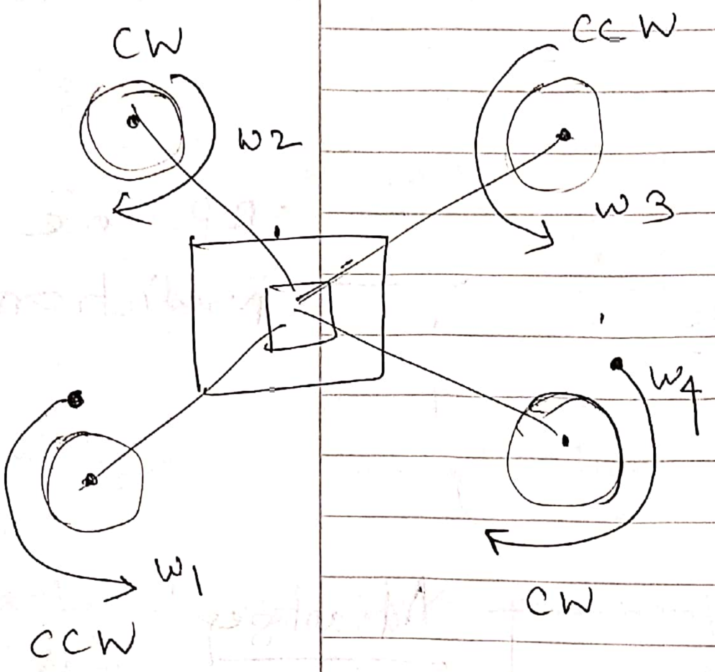
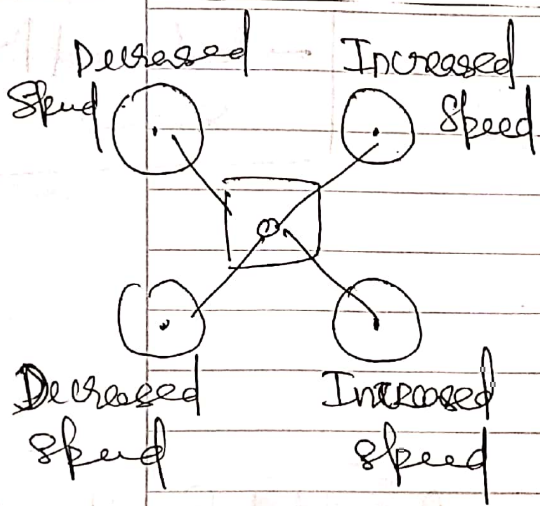
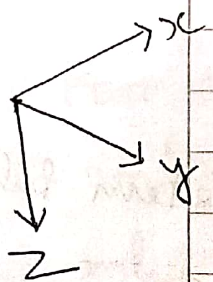
FLIGHT DYNAMICS:



To move left





State Vector $\vec{x} =$

TRANSLATION:

If all motors in same speed, it generates lift > weight of Drone (↑)

If same of all motors is decreased than the weight of Drone, then (↓)

(=) Hovering in Air; motor speed is equal to weight of Drone.

$$\text{State } \vec{x} = \left.\begin{bmatrix} \left.\begin{matrix} x \\ y \\ z \\ \phi \\ \theta \\ \psi \end{matrix}\right\} \text{6 DOF} \\ \begin{matrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{matrix} \end{bmatrix}\right\} 12$$

$$\left.\begin{aligned} \dot{p} &= R(\phi, \theta, \psi)\cdot V_B \\ \dot{V}_B &= a_B - \omega_B \wedge V_B \end{aligned}\right\}$$

$$\dot{x} = f(x, u)$$

$x \to \in \mathbb{R}^{12}$

[6 DOF + 6 Derivatives of DOF]

$u \to \boxed{w_1 \ldots w_4}$

rotation of blades.

$$\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} 1 & \tan\theta \sin\phi & \tan\theta \cos\phi \\ 0 & \cos\phi & -\sin\phi \\ 0 & \dfrac{\sin\phi}{\cos\theta} & \dfrac{\cos\phi}{\cos\theta} \end{bmatrix} \cdot w_B$$

τ_0 – Total Force/Thrust

$\tau_1/\tau_2/\tau_3 \to$ Torques

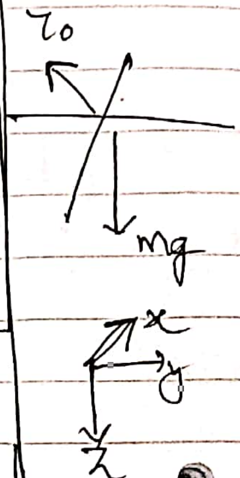
propeller speeds $\left\{ \begin{matrix} w_1 \to \\ w_2 \to \\ w_3 \to \\ w_4 \to \end{matrix} \right.$

$$\begin{bmatrix} \tau_0 \\ \tau_1 \\ \tau_2 \\ \tau_3 \end{bmatrix} = \begin{bmatrix} \beta & \beta & \beta & \beta \\ -\beta l & 0 & \beta l & 0 \\ 0 & -\beta l & 0 & +\beta l \\ -g & g & -g & g \end{bmatrix} \cdot \begin{bmatrix} w_1 \cdot |w_1| \\ w_2 \cdot |w_2| \\ w_3 \cdot |w_3| \\ w_4 \cdot |w_4| \end{bmatrix} \begin{matrix} \to \tau_0 \\ \to \tau_1 \\ \to \tau_2 \\ \to \tau_3 \end{matrix}$$

How to obtain acceleration with Forces derived?

— By Netwon's 2nd Law | Euler Formula

$$m a_R = R^T[\phi,\theta,\psi]\underbrace{\begin{bmatrix}0\\0\\mg\end{bmatrix}}_{R_0} + \begin{bmatrix}0\\0\\-\tau_0\end{bmatrix}$$



a_R → Robot Frame

R_1 – Robot Frame

"mg is +ve in z".

"To convert to Global use Rotation Matrix"

$$a_R = R^T[\phi,\theta,\psi]\begin{bmatrix}0\\0\\g\end{bmatrix} + \begin{bmatrix}0\\0\\-\frac{\tau_0}{m}\end{bmatrix}$$

Euler Rotation Equation:

$$I\dot{\omega}_R + \omega_R \wedge (I\omega_R) = \tau_R$$

↑ Inertial matrix

$$\dot{\omega}_R = I^{-1}\left[\begin{bmatrix}\tau_1\\\tau_2\\\tau_3\end{bmatrix} - \omega_R \wedge (I\omega_R)\right]$$