Hall Ticket No | | | | | | | | | | | Question Paper Code:AAEC16

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
(Dundigal-500043, Hyderabad)

B.Tech V SEMESTER END EXAMINATIONS (REGULAR) - DECEMBER 2022
Regulation:UG20

HIGH SPEED AERODYNAMICS

Time: 3 Hours **(AERONAUTICAL ENGINEERING)** **Max Marks: 70**

Answer ALL questions in Module I and II
Answer ONE out of two questions in Modules III, IV and V
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE – I

1. (a) Determine the expression for speed of sound in air (assume air as a perfect gas). Comment about the speed of sound in solids, liquids, and gases. [BL: Understand| CO: 1|Marks: 7]

   (b) At a point in an airflow the pressure, temperature, and velocity are 1 atm, 320 K, and 1000 m/s. Calculate the total temperature and total pressure at this point. [BL: Apply| CO: 1|Marks: 7]

MODULE – II

2. (a) Briefly explain the normal shock and Build the Prandtl relation for normal shock in perfect gas. [BL: Understand| CO: 2|Marks: 7]

   (b) Consider a supersonic flow with M = 2, P = 1 atm, and T = 288 K. This flow is deflected at a compression corner through 20^0. Calculate M_2, P_2, T_2, P_{02}, and T_{02} behind the resulting oblique shock wave. [BL: Apply| CO: 2|Marks: 7]

MODULE – III

3. (a) Develop the area velocity relation. Using this, elucidate the shapes required for the following flight conditions
   i) Subsonic diffuser
   ii) Supersonic diffuser
   iii) Supersonic nozzle [BL: Understand| CO: 2|Marks: 7]

   (b) Air enters a constant-area duct at $M_1 = 3$, $P_1, = 1atm$, and $T_1 = 300K$. Inside the duct, the heat added per unit mass is q = 3 $\times 10^5$ J/kg. Calculate the flow properties M_2, P_2, T_2. ρ_2, P_{02} and T_{02} at the exit of the duct. [BL: Apply| CO: 2|Marks: 7]

4. (a) With neat sketches, elucidate isentropic flow through a convergent-divergent nozzle. Draw and explain the Fanno curve. [BL: Understand| CO: 4|Marks: 7]

   (b) Using the results of linearized theory, calculate the lift and wave-drag coefficients for an infinitely thin flat plate in a Mach 2.6 freestream at angles of attack of i) $\alpha = 5^0$ ii) $\alpha = 15^0$ iii) $\alpha = 30^0$ What can you conclude about the accuracy of linearized theory in comparison with exact shock expansion theory from the fundamental perspective. [BL: Apply| CO: 4|Marks: 7]

MODULE – IV

5. (a) Summarize the variation of drag with Mach number. From this, explain the need for supercritical airfoil and Whit comb area rule. [BL: Understand| CO: 5|Marks: 7]

   (b) Using linearized theory, calculate the lift and drag coefficients for a flat plate at a 5^0 angle of attack in a Mach 3 flow. [BL: Apply| CO: 5|Marks: 7]

6. (a) With necessary diagrams and equations paraphrase the philosophy of Method of Characteristics (MOC). [BL: Understand| CO: 5|Marks: 7]

   (b) Design a Convergent-Divergent nozzle using method of characteristics and explain the philosophy involved in method of characteristics [BL: Apply| CO: 5|Marks: 7]

MODULE – V

7. (a) List down the various facilities used in hypersonic flows and explain any one with the help of a neat sketch. [BL: Understand| CO: 6|Marks: 7]

   (b) Explain in detail about the working of subsonic and supersonic wind tunnels with suitable sketch. [BL: Understand| CO: 6|Marks: 7]

8. (a) Illustrate the working of a shock tunnel with suitable diagrams and explain the function of each component. [BL: Understand| CO: 6|Marks: 7]

   (b) Elucidate the various visualization techniques used in compressible flow. Make a comparison of schlieren and shadowgraphy techniques. [BL: Understand| CO: 6|Marks: 7]

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