Exp 1:

a) $$E_a(s) = \frac{(R_a + L_a s)(J_m s^2 + D_m s)\,\theta_m(s)}{K_t} + K_b s\,\theta_m(s)$$

$$E_a(s) = \theta_m(s)\left[\frac{((R_a + L_a s)(J_m s^2 + D_m s) + K_b s K_t))}{K_t}\right]$$

$$\frac{\theta_m(s)}{E_a(s)} = \frac{K_t}{((R_a + L_a s)(J_m s^2 + D_m s) + K_b s K_t)}$$

$$= \frac{K_t}{R_a J_m s^2 + R_a D_m s + L_a s J_m s^2 + L_a D_m s^2 + K_b s K_t}$$

$$= \frac{1}{s}\left[\frac{K_t}{R_a J_m + R_a D_m + L_a J_m s^2 + L_a D_m s + K_b K_t}\right]$$

$$\frac{\omega_m(s)}{E_a(s)} = \frac{K_t}{R_a J_m + R_a D_m + L_a J_m s^2 + L_a D_m s + K_b K_t}$$

$$= \frac{1}{0.04 s^2 + 0.501 s + 0.8125}$$

b) $\omega_m(s) = \dfrac{10}{0.04s^2 + 0.501s + 0.8125}$

* matlab plot at end of this document.

c)

Amp = 12.4×0.63

Amp = 7.812

time = 0.625 sec

$\tau_1 = \dfrac{1}{0.625}$

$= 1.6$

$\dfrac{\omega_m(s)}{E_s(s)} = \dfrac{K}{\tau s + 1}$

$\dfrac{\omega_m(s)}{E_s(s)} = \dfrac{1.96}{1.6s + 1}$

$a_0 = \dfrac{1}{\tau}$

$\tau_2 = 0.629$

$K = 1.96 \times 0.629$

$K = 1.233$

$\boxed{\dfrac{\omega_m(s)}{E_s(s)} = \dfrac{1.233}{0.629s + 1}}$

d) $$\frac{w_m(s)}{10} = \frac{1.23}{0.1629s+1}$$

$$w_m(s) = \frac{1.23}{0.629s+1}$$

(* Matlab plot at end of this document).

e) Both graphs are highly accurate.

g) $$\frac{w_m(s)}{E_a(s)} = \frac{K_t}{R_aJ_m + R_aD_m + L_aJ_ms^2 + L_aD_ms + K_bK_t}$$

$$= \frac{1}{1.25 + 0.0125 + 0.1s^2 + 0.001s + 0.8}$$

$$\frac{W_m(s)}{E_a(s)} = \frac{1}{0.1s^2 + 0.001s + 2.0625}$$

(* Matlab plot at end of this document).

h) No.

Exp 2

a) $K_p = 25$, Step input = 150 rad/sec

1st order

DC Motor TF = $\dfrac{1.233}{0.629s+1}$

$$T.F(s) = \frac{(25)\left(\frac{1.233}{0.629s+1}\right)}{1+(25)\left(\frac{1.233}{0.629s+1}\right)}$$

$$T.F(s) = \frac{\left(\frac{30.825}{0.629s+1}\right)}{1+\left(\frac{30.825}{0.629s+1}\right)}$$

$$= \frac{30.825}{0.629s+31.825}$$

* matlab plot at end of this document

2nd order

$T.F(s)_{\text{DC motor}} = \dfrac{1}{0.04s^2+0.561s+0.8125}$

$$= \frac{\left(\frac{25}{0.04s^2+0.501s+0.8125}\right)}{\left(1+\frac{25}{0.04s^2+0.501s+0.8125}\right)}$$

$$T.F(s) = \frac{25}{0.04s^2+0.501s+26.8125}$$

* matlab plot at end of this document.

