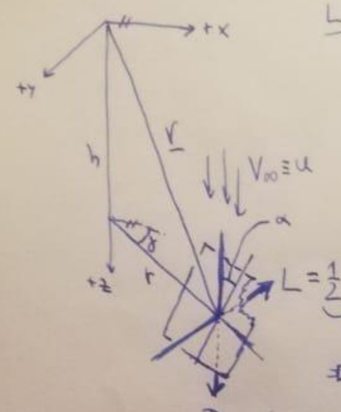
①



LIFT: $L = \frac{1}{2}\rho C_L A \cdot u^2 \cdot \text{sen}(\alpha)$

$\underline{H}$: $\alpha \ll 1$

DRAG: $D = (C_0 + C_2 \alpha^2) \cdot u^2$

$\underline{H}$: PLACA FINA

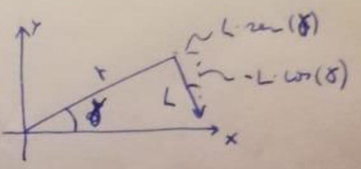
C_0: PARÁSITO

C_2: RESISTENCIA

$L = \underbrace{\frac{1}{2}\rho C_L \cdot A}_{b} \cdot u^2 \cdot \alpha$

$\Rightarrow L = b \cdot \alpha \cdot u^2$

$D = (a + c\cdot\alpha^2)\cdot u^2$



$\underline{r} = (r\cos(\gamma); r\,\text{sen}(\gamma); h)^T$

$\underline{F} = (L \cdot \text{sen}(\gamma); -L\cdot\cos(\gamma); D)^T$

$\Rightarrow \underline{Z} = (r\,\text{sen}(\gamma)\cdot D + h\cos(\gamma)\cdot L; -r\cos(\gamma) D + h\,\text{sen}(\gamma)\cdot L; -r \cdot L)^T$

OBS: NORMALIZAR F y Z POR u^2

$$\underline{Z} = \begin{pmatrix} r\cdot\text{sen}(\gamma)\cdot(a + c\alpha^2) + h\cos(\gamma)\cdot b\cdot\alpha \\ -r\cos(\gamma)\cdot(a+c\alpha^2) + h\,\text{sen}(\gamma)\cdot b\cdot\alpha \\ -r b \alpha \end{pmatrix} \cdot u^2$$

$$\underline{F} = \begin{pmatrix} \text{sen}(\gamma)\cdot b\cdot\alpha \\ -\cos(\gamma)\cdot b\cdot\alpha \\ (a + c\cdot\alpha^2) \end{pmatrix}\cdot u^2$$

$$\frac{1}{u^2}\cdot\underline{Z} = \begin{pmatrix} r\,\text{sen}(\gamma) \\ -r\cos(\gamma) \\ 0 \end{pmatrix}\cdot a + \begin{pmatrix} h\cos(\gamma) \\ h\,\text{sen}(\gamma) \\ -r \end{pmatrix}\cdot b\cdot\alpha + \begin{pmatrix} r\,\text{sen}(\gamma) \\ -r\cos(\gamma) \\ 0 \end{pmatrix}\cdot c\cdot\alpha^2$$

②

$\gamma = 0 \Rightarrow \begin{cases}\cos(\gamma) = 1 \\ \text{sen}(\gamma) = 0\end{cases}$

$\alpha = \alpha_1$

$$\frac{1}{u^2}\cdot Z(0) = \begin{pmatrix} 0 \\ -r \\ 0 \end{pmatrix}\cdot a + \begin{pmatrix} h \\ 0 \\ -r \end{pmatrix}\cdot b\cdot\alpha_1 + \begin{pmatrix} 0 \\ -r \\ 0 \end{pmatrix}\cdot c\cdot\alpha_1^2$$

$\gamma = 120° \Rightarrow \begin{cases}\cos(\gamma) = -\frac{1}{2} \\ \text{sen}(\gamma) = \frac{\sqrt{3}}{2}\end{cases}$

$\alpha = \alpha_2$

$-\frac{1}{2}$ $\frac{\sqrt{3}}{2}$

$$\frac{1}{u^2}\cdot Z(120) = \begin{pmatrix} \frac{\sqrt{3}}{2} r \\ \frac{1}{2} r \\ 0 \end{pmatrix}\cdot a + \begin{pmatrix} -\frac{1}{2}h \\ \frac{\sqrt{3}}{2}h \\ -r \end{pmatrix}\cdot b\cdot\alpha_2 + \begin{pmatrix} \frac{\sqrt{3}}{2}\cdot r \\ \frac{1}{2}\cdot r \\ 0 \end{pmatrix}\cdot c\cdot\alpha_2^2$$

$\gamma = 240° \Rightarrow \begin{cases}\cos(\gamma) = -\frac{1}{2} \\ \text{sen}(\gamma) = -\frac{\sqrt{3}}{2}\end{cases}$

