AER 307S: Assignment 1

(At sea level, the density of the standard atmosphere is 1.226 Kg/m^3, and the temperature is 288 ^oK. Also, $R = 287 m^2/sec^2\ ^oK$, $\gamma = 1.4$, $c_v = 717$ Nm/Kg^{o}K, and $c_p = 1004$ Nm/Kg^{o}K.)

1. The velocity distribution is measured in the wake of an airfoil a distance of 0.5 chords behind the airfoil. It is found that the width of the wake b is 0.1 chords and the velocity distribution in the wake is given approximately by the formula

$$U = U_\infty\left[1 - 0.83\cos^2\left(\frac{\pi y}{b}\right)\right]$$

for $y = -b/2$ to $y = +b/2$. Find the drag coefficient of the airfoil. (See section 2.6 in the text)

2. Derive the boundary-layer energy equation (17.31 in text).

3. Using the data for the NACA 2412 airfoil given in Fig. 4.5, calculate the lift and moment about the quarter chord (per unit span) when the angle of attack is 5 degrees and the freestream is at standard sea level conditions with a velocity of 70 m/s. The chord of the airfoil is 2 m. What is the Reynolds number? Use Sutherland's law to find the viscosity. What is the Mach number?

4. An airfoil has a mean camber line that has the shape of a circular arc (constant radius of curvature). The maximum mean camber is kc, where k is a constant and c is the chord. Therefore the camber line is described by

$$(x - c/2)^2 + (z + c/8k - kc/2)^2 = (c/8k + kc/2)^2$$

for $0 \le x \le c$. The freestream velocity is V_∞ and the angle of attack is 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 centre.

5. Find the cubic camber line which will provide zero pitching moment about the quarter-chord point for a given camber, that is, with $y_{\max} = \delta$.