$\Rightarrow$ To calculate Aerodynamic Derivatives.

Summary of Design :

	Wing	Tail	
Based on Previous Calc.	$S = 12.2 m^2$	$S = 2.2 m^2$	
	$b = 11 m$	$b = 2.75 m$	$\eta_t = 0.9$
	$AR = 10$	$AR = 3.43$	$V_H = 0.6$
	$c = 1.1 m$	$c = 0.8 m$	

$e = 0.7 \quad k = 0.045 = \frac{1}{\pi AR e}$

$\rightarrow$ assuming a 6 series NACA airfoil : 64,-412

$(t/c)_{max} = 0.12 \qquad c_l = 0.31 \qquad \alpha_{stall} = 12^\circ$

$c_{d_0} = 0.0097 \qquad C_{l_{max}} = 1.34 \qquad C_{m_{ac}} = -0.07$

(2D lift curve slope) $C_{l_\alpha} = \frac{dc_l}{d\alpha} \approx 5.9$ per rad. (from graph) $\left(\frac{\Delta c_l}{\Delta \alpha}\right)$

$\therefore$ 3D $C_{L_\alpha} = \frac{C_{l_{\alpha 2D}}}{1 + \frac{C_{l_{\alpha 2D}}}{\pi AR e}} = \frac{5.9}{1 + 5.9(0.045)} = 4.\cancel{65}$ per rad

$\therefore \boxed{C_{L_{\alpha_{3D_w}}} = 4.72 \text{ per rad}}$

$\boxed{C_{L_{\alpha_{t_{3D}}}} = 3.8/\text{rad}}$ for sym. airfoil.

and $\boxed{C_{L_{fuselage}} @ \alpha = 12^\circ \simeq 0.011}$

$\therefore C_{L_w} = \frac{c_l}{1 + 2/AR} = \frac{0.31}{1 + 2/10} = 0.25$

$(C_{L_\alpha})_{a/c} = C_{L_{\alpha w}} + \cancel{C_{L_{\alpha f}}}^{\approx 0} + C_{L_{\alpha t}} \cdot \left(1 - \frac{d\varepsilon}{d\alpha}\right) \frac{S_t}{S_w} \eta_t$

$= 4.72 + 3.8\left(1 - \frac{2 C_{L_\alpha}}{\pi AR_w}\right) \cdot \frac{2.2}{12.2} \cdot 0.9$

$\boxed{(C_{L_\alpha})_{a/c} = 5.15 \text{ /rad}}$

(for tail NACA0009 $c_{l_t} = 0$)

$\rightarrow C_L = C_{L_{fuselage}} + C_{L_w} + \cancel{C_{L_t}}$

$\simeq 0.25 + 0.011$

$\rightarrow \quad C_D = C_{D_0} + kC_L^2$

$\therefore$ we need to estimate C_{D_0}.

$C_{d_0 w} = 0.0097$

$C_{d_0 f} \simeq 0.004 \times$ Area f.

C_{d_0} Nacell $\simeq 0.1 \times$ Area N

C_{d_0} struts $\simeq 0.6 \times$ Area struts.

$C_{d_0 t} \simeq 0.01$

$\rightarrow \quad C_{D\alpha} = (C_{L\alpha})(2KC_L) = (2 \times 0.025)(5.15)$

$= 2.57$

$\rightarrow \quad (C_m)_{ac} = C_{m_0} + C_{m\alpha}\,\alpha.$

$(C_{m_0})_{a/c} = 0.09$ (requirement based on SM)

$(C_{m\alpha})_{a/c} = (C_{L\alpha w})\left(\frac{x_{CG}}{c} - \frac{x_{acw}}{c}\right) - \eta V_H C_{L\alpha t}\left(1 - \frac{\partial \epsilon}{\partial \alpha}\right)$

$= (4.72)(0.41 - 0.25) + (0.9)(0.6)(3.8)\left\{\left(1 - \frac{2C_{L\alpha}}{\pi AR}\right)\right.$

$= 0.7552 + 0.383$

$$\left[(C_{m\alpha})_{a/c} = 1.138 \ /\text{rad.}\right]$$