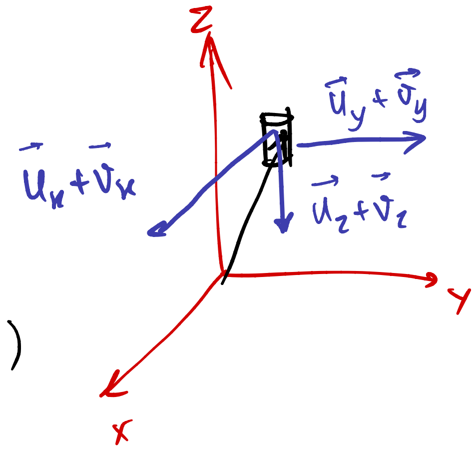
CUBE PARACHUTE EMPERICAL FORMULA

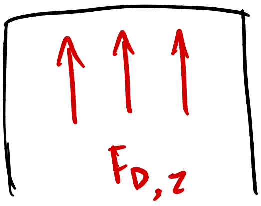


Set u_x, u_y, u_z = natural wind

Set $v_z(t)$ = descent rate

Set $v_x(t), v_y(t)$ = diffennce of rate (lateral)

CASE 1: $\|\vec{u}_z\|$, $\underline{\|\vec{u}_y\|, \|\vec{u}_x\|} = 0$



$F_{D,z} = \frac{1}{2}\rho c_D A \cdot v^2$; $c_D = 0.54$, $A = \frac{7}{3}L^2$

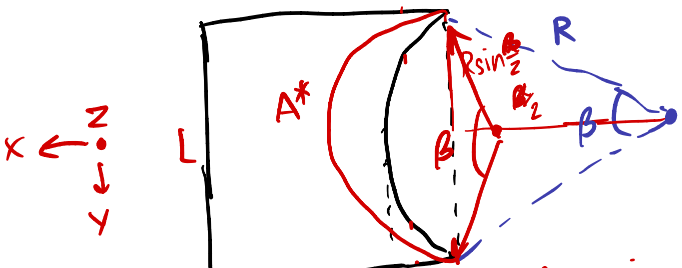
$F_{D,z} = 0.63\rho L^2 v^2$

β $\cancel{\alpha}(R)$

$\cancel{2R}\sin\frac{\alpha}{2} = \frac{L}{2R} \rightarrow \overset{\beta}{\alpha} = 2\sin^{-1}\left(\frac{L}{2R}\right)$

$R = \frac{k}{u_x}$

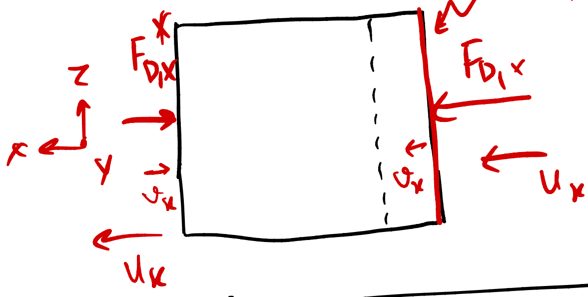
CASE 2: $\|\vec{u}_x\| > 0$, $\|\vec{u}_y\|, \|\vec{u}_z\| = 0$:



$A_z = L^2 - \left(\frac{1}{2}\overset{\beta}{\alpha}R^2 - R\sin\frac{\overset{\beta}{\alpha}}{2}\cos\frac{\overset{\beta}{\alpha}}{2}\right)$

$A_z = L^2 - \underbrace{\frac{R^2}{2}(\overset{\beta}{\alpha} - \sin\overset{\beta}{\alpha})}_{\Delta A_z}$

