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 cm^2. 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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