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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B E | **Semester: IV**
Branch: Aerospace Engineering | **Duration: 3 hrs.**
Course Code: 19AE4DCBAD | **Max Marks: 100**
Course: Basic Aerodynamics | **Date: 13.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) Discuss the Rankine's vortex and it's practical implications. **6**

b) Consider a non-lifting flow over a circular cylinder of a given radius, where $U_\infty = 1\ m/s$. Draw the streamline pattern for this case. If a small circulation of $\Gamma = 0.3\ m^2/s$ is added, calculate the amount of lift produced at standard sea-level conditions. Draw the streamline pattern for the flow over this rotating cylinder. Compare the streamline patterns for both cases. **6**

c) State Biot-Savart's law. Derive an expression for the velocity induced by the linear vortex of finite length using this law. **8**

UNIT - II

2 a) Explain, with a neat sketch, the airfoil nomenclature. **6**

b) Define (i) Center of pressure and (ii) Aerodynamic center. **4**

c) A thin airfoil made of circular arc camber line given by **10**

$$\frac{y}{c} = 4h\frac{x}{c}\left(1 - \frac{x}{c}\right)$$

Show that the zero lift angle α_0 is equal to $-2h$.

OR

3 a) Derive the expression $c_L = 2\pi\alpha$ for a flat plate, using the classical thin airfoil theory. **10**

b) Consider an airfoil at $12°$ angle of attack. The normal and axial force coefficients are 1.2 and 0.3 respectively. Calculate the lift and drag coefficients. **4**

c) Prove that, for a given system of forces and moments on the airfoil, the location of center of pressure is given as $k_{CP} = -\frac{c_{M_{LE}}}{c_L}$. **6**

UNIT - III

4 a) Consider an aircraft of wing area S, and drag coefficient C_D, flying at a speed of V_∞ in free stream air of density ρ_∞. If its single actuator, of disc area A, produces a thrust equal to the aircraft drag, show that the speed in the slipstream, V_s, based on simple momentum theory is given by **8**

$$V_s = V_\infty \sqrt{1 + C_D \frac{S}{A}}$$

b) Using blade element theory derive the expression for the efficiency of the propeller in terms of axial inflow factor and rotational inflow factor. **12**

UNIT - IV

5 a) Explain the Horseshoe vortex system and it's implication in modelling the finite wing. **8**

b) Define: Aspect Ratio and Taper Ratio. Explain the importance of both in a finite wing. **8**

c) Derive the expression for the induced downwash at the mid-bird's C.G., if three birds represented by HSV model are flying side by side. The wing span of each bird is 'b', the strength of each HSV is 'Γ', and the bound vortices of all the birds are in the same line. Neglect the distance between the birds. **4**

UNIT - V

6 a) Define source sheet. Explain the procedure to calculate the pressure coefficient at the control point over the surface of any arbitrary shaped body, using source panel method. **10**

b) Using the method of singularities, construct the flow field developed by superimposing a sink and a vortex. What is the practical implication of this combination? **5**

c) Consider two different points on the surface of an airplane wing flying at $80\ m/s$. At a particular cross-section of the wing, the pressure coefficient and flow velocity at point 1 are -1.3 and $100\ m/s$, respectively. The pressure coefficient at point 2 is -0.8. Assuming incompressible flow, calculate the flow velocity at point 2. **5**

OR

7 a) Discuss the effects of propeller on the tail plane of an aircraft. **5**

b) An airplane weighs 150 kN has flaps. The maximum lift coefficient at subsonic speed is 1.15. Calculate stalling speed at sea level. The area of wing of the airplane is 18 m^2 $\left(\rho_{SL} = 1.23 \frac{kg}{m^3}\right)$ **5**

c) Explain the following with neat sketches: **10**

(i) Drag divergence Mach number.

(ii) Transonic area rule.

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