ME597/AAE556 – Fall 2022
Purdue University
West Lafayette, IN

Homework Set No. 3

Assignment date: Tuesday, September 27
Due date: Thursday, October 6

Please submit your completed homework assignment by

- Scanning and uploading assignment to ***Gradescope***.

Instructions:

- Please upload your HW with following this name code, where ** is the assignment number (e.g., HW**=HW1): HW**ME597/AAE556_Fall22_NameInitial_Lastname
- This assignment is strictly individual.
- Your work will be evaluated considering the shown procedure to obtain final answers.
- The procedure and results should be **clear** and **ordered**.
- Consider asking questions about the assignment in advance to avoid inconveniences caused by unexpected events close to the submission date.
- **Please ensure your work is submitted via *Gradescope***.

Name____

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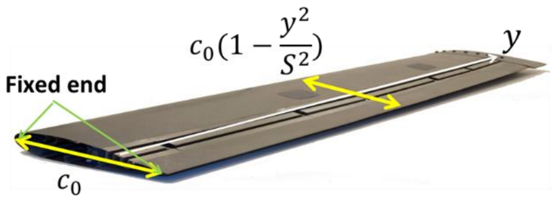
Homework Set No. 3
Problem No. 1 – 50 points

A fixed root tapered rectangular wing has semi-span s, chord $c(y) = c_0(1 - y^2/s^2)$, and torsional rigidity $GJ(y) = (GJ)_0(1 - y^2/s^2)$. The lift is calculated using strip theory where $dL = qc(y)a_w(\alpha_0 + \theta(y))$. Assume that all forces act at the aerodynamic center (a distance ec from the aerodynamic center) and that this coincides with the center of mass, as shown in the figure.



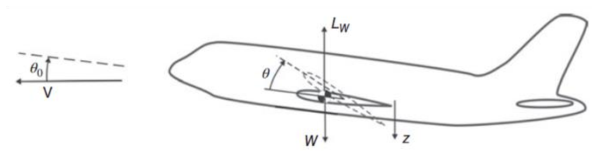


Figure 7.5 Aircraft in steady flight.

Determine the lift distribution and divergence speed for the case the aircraft is in level flight (trimming) considering wing twist $\theta(y)$ and heave z. Solve this for the following cases:

(a) Using a one-mode expansion for the twist field: $\theta(y) = \frac{y}{s}\theta_T$.

(b) Using a two-mode expansion for the twist field: $\theta(y) = \frac{y}{s}\theta_1 + \left(\frac{y}{s}\right)^2 \theta_2$.

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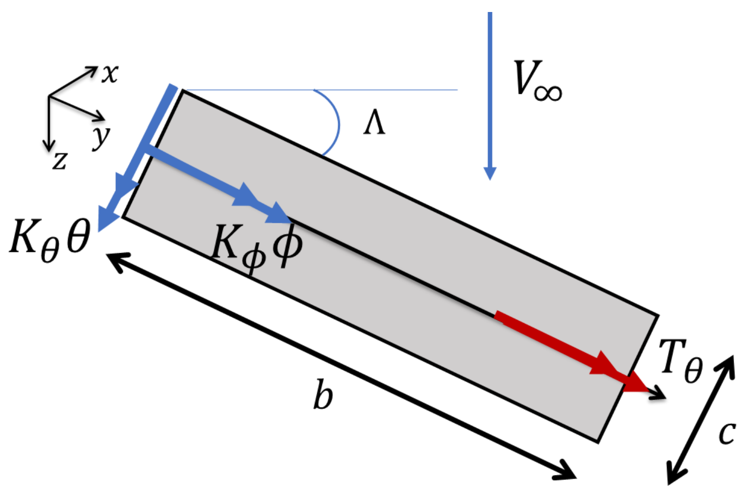
Problem No. 2 – 50 points

Flight speed and aircraft weight change during flight. These changes mean that the wing design is non-optimal for major parts of the mission. Design features such as wing camber and twist distribution can be changed in flight by ***"morphing"*** devices that alter the wing shape to bring it back into optimal performance. This homework problem will examine the interactions created by active twist wings by using a simple idealization of a swept wing.

The idealized swept wing model shown in the figure below simulates an active twist wing; it consists of the familiar semi-rigid surface restrained by bending and torsion springs to resist rotations θ and ϕ, respectively, along the swept axis of the idealization. These springs have stiffnesses K_θ and K_ϕ. The wing planform dimensions are: swept semi-span, b; and, chord, c. A mechanism contained inside a wing has the effect of applying a torque T_θ to the end of the wing, as shown in the diagram. This torque can be changed in flight. A feedback system measures the wing bending slope ϕ and produces a torque according to the control law $T_\theta = \Gamma\, \phi$. The swept wing/aircraft combination is given an angle of attack α_0 with respect to the free stream.



Find:

(a) Derive the equations of static equilibrium using energy methods in matrix form in terms of the vector $[\theta \quad \phi]^T$.
(b) Derive the characteristic equation for neutral static stability. Solve for the divergence dynamic pressure.
(c) Solve for the critical value of the gain Γ above which (or below which) wing divergence cannot occur. This answer will be a function of sweep angle and other model parameters.