Hall Ticket No | | | | | | | | | | | Question Paper Code: AAE008

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Four Year B.Tech V Semester End Examinations (Supplementary) - January, 2019

Regulation: IARE – R16

HIGH SPEED AERODYNAMICS

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. (a) Write short notes on **[7M]**
   i) Thermo dynamics systems ii) Enthalpy
   iii) Calorifically perfect gas iv) Perfect gas

   (b) A fighter aircraft attains its maximum speed of 2160 kmph at an altitude of 12 Km. The take-off speed at sea level is 270 kmph. If the flight speed increases linearly with altitude, compute the variations in stagnation temperature with altitude for a climbing up to the maximum speed in steps of 3 Km. **[7M]**

2. (a) Define the principle of momentum equation and derive the equations for the conservations of momentum in integral form. **[7M]**

   (b) Consider a Boeing 747 airliner cruising at a velocity of 885.14 Km/hr at a standard altitude of 11582.5 m, where the free stream pressure and temperature are 20.68 kPa and 487.5^0C, respectively. A one-fiftieth scale model of the 747 is tested in a wind tunnel where the temperature is 537.5^0C. Calculate the required velocity and pressure of the test airstream in the wind tunnel such that the lift and drag coefficients measured for the wind-tunnel model are the same as for free flight. Assume that both μ and a are proportional to T 1/2. **[7M]**

UNIT – II

3. (a) What is shock expansion theory? How it is applicable for super sonic airfoils. **[7M]**

   (b) The flow Mach number, pressure, and temperature ahead of a normal shock are given as 2.0, 0.5 atm and 300 K respectively. Determine M_2, P_2 , T_2, and V_2 behind the wave. **[7M]**

4. (a) Explain the theta-Beta-M relation for wide range of supersonic flow. **[7M]**

   (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, p, T , p_0, and T_0 behind the resulting oblique shock wave. **[7M]**

UNIT – III

5. (a) Write a short notes on **[7M]**
   i) Fanno flow
   ii) Rayleigh flow.

   (b) At a given point on the surface of an airfoil, the pressure coefficient is -0.3 at very low speeds. If the free stream Mach number is 0.6, calculate C_p at this point. **[7M]**

6. (a) Consider a flow through constant area pipe entering fanno flow and derive expression for ideal gas equation to calculate the density ratio from pressure and temperature ratio. **[7M]**

   (b) Consider the isentropic flow through a convergent-divergent nozzle with an exit-to-throat area ratio of 2. The reservoir pressure and temperature are 1 atm and 288 K, respectively. Calculate the Mach number, pressure, and temperature at both the throat and the exit for the cases where (a) the flow is supersonic at the exit and (b) the flow is subsonic throughout the entire nozzle except at the throat, where M = 1. **[7M]**

UNIT – IV

7. (a) Explain with neat sketches transonic area rule and explain in detail. **[7M]**

   (b) A supersonic nozzle is designed to operate at Mach 2.0. Under a certain operating condition, however, an oblique shock making a 45^0 angle with the flow direction is observed at the nozzle exit plane, as in Figure 1. What percent of increase in stagnation pressure would be necessary to eliminate this shock and maintain supersonic flow at the nozzle exit? **[7M]**

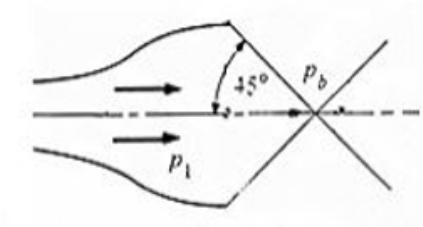

Figure 1

8. (a) How important is Prandtl-Glauert compressibility correction and derive the equations for Cl and Cm **[7M]**

   (b) At a given point on the surface of an airfoil, the pressure coefficient is -0.3 at very low speeds in an incompressible flow cl $= 2\pi\alpha$. If the free stream Mach number is 0.6, calculate Cp and lift coefficient for at this point. **[7M]**

UNIT – V

9. (a) Draw a neat sketch of a low speed wind tunnel circuit and explain the function of each component. **[7M]**

   (b) What is the reservoir pressure for the tunnel if The nozzle of a supersonic wind tunnel has an exit to throat area ratio of 6.79 when the tunnel is running, a pitot tube mounted in the test section, measures 1.448 atm. **[7M]**

10. (a) Draw a neat sketch of a free-piston shock wind tunnel and explain the function of each component. **[7M]**

