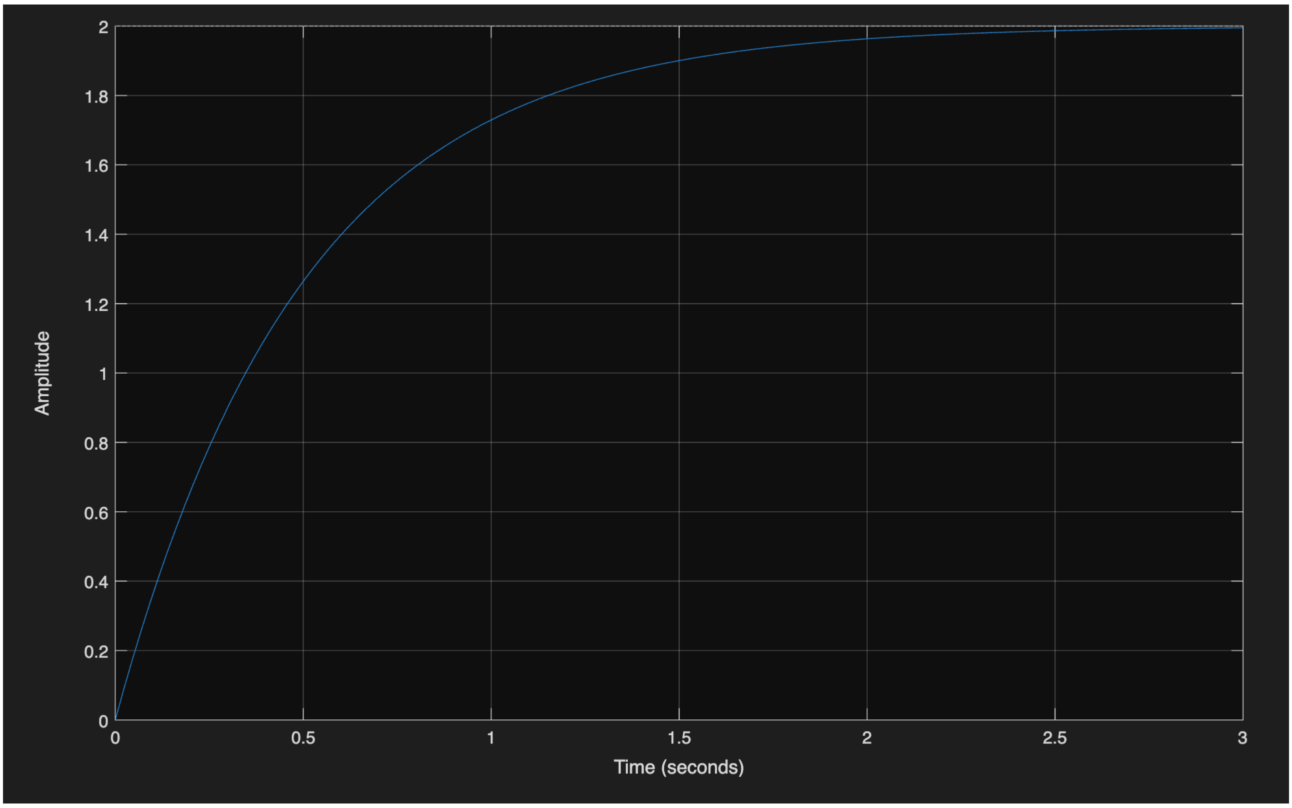
Dhairya Gupta_240347_Smart Throttle Control_Assignment 1

