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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fourth Semester

Aeronautical Engineering

AE 3401 — AERODYNAMICS – I

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What are the conditions of Stokes theorem?

2. Consider the lifting flow over a circular cylinder of a given radius and with a given circulation. If $V\infty$ is doubled, keeping the circulation the same, does the shape of the streamlines change? Explain.

3. Write all three kutta conditions.

4. How is D Alembert's paradox resolved?

5. List the properties of potential function?

6. What are the assumptions for thin airfoil theory?

7. State Biot and Savart law.

8. What causes vortices on aircraft?

9. Define shape factor and critical Reynolds number.

10. Reduced drag and lift are benefits of frictionless wing surfaces. Justify.

PART B — (5 × 13 = 65 marks)

11. (a) Derive an expression for the Angular velocity and vorticity of a fluid element in three-dimensional space.

Or

(b) Derive the equation for non-lifting flow over circular cylinder and state the assumptions made.

12. (a) Illustrate the ideal flow over circular cylinder with examples.

Or

(b) State and prove Kutta Joukowski's theorem.

13. (a) The circle $|\zeta| = a$ is mapped into the flat-plate aerofoil under the transformation $Z = \zeta + \frac{a^2}{\zeta}$. Show that, near $z = 2a$, we have the property $\frac{d\zeta}{dz} = \frac{1}{2}\frac{\sqrt{a}}{\sqrt{z-2a}}$, approximately.

Or

(b) Derive the fundamental equation for thin airfoil theory and give the assumptions that are made in thin aerofoil theory.

14. (a) Derive the fundamental equation of Prandtl's lifting-line theory.

Or

(b) Explain the following:

(i) Biot Sarvart Law (6)

(ii) Bound vortex and trailing vortex (7)

15. (a) Assume that air 25°C and normal atmospheric pressure flows over a smooth, flat plate with a velocity of 25 m/s. The initial boundary layer is laminar and then becomes turbulent at a transitional Reynolds number of the plate is 3 m long and 1 m wide. What will be the average resistance coefficient C_f for the plate? Also, what is the total shearing resistance of one side of the plate, and what will be the resistance due to the turbulent part and the laminar part of the boundary layer? (take density = 1.2 kg/m³, kinematic viscosity = 1 .51 × 10- m²/s).

Or.

(b) Obtain the displacement, momentum and energy thickness for the given velocity profile. $u/U = 2(y/\delta) - (y/\delta)^2$.

PART C — (1 × 15 = 15 marks)

16. (a) For the velocity distributions given below for laminar boundary layer on a flat plate, obtain expression for the boundary layer thickness, local drag coefficient and shear stress. $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$.

Or

(b) Clearly explain the method of obtaining the Zoukowski transformation to get a cambered airfoil.
