CONTROL SYSTEM-2

PRACTICAL FILE

SUBMITTED BY: MANAN MADAN

ROLL NUMBER: 2018UIC3087

Branch: Instrumentation and Control Engineering

List of Experiments

1. **Practical problems using state-space equations in MATLAB**
2. **Pole placement and observer design for a given state-space model using MATLAB**
3. **Modeling and control of Cruise control system using MATLAB**
4. **Modeling and control of DC motor using MATLAB**
5. **The Frequency design method of a Cruise control system.**
6. **Obtain the transfer function of the system-defined by the following state-space equations:**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -25 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 25 \\ -120 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

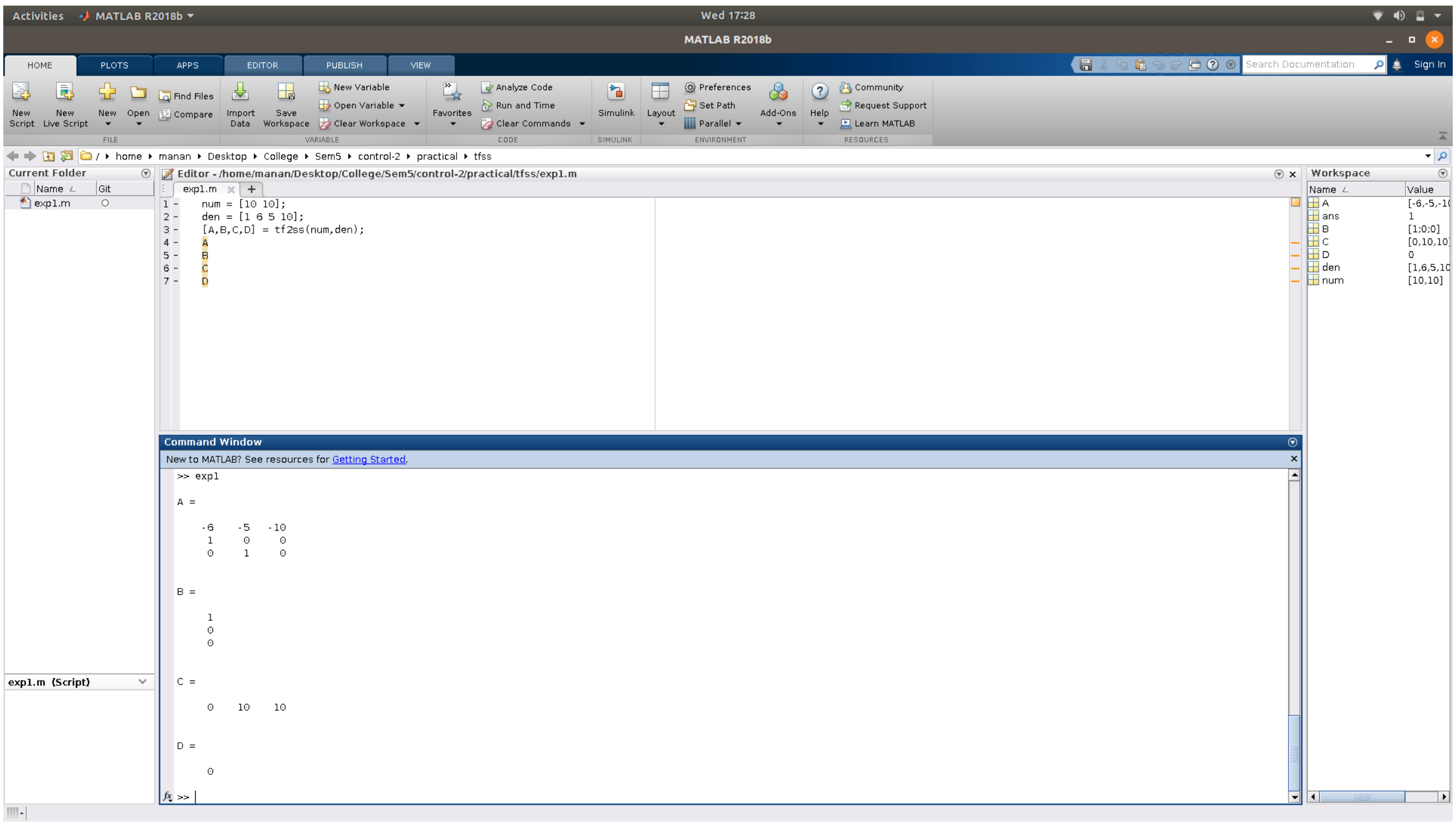
7. **Step response and impulse response of second-order systems for varying damping ratio:**

