1. Explain how you can estimate the following stability derivatives and how these stability derivatives do relate to the aircraft static stability characteristics.

C_{m_u} , C_{m_α} , C_{m_q} , C_{l_β} , C_{n_β} , C_{n_r}

(25%)

2. Let the short period mode of an aircraft be represented as the following equations,

$$\dot{w} = Z_w w + U_0 q + Z_{\delta_e} \delta_e$$
$$\dot{q} = (M_w + M_{\dot{w}} Z_w) w + (M_q + U_0 M_{\dot{w}}) q + (M_{\dot{w}} Z_{\delta_e} + M_{\delta_e}) \delta_e$$

where $Z_w = -0.74$ 1/sec , $U_0 = 630$ ft/sec

$Z_{\delta_e} = -1.56$ ft/sec²

$M_w = -.004$ 1/ft-sec , $M_{\dot{w}} = -7.62 \times 10^{-5}$ 1/ft

$M_q = -.286$ 1/sec , $M_{\delta_e} = -8.3$ 1/sec²

$w \sim$ (ft/sec) , $q \sim$ (rad/sec) , $\delta_e \sim$ (rad)

Find (1) The damping ratio and natural frequency of the short period mode.

(2) If $\delta_e = -5\, u(t)$ (deg) find the responses of $\alpha(t)$, $q(t)$ and $a_z(t)$, where a_z is the normal acceleration (positive up).

(3) Sketch $\alpha(t)$, $q(t)$ and $a_z(t)$ obtained in (2). Indicate the envelope curves, the period, the steady state values and the overshoots clearly.

Note: $u(t) = \begin{cases} 0 , & t < 0 \\ 1 , & t \geq 0 \end{cases}$ (25%)

(接下頁)

3\. An aircraft is maneuvering with an angular speed

$$\bar{\omega} = 90\bar{i} + 5\bar{j} - 5\bar{k} \ (\mathrm{deg/sec})$$

where $\bar{i}$, $\bar{j}$ and $\bar{k}$ are the unit vectors in the (aircraft) body frame. Determine the attitude changing rate $\dot{\phi}$, $\dot{\theta}$ and $\dot{\psi}$ at the instant that the aircraft has the attitude, $\theta = 30^{\mathrm{deg}}$ and $\phi = 60^{\mathrm{deg}}$.

(25%)

4\. The thrust available at an angle of attack of 8 degrees is 30% more than required to fly the airplane horizontally. The airplane weights 8000 pounds and has a wing area of 500 square feet. The lift coefficient of the wing is 0.975 and the L/D of the airplane is 10.15. What is the rate of climb? (Use $\rho = .002378 \ \mathrm{slug/ft^3}$)

(25%)