13.49 Homework #1

1. Consider a weather vane in a wind of velocity U_o. If θ is the angle of the vane with respect to the wind direction,

   (a) Write the single-degree of freedom (N) linearized equations of motion about the fixed axis **0**.

   (b) Write N_θ, $N_{\dot\theta}$, and $N_{\ddot\theta}$ in terms of N_v, N_r, $N_{\dot r}$, etc..

   (c) If we consider the differential equation

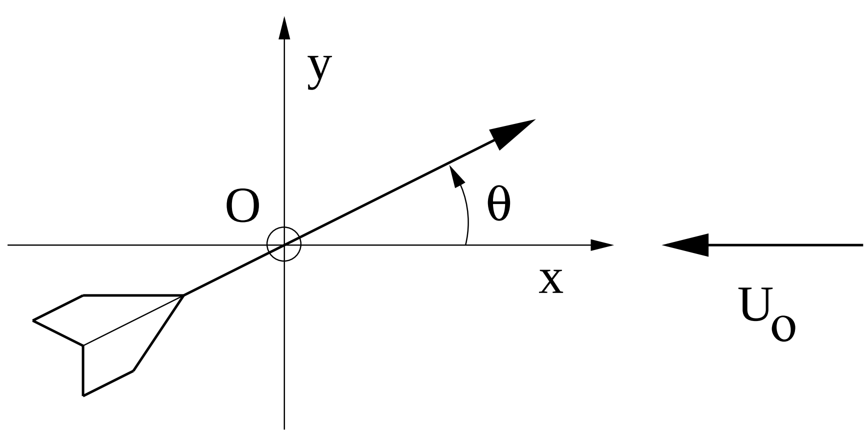
   $$A\ddot{y}(t) + B\dot{y}(t) + Cy(t) = 0,$$

   the condition for stability is that A, B, and C must have the same sign. Express this requirement in terms of the derivatives in the previous question. Give physical interpretations for what would make such a device stable or unstable.

   (d) Create a numerical model of this system, using the MATLAB ODE solver `ode45`. The system equation can be written as two first-order equations:

   $$\frac{d}{dt}\left\{ \begin{array}{c} \dot\theta \\ \theta \end{array} \right\} = \left[\begin{array}{cc} -B/A & -C/A \\ 1 & 0 \end{array} \right] \left\{ \begin{array}{c} \dot\theta \\ \theta \end{array} \right\}.$$

   Simulate the system response to nonzero initial conditions (e.g., $\theta(0) = 1, \dot\theta(0) = 0$). Discuss, using several examples, response sensitivity to B and C, which are related to the aerodynamic coefficients. For example, look at the range $\{A, B, C\} = \{1, \pm 3, \pm 3\}$.



2. The figure below shows some characteristic fluid force curves versus a motion parameter. Give the linear hydrodynamic coefficient at two different operating conditions, origin O and A: is it zero, small, finite positive, finite negative?