Project - EECE 340

Monday, March 28, 2022 2:05 PM

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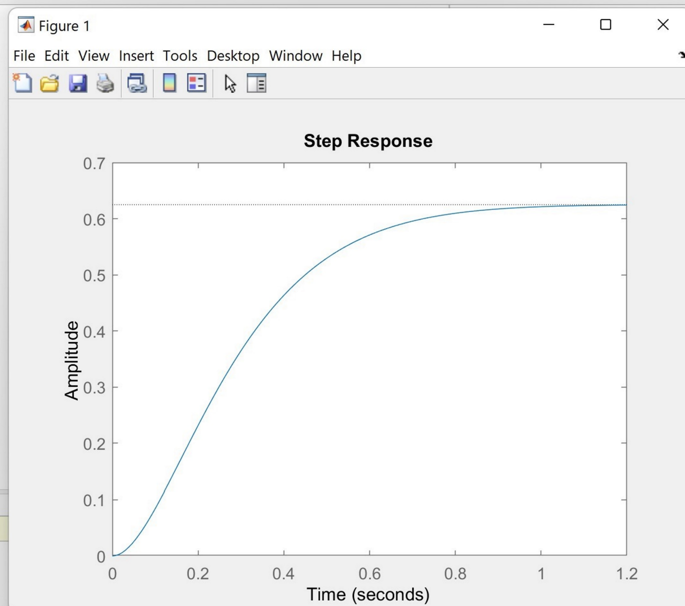
Problem 1:

a) The plot of the output representing the temperature at the back stabilizes at an "amplitude of 0.6" which is 12 degrees celsius. The temperature at the back is always gonna be less than the one at the front because the air traveling to the back is gonna loose energy along the way and become colder

Editor - C:\Users\Ghassan\Documents\MATLAB\MATLAB projects\Manyake\Proj.m

ex_a.m | Proj.m

```
%a)
num=[25];
denom=[1 12 40];
SYS=tf(num,denom)
figure(1)
hold on
step(SYS)
hold off
```



Command Window

New to MATLAB? See resources for Getting Started.

```
SYS =

        25
  ---------------
  s^2 + 12 s + 40

Continuous-time transfer function.

>>
```

b)

b-1) $\frac{E(s)}{R(s)} = \frac{1}{1+G(s)P(s)} = \frac{s^2+12s+40}{s^2+12s+40+25K} \longrightarrow E(s) = \frac{s^2+12s+40}{(s^2+12s+(40+25K))s}$

$$\lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s) = \lim_{s\to 0} \frac{s^2+12s+40}{s^2+12s+40+25K} = \frac{40}{40+25K} = 0{,}02$$

$$40 = 0{,}8 + 0{,}5K \rightarrow K = 78{,}4$$

b-2) $H(s) = \frac{1960}{s^2+12s+2000}$

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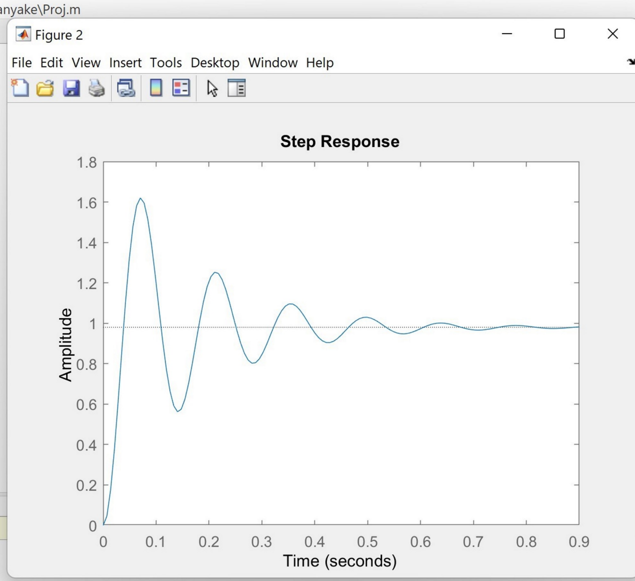
ex_a.m | Proj.m

```
%b)
num_2=[1960];
denom_2=[1 12 2000];
sys_2=tf(num_2,denom_2)
figure(2)
hold on
step(sys_2)
hold off
```



