3.3 Open Loop Plant Analysis

1. BIBO Stability

The transfer function of the open-loop plant is given by:

$$G(s) = \frac{1}{ms^2 + bs} = \frac{1}{s(ms + b)}$$

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

The poles of $G(s)$ are 0 and $-\frac{b}{m}$ (5.8×10^{-5}). Since there is a pole at 0, the system is not BIBO stable.

2. Simulation Behavior

The step response shown in Figure 1 does not settle to a steady-state value. Instead, the output continuously increases over time, which is consistent with the presence of a pole at the origin in the transfer function (type-1 plant), causing the step input to produce a ramp-like output. The second pole at $s = -\frac{b}{m}$ is very close to the origin, resulting in a slow transient before the output becomes nearly linear. Overall, the simulated behavior aligns with theoretical expectations based on the system's poles.

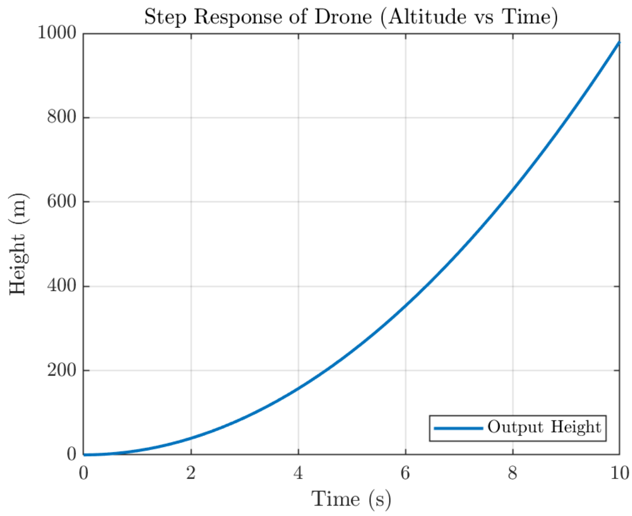

Figure 1: Step response of the open-loop plant $G(s)$.

3. Disturbance and Modeling

Yes, the plant will likely face external disturbances. For a drone's vertical motion, these include air turbulence, rotor thrust changes, or sudden payload shifts. Such disturbances alter the net force on the drone, affecting its acceleration and height. The configuration in Figure 2 models this accurately: disturbances enter the plant input, subtract from the control signal, and pass through G(s), effectively representing how external forces influence the dynamics of the real-world system.

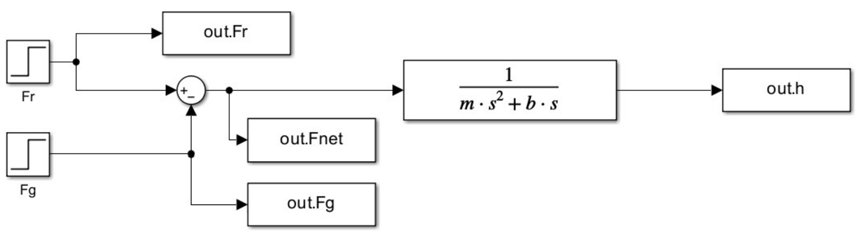

Figure 2: Simulink Block Diagram of Plant Function $G(s)$.

4. Additional Questions

- How sensitive is the system to uncertainty in mass (m) or the drag coefficient (b)?
- What is the steady-state error for standard inputs (step, ramp)?
- Which controller type will be most optimal for the system given the existing poles?

References:

- Kathryn Johnson, *EENG307: Semester Project*, Colorado School of Mines, Fall 2025.