AE6520
Fall 2007
Homework #6
Due: Wednesday December 5, 2007 at 2:05pm (beginning of class)

1. The stability derivatives of an airplane are given as:

	C_y	C_l	C_n
β	-0.14	-0.0689 - 0.0917C_L	0.01326 + 0.017C_L^2
$\hat{p}$	-0.039	-0.441	-0.00109 - 0.0966C_L
$\hat{r}$	0.165	-0.0144 + 0.271C_L	-0.048 - 0.0238C_L^2

The airplane weighs 2400 lb (10.675 N) and has a wing area of 160 square feet (14.9 square meters). Wing span is 30 feet (9.14 meters), I_x = 170 slug-ft2 (230 Kg-m2), I_z = 1312 slug-ft2 (1778 kg-m2), and I_{zx} = 0. The flight altitude is sea level.
Calculate and plot the spiral stability criterion E (below) as function of speed (lift coefficient between 0.15 and 1.7) and values of flight path angle (gamma$_e$ in book, or theta$_0$) for values of -10^o, 0, and 10^o. From your notes:

$$E = g\left[\left(\bar{L}_v\bar{N}_r - \bar{L}_r\bar{N}_v\right)\cos\theta_0 + \left(\bar{L}_p\bar{N}_v - \bar{L}_v\bar{N}_p\right)\sin\theta_0\right]$$

which came from the lateral-directional stability matrix put in the special form:

$$\frac{d}{dt}\begin{bmatrix} v \\ p \\ r \\ \phi \end{bmatrix} = \begin{bmatrix} \bar{Y}_v & 0 & \bar{Y}_r & g\cos\theta_0 \\ \bar{L}_v & \bar{L}_p & \bar{L}_r & 0 \\ \bar{N}_v & \bar{N}_p & \bar{N}_r & 0 \\ 0 & 1 & \tan\theta_0 & 0 \end{bmatrix}$$

2. A hovercraft in ground effect is acted on by the following aerodynamic forces, expressed as body frame components:

$X = Y = 0$
$Z = -mg + Z_z z_E$
$L = L_\phi \phi$
$M = M_\theta \theta$
$N = 0$

The body axes are principal axes, and the engine/rotor angular momentum is
$h'_B = [0\ 0\ H]^T$
Derive small perturbation equations of motion and find the characteristic equation. Show that it is statically unstable with both M_θ and L_ϕ positive in can be gyrostabilized (like a spinning top) if H is large enough
(hint: showing modes have real parts less than *or equal* to zero will be sufficient).

3. A conventional stable aircraft is on a steady descent to landing on a shallow glide slope when the headwind suddenly vanishes. What initial condition problem describes the subsequent motion? Describe qualitatively, from your knowledge of longitudinal modes, what the subsequent flight path will be if the elevator and throttle controls remain fixed at their prior positions.

4. An additional control surface (δ_s) is added above the fuselage of an airplane, near the c.g.. It is capable of providing a side force, accompanied by a rolling moment, given by

   $\Delta Y = Y_{\delta s}\delta_s$

   $\Delta L = L_{\delta s}\delta_s$

   What condition must be satisfied if the aileron, rudder, and this new surface are to generate a specified Y, L, N?

5. Estimate how fast a football must be spinning to be stabilized for a long pass. Estimate/guess any parameters you need. Also, note which part of the pass requires the greatest spin.

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