A: $proj_{YZ} A^*$



$F_{D,x} = 0.63\rho L^2 v_x^2$

$F_{D,z} = 0.63\rho\left(L^2 - \frac{R^2}{2}(\alpha - \sin\alpha)\right)v_z^2$

Đặt $k = \theta$ (shape parameter)

$$\boxed{F_{D,z} = 0.63\rho\left(L^2 - \overbrace{\frac{\theta^2}{2u_x}\left(2\sin^{-1}\left(\frac{u_xL}{2}\right) - u_xL\sqrt{1-\left(\frac{u_xL}{2}\right)^2}\right)}^{\zeta}\right)v_z^2} \quad \text{—(**)}$$

$$F_{D,x} = \underbrace{0.63\rho}_{\alpha} L^2 v_x^2 \quad \text{—(*)}$$

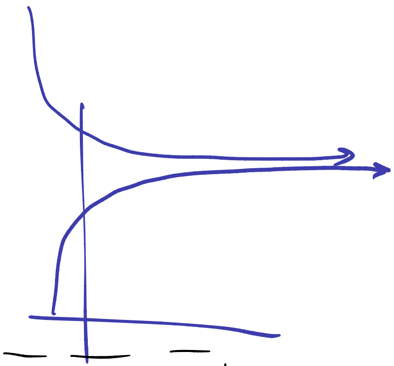
คิด motion ตาม (*)

$$x: \quad m\frac{dv_x}{dt} = F_{D,x} - F^{*}_{D,x}$$

$$= \alpha(u_x - v_x)^2 - \alpha(u_x + v_x)^2$$

$$= -\alpha(2v_x)(2u_x)$$

$$m\frac{dv_x}{dt} = -4\alpha u_x v_x$$

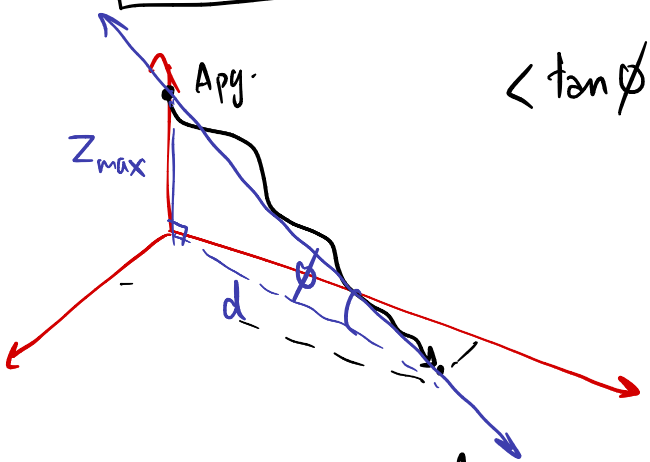


$$\frac{1}{v_x}\,dv_x = -\frac{4\alpha u_x}{m}\,dt$$

$$\ln\left|\frac{v_x}{v_0}\right| = -\frac{4\alpha u_x}{m}t + C_0$$

∴

$$\boxed{\begin{aligned} v_x &= \epsilon u_x\left(1 - e^{-\frac{4\alpha u_x}{m}t}\right) \\ v_x &= \epsilon \underbrace{u_x}_{u_x(t)}\left(1 + \underbrace{e^{-\frac{4\alpha u_x}{m}t}}_{\xi(t)}\right) \end{aligned}} \quad \begin{aligned} &;\ v_x < u_x \\ &;\ v_x > u_x \end{aligned}$$

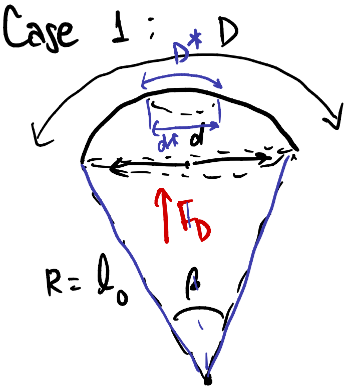


$$\langle \tan\phi \rangle_{set} = \frac{Z_{max}}{v_x t}$$

$$\epsilon = \frac{v_x}{u_x}\Big(\underbrace{1 \pm e^{-\frac{4\alpha u_x}{m}t}}_{\gamma}\Big)^{-1} \longleftrightarrow \epsilon = \frac{v_x}{u_x}\gamma^{-1}$$

