Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)
END SEMESTER EXAMINATIONS, NOV/DEC 2018

SUBJECT: HYPERSONIC AEROTHERMODYNAMICS [AAE 4003]

REVISED CREDIT SYSTEM

(29/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Gas tables will be provided by the department

1A. Define hypersonic similarity parameter and write down an example. **(02)**

1B. Derive the equation for centrifugal correction to Newtonian theory. **(04)**

1C. Define the concept of thin shock layer theory and also explain the Maslen's method and its procedures. **(04)**

2A. According to blast wave theory write down results of blunt nose cylinder and blunt nosed slab. **(02)**

2B. Derive the x-momentum and y-momentum equations for hypersonic boundary layer. **(04)**

2C. Define self-similar solution and also explain the procedures and results of self-similar solution. **(04)**

3A. Differentiate between limiting characteristics and initial data line in method of characteristics. **(02)**

3B. Derive and prove that the pressure ratio depends only on $\bar{\chi}$ (chi bar) for strong viscous interaction in hypersonic flow. **(04)**

3C. Consider a flat plate at zero angle of attack in airflow at standard sea level conditions. The chord length of the plate is 2.1m and platform area is $28m^2$. 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 0.4m 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

4A. Write down the main factors influencing hypersonic transition. **(02)**

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 2m with $30m^2$ plan form area. Calculate the shear stress by using reference temperature method. ($T_w=T_{aw}=5500K$, $T_e=T_\infty$, $M_e=M_\infty$, $u_e=3400m/s$). **(04)**

4C. Derive and prove that for hypersonic flow heating can be reduced by increasing the radius of the body at stagnation point. **(04)**

5A. Explain the concepts and features of shock tunnel and arc tunnel for hypersonic flow. **(02)**

5B. Consider the flat plate at an angle of attack 10deg in a Mach 10 inviscid flow. Calculate the pressure coefficients on the top and bottom surface of the plate, the lift and drag coefficients and the lift-to-drag ratio by using **(04)**

a) Exact shock – wave and expansion wave theory
b) Newtonian theory
c) Compare the both results

5C. Describe the followings: **(04)**

a) shock expansion method
b) tangent wedge method
c) Ballistic coefficient
d) Entropy layer