MEM 453, 530: AIRCRAFT DYNAMICS
Winter 2018-2019 (Term: 201825)

Exam 2
Due: March 05, 2019
Submit PRINTED report and include the Effort Sheet

You are to analyze the perturbed longitudinal dynamics of a transport airplane. The parameters of the vehicle are provided in the 'transp' function of text and repeated below.
The airplane's equilibrium flights (trim conditions) are given below (specific for each team), and all are in clean (retracted landing gear; LAND == 0) configuration.

Respond to the following, **with pertinent observations** [use the state space model except in (e)]:

a. *The phugoid and short-period characteristics, their frequencies, damping ratios, time periods, etc.*
b. *Argand diagrams associated with phugoid and short-period modes.(you may have to 'suppress/down-play' the velocity component for better observations)*
c. *Response plots of all the state variables for an initial, simultaneous 10% perturbation in all the states.*
d. *Using appropriate eigenvectors as initial conditions, excite each mode separately and plot the time response of all the states.*
e. *Determine the transfer functions* v_T / δ_T *and* α / δ_e. *Can you justify any pole-zero cancellations? If so, what modes get cancelled? Verify this by response plots for a unit step input – ie. compare the response plots resulting from the full and the approximate transfer functions.*
f. *Generate the time-response plots of all states for (i) +0.1 units throttle with 'zero' elevator, and (ii) +2 deg. Elevator with 'zero' thrust. (These 'inputs' are perturbations from their trim values)*
g. *(For MEM530 only): in cases (c), (d), and (f), plot (i)the flight path of the vehicle as seen from the inertial frame, and (ii) the path of the cg of the perturbed airplane as seen from an adjacent airplane in the unperturbed equilibrium flight.*

Comments on generating the linearized state-space model:

1. *You may use the 'trim' driver (along with 'cost' function)from text book, or the 'qtrim' (along with 'feq') function I have provided, to determine the trim values for {throttle, elevator, angle-of-attack} settings.*
2. *These programs require the 'adc' function (in Appendix), and the 'fminsearch' function (built-in matlab function).*

Team	**Altitude (ft.)**	**Velocity (ft/se.)**	**Climb angle (deg.)**
A	0	300	0
B	0	500	0
C	10,000	300	0
D	10,000	500	0
E	20,000	500	0
F	20,000	300	0

If you find any discrepencies between the data given below and the ones in 'transp', let me know.

Airplane data:

Wing area: 2170 ft^2, mean aerodynamic chord: 17.5 ft., mass: 5.0E03 slug, pitch moment of inertia: 4.1E06 slug.ft^2, gravity: 32.17 ft/sec^2.

Engine characterisitics:

Thrust: $T = (T_{stat} + \frac{\partial T}{\partial V_T} V_T)\delta_T$; $\delta_T =$ *throttle setting.* T_{stat} *= 6.0E04 lbs,* $\frac{\partial T}{\partial V_T} = -38 lbs.\sec/\ ft.$

The thrust vector's 'line of action' is off-set from the CM by Z_E *= 2 ft. so that* $m_T = TZ_E$.

Note: $X_{\delta_T}, Z_{\delta_T}, M_{\delta_T}$ *can be computed from the expression for T.*

Non-dimensional coefficients:

$$C_L = C_{L_0} + C_{L_\alpha}\alpha; C_{L_o} = 0.2, C_{L_\alpha} = 0.085\,\text{deg}^{-1}$$

$$C_D = C_{D_0} + k_1 C_L^2; C_{D_0} = 0.016, k_1 = 0.042$$

$$C_m = C_{m_0} + C_{m_\alpha}\alpha + C_{m_{\delta_e}}\delta_e; C_{m_0} = 0.05, C_{m_\alpha} = -0.022\,\text{deg}^{-1}, C_{m_{\delta_e}} = -0.016\,\text{deg}^{-1}$$

$$C_{L_V} = C_{D_V} = C_{m_V} = 0$$

$$C_{L_{\dot\alpha}} = C_{D_{\dot\alpha}} = 0, C_{m_{\dot\alpha}} = -6\sec/\,rad.$$

$$C_{L_q} = C_{D_q} = 0, C_{m_q} = -16\sec/\,rad.$$

$$C_{L_{\delta_e}} = C_{D_{\delta_e}} = 0, C_{m_{\delta_e}} = -0.016/\,\text{deg}.$$