MECE-410: Flight Dynamics **Project #5**
Spring 2014-2015 (2145) **Due: *<u>05/12/15</u>***

Instructions: Use Simulink to solve all problems. Save your work in an m-file and Simulink mdl-file.

Using the Simulink diagram developed for Project #4, find the linearized state-space model using the Matlab "linmod" command. Decouple the resulting matrices so the following state-space systems are defined (note, each resulting $\mathbf{A}$ matrix will be a 4x4 matrix) and **display** each state-space model:

a. Longitudinal Model with states and outputs $\begin{bmatrix} V_T & \alpha & q & \theta \end{bmatrix}^T$ and input $\begin{bmatrix} \delta e \end{bmatrix}$
b. Lateral/Directional Model with states and outputs $\begin{bmatrix} \beta & p & r & \phi \end{bmatrix}^T$ and inputs $\begin{bmatrix} \delta a & \delta r \end{bmatrix}^T$

Using the Longitudinal state-space model

1. Determine the short period and phugoid mode eigenvalues, natural frequencies, and damping ratios. Clearly define each eigenvalue, natural frequency, and damping ratio for each mode.
2. State whether the system is stable and why?
3. Find the pitch-rate due to elevator transfer function, i.e., $q(s)/\delta e(s)$.
4. Find the angle-of-attack due to elevator transfer function, i.e., $\alpha(s)/\delta e(s)$.
5. Use Simulink with the "ode5" solver with a fixed step size to simulate the response of the linearized state-space model and your original model from Project #3 for the time interval of $[0,10]$ sec with $\Delta t = 0.01$ sec for a step input to the elevator with the step starting at time 1 sec and with a magnitude of -0.5 deg. Develop overlay plots (state-space and full nonlinear model results) of True Velocity vs time, Angle-of-Attack vs time, Pitch Rate vs time, and Pitch Angle vs time, Sideslip angle vs time, Roll Rate vs time, Yaw Rate vs time, Bank Angle vs time, and Heading Angle vs time for the step response. Use units of degrees for your plots.

Using the Lateral/Directional state-space model

1. Determine the dutch roll mode, roll and spiral mode eigenvalues. Clearly define the modes!!!
2. Find the dutch roll natural frequency and damping ratio.
3. Find the roll mode time constant.
4. Find the spiral mode time constant.
6. State whether the system is stable and why?
5. Use Simulink with the "ode5" solver with a fixed step size to simulate the response of the linearized state-space model and your original model from Project #3 for the time interval of $[0,10]$ sec with $\Delta t = 0.01$ sec for a step input to the aileron with the step starting at time 1 sec and with a magnitude of -0.5 deg. Develop overlay plots (state-space and full nonlinear model results) of True Velocity vs time, Angle-of-Attack vs time, Pitch Rate vs time, and Pitch Angle vs time, Sideslip angle vs time, Roll Rate vs time, Yaw Rate vs time, Bank Angle vs time, and Heading Angle vs time for the step response. Use units of degrees for your plots.
6. Use Simulink with the "ode5" solver with a fixed step size to simulate the response of the linearized state-space model and your original model from Project #3 for the time interval of $[0,10]$ sec with $\Delta t = 0.01$ sec for a step input to the rudder with the step starting at time 1 sec and with a magnitude of -2.0 deg. Develop overlay plots (state-space and full nonlinear model results) of True Velocity vs time, Angle-of-Attack vs time, Pitch Rate vs time, and Pitch Angle vs time, Sideslip angle vs time, Roll Rate vs time, Yaw Rate vs time, Bank Angle vs time, and Heading Angle vs time for the step response. Yaw Rate vs time, Bank Angle vs time, and Heading Angle vs time for the step response. Use units of degrees for your plots.