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INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Four Year B.Tech V Semester End Examinations (Regular) - November, 2018

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) Define compressible flow. Derive differential form of continuity equation for compressible flow. [7M]
 (b) Calculate the standard atmosphere values of T, P, and ρ at a Geopotential altitude of 15 km. [7M]
2. (a) Define the principle of energy equation and derive the equations for the conservations of energy in integral form. [7M]
 (b) Consider an executive jet transport patterned after the Cessna 560. The airplane is cruising at a velocity of 492 mph at an altitude of 33,000 ft, where the ambient air density is 7.9656×10^{-4} slug/ft³. The weight and wing planform areas of the airplane are 15,000 lb and 342.6 ft², respectively. The drag coefficient at cruise is 0.015. Calculate the lift coefficient and the lift-to-drag ratio at cruise. [7M]

UNIT – II

3. (a) What is shock expansion theory? how it is applicable to supersonic airfoils? [7M]
 (b) For the flow field shown in Figure 1, determine β_r with respect to the flow direction in zone 2, M_2 and M_3 if $M_1 = 2.0$ and $\beta_i = 40^\circ$. [7M]

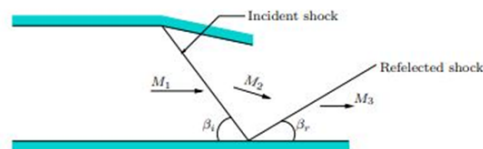


Figure 1

4. (a) Derive the expression for density relationship for normal shock for a perfect gas in terms of Mach number. [7M]

- (b) A Mach 2 uniform air stream at $p_1 = 800$ kPa and temperature 270 K expands through two convex corners of 10° each, as shown in Figure 2. Determine the Mach number M_3 , downstream of the second fan and p_2 , T_2 and the angle of the angle of the second expansion fan. [7M]

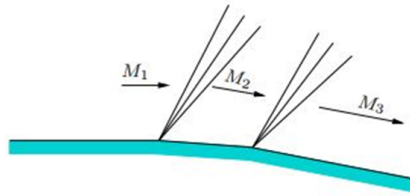


Figure 2

UNIT – III

5. (a) Explain Quasi-one dimensional flow and area velocity relation. [7M]
 (b) Explain about [7M]
 i. choked flow
 ii. ideally expanded
 iii. over-expanded
 iv. under expanded flows
6. (a) Define De Laval Nozzle and derive the Area Mach number relation. [7M]
 (b) Give a brief outline of operation of supersonic wind tunnels employing convergent-divergent nozzles? [7M]

UNIT – IV

7. (a) Derive the equation for determining characteristic lines for two dimensional irrotational flow? [7M]
 (b) Explain about Whitcomb's transonic area rule? How it will affect the performance of aircraft? [7M]
8. (a) Write Convergent-Divergent nozzle design by using method of characteristics. Explain the philosophy of method of characteristics. [7M]
 (b) Derive the linearized velocity potential equation for steady irrotational flow with neat diagram. [7M]

UNIT – V

9. (a) Write about supersonic wind tunnel operation and fluid properties along the flow direction with a neat sketch. [7M]
 (b) What do you understand by shock tunnel? Explain with suitable diagram? [7M]
10. (a) What do you understand by expansion tube? Explain with suitable diagram? [7M]
 (b) Differentiate the working of low speed wind tunnels and high speed wind tunnels with neat sketches? [7M]