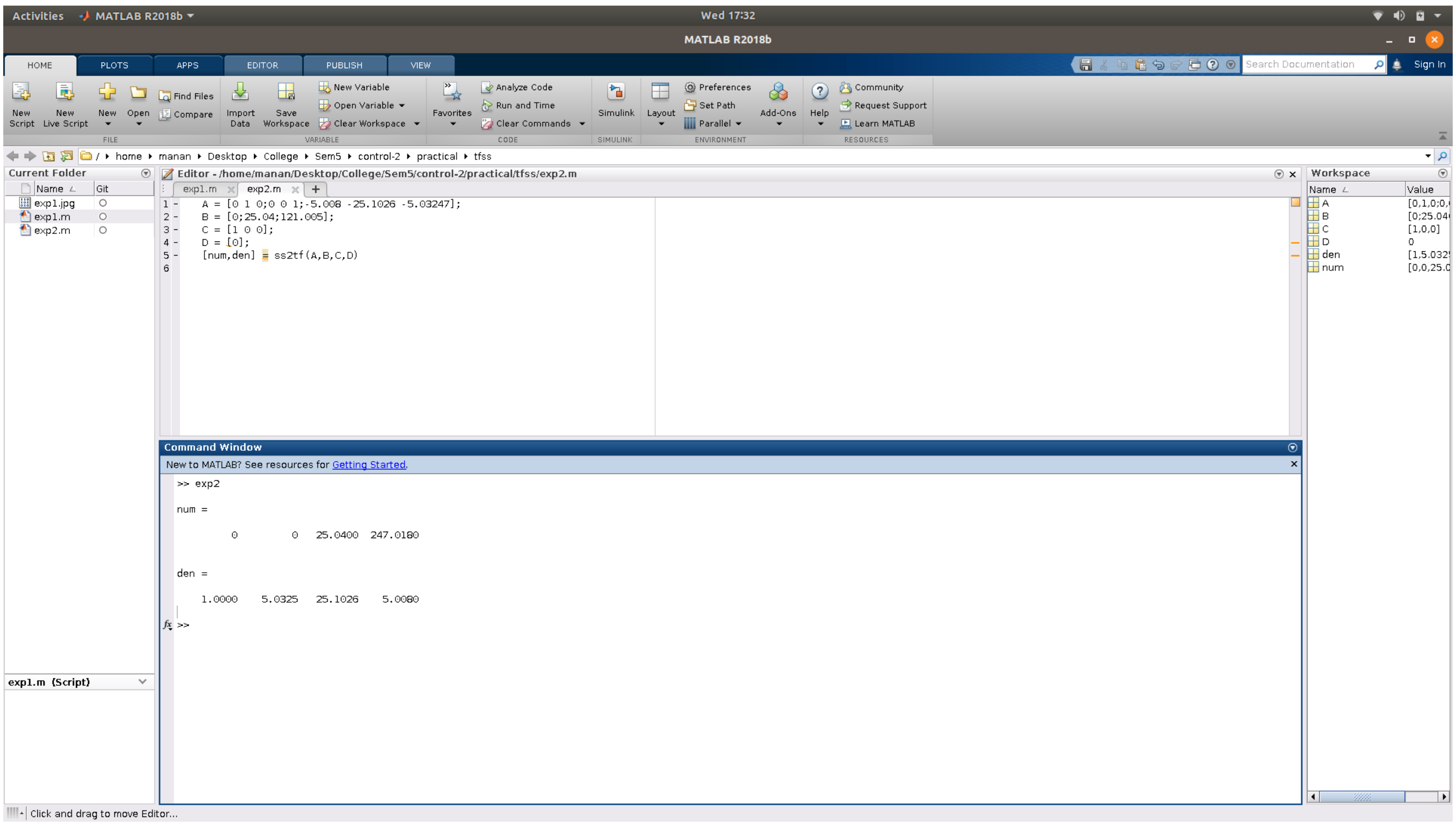
   (i) G(s) = $\frac{10}{s^2+2s+10}$

   (ii) G(s) = $\frac{25}{s^2+4s+25}$

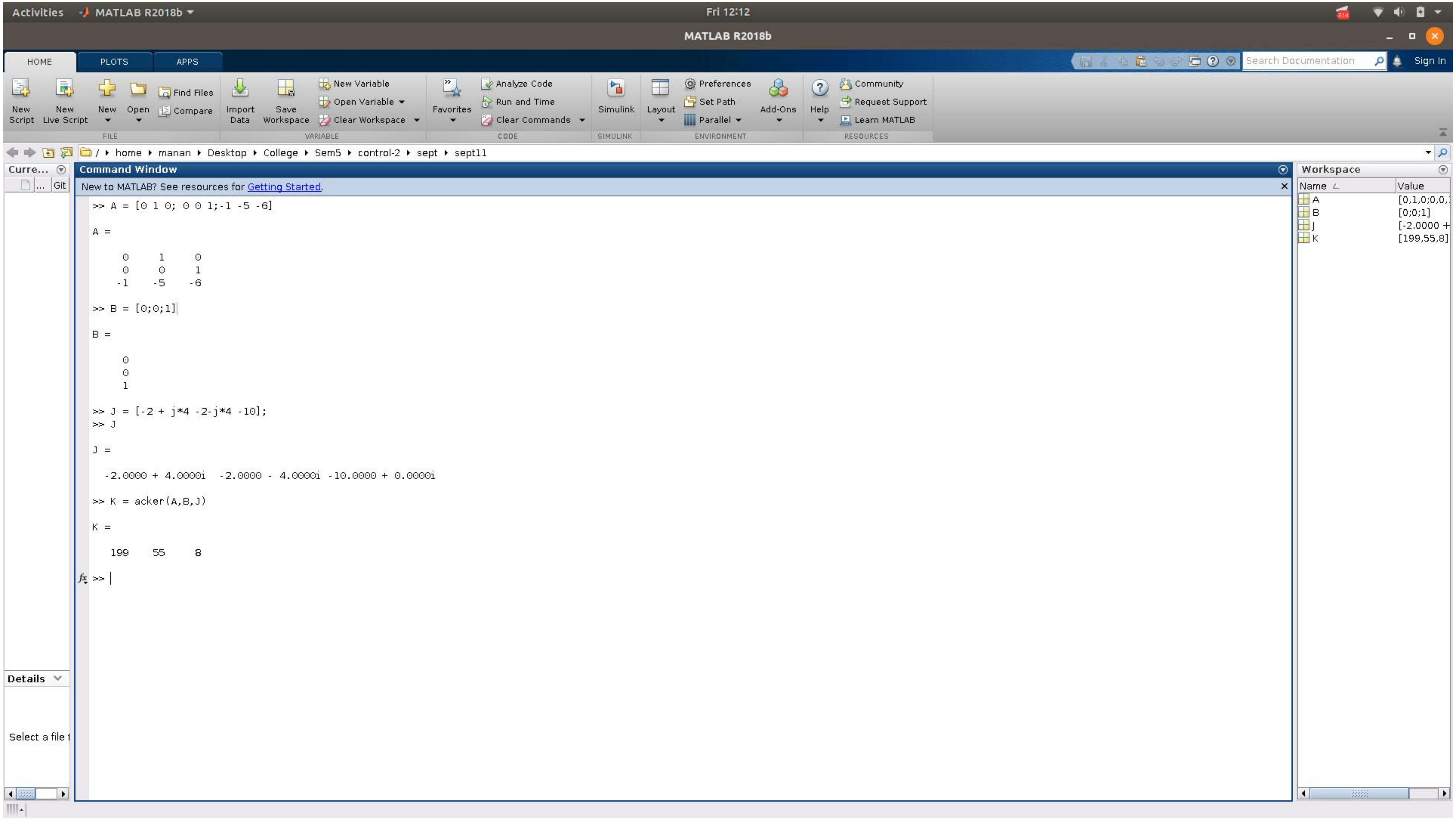
8. **The Frequency design method of DC motor using MATLAB.**

STATE SPACE AND TRANSFER FUNCTION

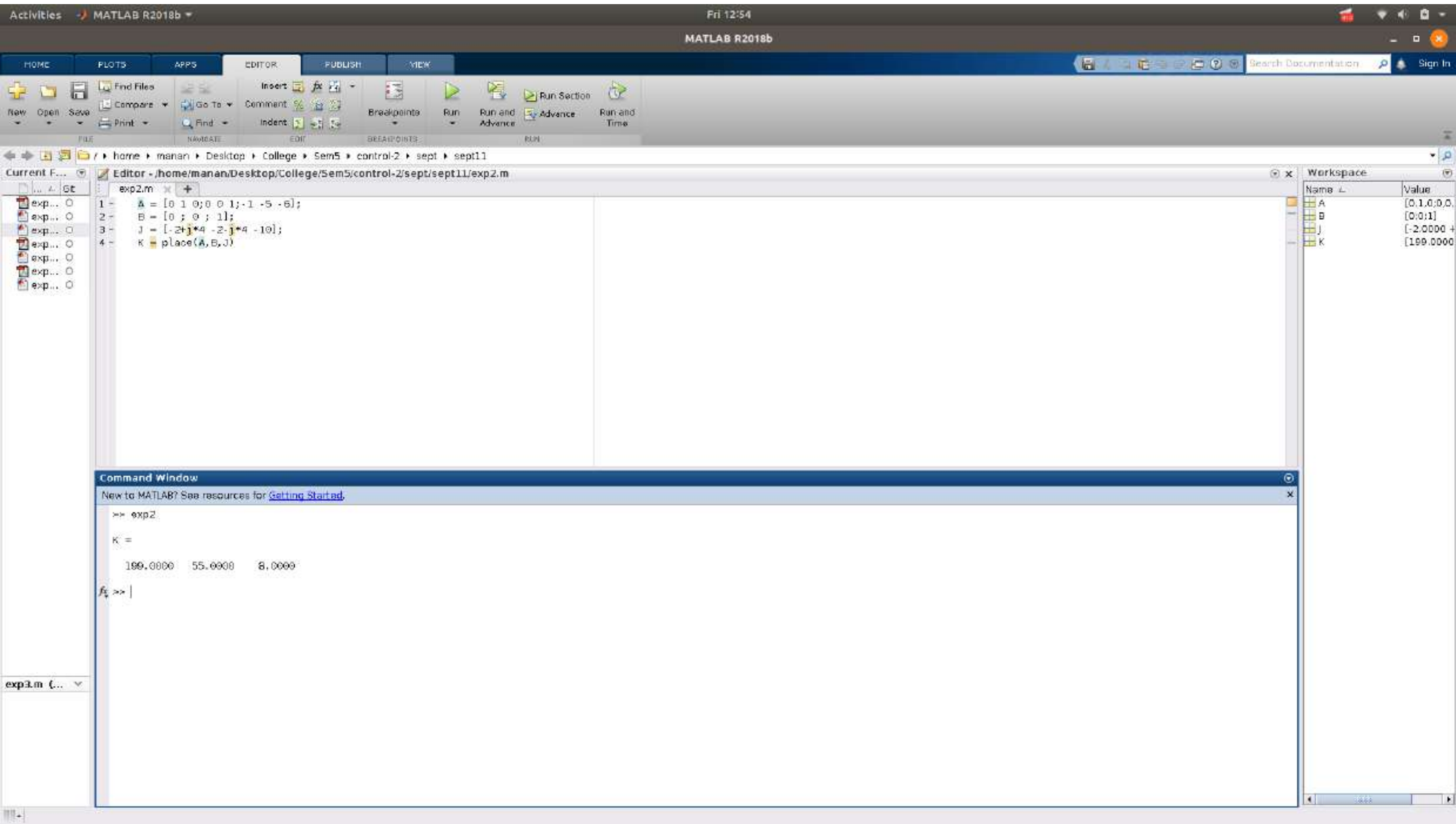

MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/tfss/exp1.m
num = [10 10];
den = [1 6 5 10];
[A,B,C,D] = tf2ss(num,den);
A
B
C
D
Command Window
>> exp1
A =
-6 -5 -10
1 0 0
0 1 0
B =
1
0
0
C =
0 10 10
D =
0
Workspace
A [-6,-5,-10
ans 1
B [1;0;0]
C [0,10,10]
D 0
den [1,6,5,10
num [10,10]


MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/tfss/exp2.m
A = [0 1 0;0 0 1;-5.008 -25.1026 -5.03247];
B = [0;25.04;121.005];
C = [1 0 0];
D = [0];
[num,den] = ss2tf(A,B,C,D)
Command Window
>> exp2
num =
0 0 25.0400 247.0180
den =
1.0000 5.0325 25.1026 5.0080
>>
Workspace
Click and drag to move Editor...

