ASEN 3128 Assignment 8

Due: Thursday, October 31 at 11:59 PM on Canvas

1) Determine the tail modifications necessary to double the pitch stiffness of the B747, case II, from Assignment 7. Assume the vehicle is loaded so that the c.g. is at the neutral point of the wing-body. What is the resulting effect on the damping ratio of the short period mode, based on the short period approximation from class?
2) Add elevator control derivatives to the linearized model for the B747 (with the nominal tail design), based on the non-dimensional values on p. 229 in the textbook, dimensionalizing according to table 7.1 (in SI units), using the case II flight conditions from Appendix E.
3) Design a proportional-derivative feedback control from elevation angle to elevator control in the form

$$\Delta\delta_e = -k_2\Delta\theta - k_1\Delta q$$

to augment damping in the phugoid mode, as follows:

a) First design for increased pitch stiffness in the short period mode by a variable scale factor k_s, ranging from 1 to 3, in steps of 0.01, while retaining the original (no control) damping ratio, using the short period approximation from class. Plot the resulting locus of these eigenvalues in the complex plane to verify increasing pitch stiffness and constant damping ratio in the 2nd order short period approximation as k_s varies.
b) Implement the above range of control laws on the full linearized longitudinal dynamics and calculate the actual short period and phugoid mode eigenvalues. Plot the locus of these eigenvalues in the complex plane. Discuss the general trends in modal behavior as k_s varies.
c) Simulate the closed loop behavior of the linearized longitudinal system, starting from trim except for a 0.1 rad deviation in $\Delta\theta$, for the case of k_s = 1 (no feedback) and for the case k_s = 2 (doubled pitch stiffness). Does this behavior make sense given the corresponding closed loop eigenvalues?
d) Determine the reason for the effects on phugoid induced by the short period control. Is this primarily due to the natural coupling in the A matrix between the rotational and translational states, or due to the additional control effects in the B matrix (not modeled in the short period control design) of elevator actuation on the translational states?