11 Airload-Structure Interaction and Aeroelastic Effects

11.1 Introduction
11.2 Model of Wing Section in Torsion
11.3 Aeroelastic Configuration Model
11.4 Modular Framework for Aeroelastic Loop
11.5 Case Studies: Elasto-Static Wing Effects

Tutorial: Under Construction
Exercises and Projects – software here `pyTornado` and `Framat`.

Review questions to consider before doing calculations

1. Explain the terms static and dynamic aero-elasticity

2. What does "divergence" mean in this context? Why is a forward-swept wing more prone to divergence than an aft-swept wing ?

3. How can the divergence speed be estimated? What data is necessary?

4. Explain the transfer operators from CFD to structures and vice versa. Why and how might a structural model with shell elements on the skin be easier than the classical "elastic axis" beam model?

Computations for static aero-elasticity

5. The example in Ch 11 on a straight wing in a wind-tunnel is modeled by the script `WTexample` which runs the aero-elastic loop between VLM and an "elastic axis" beam model. Look into the script and make it plot the deformed wing at each iteration.

6. HALE configurations are very flexible and have very long wing span to reduce the induced drag. The HALE model from Ch 10 has a straight, rectangular wing which can be modeled easily by a beam with constant cross section from root to tip. The beam bending equation says

   $EI\mathrm{d}^4w/\mathrm{d}y^4 = Q$ with $w(0) = w'(0) = 0$, $w''(b/2) = w'''(b/2) = 0$

   where $Q(y)$ [N/m] is the lift force distribution, so the deflection/EI can be computed easily. If Q were constant across the span even by a simple degree 4 polynomial. Since the total lift equals the weight you can do that and plot the deformed wing. Choose EI to make the tip move up 10% of the half-span.

   Then investigate the "`results`" returned from VLM (see `../Ch3Docs` for information about the octave Tornado), figure out how to extract $Q(y)$. Then use a simple difference scheme to solve (*) with the correct distribution. The "elastic loop" can now be put in motion by editing the geo file and running VLM on the deformed geometry. Do that manually once.