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Question Paper Code : 40525

B.E./B.Tech.DEGREE EXAMINATION, APRIL/MAY 2018
Fifth Semester
Aeronautical Engineering
AE 6503 –AERODYNAMICS – II
(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions

(Gas tables may permitted.)

PART – A **(10×2=20 Marks)**

1. Differentiate isothermal compressibility and isentropic compressibility.
2. Determine the speed of sound for a hydrogen molecule at standard atmospheric condition.
3. Sketch the shock polar diagram.
4. What is meant by Mach reflection.
5. List out the possible methods to obtain the solution for velocity potential equation.
6. What is meant by characteristics lines ?
7. What are the advantages of sweptback wing ?
8. What is meant by shock stall ?
9. State the importance of plenum chamber in transonic wind tunnel.
10. What is the basic principle behind the optical flow visualization techniques ?

PART – B **(5×13=65 Marks)**

11. a) Obtain the expression which relates the change in pressure, temperature, density and velocity in terms of Mach number for a one dimensional flow in a variable duct. And discuss how the above properties varying with subsonic and supersonic Mach number in convergent and divergent passage.

(OR)

b) i) Air enters a convergent – divergent nozzle at 20×10^5 N/m² and 40°C. The receiver pressure is 2×10^5 N/m² and the nozzle throat area is 10 cm². Determine :

a) What should be the exit area for the design conditions above to operate at third critical ?

b) With the nozzle area fixed and the inlet pressure held at 20×10^5 N/m², what receiver pressure would cause a shock to stand at the exit ?

c) With the nozzle area fixed and the receiver pressure held at 2×10^5 N/m², what reservoir pressure would cause a shock to stand at the exit ? (8)

ii) Air enters a converging section where $A_1 = 0.50$ m². At a downstream section $A_2 = 0.25$ m², $M_2 = 1.0$ and $\Delta S_{1-2} = 0$. It is known that $p_2 > p_1$. Find the initial Mach number M_1 and the temperature ratio T_2/T_1. (5)

12. a) i) Show that the wave velocity of moving shock depends on the pressure ratio across the wave and the speed of sound of the gas which the wave is propagating. And prove that the induced velocity of stagnant air due to moving shock also the same dependence. (8)

ii) A simple wedge with a total included angle of 28° is used measure the Mach number of supersonic flows. When inserted into a wind tunnel and aligned with the flow, oblique shocks are observed at 50° angles to the free stream.

a) What is the Mach number in the wind tunnel ?

b) Through what range of Mach numbers could this wedge be useful ? (5)

(OR)

b) i) Air flows out of a pipe with a diameter of 0.3 m at a rate of 1000 m³ per minute at a pressure and temperature of 150 kPa and 293 K respectively. If the pipe is 50 m long, find the exit Mach number, pressure and temperature at the inlet. Assuming f = 0.005. (8)

ii) Prove that the two dimensional supersonic inviscid flow over an infinite wing has finite drag. (5)

13. a) Using Linearized perturbation – velocity potential equation, show that an incompressible flow over airfoil in (ξ, η) plane which is related to a compressible flow in (x, y) plane. And also obtain Prandtl – Glauert rule.

(OR)

b) Explain in detail the design procedure of convergent – divergent nozzle using the method of characteristics.

14. a) i) Consider the NACA 0012 airfoil, the minimum pressure coefficient over the surface of the airfoil at a zero angle of attack is – 0.43. From this information, estimate the critical Mach number of the NACA 0012 airfoil at a zero angle of attack. Use graphical approach. **(8)**

ii) Write short note on transonic area rule. **(5)**

(OR)

b) Using shock – expansion theory, calculate the lift and drag coefficient of a symmetrical diamond airfoil of semiangle $\theta = 5°$ at an angle of attack to the free stream of 10° when upstream Mach number and pressure are 3.0.

15. a) The driver section of an air – air shock tube is pressurized to 8 atm and the expansion section is evacuated to 0.05 atm. If the initial temperature of the air in both sections is 300 K. Determine the temperature, pressure and velocity downstream of the shock waves and downstream of the rarefaction waves.

(OR)

b) i) With neat sketch explain the working principle of Helium based hypersonic wind tunnel. **(8)**

ii) Write short note on shadowgraph flow visualization technique. **(5)**

PART – C **(1×15=15 Marks)**

16. a) Consider the intersection of two shocks of opposite families as sketched in Fig 16.1. For $M_1 = 3$, $P_1 = 1$ atm, $\theta_2 = 20°$ and $\theta_3 = 15°$. Calculate the Mach number and pressure in region 4 and 4'. And also find the flow direction behind the refracted shocks.

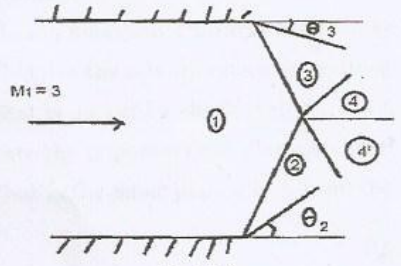

Fig 16.1

(OR)

b) Air enters a constant-area duct with a Mach number of 1.6, a temperature of 200 K, and a pressure of 0.56 bar as shown in Fig. 16.2. After some heat transfer a normal shock occurs, whereupon the area is reduced as shown. At the exit the Mach number is found to be 1.0 and the pressure is 1.20 bar. Compute the amount and direction of heat transfer.

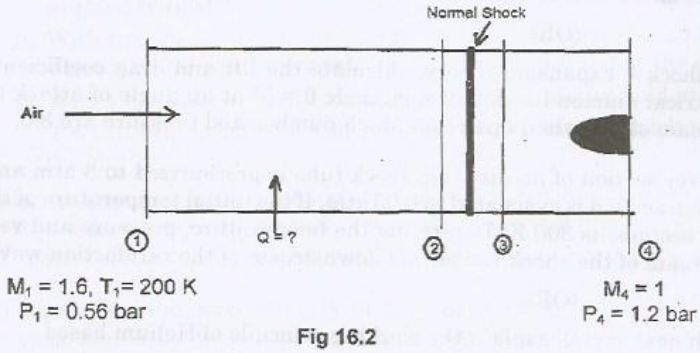

Fig 16.2