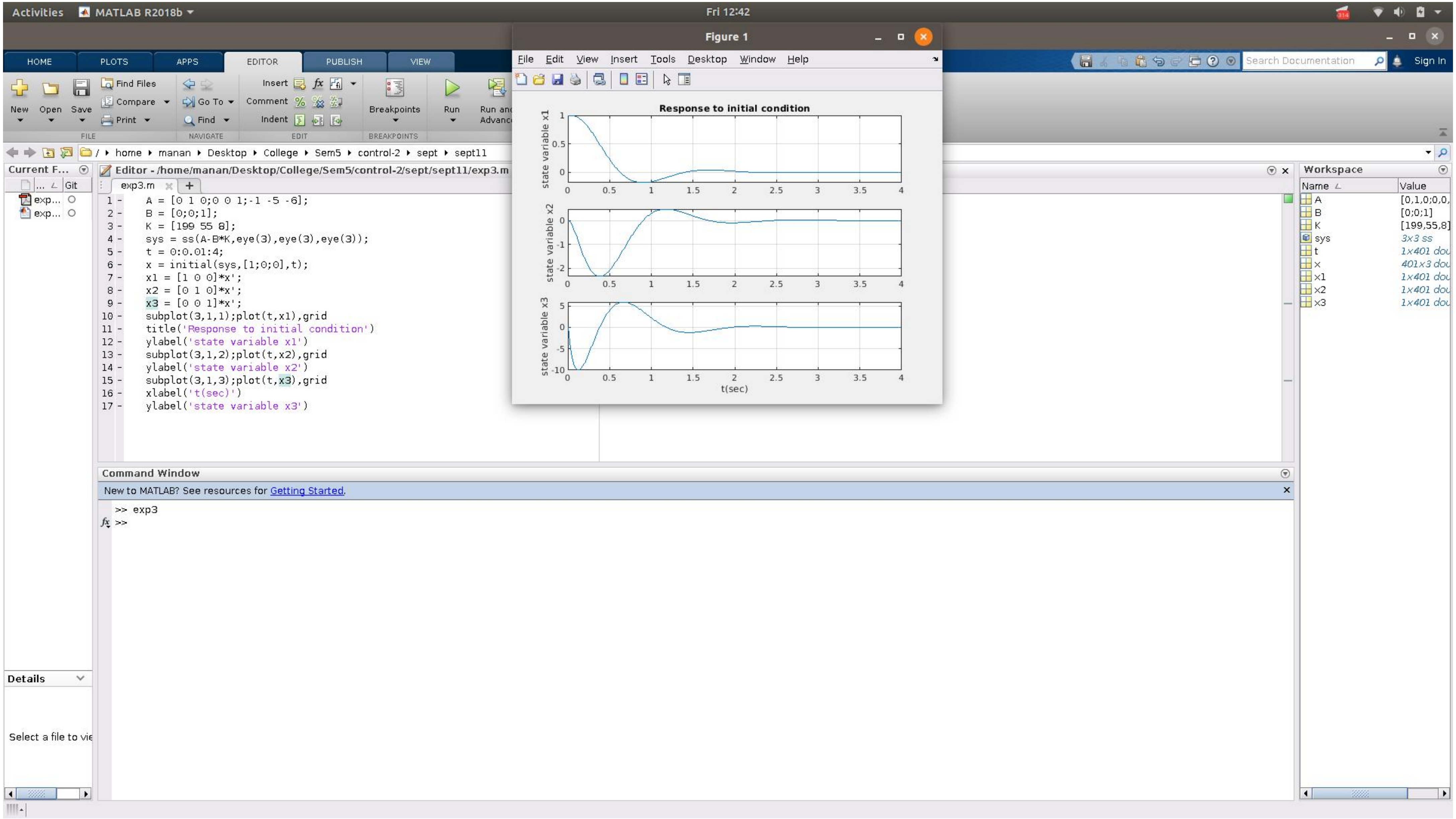
POLE PLACEMENT



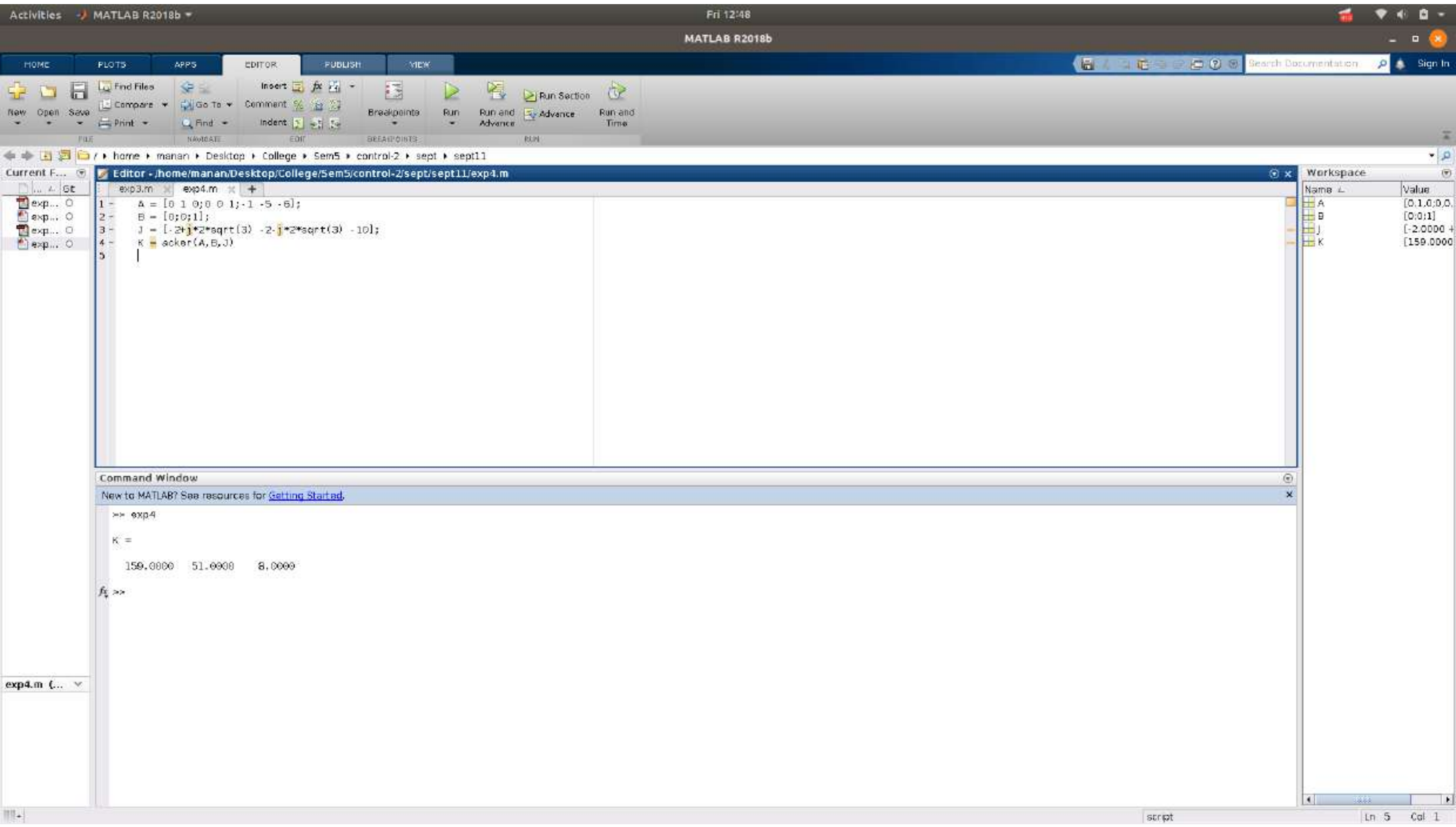
MATLAB R2018b
/ home manan Desktop College Sem5 control-2 sept sept11
Command Window
New to MATLAB? See resources for Getting Started.
>> A = [0 1 0; 0 0 1;-1 -5 -6]
A =
0 1 0
0 0 1
-1 -5 -6
>> B = [0;0;1]
B =
0
0
1
>> J = [-2 + j*4 -2-j*4 -10];
>> J
J =
-2.0000 + 4.0000i -2.0000 - 4.0000i -10.0000 + 0.0000i
>> K = acker(A,B,J)
K =
199 55 8
>>
Workspace
Name
Value
A
[0,1,0;0,0,
B
[0;0;1]
J
[-2.0000 +
K
[199,55,8]



MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/sept/sept11/exp2.m
exp2.m
A = [0 1 0;0 0 1;-1 -5 -6];
B = [0 ; 0 ; 1];
J = [-2+j*4 -2-j*4 -10];
K = place(A,B,J)
Command Window
New to MATLAB? See resources for Getting Started.
>> exp2
K =
199.0000 55.0000 8.0000
>>
Workspace



Activities MATLAB R2018b
Fri 12:42
Figure 1
File Edit View Insert Tools Desktop Window Help
Response to initial condition
state variable x1
state variable x2
state variable x3
t(sec)
Editor - /home/manan/Desktop/College/Sem5/control-2/sept/sept11/exp3.m
exp3.m
A = [0 1 0;0 0 1;-1 -5 -6];
B = [0;0;1];
K = [199 55 8];
sys = ss(A-B*K,eye(3),eye(3),eye(3));
t = 0:0.01:4;
x = initial(sys,[1;0;0],t);
x1 = [1 0 0]*x';
x2 = [0 1 0]*x';
x3 = [0 0 1]*x';
subplot(3,1,1);plot(t,x1),grid
title('Response to initial condition')
ylabel('state variable x1')
subplot(3,1,2);plot(t,x2),grid
ylabel('state variable x2')
subplot(3,1,3);plot(t,x3),grid
xlabel('t(sec)')
ylabel('state variable x3')
Command Window
New to MATLAB? See resources for Getting Started.
>> exp3
>>
Workspace
Name Value
A [0,1,0;0,0,
B [0;0;1]
K [199,55,8]
sys 3x3 ss
t 1x401 dou
x 401x3 dou
x1 1x401 dou
x2 1x401 dou
x3 1x401 dou


Activities
MATLAB R2018b
Fri 12:48
MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Sign In
Find Files
Compare
Print
Go To
Find
Insert
Comment
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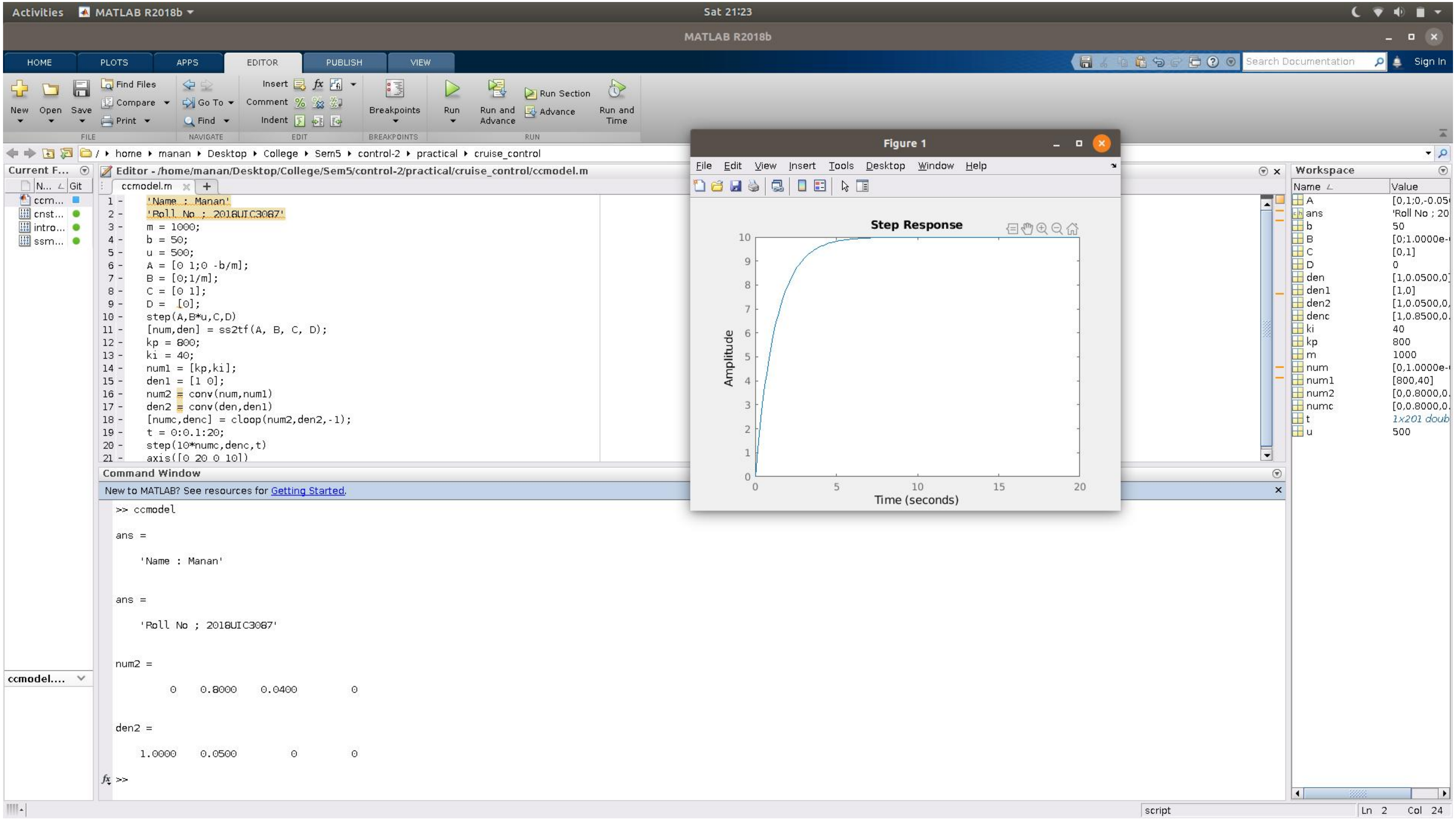
Breakpoints
Run
Run and Advance
Run Section
Advance
Run and Time
/ home manan Desktop College Sem5 control-2 sept sept11
Editor - /home/manan/Desktop/College/Sem5/control-2/sept/sept11/exp4.m
exp3.m
exp4.m
A = [0 1 0;0 0 1;-1 -5 -6];
B = [0;0;1];
J = [-2+j*2*sqrt(3) -2-j*2*sqrt(3) -10];
K = acker(A,B,J)
Command Window
New to MATLAB? See resources for Getting Started.
>> exp4
K =
159.0000 51.0000 8.0000
>>
Workspace
Name
Value
A
[0,1,0;0,0,
B
[0;0;1]
J
[-2.0000 +
K
[159.0000
exp4.m
script
Ln 5
Col 1

