Exam Date & Time: 24-Jun-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

IV SEMESTER B.TECH MAKE-UP EXAMINATIONS, JUNE 2024

INCOMPRESSIBLE AERODYNAMICS [AAE 2221]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Synthesize lifting flow over a circular cylinder and locate the stagnation points in the flow. Comment on the influence of circulation on the location of stagnation points. (5)

A)

B) Prove that vorticity normal to a surface is equal to circulation per unit area. (3)

C) Briefly describe the Eulerian and Lagrangian flow models. (2)

2) Comment on the lift and drag forces on a lifting and non-lifting circular cylinder in an inviscid incompressible flow. Also, comment on the same in a real flow. (2)

A)

B) In an inviscid incompressible flow, differentiate between velocity potential and stream function. (3)

C) Consider the lifting flow over a circular cylinder with a diameter of 0.6 m. The freestream velocity is 20 m/s, density is 0.909 kg/m^3 and the maximum velocity on the surface of the cylinder is 70 m/s. Calculate the lift per unit span on the cylinder. (5)

3) Consider a NACA 23012 airfoil. The mean camber line for this airfoil is given by:

$$\mathbf{z/c = 5.3\ [\ 2.5\ (x/c)^3 + (x/c)^2 - 0.4\ (x/c) + 0.7]\ for\ 0 \le x/c \le 1}$$

A) Calculate (a) the angle of attack at zero lift, (b) the lift coefficient when $\alpha = 6^o$, (c) the moment coefficient about the quarter chord, and (d) the location of the center of pressure in terms of x_{cp}/c, when $\alpha = 6^o$. (5)

B) Briefly discuss on the leading and trailing edge high lift devices and show how their deployment affects the lift curve. (3)

C) Consider an airfoil in a flow with a freestream velocity of 46 m/s. The velocity at a given point on the airfoil is 68 m/s. Calculate the coefficient of pressure at this point. (2)

4) Consider a rectangular wing with an aspect ratio of 8, an induced drag factor $\delta=0.045$, and a zero-lift angle of attack of -3^o. At an angle of attack of 3.4^o, the induced drag coefficient for the wing is 0.02. Calculate the induced drag for a similar wing of the same airfoil section at the same angle of attack, but with an aspect ratio of 12. Assume that the induced factors for drag and the lift slope, δ and τ, respectively are equal. Also, for AR = 12, $\delta=0.11$.

A) (4)

B) For a thin symmetric airfoil, circulation per unit length is given by $\gamma(\theta)=2\alpha V_\infty (1+\cos\theta)/\sin\theta$. Using the Kutta-Joukowski theorem, derive the expression for lift force and lift curve slope. (4)

C) Discuss the advantages and disadvantages of the ground effect on an aircraft flying close to the ground. (2)

5) Explain how the aerodynamics of a complete wing differs from that of its airfoil sections and discuss the flow phenomena responsible for these distinctions. (4)

A)

B) Briefly describe the following:

i. Horseshoe vortex

ii. Lifting line

(4)

C) Discuss the panel methods and its significance in aerodynamic studies. (2)

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