Pitching Moment

To estimate the pitching moment for the delta and double delta at subsonic speed of $M = 0.1$, the datcom shall be used. The pitching moment is presented in terms of the wing aerodynamic center and is described by the following formula about any point along the chord line:

$$\frac{dC_m}{dC_L} = \left(n - \frac{x_{a.c.}}{c_r}\right)\frac{c_r}{\bar{c}}$$

where

$\frac{x_{a.c.}}{c_r}$ is the distance from the wing apex to the aerodynamic center measured in root chords, positive aft.

n is the distance from the wing apex to the desired moment reference center measured in root chords, positive aft.

$\frac{c_r}{\bar{c}}$ is the ratio of the root chord to the mean aerodynamic chord.

Method 1 in the datcom is applicable for most low aspect ratio wings configurations and shall be used for estimating the pitching moment. The method is basically finds the fraction of the aerodynamic center location to the respect of the wing root chord. For most wings configuration based of planform characteristics this fraction is given in charts (i.e. figures 4.1.4.2-26a through 4.1.4.2-26f in datcom). These charts are limited to $M \le 0.6$. n will be taken as the distance to the centroide of the wing.

Delta Wing

$n = 0.20$ m

$A = 1.865$, $\lambda=0$, $\Lambda_{LE}=65^\circ$, $c_r=0.3$ m

$A \tan\Lambda_{LE} = 4$

$$\frac{\beta}{\tan\Lambda_{LE}} = \frac{\sqrt{1-M^2}}{\tan\Lambda_{LE}} = 0.464$$

$$\bar{c} = \frac{2}{3}c_r\frac{1+\lambda+\lambda^2}{1+\lambda} = 0.2$$

$$\left(\frac{x_{a.c.}}{c_r}\right) = 0.60 \text{ (Figure 4.1.4.2-26a)}$$

Delta Wing Pitching Moment, $\frac{dC_m}{dC_L} = -0.6$

Double Delta Wing

The double delta wing is divided into two panels:

Inboard Panel: the leading and trailing edges are extended to the center line of the wing and tip chord span station is fixed at the break formed by the

	discontinuity in the sweep of the leading edge of the composite edge.
Outboard Panel:	the leading and trailing edges are extended to the midpoint between the center line and the break formed by the discontinuity in the sweep of the leading edge of the composite edge.

$n = 0.2134$ m

Total Wing:

$A_w = 4.046,\ \lambda_w = 0,\ \Lambda_{\mathrm{LE_i}} = 65^\circ,\ \Lambda_{\mathrm{TE_\circ}} = 40^\circ,\ \mathrm{c_{r_w}} = 0.301\ \mathrm{m},\ \frac{\mathrm{b}_w}{2} = 0.234\ \mathrm{m}$

Constructed Inboard Panel Characteristics:

$A_i = 0.745\ \mathrm{m}^2,\ \lambda_i = 0.429,\ \Lambda_{LE_i} = 65^\circ,\ \Lambda_{TE_i} = 0^\circ,\ c_{r_i} = 0.301\ \mathrm{m},\ c_{t_i} = 0.1291\ \mathrm{m}$

$\left(\frac{b}{2}\right)_i = 0.0801\ \mathrm{m},\ S_i = 0.03445\ \mathrm{m}^2,\ \left(\Lambda_{\mathrm{c/2}}\right)_i = 47.02^\circ$

Constructed Outboard Panel Characteristics

$A_\circ' = 3.357\ \mathrm{m}^2,\ \lambda_\circ' = 0,\ \Lambda_{LE_\circ} = 40^\circ,\ \Lambda_{TE_\circ} = 0^\circ,\ c_{r_i}' = 0.2311\ \mathrm{m},\ c_{t_i}' = 0\ \mathrm{m}$

$\left(\frac{b}{2}\right)_\circ' = 0.19395\ \mathrm{m},\ S_\circ' = 0.04482\ \mathrm{m}^2,\ \left(\Lambda_{\mathrm{c/2}}\right)_\circ = 30.79^\circ,\ \Delta y = 0.04005\ \mathrm{m}$

Assuming $\kappa = 1$

For Double Delta Wing $\frac{x_{a.c.}}{c_r} = \frac{\left(C_{L_\alpha}\right)_i S_i \left(\frac{x_{a.c.}}{c_r}\right)_i + \left(C_{L_\alpha}\right)_\circ' S_\circ' \frac{\left(x_{a.c.}\right)_\circ'}{c_r}}{\left(C_{L_\alpha}\right)_i S_i + \left(C_{L_\alpha}\right)_\circ' S_\circ'}$ (Eq 4.1.4.2-d in the datcom)

Finding $\left(C_{L_\alpha}\right)_i$, $\left(\frac{x_{a.c.}}{c_r}\right)_i$

$\frac{A_i}{\kappa}\left[\beta^2 + \tan^2\left(\Lambda_{c/2}\right)_i\right]^{1/2} = 1.09$

$\left(\frac{C_{L_\alpha}}{c_r}\right)_i = 1.47$ (Figure 4.1.3.2-49 in the datcom)

$\left(C_{L_\alpha}\right)_i = \left(\frac{C_{L_\alpha}}{c_r}\right)_i A_i = 1.095$

$\left(A \tan \Lambda_{LE}\right)_i = 1.598;\quad \frac{\beta}{\tan \Lambda_{LE}} = 0.464 \Rightarrow \left(\frac{x_{a.c.}}{c_r}\right)_i = 0.395$ (by interpolation)

Finding $\left(C_{L_\alpha}\right)_\circ'$, $\left(\frac{x_{a.c.}}{c_r}\right)_\circ$

$$\frac{A_{\circ}'}{\kappa}\left[\beta^2+\tan^2\left(\Lambda_{c/2}\right)_{\circ}\right]^{1/2}=3.9$$

$$\left(\frac{C_{L_\alpha}}{c_r}\right)_{\circ}=0.9844$$

$$\left(C_{L_\alpha}\right)_{\circ}'=\left(\frac{C_{L_\alpha}}{c_r}\right)_{\circ}A_{\circ}'=3.305$$

$$\left(A\tan\Lambda_{LE}\right)_{\circ}'=2.81;\quad \frac{\tan\Lambda_{LE_\circ}}{\beta}=0.84\quad\Rightarrow\quad\left(\frac{\mathrm{x_{a.c.}}}{c_r}\right)=0.53$$

Finding $\frac{\left(x_{a.c.}\right)_{\circ}'}{c_{r_i}}$

$$\frac{\left(x_{a.c.}\right)_{\circ}'}{c_{r_i}}=\left(\frac{x_{a.c.}}{c_r}\right)_{\circ}'\left(\frac{c_{r_\circ}'}{c_{r_i}}\right)-\frac{\Delta y}{c_{r_i}}\tan\Lambda_{LE_\circ}+\frac{b_i}{2c_{r_i}}\tan\Lambda_{LE_i}=0.866$$ (Eq 4.1.4.2-d from datcom)

Thus; $\frac{x_{a.c.}}{c_r}=0.7704$

Also finding that $\bar{c}=\frac{\bar{c}_i S_i+\bar{c}_{\circ}S_{\circ}}{S_i+S_{\circ}}=0.1762$,

Where $\bar{c}_i=0.227,\ S_i=0.03445,\ \bar{c}_{\circ}=0.0861,\ S_{\circ}=0.01945$

Delta Wing Pitching Moment, $\frac{dC_m}{dC_L}=-0.9515$