Reg. No. :

Question Paper Code : 90067

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Fourth Semester

Aeronautical Engineering

AE 8401 — AERODYNAMICS – I

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define rotational and irrotational flow.
2. What is meant by equipotential lines?
3. What is meant by Magnus effect?
4. Write short note on d'Alembert's paradox.
5. What is meant by complex potential?
6. What is meant by Cauchy-Riemann relations?
7. What is meant by geometric twist of a wing? How it differs from aerodynamic twist.
8. What is the difference between bound vortex and trailing vortex?
9. What is meant by laminar sublayer?
10. Define critical Reynolds number.

PART B — (5 × 13 = 65 marks)

11. (a) Derive the 2-D momentum equations for incompressible flows and deduce the steady Euler equations.

Or

(b) Obtain the stagnation points for the flow over a non-lifting circular cylinder by combining elementary flows.

12. (a) State and prove Kutta Joukowski theorem.

Or

(b) (i) With neat illustrations, explain the real and ideal flow over a smooth and rough circular cylinder. (8)

(ii) State the Kutta condition with a neat sketch. (5)

13. (a) By using Kutta-Joukowski transformation, transform a circle into unsymmetrical airfoil profile and also find the thickness to chord ratio.

Or

(b) (i) Derive the fundamental equation of thin airfoil theory. (8)

(ii) Find the complex potential function and complex velocity for the vortex flow. (5)

14. (a) State Biot-Savart law and derive an expression for the velocity induced by an infinite vortex filament at a point, which is at a distance 'n' from the filament.

Or

(b) (i) For a wing with elliptic spanwise circulation, show that the downwash and induced angle of attack are constant along the span. (8)

(ii) A wing with an elliptical planform and an elliptical lift distribution has an aspect ratio of 6 and a span of 12 m. The wing loading is 900 N/m^2 when flying at a speed of 150 km/hr at sea level. Compute the induced drag for this wing. (5)

15. (a) Derive the boundary layer equations for a steady, two dimensional incompressible flow over a flat plate.

Or

(b) Define and drive the expression for the following with appropriate sketches wherever necessary.

(i) Displacement thickness. (7)

(ii) Momentum thickness. (6)

PART C — (1 × 15 = 15 marks)

16. (a) (i) Show that the equation for the streamlines in doublet flow is a circle with a diameter 'd' on the vertical axis with centre located at 'd/2' above the origin. (10)

(ii) The stream function for a two-dimensional flow is given by $\psi = 2xy$, calculate the velocity at the point P (2, 3). Find the velocity potential function. (5)

Or

(b) (i) Air flows over a flat plate of 1 m × 0.5 m size kept parallel to the flow in a stream of velocity 5 m/s. Assuming a velocity profile given by $\frac{u}{U} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$, kinematic viscosity and density of air as 1.5×10^{-5} m²/s and 1.226 kg/m³ respectively, estimate

(1) Boundary layer thickness at 0.75 m from the leading edge of the plate and

(2) The drag on one side of the plate. (10)

(ii) Consider the non-lifting flow over a circular cylinder. Calculate the locations on the surface of the cylinder where the surface pressure equals the freestream pressure. (5)