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10AE54

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

Time: 3 hrs. Max. Marks:100

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

1 a. Define and explain the compressibility. **(04 Marks)**

b. Distinguish between inviscid and viscous flow. **(04 Marks)**

c. Derive the integral form of momentum equation applied to a finite volume fixed in space flow. **(12 Marks)**

2 a. Derive an expression for angular velocity and vorticity. **(08 Marks)**

b. Define and briefly explain the following:
(i) Circulation.
(ii) Stream function.
(iii) Velocity potential. **(06 Marks)**

c. The stream function for a two-dimensional flow is given by $\psi = 2xy$, calculate the velocity at the point P(2, 3). Find the velocity potential function, ϕ. **(06 Marks)**

3 a. Obtain the expression for N′ and A′ in terms of τ, p and θ. **(08 Marks)**

b. Consider an airfoil with chord length 'C' and the running distance 'x' measured along the chord. The leading edge is located at $\frac{x}{c} = 0$ and the trailing edge at $\frac{x}{c} = 1$. The pressure co-efficient variations over the upper and lower surfaces are given, respectively, as

$$Cp,u = 1 - 300\left(\frac{x}{C}\right)^2 \text{ for } 0 \le \frac{x}{C} \le 0.1$$

$$Cp,u = -2.2277 + 2.2777\left(\frac{x}{C}\right) \text{ for } 0.1 \le \frac{x}{C} \le 1.0$$

$$Cp,l = 1 - 0.95\left(\frac{x}{C}\right) \text{ f}$$

Calculate the normal force coefficient. **(06 Marks)**

c. Define center of pressure. In low speed, incompressible flow, the following experimental data are obtained for an NACA 4412 airfoil section at an angle of attack of 4° : $C_l = 0.85$ and $C_{m_{c/4}} = -0.09$. Calculate the location of the center of pressure. **(06 Marks)**

4 a. Consider the nonlifting flow over a circular cylinder. Calculate the location on the surface of the cylinder where the surface pressure equals the free stream pressure. **(10 Marks)**

b. Prove that resultant stream lines will be circular arc passing through source and sink. **(10 Marks)**

5 a. Consider the lifting flow over a circular cylinder. The lift coefficient is 5, calculate the location of the stagnation points and the points on the cylinder where the pressure equals free stream static pressure. **(10 Marks)**

b. Consider a lifting flow over a circular cylinder. Derive the expression for the lift per unit span. Also discuss the location of stagnation points for various 'Γ'. **(10 Marks)**

6 a. Derive the relation for lift coefficient and lift slope for a cambered airfoil based on Classical thin airfoil theory. **(10 Marks)**

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

7 a. Explain i) Boundary layer ii) Displacement thickness iii) Momentum thickness. **(06 Marks)**

b. The velocity profile is a laminar boundary layer flow at zero frame gradient is approximated as

$\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$. Obtain the expression for $\frac{\delta}{x}$ and e_f, using the momentum integral equation. **(14 Marks)**

8 a. Write short notes on the following :
i) Open and closed circuit wind tunnels.
ii) Flow visualization techniques. **(10 Marks)**

b. Show that i) Lift slope = $\frac{d_{c\ell}}{d_\alpha} = 2\pi$ ii) Circle = $\frac{-\pi\alpha}{2}$ **(10 Marks)**

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