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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fifth Semester

Aeronautical Engineering

AE 3502 — AERODYNAMICS – II

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Use of Gas tables is permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the term 'isentropic compressibility'.
2. What is meant by choking in an nozzle?
3. What is the reason for using C-D nozzle for generating supersonic flow?
4. What is Shock polar?
5. State the fundamental differences between Rayleigh flow and Fanno flow.
6. Give any two practical examples of interaction and reflection of shock waves.
7. Define the term 'Mach angle'.
8. What is Prandtl-Glauert rule?
9. Define critical Mach number.
10. What do you mean by shock induced separation?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive an expression for a speed of sound. (5)

(ii) Air from a reservoir at 10 atm and 80°C is discharged through a convergent-divergent nozzle fitted to the reservoir. The thrust exerted by the jet issuing from the nozzle is 11.12 kN. If the backpressure is 1 atm, calculate the nozzle throat and exit areas and Mach number of the jet issuing from the nozzle. Assume the flow through the nozzle to be isentropic and correctly expanded. (8)

Or

(b) Air enters a nozzle at pressure 3 MPa and temperature 400°C. At the nozzle exit, $A_2 = 5000\ mm^2$ and $p_2 = 0.5$ MPa. Expansion through nozzle is isentropic according to the law $pv^y = const$. Determine

(i) the Mach number at the nozzle exit. (5)

(ii) the throat area (4)

(iii) the mass flow rate through the nozzle. (4)

12. (a) If a strong shock of strength 60 is to be generated by piston motion in a cylinder filled with nitrogen gas at 290 K.

(i) what should be the piston speed? (4)

(ii) what will be the static temperature behind the shock? (4)

(iii) what will be the mach number behind the shock, if the field traversed by this strong shock is assumed to be isentropic with specific heats ratio $y = 1.4$? (5)

Or

(b) Derive Rankine Hugoniot equation. Also state its applications.

13. (a) (i) Determine the wave angle and Mach number behind and the pressure ratio across the oblique shock in air with $M_1 = 3.0$ and $\theta = 10°$, treating the shock as

(1) weak and

(2) strong. (9)

(ii) A Mach 2 air stream passes over a 10 expansion corner. Find the Mach number of the flow downstream of the expansion fan. (4)

Or

(b) A normal shock, generated by impulsively moving the piston in a cylinder piston device with stagnant air at 300 K and 1 atm, moves toward the closed end of the cylinder and reflects back. If the pressure losses caused by the incident and reflected shocks are 23.26 and 14.01%, respectively, determine

(i) the speed of the incident shock and piston speed and (5)

(ii) the pressure behind the reflected shock and the speed of sound ahead of the reflected shock. (8)

14. (a) A symmetric diamond aerofoil of sides 1 m and maximum thickness 150 mm is in a Mach 1.6 air stream at zero angle of attack. Determine the drag coefficient using

(i) shock-expansion theory and (5)

(ii) thin aerofoil theory. Also, estimate the percentage error involved in assuming the aerofoil as thin. (8)

Or

(b) Using small perturbation theory, derive lineraized supersonic pressure coefficient formula.

15. (a) Write short notes on the following :

(i) Super critical Aerofoils (5)

(ii) Characteristics of swept wings. (8)

Or

(b) Write short notes on the following :

(i) Transonic Area Rule (6)

(ii) Airfoils for supersonic flows. (7)

PART C — (1 × 15 = 15 marks)

16. (a) Derive Area-Mach relationship for convergent-divergent nozzle. Plot graph between area ratio and Mach Number. Discuss its significance.

Or

(b) Discuss in detail the principle and methodology adopted in Method of characteristics deriving the necessary equations.