Command Window

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```
sys_2 =

        1960
  -----------------
  s^2 + 12 s + 2000

Continuous-time transfer function.
```

b_3) The presence of K in the denuminator affects the wideness of the oscillations at the begining so the bigger the K, the less wide the oscillations are and so the faster the output stabilizes. But the presence of K in the numerator is gonna affect the peak of the oscillations, the higher the K, the higher the temperature jumps and so we would be reaching undesirable temperatures at the begining before reaching stability

c-1) $H(s) = \dfrac{G(s)P(s)}{1+G(s)P(s)} = \dfrac{25K(1+0.05s)}{s^2+12s+40+25K(1+0,05s)} = \dfrac{25+1.25s}{s^2+13,25s+65}$

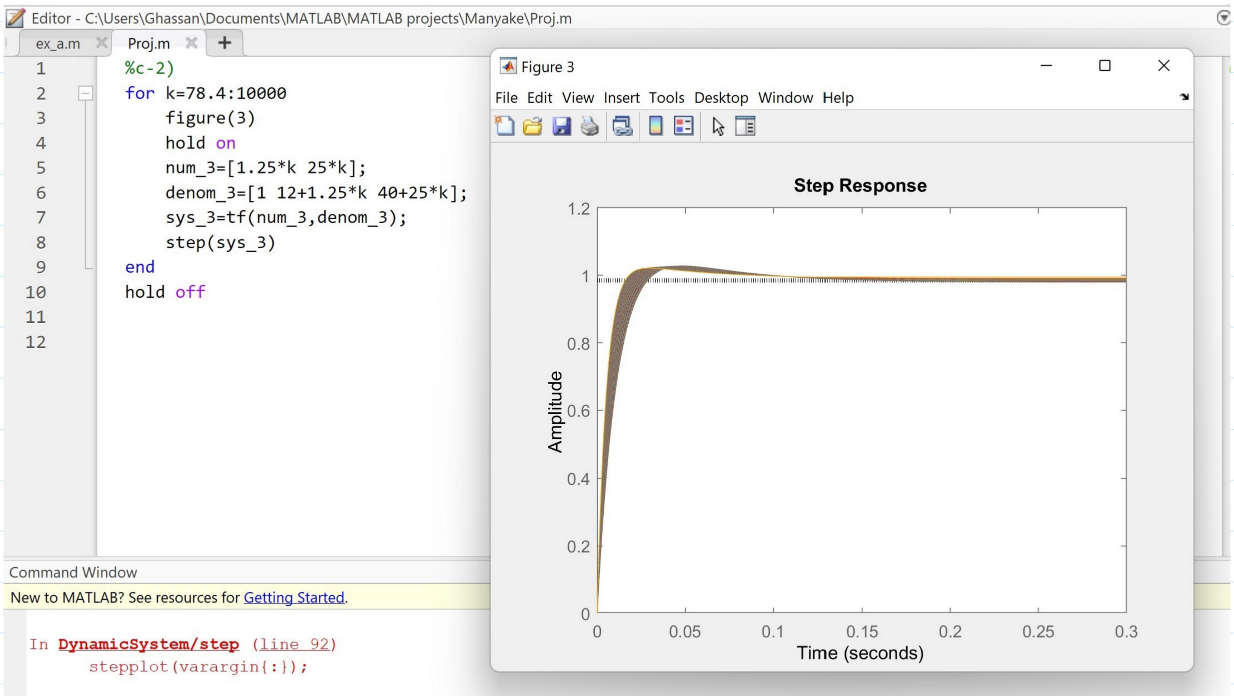
the zero is $s=-20$

c-2) $\dfrac{E(s)}{R(s)} = \dfrac{1}{1+G(s)P(s)} = \dfrac{s^2+12s+40}{s^2+12s+40+25K(1+0,05s)}$

$\lim\limits_{t\to\infty} e(t) = \lim\limits_{s\to 0} sE(s) = \dfrac{40}{40+25K} \leq 0,02 \;\rightarrow K \geq 78,4$

Using MatLAB we try $K = 78,4 \rightarrow y(t) < 1.5$
the bigger the K, the smaller the peak of y(t)
So any $K \geq 78.4$ will satisfy the 2 conditions

Using a for loop we vary K from 78.4 to 10000, we notice that none of the plot surpasses 1.5



d) $\frac{E(s)}{R(s)} = \frac{s^2+12s+40}{s^2+(12+1.25K)s+25K+40+25K/s} = \frac{s(s^2+12s+40)}{s^3+(12+1.25K)s^2+(25K+40)s+25K}$

$\lim_{t\to\infty} e(t) = \lim_{s\to 0} sE(s) = 0 \quad \forall K \in \mathbb{R}$

We shall need to satisfy stability

R.H. Tables

s^3	1	$25K+40$
s^2	$12+1.25K$	$25K$
s	c_1	0
s^0	$25K$	

$c_1 = \frac{(12+1.25K)(25K+40)-25K}{12+1,25K}$

$= \frac{300K+480+31,25K^2+50K-25K}{12+1,25K}$

$c_1 = \frac{31,25K^2+325K+480}{12+1,25K} > 0$

$12+1,25K>0$, $25K>0$

$K>-9,6$ $\quad K>0 \quad K<-8,617$ or $K>-1,78$

So $\boxed{K>0}$

$\frac{Y(s)}{R(s)} = \frac{G(s)P(s)}{1+G(s)P(s)} = \frac{25(1+0.05s+1/s)}{s^3+12s+40+25(1+0.05s+1/s)} = \frac{25s+1.25s^2+25}{s^3+(13.25)s^2+65s+25}$

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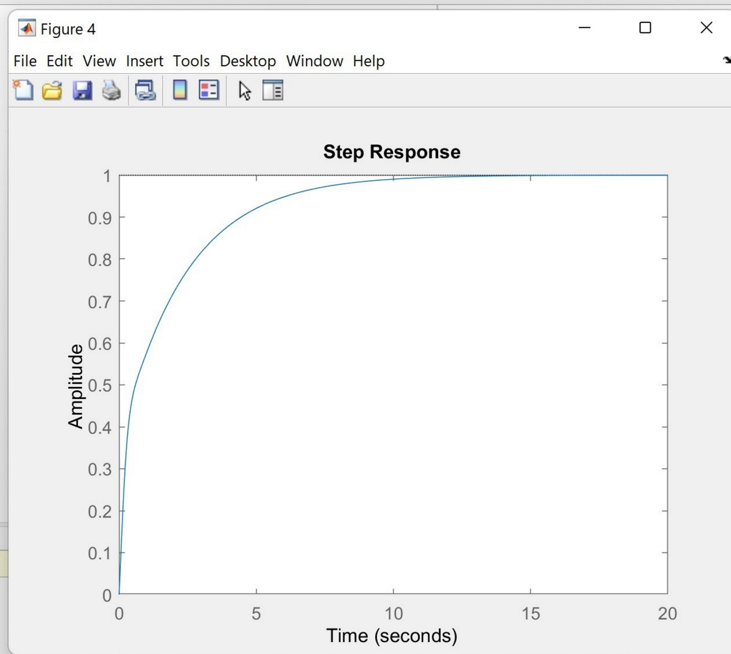
ex_a.m | Proj.m

