CBCS SCHEME

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17AE/AS42

Fourth Semester B.E. Degree Examination, Jan./Feb. 2021
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. Develop continuity equation for any finite control volume fixed in space. **(08 Marks)**

b. Explain the following aerodynamic flows :
   i) Inviscid Vs Viscous flow
   ii) Laminar Vs Turbulent flow
   iii) Steady Vs Unsteady flow
   iv) Rotational Vs Irrotational flow **(12 Marks)**

OR

2 a. Explain Mach Number regimes. **(10 Marks)**

b. Derive the relationship between the following :
   i) Stream function and velocity potential function
   ii) Circulation and Verticity. **(10 Marks)**

Module-2

3 a. Name the classifications of NACA airfoils and write down the explanation of the digits in each if the following :
   i) NACA 2414
   ii) NACA 23014
   iii) NACA 65-214 **(10 Marks)**

b. Consider an airfoil in a flow with a free stream velocity of 45.72m/s. The velocity at a given point on the airfoil is 68.58m/s. Calculate the pressure co-efficient at this point. **(04 Marks)**

c. Derive an expression for the pressure co-efficient for incompressible flow using Bernoulli's equation. **(06 Marks)**

OR

4 a. Define Aerodynamics center. Derive an expression for the location of the aerodynamics center. **(10 Marks)**

b. Consider the NACA 23012 airfoil. It shows that, at $\alpha = 4^\circ$, $C_\ell = 0.55$ and $C_{m,C/4} = -0.005$. The zero lift angle of attack is -1.1°. Also at $\alpha = -4^\circ$, $C_{m\,C/4} = -0.0125$. From the given information, calculate the location of the aerodynamic center. **(06 Marks)**

c. Explain the airfoil aerodynamic characteristics. **(04 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. **(12 Marks)**

b. Consider the lifting flow over a circular cylinder with a diameter of 0.5m. The free stream velocity is 25 m/s, and the maximum velocity on the surface of the cylinder is 75m/s. The free stream conditions are those for a standard altitude of 3km. Calculate the lift per unit span on the cylinder. Assume at altitude 3km, $\rho = 0.90926\ kg/m^3$. **(08 Marks)**

OR

6 a. Prove that the center of pressure is at the quarter – chord point for a symmetric airfoil. **(10 Marks)**

b. Consider a thin flat plate at 5 deg. angle of attack. Calculate the
   i) lift co –efficient
   ii) moment co-efficient about the leading edge
   iii) moment co-efficient about the quarter – chord point and
   iv) moment co-efficient about the trailing edge. **(10 Marks)**

Module-4

7 a. Derive the expression for the induced angle of attack and induced drag co-efficient using elliptical lift distribution. **(12 Marks)**

b. Consider a rectangular wing with an aspect ratio of 6, an induced drag factor $\delta = 0.055$, and a zero-lift angle of attack of -2°. At an angle of attack of 3.4°, the induced drag co-efficient for this wing is 0.01. Calculate the induced drag co-efficient for a similar wing (a rectangular wing with the same airfoil section) at the same angle of attack, but with an aspect ratio of 10.Assume $\delta = \tau$. Also, for AR =10, $\delta = 0.105$. **(08 Marks)**

OR

8 a. Obtain the expression for the velocity induced by infinite and Semi-infinite vortex filament using Biot – Savart law. **(10 Marks)**

b. Briefly explain Prandtl's Classical Lifting – Line theory and its Limitations. **(10 Marks)**

Module-5

9 Write short notes on the following :
   a) Formation of Flight
   b) Influence of downwash on fail plane
   c) Ground effect
   d) Simplified Horseshoe Vortex. **(20 Marks)**

OR

10 a. Briefly explain Critical Mach Number and Drag divergence Mach Number. **(08 Marks)**

b. Write short notes on Subsonic and Supersonic Leading edges. **(06 Marks)**

c. Explain Transonic area rule. **(06 Marks)**

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