**What is the setup of the four rotors for a stable fight? What if all the rotors were to spin in the same direction?**

* what is the setup of four rotors for a stable flight? What if all the rotors were to spin in the same direction.

Ans The four rotors are should need to arranged in a cross configuration (like to be two cross propeller should move in one direction and other two propeller should move to the opposite of 1st cross propeller) (two rotating clockwise) & other two counter Clockwise. This setup provides stability & balance for stable flight.
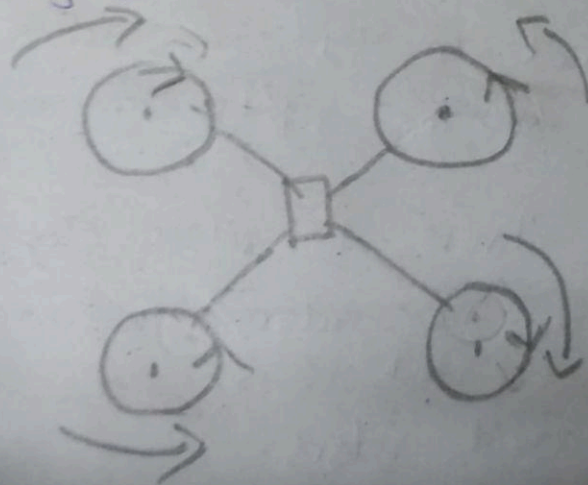
Roo
Rough diagram
for stable
flight

* If all rotors were to spin in the same direction then, the drone would lose stability, as torques produced by rotors would be unbalanced

* When all rotors in one direction the body frame will move opposite causes unbalances (due to newtons 3rd law).

→ rotors moves in these direction.

body frame will move in this direction
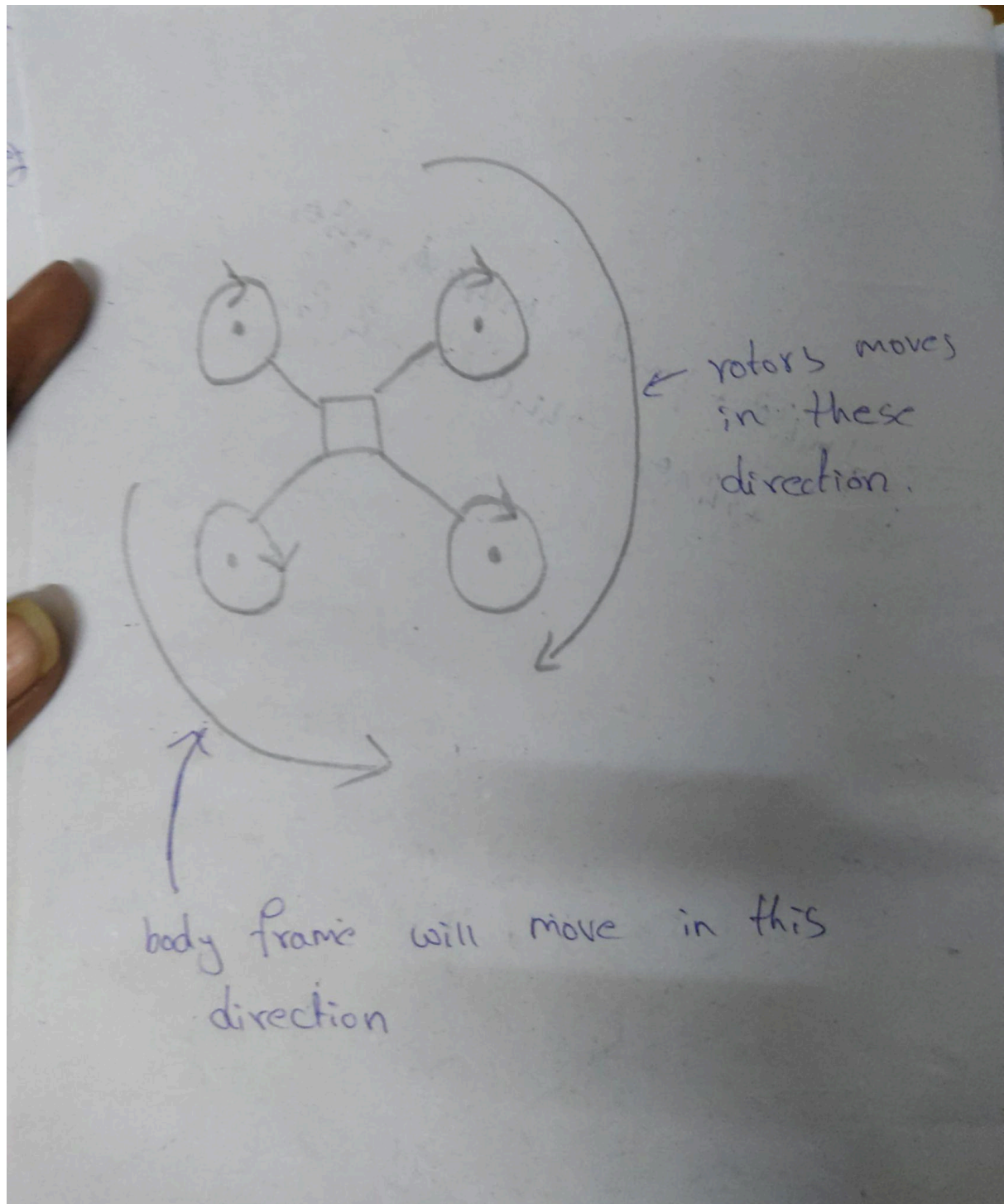
What is the change in thrust of rotors for take off, hover, roll right, and pitch up?