```
%d)
num_4=[1.25 25 25];
denom_4=[1 13.25 65 25];
sys_4=tf(num_4,denom_4)
figure(4)
step(sys_4)
```



Command Window

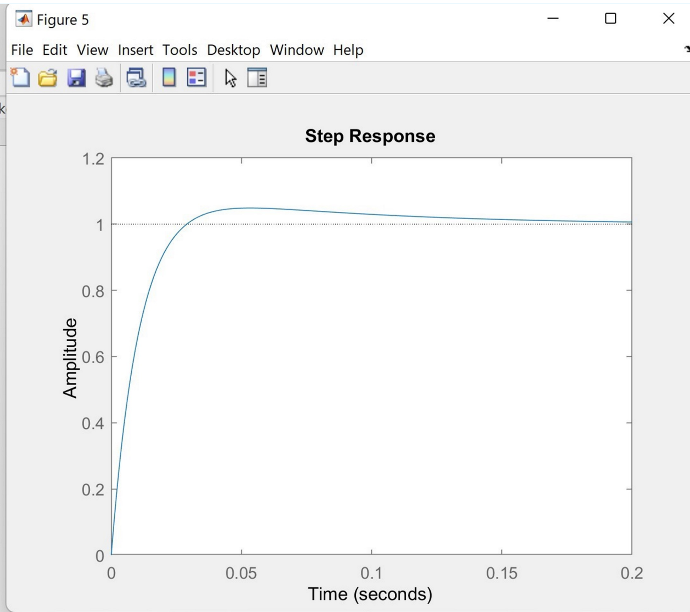
New to MATLAB? See resources for Getting Started.

```
sys_4 =

    1.25 s^2 + 25 s + 25
  ---------------------------
  s^3 + 13.25 s^2 + 65 s + 25

Continuous-time transfer function.

fx >>
```

e)

e-1) $\frac{Y(s)}{R(s)} = \frac{2000s + 100s^2 + 10000}{s^3 + 112s^2 + 2040s + 10000}$

```
num_5=[100 2000 10000];
denom_5=[1 112 2040 10000];
sys_5=tf(num_5,denom_5)
figure(5)
step(sys_5)
stepinfo(sys_5) %gets you risetime and
```



Command Window

New to MATLAB? See resources for Getting Started.

```
        RiseTime: 0.0184
   TransientTime: 0.1269
    SettlingTime: 0.1269
     SettlingMin: 0.9135
     SettlingMax: 1.0487
       Overshoot: 4.8720
      Undershoot: 0
            Peak: 1.0487
        PeakTime: 0.0538
```

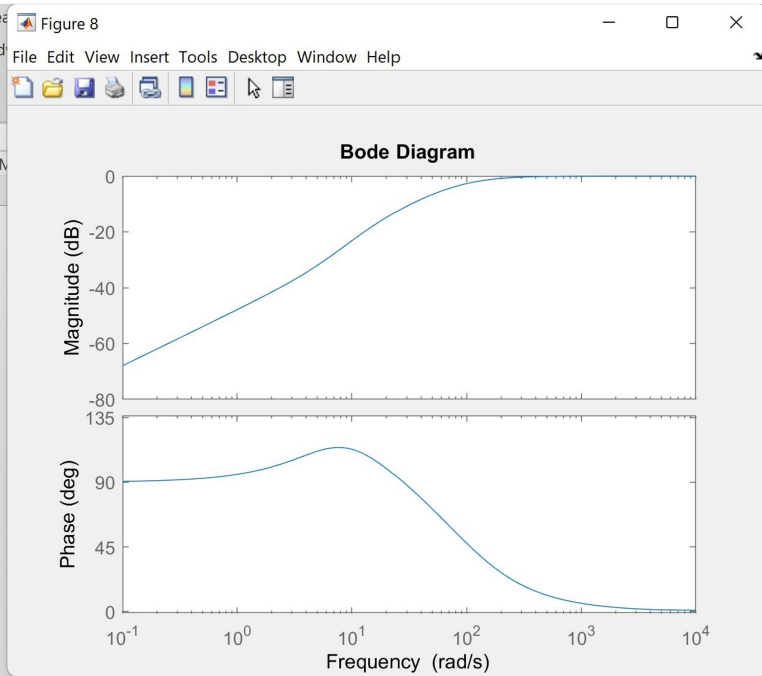
e-2) $G(s)P(s) = \dfrac{80(1+0{,}05s+5/s)\times 25}{s^2+12s+40} = \dfrac{100s^2+2000s+10000}{(s^2+12s+40)s}$

$$H_o(s) = \frac{1}{1+G(s)P(s)} = \frac{(s^2+12s+40)s}{s^3+112s^2+2040s+10000}$$

$$H_N(s) = -\frac{G(s)P(s)}{1+G(s)P(s)}$$

```
num_7=[1 12 40 0];
denom_7=[1 112 2040 10000];
sys_7=tf(num_7,denom_7)
figure (8)
hold on
bode(sys_7)%H=Y/D
hold off
```

H_D



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ew to MATLAB? See resources for Getting Started.

