

PART B — (5 × 16 = 80 marks)

11. (a) (i) Derive the steady three dimensional flow continuity equation in partial differential form using finite volume approach. (12)
- (ii) Check whether the flow is possible with the following velocity components.
- $$u = -2x^2y + 4yzx ; v = 2xy^2 + 4x^2yz ; w = -2x^2z^2 - 2z^2y. \quad (4)$$

Or

- (b) (i) Derive the Euler's equations of motion for 3-d incompressible, steady flows. (10)
- (ii) Show how Bernoulli's equation and hydrostatic equation can be deduced from Euler's equation. (6)
12. (a) (i) What is Magnus effect? Mention a few applications of this effect. (4)
- (ii) Show that the combination of a doublet flow and uniform flow is equivalent to a non-lifting flow over a circular cylinder, Obtain expressions for the velocity potential, stream function and the location of stagnation points. (12)

Or

- (b) (i) State and prove Kutta-Joukowski's theorem. (12)
- (ii) Sketch the flow pattern over an aerofoil for
- $$\Gamma < \Gamma_{Kutta} ; \Gamma = \Gamma_{Kutta} \text{ and } \Gamma > \Gamma_{Kutta} ;$$
- Where Γ denotes the circulation over the aerofoil. (4)
13. (a) (i) Explain Joukowski's transformation to obtain a symmetrical aerofoil profile from a circle. (10)
- (ii) Using the above transformation show how a flat plate of length 'l' can be obtained. (6)

Or

- (b) Write short notes on the following :
- (i) Von Mises and Karman-Trefftz profiles.
- (ii) Assumptions of thin aerofoil theory.
- (iii) Pressure distribution on circular Cylinder in ideal and real flows.
- (iv) Bluff and Streamlined bodies. (4 × 4 = 16)

14. (a) (i) Using Biot-Savart law derive an expression for the induced velocity at a point by a semi-infinite vortex filament. (8)
- (ii) Based on the lifting line theory show that the downwash is constant over the span for elliptic lift distribution. (8)

Or

- (b) (i) Explain the horse-shoe vortex system over a lifting wing. (6)
- (ii) What are the limitations of the lifting line theory? (4)
- (iii) Explain how induced drag is produced by a lifting wing. (6)
15. (a) (i) Explain the phenomenon of boundary layer separation with a neat sketch. (8)
- (ii) Prove that the laminar boundary layer thickness on a flat plate at a distance x from the leading edge is proportional to $x/\sqrt{R_{ex}}$. (8)

Or

- (b) (i) Derive the Von Karman momentum integral equation for boundary layer flows. (6)
- (ii) Using the above theorem derive expressions for the boundary layer thickness and the drag coefficient over one side viscous flow of a flat plate in laminar flow. (5 + 5)
