MECH 427 – AIRCRAFT DESIGN

WITH DR. GOUSHCHA

HOMEWORK #6

Date Due: 2020 December 2nd at 11:00am

You will need to **short report and attach your MATLAB code**. The word document should include comprehensive explanation of your calculation steps, including all formulas, constants, and conversion factors you used.

Consider the following propeller:

1) Blades are constructed from an airfoil whose C_l and C_d values can be found in the reference uploaded with this homework in Figure 3. You may want to digitize each plot to automate the process.
2) Airfoils are placed at 45^o angle of attack ($\theta = 45^o$)
3) The shaft rotational speed is $6{,}000\ rpm$ (convert to rad/s)
4) Chord of the airfoils is $2cm$
5) Free stream speed of the airplane is $7m/s$

Choose a 1 cm wide ($dr = 1cm$) section of the propeller which is located $3cm$ ($r = 3cm$) from the hub.

Perform **BY HAND** first **THREE** iterations to find a and b using the procedure outlined in the video recording from 11/22/2020 .
Once you have the three iterations by hand, code the rest of the iterations in MATLAB to converge a and b.

1) Guess b
   a. Guess a
   b. Use these a and b values to calculate:

$$V_{disc} = V_\infty + V_\infty a$$
$$V_2 = \omega r - \omega r b$$
$$V_1 = \sqrt{V_{disc}^2 + V_2^2}$$
$$\alpha = \theta - \tan^{-1}\frac{V_{disc}}{V_2}$$

   c. Knowing V_1 , b, and α calculate dT_a and dQ_a using aerodynamics equations

$$dT_a = \frac{1}{2}V_1^2\rho c\,(C_L\cos\phi - C_D\sin\phi)dr$$

$$dQ_a = \frac{1}{2} V_1^2 \rho c (C_L \ \sin\phi + C_D \cos\phi) dr\, r$$

d. Use the linear and angular momentum equations to calculate dT_m and dQ_m

$$dT_m = 4\pi\, r\, dr\, \rho V_\infty^2 a(1+a)$$

$$\mathrm{d}Q_m = \rho 4\, \pi r^3 V_\infty (1+a) b\omega dr$$

e. Change a until dT_a is within 5% of dT_m.

2) Change b until dQ_a is within 10% of $\mathrm{d}Q_m$