    (b) Draw a neat sketch of blow down type supersonic wind tunnel and explain the function of each of the component. **[7M]**

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INSTITUTE OF AERONAUTICAL ENGINEERING

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Four Year B.Tech V Semester End Examinations (Supplementary) - July, 2019

Regulation: IARE – R16

HIGH SPEED AERODYNAMICS

Time: 3 Hours **(AE)** **Max Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. (a) Derive the energy equation which is valid even in the presence of friction or non-equilibrium conditions **[7M]**

   (b) A needle nose projectile traveling at a speed of M=3 passes 200m above an observer. Find the projectiles velocity and determine how far beyond the observer the projectile will first be heard. **[7M]**

2. (a) Explain briefly compressible flow regimes with suitable sketches. Derive the speed of sound equation for a perfect gas. **[7M]**

   (b) Consider airplane flying at an altitude of 20,000m. The pressure at a point on the wing is 19152N/m^2, assuming isentropic flow over the wing, calculate the temperature at this point? **[7M]**

UNIT – II

3. (a) Explain entropy rise across normal shock and its relation to pressure rise? Write notes on supersonic flow over a wedge and cone with attached shock with neat sketches? **[7M]**

   (b) Calculate the lift and drag coefficients for a flat plate at 5^0 angle of attack in a Mach 3 flow **[7M]**

4. (a) Derive the expression for total pressure change across a normal shock. **[7M]**

   (b) Consider a point in an airflow where the local Mach number, static pressure, and static temperature are 3.5, 0.3 atm, and 180 K, respectively. Calculate the local values of p_0, T_0, T*, a*, and M* at this point. **[7M]**

UNIT – III

5. (a) Explain about choked flow, ideally expanded, over expanded, under expanded flows. **[7M]**

   (b) Atmospheric air at 101.35 kP_a and 300 K is drawn through frictionless bell-mouth entrance into a 3 m long tube having a 0.05 m diameter. The average friction coefficient f = 0.005, for the tube. The system is perfectly insulated. (i) Find the maximum mass flow rate and the range of back pressure that will produce this flow. (ii) What is the exit pressure required to produce 90% of the maximum mass flow rate and what will be the stagnation pressure and the velocity at the exit for that mass flow rate? **[7M]**

6. (a) Define fanno flow and write its application. Obtain an expression for area velocity relation? **[7M]**

   (b) Consider the isentropic supersonic flow through a convergent-divergent nozzle with an exit - to - throat area ratio of 10.25. The reservoir pressure and temperature are 5 atm and 333.3 K, respectively. Calculate M, p, and T at the nozzle exit **[7M]**

UNIT – IV

7. (a) Explain about i) Critical Mach number ii) Drag Divergence Mach number **[7M]**

   (b) For certain aerofoil at given point on the upper surface of the aerofoil, the pressure coefficient is -0.27 at very low speed. If the free stream Mach number is 0.75, calculate C_p and C_m at this point. **[7M]**

8. (a) Explain transonic flow past wedge sections with suitable equations. **[7M]**

   (b) A supersonic nozzle is designed to operate at Mach 2.0. Under a certain operating condition, however, an oblique shock making a 45^0 angle with the flow direction is observed at the nozzle exit plane, as in Figure 1. What percent of increase in stagnation pressure would be necessary to eliminate this shock and maintain supersonic flow at the nozzle exit? **[7M]**

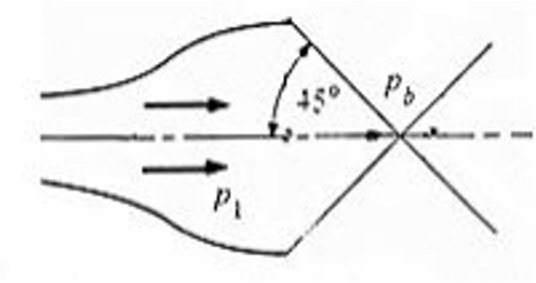

Figure 1

UNIT – V

9. (a) Write about supersonic wind tunnel operation ad fluid properties along the flow direction with a neat sketch. **[7M]**

   (b) What is the reservoir pressure for the tunnel if the nozzle of a supersonic wind tunnel has an exit to throat area ratio of 6.79 when the tunnel is running, a pitot tube mounted in the test section, measures 1.448 atm. **[7M]**

10. (a) Draw a neat diagram of blow down wind tunnel and explain the working principle and give advantages of the tunnel. **[7M]**

    (b) Write about supersonic wind tunnel operation and fluid properties along the flow direction **[7M]**

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