AerE310: Incompressible Aerodynamics

Homework Problem Set #06:

<u>Due</u>: 5;00pm on Friday, 04/19/2024

Problem#1:

Consider an airplane that weighs 14,700 N and cruises in level flight at 300 km/h at an altitude of 3000 m. The wing has a surface area of 17.0 m^2 and an aspect ratio of 6.2. Assume that the lift coefficient is a linear function of of the angle of attack and $\alpha_{L=0}$ =-1.2°. If the load distribution is elliptic, calculate the value of circulation in the plane of symmetry (Γo), the down wash (W_{y1}), the induced drag coefficient (C_{Di}), the geometric angle of attack (α), and the effective angle of attack (α_{eff}).

Problem#2:

Consider the case where the spanwise circulation distribution for a wing is parabolic: $\Gamma(y) = \Gamma_0(1 - y^2/s^2)$. If the total lift generated by the wing with the parabolic circulation distribution is to be equal to the lift generated by a wing with an elliptic circulation distribution,

- What is the relation between Γ_0 values for the two distributions?
- What is the relation between the induced downwash velocities at the plane of symmetry for the two configurations?

Problem#3:

For a wing with an aspect ratio of AR_1 at the geometric angle of attack of α_1 generates the same amount of the lift as the other wing with an aspect ratio of AR_2, **then** at the geometric angle of attack of α_2 can be expressed as,

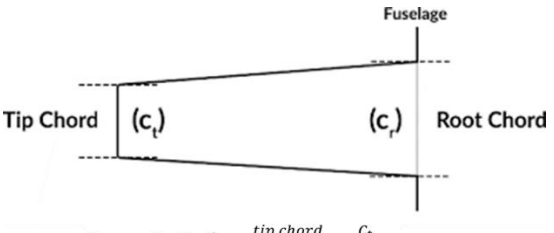
$$\alpha_2 = \alpha_1 + (C_L/\pi)[(1/AR_2) - (1/AR_1)]$$

When a GA(W)-1 airfoil section (i.e., a wing of infinite span) is at an angle of attack of 4.0°, the lift coefficient is 1.0. using the above equation to determine:

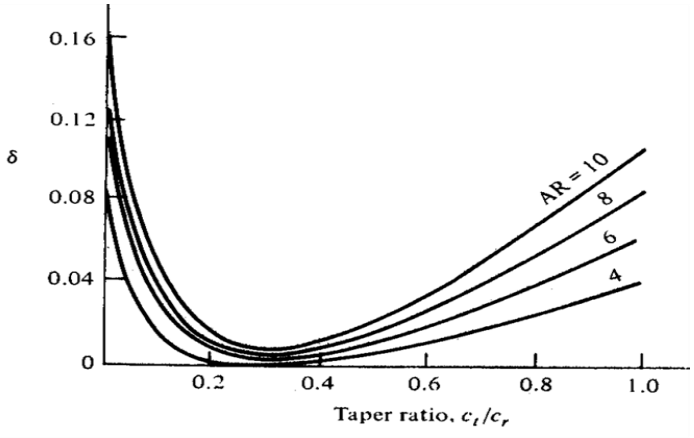
- Calculate the angle of attack at which a wing whose aspect ratio is 7.5 would have to operate to generate the same lift coefficient.
- What would the angle of attack have to be to generate this lift coefficient for a wing whose aspect ratio is 6.0?

Problem#4:

For a finite wing with an aspect ratio of 8.0 and taper ration of 0.8. The airfoil section is thin and symmetrical. By using the data given in the following figure, please calculate the lift and induced drag coefficient for the wing when it is at an angle of attack α=5.0°.



$$Taper\ Ratio\ \lambda = \frac{tip\ chord}{root\ chord} = \frac{C_t}{C_r}$$



Problem#5: For a flat delta wing with sharp leading edge and an aspect ratio of 1.5.

- (a). Please calculate of the lift coefficient of the delta wing and then compare the solution with the experimental data given in the following figures.
- (b). Please calculate of the induced drag coefficient of the delta wing and then compare the solution with the experimental data given in the following figures.

Note: For a triangle wing at the angle of attack of α, the lift and drag coefficients can be estimated as:

$$C_L = K_p \sin\alpha \cdot \cos^2\alpha + K_v \sin^2\alpha \cdot \cos\alpha$$

Where C_{Dp} is drag coefficient of a flat plate perpendicular to the flow ($C_{Dp} \approx 1.95$).

$$C_{D,i} = C_D - C_{D0} = C_L \tan\alpha$$

$$C_D = C_{D0} + C_{D,i} = C_{D0} + K_p \sin^2\alpha \cdot + K_v \sin^3\alpha$$