

CBCS SCHEME

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21AE/AS42

Fourth Semester B.E. Degree Examination, June/July 2023

Aerodynamics

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. Explain the concept of source and sink flow. Obtain the expression for velocity, stream function and velocity potential for source flow. (10 Marks)
- b. Discuss the following concepts with neat sketch:
 - (i) Kutta condition
 - (ii) Kelvin's circulation theorem and starting vortex(10 Marks)

OR

- 2 a. How to produce lift in a cylinder? Explain with sketch and obtain the relation for coefficient of lift and drag. (10 Marks)
- b. Derive the expression for coefficient of lift and the lift slope for a symmetrical airfoil using Thin Airfoil theory. (10 Marks)

Module-2

- 3 a. Derive the fundamental expression for Prandtl's classical lifting line theory and write the observation from the equation. (10 Marks)
- b. Consider a rectangular wing with an aspect ratio of 6, an induced drag factor $\delta = 0.055$, and zero-lift angle of attack -2° . Induced drag coefficient for this wing is 0.01 at the angle of attack 3.4° . Calculate the induced drag coefficient for a similar wing with same airfoil at same angle of attack, but with an aspect ratio of 10. Assume that the induced factors for drag and lift slope, δ and τ are equal to each other. ($\delta = \tau$). Consider $\delta = 0.105$ for $AR = 10$. (10 Marks)

OR

- 4 a. Obtain the expression for induced drag coefficient and induced angle of attack for an elliptical lift distribution on a wing. (10 Marks)
- b. Discuss the following concept with neat sketch:
 - (i) Biot-Savart law for infinite and semi-infinite vortex filament
 - (ii) Downwash and induced drag(10 Marks)

Module-3

- 5 a. Define critical Mach number and obtain the expression for critical pressure coefficient as a function of critical Mach number. (10 Marks)
- b. Discuss the following concept with neat sketch:
 - (i) Transonic Area Rule
 - (ii) Super Critical Airfoil(10 Marks)

OR

- 6 a. Draw and explain about swept wings and discuss the advantages of swept wings. (08 Marks)
- b. Discuss about various lift enhancing devices used in aircraft with neat sketch. (12 Marks)

Module-4

- 7 a. Derive the energy equation for flow and non-flow process. (08 Marks)
 b. The pressure, temperature and Mach number at the entry of flow passage are 2.45 bar, 26.5°C and 1.4 respectively. If the exit Mach number is 2.5. Determine the following properties ($\gamma = 1.3$, $R = 0.469$ kJ/kg-K)
 (i) Stagnation temperature
 (ii) Temperature and velocity of gas at exit
 (iii) Mass flow rate per area (08 Marks)
 c. Write the Bernoulli's equation for isentropic compressible flow and explain. (04 Marks)

OR

- 8 a. How to obtain supersonic flow in a De-Laval nozzle? Explain the performance for various back pressure using necessary curves. (08 Marks)
 b. A nozzle in a wind tunnel gives a test-section Mach number of 2. Air enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross-sectional area of the throat is 1000 cm². Determine the following properties for one-dimensional isentropic flow.
 (i) Pressure, temperature and velocity at the throat and test sections.
 (ii) Mass flow rate
 (iii) Power required to drive the compressor. (12 Marks)

Module-5

- 9 a. Write the equation of motion for normal shock wave and obtain Prandtl relation. (12 Marks)
 b. The flow of gas is supersonic and there is a formation of normal shock in a flow. The properties of gas ahead of normal shock is given as $M_1 = 2$, $P_1 = 0.5$ atm and $T_1 = 300$ K. Determine the following properties behind the shock wave:
 (i) Mach number
 (ii) Pressure
 (iii) Temperature
 (iv) Velocity (08 Marks)

OR

- 10 a. Draw and explain the flow characteristics of oblique shock. Obtain the expression for θ - β - M . (10 Marks)
 b. Draw and explain the following:
 (i) Shock polar and hodograph plane
 (ii) Reflection and intersection of shock waves. (10 Marks)

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