AOE 3134 Stability and Control
Problem Sheet Eight

Due April 11, 2002

A version of the Boeing 747 has the following characteristics:

W = 636,600 lbs	$S = 5{,}500$ ft^2	(M = 0.9 (40k ft))
Ix = 18.2 x 10^6 Slug ft^2	b = 195.68 ft	Max control
Iy = 33.1 x 10^6 Slug ft^2	c-bar = 27.31 ft	deflections (all axes)
Iz = 49.7 x 10^6 Slug ft^2	M = 0.25 (sea level)	δ_{max} = 30 deg.

	C_Y	C_l	C_n
β	-0.96(-0.85)	-0.221(-0.10)	0.150(0.20)
p	0.0(0.0)	-0.45(-0.30)	-0.121(-0.20)
r	0.0(0.0)	0.101(0.20)	-0.30(-0.325)
δ_a	0.0(0.0)	0.0461(0.014)	0.0064(0.003)
δ_r	0.175(0.075)	0.007(0.005)	-0.109(-0.09)

all values in per/radian where applicable, (•) values at M = 0.9 @ 40,000ft

30. Determine the response of the 747 to a 5 degree step change in elevator deflection. Determine the roll rate response, p(t), and the angle time history $\phi(t)$.

31. In 1960?, when Boeing was trying to sell the 707, a Boeing test pilot flew over Lake Washington where there were unlimited hydroplane races going on for Seattle Sea Fair days. Many big wigs from Washington and from the airlines were there attending the races. The Test pilot wanted to demonstrate the agility of the aircraft and also how safe it was. Unannounced and certainly not approved, the test pilot flew at altitude (several thousand feet) over the lake and did an aileron roll, 360 degrees! Needless to say he was chewed out shortly afterward, but Boeing made the sales. Suppose now that one was to do the same thing with our 747. Estimate the following assuming ***full control.***
a) The steady state roll rate at sea level and at 40,000 ft.
Do the following at sea level:
b) The time to roll from 0 to 90 degrees (assuming one is going to roll through 90 degrees)
c) The time to roll from 0 to 180 degrees (assuming one is to roll through 180 degrees)
d) The time for the full 360 degree roll (assuming one is to roll through 360 degrees)

32. What would be the frequency of directional oscillations and the damping ratio if a full scale model were placed in a huge wind tunnel at M=0.25?

33. What would be the frequency and damping ratio of directional oscillations of a 1/10 model placed in a wind tunnel (still it has a 19 ft wing span!).

34. In a full scale wind tunnel, an aircraft with the following properties is allowed to pitch freely about the cg.:
$\bar{q}$=49.6 lbs/ft^2, I_y = 1346 slug ft^2,

$$C_{m_\alpha} = -0.613,\ C_{m_{\dot\alpha}} = -7.27,\ C_{m_q} = -12.4,\ V = 220.5\text{ft/sec},\ \bar{c} = 4.9\text{ ft}, S = 174.0\text{ ft}^2$$

Determine:
a) time to half amplitude
b) frequency of oscillation in hz
c)damping ratio
d) cycles to half amplitude
e) What would the effect on the above 4 quantities be if the cg were moved forward (and the pivot moved with it) 0.5 ft?

35. Extra credit problem (non trivial problem!) For the 747 (data given above) determine the time for the full 360 degree roll assuming one is to stop at 360 degrees.