ASEN 3128 Aircraft Dynamics, Fall 2019, Assignment 10
Due: Thursday 11/21/2019 at 11:59pm on Canvas

1. Use the non-dimensional stability coefficient data from Table 6.6 in the textbook, together with the data in Table E.1 in Appendix E, **case II**, for the B747 airplane to construct a table like Table 6.7, but in SI units. Since this case is for constant-altitude flight, the flight path angle is zero, hence the trimmed pitch angle (of the stability frame) has $\theta_0 = 0$.

2. Use the results from problem 1 together with eq. 4.9,19 to build the 4x4 A matrix for the B747 linearized lateral dynamics (also called A_{lat} in lecture).

3. Find eigenvectors and eigenvalues of the lateral A matrix. Identify roll, spiral, and Dutch roll modes (review Sec 6.7 for the characteristics of each). What are the time constants for each mode? Also identify modal damping ratios and modal natural frequencies for any complex conjugate eigenvalues. Which, if any, of these modes are unstable for this flight condition?

4. Compare the eigenvalues above of the Dutch roll mode to the eigenvalues obtained using the 'Dutch roll dynamics approximation', described in pages 195-196 of the book. This approximation uses 2 equations of motion for Δv and Δr at the top of p. 196, derived by treating the Dutch roll mode as a combination of yawing and sideslip motions only (i.e. ignoring the rolling motion that is actually present). **Note: be careful:** the calligraphic symbols $\mathcal{Y}_v$, $\mathcal{N}_v$, etc. are ***NOT*** the same as the stability derivatives Y_v, N_v, etc. (see eq. 6.8,2 and explanation after for what $\mathcal{Y}_v$, $\mathcal{N}_v$, etc. mean).

5. Simulate the linearized lateral dynamics from eq. 4.9,19.

a. Verify that the trim state is an equilibrium.

b. Perturb the initial state $y(0) = [\Delta v(0), \Delta p(0), \Delta r(0), \Delta\phi(0)]^T$ as follows, and plot the responses. Discuss the results in reference to the modal behaviors found above:

   (i) $\Delta v(0) = 10$ m/s; all other states initially at 0;

   (ii) $\Delta p(0) = 0.15$ rad/s; all other states initially at 0;

   (iii) $y(0) = [-1.8563, -0.4185, 0.0311, 0.6148]^T$;

   (iv) $y(0) = [2.9477, -0.0063, 0.0758, 1.2431]^T$.

c. Which initial deviations are good at exciting the spiral mode? The roll mode? The Dutch roll mode? Explain the correspondence between the observed behaviors and the initial conditions in each case.