Assignment #2: Panel Code — ME 515

due 2/12/2020 before midnight via Learning Suite — 50 possible points

A NACA 4-series airfoil is defined by four numbers, which we will call ABCC. The first number is the maximum amount of camber as a percentage of chord. In the formulas below we define $\epsilon = A/100$. The second number gives the location of the maximum camber in tenths of a chord. In the formulas below we define $p = B/10$. Finally, the last two numbers give the thickness of the airfoil as a percentage of chord. We define $\tau = CC/100$. The airfoil is defined on a unit chord ($0 \le x \le 1$). With these definitions we can compute the thickness distribution:

$$T(x) = 10\tau \left[0.2969\sqrt{x} - 0.1260x - 0.3516x^2 + 0.2843x^3 - 0.1015x^4\right]$$

(note: if you want a sharp-tailed airfoil change 0.3516 with 0.3537), and the camber line distribution:

$$\bar{y}(x) = \begin{cases} \frac{\epsilon}{p^2}\left(2px - x^2\right) & 0 \le x \le p \\ \frac{\epsilon}{(1-p)^2}\left(1 - 2p + 2px - x^2\right) & p \le x \le 1 \end{cases}$$

The upper and lower surface of the airfoil are then given as:

$$y_u(x) = \bar{y}(x) + T(x)/2$$
$$y_l(x) = \bar{y}(x) - T(x)/2$$

2.1 *Thin Airfoil Theory (in-class)*: Using thin airfoil theory with a NACA 2412 airfoil (you can use an analytic or numerical approach, but either way be sure to show your work):

- report the first three Fourier coefficients
- plot c_l and c_{mac} as a function of angle of attack
- plot the C_p distribution for the angle of attack where $c_l = 1.0$ (you may need more than 3 Fourier coefficients for this part).

2.2 *Panel Method*: Write a computer program that implements a surface panel method. You're going to need this code next week also so make sure it is working correctly.

- plot the convergence in c_l, c_d, and c_m about the quarter-chord as a function of the number of panels (using both surface integration and the Kutta-Joukowski theorem where it applies). How many panels are needed to produce reasonable results?
- compare the results from the previous problem (lift and moment curves, C_p distributions at the same angle of attack).

2.3 *Computational Fluid Dynamics*: Use StarCCM+ to compare the same set of results (lift and moment at just two angles of attack is sufficient, C_p distributions at both angles of attack) for inviscid flow. You should be able to reuse your same simulation from last week, just change the angle of attack.

2.4 *Discussion*: Provide a brief discussion on how well the methods compare, and the limitations and sources of error for each.