Reg. No. :

Question Paper Code : 50028

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Fifth Semester

Aeronautical Engineering

AE 6503 : AERODYNAMICS – II

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Gas tables may permitted

Answer ALL questions

PART – A (10×2=20 Marks)

1. State why the low speed gases were treated as incompressible flows ?
2. Sketch the variation of mass flow rate with exit pressure and total pressure in a nozzle flow.
3. Compare isentropic compression and shock compression.
4. State the physical conditions must holds good across the slip line.
5. What is meant by small perturbation theory ?
6. State Prandtl-Glauert similarity rule.
7. What is meant by drag divergence Mach number ?
8. Why aerodynamic heating very important for hypersonic flows rather than supersonic flows ?
9. List out the components of shock tube.
10. What is meant by plenum chamber ?

PART – B (5×13=65 Marks)

11. a) Consider adiabatic air flow through a duct. At a certain section of the duct, the flow area is 0.2 m^2, the pressure is 80 kPa, the temperature is 5°C and the velocity is 200 m/s. if at this section, the duct area is changing at a rate of 0.3 m^2/m. Find dp/dx, dV/dx and dρ/dx.

a) Assuming incompressible flow. (5)

b) Taking compressibility into account. (8)

(OR)

b) i) Air flows through a nozzle which has inlet area of 10 cm^2. If the air has a velocity of 80 m/s, a temperature of 28°C and a pressure of 700 kPa at the inlet section and a pressure of 250 kPa at the exit, find the mass flow rate through the nozzle and assuming one dimensional isentropic flow the velocity at the exit section of the nozzle. (8)

ii) An observer on the ground finds that an airplane flying horizontally at an altitude of 6000 m has travelled 12 km from the overhead position before the sound of the airplane is first heard. Estimate the speed at which the airplane is flying. (5)

12. a) What is meant by mass – motion velocity ? And show that the mass – motion velocity depends on the pressure ratio across the shock wave and the speed of sound ahead of the wave.

(OR)

b) Air flow at Mach 4.0 and pressure 105 N/m^2 is turned abruptly by a wall into the flow with a turning angle of 20°, as shown in Fig. 12.b. If the shock is reflected by another wall determine the flow properties M and p downstream of the reflected shock.

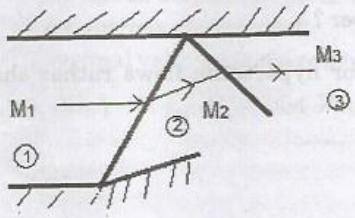

Fig 12.b

13. a) Derive an expression for the velocity potential equations and state the assumptions made. And also discuss the various methods available to obtain the solution for the equation.

(OR)

b) Using linearized theory, calculate the lift and drag coefficients for a flat plate at a 5° angle of attack in a Mach 3 flow. Compare with the exact results. (5+8)

14. a) i) Show that the $C_{p,cr}$ is a unique function of M_{cr}. (8)

ii) Write short note on supercritical airfoil. (5)

(OR)

b) Using shock-expansion theory, calculate the lift and drag coefficients of a symmetrical diamond airfoil of semiangle $\theta = 10°$ at an angle of attack to the free stream of 12° when upstream Mach number and pressure are 3.0 and 100 kPa.

15. a) The data of a Mach 2 supersonic wind tunnel is given below :

Pressure in the test section	0.69 bar
Area of cross section of the nozzle throat	1000 cm^2
Ambient pressure	1.02 bar
Ambient temperature	311 K

The air is taken from the atmosphere and compressed continuously in a multistage compressor to the reservoir pressure. The test section of tunnel directly exhausts into the atmosphere. Determine :

a) Temperature of air in the test section

b) Mass flow rate of air

c) Cross sectional area of test section

d) Power required to drive the compressor.

Assume reversible flow throughout.

(OR)

b) i) With neat sketch explain the working principle of blow down supersonic wind tunnel. (6)

ii) Explain the Mach-Zhanta interferometer techniques for flow visualisation. (7)

PART – C (1×15=15 Marks)

16. a) A convergent-divergent nozzle is designed to expand air from a chamber in which the pressure is 800 kPa and the temperature is 40°C to give a Mach number of 2.7. The throat area of the nozzle is 0.08 m^2. Find :

a) The exit area of the nozzle. (1)

b) The mass flow rate through the nozzle when operating under design condition. (2)

c) The design back pressure. (2)

d) The lowest back pressure for which there is only subsonic flow in the nozzle. (2)

e) The back pressure at which there will be a normal shock wave on the exit plane of the nozzle. (2)

f) The back pressure below which there are no shock waves in the nozzle. (2)

g) The range of back pressure over which there are oblique shock wave in the exhaust from the nozzle. (2)

h) The range of back pressure over which there are expansions waves in the exhaust from the nozzle. (2)

(OR)

b) Air leaves the subsonic diffuser of a ramjet engine with a static pressure of 0.5516×10^5 N/m^2. Between the diffuser exit and the combustion chamber inlet sections, a liquid fuel is sprayed into the air, the fuel-air ratio being f = 1/29. The fuel is vaporized and thoroughly mixed with the air and enters the constant – area combustion chamber with a static temperature of 333.3 K and an average velocity of 73.15 m/s. The fuel has a calorific value of 41,867 kJ/kg. Assume that the working fluid has the same thermodynamic properties as air before and after combustion and that friction is negligible. Calculate

a) the stagnation temperature after combustion

b) the Mach number after combustion

c) the final static temperature

d) the loss in stagnation pressure due to heat addition

e) the entropy change and

f) the final velocity of the combustion products.

Assume $\gamma = 1.4$, R = 287.04 J/kg-K and Cp = 1.0048 kJ/kg-K.