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10AE54

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Aerodynamics - I

Time: 3 hrs. Max. Marks:100

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.

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART - A

1 a. Distinguish between inviscid and viscous flow. **(04 Marks)**
b. Explain Mach number regimes with a neat sketch. **(06 Marks)**
c. The air speed indicator fitted to an airplane has no instrument error, the airplane is flying at ISA condition and the airspeed indicator indicates 900 kmph. What is the true air speed? Given $\gamma = 1.4$, $\rho_{SL} = 1.226$ kg/m^3, sonic velocity at S.L. = 340.3 m/sec. Comment on the answer. **(10 Marks)**

2 a. Bring out the essential difference between Eulerian and Langrangian approach to fluid flow. **(04 Marks)**
b. Obtain the relationship between stream function and velocity potential. **(04 Marks)**
c. Derive momentum equation based on control volume approach. **(12 Marks)**

3 a. Obtain the expression for N′ and A′ in terms of τ, p and θ. **(08 Marks)**
b. Consider an airfoil with chord length 'C' and the running distance 'x' measured along the chord. The leading edge is located at $\frac{x}{c} = 0$ and the trailing edge at $\frac{x}{c} = 1$. The pressure co-efficient variations over the upper and lower surfaces are given, respectively, as

$$C_{p,u} = 1 - 300\left(\frac{x}{C}\right)^2 \quad \text{for } 0 \le \frac{x}{C} \le 0.1$$

$$C_{p,u} = -2.2277 + 2.2777\left(\frac{x}{C}\right) \quad \text{for } 0.1 \le \frac{x}{C} \le 1.0$$

$$C_{p,l} = 1 - 0.95\left(\frac{x}{C}\right) \quad \text{for } 0 \le \frac{x}{C} \le 1.0$$. Calculate the normal force coefficient. **(06 Marks)**

c. Define Center of pressure. In low speed, incompressible flow, the following experimental data are obtained for an NACA 4412 airfoil section at an angle of attack of 4° : $C_l = 0.85$ and $C_{m_{\frac{C}{4}}} = -0.09$. Calculate the location of the center of pressure. **(06 Marks)**

4 a. Derive the relationship between velocity and pressure for a incompressible, inviscid flow. **(10 Marks)**
b. Obtain stream function and potential function for a doublet flow. **(10 Marks)**

PART - B

5 a. Explain D'Alembert's Paradox with neat sketches. **(04 Marks)**
b. What is the required cylinder diameter in order to have Re = 1? The data given are $\rho_\infty = 1.223$ kg/m^3 and $u_\infty = 1.79 \times 10^{-5}$ kg/m-sec and the air flow is 30 m/sec. **(04 Marks)**
c. Diameter of a cylinder is 0.5 m, the free stream velocity is 25 m/sec, the max velocity on the surface of the cylinder is 75 m/sec. The free stream conditions are those for a standard altitude of 3 kilometer is $\rho_{3000} = 0.90926$ kg/m^3. Calculate the lift/unit span of the cylinder. **(12 Marks)**

6 a. Briefly explain the following, with neat sketches and relevant expressions :
i) Kelvin's circulation theorem ii) The starting vortex iii) Vortex sheet. **(10 Marks)**
b. Derive an expression for lift co-efficient for symmetric airfoil, using classical thin airfoil theory. **(10 Marks)**

7 a. Explain with neat sketch about the transition of flow from laminar to turbulent. **(06 Marks)**
b. Derive Navier-Stokes equations for as unsteady, compressible 3-d viscous flow. **(14 Marks)**

8 a. With a neat sketch, explain the operation of open circuit and closed circuit wind tunnel. **(10 Marks)**
b. Name and describe two flow visualization techniques in low speed wind tunnels. **(05 Marks)**
c. Consider a low speed wind tunnel with a throat-to-inlet area ratio of 0.8 mounted in a flow at standard sea level conditions. If the pressure difference between the inlet and the throat is 335.16 Pa, calculate the velocity of the flow at the inlet. Take sea level density, $\rho = 1.225\ kg/m^3$. **(05 Marks)**

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