Q1. Understanding a First-Order Plant Using Step Response

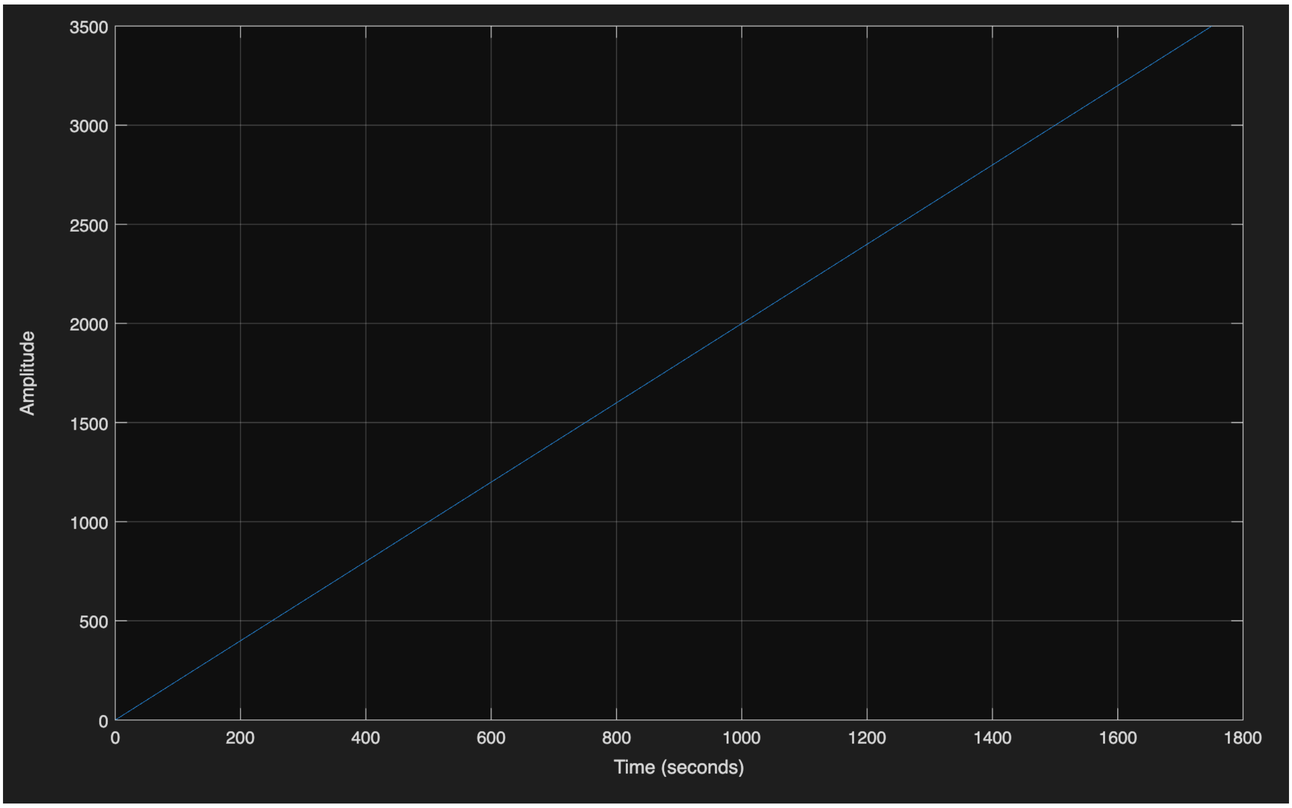
Given $G(s) = 4/(s+2) = 2/(1 + 0.5s)$
from standard form, $G(s) = K/(1 + \tau s)$

- Time Constant = 0.5s
- Rise Time = 2.2τ = 1.1s
- Settling time = 4τ = 2s
- Final Value = $G(0)$ = 2
- Steady-state error = 1 - 2 = -1
  MATLAB final value matches y_ss.



Q2. System Type, Step Error, and Final Value Theorem

Given $G(s) = 10/s(s + 5)$
1. Type 1 system as only one pole at origin.
2. For open loop system,
   $G(s)$ shoots to inf as $s \to 0$, e_ss = -inf
   For closed loop system,
   e_ss = lim $1/(1 + G) = 0$
3. Overshoot 1 and increase indefinitely