```
sys_7 =

       s^3 + 12 s^2 + 40 s
  -----------------------------
  s^3 + 112 s^2 + 2040 s + 10000

Continuous-time transfer function.
```

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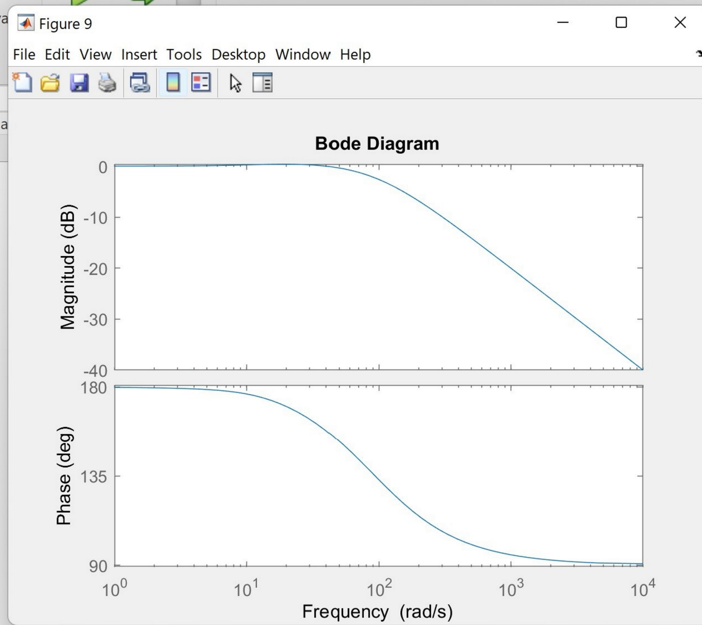
```
num_8=[-100 -2000 -10000];
denom_8=[1 112 2040 10000];
sys_8=tf(num_8,denom_8)
figure(9)
hold on
bode(sys_8)%H=Y/N
hold off
```

Hr



Command Window

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```
sys_8 =

    -100 s^2 - 2000 s - 10000
  ------------------------------
  s^3 + 112 s^2 + 2040 s + 10000

Continuous-time transfer function.
```

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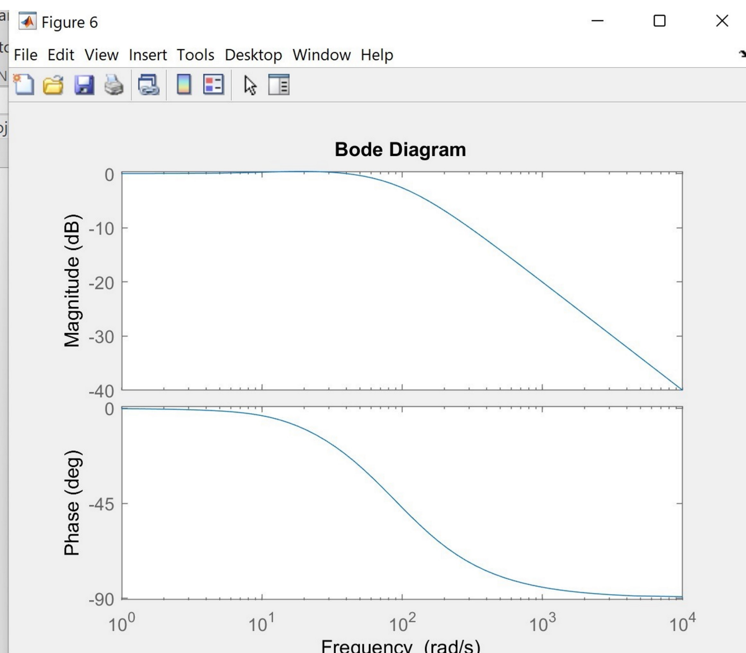
```
num_5=[100 2000 10000];
denom_5=[1 112 2040 10000];
sys_5=tf(num_5,denom_5)
figure(6)
hold on
bode(sys_5)%H=Y/R
hold off
```

H(s)



Command Window

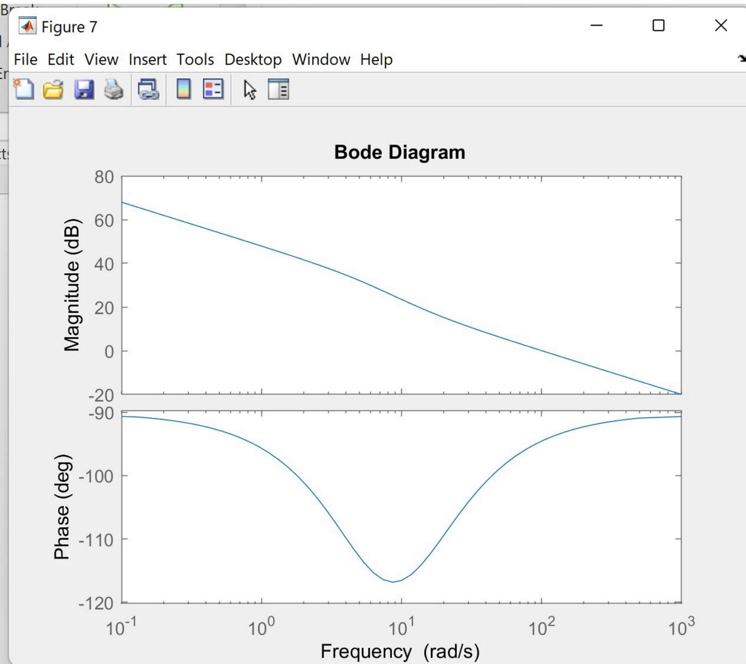
New to MATLAB? See resources for Getting Started.

```
sys_5 =

     100 s^2 + 2000 s + 10000
  ------------------------------
  s^3 + 112 s^2 + 2040 s + 10000

Continuous-time transfer function.
```

```
num_6=[100 2000 10000];
denom_6=[1 12 40 0];
sys_6=tf(num_6,denom_6)
figure(7)
hold on
bode(sys_6)%open loop
hold off
```

