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10AE54

Fifth Semester B.E. Degree Examination, Dec.2014/Jan.2015
Aerodynamics – I

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast 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 airfoil 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. Consider the non-lifting flow over cylinder circular in cross section. Derive an expression for the pressure coefficient as, $C_p = 1 - 4\sin^2\theta$, considering an arbitrary point (r, θ) in the flow. **(06 Marks)**

b. Show that the source flow is a physically possible in compressible flow every where except at the origin. Also show that it is irrotational everywhere. **(10 Marks)**

c. Consider a low-speed open circuit subsonic wind tunnel with an inlet to throat area ratio of 12. The tunnel is turned on, and the pressure difference between the inlet (settling chamber) and the test section is read as a height difference of 10cm on a U-tube mercury manometer. Calculate the velocity of air in the test section. **(04 Marks)**

PART – B

5 a. Write short notes on the following:
i) D' Alemberts paradox ii) Magnus effect. **(08 Marks)**

b. Consider a lifting flow over a circular cylinder with a diameter of 0.5m. The free stream velocity is 30m/s and the maximum velocity on the surface of the cylinder is 75 m/s. The free stream conditions are those for a standard altitude of 3km, having a density of 0.90926 kg/m^3. Calculate the lift per unit span on the cylinder. **(06 Marks)**

c. For a flow over a circular cylinder, the lift coefficient is 5. Calculate the following:
i) Maximum negative pressure coefficient.
ii) Values of θ, where $P = P_\infty$. **(06 Marks)**

6 a. Explain briefly about Kelvin's circulation theorem and starting vortex. **(10 Marks)**

b. Derive the relation for lift coefficient and lift slope for a symmetrical airfoil based on classical thin airfoil theory. **(10 Marks)**

7 a. The velocity profile for a laminar boundary layer over a flat plate is given by, $\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^2$. Determine the boundary layer thickness and shear stress at the wall interms of Reynold's number. **(12 Marks)**

b. Write short notes on flow separation and airfoil stall. **(08 Marks)**

8 a. Explain the construction and working of various components in a typical subsonic open circuit wind tunnel with neat sketch. **(10 Marks)**

b. Stating the importance of flow visualization, explain about the operation and working of smoke and tuft flow visualization techniques. **(10 Marks)**

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