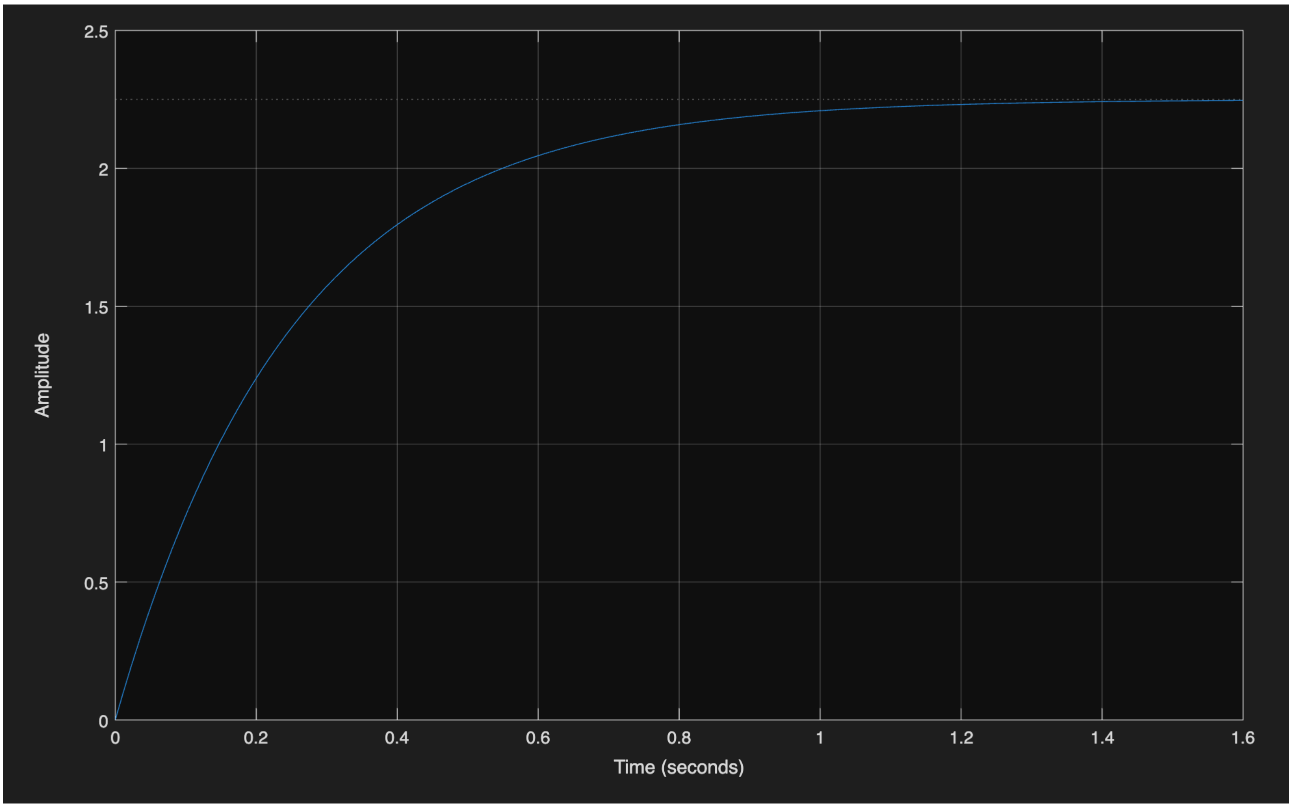
Q3. Required Specifications →Modify Transfer Function

Required, settling time < 1.2 and e_ss = 0.1

1. t_s = 4/a => a > 3.33, so choosing a = 4
   e_ss = 1/(1 + K) = 0.1 => K = 9

2. G(s) = 9/(s + 4)

3. Since time constant(=0.25) is smaller here, it should be faster than one in Q1.
   Final value = lim sG(s) = 2.25 => higher than Q1



