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10AE54

Fifth Semester B.E. Degree Examination, June/July 2017

Aerodynamics – I

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

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

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

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

$$Cp,l = 1 - 0.95\left(\frac{x}{C}\right) \quad \text{for } 0 \le \frac{x}{C} \le 1.0$$

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 $C_{m_{\frac{C}{4}}} = -0.09$. Calculate the location of the center of pressure. **(06 Marks)**

4 a. With a neat sketch, briefly explain the method to measure, flow velocity V_1 using pitot-static tube and derive the expression for the same. **(04 Marks)**

b. State and explain infinity boundary conditions and wall boundary conditions over any arbitrary body. **(06 Marks)**

c. Tabulate the velocity, ϕ and ψ expressions for, (i) Uniform flow in x-direction (ii) Source (iii) Vortex (iv) Doublet. **(10 Marks)**

PART – B

5 a. Consider a lifting flow over a circular cylinder and derive the expression following:
(i) Stream function
(ii) Location of stagnation points.
(iii) Pressure co-efficient. (10 Marks)

b. Consider the lifting flow over a circular cylinder. The lift co-efficient 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)

6 a. Briefly explain the following, with neat sketches and relevant expressions:
(i) Kelvin's circulation theorem.
(ii) The starting vortex.
(iii) Vortex sheet. (10 Marks)

b. Derive an expression for lift co-efficient for symmetric airfoil, using classical thin airfoil theory. (10 Marks)

7 a. Explain the boundary layer, with a relevant sketch. Derive the expressions for ,
(i) Displacement thickness.
(ii) Momentum thickness. (10 Marks)

b. Derive Navier-Stokes equations. (10 Marks)

8 a. With a neat sketch, explain the operation of open circuit and closed circuit wind tunnel. (10 Marks)

b. Name and describe two flow visualization techniques in low speed wind tunnels. (05 Marks)

c. Consider a low speed wind tunnel with a throat-to-inlet area ratio of 0.8 mounted in a flow at standard sea level conditions. If the pressure difference between the inlet and the throat is 335.16 Pa, calculate the velocity of the flow at the inlet. Take sea level density, $\rho = 1.225\ kg/m^3$. (05 Marks)

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