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15AE42

Fourth Semester B.E. Degree Examination, July/August 2022
Aerodynamics – I

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain briefly Mach number regimes with relevant sketches of flow over an air foil. **(08 Marks)**

b. Consider the velocity field given by $u = \frac{y}{(x^2+y^2)}$ and $v = \frac{-x}{(x^2+y^2)}$. Calculate the equation of the stream line passing through the point (0, 5) and also calculate the vorticity. **(08 Marks)**

OR

2 a. Define following with relevant expressions:
(i) Path line (ii) Stream line (iii) Angular velocity (iv) Circulation **(08 Marks)**

b. Derive the integral form of momentum equation, according to control volume approach. **(08 Marks)**

Module-2

3 a. Explain airfoil section nomenclature and wing planform geometry with a neat sketch. **(08 Marks)**

b. Obtain the expression for N′ and A′ in terms of z, P and θ. Deduce C_n and C_a. **(08 Marks)**

OR

4 a. Explain briefly the center of pressure and aerodynamic center. **(08 Marks)**

b. Consider the NACA 23012 airfoil. At $\alpha = 4°$, $C_\ell = 0.55$ and $C_{mc/4} = -0.005$. The zero-lift angle of attack is -1.1°. Also, at $\alpha = -4°$, $C_{mc/4} = -0.0125$. Calculate the location of the aerodynamic center for the NACA 23012 airfoil. **(08 Marks)**

Module-3

5 a. Obtain an expression for the following for a lifting flow over cylinder:
(i) Stream function (ψ) (ii) Location of stagnation points (iii) Pressure co-efficient. **(08 Marks)**

b. Consider the lifting flow over a circular cylinder with a diameter of 0.5m. The freestream velocity is 25 m/s and the maximum velocity on the surface of the cylinder is 75m/s. The free stream conditions are those for a standard altitude of 3 km. Calculate the lift per unit span on the cylinder. [Assume $\rho = 0.90926$ kg/m^3 at 3 km altitude, maximum velocity occurs at when $\theta = 90°$.] **(08 Marks)**

OR

6 a. Write short notes on the following :
(i) Kutta condition (ii) Kelvin's circulation theorem. **(08 Marks)**

b. Using classical thin airfoil theorem, obtain the expression $C_\ell = 2\pi\alpha$ for a symmetric airfoil. **(08 Marks)**

Module-4

7 a. Obtain the expression for the velocity, induced by infinite and semi-finite vortex element using the Biot-Savart law. **(08 Marks)**

b. Explain Downwash and induced drag. **(08 Marks)**

OR

8 a. The circulation distribution over a finite wing is of elliptic form

$\Gamma_{(y)} = \Gamma_0 \sqrt{1-\left(\frac{2y}{b}\right)^2}$, where b/2 is the semispan of wing. Obtain the closed form of expression, the induced angle of attack and induced drag co-efficient. **(08 Marks)**

b. Consider a finite wing with an aspect ratio of 8 and taper ratio of 0.8. The airfoil section is thin and symmetric. Calculate the lift and induced drag coefficient for the wing when it is at an angle of attack of 5°. Assume that $\sigma = \tau = 0.055$. **(08 Marks)**

Module-5

9 a. Briefly explain simplified horse-shoe vortex model and formation flight. **(08 Marks)**

b. What are high lift devices? List them. Explain their effects on aerodynamics characteristics. **(08 Marks)**

OR

10 a. What is swept wing? Bring out the aerodynamics characteristics of swept wing, with relevant graphs and sketches. **(08 Marks)**

b. Explain :

(i) Drag – Divergence Mach number

(ii) Transonic area rule. **(08 Marks)**

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