Register Number: ……..

B.E DEGREE EXAMINATIONS: APRIL/MAY 2014

Fifth Semester

AERONAUTICAL ENGINEERING

AER108: Aerodynamics II

(Use of Gas Table is permitted)

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. The speed of sound in air at standard sea level conditions is
   a) 340.9 m/s b) 288.16 m/s
   c) 445 m/s d) 287 m/s
2. The process in which no dissipative phenomena occur, i.e., where the effects of viscosity, thermal conductivity, and mass diffusion are absent
   a) Adiabatic process b) Isentropic
   c) Isothermal process d) Reversible process
3. The Mach angle is simply determined by _____
   a) Local pressure b) Local Velocity of sound
   c) Geometry d) Local Mach number
4. The Mach number behind the normal shock is always _____
   a) Subsonic b) Supersonic
   c) Sonic d) None of the above
5. Airflow passing through an expansion wave
   a) Speeds up b) increase the energy of the airstream
   c) increase the energy of the airstream d) Both (a) and (c).
6. A uniform supersonic stream with $M_1 = 3$, $p_1 = 1$ atm, and $T_1 = 288$ K encounters a compression corner which deflects the stream by an angle $\theta = 30°$. Calculate the Mach number behind the shock wave.
   a) 3.8 b) 9.16
   c) 1.41 d) 2.95
7. After the flow becomes choked, the _____remains constant
   a) Velocity b) Mach number
   c) Total temperature d) Mass flow
8. Which one of the following equation represents the continuity equation for quasi steady one-dimensional flow?
   a) $\rho_1 u_1 A_1 = \rho_2 u_2 A_2$ b) $\rho_1 u_1 A_1 = \rho_2 u_2 A_1$
   c) $\rho_1 u_1 = \rho_2 u_2$ d) $\rho_1 A_1 = \rho_2 A_2$
9. If the exit pressure is higher than the back pressure, then the nozzle is said to be
   a) Under expanded b) Over expanded
   c) Critically expanded d) Choked
10. Critical Mach number, M_{crit}, is the aircraft's speed when
    a) It goes supersonic. b) the airflow first reaches sonic speed.
    c) Shock waves form d) Both (b) and (c).

PART B (10 x 2 = 20 Marks)

11. Give the relation which relates pressure, density and temperature of an isentropic process
12. Briefly explain the compressibility of the fluid.
13. Consider a Mach 2.8 supersonic flow over a compression corner with a deflection angle of 15°. If the deflection angle is doubled to 30°, what is the increase in shock strength? Is it also doubled?
14. Bring out two important differences between Rayleigh Flow and Fanno Flow
15. Define Oblique Shock and Expansion waves
16. Differentiate between Mach waves and Mach angles
17. Compare one dimensional and quasi one dimensional flow
18. List out the features of Method of characteristics
19. What is transonic area rule?
20. Define critical Mach number and drag divergence Mach number

PART C (5 x 14 = 70 Marks)

21. a) (i) Derive the continuity and momentum equation for steady 1-D flow (10)
    (ii) Discuss about the aerodynamic forces on a body (4)

    (OR)

    b) Obtain an expression for velocity of sound in terms of ratio of specific heats and local temperature in air medium from the one dimensional continuity, momentum and energy equations.

22. a) (i) Derive the Prandtl's relation for flow across a normal shock and explain its significance. (8)
    (ii) Consider two flows, one of helium and one of air. Denoting the strength of a normal shock by the pressure ratio across the shock, P_2/P_1, which gas will (6)

result in the stronger shock? For a monatomic gas such as helium, $\gamma = 1.67$, and for a diatomic gas such as air, $\gamma = 1.4$. Assuming equal velocities of 1700 m/s and temperatures of 288 K for both gas flows

(OR)

b) Consider the flow of air through a pipe of inside diameter = 0.4 ft and length = 5 ft. The inlet flow conditions are $M_1 = 3$, $p_1 = 1$ atm, and $T_1 = 300$ K. Assuming f = const = 0.005, calculate the flow conditions at the exit, M_2, p_2, T_2, and po_2. What is the length of the duct required to choke the flow?

23. a) (i) With a neat sketch explain Prandtl – Meyer expansion waves. Derive an expression for prandtl–Meyer function. (10)

(ii) Explain: Shock polar (4)

(OR)

b) (i) A uniform supersonic stream with $M_1 = 3$, $p_1 = 1$ atm, and $T_1 = 288$ K encounters a compression corner which deflects the stream by an angle $\theta = 20°$. Calculate the shock wave angle, and P_2, T_2, M_2, P_{02} and T_{02} behind the shock wave. (8)

(ii) Explain the Supersonic flows over wedges and cones (6)

24. a) (i) Derive the Area-Velocity relation for isentropic flow through variable area duc and discuss it in detail (7)

(ii) Consider the isentropic subsonic-supersonic flow through a convergent-divergent nozzle. The reservoir pressure and temperature are 10 atm and 300 K, respectively. There are two locations in the nozzle where $A/A^* = 6$: one in the convergent section and the other in the divergent section. At each location, calculate M, p, T, and u. (7)

(OR)

b) Derive the continuity, momentum and energy equation for steady Quasi One Dimensional flow

25. a) (i) Write short notes on: Shock induced separation and Characteristics of swept wings (8)

(ii) Explain the role of area rule in the design of high speed aircraft (6)

(OR)

b) What are the salient features of small perturbation theory of air flows? Obtain an expression for linearized perturbation velocity potential equation

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