Assignment 1

Q1. Performed in astrobee_1d one_axis_ground_dynamics().

Q2. The numerical values returned from casadi_c2d correspond to the matrices:

$$A = \begin{bmatrix} 1 & 0.01 \\ 0 & 1 \end{bmatrix} \text{ and } B = \begin{bmatrix} 0.00024 \\ 0.0048 \end{bmatrix}$$

The numerical values from analytically derived model in exercise 13 c gives the following matrices:

$$A = \begin{bmatrix} 1 & 0.01 \\ 0 & 1 \end{bmatrix} \text{ and } B = \begin{bmatrix} 0.005 \\ 0.1 \end{bmatrix}$$

The discrete A-matrices is the same for both cases because the B matrix in general doesn't affect the A matrix during the transition. Since the continuous B-matrices differ they are also not the same in the discrete time domain. See the equations below:

$$A_d = e^{A_c h} \text{ and } B_d = \int_{s=0}^{h} e^{A_c s} B_c \, ds$$

Q3. The continuous system has the following transfer function:

$$G(s) = \frac{1}{s^2 \cdot m_G}$$

There are two poles at origin, i.e. 0 and no zeros in the nominator of the transferfuntion. Our intuition was that there are two poles at 0 since matrix A's characteristic polynomial will be $\lambda^2 = 0$. For verification, see figure 1 below.

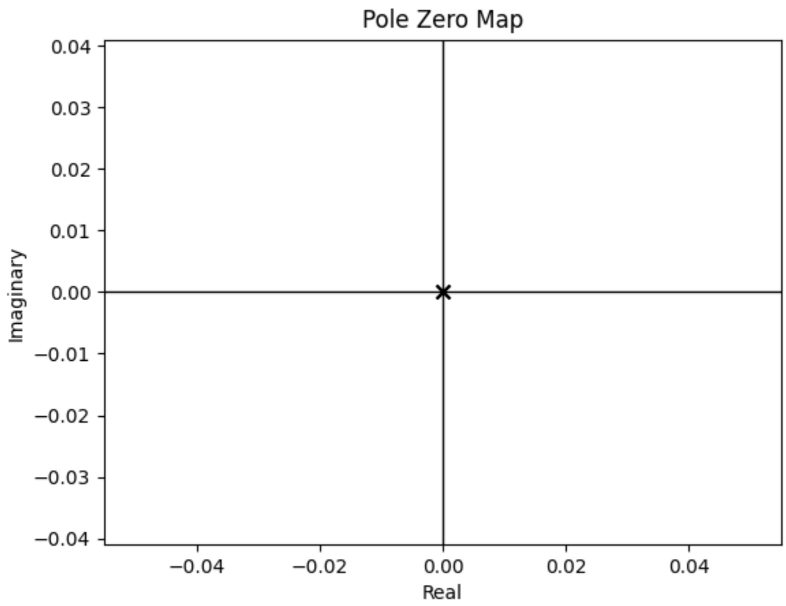

Figure 1 - Poles for continuous system

Regarding the discrete system we expected 2 poles at 1 since the following expression:

$$\lambda(A_d) = e^{\lambda(A_c)\cdot h}$$

Since $e^0 = 1$ this assumption holds. See the figure 2 below for verification.

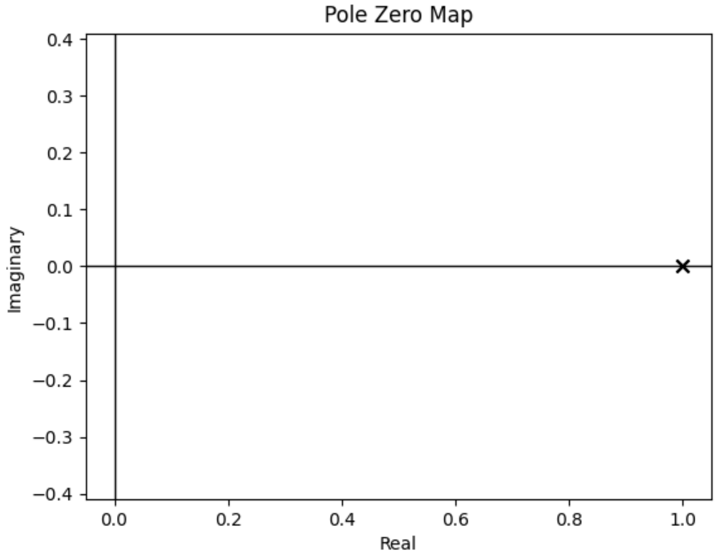

Figure 2 - poles for discrete system

Q4. If the control gain L for the state feedback controller is designed with the two desired poles at $\lambda_1 = 0.975$ and $\lambda_2 = 0.985$ the requirements $x_T = [0\ 0]^T$, $|u| < 0.85\ N$ and $x_{1,25s} < 0.9 \cdot |x_0 - x_{ref}|$, see figure 3.

