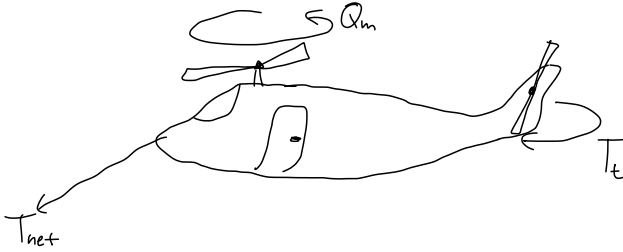


## Formulas:

### Forces Body Diagram



Main Rotor Lift At Hover ( $T_m$ ):

$$T_m = mg \text{ (mass} \cdot \text{gravity) [N]}$$

Main Rotor Area ( $A_m$ ):

$$A_m = 2\pi R_m^2 \text{ (R} \rightarrow \text{blade radius) [m}^2\text{]}$$

Main Rotor Power ( $P_m$ ):

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

Main Rotor Torque ( $Q_m$ ):

$$Q_m = \frac{P_m}{\omega_m} \text{ (} P_m \rightarrow \text{Power, } \omega_m \rightarrow \text{angular velocity) [N} \cdot \text{m]}$$

Tail Rotor Thrust ( $T_t$ )

$$T_t = \frac{Q_m}{L_t} \text{ (} L_t \rightarrow \text{length of tail) [N]}$$

Tail Rotor Power ( $P_t$ ):

$$P_t = T_t \cdot V_t \text{ (} V_t \rightarrow \text{Nominal velocity) [W]}$$

## Main Propeller Calculations:

Assuming  $m = 750 \text{ g}$  (50g below recommended maximum weight)

$$T_m = (0.75)(9.81) = 7.36 \text{ N} \text{ (Thrust generated by main rotor)}$$

Our blades are 180mm each, so:

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

Assuming an air density of  $1.262 \text{ kg/m}^3$ , the ideal hover power is:

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

└ overestimated for non-ideal conditions

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

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

At 4200 rpm, our angular velocity is:

$$\omega_m = (RPM)\left(\frac{2\pi}{60}\right) = 440 \text{ rad/sec}$$

So the torque generated by our main motor is:

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

## 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  $\sim 2N$  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:

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