$K_p = 40$

1st order

$$T.F(s) = \frac{49.32}{0.629s + 50.32}$$

2nd order

$$T.F(s) = \frac{40}{0.04s^2 + 0.501s + 41.8125}$$

c) when $K_p = 40$

$$e(\infty) = \frac{1}{1+40}$$

$$\boxed{e(\infty) = 0.024}$$

when $K_p = 25$

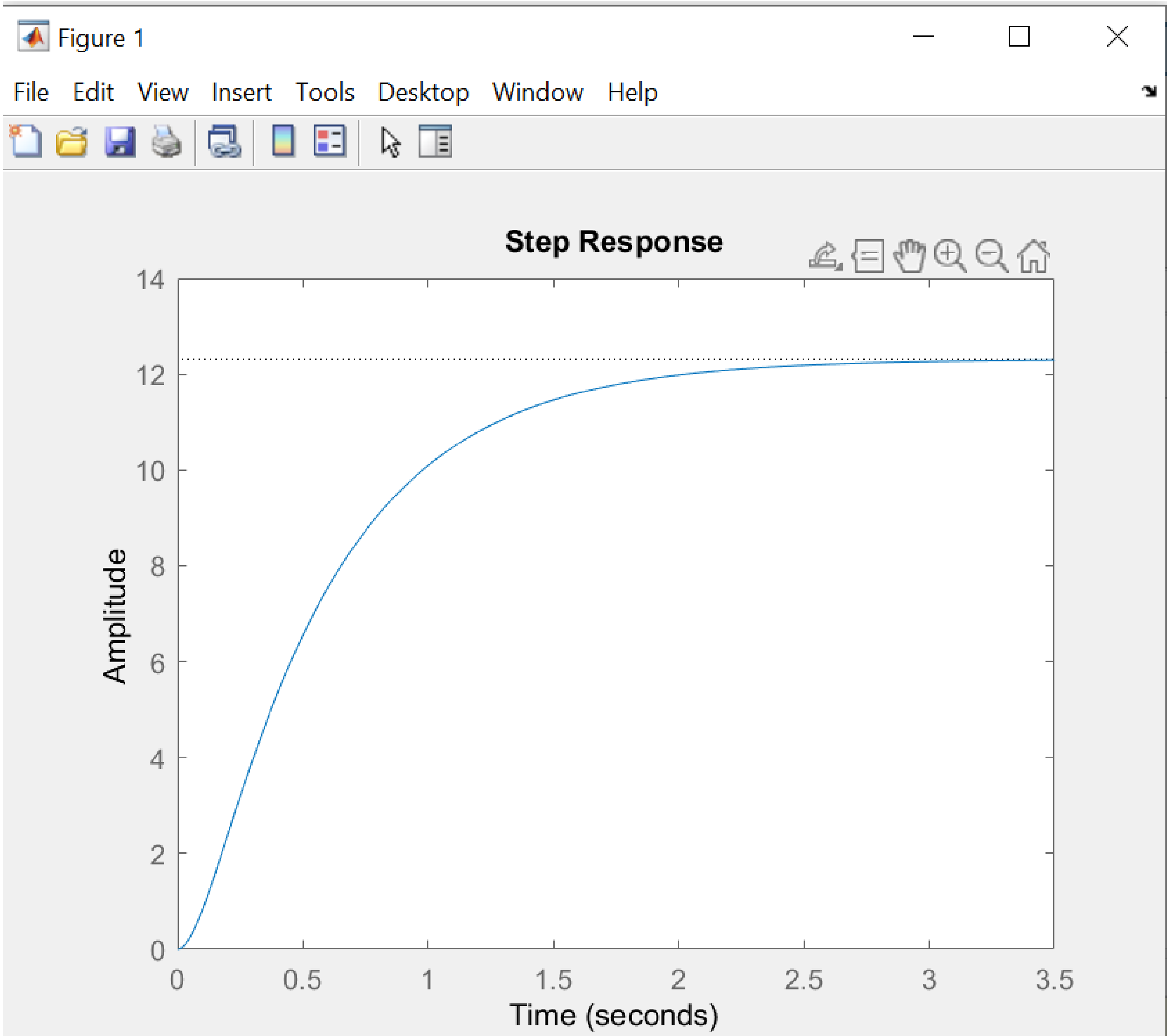
$$e(\infty) = \frac{1}{1+25}$$

$$\boxed{e(\infty) = 0.0385}$$

As Kp decreases, steady state error increases.

