ENGR 2340 Dynamics
Parameter Estimation

An airfoil test system has been built for the Olin wind tunnel for flutter research. It is designed to allow the airfoil to move in the vertical (plunge) direction and rotate (pitch) about an axis. The airfoil is fixed to a steel rod which is fixed (clamped) at one end and free to rotate at the other. The rod acts as a torsional spring. The torsional stiffness, k_θ, of the rod can be determined from a plot (below) of applied torque vs. angle of twist (rad) that generated by clamping one end of the rod and twisting the free end with a torque sensor. Also shown below is the damped, free response (degrees) of the airfoil, measured by an angular encoder mounted to the free end. Motion was initiated by an initial pitch angle.

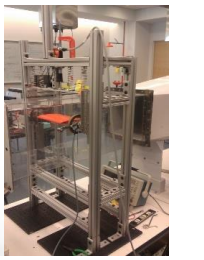
Assuming that the pitch of the airfoil can be described by a single harmonic oscillator

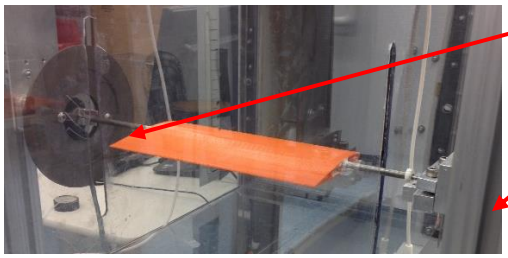
$$\ddot{\theta} + 2\zeta\omega_n\dot{\theta} + \omega_n^2\theta = 0$$

where θ is the pitch angle (wrt horizontal), ζ is the viscous damping ratio, and ω_n = sqrt (k_θ/I_{ZZ}) is the natural frequency of the airfoil.

a) Estimate the natural frequency, ω_n, the mass moment of inertia about the axis of the rod (I_{ZZ}), and the viscous damping ratio, ζ, from the measured data.
b) Is this linear system a good representation of the pitching of the airfoil? Explain your answer.

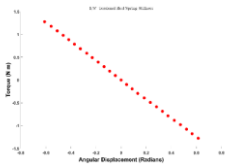
The MATLAB figures (.fig) and data files (both .mat and .txt) are available in the course folder. Please remember to copy them to your laptop for processing. The command 'findpeaks' may be useful here.

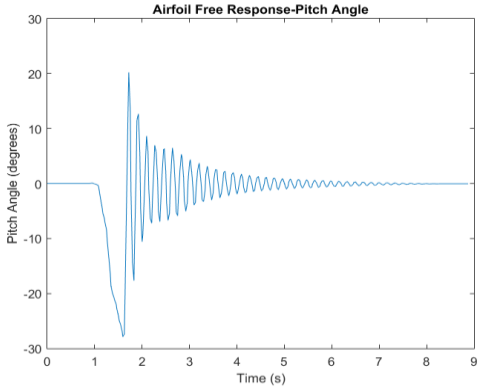




free end with encoder

fixed (clamped) end





torsion-rod_data
(twist and torque)

pitch-angle_data
(pitch_angle and time)

Load data in MATLAB
>> load filename