• What is the change in thrust of rotors for take off, hover, roll right & Pitch up?

for Take off :- we should provide maximum thrust greater than weight of quadra copter.

hover :- When quadcopter is hover then the trust of all rotors will be balanced inorder to cancel the weight on Copter due to gravity.

roll right :- for this the thrust of rotors will be increased on left side rotors and decrease on the right side rotors.

Pitch up :- The thrust of rotors Change to Increase on the rear rotors, & decreases (back rotors) on the front rotors.

How many degrees of freedom does a quadcopter has? Show.

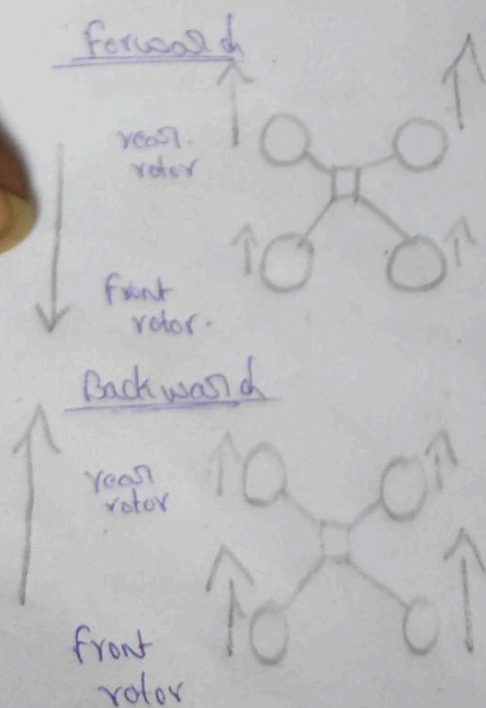3, How many degree of freedom does a
for quadcopter has? Show

A quadcopter has six degree of freedom
that are 3 translational &
3 rotational.

3 translational :-
   1, Forward / backward
   2, left / right
   3, up / down.

3 rotational
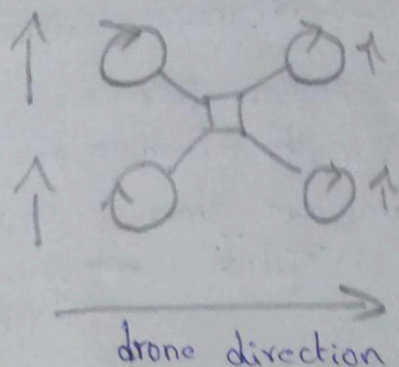   1, roll
   2, Pitch
   3, Yaw

forward

rear rotor

front rotor.

