B.E. Mechanical Engineering - Third Year - Second Semester, 2024

SUBJECT: Aerodynamics

Time: Three hours | Full Marks 100

[Answer any 5 (five)]

Q1. Justify the following statements:
a. In a 2D analysis of aerofoil with infinite span hypothesis, no induced drag can be generated
b. Without Drag no Lift can be achieved
c. Two high speed vehicles moving side by side tend to attract one another [6+7+7]

Q2. a. Consider a model of wing-body shape mounted in a wind tunnel. The flow conditions in the test section are standard sea level properties with a velocity of 100m/s. The wing area and chord are 1.5 sqm and 0.45m respectively. The zero lift moment about centre of gravity is found to be - 12.4Nm. When the model is pitched to another angle of attack, the lift and moment about CG are measured to be 3675N and 20.67Nm respectively. Find the location of aerodynamic centre and calculate the moment co-efficient about the same.
b. If a mass is added in a way that the CG is shifted rearwards by 0.2c, calculate the moment about CG when the lift is 4000N.
c. Assume a horizontal tail with no elevator is added to this model. The distance of the tail's aerodynamic centre from the CG of the airplane model is 1.0m. The area of the tail is 0.4 sqm, the tail setting angle being 2 degree. The lift slope of the tail is 0.12 per degree. From experimental measurements, α_a = 5degree, ε_0 = 0.01 and $\delta\varepsilon/\delta\alpha$ = 0.42. If the lift at absolute angle of attack if 4134N, calculate the moment about CG. Does this model have longitudinal static stability and balance? [5+5+10]

Q3. a. Explain the nomenclature NACA2412.
b. Find out the contribution of wing and tail to the total pitching moment about the centre of gravity of an airplane and find out the expression for the co - efficient of the same. [4+16]

Q4. Write short notes on
a. 'Camber' and 'Mean Camber line' of an aerofoil, b. Kelvin's Circulation Theorem and Starting Vortex
c. Aerodynamic Centre, d. Canard Configuration [4+6+4+6]

Q5. a. What frequency of oscillation is expected when air of kinematic viscosity 15 sqmm/s flows at 25m/s past a 4 mm diameter telephone wire which is perpendicular to the air stream.
b. Deduce the Fundamental equation of Thin Aerofoil theory. Using the same find out the Lift slope for a symmetric aerofoil. [4+16]

Q6. a. Explain the working principles of Vertical and Horizontal Stabilizers associated to the longitudinal, lateral and directional control of an airplane.
b. Briefly discuss about maneuvering of a helicopter in the air using the main rotor and tail rotor. [12+8]

Q7. a. Starting from the concept of Vortex Sheet, explain Kutta Condition associated to Lifting flow around an aerofoil.

b. Consider an infinitely thin plate of 1 m chord at an angle of attack of 10 degree in a supersonic flow. The pressure and shear stress distribution of upper and lower surfaces respectively are:

$p_u = 4 \times 10^4 (x\text{-}1)^{0.2} + 5.4 \times 10^4$

$p_l = 2 \times 10^4 (x\text{-}1)^{0.2} + 1.7 \times 10^5$

$\tau_u = 288x^{-0.2}$

$\tau_l = 731x^{-0.2}$

where x is the distance from the leading edge in meter and p and τ are in N/m^2. Calculate the lift and drag, moment about the quarter chord point, all per unit span. Locate the centre of pressure. [12+8]