AER1216: Fundamentals of UAVs
Lecture 6 Exercise Questions

Winter 2015-16

1. Please derive the force equations of motion expressed in terms of the air-trajectory frame $F_W$.

2. A paper airplane is perhaps the simplest and earliest UAV. The point-mass longitudinal motions of the paper airplane is described by

$$m\dot{V} = W \sin \gamma - D = W \sin \gamma - C_D \left(\frac{1}{2} \rho V^2 S \right)$$

$$mV\dot{\gamma} = W \cos \gamma - L = W \cos \gamma - C_L \left(\frac{1}{2} \rho V^2 S \right)$$

where $V, \gamma$ are the airspeed, flight path angle respectively. Treat a steady descending as the equilibrium point of $V_e, \gamma_e$, develop a linearized equation to describe its motion in the neighbourhood of the equilibrium.

3. The Boeing 747-100 transport is cruising in horizontal flight at 40,000 ft at Mach number 0.8 [1]. Geometric and aerodynamic data are given in Assignment 5, also available in [1].

(a) Based on linearized longitudinal model, design an altitude control system to climb up to a new altitude command $h_c = 45,000 ft$. The design requirements (specifications) are: 1) the aircraft is stable; 2) the overshoot $\leq 10\%$; and 3) the steady state error $\leq 5\%$.

(b) Use the linear system platform to design a heading-hold controller. During the steady flight at 40,000ft, command the airplane for a steady 90 degree turn under the heading-holding autopilot, i.e., the autopilot controls the heading step change of $\psi = 0 \rightarrow 90$ (deg). The design requirements (specifications) are: 1) the aircraft is stable during the motion; 2) the heading overshoot: $\leq 10\%$; and 3) the steady heading error: $\leq 5\%$.

References