Bengal Engineering and Science University, Shibpur
Department of Aerospace Engineering and Applied Mechanics
BE (Aero) Part II 5th Semester Final Examination, November 2012

Low Speed Aerodynamics
(AE 501)

Time : 3 hours Full Marks : 70

Answer any five of the following.
The questions are of equal value.

1. a) Derive the fundamental equation of Prandtl's Lifting line theory.

   b) Show that the downwash is constant over the span for an elliptical lift distribution.

2. a) Consider a finite wing with an aspect ratio of 8 and a taper ratio of 0.8. The airfoil section is thin and symmetric. Calculate the lift and induced drag coefficients for the wing when it is at an angle of attack of 5^0. Assume that $\delta = \tau = 0.055$.

   b) Consider a rectangular wing with an aspect ratio of 6, an induced drag factor $\delta = 0.055$, and a zero-lift angle of attack of -2^0. At an angle of attack of 3.4^0, the induced drag coefficient for this wing is 0.01. Calculate the induced drag coefficient for a similar wing at the same angle of attack but with an aspect ratio of 10. Assume that $\delta = \tau$. Assume at AR = 10, $\delta = 0.105$.

3. Derive the expression for induced drag coefficient for incompressible flow over finite wing with general lift distribution.

4. Use thin-aerofoil theory to show that the quarter chord point of a symmetric airfoil is both the centre of pressure and the aerodynamic centre.

5. The NACA 4412 airfoil has a mean camber line is given by

   $z/c = 0.25[0.8\,(x/c) - (x/c)^2]$ for $0 <= x/c <= 0.4$
   and
   $y/c = 0.111[0.2 + 0.8(x/c) - (x/c)^2]$ for $0.4 <= x/c <= 1.0$

   Using thin airfoil theory calculate (a) the angle of attack at zero lift, (b) the lift coefficient, (c) the moment coefficient about the quarter chord and (d) the location of the center of pressure from the leading edge with respect to chord when angle of attack $(\alpha) = 3^0$.

6. Consider the lifting flow over a circular cylinder. The lift coefficient is 5. Calculate (a) the peak (negative) pressure coefficient, (b) location of stagnation points, and (c) the location of points where the pressure equals freestream static pressure.

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7. a) Derive the equation of a symmetrical Joukovsky airfoil from a circle of radius a.

b) Prove that the thickness ratio of a symmetrical Joukovsky airfoil is approximately $1.3(a/b - 1)$ where b is the constant of transformation and a is the radius of the circle from which the airfoil is derived.

8. Calculate the theoretical lift coefficient of a Joukovsky airfoil having thickness ratio 0.2% and 2% camber, set at 4^0 incidence in a two dimensional irrotational flow. Derive your formula for lift coefficient..