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B. M. S. College of Engineering, Bengaluru - 560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: V**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 20AE5DCAAD **Max Marks: 100**
Course: Advanced Aerodynamics **Date: 25.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. ISA Tables, Gas Tables are allowed to be used.

UNIT - I

1. a) What is meant by isentropic flow? Derive an expression for momentum conservation through a constant area isentropic duct. Assume the flow to be steady and one-dimensional. **6**

b) Show that the supersonic flow is only affected by the upstream flow conditions. **4**

c) Derive the Bernoulli's equation for a 1D isentropic compressible flow. Write down the observations, comparing it with the incompressible flow Bernoulli's equation? **6**

d) Air flows isentropically through a nozzle. If the velocity and the temperature at the exit are 400 m/s and 30^{o} C, respectively, determine the Mach number and stagnation temperature at the exit. What will be the Mach number just upstream of a station where the temperature is 95^{o}C? **4**

UNIT - II

2. a) A supersonic flow can be induced in a stationary medium by sending a shock wave. Show that the maximum induced Mach number that can be achieved behind the moving shock wave in air does not exceed 1.89. **5**

b) A blunt nosed model is placed in a Mach 3 supersonic tunnel test-section. If the settling chamber pressure and temperature of the tunnel are 10 atm and 315 K, respectively, calculate the pressure, temperature and density at the nose of the model. Assume the flow to be one-dimensional. Take $\gamma = 1.4$ and $R = 287\ J/kgK$. Construct the flow field in front of the blunt nosed model for $\gamma = 1.3,\ \ \gamma = 1.4, and\ \ \gamma = 1.67$. **10**

c) Define moving normal shock wave. Compare it with standing normal shock wave. **5**

OR

3. a) A Mach 3 air stream passes over a 10^{o} compression corner. The oblique shock from the corner is reflected from a flat wall which is parallel to the freestream, as shown in fig. Q3a. Calculate (i) the angle of the reflected shock wave relative to the flat wall and (ii) the Mach number downstream of the reflected shock. **6**

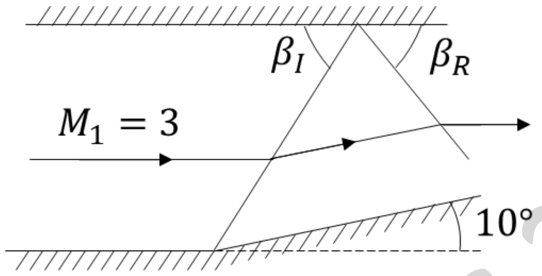

Fig Q3a

b) Air, assumed to be a perfect gas, flows from the storage tanks of a blow-down wind tunnel where temperature is 290 K and pressure is 70 x 10^5 N/m^2. A symmetrical wedge having a semi angle of 15 degree is placed in the test section where M = 3.0. Calculate the following properties on the surface of the wedge: (a) T, (b) p, (c) M, (d) the wave angle, and (e) the minimum Mach number for which the shock wave will remain attached to the wedge. Assume gamma =1.4. **7**

c) Discuss the formation of shock waves in front of a vehicle travelling at supersonic speed in (i) highly compressible gaseous medium and (ii) less compressible gaseous medium. **6**

UNIT - III

4. a) Air flows over a succession of four convex corners having flow deflection angles of 5 deg, 10 deg, 20 deg and 30 deg. If the initial Mach number is 1.4, determine the Mach number after each corner. Also, evaluate the fan angles at all the corners. **10**

b) Explain Prandtl-Meyer expansions with neat sketch. **4**

c) Derive area-velocity relation for a quasi-one-dimensional flow. **6**

UNIT - IV

5. a) Consider the flow of air through a pipe of inside diameter $= 0.15\,m$ and length $30\,m$. The inlet flow conditions are $M_1 = 0.3,\ p_1 = 1\,atm,$ and $T_1 = 273\,K$. Assuming $f = constant = 0.005$, calculate the flow conditions at the exit, $M_2,\ p_2,\ T_2,$ and p_{02}. **10**

b) Discuss the effect of heat addition to the flow through constant area duct. **10**

UNIT - V

6. a) Obtain an expression for the variation in $\frac{dC_L}{d\alpha}$ due to the effects of compressibility.

Hint: Use two-dimensional compressible and incompressible Laplace equations. Find a transformation for the profile such that the pressure distribution in the incompressible flow is identical to its compressible counterpart **12**

b) A given profile has at $M_\infty = 0.28$ the following lift coefficient:

$$C_L = 0.3 \quad at \;\; \alpha = 4°$$

$$C_L = -0.1 \quad at \;\; \alpha = -2°$$ **8**

where α is the angle of attack. Plot the relation showing $\frac{dC_L}{d\alpha}$ $Vs. M_\infty$ for the profile for values of M_∞ up to 1.0

OR

7. a) Derive an expression for the slope of characteristic lines for 2-D irrotational flow. **12**

b) Obtain compatibility conditions along each characteristic lines in a 2-D irrotational flow. **8**

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