CBCS SCHEME

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18AE752

Seventh Semester B.E. Degree Examination, Dec.2023/Jan.2024
Fundamentals of Aerodynamic Theory

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Derive the Integral form of continuity equation from control volume approach. **(10 Marks)**

b. Define Mach number. Explain the Mach number regimes with neat sketches. **(10 Marks)**

OR

2 a. Define the following :
(i) Path lines.
(ii) Streak lines.
(iii) Vorticity.
(iv) Angular velocity.
(v) Circulation. **(10 Marks)**

b. If for a two-dimensional flow, the velocity potential is given by, $\phi = x(2y-1)$, determine the velocity at a point Q(4, 5). Determine also the value of the stream function at this point. **(10 Marks)**

Module-2

3 a. With neat sketch, explain the Airfoil Nomenclature and Wing Planform Geometry. **(10 Marks)**

b. Obtain the Expression for N′ and A′ and the moment M'_{LE} interms of P, θ and τ. **(10 Marks)**

OR

4 a. Define Drag. Explain the different types of drag with in detail. **(08 Marks)**

b. Consider the NACA23012 airfoil at $\alpha = 4°$, $C_l = 0.55$ and $C_{m_{C/4}} = -0.005$. The zero lift angle of attack is $-1.1°$ also at $\alpha = -4°$, $C_{m_{C/4}} = -1.0125$. Calculate the location of the aerodynamic center for the NACA23012 Airfoil. **(12 Marks)**

Module-3

5 a. Derive an expression for lift considering the lifting flow over a circular cylinder. **(10 Marks)**

b. Explain the following :
(i) D'Alembert's Paradox.
(ii) Doublet flow. **(10 Marks)**

OR

6 a. Explain the following with relevant sketches :
(i) Kelvin's circulation theorem.
(ii) Kutta condition. **(10 Marks)**

b. Consider an NACA 23012 airfoil. The mean camber line for this airfoil is given by,

$$\frac{Z}{C} = 2.6595\left[\left(\frac{x}{C}\right)^3 - 0.6075\left(\frac{x}{C}\right)^2 + 0.1147\left(\frac{x}{C}\right)\right]$$

for $0 \le \frac{x}{C} \le 0.2025$ and $\frac{Z}{C} = 0.02208\left(1 - \frac{x}{C}\right)$ for $0.2025 \le \frac{x}{C} \le 1.0$.

Calculate (i) The angle of attack at zero lift.
(ii) The lift coefficient when $\alpha = 4^\circ$
(iii) The moment coefficient about the quarter chord. **(10 Marks)**

Module-4

7 a. Explain the following :
(i) Down wash.
(ii) Induced drag.
(iii) Helmholtz's theorem. **(10 Marks)**

b. Obtain the expression for the velocity induced by infinite and semi-infinite Vortex element using the Biot-Savart Law. **(10 Marks)**

OR

8 a. Explain Prandtl's classical lifting line theory with relevant sketches and expressions. **(10 Marks)**

b. Enumerate the limitations of Prandtl's lifting line theory. **(10 Marks)**

Module-5

9 a. Explain the following :
(i) Simplified horse-shoe Vortex model.
(ii) Formation flight. **(10 Marks)**

b. Explain the influence of Downwash on the tail plane and prove $\frac{d\alpha}{dN} = \frac{8a_0}{\pi^3 AR}(1 + \sec\beta)$ **(10 Marks)**

OR

10 a. What are high lift devices? Explain with neat sketches. **(10 Marks)**

b. Explain the following :
(i) Transonic Area Rule.
(ii) Ground effects.
(iii) Tip effects. **(10 Marks)**

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