Lecture F03 Mud: Thin-Airfoil Analysis Problem (continued)

1. **Tough to visualize the θ coordinate?** (1 student)
   It's similar to the physical x coordinate, except that the θ coordinate is more "bunched up" at the leading edge and trailing edge. Imagine sliding along the half-circle (3rd figure in F2 notes) at a uniform speed in θ. Your horizontal velocity in x will be very slow near the leading edge, normal in the middle, and then slow again near the trailing edge.

2. **What's the origin that θ is measured from? The quarter-chord?** (1 student)
   No, from the leading edge. As x runs from 0 to c along the chord, θ runs from 0 to π. See the 3rd figure in F2 notes.

3. **What exactly is the Fourier series representing?** (1 student)
   The function $f(\theta) \equiv \alpha - dZ/dx$. This is the angle between the freestream direction and the camberline surface.

4. **What does $c_{m,c/4} = \frac{\pi}{4}(A_2 - A_1)$ physically mean?** (1 student)
   The moment about the quarter-chord point can be written as the net moment of all the lift forces dL' distributed on the airfoil, each with moment arm $(c/4 - x)$. Therefore:

   $$M'_{c/4} \;=\; \int (c/4 - x)\, dL' \;=\; \int \rho V_\infty \gamma (c/4 - x)\, dx$$

   When you plug in the A_n series for γ and do the integral, only the A_1 and A_2 terms end up nonzero. Nondimensionalizing then gives $c_{m,c/4}$, still only involving A_1 and A_2.

5. **You wrote two expressions for A_0 and two for A_n. Which ones do we use?** (1 student)
   The first expressions were for any general $f(\theta)$. The second expressions had our particular $f(\theta)$, and hence are specific to TAT. So we'll be using the second forms.

6. **How do you know $\frac{1}{\pi}\int_0^\pi f(\theta)\, d\theta$ is the average?** (1 student)
   The <u>definition</u> of a function over an interval $a \ldots b$ is

   $$\frac{1}{b-a}\int_a^b F(t)dt$$

7. **Why was α taken out of the A_0 integral, and why did it disappeared from A_n?** (1 student)
   Since α is a constant, I just integrated it trivially.

   $$\frac{1}{\pi}\int_0^\pi \alpha\, d\theta \;=\; \alpha$$

   It disappeared from the A_n integrals because

   $$\frac{2}{\pi}\int_0^\pi \alpha\, \cos n\theta\, d\theta \;=\; 0$$

   for any integer $n > 0$.

8. **Why does M'_{LE} have an A_0 term, but $M'_{c/4}$ doesn't?** (1 student)
   That's just how it comes out. Intuitively, if you look at A_0's function $(1 + \cos\theta)/\sin\theta$ plotted in x, you can sorta see it has zero moment about the quarter-chord point. So $M'_{c/4}$ cannot be affected by A_0, and hence cannot be affected by α.

9. **How else are Fourier series used?** (1 student)
   We will use them again when we look at 3-D wings.

10. **Isn't the moment about the quarter chord always zero?** (1 student)
    It is not zero for a general cambered airfoil. It is zero only for a symmetrical (zero-camber) airfoil, and also for some special *reflexed* airfoils which have S-shaped camber lines.

11. **Still don't understand what θ_o is.** (1 student)
    To evaluate $w(x)$ from the vortex sheet, we need two x-locations:
    1) the x where w is being calculated, simply called "x".
    2) the x location where the piece of the vortex sheet is being considered, called "ξ".
    The θ-value corresponding to x is called "θ_o".
    The θ-value corresponding to ξ is called "θ".

12. **Are we supposed to be able to reproduce all this math?** (1 student)
    You are expected to understand the concepts involved. The "math" really just boils down to a few integrals in the end. I don't expect you to memorize all the formulas. A practicing aerodynamicist can always look them up.

13. **Explain how you got the PRS result again.** (1 students)
    Difficult without a board. I'll go over it in F4.

14. **Completely lost in the math.** (5 students)
    I'll work out an application example in the F4 lecture. Hopefully that will help.

15. **No mud** (9 students)