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10AE54

Fifth Semester B.E. Degree Examination, June/July 2016

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. Derive 3D continuity equation for incompressible flow. **(10 Marks)**

b. Explain briefly Mach number regimes with relevant sketches of flow over an airfoil and derive an expression for compressibility. **(10 Marks)**

2 a. Define following with relevant expressions.
i) Path line ii) streamline iii) Streak line iv) Angular velocity v) Circulation. **(10 Marks)**

b. Derive the integral form of continuity equation, according to control volume approach. **(10 Marks)**

3 a. Explain geometrical parameters of airfoil and wing geometry with neat sketch. **(10 Marks)**

b. Consider NACA 2412 airfoil with a chord of 0.64m in an airstream at standard sea level condition. The free steam velocity is 70m/s. The lift per unit span is 1254 N/m. Calculate the angle of attack and Drag per unit span [at $C_L = 0.65$, $\alpha = 4°$] where $C_D = 0.0068$. **(10 Marks)**

4 a. Derive momentum equation and hence deduce Bernoulli's equation and state its application. **(06 Marks)**

b. Define :
i) Sink
ii) Source
iii) Doublet **(04 Marks)**

c. Consider an airfoil at sea level condition with free stream velocity of 50m/s. At a given point on the airfoil, the pressure is 0.9×10^5 N/m^2. Calculate the velocity at that point (Assume standard sea level $P_\infty = 1.23$ kg/m^3 and $P_\infty = 1.01 \times 10^5$ N/m^2) **(10 Marks)**

PART – B

5 a. Explain D'Alembert's Paradox and Kutta Joukourki theorem. **(05 Marks)**

b. An aircraft has a wing span of 10m and chord of 2m. Calculate the surface area of the wing (s) and also calculate the magnitude of moment acting on the wing when $V_\infty = 100\text{m/s}$. [Assume $P_{sealevel} = 1.23\text{kg/m}^3$ & $C_m = 0.7$] **(05 Marks)**

c. Lifting flow over a cylinder obtain expression for the following
i) Stream function ψ
ii) Location of stagnation point 'θ'
iii) Pressure co-efficient 'C_p'
Also explain with a sketch the location of stagnation points for different values of 'Γ'. **(10 Marks)**

6 a. Briefly explain the following with a neat sketch and relevant expression
   i) Kelvin's circulation theorem
   ii) Thin Airfoil theory and prove $C_L = 2\pi\alpha$. **(10 Marks)**

   b. Consider a thin flat plate of 6° angle of attack.
   Calculate i) Lift co-efficient ii) Momentum co-efficient about leading edge. iii) Moment co- efficient about quarter chord point. **(10 Marks)**

7 a. Derive:
   i) Displacement Thickness
   ii) Momentum Thickness
   iii) Energy Thickness. **(10 Marks)**

   b. Consider a flat plate at zero angle of attack in an airflow at standard sea level condition $\left(\rho_\infty = 1.01\times10^5 \text{N/m}^2 \text{ and } T_\infty = 288\text{K}\right)$. The chord length of the plate is 2 m. The platform area of the plate is 40 m^2. At standard sea level condition $\mu_\infty = 1.7894\times10^{-5}$ kg/m (s). Assume the wall temperature is adiabatic wall temperature T_{aw}.
   Calculate the friction drag on the plate when free stream velocity is 100m/s. **(10 Marks)**

8 a. Sketch neatly open circuit wind tunnel and explain its operations. Mention the advantages of open circuit wind Tunnel. **(10 Marks)**

   b. List the various methods of visualization techniques at low speed and high speed wind Tunnel. **(02 Marks)**

   c. With neat sketch, explain in detail the smoke and tuft flow visualization techniques in wind tunnel. **(08 Marks)**

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