CRUISE CONTROL


Activities
MATLAB R2018b
Sat 21:23
MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Search Documentation
Sign In
New
Open
Save
Find Files
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Go To
Find
NAVIGATE
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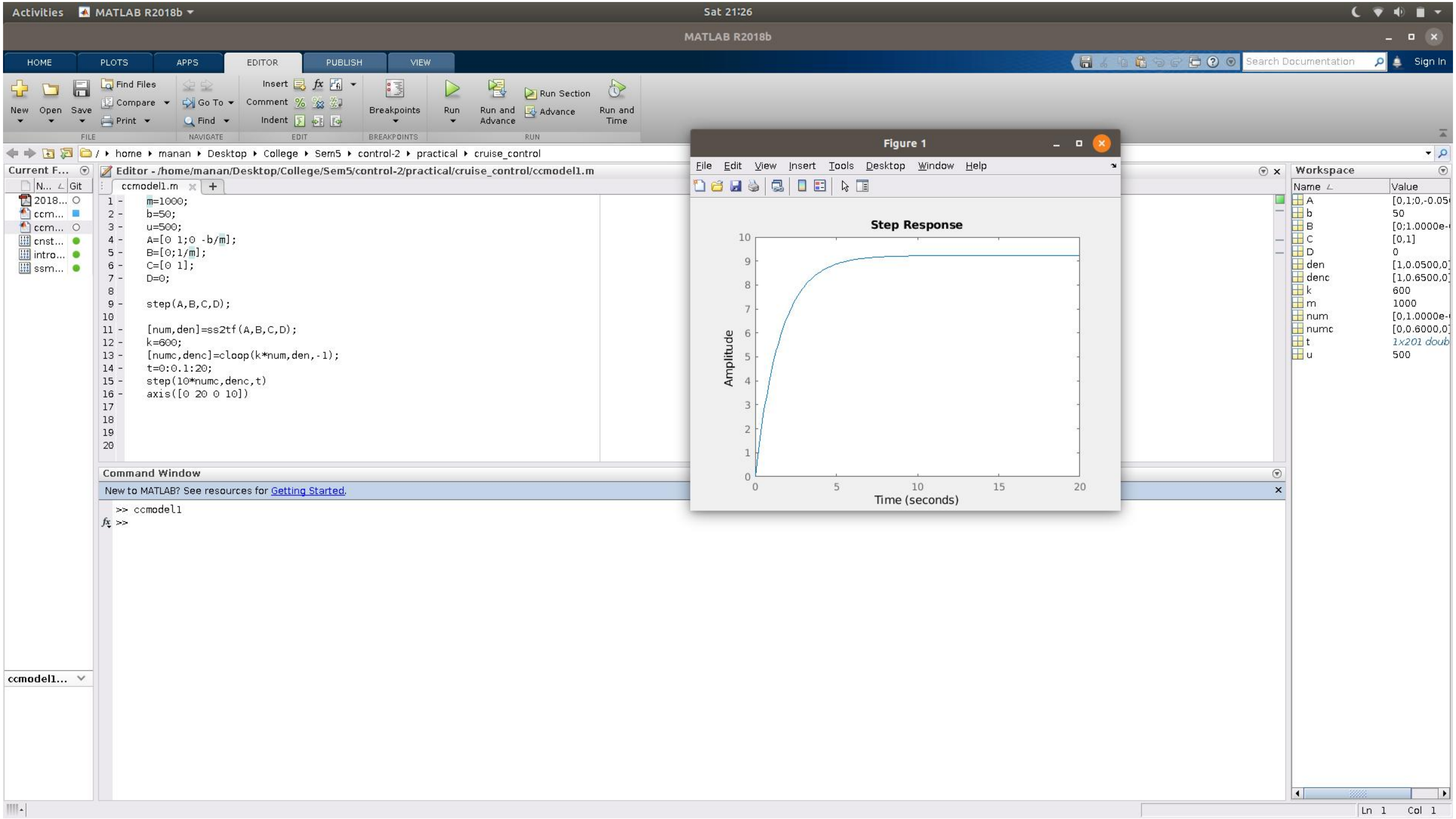
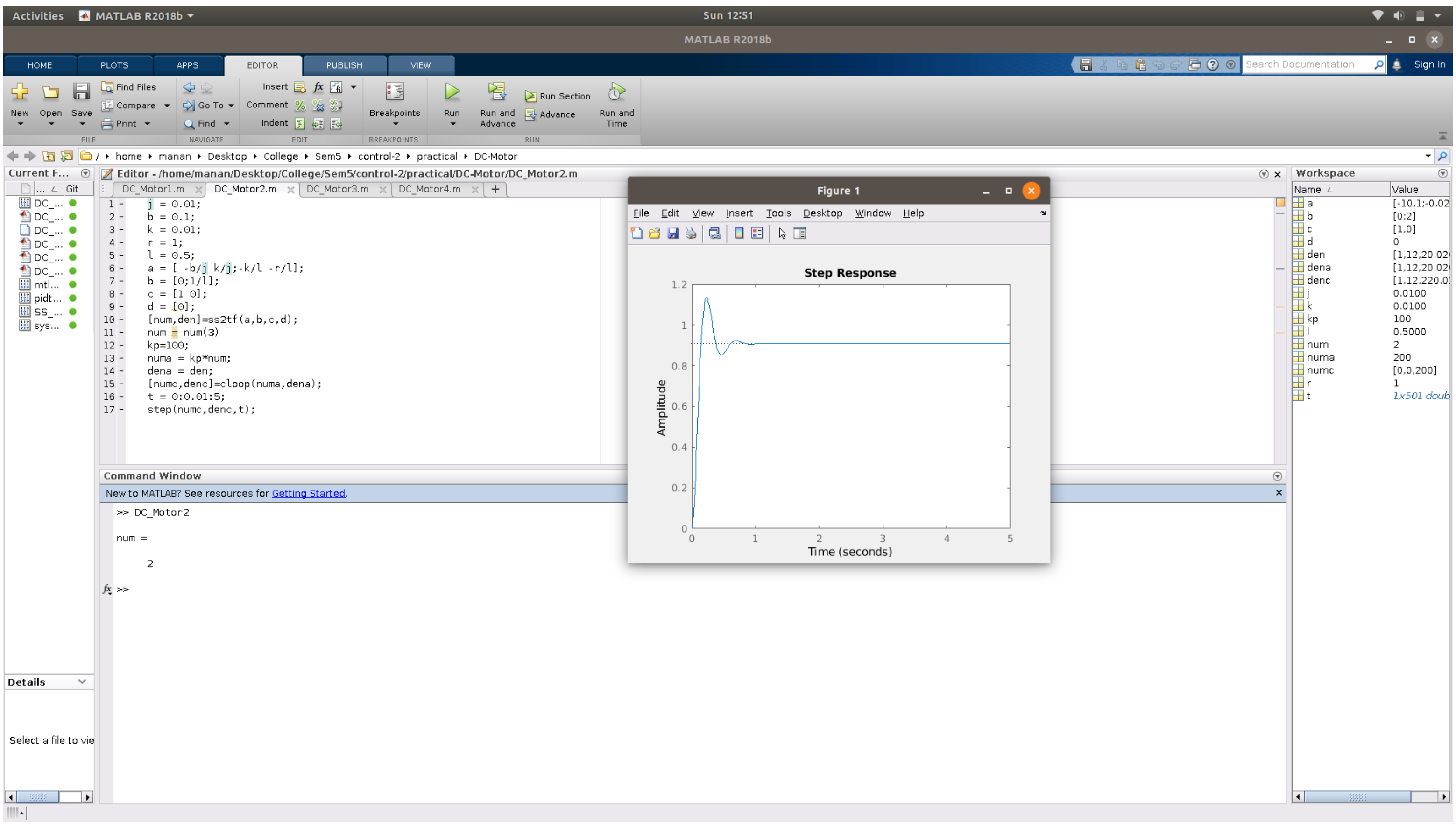
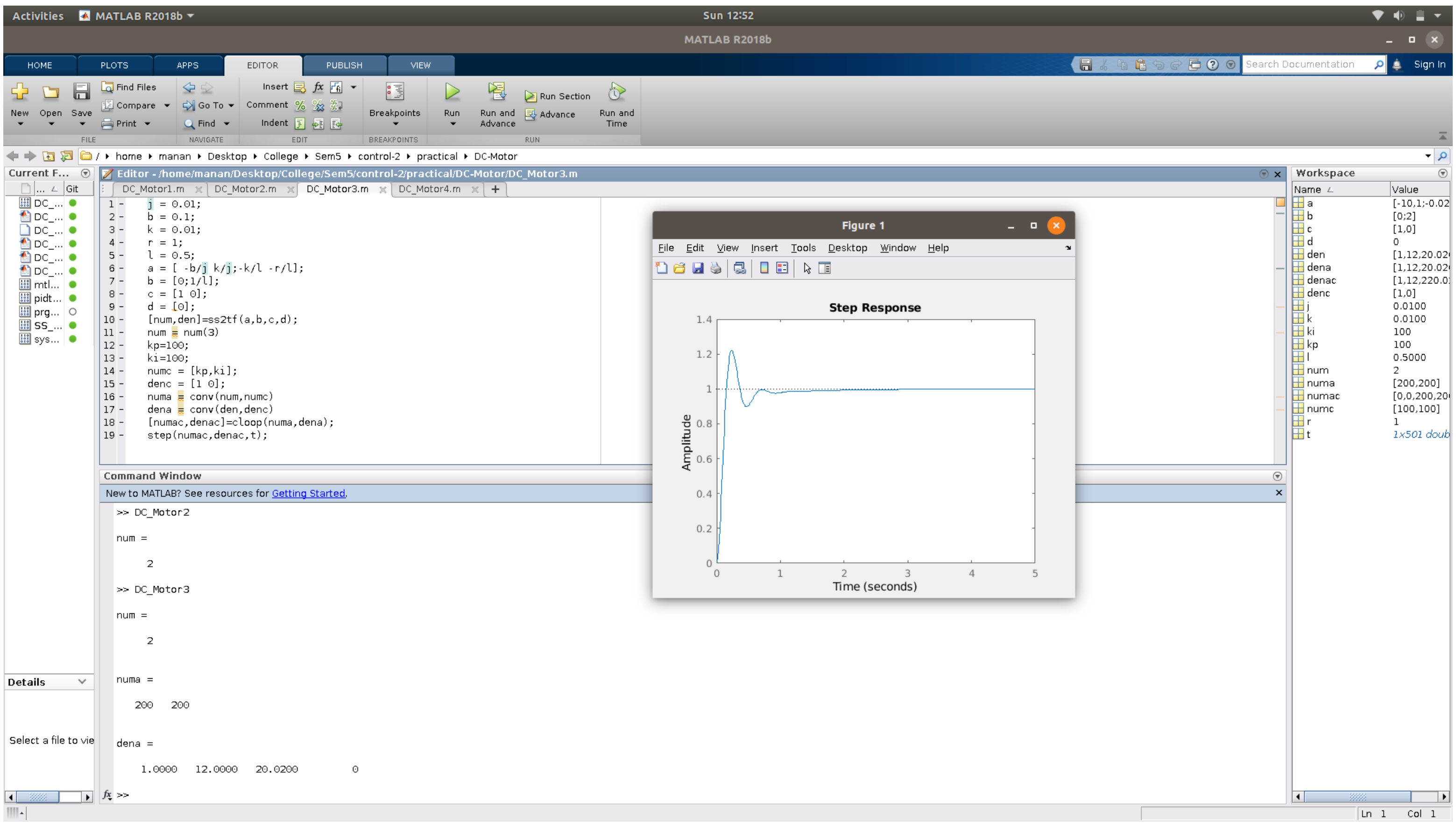
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
/ home manan Desktop College Sem5 control-2 practical cruise_control
Current F...
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/cruise_control/ccmodel.m
ccmodel.m
'Name : Manan'
'Roll No ; 2018UIC3087'
m = 1000;
b = 50;
u = 500;
A = [0 1;0 -b/m];
B = [0;1/m];
C = [0 1];
D = [0];
step(A,B*u,C,D)
[num,den] = ss2tf(A, B, C, D);
kp = 800;
ki = 40;
num1 = [kp,ki];
den1 = [1 0];
num2 = conv(num,num1)
den2 = conv(den,den1)
[numc,denc] = cloop(num2,den2,-1);
t = 0:0.1:20;
step(10*numc,denc,t)
axis([0 20 0 10])
Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
Amplitude
Time (seconds)
Command Window
New to MATLAB? See resources for Getting Started.
>> ccmodel
ans =
'Name : Manan'
ans =
'Roll No ; 2018UIC3087'
num2 =
0 0.8000 0.0400 0
den2 =
1.0000 0.0500 0 0
>>
Workspace
Name
Value
A [0,1;0,-0.05
ans 'Roll No ; 20
b 50
B [0;1.0000e-
C [0,1]
D 0
den [1,0.0500,0]
den1 [1,0]
den2 [1,0.0500,0,
denc [1,0.8500,0.
ki 40
kp 800
m 1000
num [0,1.0000e-
num1 [800,40]
num2 [0,0.8000,0.
numc [0,0.8000,0.
t 1x201 doub
u 500
script
Ln 2 Col 24


MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/cruise_control/ccmodel1.m
ccmodel1.m
m=1000;
b=50;
u=500;
A=[0 1;0 -b/m];
B=[0;1/m];
C=[0 1];
D=0;
step(A,B,C,D);
[num,den]=ss2tf(A,B,C,D);
k=600;
[numc,denc]=cloop(k*num,den,-1);
t=0:0.1:20;
step(10*numc,denc,t)
axis([0 20 0 10])
Command Window
New to MATLAB? See resources for Getting Started.
>> ccmodel1
>>
Figure 1
Step Response
Amplitude
Time (seconds)
Workspace
Name
Value
A
[0,1;0,-0.05
b
50
B
[0;1.0000e-
C
[0,1]
D
0
den
[1,0.0500,0]
denc
[1,0.6500,0]
k
600
m
1000
num
[0,1.0000e-
numc
[0,0.6000,0]
t
1x201 doub
u
500

DC MOTOR


MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/DC-Motor/DC_Motor2.m
DC_Motor1.m
DC_Motor2.m
DC_Motor3.m
DC_Motor4.m
j = 0.01;
b = 0.1;
k = 0.01;
r = 1;
l = 0.5;
a = [-b/j k/j;-k/l -r/l];
b = [0;1/l];
c = [1 0];
d = [0];
[num,den]=ss2tf(a,b,c,d);
num = num(3)
kp=100;
numa = kp*num;
dena = den;
[numc,denc]=cloop(numa,dena);
t = 0:0.01:5;
step(numc,denc,t);
Command Window
New to MATLAB? See resources for Getting Started.
>> DC_Motor2
num =
2
Figure 1
Step Response
Amplitude
Time (seconds)
Workspace
Name
Value
a [-10,1;-0.02
b [0;2]
c [1,0]
d 0
den [1,12,20.02
dena [1,12,20.02
denc [1,12,220.0
j 0.0100
k 0.0100
kp 100
l 0.5000
num 2
numa 200
numc [0,0,200]
r 1
t 1x501 doub