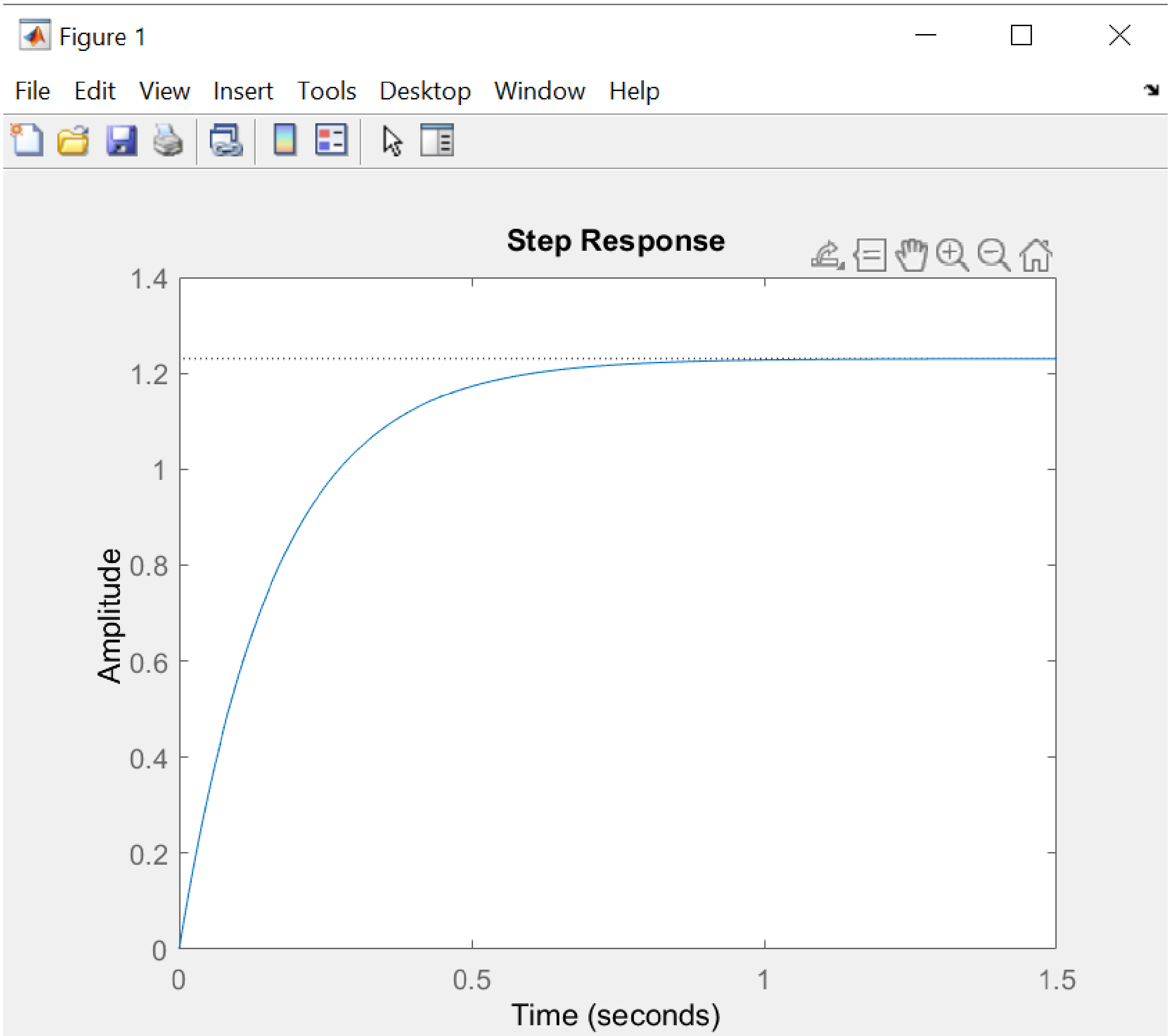
Experiment 1

b)



