MAE 5500 Aerodynamics : Wing Project (100 Points)

Note: All equation numbers refer to the Aeronautical Engineering Handbook (link in the syllabus).

Write a computer program that uses the numerical Fourier series solution to Prandtl's lifting-line theory to predict the aerodynamic characteristics of a finite wing with a linear tapered planform, washout, aileron deflection, and rigid-body roll. Your code must be contained in a single file called "LastName_FirstName_LL.py". The code must run from a command line by simply typing "python LastName_FirstName_LL.py". The code must include at least the following:

1. The code must get **all user inputs** from the provided "input.json" file.
2. Your code must model a tapered wing (for a given aspect ratio and taper ratio) Eq. (6.28).
3. Your code must allow the following washout distribution types:
   a. None
   b. Linear Eq. (6.30)
   c. Optimum Eq. (6.31)
   Additionally, your code must allow the washout amount Ω to be specified directly in degrees or by selecting an optimum washout amount (Eq. (6.32)) based on a specified lift coefficient.
4. Your code must allow specification of aileron geometry. The user should be able to specify the spanwise coordinate (z/b) and flap fraction (c_f/c) for the aileron tip and root, as well as the hinge efficiency, η_h. For the deflection efficiency, set $\eta_d = 1.0$. Your code should account for the ideal section flap effectiveness of a traditional flap (Eq. (6.37)).
5. The code must write the $[\boldsymbol{C}]$ matrix, $[\boldsymbol{C}]^{-1}$ matrix, and Fourier coefficients $\{a_n\}$, $\{b_n\}$, $\{c_n\}$, and $\{d_n\}$ to a formatted text file.
6. The program must compute and display κ_L, $C_{L,\alpha}$, ϵ_Ω, κ_D, κ_{DL}, $\kappa_{D\Omega}$, C_{ℓ,δ_a}, and $C_{\ell,\bar{p}}$.
7. The operating condition is to be specified in terms of the root aerodynamic angle of attack $(\alpha - \alpha_{L0})_{\text{root}}$ in degrees, the aileron deflection δ_a in degrees, and the dimensionless rolling rate $\bar{p} = pb/2V_\infty$.
8. The user must also be given the option of:
   a. Specifying an **operating** lift coefficient and having the program calculate the required root aerodynamic angle of attack.
   b. Choosing the steady-state rolling rate as the operating rolling rate.
9. For a user specified operating condition, the program must compute and display C_L, C_{D_i}, C_ℓ, C_n, and $\bar{p}_{\text{steady}}$ (that is, the steady dimensionless rolling rate for the specified aileron deflection). The lift coefficient can be computed using either Eq. (6.5) or Eq. (6.19). The induced drag coefficient must be computed using Eq. (6.6), which properly includes the effects of rolling rate and aileron deflection.
10. The code must have the ability to display the following plots as a function of z/b, with each plot properly labeled:
    a. A planform plot with:
       i. wing planform
       ii. aileron geometry
       iii. the location of the wing sections that are used to obtain the Fourier coefficients
    b. The dimensionless washout distribution $\omega(z)$
    c. The dimensionless aileron distribution $\chi(z)$
    d. A $\hat{C}_L = \tilde{L}/\left(\frac{1}{2}\rho V_\infty^2 b\right)$ distribution plot with:
       i. the dimensionless lift distribution due to planform from Eq. (6.42)
       ii. the dimensionless lift distribution due to washout from Eq. (6.43)
       iii. the dimensionless lift distribution due to aileron deflection from Eq. (6.44)
       iv. the dimensionless lift distribution due to rolling rate from Eq. (6.45)
       v. the total dimensionless lift distribution, $\hat{C}_L = \tilde{L}/\left(\frac{1}{2}\rho V_\infty^2 b\right)$, from Eq. (6.41)
    e. A $\tilde{C}_L = \tilde{L}/\left(\frac{1}{2}\rho V_\infty^2 c\right)$ distribution plot with:
       i. the dimensionless lift distribution due to planform from Eq. (6.48)
       ii. the dimensionless lift distribution due to washout from Eq. (6.49)
       iii. the dimensionless lift distribution due to aileron deflection from Eq. (6.50)
       iv. the dimensionless lift distribution due to rolling rate from Eq. (6.51)
       v. the total dimensionless lift distribution, $\tilde{C}_L = \tilde{L}/\left(\frac{1}{2}\rho V_\infty^2 c\right)$, from Eq. (6.47)

Submission Requirements

Your submission should be your computer code in a single file (.py).