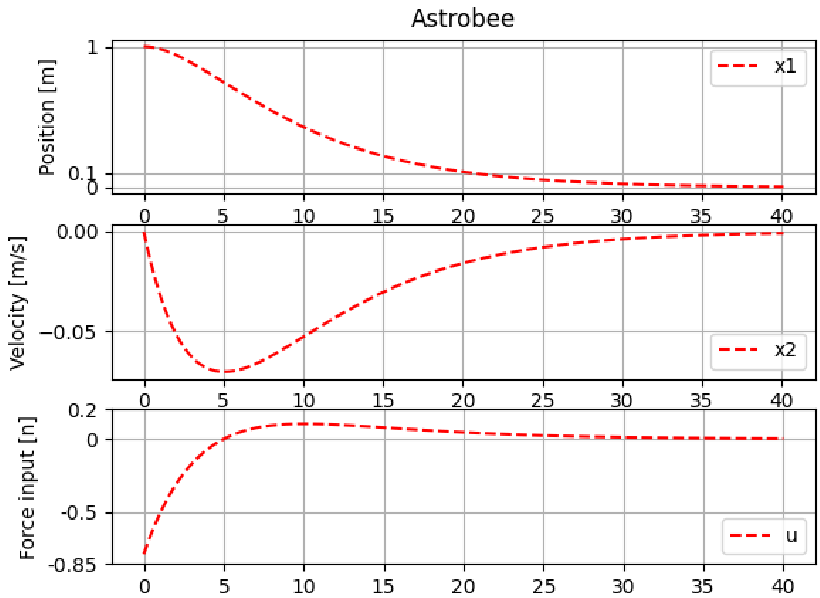

Figure 3: Control of the astrobee - Linear control without disturbance and without feedback

Including disturbances, the terminal condition couldn't be reached, see picture 4.

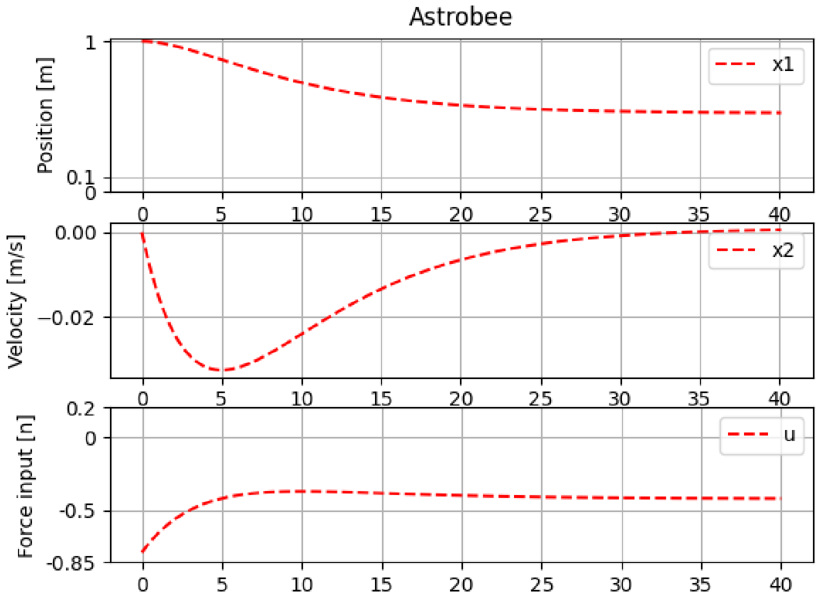

Figure 4: Control of the astrobee - Linear control with disturbance and without feedback

Q5. Design of Feedback loop with integral part needed to deal with disturbances. For reaching the requirement 90 % within 30 seconds, the Linear feedback gain L is to be manipulated to accelerate the control with desired poles $\lambda_1 = 0.974$ and $\lambda_2 = 0.984$ for calculation. By implementing the integral state feedback with an integral gain $k_i = 0.028$ the disturbance is controlled without overshooting, see figure 5.

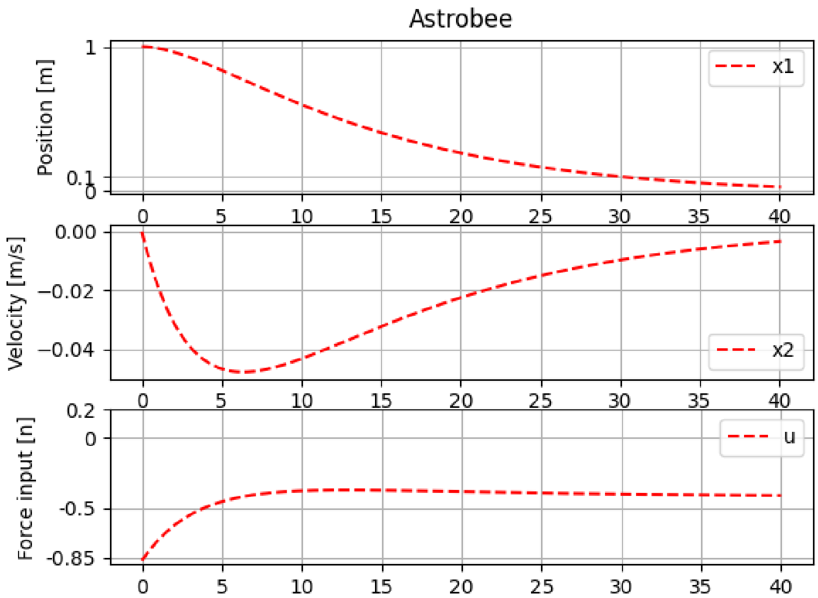

Figure 5: Control of Astrobee – Linear control, with disturbance and integral feedback control