Activities
MATLAB R2018b
Sun 12:52
MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Search Documentation
Sign In
New
Open
Save
Find Files
Compare
Print
FILE
Go To
Find
NAVIGATE
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Comment
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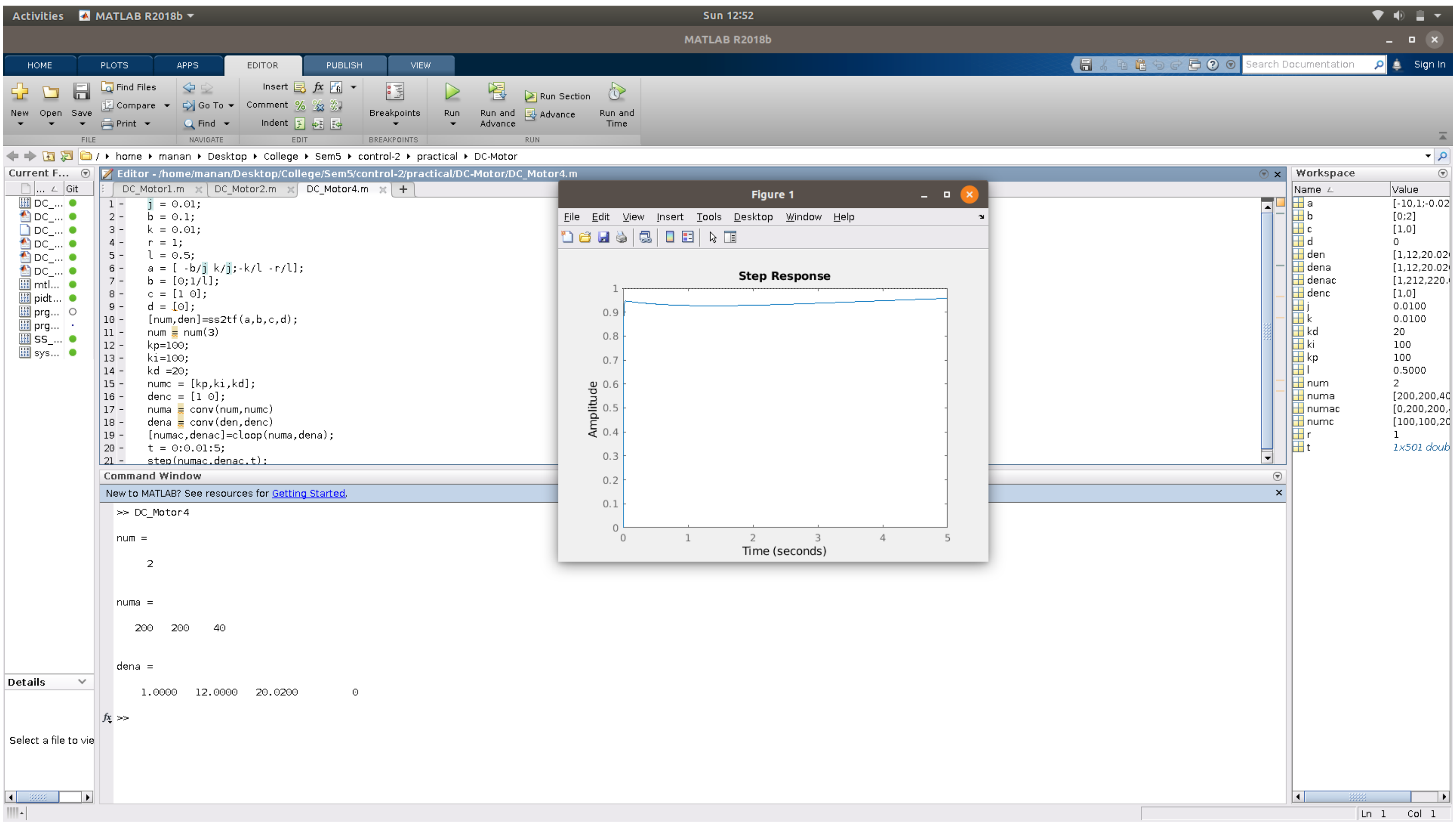
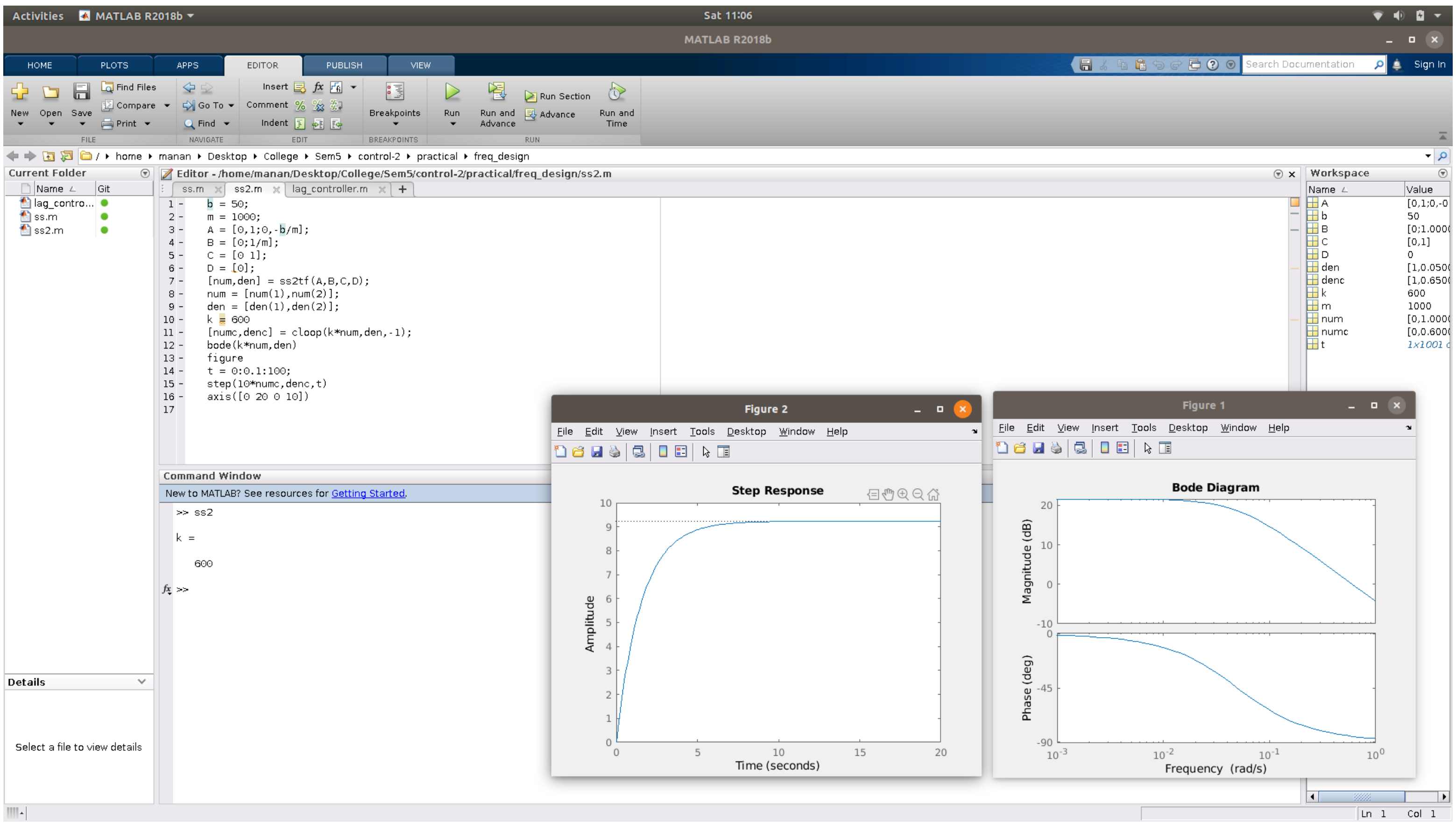
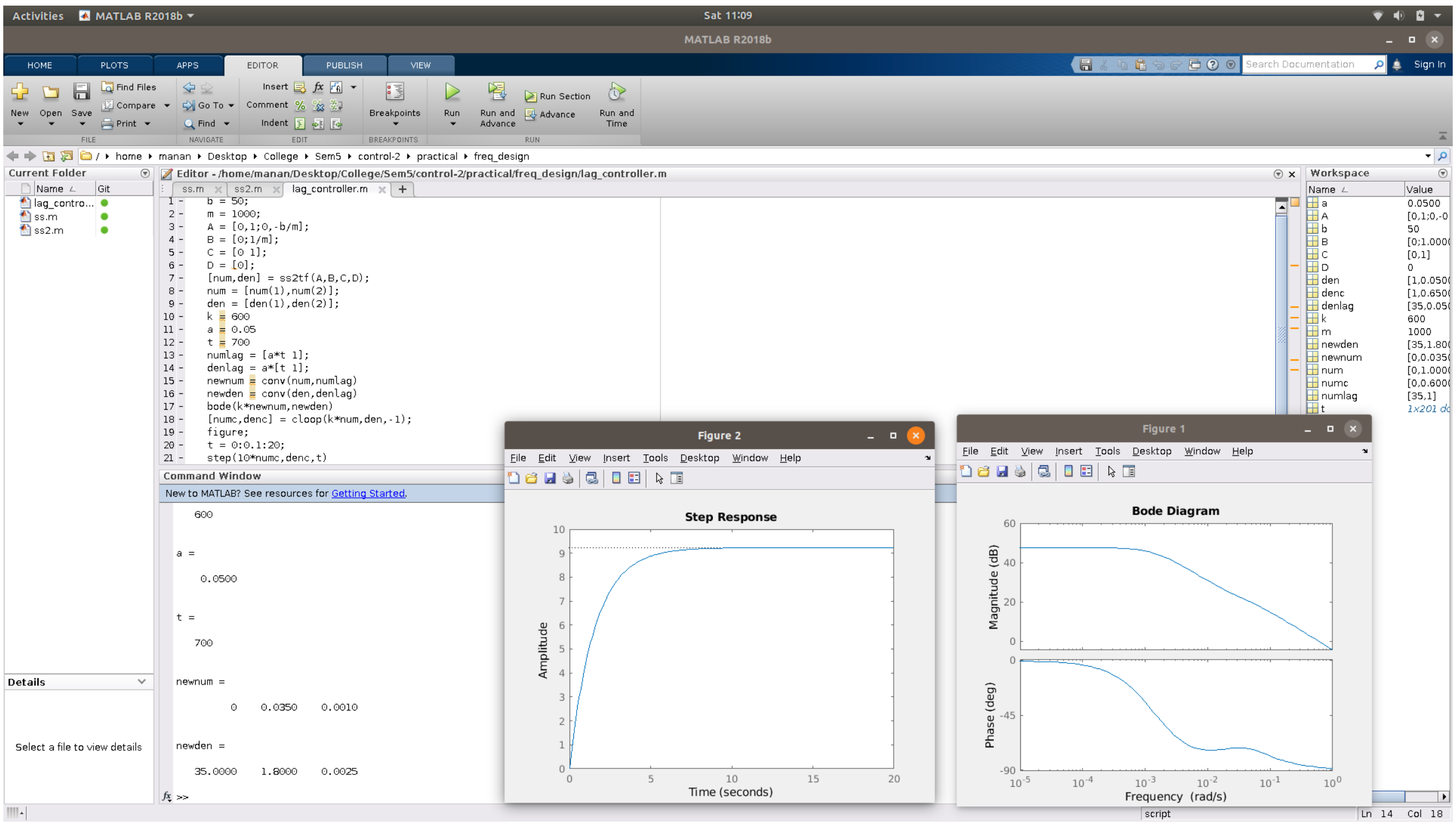
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
/ ▸ home ▸ manan ▸ Desktop ▸ College ▸ Sem5 ▸ control-2 ▸ practical ▸ DC-Motor
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/DC-Motor/DC_Motor3.m
DC_Motor1.m
DC_Motor2.m
DC_Motor3.m
DC_Motor4.m
j = 0.01;
b = 0.1;
k = 0.01;
r = 1;
l = 0.5;
a = [-b/j k/j;-k/l -r/l];
b = [0;1/l];
c = [1 0];
d = [0];
[num,den]=ss2tf(a,b,c,d);
num = num(3)
kp=100;
ki=100;
numc = [kp,ki];
denc = [1 0];
numa = conv(num,numc)
dena = conv(den,denc)
[numac,denac]=cloop(numa,dena);
step(numac,denac,t);
Command Window
New to MATLAB? See resources for Getting Started.
>> DC_Motor2
num =
2
>> DC_Motor3
num =
2
numa =
200 200
dena =
1.0000 12.0000 20.0200 0
>>
Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
Amplitude
Time (seconds)
0 1 2 3 4 5
0 0.2 0.4 0.6 0.8 1 1.2 1.4
Workspace
Name
Value
a [-10,1;-0.02
b [0;2]
c [1,0]
d 0
den [1,12,20.02
dena [1,12,20.02
denac [1,12,220.0
denc [1,0]
j 0.0100
k 0.0100
ki 100
kp 100
l 0.5000
num 2
numa [200,200]
numac [0,0,200,20
numc [100,100]
r 1
t 1x501 doub
Current F...
Git
Details
Select a file to vie
Ln 1 Col 1



MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/DC-Motor/DC_Motor4.m
j = 0.01;
b = 0.1;
k = 0.01;
r = 1;
l = 0.5;
a = [-b/j k/j;-k/l -r/l];
b = [0;1/l];
c = [1 0];
d = [0];
[num,den]=ss2tf(a,b,c,d);
num = num(3)
kp=100;
ki=100;
kd =20;
numc = [kp,ki,kd];
denc = [1 0];
numa = conv(num,numc)
dena = conv(den,denc)
[numac,denac]=cloop(numa,dena);
t = 0:0.01:5;
step(numac,denac,t);
Command Window
>> DC_Motor4
num =
2
numa =
200 200 40
dena =
1.0000 12.0000 20.0200 0
Figure 1
Step Response
Amplitude
Time (seconds)

