3.2.1: Transfer Function Derivation

In our system, we are modeling the force of the rotors (f_r), the drag force from air resistance ($f_{drag} = b\dot{h}$), and the disturbance force of gravity (f_g). Using Newtons 2nd Law, the systems motion is described by:

$$m\ddot{h} = f_r(t) - b(\dot{h}) - f_g(t)$$

Next, we take the Laplace transform of the function. Solving this equation out, we derive that the transfer function $G(s)$ can be defined by:

$$H(s) = \frac{F_r(s)}{s^2m+sb} - \frac{F_g(s)}{s^2m+sb}\text{ , Where } G(s) = \frac{1}{s^2m+bs}$$

3.2.2: Paramater Estimates

The two transfer function parameters are the mass of the drone and the damping constant from air resistance. For consistency, we used the specifications of one of the most common commercial UAVs, the DJI Mavic 3 [2]. From [1], we are able to derive the following function for the dampening coefficient:

$$b = \beta D = 1.6 \times 10^{-4}\text{ N·s/m}^2 \cdot 347.5 \cdot 10^{-3}m = 5.56 \times 10^{-5}\text{ N·s/m}$$

Therefore, $m = 0.958$ kg and $b = 5.56 \times 10^{-5}$ N·s/m

3.2.3: Simulink Analysis

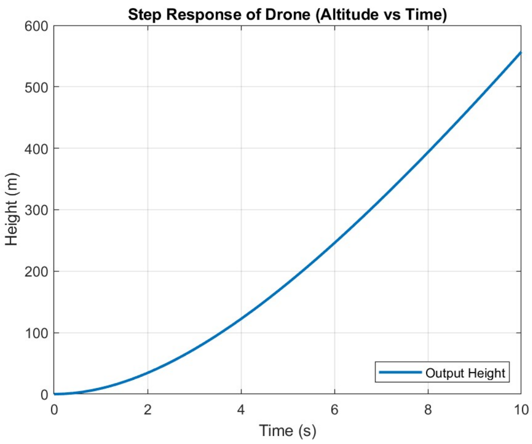

Figure 1: The rotor force F_r was modeled as a step input with a magnitude of $3mg$, while $F_g = mg$ acted as a constant disturbance. The resulting step response shows a continuously increasing height, matching the reference response from Section 8. Minor differences in slope are due to the specific parameter values of F_r, m, and b, which influence the rate of ascent.

[1] Classical Mechanics. Annai Academy Online School, Mar. 2025. [Online]. Available: https://annaiacademyonlineschool.com/wp-content/uploads/2025/03/classical-mechanics.pdf [Accessed: Oct. 8, 2025].
[2] “Mavic 3 Pro — Specifications,” DJI, 2025. [Online]. Available: https://www.dji.com/mavic-3-pro/specs [Accessed: Oct. 8, 2025].