CBCS SCHEME

USN

18AE/AS42

Fourth Semester B.E. Degree Examination, June/July 2024

Aerodynamics – I

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 and hence deduce the differential form. **(10 Marks)**

b. Explain the following aerodynamic flows:
(i) Inviscid versus Viscous flow
(ii) Incompressible versus compressible flow **(10 Marks)**

OR

2 a. Obtain an expression for angular velocity and vorticity and also show the condition of irrotationally for two-dimensional flow. **(10 Marks)**

b. Derive speed of sound in terms of density and isentropic compressibility. **(10 Marks)**

Module-2

3 a. Explain typical airfoil aerodynamic characteristics at low speeds. **(09 Marks)**

b. Name the classifications of NACA airfoils and write down the explanation of the digits:
(i) NACA 2412 (ii) NACA 23012 (iii) NACA 65-218 **(11 Marks)**

OR

4 a. Define aerodynamic center. **(02 Marks)**

b. Derive $x_{ac} = -\frac{m_0}{a_0} + 0.25$, where $c\bar{x}_{ac}$ - location of the aerodynamic center, m_0 - slope of the moment coefficient curve, a_0 - slope of the lift coefficient curve. **(10 Marks)**

c. In low-speed, incompressible flow, the following experimental data are obtained for NACA 4412 airfoil section at an angle of attack of 4° : $c_\ell = 0.85$ and $c_{m,\ c/4} = -0.09$. Calculate the location of the center of pressure. **(08 Marks)**

Module-3

5 a. Consider non-lifting flow over a circular cylinder and derive the expression $C_p = 1 - 4\sin^2\theta$ and also show the C_p variation over the surface of the cylinder graphically. **(10 Marks)**

b. Consider the lifting flow over a circular cylinder with a diameter of 0.5 m. The free stream velocity is 25 m/s, and the maximum velocity on the surface of the cylinder is 75 m/s. The free stream conditions are those for a standard altitude of 3 km. Calculate the lift per unit span on the cylinder. (Take at an altitude of 3 km, $\rho = 0.90926$ kg/m^3) **(10 Marks)**

OR

6 a. Using classical airfoil theory, obtain the expression for a symmetric airfoil. **(10 Marks)**

b. For symmetric airfoil, prove that the quarter-chord point is both the center of pressure and the aerodynamic center. **(10 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-4

7 a. Obtain the expression for the velocity induced by infinite and semi-infinite vertex filament using the Biot Savart Law. **(10 Marks)**

b. Discuss briefly the following :
(i) Downwash and Induced drag
(ii) Helmholtz's Vortex theorem **(10 Marks)**

OR

8 a. Consider Elliptical Lift Distribution given by $\Gamma(y)=\Gamma_0\sqrt{1-\left(\frac{2y}{b}\right)^2}$. Derive the expression for the induced angle of attack and induced drag coefficient. **(12 Marks)**

b. Consider a finite wing with an aspect ratio of 8 and a taper ratio of 0.8. The airfoil section is thin and symmetric. Calculate the lift and induced drag coefficients for the wing when it is at an angle of attack of 5°. Assume that $\delta = \tau = 0.055$. **(08 Marks)**

Module-5

9 a. Describe the aerodynamic characteristics of swept wings with relevant graphs and sketches. **(10 Marks)**

b. What are high lift devices? Discuss in detail about the high lift devices. **(10 Marks)**

OR

10 Write short notes on the following:
a. Influence of downwash on tail plane
b. Ground effects
c. Critical Mach Number
d. Drag-Divergence Mach Number **(20 Marks)**

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