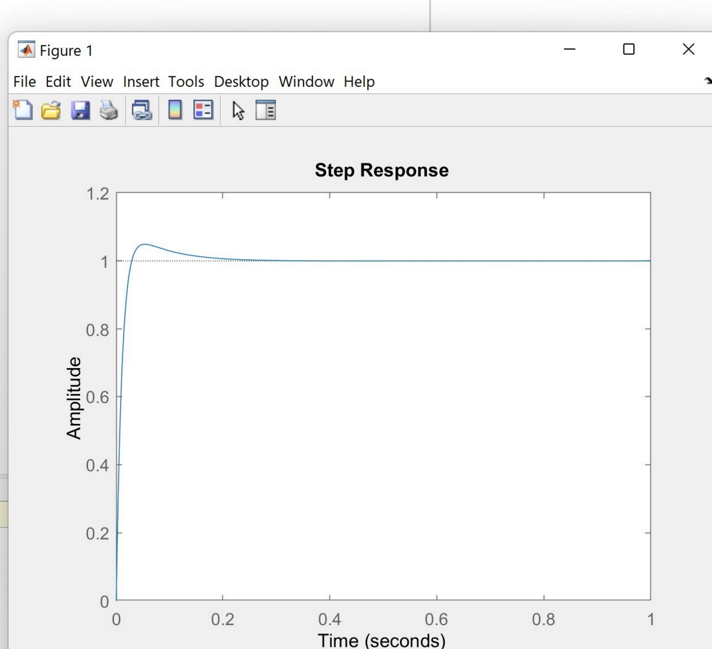


e-3)

```
load("data_proj_matlab.mat","d","n","time_vec");
num_5=[100 2000 10000];
denom_5=[1 112 2040 10000];
sys_5=tf(num_5,denom_5)
step(sys_5,time_vec)
```

H(s)

0<t<1



Command Window

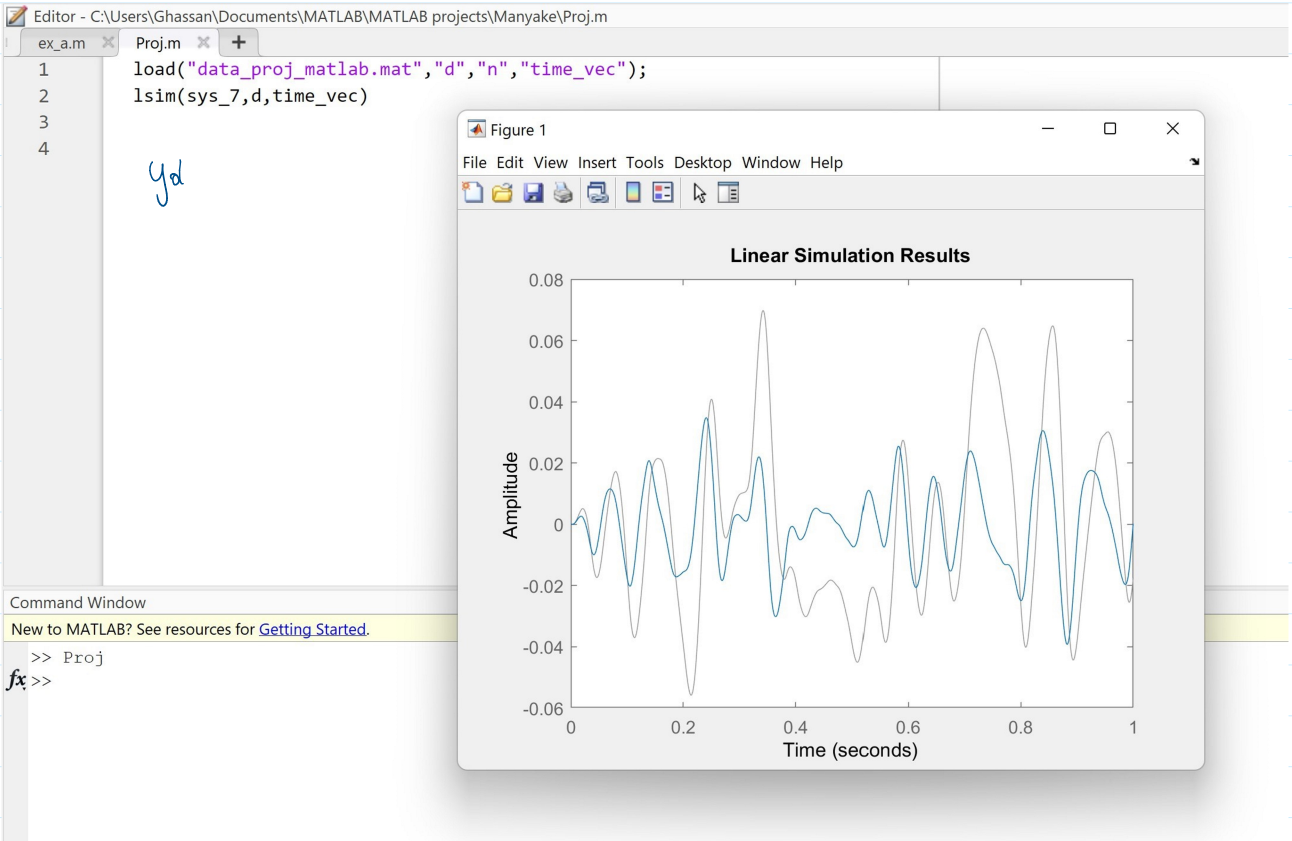
New to MATLAB? See resources for Getting Started.