Backward

rear rotor

front rotor

high

if rear rotors has high
speed than front rotor
than it cause forward
transfational &
similarly for backward
it would be vice versa.

right tranclational

drone direction

if we move right
rotor according
to right hand
at low then
the left hand
rotors then it
cause drone to
move in right

left tranctational
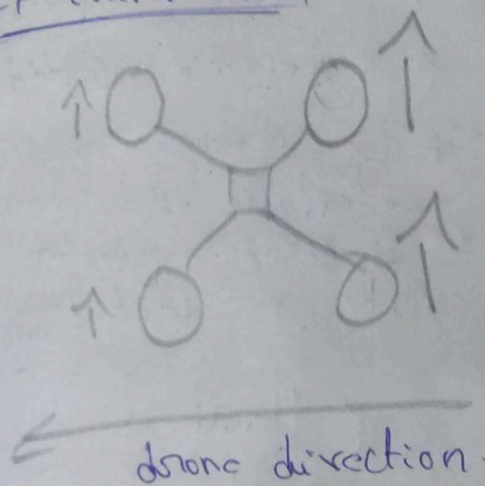
drone direction.

Similarly to
right tranctation
if we move right
rotor high than
speed of left
rotor then that
cause drone to
move in left
direction

roll
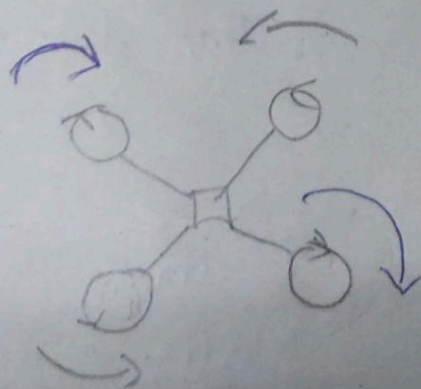
↑→ Increase speed
↑→ decrease speed

if we increase speed
of the bule colour line
rotor then the
dot drone
cause to move
across in roll

Similar to left/
right movement.

Pitch
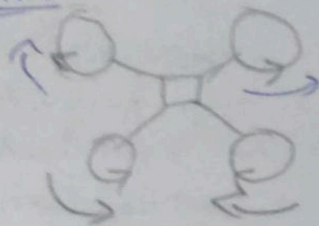
↑ → increase speed

↑ – decrease speed.

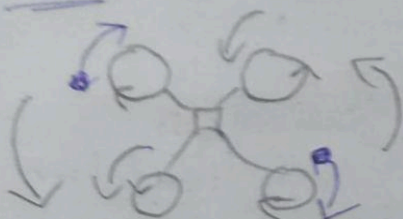If we an parallel rotor to acording to diagram then it cause Pitch. (forward/backward)
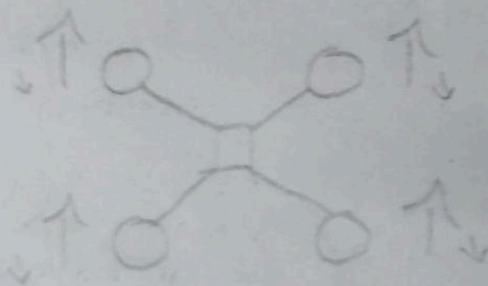
Yaw

↑ → Increase speed

↑ → decrease speed.

If we increase any two cross opposite rotor then it causes yaw in right or left according rotors

Up/down

if thrust is greater than gravity or weight then drone will move up.
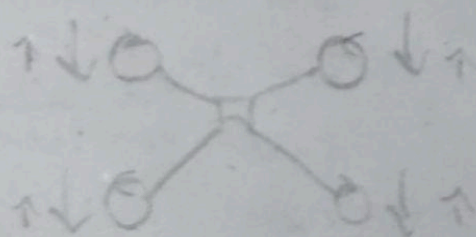
if thrust is less than weight of quadcopter then drone will down.

