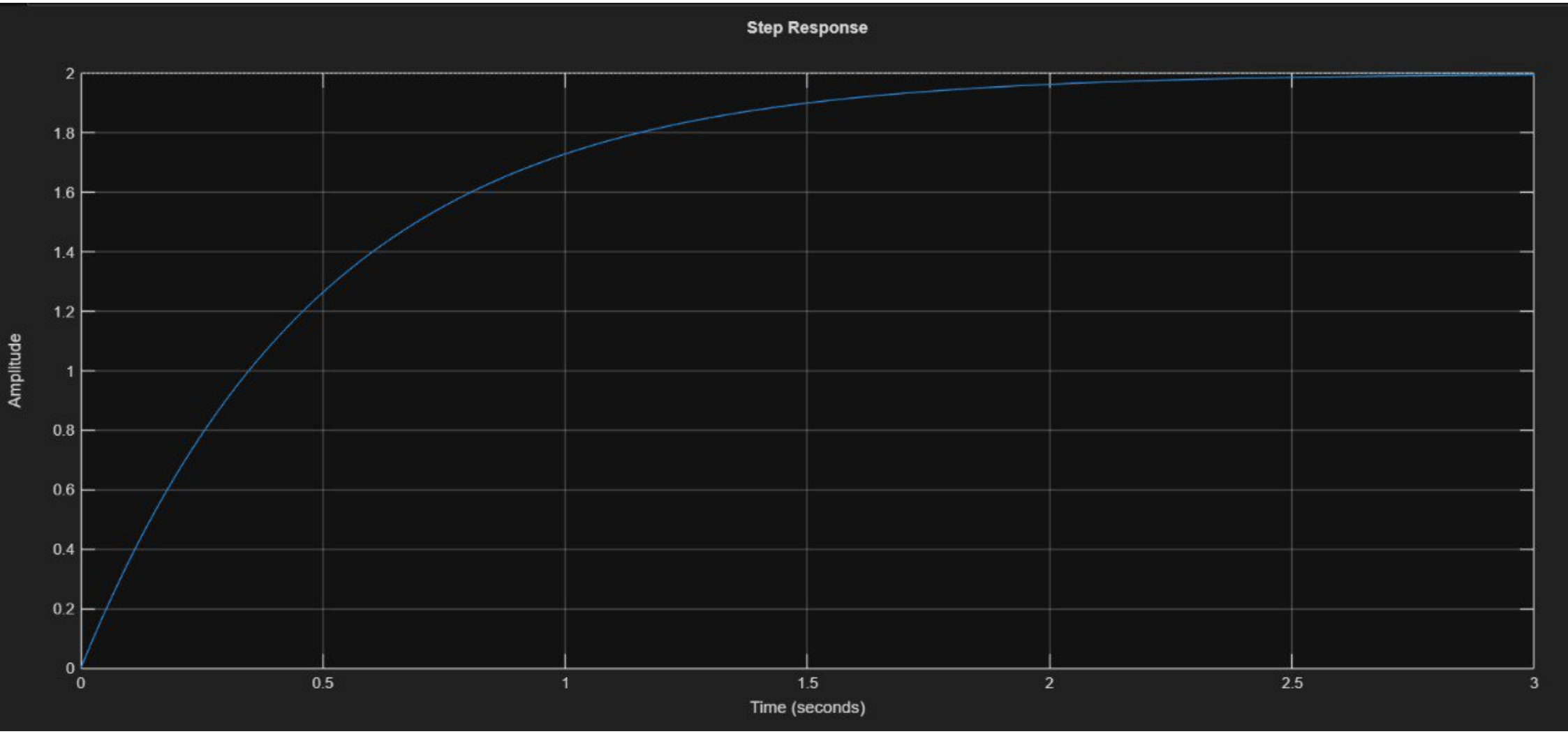
Assignment-1

Q1) 1) → .


