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

Homework Set No. 1

Assignment date: Tuesday, September 13
Due date: Thursday, September 22

Please submit your completed homework assignment by

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

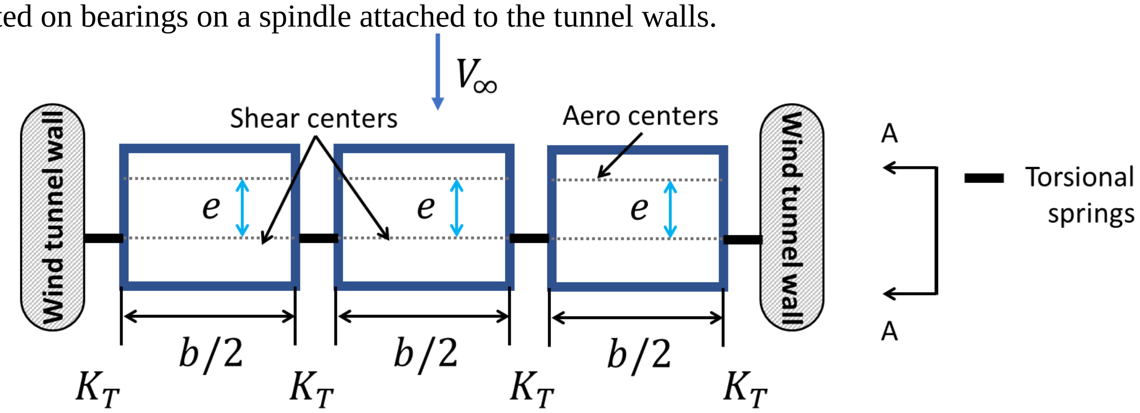
Instructions:

- 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____

ME597/AAE556 – Fall 2022
Homework Set No. 2
Problem No. 1 – 33 points

Three identical uncambered wing segments are connected to each other by torsional springs and to the wind tunnel walls by additional torsion springs, as indicated in the figure (black thick lines indicate torsional springs). The four torsion springs have the same spring constant K_T. The wing segments are mounted on bearings on a spindle attached to the tunnel walls.



(a) Develop the equations of static equilibrium. The three degrees of freedom are θ_1, θ_2, and θ_3.
(b) Write the expression for the strain energy stored in this configuration as a function of the torsional displacements. Use the energy method to derive the system stiffness matrix in terms of the three torsional deflections. Compare this result to that found in part (a). They should be identical.
(c) Solve for the three dynamic pressures where divergence appear.
(d) Find the mode shapes at all neutral stability points, i.e., at the onset of divergence. Describe the mode shapes (how do the surfaces deflect relative to each other?).
(e) Which of the three dynamic pressures in part (c) is the divergence dynamic pressure?

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Homework Set No. 2
Problem No. 2 – 33 points

Two wing sections are mounted on shafts attached to each other and to a wind tunnel wall, as indicated. The wings areas are given by S. Note that the two torsional spring stiffnesses are equal, but are offset an amount d. When the sections are placed in the wind tunnel at an angle of attack α_0, the two springs deform, as indicated in the diagram. Lift on the two, identical, uncambered wing sections is

