MAE 5070 **Exercise Set II** February 21, 2011

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We continue our study of the Boeing 747 aircraft. We will want to use some of the results from Exercise Set I, so they are summarized here (so that we all use the same values as a starting point).

The relevant dimensions and parameters are as follows for Flight Condition I ($V = 279.$ ft/s at standard sea level conditions) – which is the only flight condition we will consider here. Also listed below are some properties of the elevator that will be needed in these exercises.

$S = 5500.$ ft^2	$S_t = 1460.$ ft^2	$S_e = 365.$ ft^2
$\bar{c}_w = 30.9$ ft	$\bar{c}_t = 22.3$ ft	$\bar{c}_e = 5.58$ ft
$\eta = 0.95$	$\dfrac{\mathrm{d}\varepsilon}{\mathrm{d}\alpha} = 0.276$	$G = 0.30$ ft^{-1}
$\dfrac{\partial \mathbf{C}_{Lw}}{\partial \alpha_w} = 4.02$	$\dfrac{\partial \mathbf{C}_{Lt}}{\partial \alpha_t} = 3.37$	$\dfrac{\partial \mathbf{C}_L}{\partial \alpha} = 4.64$
$W = 564,000.$ lbf	$\ell_t = 102.7$ ft	$\dfrac{x_{NP}}{\bar{c}} = 0.54$
$a_e = \dfrac{\partial \mathbf{C}_{Lt}}{\partial \delta_e} = 1.35$	$\mathbf{C}_{h\alpha_t} = -0.0060$	$\mathbf{C}_{h\delta_e} = -0.010$

For all exercises below, assume that the vehicle c.g. is located at the wing aerodynamic center (i.e., $\frac{x_{\rm cg}}{\bar{c}} = \frac{x_{\rm ac}}{\bar{c}}$), and express the locations of all neutral and maneuver points in per cent mean aerodynamic chord.

1(a). Estimate the control position gradient for trim $\left.\frac{\mathrm{d}\delta_e}{\mathrm{d}\mathbf{C}_L}\right)_{\rm trim}$ at the given velocity.

1(b). Estimate the location of the basic maneuver point and the control position gradient $\frac{\mathrm{d}\delta_e}{\mathrm{d}n}$ for a pull-up maneuver.

2(a). Estimate the control-free lift curve slope $\mathbf{C}_{L'_\alpha}$, the control-free pitch stiffness $\mathbf{C}_{m'_\alpha}$, and the location of the control-free neutral point $\frac{x'_{NP}}{\bar{c}}$.

2(b). Estimate the control force gradient for trim $\left.\frac{\mathrm{d}F}{\mathrm{d}V}\right)_{V_{\rm trim}}$ at the given velocity.

2(c). Estimate the control free maneuver point and the control force gradient $\frac{\mathrm{d}F}{\mathrm{d}n}$ for a pull-up maneuver.

Note: You should expect to find control force gradients that are quite large; the Boeing 747, of course, has hydraulically actuated controls.