EAE 127 – MIDTERM 11/08/2005

(Open notes, open book)

1. Inviscid, Incompressible Flow past a Thin Airfoil (15 points)

The camber line of an airfoil is given as $d(x) = \frac{1}{3} \cdot A \cdot c \cdot \frac{x}{c} \cdot \left(1 - \frac{x}{c}\right) \cdot \left(3 - 4\frac{x}{c}\right)$ and $A > 0$.

1.1 Sketch the camber line in the (x,z)-plane.

1.2 Find the coefficients $A_0, A_1, A_2, \ldots$ from the infinite series solution …

$$-A_0 + \sum_{n=1}^{\infty} A_n \cdot \cos(nt) = d'[x(t)] - \alpha$$

(Hint: Expand *d(x)*, determine *d'(x)*, perform the transformation using

$$\frac{x}{c} = \frac{1}{2}\left[1 - \cos(t)\right] \quad \text{and} \quad \cos^2 t = \frac{1}{2}\left[1 + \cos(2t)\right] \;)$$

Check your results carefully, as several results depend on them!

1.3 Find the angle of adaptation α_{adapt} and sketch the flow field for $\alpha < \alpha_{adapt}$, $\alpha = \alpha_{adapt}$, and $\alpha > \alpha_{adapt}$.

1.4 Find the aerodynamic coefficients c_l, c_d, and $c_{m,0}$.

1.5 Find the aerodynamic center $\frac{x_{a.c.}}{c}$ and the center of pressure $\frac{x_{c.p.}}{c}$.

1.6 Find the angle of attack α for which $\frac{x_{c.p.}}{c} = \frac{1}{2}$.

2. Linearized Supersonic Flow past a Thin Airfoil (15 points)

Consider a symmetric wedge of half angle Θ

$$f^{+}(x) = \frac{1}{2} \cdot e(x) = \Theta \cdot x \qquad 0 \le x \le 1$$

$$f^{-}(x) = -\frac{1}{2} \cdot e(x) = -\Theta \cdot x$$

$$f^{\pm}(x) = 0 \qquad x > 1$$

2.1 At $a = 0$, find the surface pressure distribution $c_p^+(x)$ and $c_p^-(x)$, sketch the pressure distribution along the chord, and sketch the flow field around the airfoil indicating shock waves and expansion fans.

2.2 At $a = \Theta$, find the surface pressure distribution $c_p^+(x)$ and $c_p^-(x)$, sketch the pressure distribution along the chord, and sketch the flow field around the airfoil indicating shock waves and expansion fans.

2.3 Find the aerodynamic coefficients c_l, c_d, and $c_{m,0}$.

2.4 Find the aerodynamic center $\frac{x_{a.c.}}{c}$ and the center of pressure $\frac{x_{c.p.}}{c}$.

2.5 Why are supersonic airfoils usually symmetric, i.e. without camber ?

2.6 Sketch the profile polar c_l *vs.* c_d. Find c_l, c_d, and a that correspond to "maximum finess" $\left(\frac{c_l}{c_d}\right)_{\max}$.