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10AE54

Fifth Semester B.E. Degree Examination, Aug./Sept. 2020
Aerodynamics – I

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Classify the flow regimes based on Mach number with suitable sketches. **(08 Marks)**

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

2 a. Differentiate between path line, stream line and streak line. **(04 Marks)**

b. Consider a uniform flow with velocity V_∞. Show that this flow is a physically possible incompressible flow and also irrotational. **(08 Marks)**

c. Derive the relationship between the following:
i) Stream function and velocity potential function.
ii) Circulation and vorticity. **(08 Marks)**

3 a. The NACA4412 airfoil has a mean camber line given by

$$\frac{Z}{C} = \begin{cases} 0.25\left[0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right] & \text{for } 0 \le \frac{x}{c} \le 0.4 \\ 0.111\left[0.2 + 0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right] & \text{for } 0.4 \le \frac{x}{c} \le 1 \end{cases}$$

Using thin air foil theory calculate: i) $\alpha_{L=0}$ ii) Cl when $\alpha = 3°$ iii) also calculate C_m, c/4 and x_{c_p}/c when $\alpha = 3°$ **(14 Marks)**

b. For the NACA 2412 airfoil, the lift coefficient and moment coefficient about quarter-chord at -6° angle of attack are -0.39 and -0.045 respectively. At 4° angle of attack, these co-efficient are 0.65 and -0.037 respectively. Calculate the location of aerodynamic center. **(06 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 $V_\infty = 100 m/s$. [Assume $P_{sealevel} = 1.23 kg/m^3$ & $C_m = 0.7$] **(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. 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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