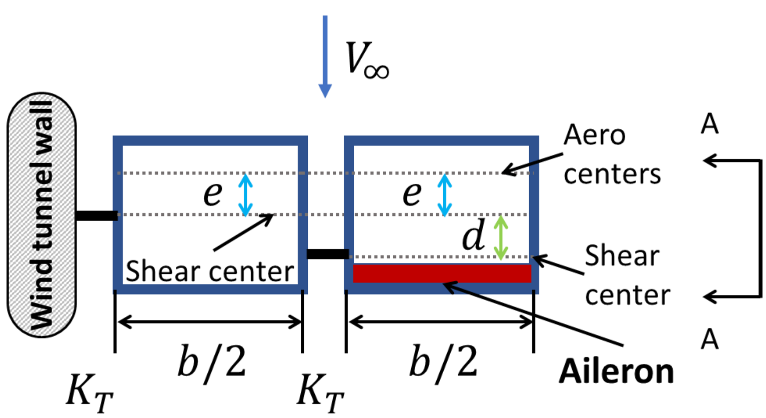
$$L_1 = qSa_1(\alpha_0 + \theta_1)$$

$$L_2 = qSa_1(\alpha_0 + \theta_2)$$

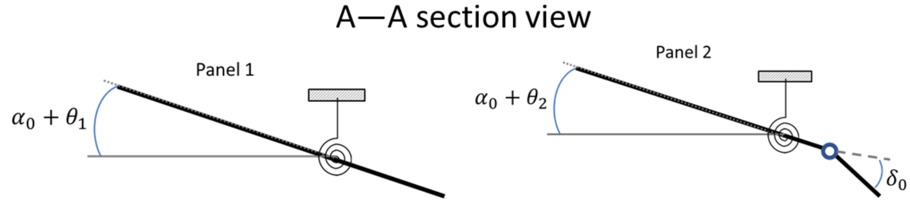
(a) Place an aileron on the outer (right-hand) section. This aileron has aerodynamic coefficients C_{L_δ} and $C_{M_{AC_\delta}}$. Develop the static equilibrium equations for the system when there is no initial angle of attack, but the control surface is deflected downward an amount δ_o.

(b) Specialize the result in part (a) by making the aileron flap-to-chord ratio E = 0.15 with $d/e = 1$ and $e/c = 0.10$. Solve for the rolling moment generated by the aileron as a function of dynamic pressure, q. Use Section 2.18 as an example of how this is done.

(c) Solve for the reversal speed.



A—A section view



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Homework Set No. 2
Problem No. 3 – 34 points

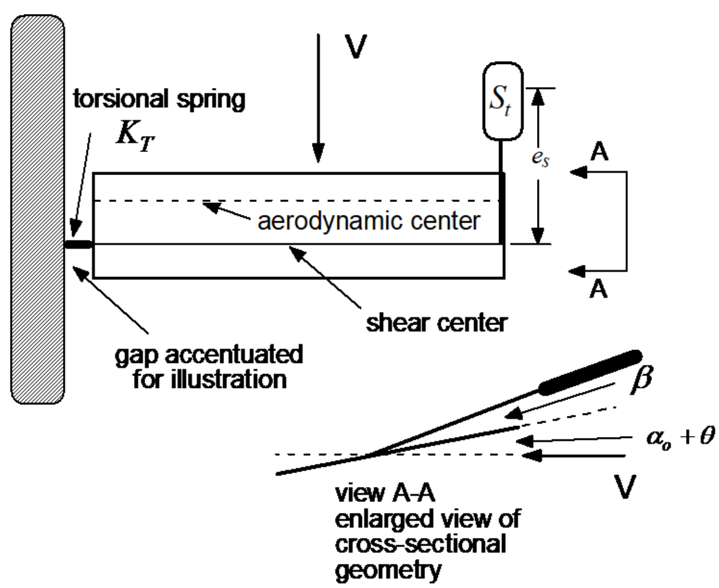
A rigid wing is attached to a wind-tunnel wall by a linear torsion spring. This wing also has a small wing attached to its tip. The idealized tip surface produces lift L_S according to the assumed simple relationship

$$L_S = qS_{tip}C_{L_{\alpha S}}\alpha_S$$

where α_S is the streamwise angle of attack of this small surface; $C_{L_{\alpha S}}$ is the tip surface lift curve slope, while S_{tip} is the tip surface area.

The tip device is connected to the wing tip by a torsion spring with stiffness k in-lb/radian. When the tip device rotates an angle β with respect to the wing tip a restoring torque $k * \beta$ is generated to oppose this rotation.

The idealized wing lift is $L = qSC_{L_\alpha}\alpha$ with $\alpha = \alpha_o + \theta$.



a) Write the equations of torsional equilibrium for this system when the entire system is given an initial angle of attack. Express these equations in terms of the following non-dimensional parameters; $\bar{q} = \frac{qSeC_{L_\alpha}}{K_T}$; $S_R = \frac{S_{tip}C_{L_{\alpha\delta}}e_s}{SC_{L_\alpha}e}$; $k_R = \frac{k}{K_T}$. Derive the characteristic equation for aeroelastic divergence $\bar{q}_D$ in terms of these parameters.
b) Plot the divergence dynamic pressure parameter $\bar{q}_D$ as a function of S_R when $k_R = 10$ and $k_R = 1$