What are the rules that determine rotaioal movement?

what are rules that determine rotational movement

* If the lift of Propellers 1 & 3 add
  up to more than the lifts of propellers
  2 & 4 it rotates counter clockwise

* If the lifter of propeller 2 & 4
  add up to more than the lift of propellers
  1 & 3 it rotates clockwise.

* otherwise there is no net rotational
  movement

  →

* Roll is controlled by varying speed of
  clock wise & counter clock wise based
  on rotating rotors

* Pitch should be controled by adjusting
  speed in front & rear rotor

* Yaw is controlled by changing the
  relative to speed of rotors on
  one side relative to other.

Write the equations of translational motion?

3. Write the Equation of translational motion

The Equation of Translational is described by newton's second law

$$f = ma$$

where $f = $ force

$$m = mass$$

$$a = acceleration.$$

• Fill the following table.

Lift Produced (N)				vertical movement (none, up, down)	lateral movement (none, Right, left, forward, Backward)	Rotational movement (none, clockwise, Counter clockwise)
Prope-1	Propell-2	Propeller-3	Prol-H			
1.25	1.25	1.25	1.25	up	None	None
1.2	1.2	~~1.5~~ 0.8	0.8	None	Backward	None
0.25	0.25	0.5	0.5	down	forward	None
1	1.5	1	1.5	up	None	clockwise
1.5	0.5	1.25	0.75	None	right	Counter clockwise
0.5		0.5		None	Right(or)None	None (or) Counterclockwise
2	1	1	1	up	right & backward	Counter clockwise
0.25	1	1	0.25	down	left	None

Propeller-1   Propeller-2   Propeller-3   4

1.25   1.25   1.25   1.25

We known that force of gravity (4N)

To know vertical movement-

we will calculate total lift &
add up the created by each of four
propellers.

1.25 +   1.25 + 1.25 + 1.25 = $5.(N)$

So, 5N (total lift) > force gravity (4N)

then, quadcopter move up.

Lateral movement

we have '4' Rule's for this mover.

~~lift propeller 1 & propeller 4 add up to~~
~~more than the lift~~

$P-1 + P-4 > P_2 + P_3$ → move right

$P_2 + P_3 > P_1 + P_4$ → move left

$P_1 + P_2 > P_3 + P_4$ → move backward

$P_3 + P_4 > P_1 + P_2$ → move forward

for

P_1	P_2	P_3	P_4
1.25	1.25	1.25	1.25

$$P_1 + P_2 = P_3 + P_4 \quad , \quad P_2 + P_3 = P_1 + P_4$$

$$P_1 + P_4 = P_2 + P_3 \quad , \quad P_3 + P_4 = P_1 + P_2$$

So, lateral movement is none.

→ rotational movement

rules

$$P_1 + P_2 > P_2 + P_4 \qquad \rightarrow \text{Counter clockwise}$$

$$P_2 + P_4 > P_1 + P_3 \qquad \rightarrow \text{Clockwise}$$

~~for example~~ other wise   no rotational

~~1.25 + 1.25 = PP~~

So, given 1.25 for all propeller

So, their it no rotational (due to

rules)

for example - 2

P_1	P_2	P_3	P_4
1.2	1.2	0.8	0.8

• vertical movement

total lift = force of gravity (4N)

(4N)   =   4N

Here quadcopter does not move vertically

2, lateral movement

$$P_1 + P_4 = 2 \quad (1.2 + 0.8)$$

$$P_2 + P_3 = 2 \quad (1.2 + 0.8)$$

$$P_1 + P_2 = 2.4 \quad (1.2 + 1.2)$$

$$P_3 + P_4 = 1.6. \quad (0.8 + 0.8)$$

$P_1 + P_4$ is not greater than $P_2 + P_3$

$P_2 + P_3$ is not greater than $P_1 + P_4$.

$P_1 + P_2$ is greater than $P_3 + P_4$

So, it move backward.