Q4. Designing a Simple Controller to Meet Specifications

Given, $G(s) = 3/(1 + s)$
Required, $t_s < 2$, $M_p < 10\%$, $y_{ss} = 0.8$

$$T(s) = \frac{3k(s+z)}{1+s+3k(s+z)}$$

- $y_{ss} = 3kz/(1 + 3kz) = 0.8 \Rightarrow kz = 4/3$

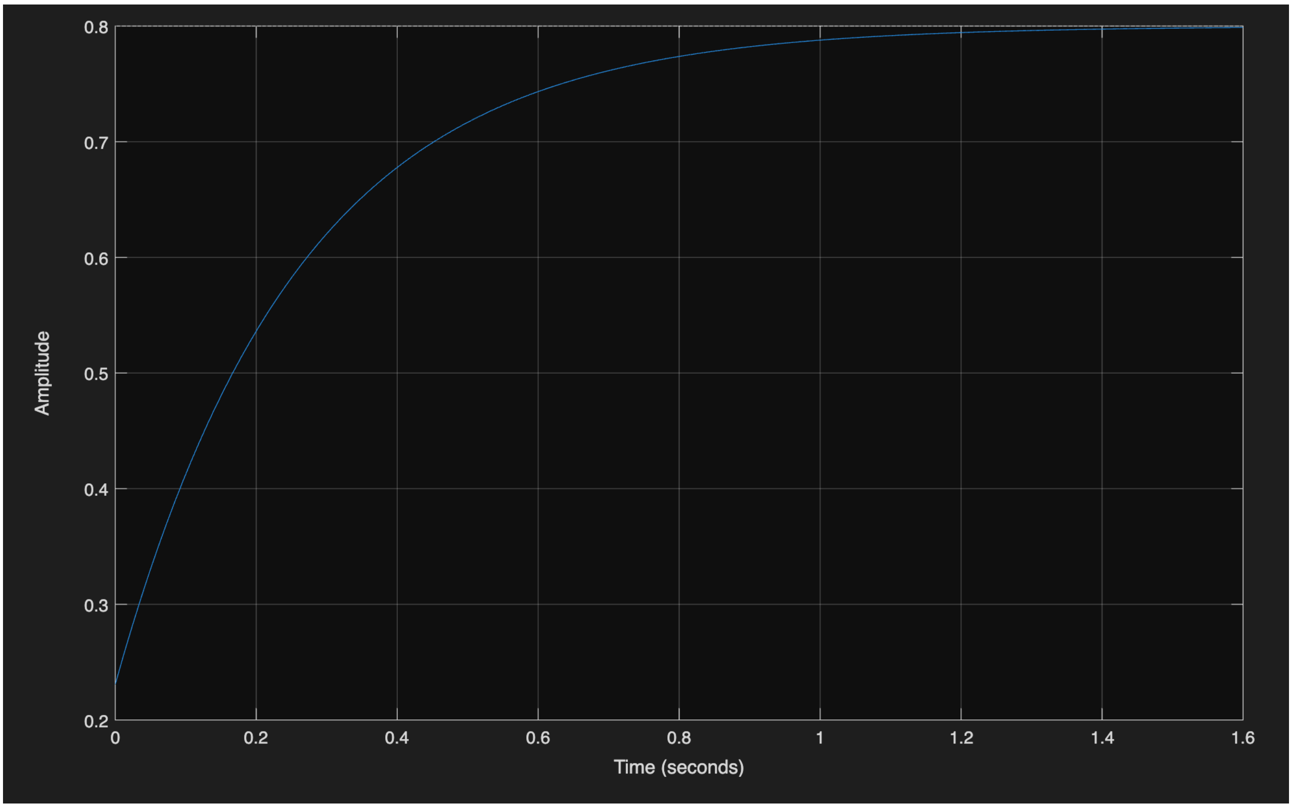
- $Mp = \exp(-\pi d/\sqrt{1 - d^2}) < 0.1 \Rightarrow \pi d/\sqrt{1-d^2} > 2.3 \Rightarrow d > 0.59$
  Taking damping ratio(d) = 0.6

- $t_s = 4/a < 2 \Rightarrow a = \dfrac{1 + 3kz}{1 + 3k} > 2 \Rightarrow \dfrac{5}{1+3k} > 2 \Rightarrow k < 0.5$

1) Choosing $k = 0.1$ and $z = 13.33$

2) $T(s) = \dfrac{0.3(s + 13.33)}{1.3s + 5}$

3)
- Adding zero will increase overshoot
- Increasing K increases y_{ss} as $y_{ss} < 1$
- The response would be faster



Q5. Ramp Tracking and System Type

1) It is a type 0 system.
2) For type 0 system, there is infinite ramp error
3) Using FVT, we can see that there is a remaining ’s’ term at the denominator, hence the error would be infinite.
4) Adding zero doesn’t helps the ramp tracking.