, the properties become independent of Mach number. **(04)**

4B. Consider a flat plate at zero angle of attack in an airflow at standard sea level condition and the chord length of the plate is 1.5m with 38m^2 planform area. Calculate the shear stress on the body by using reference temperature method. (T_w=T_{aw}=6350K, T_e=T_∞, M_e=M_∞, u_e=4400m/s) **(04)**

4C. Draw the schematic diagrams of Arc Tunnel and Shock tunnel and explain their functions and operations. **(02)**

5A. Draw the schematic diagrams of shock-wave boundary layer interaction & shock-shock interactions and explain their features. **(04)**

5B. Consider a flat plate at angle of attack 10^0 with M=10 at standard atmospheric conditions. Calculate the lift and drag of the plate by using **(04)**

a) Exact oblique shock relations
b) Modified Newtonian
c) Straight Newtonian
d) Compare the above three results

5C. Explain several methods to increase aero-dynamic efficiency for hypersonic vehicles. **(02)**