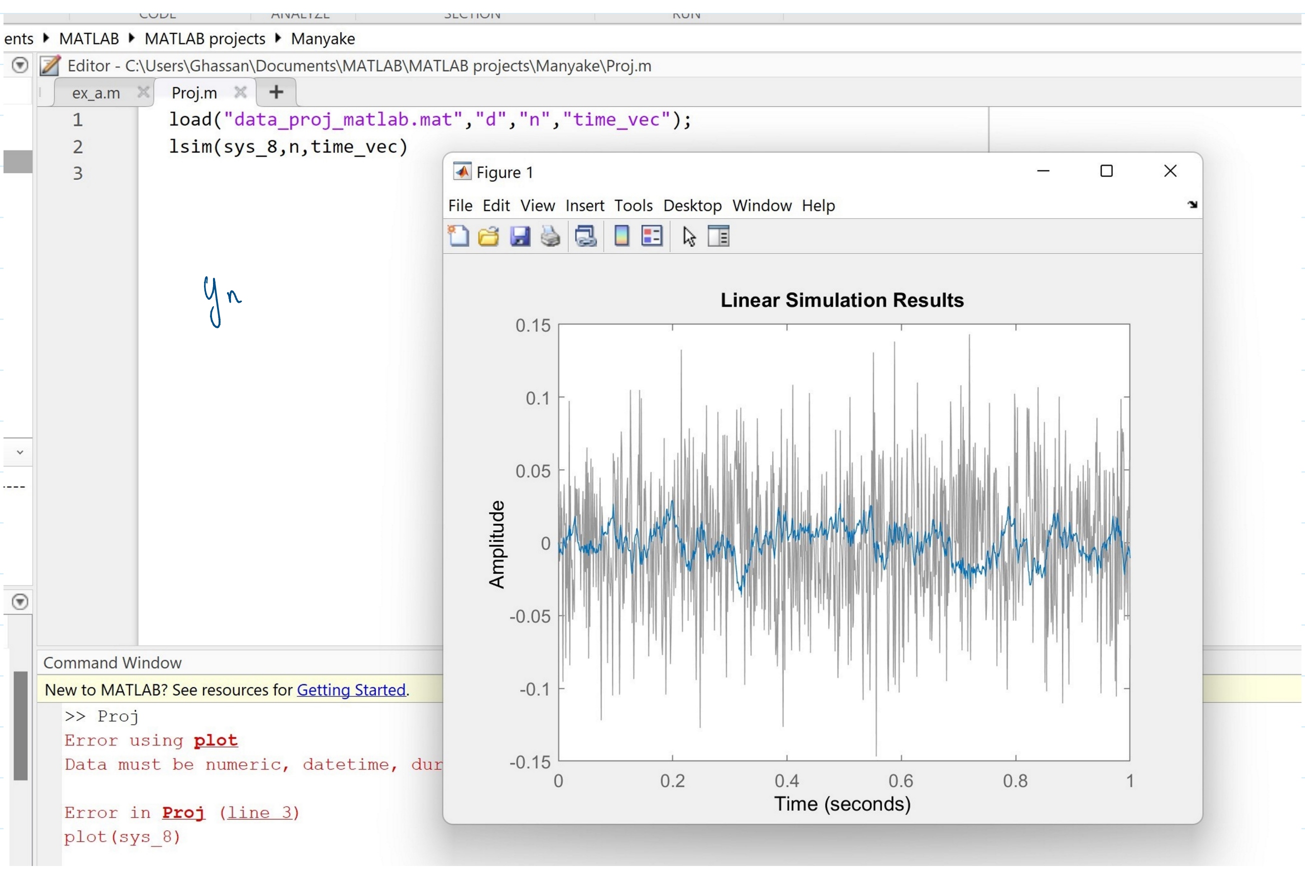
```
sys_5 =

    100 s^2 + 2000 s + 10000
  ----------------------------
  s^3 + 112 s^2 + 2040 s + 10000

Continuous-time transfer function.

>>
```


Editor - C:\Users\Ghassan\Documents\MATLAB\MATLAB projects\Manyake\Proj.m
ex_a.m
Proj.m
load("data_proj_matlab.mat","d","n","time_vec");
lsim(sys_7,d,time_vec)
Yd
Figure 1
File Edit View Insert Tools Desktop Window Help
Linear Simulation Results
Amplitude
Time (seconds)
Command Window
New to MATLAB? See resources for Getting Started.
>> Proj
>>


