3D Lift Coefficient Calculations

In order to calculate 3D Lift Coefficients for our wing and horizontal stabilizer our team utilized Prandtl's lifting line theory. In order to calculate a wing lift curve slope our team assumed our wing section lift curve slope to be 2π. Our wing has a rectangular platform, resulting in an Oswald efficiency factor (e) of 0.7. Our chosen aspect ratio is 3.8. Using the equations below our team calculated 3D lift coefficients for angles of attack ranging from −5 to 10 degrees.

Wing Lift Curve Slope Equation

$$a = \frac{dC_L}{d\alpha} = \frac{a_0}{1 + \frac{a_0}{\pi e AR}}$$

Wing Lift Curve Slope Assumption: $a_0 = 2\pi, e \simeq 1$

Lift Coefficient Equation

$$C_L = \frac{a_0}{1 + \frac{a_0}{\pi e AR}}(\alpha - a_0) = a(\alpha - a_0)$$

After calculating 3D lift coefficients our team back calculated the area needed to produce 5.1 lbs of lift at 10 m/s using the lift equation.

$$L = 0.5\rho \cdot V^2 \cdot Cl \cdot A$$

The following assumptions were made

$$\rho = 0.98 \; \frac{kg}{m^3}$$

$$V = 10 \; \frac{m}{s}$$

$$AOA = 9^o$$

$$C_l = 1.189$$

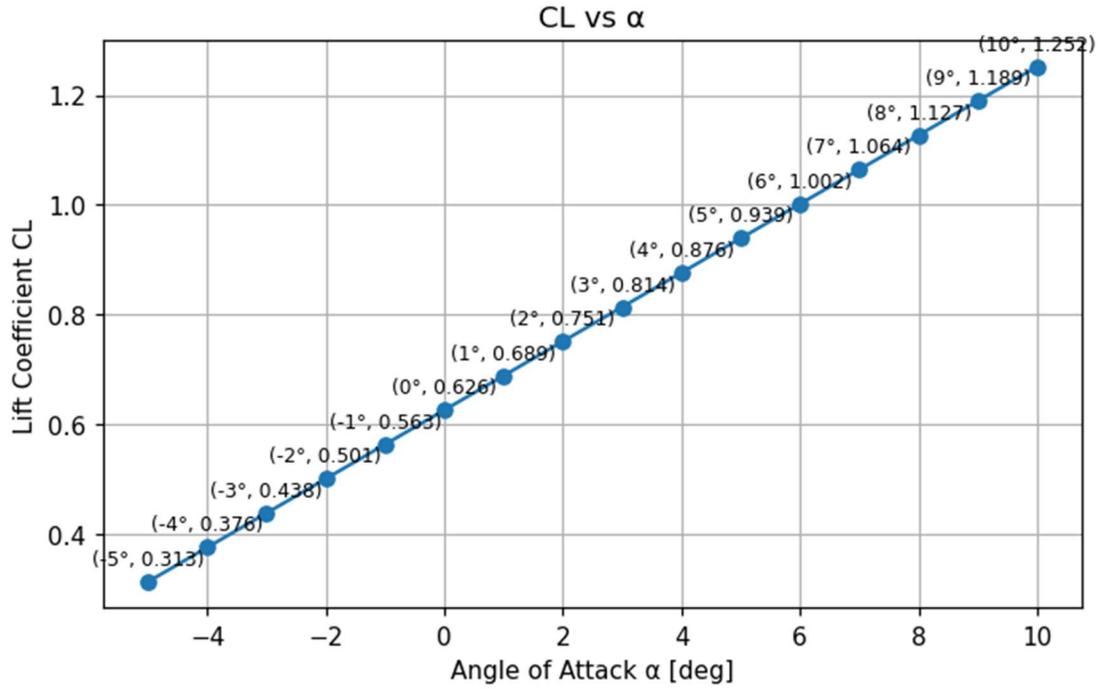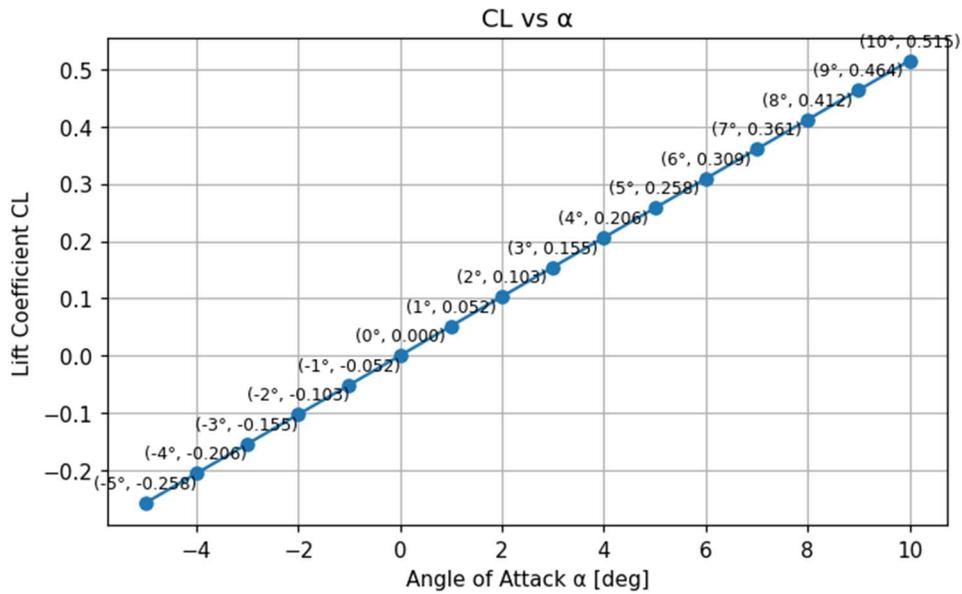*Figure 1: 3-D Lift Coefficients for Main Wing Eppler E423*

Figure 2: 3-D Lift Coefficients for Horizontal Stabilizer NACA 0012

Horizontal Stabilizer Area

$$S_{HT} = \frac{c_{HT} \cdot S_w \cdot c}{L_{ht}} = 171.12 in^2$$

Using an Aspect Ratio of 2.53, the span and chord can be calculated. Span = 22.65", Chord = 7.55". Elevators span should be 90% of the horizontal tail span (cite page 114) and 50% of the Chord. Thus, elevator span is 20.385" and elevator chord is 3.775".

Vertical Stabilizer Area

$$S_{VT} = \frac{C_{VT} \cdot S_w \cdot b_w}{L_{ht}} = 38.475 in^2$$

Using an aspect ratio of 1.5 for the vertical stabilizer the span and chord will be calculated and found to be 8.77" and 4.38" respectively. The same sizing ratios will be used as they were used in the Horizontal Tail sizing calculations. Rudder span = 4.38" and the Rudder chord = 2.17".

Control Surface Sizing

Ailerons should be 50-90% of the wingspan. The wingspan in total is 50" meaning the ailerons should take up 25" total of the wingspan. Therefore, each aileron should be sized at 12.5" in span. However, the wingspan includes Hoerner tips to reduce drag, thus increasing wingspan. Because of this, it might seem the ailerons are slightly undersized with a span of 11.97" and a chord of 3.125".

The elevator and rudder were sized to be 90% the span of the horizontal and vertical stabilizer respectively. The chord and elevator and rudder were sized to be 50% of the span of their respective stabilizers.