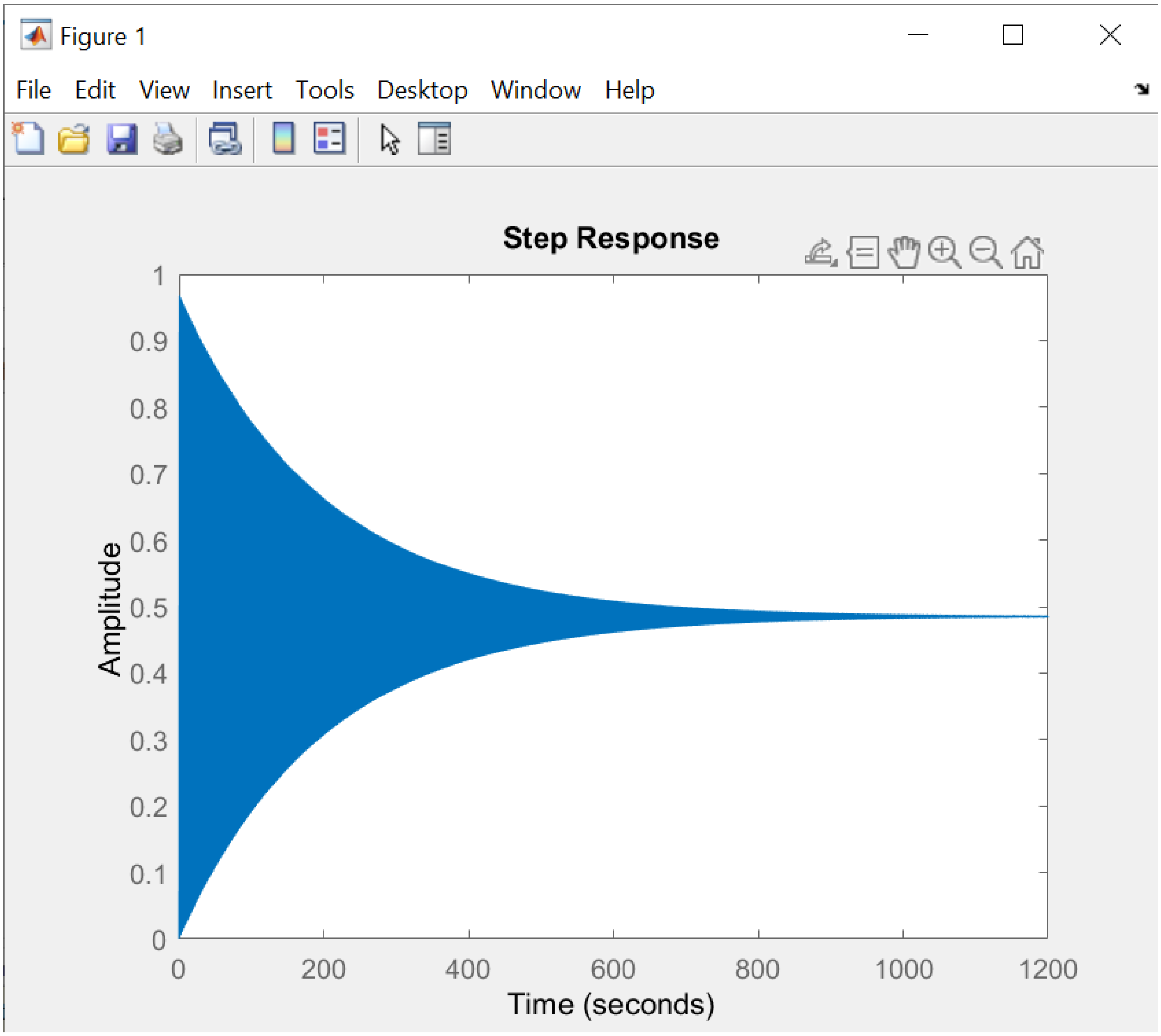
Experiment 1

d)



