Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, DECEMBER 2016

SUBJECT: GAS DYNAMICS [AAE 3102]

REVISED CREDIT SYSTEM
(29/12/2016)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. Derive and explain $\theta - \beta - M$ relation and define strong and weak solutions **(03)**

1B. Describe the followings: **(05)**
a) supercritical airfoil
b) compressibility correction
c) difference between total parameter and characteristic parameter
d) area rule
e) diffuser

1C. Why do we use conical surfaces at the nose section instead of wedge surfaces in supersonic speeds? **(02)**

2A. Consider a flat plate with chord length of 1.2m. The free stream flow properties are M_1=2.8, P_1=1atm and T_1=270K. Using shock expansion theory, tabulate and plot following properties as functions of 'α' by considering angle of attack varying as 2, 5 and 8 deg. **(04)**
a) Pressure on top & bottom surfaces
b) Temperature on top & bottom surfaces
c) L/D

2B. Consider a rocket burning its fuel and oxidizer inside the combustion chamber, the temperature and pressure are 3600K and 28atm respectively. The molecular weight of the chemically reacting gas inside the combustion chamber is 18 and γ = 1.2. The exit pressure at the convergent-divergent nozzle is 1.32×10^{-2} atm. The area of the throat is 0.46m^2. By assuming this is calorically perfect gas, then calculate the followings **(04)**
a) The exit Mach number
b) The exit velocity
c) The mass flow and Area of the exit.

2C. What is characteristic parameter? Write an expression in terms of characteristic which shows downstream Mach number is always lesser value than the upstream Mach number after a shock wave. **(02)**

3A. Draw the diagrams of intersection of same and opposite families of shocks and define the concept of slip line. **(05)**

3B. Draw the schematic diagram of supersonic wind tunnel and explain their features. Prove that diffuser throat area is bigger than inlet throat area. **(03)**

3C. What are the limitations of linearized perturbation theory and explain it. **(02)**

4A. Derive the equations of supersonic airfoils by considering linearized supersonic theory. Using the linearized theory calculate the drag coefficient for flat plate at 5^0 angle of attack in a Mach number 3.75 flow. **(05)**

4B. Consider air enters a constant area duct at M_1=3, P_1=1.2atm, T_1=320K and ρ=1.225 kg/m^3. Inside the duct heat added per unit mass is q=10^5 J/Kg. Calculate the flow properties M_2, P_2, ρ_2, T_2, P_{02} and T_{02} at the exit of the duct **(03)**

4C. What is compressibility effect? Also write down the working principle of the pitot tube in a supersonic flow. **(02)**

5A. Draw the graph of variation of linearized pressure coefficient with Mach number for both subsonic and supersonic flows. And also calculate the following numerical problem.(γ=1.4, R=287, ρ_∞=0.3648kg/m^3, T_∞=216.78K) **(04)**

Consider a supersonic fighter aircraft in a Mach 2 flow at 11km altitude and planform area of the wing is 18m^2. The weight of the aircraft is 9500kgf. Assume that all the lift of the airplane comes from the lift of the wing. Calculate the angle of attach of the wing relative to the freestream (use linearized supersonic equation)

5B. Derive and explain the one dimensional flow with heat addition and explain their physical properties in subsonic and supersonic flows. **(04)**

5C. What is initial data line in Method of characteristics? Explain the importance of this. **(02)**