CBCS SCHEME

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17AE/AS42

Fourth Semester B.E. Degree Examination, July/August 2021
Aerodynamics – I

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. Derive the integral form of momentum equation by control volume approach. **(10 Marks)**

b. Define the following:
i) Path line
ii) Streak line
iii) Circulation
iv) Stream function
v) Velocity potential function. **(10 Marks)**

2 a. Define Mach number. Derive the equation for speed of sound and explain Mach cone. **(10 Marks)**

b. Derive the relationship between stream function and velocity potential function. **(04 Marks)**

c. The velocity potential (ϕ) is given by an expression

$$\phi = \frac{-xy^3}{3} - x^2 + \frac{x^3 y}{3} + y^2$$

i) Find the velocity components in x and y direction.
ii) Show that ϕ represents a possible case of flow. **(06 Marks)**

3 a. With neat sketches, explain i) Airfoil nomenclature ii) Wing planform geometry. **(10 Marks)**

b. Explain the following:
i) Aerodynamic center
ii) Centre of pressure
iii) Pressure coefficient
iv) Aerodynamic forces and moments. **(10 Marks)**

4 a. Derive the relationship to calculate the aerodynamic forces N′ and A′ and the moment M'_{LE} in terms of P, θ and τ. **(12 Marks)**

b. Explain different types of drag. **(08 Marks)**

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)**

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)**

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)**

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)**

9 a. Explain the horse-shoe vortex system over a lifting wing. **(08 Marks)**

b. Discuss the advantages of swept wings in model airplane. **(04 Marks)**

c. Explain in detail about lift enhancing devices. **(08 Marks)**

10 a. Write short note on the following:
   i) Transonic area rule.
   ii) Super critical airfoil. **(08 Marks)**

b. What is critical Mach number and Tip effects? **(04 Marks)**

c. Explain in detail drag divergence. **(08 Marks)**

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