

AER1216: Fundamentals of UAS

Assignment # 1 Due: Sept. 30th

1. For a symmetrical airfoil, based on thin airfoil theory, calculate the lift and moment about the leading edge (per unit span) when the angle of attack is 3° and the freestream is at standard sea level conditions with a velocity of 40 m/s. The chord of the airfoil is 1 m. What is the Reynolds number? Use tables to find the density and the viscosity of air at sea level. **[10 marks]**
2. An airfoil has a mean camber line that has the shape of a circular arc. The maximum mean camber is kc , where k is a constant and c is the chord. Therefore, the camber line is described by

$$\left(x - \frac{c}{2}\right)^2 + \left(z + \frac{c}{8k} - \frac{kc}{2}\right)^2 = \left(\frac{c}{8k} + \frac{kc}{2}\right)^2 \quad (1)$$

for $0 \leq x \leq c$. Let the freestream velocity be V_∞ and the angle of attack be α . Under the assumption that $k \ll 1$, express the γ distribution in terms of V_∞ , α , θ , and k . Find the angle of zero lift and the moment coefficient about the aerodynamic center. **[20 marks]**

3. An airplane weighing 60,000 N has elliptically loaded wings 12 m in span. For a speed of 70 m/s in straight and level flight at low altitude, find the induced drag. (Hint: Note that you are asked to find the induced drag, not the induced drag coefficient.) **[10 marks]**
4. Consider an untwisted wing with an aspect ratio of 8. The chord at the tip is 0.4 times the chord at the root and varies linearly in between. The zero-lift angle of attack is -1.2° across the span. Using four stations located at $\frac{\pi}{8}$, $\frac{\pi}{4}$, $\frac{3\pi}{8}$ and $\frac{\pi}{2}$, find the linear system of equations for A_1 , A_3 , A_5 , and A_7 . Find the lift coefficient and the induced drag coefficient as functions of the geometric angle of attack. Find their values when the geometric angle of attack is 3° . **[20 marks]**

5. Analyses such as thin airfoil theory or Prandtl's lifting line theory are simple and straightforward compared to the advanced numerical analyses used to create the final product in modern aircraft design. However, that is not to say that these methods are never useful. How do you think these methods can be used in the aircraft design process? Provide the reasoning behind your answer. **[10 marks]**