$\alpha = \alpha_3$

$-\frac{\sqrt{3}}{2}$ $-\frac{1}{2}$

$$\frac{1}{u^2}\cdot Z(240°) = \begin{pmatrix} -\frac{\sqrt{3}}{2}\cdot r \\ \frac{1}{2} r \\ 0 \end{pmatrix}\cdot a + \begin{pmatrix} -\frac{1}{2}h \\ -\frac{\sqrt{3}}{2}h \\ -r \end{pmatrix}\cdot b\cdot\alpha_3 + \begin{pmatrix} -\frac{\sqrt{3}}{2} r \\ \frac{1}{2} r \\ 0 \end{pmatrix}\cdot c\cdot\alpha_3^2$$

$$\frac{1}{u^2}\underline{Z} = \begin{pmatrix} hb\cdot(\alpha_1 - \frac{1}{2}\alpha_2 - \frac{1}{2}\alpha_3) \\ \frac{\sqrt{3}}{2}hb\cdot(\alpha_2 - \alpha_3) \\ -rb\cdot(\alpha_1 + \alpha_2 + \alpha_3) \end{pmatrix} + \begin{pmatrix} \frac{\sqrt{3}}{2}\cdot r\cdot c\cdot(\alpha_2^2 - \alpha_3^2) \\ -rc\cdot(\alpha_1^2 - \frac{1}{2}\alpha_2^2 - \frac{1}{2}\alpha_3^2) \\ 0 \end{pmatrix}$$

$$\boxed{\frac{1}{u^2}\cdot\underline{Z} = b\cdot\begin{pmatrix} h & -\frac{1}{2}h & -\frac{1}{2}h \\ 0 & \frac{\sqrt{3}}{2}h & -\frac{\sqrt{3}}{2}h \\ -r & -r & -r \end{pmatrix}\cdot\begin{pmatrix}\alpha_1 \\ \alpha_2 \\ \alpha_3\end{pmatrix} + c\cdot\begin{pmatrix} 0 & \frac{\sqrt{3}}{2}r & -\frac{\sqrt{3}}{2}r \\ -r & +\frac{1}{2}r & +\frac{1}{2}r \\ 0 & 0 & 0 \end{pmatrix}\cdot\begin{pmatrix}\alpha_1^2 \\ \alpha_2^2 \\ \alpha_3^2\end{pmatrix}}$$

OBS: CUANTO MENOR SEA $\frac{r}{h}$; MENOS INFLUENCIA TENDRÁN LOS TÉRMINOS CUADRÁTICOS (DRAG)

OBS 2: con N=4 el último término cuadrático $+ c\cdot\begin{pmatrix} 0 & +r & 0 & -r \\ -r & 0 & +r & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}\cdot\begin{pmatrix}\alpha_1^2 \\ \alpha_2^2 \\ \alpha_3^2 \\ \alpha_4^2\end{pmatrix}$

$\Rightarrow$ MOVIÉNDOLOS de a PARES ($\alpha_1 = \pm\alpha_3$) SE CANCELAN LOS EFECTOS NO LINEALES

③

ASO $c=0$ $(D \ll L)$

$\alpha_1 = \frac{2}{3}\cdot\frac{1}{bh}\cdot Z_x - \frac{1}{3}\cdot\frac{1}{br}\cdot Z_z$

$\alpha_2 = -\frac{1}{3}\cdot\frac{1}{bh}\cdot Z_x + \frac{1}{\sqrt{3}}\cdot\frac{1}{bh}\cdot Z_y - \frac{1}{3}\cdot\frac{1}{br}\cdot Z_z$

$\alpha_3 = -\frac{1}{3}\cdot\frac{1}{bh}\cdot Z_x - \frac{1}{\sqrt{3}}\cdot\frac{1}{bh}\cdot Z_y - \frac{1}{3}\cdot\frac{1}{br}\cdot Z_z$

$$\begin{pmatrix}\alpha_1 \\ \alpha_2 \\ \alpha_3\end{pmatrix} = \frac{1}{b}\begin{pmatrix} \frac{2}{3}\cdot\frac{1}{h} & 0 & -\frac{1}{3}\cdot\frac{1}{r} \\ -\frac{1}{3}\cdot\frac{1}{h} & +\frac{1}{\sqrt{3}}\cdot\frac{1}{h} & -\frac{1}{3}\cdot\frac{1}{r} \\ -\frac{1}{3}\cdot\frac{1}{h} & -\frac{1}{\sqrt{3}}\cdot\frac{1}{h} & -\frac{1}{3}\cdot\frac{1}{r} \end{pmatrix}\cdot\begin{pmatrix} Z_x \\ Z_y \\ Z_z \end{pmatrix}$$