

EMT 101- Engineering Programming Test 1 (1 HOUR)

Handed out 1/11/2016

1 Center of Gravity (CG) of NACA 0012 Airfoil(100 %)

In designing a wing of any aircraft, it is important to determine its location of center of gravity. Once we know the CG of the wing, we can design the wing to be aerodynamically stable. Without a stable wing, it would be very difficult (sometimes impossible) to fly the aircraft.

Of course, it would be too much to do for this test if we are to find the CG of a wing. As such, we are only going to focus finding the CG for the cross-section of the wing (i.e. airfoil) as shown in Figure 1.

The airfoil is divided into two parts: the top y_t and bottom half y_b . Each part is essentially a polynomial function which depends on the x-location. For example, a NACA 0012 (top-bottom symmetric) airfoil is given by

$$y(x) = \frac{5t}{c} \left[0.2969 \left(\frac{x}{c} \right)^{1/2} - 0.1260 \left(\frac{x}{c} \right) - 0.3516 \left(\frac{x}{c} \right)^2 + 0.2843 \left(\frac{x}{c} \right)^3 - 0.1015 \left(\frac{x}{c} \right)^4 \right]. \quad (1)$$

We shall assume the following:

- The top part of airfoil $y_t = y(x)$.
- The bottom part is just $y_b = -y(x)$.
- The chord length c of the airfoil is 1 m.
- The thickness t of airfoil is 0.12 m to ensure that the airfoil is slender.

You are to write, compile and execute a C++ code to calculate the location of center of gravity (CG) of a NACA 0012 airfoil as given in Figure 1. Assuming $\int_S dA$ is the area size of the airfoil, the CG (\bar{x}, \bar{y}) can be determined via

$$\bar{x} = \frac{\int_S x dA}{\int_S dA}, \quad (2)$$

$$\bar{y} = \frac{\int_S y dA}{\int_S dA}. \quad (3)$$

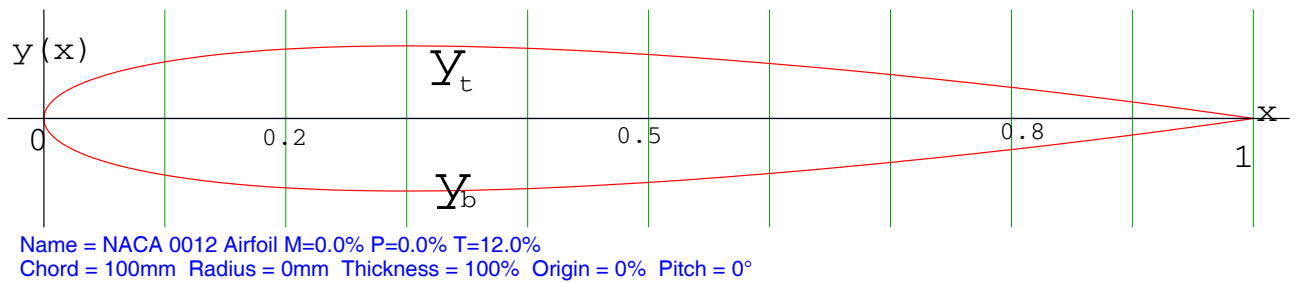


Fig. 1: The NACA 0012 airfoil.

You would need the discrete area intervals dA to set up the integration. To determine the discrete area intervals, you could select either $dA = ydx$ and/or $dA = xdy$. Using your code, please calculate the following:

- Estimate (\bar{x}, \bar{y}) by dividing the elements into (10,20,100) equal sub-elements in either x or y directions.

Your code should contain at least these items:

1. User-input statement to determine the size of the sub-elements (i.e. 10,20, 100).
2. Initialization process to define each relevant variables and their array sizes.
3. A Main program to perform the task.
4. A function or subroutine to perform the integration and called upon by the Main program.
5. An output for the CG values (\bar{x}, \bar{y}) .
6. Comments on the source code to illustrate your algorithm

Once done, please email your source code (*.cpp file) to Mr Azizul. Please only email once (any files sent more than once will be discarded) and only the *.cpp file.