3, rotational movement

$$P_1 + P_3 = 2 \quad (1.2 + 0.8)$$

$$P_2 + P_4 = 2 \quad (1.2 + 0.8)$$

$P_1 + P_3$ is not $>$ $P_2 + P_4$

$P_2 + P_4$ is not $>$ $P_1 + P_3$

So, their is no rotational movement

$P_1 = 0.25$ $P_2 = 0.25$ $P_3 = 0.5$ $P_4 = 0.5$

vertical movement

total lift = $0.25 + 0.25 + 0.5 + 0.5$

total lift = $1.5 (N)$

total lift is not greater than force
of gravity

$1.5 (N) ! > 4 (N)$

So, $1.5 (N) < 4 (N)$ $\rightarrow$ drone move down

rotational movement

$P_1 + P_3 = 0.25 + 0.5 = 0.75$

$P_2 + P_4 = 0.25 + 0.5 = 0.75$

$P_1 + P_3$ not $> P_2 + P_4$

$P_2 + P_4$ is not $> P_1 + P_3$

So,   no   rotational movement

lateral movement

$P_1 + P_4 = 0.25 + 0.5 = 0.75$

$P_1 + P_2 = 0.25 + 0.25 = 0.5$

$P_2 + P_3 = 0.25 + 0.5 = 0.75$

$P_3 + P_4 = 0.5 + 0.5 = 1$

$P_3 + P_4$ is greater than $P_1 + P_2$ So,
drone moves forward.

$P_1 = 1$, $P_2 = 1.5$, $P_3 = 1$, $P_4 = 1.5$.

Vertical movement

total lift = $1 + 1.5 + 1 + 1.5$

= 5

total lift $5(N)$ is greater than force
of gravity $H(N)$

So, drone move UP

Lateral movement

$P_1 + P_4$ = $1 + 1.5$ = 2.5

$P_2 + P_3$ = $1.5 + 1$ = 2.5

$P_1 + P_2$ = $1 + 1.5$ = 2.5

$P_3 + P_4$ = $1 + 1.5$ = 2.5.

$P_1 + P_4$ is not > $P_2 + P_3$.

$P_2 + P_3$ is not > $P_1 + P_4$

$P_1 + P_2$ is not > $P_3 + P_4$

$P_3 + P_4$ is not > $P_1 + P_2$

So, their is no lateral movement

Rotational movement

$P_1 + P_3 = 2.5$ & $P_2 + P_4 = 3$

$P_2 + P_4 > P_1 + P_3$ so the drone rotates

clock wise

$P_1 = 1.5$ $P_2 = 0.5$ $P_3 = 1.25$, $P_4 = 0.75$

vertical movement

total lift = + 1.5 + 0.5 + 1.25 + 0.75

= 4(N)

So, total lift = ~~gradive~~ force of gravity

4(N) = 4(N)   (None

lateral movement

$P_1 + P_4 =$ 1.5 + 0.75   =   2.25

$P_2 + P_3 =$ 0.5 + 1.25   =   1.75

$P_1 + P_2 =$ 1.5 + 0.5   =   2.

$P_3 + P_4 =$ 1.25 + 0.75   =   2.

$P_1 + P_4 > P_2 + P_3$ So   drone move right

(2.25) > (1.75)

rotational movemet

$P_1 + P_3 =$ 1.5 + 1.25 = 2.75 ✓

$P_2 + P_4 =$ 0.5 + 0.75 = 1.25

$P_1 + P_3 > P_2 + P_4$ So,   it turn to

Counter clockwise.

$P_1 = 0.5$ $P_2 = ?$ $P_3 = 0.5$ $P_4 = ?$

~~to~~ vertical movement

total lift $= P_1 + P_2 + P_3 + P_4$

$= 0.5 + 0 + 0.5 + 0$

$= 1 (N)$

total lift $<$ force of gravity

$1 (N) < 4(N)$

So, ~~#~~ drone moves <u>down</u>

lateral movement

$P_1 + P_4 = 0.5 + ? = 0.5$

$P_2 + P_3 = ? + 0.5 = 0.5$

$P_1 + P_2 = 0.5 + ? = 0.5$

$P_3 + P_4 = ~~?~~ 0.5 + ? = 0.5$

$P_1 + P_2 \not> P_2 + P_3$

$P_2 + P_3$ is not greater than $P_1 + P_4$

$P_1 + P_2$ " " " " $P_3 + P_4$

$P_3 + P_4$ " " " " $P_1 + P_2$

So, <u>No lateral movement exist.</u>

Rotational movement

$P_1 + P_3 = 0.5 + ? = 0.5$ $P_2 + P_4 = 0$

$P_1 + P_3 > P_2 + P_4$ So, it turn to

Counter clockwise.

for $P_1 = 2$ $P_2 = 1$ $P_3 = 1$ $P_4 = 1$

vertical movement

total lift $= 2 + 1 + 1 + 1$

$= 5$

total lift $>$ force of gravity

$5 > 4$ So, drone move <u>up</u>

lateral movement

$P_1 + P_4 = 2 + 1 = 3$

$P_2 + P_3 = 1 + 1 = 2$

$P_1 + P_2 = 2 + 1 = 3$

$P_3 + P_4 = 1 + 1 = 2$

$P_1 + P_2$ is greater than $P_3 + P_4$.

then drone move <u>back ward</u> &

$P_1 + P_4 > \cancel{P_2 P_3}$ $P_2 + P_3$ drone move <u>right</u>.

Rotational movement

$P_1 + P_3 = 2 + 1 = 3$

$P_2 + P_4 = 1 + 1 = 2$

$P_1 + P_3 > P_2 + P_4$

So it turn to   <u>Counter clockwise</u>

$P_1 = 0.25 \qquad P_2 = 1 \qquad P_3 = 1 \qquad P_4 = 0.25$

total lift $= \cancel{3.25} \quad 2.5$

$\cancel{3.25} \quad 2.5 < 4(N)$ force f gravity

So, drone move down

lateral movement

$P_1 + P_4 = 0.25 + 0.25 = \cancel{0.25} \; 0.5$

$P_2 + P_3 = 1 + 1 \qquad\qquad = 2$

$P_1 + P_2 = 0.25 + 1 \qquad = 1.25$

$P_3 + P_4 = 1 + 0.25 \qquad = 1.25$

$P_2 + P_3$ is greater than $P_1 + P_2$

$2 > 1.25$

So, drone $\cancel{\text{move}}$ rotates left

rotational movement

$\cancel{P_1 + P.} \quad P_1 + P_3 = 0.25 + 1 = 1.25$

$P_2 + P_4 = 1 + 0.25 = 1.25$

$\cancel{P_2 + P_4 > P_1 + P_3 \text{ So } \text{drone rotates}}$

$\cancel{\underline{\text{clockwise}}}$

$P_2 + P_4$ not $\cancel{\text{equal}}$ to greater $P_1 + P_3$

similar $P_1 + P_3$ not greater $P_2 + P_4$

So, no rotate f drone

By using this rule i have calculated the table and filled them

Vertical Movement:

- If the total lift from all four propellers is greater than the force of gravity, the quadcopter goes up.
- If the total lift equals the force of gravity, the quadcopter stays at the same vertical position.
- If the total lift is less than the force of gravity, the quadcopter descends.

Lateral Movement:

- If the combined lift from propellers 1 and 4 is greater than from propellers 2 and 3, the quadcopter moves to the right.
- If the combined lift from propellers 2 and 3 is greater than from propellers 1 and 4, the quadcopter moves to the left.
- If the combined lift from propellers 1 and 2 is greater than from propellers 3 and 4, the quadcopter moves backward.
- If the combined lift from propellers 3 and 4 is greater than from propellers 1 and 2, the quadcopter moves forward.

Rotational Movement:

- If the combined lift from propellers 1 and 3 is more than from propellers 2 and 4, the quadcopter rotates counterclockwise.
- If the combined lift from propellers 2 and 4 is more than from propellers 1 and 3, the quadcopter rotates clockwise.
- If none of the above conditions are met, there is no rotational movement.

Remember:

- Up or down is based on total lift and gravity.
- Left or right depends on the balance between propellers 1, 2, 3, and 4.
- Rotation is determined by the comparison of lift between propellers 1, 2, 3, and 4.