Step Response
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
0.5
1
1.5
2
2.5
3

2) → Time constant : - 0.5 sec = τ

Rise time, $t_r = 2.2\tau = 1.1s$

Settling time, $t_s = 4\tau = 2.0s$

Final value :-

$$y_{ss} = \lim_{t \to \infty} y(t) = \lim_{s \to 0} s \cdot G(s) \cdot \frac{1}{s}$$

$$= G(0) = \frac{4}{2} = 2$$

steady-state errors, $e_{ss} = 1 - y_{ss}$

$$= 1 - 2 = -1$$

3) From matlab ; $y_{ss} = 2$

Analytical ; $y_{ss} = 2$

both the way gives same result i.e, 2

Date
Page

Q2) 1) → denominators:- $s(s+5) = s^2+5s$

This shows two poles.
one at $s=0$ and one at $s=-5$

identify integrators:-
- A pole at $s=0$. corresponds to an integrator.
- The pole at $s=-5$ is a stable finite pole, not an integrator

∴ The system has one integrator, so it is a Type 1 system

2) → Final Value Theorem:-

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} s\,F(s).$$

$$E(s) = \frac{1}{s(1+G(s))} = F(s)$$

$$\therefore e_{ss} = \lim_{t\to 0} e(t) = \lim_{s\to 0} s.E(s)$$

$$e_{ss} = \lim_{s\to 0} \frac{1}{1+G(s)} = \cancel{\frac{s.1}{s}}$$

$$= \lim_{s\to 0} s\frac{1}{s} - G(s) = \frac{1}{s}$$

$$= \lim_{s\to 0} \frac{1}{1+G(s)} = \frac{1}{1+\infty} = \underline{\underline{0}}$$

3) → Matlab's step response will rise towards 1, exhibit a small overshoot and settle at 1.

Q3). 1) → i)

$$t_s \approx \frac{4}{a}$$

$$\frac{4}{a} < 1.2 \Rightarrow a > \frac{4}{1.2} = 3.3$$

Choose a strictly greater than 3.3 to meet $t_s < 1.2_s$

ii)

$$e_{ss} = \frac{1}{1+k}$$

For $e_{ss} = 0.1$ $\frac{1}{1+k} = 0.1 \Rightarrow 1+k = 10$

$$\Rightarrow k = 9.$$

For $e_{ss} = 1$, $\frac{1}{1+k} = 1 \Rightarrow k = 0.$

This is degenate plant

so, $e_{ss} = 0.1 \Rightarrow k = 9$

2) → The k that we found in the answer is the DC gain (G[0]) of the plant and the a is same as above. Therefore, $k/3.33 = 9$, $k = 29.97$.

3) → The system should be faster than Q1 as the time constant is 0.3 s which is lesser than 0.5 s and the output value is (1−0.1=0.9) thus it is lesser.

Q4). 1) → By solving the equation for $T(s) = \frac{3k(s+z)}{s(1+3k)+(1+3kz)}$

Using the condition $y_{ss} = 0.8$ i.e. $\lim_{s \to 0} T(s)$.

this gives us $kz = 4$. The Damping ratio is greater than or equal to 0.6, let $z < 2.67$ and $k > 0.5$ using $t_s < 2$.

2) → $T(s) = \frac{3k+4}{(s(1+3k)+5)}$

3) → i) Increase. Adding a zero to the closed-loop transfer function generally increases the overshoot because it adds a derivative term to the response, making it react faster.

ii) Increases as we can observe from the steady state output value (y_{ss}).

iii) The controller adds a zero (which speeds up rise time) and gain k (which increases

~~bad~~ bandwidth). Both factors contribute to a faster response time compared to the original plant.

Q5) 1) → System type is defined by number of integrators in the open loop system. Thus it is zero.

2) → It will show infinite error.

3) → We had $y_{ss} = 0.8$ thus substituting it in the equation we got $0.2/s$ which will tend to infinity at s tends to infinity.

4) → No. as the ramp error requires an integrator for the error to fix and addition of zero does smoothen the transient state but it does not fix the infinity situation.