Duocopter Controls Logbook

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14th May 2025 | Creating Physics Model | 14/5/25

Priorities:
1) List known & unknown important variables
2) Define Equations of motion
3) Create simulink model of quadcopter

Timeline
} Hopefully finished by EOD
} Start by EOD, finish by 16/5/25

Known & Unknowns

Input → Real Altitude ← LIDAR Sensor ← cm?
→ Target Altitude ← ??? cm?

Output → Throttle as integer value between 0-100 0-90 linear 91-100 constant
Let throttle output be setting of thrust (S_T) $0 \leq S_T \leq 90$

Given:

		Option 1	Option 2
→ Mass of motor assembly	(M_m)	2x 124 g	2x 164 g
→ Thrust of motors	(T_{max})	2x 780 gf	2x 1280 gf
→ Mass of cart	(M_k)	150 g	
→ Cable mass	(M_c)	2x 190 g (1m long)	
→ Static Friction	(F_s)	130 g	
→ Coefficients of Dynamic Friction	(C_{DF})	$0.11 \leq C_{DF} \leq 0.17$	

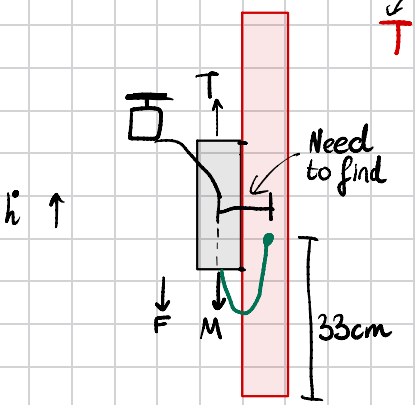
Subscript k because MarioKart so c can be used for cable

} 2 cases → While moving
→ Stationary

Not Given
→ Mass of "arm" → Estimated to be ~50g (13:45 14/5/25) (M_a)

Physics Model

Free body diagram:



T (Thrust) $= M$ (Mass) $+ F$ (Friction) (all in grams)

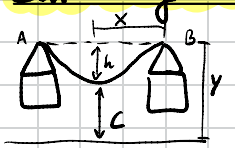
$T = T_{max} \times \frac{S_T}{90}$

$F = 130$ (Stationary) or $0.11 \times Normal \rightarrow 0.17 \times Normal$ (moving)

$M = M_a + M_m + M_k + M_c(h)$

$M_c(h)$ is mass of wire hanging from the cart. based on "catenary curves"

Catenary Curve math.stackexchange.com/questions/3557767/how-to-construct-a-catenary-of-a-specified-length-through-two-specified-points



$c = \frac{T_0}{w}$ $s = c\sinh\frac{x}{c}$

$T = w\sqrt{c^2+s^2}$ $y = c\cosh\frac{x}{c}$

$y^2 - s^2 = c^2$

$T = wy$

i lecture online videos

physicswithelliot.com/hanging-rope-classic-notes

$\frac{1}{k}\cosh(A) + B = 0$

$\frac{1}{k}\cosh(kx+A) + B = h - 0.33m$

$\frac{1}{k}(\sinh(kx+A) - \sinh(A)) = L$

$y(x) = \frac{1}{k}\cosh(kx+A) + B$

$y'(x) = \sinh(kx+A)$

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$$\frac{1}{\kappa}(\cosh(\kappa 2x+A)-\cosh(A))=h-0.33$$
$$\frac{1}{\kappa}(\sinh(\kappa 2x+A)-\sinh(A))=1$$

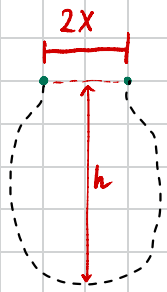
} solve numerically for κ & A

$$M_c=\frac{190}{\kappa}(\sinh(\kappa 2x+A)-\sinh(\kappa x+A))$$

Repeat for each h, interval of $0 \rightarrow 1.44m$
step of $1cm$ $(0.01m)$

Need to Measure X & create a linear model to confirm

Arush Tasks:
→ Normal Reaction Force Function
→ Hori - Distance between pin & bottom of cart



Make equal height & measure

$T=Wy$
$T=\frac{1}{2}mx\,190g/m$

16th May 2025 | Physics Model & Simulink | 16/5/25

Goal:

→ Create Eq of motion in form Highest order = f(Lower orders)
→ Create Simulink schematic of Equations of Motion

Equations of Motion:

Reminder: $M = M_a + M_k + M_m + M_c(h)$

$T = 2 \times T_{max} \times \frac{S_T}{90}$ (S_T = Setting of thrust)

$F = F_r(\dot{h})$

$$F_r(\dot{h}) \begin{cases} = 130 & \dot{h} = 0 \\ = -C_{DF} N_f & \dot{h} > 0 \\ = C_{DF} N_f & \dot{h} < 0 \end{cases}$$

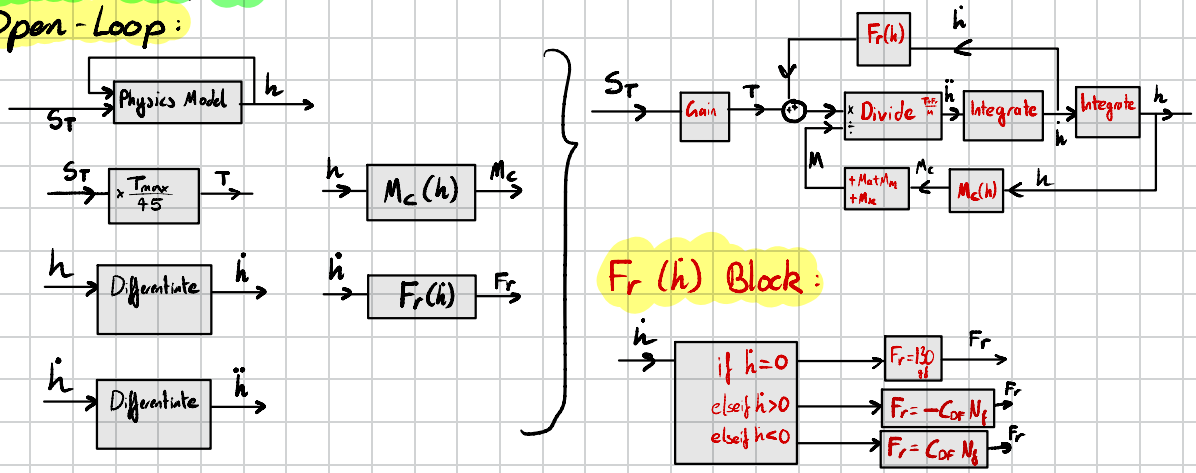
Eq(1) (N's 2nd Law) $M\ddot{h} = T + F_r(\dot{h})$

$$\ddot{h} = \frac{T + F_r(\dot{h})}{M}$$

$$\ddot{h} = \frac{T + F_r(\dot{h})}{M_a + M_k + M_m + M_c(h)}$$

Simulink Schematic:

Open-Loop:



$F_r(\dot{h})$ Block: