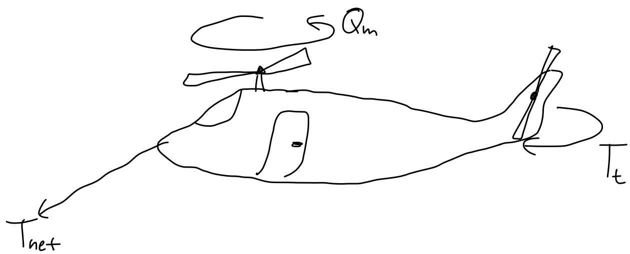
Formulas:

Forces Body Diagram



Main Rotor Lift At Hover (T_m):

$T_m = mg$ (mass · gravity) [N]

Main Rotor Area (A_m):

$A_m = 2\pi R_m^2$ (R → blade radius) [m^2]

Main Rotor Power (P_m):

$P_m = \frac{\sqrt{T_m^3}}{\sqrt{2\rho A_m}}$ (ρ → density, A_m → Area) [W]

Main Rotor Torque (Q_m):

$Q_m = \frac{P_m}{\omega_m}$ (P_m → power, ω_m → angular Velocity) [N·m]

Tail Rotor Thrust (T_t)

$T_t = \frac{Q_m}{L_t}$ (L_t → Length of tail) [N]

Tail Rotor Power (P_t):

$P_t = T_t \cdot V_t$ (V_t → Nominal velocity) [W]

Main Propeller Calculations:

Assuming m = 750 g (50g below recommended maximum weight)

$T_m = (0.75)(9.81) = 7.36N$ (Thrust generated by main rotor)

Our blades are 180mm each, so:

$A_m = \pi(0.18)^2 = 0.102m^2$ (Area of the rotor blades)

Assuming an air density of 1.262 kg/m³, the ideal hover power is:

$$P_{m,i} = \frac{(7 \cdot 36)^{3/2}}{\sqrt{2(1.262)(0.102)}} = 40W \longrightarrow P_m = (P_{m,i})(2.5) = 100W$$

overestimated for non-ideal conditions

Our motor's KV is 380 rpm/v, so using a 4s (14.8V) battery, the rpm output is:

$$RPM_{no-load} = (380)(14.8) = 5624 \xrightarrow{\text{25\% reduction to account for load}} RPM_{loaded} = (RPM_{no-load})(75\%) = 4200$$

At 4200 rpm, our angular velocity is:

$$w_m = (RPM)(\frac{2\pi}{60}) = 440rad/sec$$

So the torque generated by our main motor is:

$$Q_m = \frac{100}{440} = 0.23N \cdot m$$

Tail Propeller Calculations:

We chose a 0.25m tail boom, so our required tail moment is:

$T_t = \frac{0.23}{0.25} = 0.92N$. Because our input is harmonic, T_t will fluctuate so ideally we want ~2N of thrust capacity

Our tail blades are 60mm each, so the tail rotor area is:

$A_t = \pi(0.06)^2 = 0.0113m^2$

So the ideal power required for our motor is:

$$P_t = \frac{(T_t)^{3/2}}{\sqrt{2\rho A_t}} = \frac{2^{3/2}}{\sqrt{2(1.262)(0.0113)}} = 16.7W \xrightarrow[\text{1.8X to account for drag and energy losses}]{} P_{t,real} \approx 30W$$

Motor specs based on Calculations:

Assumptions:

- weight = 750 g (50 g below rec. max weigth)
- $\rho = 1.262\ kg/m^3$ (Avg. air density)
- Tail rotor blades are 60mm each

Main Rotor.

$Q_m = 0.23\ Nm$ (torque)

Tail Rotor:

$T_t = 2N$ (required tail moment)

$A_t = 0.01131\ m^2$ (Area of tail blades)

$P_t = 20W$ (Power)

$L_t = 0.25m$ (length)

Motor Requirements:

Target KV: ~1000 – 1300 RPM/V

Power: ~ 20–30V Continuous (15 V req)

Current: ~ 5A Continuous (1-12 A req)