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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: V**
Branch: Aerospace Engineering | **Duration: 3 hrs.**
Course Code: 20AE5DCBFM | **Max Marks: 100**
Course: Basic Flight Mechanics | **Date: 13.09.2023**

Instructions: 1. Draw figures/expressions wherever necessary.
2. Assume suitable data wherever necessary.

UNIT - I

1. a) Prove that $c_{D,0} = \frac{1}{3} c_{D,i}$ for the power required for a steady level, unaccelerated flight. **15**

   b) Consider the Northrop F-5 fighter airplane, which has a wing area in 16 m^2 and wing span of 7.7 m. The wing is generating 80068 N of lift. For a flight velocity of 112 m/s at standard sea level, Calculate the lift co-efficient, induced drag co-efficient and induced drag. (Assume e = 0.8) **5**

OR

2. a) Estimate the landing ground roll distance at sea level for the Jet powered aircraft (CJ-1) whose mass is 5603 kg with wing area 29.54 m^2. The zero-lift drag co-efficient is 0.02. No thrust reversal is used, however, spoilers are employed such that L=0. The spoilers increase the zero-lift drag-coefficient by 10 percent. The fuel tanks are essentially empty, so neglect the weight of any fuel carried by the airplane. The maximum lift co-efficient, with flaps fully employed at touchdown is 2.5 and the co-efficient of rolling friction is 0.4. **10**

   b) Derive the Bruguet endurance formula for a propeller-driven airplane and explain how to maximize the same. **10**

UNIT - II

3. a) Consider the propeller driven executive airplane CP-1 having the normal gross weight, wingspan and wing area to be 13,138.533 N, 10.919 m, 16.16 m^2 respectively. The maximum lift to drag ratio for CP-1 is 13.6 (C_L = 0.634). Calculate the minimum glide angle and the maximum range measured along the ground covered by the CP-1 in a power off glide that starts at an altitude of 3,048 m (ρ_∞ = 0.9048 kg/m^3) and 610 m (ρ_∞ = 1.1549 kg/m^3). Also, calculate the equilibrium glide velocities for different altitudes, corresponding to the minimum glide angle. **5**

b) Estimate the lift-off distance for the Jet powered airplane (CJ-1) at sea level with mass 8988 kg, wingspan 16.25 m, wing area 29.54 m^2 with zero-lift parasite drag co-efficient is 0.02 having a thrust of 32,472 N and the Oswald's efficiency factor is 0.81. Assume a paved runway having μ_r = 0.02. Also, during the ground roll, the angle of attack of the airplane is restricted by the requirement that the tail not drag the ground, and therefore, assume that C_{Lmax} during the ground roll is limited to 1.0. Also, when the airplane is on the ground, the wings are 1.83 m above the ground. [Note: The average force is calculated based on Shevell's suggestion of being equal to 0.7 VLO which is considered as the freestream velocity.] **7**

c) Write short notes on V-n diagram. **8**

UNIT - III

4. a) State the criteria for longitudinal static stability from the illustration of static stability and instability. **15**

b) Explain briefly the control surfaces of the airplane. **5**

OR

5. a) A wing body model is tested in a subsonic wind tunnel. The lift is found to be zero at a geometric angle of attack α = -1.5°. At α =5°, the lift co-efficient is measured as 0.52. Also, at α =1.0° and 7.88°, the moment co-efficient about the center of gravity are measured as -0.01 and 0.05, respectively. The center of gravity is located at 0.35c from the leading edge. Calculate the location of the aerodynamic center and the value $C_{M,ac\ wb}$. **5**

b) Prove that the neutral point is the aerodynamic center of the complete airplane. **8**

c) Show that the satic margin is a direct measure of static stability. **7**

UNIT - IV

6. a) Explain how the elevator helps in changing the value of $C_{M,0}$ and hence changing the trimmed angle of attack for different flight speeds. **20**

UNIT - V

7. a) A tilt rotor has a gross weight of 25,500 kg. The rotor diameter is 12 m. On the basis of momentum theory, estimate the power required for the helicopter to hover at the sea level conditions. Assume that the figure of merit of the rotor is 0.8 and the transmission losses ≈ 5%. **5**

b) Derive the ratio of induced flow velocity to the hovering velocity for an axial climb for a helicopter through momentum analysis. **15**

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