MATLAB ▸ MATLAB projects ▸ Manyake
Editor - C:\Users\Ghassan\Documents\MATLAB\MATLAB projects\Manyake\Proj.m
ex_a.m
Proj.m
load("data_proj_matlab.mat","d","n","time_vec");
lsim(sys_8,n,time_vec)
Yn
Figure 1
File Edit View Insert Tools Desktop Window Help
Linear Simulation Results
Amplitude
Time (seconds)
Command Window
New to MATLAB? See resources for Getting Started.
>> Proj
Error using plot
Data must be numeric, datetime, dur
Error in Proj (line 3)
plot(sys_8)

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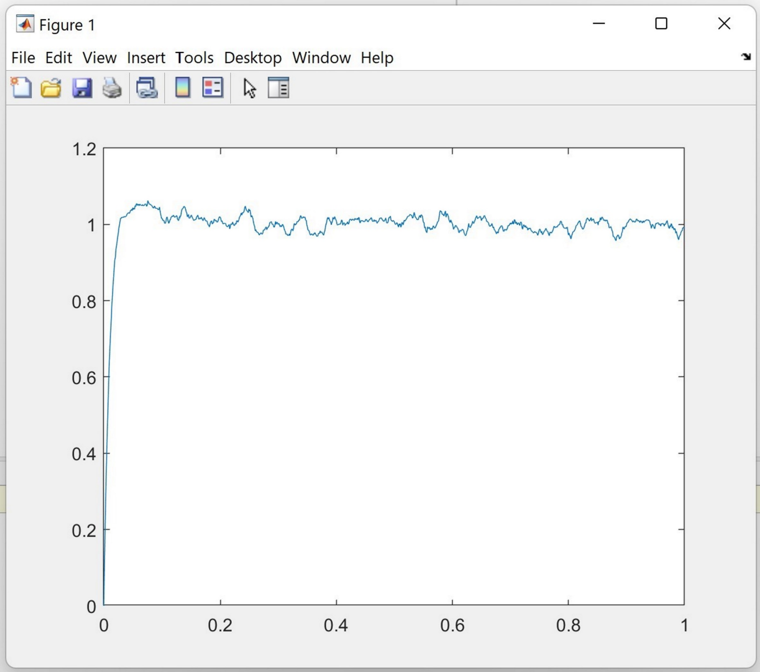
ex_a.m | Proj.m

```
load("data_proj_matlab.mat","d","n","time_vec");
plot(time_vec, step(sys_5,time_vec)+lsim(sys_7,d,time_vec)+lsim(sys_8,n,time_vec))
```

$y_T(t)$



Command Window

New to MATLAB? See resources for Getting Started.

```
     100 s^2 + 2000 s + 10000
  ------------------------------
  s^3 + 112 s^2 + 2040 s + 10000

Continuous-time transfer function.

>> Proj
>> Proj
>> Proj
fx >>
```

e-4) $G(s)P(s) = \frac{8(1+0.05s+5(s)\times 25}{s^2+12s+40} = \frac{10s^2+200s+1000}{s^3+12s^2+40s}$

– $\frac{Y(s)}{R(s)} = \frac{G(s)P(s)}{1+G(s)P(s)} = \frac{10s^2+200s+1000}{s^3+22s^2+240s+1000}$

The overshoot and rise time are much bigger than the ones obtained with $K=80$, which is bad because this means it reaches a higher peak and takes longer to stabilize.

– $\frac{Y(s)}{D(s)} = \frac{s^3+12s^2+40s}{s^3+22s^2+240s+1000}$

$\frac{Y(s)}{N(s)} = -\frac{G(s)P(s)}{1+G(s)P(s)} = -\frac{Y(s)}{R(s)}$

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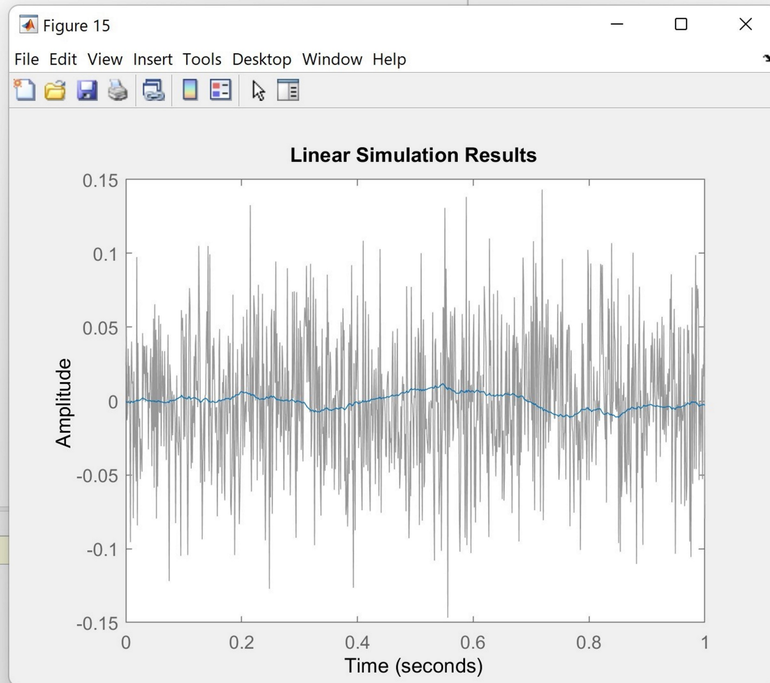
ex_a.m | Proj.m

```
num_11=[-10 -200 -1000];
denom_11=[1 22 240 1000];
sys_11=tf(num_11,denom_11)
figure(15)
hold on
lsim(sys_11,n,time_vec)%H=Y/N
hold off
```



