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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2008.

Fourth Semester

Aeronautical Engineering

AE 1251 — AERODYNAMICS — I

(Regulation 2004)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define streamline and stream function.
2. Differentiate between free and forced vortex.
3. What is meant by irrotational flow?
4. What is a doublet? Sketch its streamline pattern.
5. Consider a circular cylinder kept in a uniform flow of free stream velocity 100 m/s. The velocity at a given point on the cylinder is 200 m/s. Calculate the pressure coefficient at this point.
6. State Blasius theorem.
7. What is horse shoe vortex?
8. What are the limitations of Prandtl's lifting line theory?
9. Define momentum thickness.
10. What is the physical interpretation of displacement thickness?

11. (a) A thin airfoil has a camberline defined by the relation $y = kx(x-1)(x-2)$ where x and y are its coordinates expressed in terms of unit chord and the origin is at the leading edge. If the maximum camber is 2% of the chord, determine
- the lift coefficient at 3° angle of incidence
 - the angle incidence at zero lift
- based on thin airfoil theory.

Or

- (b) For the above airfoil determine :
- the pitching moment coefficient about quarter chord point.
 - the location of centre of pressure in terms of unit chord at 3° angle of incidence.
12. (a) (i) Does the velocity potential function $\phi = 2(x^2 + 2y - y^2)$ describe the possible flow of an incompressible fluid? If so, find out the equation for the velocity vector \vec{V} . Also determine the equation for streamlines. (8)
- (ii) The radial velocity of a flow is described by $U_r = \frac{k}{\sqrt{r}} \cos \theta$. If $U_\theta = 0$ at $\theta = 0$, find out U_θ and the stream function for the flow. Also find out the potential function for the flow. (8)

Or

- (b) (i) Derive the continuity equation in polar coordinates. (8)
- (ii) Consider a circular cylinder of radius R , kept in a uniform flow which is flowing in positive X-direction with respect to a standard X-Y coordinate system. A clockwise circulation of strength Γ is imposed on the flow. The lift coefficient is estimated to be 5. Calculate the maximum negative pressure coefficient on the cylinder. (8)

13. (a) (i) Derive the momentum equation for three dimensional incompressible inviscid flow. (8)
- (ii) Show that streamlines and equipotential lines intersect each other at right angles. (3)
- (iii) Draw the surface pressure distribution in the case of flow over a circular cylinder for both ideal and real flow and briefly explain. (5)

Or

- (b) (i) Show that the combination of uniform stream, doublet and line vortex is equivalent to a spinning cylinder in a uniform flow and obtain an expression for lift per unit span of the cylinder. (10)
- (ii) Discuss briefly the significance of the expression obtained highlighting its practical application. (6)
14. (a) Based on the principle of conformal transformation show that a circle can be transformed into a cambered airfoil and obtain an expression for its thickness to chord ratio.

Or

- (b) (i) Write short notes on Karman-Trefftz profiles. (6)
- (ii) State Biot-Savart law. (2)
- (iii) Based on Biot-Savart law obtain an expression for the velocity induced at a point due to a semi-infinite vortex filament. (8)
15. (a) Derive the fundamental equation of Prandtl's lifting line theory and obtain an expression for induced drag coefficient for elliptic lift distribution.

Or

- (b) Air at standard conditions flows over a flat plate kept parallel to the flow. The free stream velocity is 4 m/s. Assume a velocity profile given by $\frac{u}{U_\infty} = \frac{3}{2} \left(\frac{y}{\delta} \right) - \frac{1}{2} \left(\frac{y}{\delta} \right)^3$. For air, kinematic viscosity is 1.5×10^{-5} m²/s and density is 1.226 kg/m³ at standard atmospheric conditions at sea level.
- Estimate the boundary layer thickness and wall shear stress at $x = 2$ m from the leading edge of the plate.