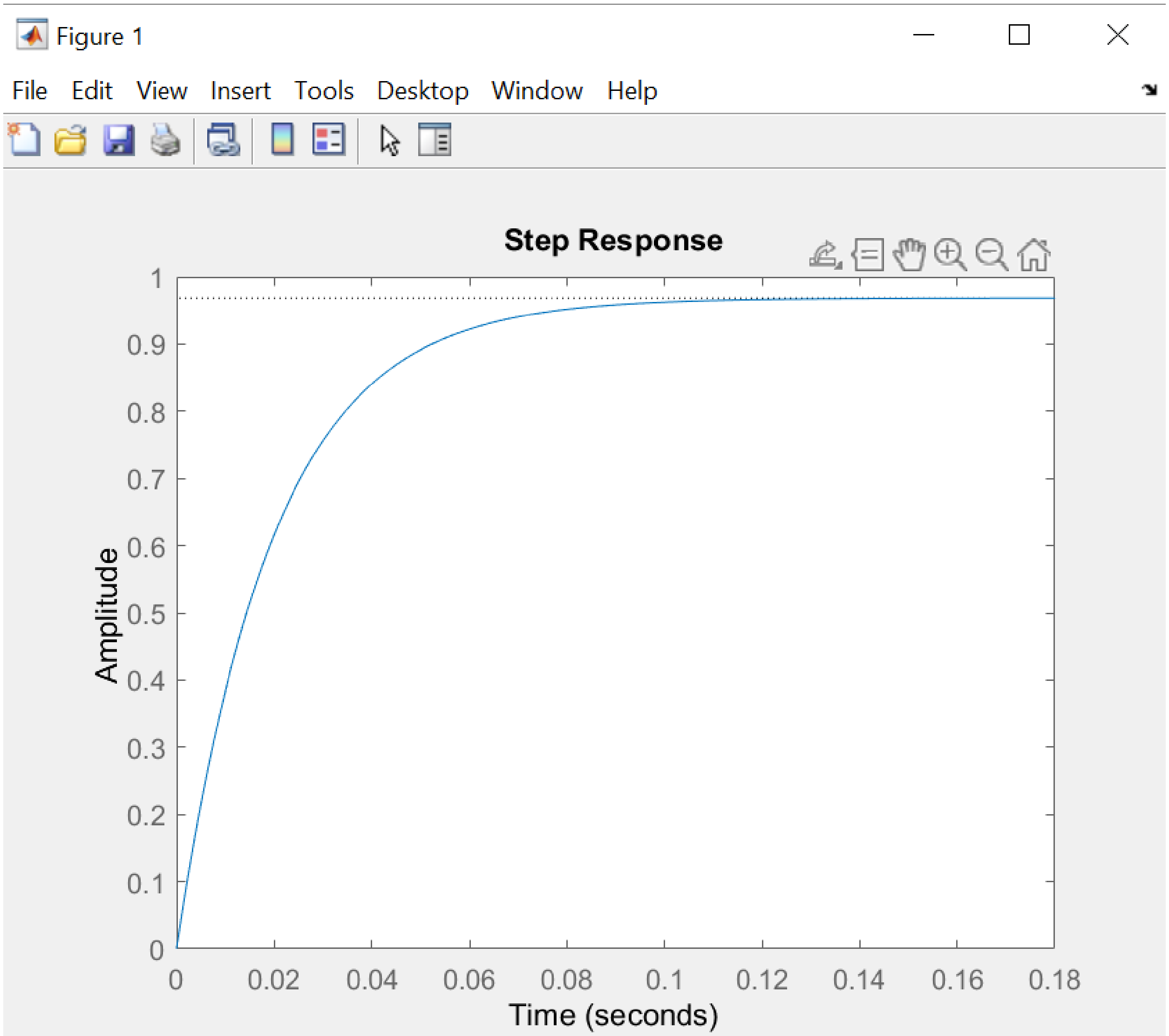
Experiment 1

g)

