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Question Paper Code : 52525

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Fourth Semester

Aeronautical Engineering

AE 6401 – AERODYNAMICS – I

(Regulation 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define divergence of Vector field.

2. Consider the velocity field given by $u = y/(x^2 + y^2)$ and $v = -x/(x^2 + y^2)$. Calculate the vorticity.

3. Define D'Alembert's paradox.

4. What is starting vortex?

5. State Cauchy – Riemann relation.

6. List the important theoretical results for a symmetric airfoil from thin airfoil theory.

7. What is meant by trailing vortex?

8. Define aerodynamic twists.

9. Sketch the velocity and temperature profile within the boundary layer.

10. What are factors which encourage transition from laminar to turbulent flow?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Show that the slope of an equipotential line is the negative reciprocal of the slope of a streamline. (5)

(ii) When a line source-sink pair with m = 2 m²/s is combined with a uniform stream, it forms a Rankine oval whose minimum dimension is 40 cm, as shown in Fig. 11(a). If a = 15 cm, what are the stream velocity and the maximum velocity? What is the length? (8)

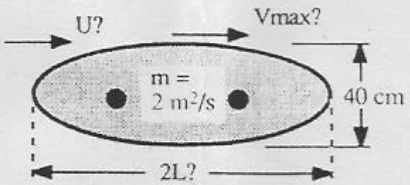

Fig. 11 (a)

Or

(b) What is doublet? Obtain stream function and velocity potential for a doublet flow.

12. (a) (i) Consider the non lifting flow over a circular cylinder of a given radius. Where the velocity is 20 m/s. if velocity is doubled as 40 m/s, does the shape of the streamline, change? Explain. (8)

(ii) State and prove Kelvin's circulation theorem. (5)

Or

(b) (i) Show that the local jump is tangential velocity across the vortex sheet is equal to the local sheet strength. (6)

(ii) Illustrate in detail about the qualitative aspect of various flow field behind the real flow over circular cylinder. (7)

13. (a) Transform the uniform flow parallel to x-axis of the physical plane, with the transformation function $\zeta = z^2$.

Or

(b) For a wing with root chord 18 m, tip chord 3.5 m and span 25 m, calculate the wing area, aspect ratio, taper ratio and the mean aerodynamic chord.

14. (a) A wing of elliptic planform, of aspect ratio 7, wing area 26 m^2, in level flight at an altitude of 3000 m with a speed of 88 m/s, supports a weight of 38,000 N. Determine (i) the lift coefficient, (ii) the circulation at the mid-span (iii) the induced drag coefficient and (iv) the downwash induced by the trailing vortex.

Or

(b) The variation of circulation over a wing having elliptic plan form with span 'b' is given below :

$$L'(y) = \rho_\infty \cup_\infty \Gamma_0 \sqrt{1 - \left(\frac{2y}{b}\right)^2}$$

Determine :

(i) Downwash

(ii) Induced angle of attack

(iii) Induced drag.

15. (a) Consider a laminar flow over on a flat plate at zero incidence with uniform velocity U. And velocity distribution across the boundary layer is linear variation, so that satisfying the boundary condition $u = 0$ when $y = 0$ and $u = U$ when $y = \delta$. Determine displacement thickness, momentum thickness, shape parameter and boundary thickness.

Or

(b) Consider a flow over a horizontal flat plate (1.25 m × 2.5 m) with velocity 3.0 m/s. Calculate

(i) Boundary layer thickness at the trailing edge

(ii) Shear stress at the middle of the flat plate

(iii) Resultant drag force on both sides of the flat plate

(Take $\rho = 850$ kg/m^3, $\upsilon = 10^{-5}$ m^2/s)

PART C — (1 × 15 = 15 marks)

16. (a) Consider an airfoil with chord length c and the running distance x measured along the chord. The leading edge is located at $x/c = 0$ and the trailing edge at $x/c = 1$. The pressure coefficient variations over the upper and lower surfaces are given, respectively, as

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

$$C_{p,u} = -2.2277 + 2.2777\frac{x}{c} \quad \text{for} \quad 0.1 \le \frac{x}{c} \le 1.0$$

$$C_{p,l} = 1 - 0.95\frac{x}{c} \quad \text{for} \quad 0 \le \frac{x}{c} \le 1.0$$

Calculate the normal force coefficient.

Or

(b) Find the resultant velocity vector induced at point A in Fig. 16(b) due to the combination of uniform stream, line source, line sink and line vortex.

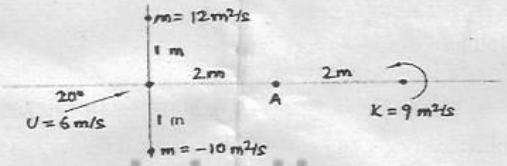

Fig. 16 (b)

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