TEST FOR CIRCULAR VENTED PARCHUTE

Case 1 :



$$l_0 \beta = D \rightarrow \beta = \frac{D}{l_0}$$

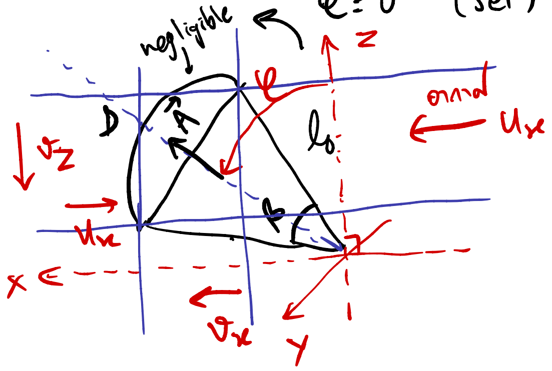
$$A_{proj} = \pi \left(\frac{d}{2}\right)^2 ; \quad \frac{d}{2} = l_0 \sin\left(\frac{\beta}{2}\right)$$

$$= \pi\, l_0^2 \sin^2\left(\frac{\beta}{2}\right) \approx \frac{\pi D^2}{4} ; \; l_0 \to \infty$$

$$A_{proj} = \pi\, l_0^2 \sin^2\left(\frac{D}{2 l_0}\right) \qquad * \; l_0 > \frac{D}{2}$$

$$F_{D,z} = \underbrace{\frac{1}{2}\rho C_D \pi\, l_0^2 \sin^2\left(\frac{D}{2 l_0}\right)}_{\alpha} v^2$$

Case 2: $\dot{\varphi} = 0$ (set)



คิด $F_{D,z}$ จาก $A_{proj\,xy}$ ซึ่ง $\approx A_{proj} \cos\varphi$

(ขนาด $proj_{xy}(\vec{A})$)

ได้ $F_{D,z} = \alpha v_z^2 \cos\varphi$, $F_{D,x} = \alpha v_z^2 \sin\varphi$

ซึ่งโดยทั่วไปที่อุดมคติ $\tan\varphi \quad \dfrac{\Sigma v_z}{\Sigma v_x}$

และคิดค่าประสิทธิภาพ ได้ $\tan\varphi = \epsilon \dfrac{\Sigma v_z}{\Sigma v_x}$

$$\tan\varphi = \frac{\epsilon v_z}{u_x + v_x}$$

$$\therefore \cos\varphi = \frac{u_x + v_x}{\sqrt{\epsilon^2 v_z^2 + (u_x + v_x)^2}}$$ → ใช้คิด $F_{D,z}$ ต่อได้เลย

$$\sin\varphi = \frac{\epsilon v_z}{\sqrt{\epsilon^2 v_z^2 + (u_x + v_x)^2}}$$

* For vented parachute :
use $A_{proj} = \pi l_0^2 \left(\sin^2\left(\frac{D}{2l_0}\right) - \sin^2\left(\frac{d}{2l_0}\right)\right)$
if D is OD , d is vent D .

หา v_x :

$$m\frac{dv_x}{dt} = F_{D,x} - F_{D,x}^{*}$$

$$= \alpha \cos\varphi \left[(u_x - v_x)^2 - (u_x + v_x)^2\right]$$

Sol'n :

$$\boxed{v_x' + \frac{4\alpha u_x}{m} v_x \left(\frac{u_x + v_x}{\sqrt{\epsilon^2 v_z^2 + (u_x + v_x)^2}}\right) = 0}$$

Approximation (special case : $\varphi = 45^\circ$; $\cos\varphi = \frac{1}{\sqrt{2}}$)

$$\begin{cases} v_x' + \frac{4\alpha u_x}{m} v_x \left(\frac{1}{\sqrt{2}}\right) = 0 \; : \; v_x = u_x \Big(1 \underbrace{\pm e^{-\frac{2\sqrt{2}\alpha u_x}{m} t}}_{\gamma}\Big) \\ \epsilon v_z = u_x + v_x \rightarrow v_x = \epsilon v_z - u_x \end{cases}$$

$$\epsilon = \frac{u_x}{v_z}\left(2 \pm e^{-\frac{2\sqrt{2}\alpha u_x}{m} t}\right)$$ time factor

$$\epsilon = \frac{u_x}{v_z}(1+\gamma)$$