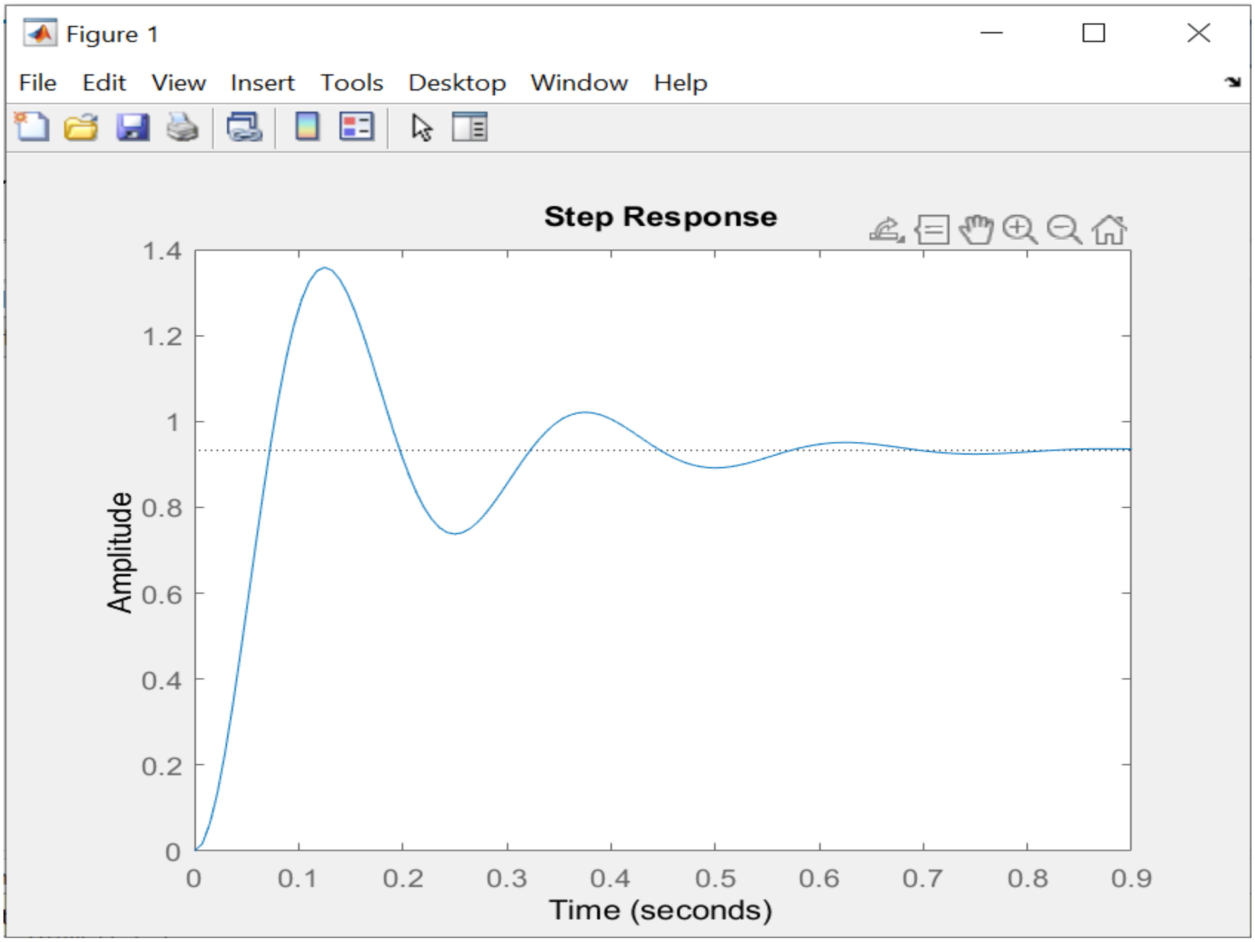


Experiment 2

a) 1st order

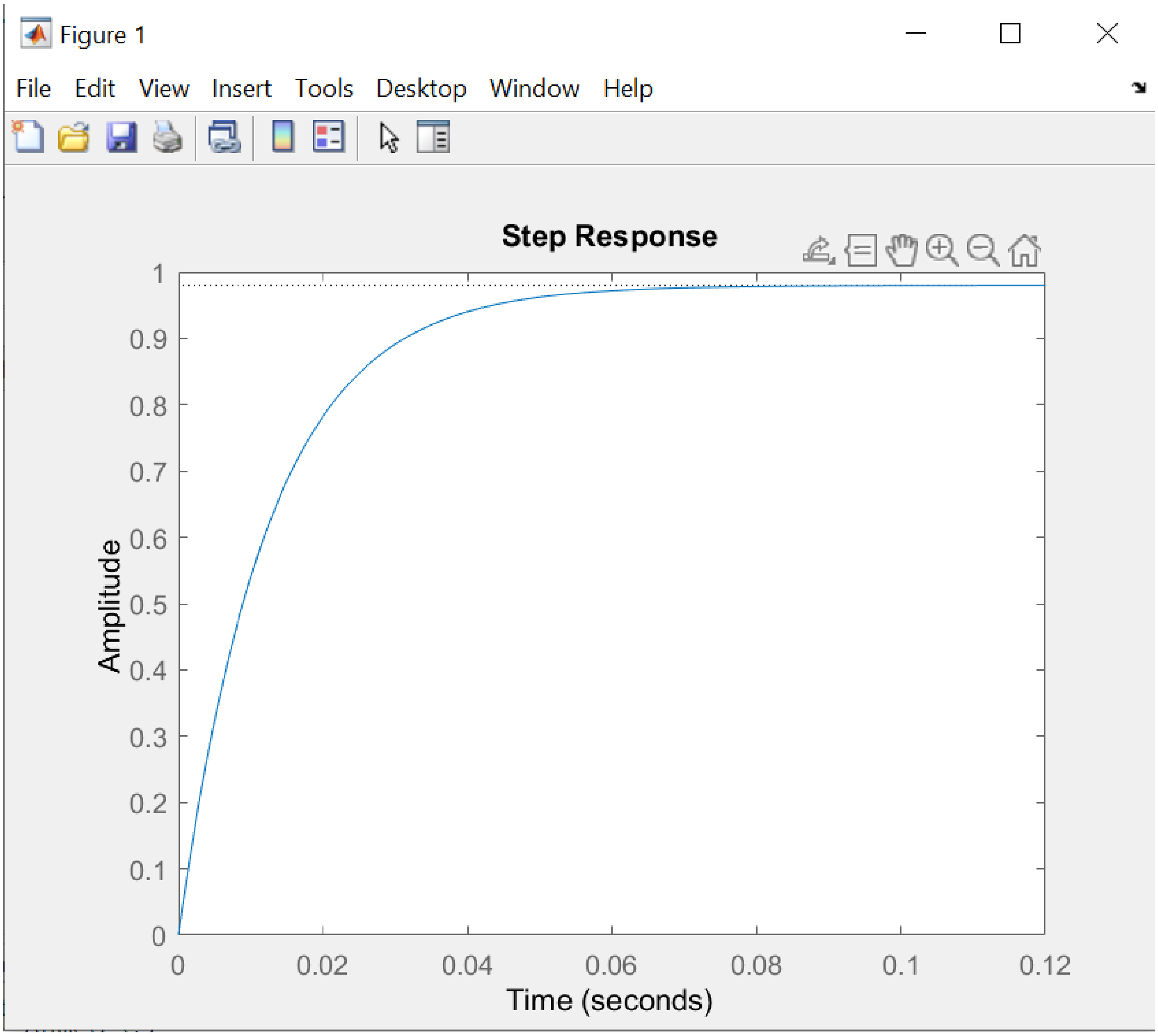


2^{nd} order (Experiment 2 a)



Experiment 2 b)

1st order



Experiment 2b)

2^{nd} order