Command Window

New to MATLAB? See resources for Getting Started.

```
sys_11 =

    -10 s^2 - 200 s - 1000
  --------------------------
  s^3 + 22 s^2 + 240 s + 1000

Continuous-time transfer function.

fx >>
```

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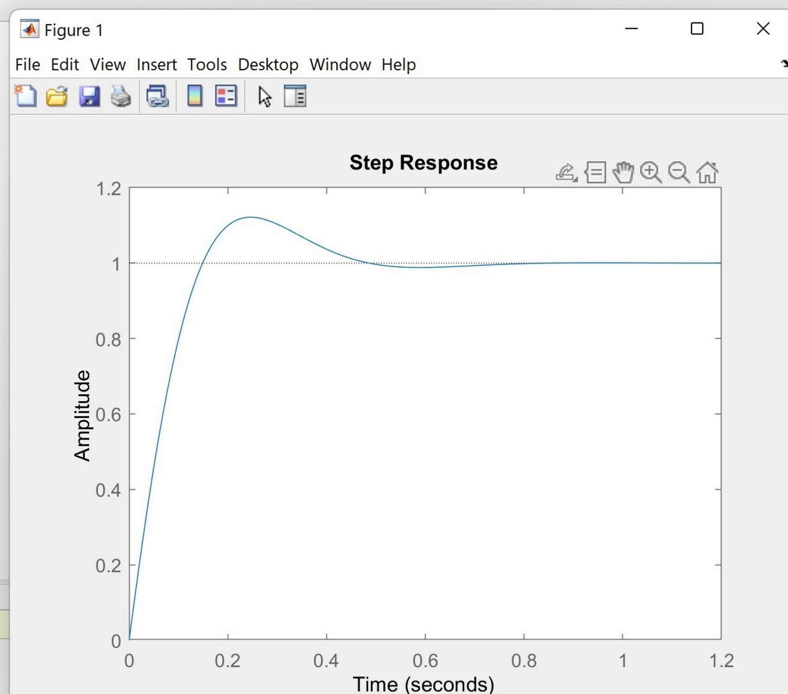
ex_a.m | Proj.m

```
num_9=[10 200 1000];
denom_9=[1 22 240 1000];
sys_9=tf(num_9,denom_9)%H=Y/R
step(sys_9)
stepinfo(sys_9)
```



Command Window

New to MATLAB? See resources for Getting Started.

```
        RiseTime: 0.1111
   TransientTime: 0.4314
    SettlingTime: 0.4314
     SettlingMin: 0.9051
     SettlingMax: 1.1217
       Overshoot: 12.1728
      Undershoot: 0
            Peak: 1.1217
        PeakTime: 0.2447
fx
```

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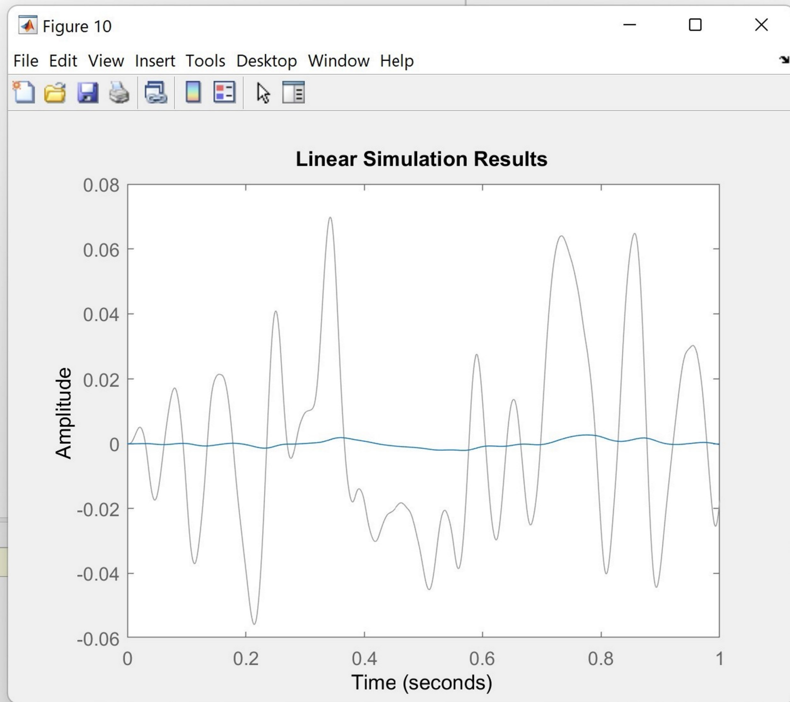
ex_a.m | Proj.m

```matlab
num_10=[1 12 40];
denom_10=[1 22 240 1000];
sys_10=tf(num_10,denom_10)
figure(10)
lsim(sys_10,d,time_vec)%H=Y/D
```



Command Window

New to MATLAB? See resources for Getting Started.

```
sys_10 =

        s^2 + 12 s + 40
  ---------------------------
  s^3 + 22 s^2 + 240 s + 1000

Continuous-time transfer function.
```