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DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

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Unsteady Aerodynamics and Aeroacoustics
AME-9034

HOMEWORK 1

1. For harmonic oscillations, the Theodorsen function $C(\omega)$ accounts for the contribution of the wake to the lift and moment. Plot a vector diagram of the real and imaginary parts of its complex conjugate $\overline{C}(\omega)$ versus the frequency $\omega \in \{0, \infty\}$. Also plot its magnitude and phase.

2. Translatory oscillations are an approximation of bending oscillations. Plot a vector diagram of the total lift coefficient of a thin airfoil undergoing bending oscillations versus the reduced frequency. Also plot its magnitude and phase.

3. Calculate the wok W done by a bending oscillation over a cycle of oscillation. Consider first the case of low frequency where the lift can be approximated by the quasi-steady lift. Then calculate the work at any frequency and plot W versus ω. Comment on the contribution of the apparent mass lift and the wake effect on W. What can you say about the stability of a wing in bending oscillation at low Mach number flow?

Hint:

- If a periodic force $\mathbf{f}$ is acting on a body moving with a velocity $\mathbf{v}$,

$$W = \int_0^T \mathbf{f} \cdot \mathbf{v}\, \mathbf{dt},$$

  where T is the period.

- Verify that for a harmonic oscillation where $\mathbf{f}$ and $\mathbf{v}$ are given in complex form

$$W = \frac{T}{2} Re\{\mathbf{f} \cdot \overline{\mathbf{v}}\},$$

  where Re denotes the real part.