FREQUENCY DESIGN

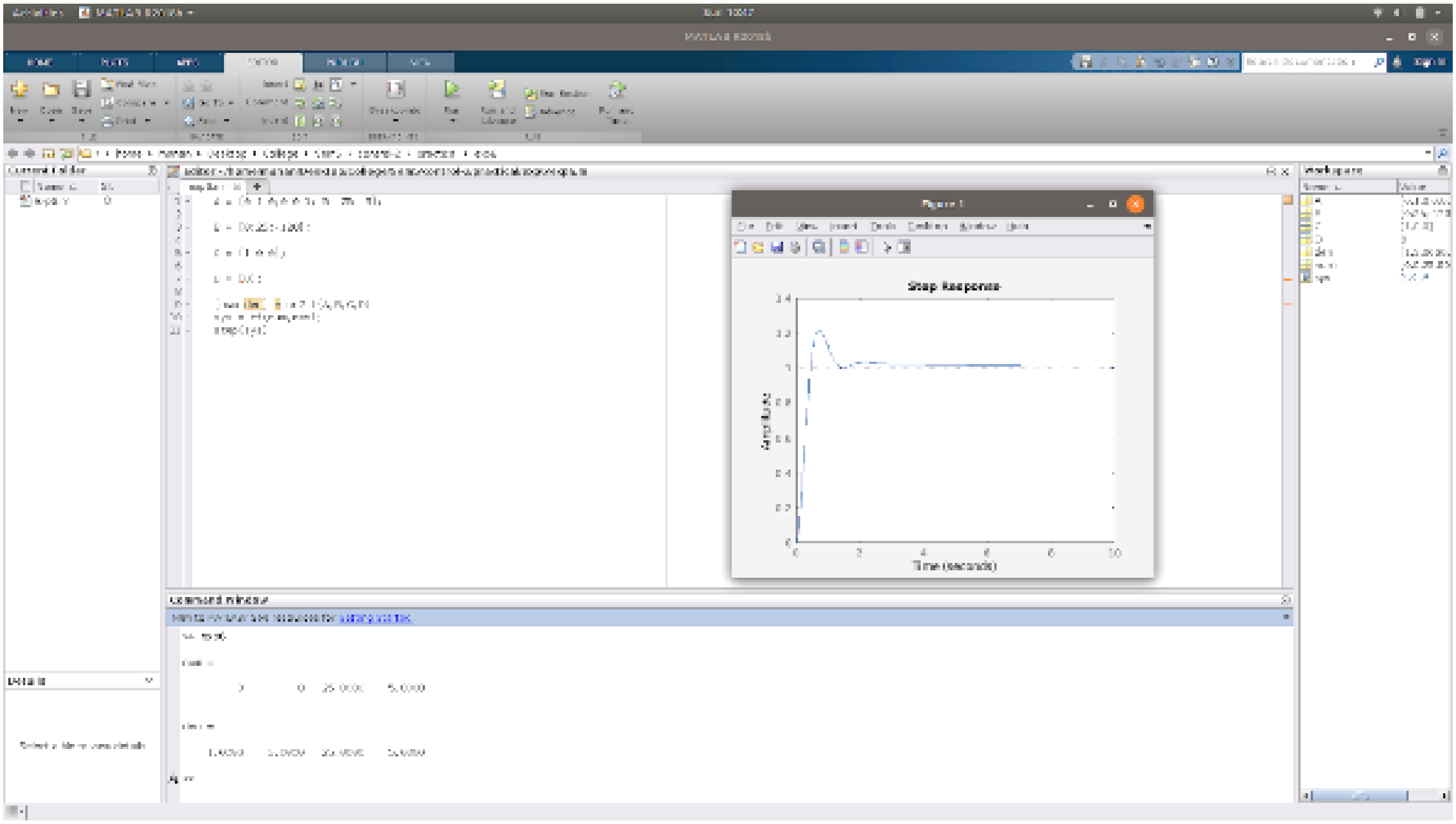

Activities
MATLAB R2018b
Sat 11:06
MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Search Documentation
Sign In
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/freq_design/ss2.m
ss.m
ss2.m
lag_controller.m
b = 50;
m = 1000;
A = [0,1;0,-b/m];
B = [0;1/m];
C = [0 1];
D = [0];
[num,den] = ss2tf(A,B,C,D);
num = [num(1),num(2)];
den = [den(1),den(2)];
k = 600
[numc,denc] = cloop(k*num,den,-1);
bode(k*num,den)
figure
t = 0:0.1:100;
step(10*numc,denc,t)
axis([0 20 0 10])
Command Window
New to MATLAB? See resources for Getting Started.
>> ss2
k =
600
Current Folder
lag_contro...
ss.m
ss2.m
Details
Select a file to view details
Workspace
Name
Value
A [0,1;0,-0
b 50
B [0;1.000
C [0,1]
D 0
den [1,0.050
denc [1,0.650
k 600
m 1000
num [0,1.000
numc [0,0.600
t 1x1001
Figure 2
Step Response
Amplitude
Time (seconds)
Figure 1
Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)


MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/freq_design/lag_controller.m
ss.m
ss2.m
lag_controller.m
b = 50;
m = 1000;
A = [0,1;0,-b/m];
B = [0;1/m];
C = [0 1];
D = [0];
[num,den] = ss2tf(A,B,C,D);
num = [num(1),num(2)];
den = [den(1),den(2)];
k = 600
a = 0.05
t = 700
numlag = [a*t 1];
denlag = a*[t 1];
newnum = conv(num,numlag)
newden = conv(den,denlag)
bode(k*newnum,newden)
[numc,denc] = cloop(k*num,den,-1);
figure;
t = 0:0.1:20;
step(10*numc,denc,t)
Command Window
New to MATLAB? See resources for Getting Started.
600
a =
0.0500
t =
700
newnum =
0 0.0350 0.0010
newden =
35.0000 1.8000 0.0025
Figure 2
Step Response
Amplitude
Time (seconds)
Figure 1
Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)

Obtain the transfer function of the system-defined by the following state-space equations:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -5 & -25 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 25 \\ -120 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

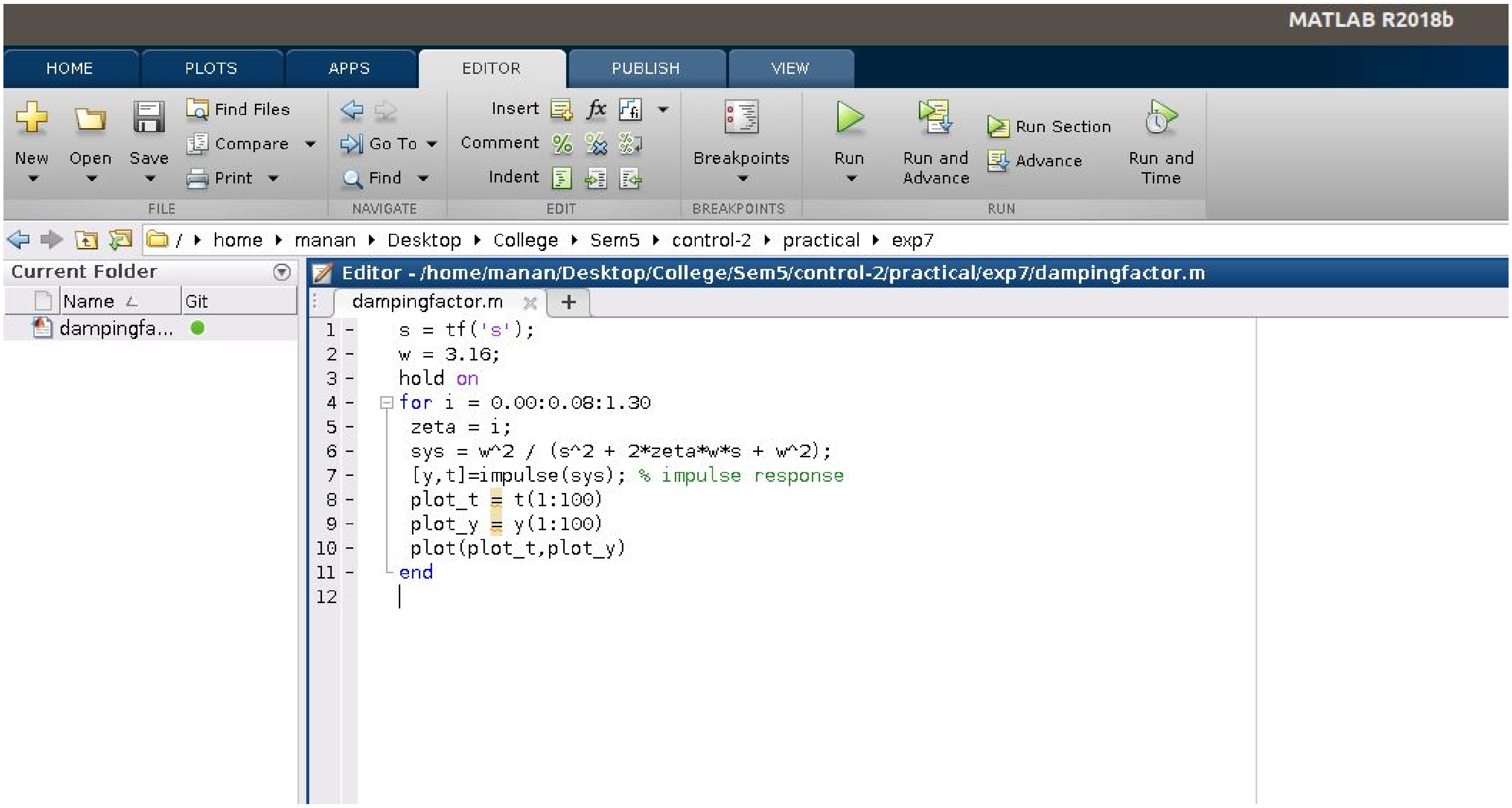

Step Response
Time (seconds)

Step response and impulse response of second-order systems for varying damping ratio:

(i) G(s) = $\frac{10}{s^2+2s+10}$

(ii) G(s) = $\frac{25}{s^2+4s+25}$

Part 1


MATLAB R2018b
HOME
PLOTS
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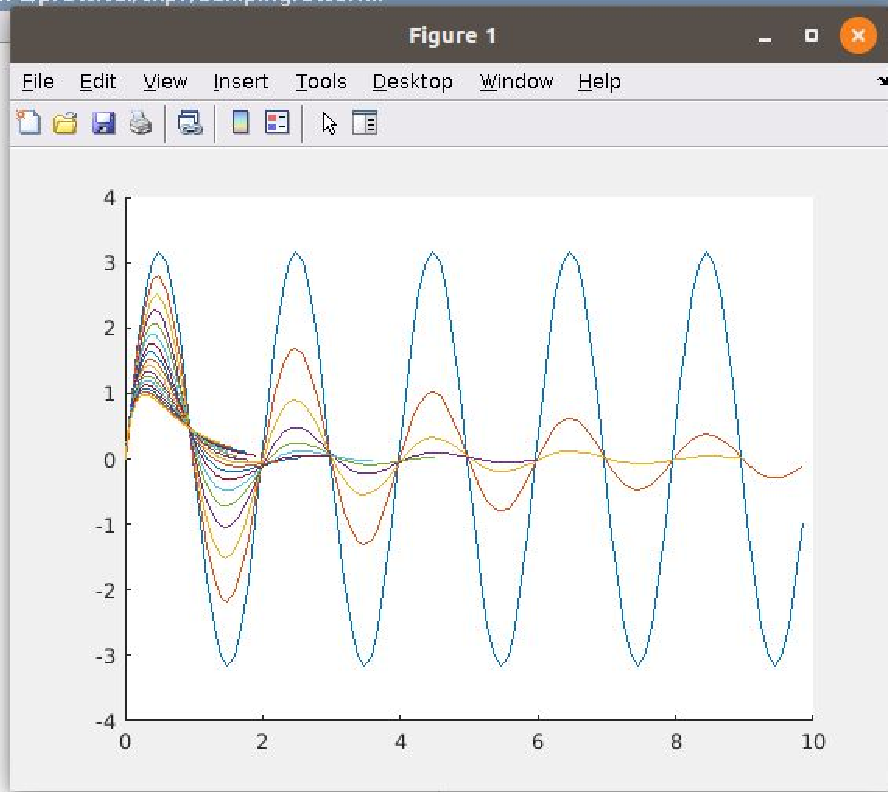
NAVIGATE
Insert
Comment
Indent
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
/ home manan Desktop College Sem5 control-2 practical exp7
Current Folder
Name
Git
dampingfa...
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/exp7/dampingfactor.m
dampingfactor.m
s = tf('s');
w = 3.16;
hold on
for i = 0.00:0.08:1.30
zeta = i;
sys = w^2 / (s^2 + 2*zeta*w*s + w^2);
[y,t]=impulse(sys); % impulse response
plot_t = t(1:100)
plot_y = y(1:100)
plot(plot_t,plot_y)
end

Editor - /home/manan/Desktop/College/Sem5/control-2/practical/exp7/dampingfactor.m

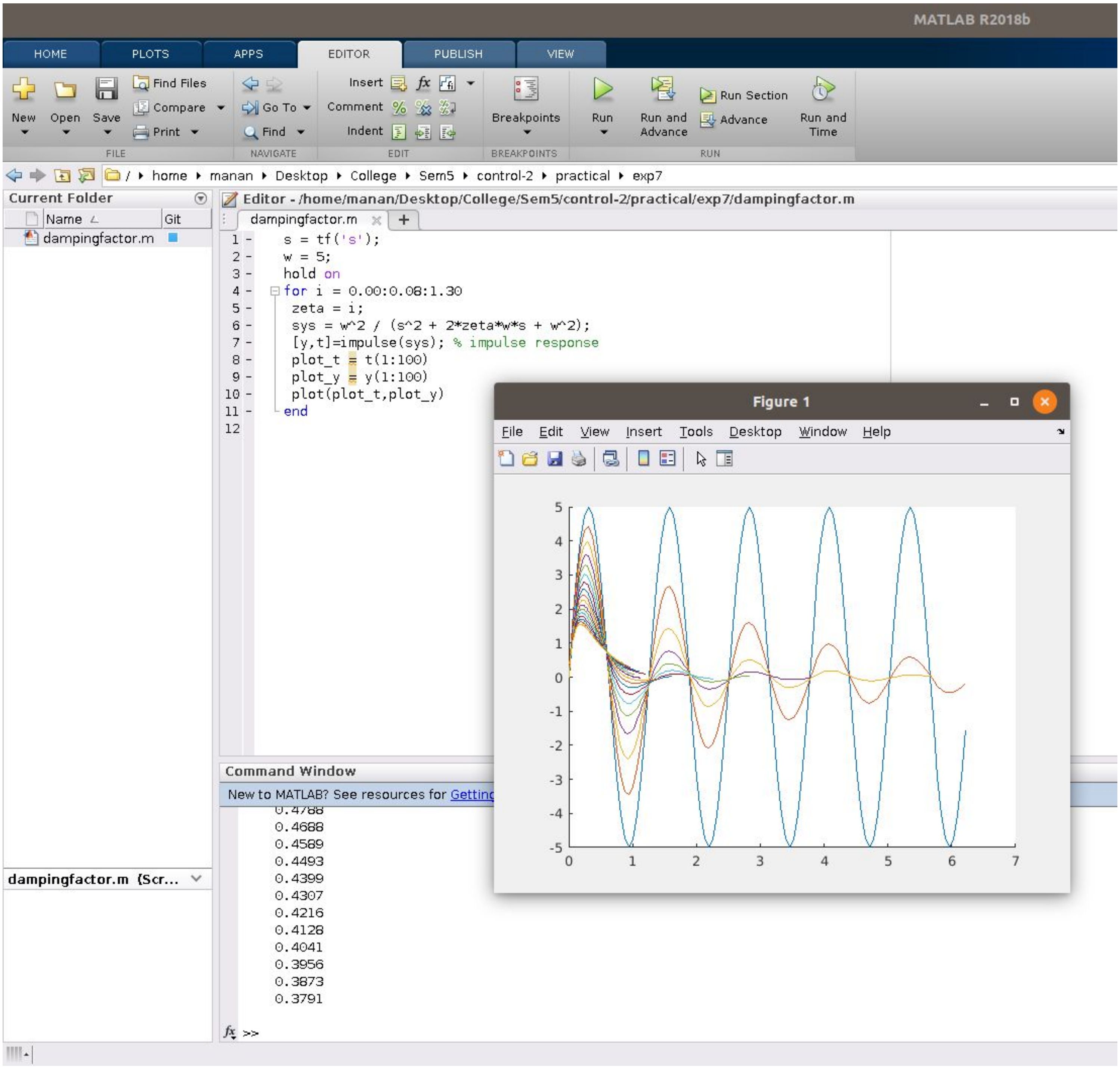
dampingfactor.m

```
s = tf('s');
w = 3.16;
hold on
for i = 0.00:0.08:1.30
 zeta = i;
 sys = w^2 / (s^2 + 2*zeta*w*s + w^2);
 [y,t]=impulse(sys); % impulse response
 plot_t = t(1:100)
 plot_y = y(1:100)
 plot(plot_t,plot_y)
end
```



Command Window

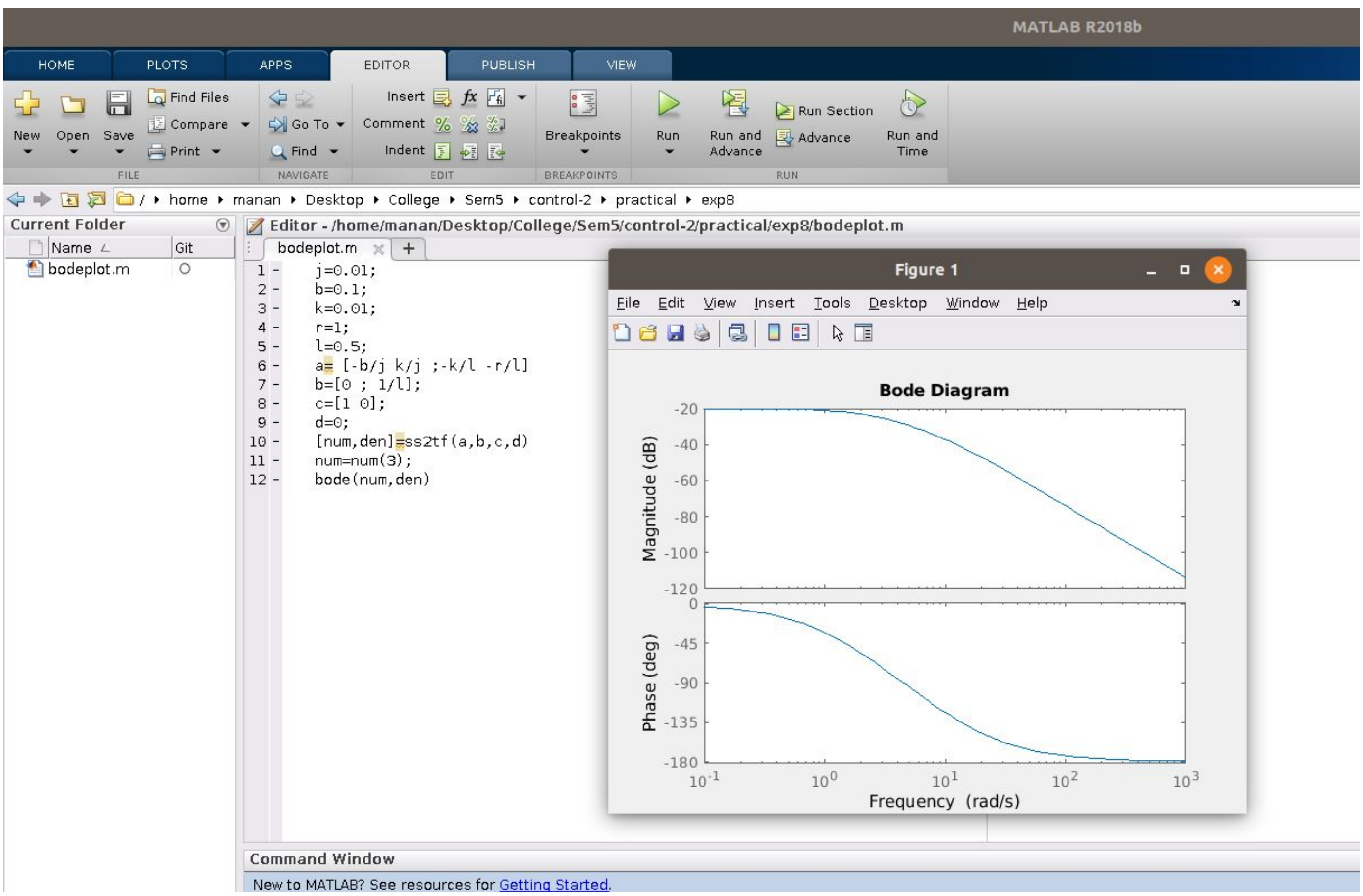
Part 2



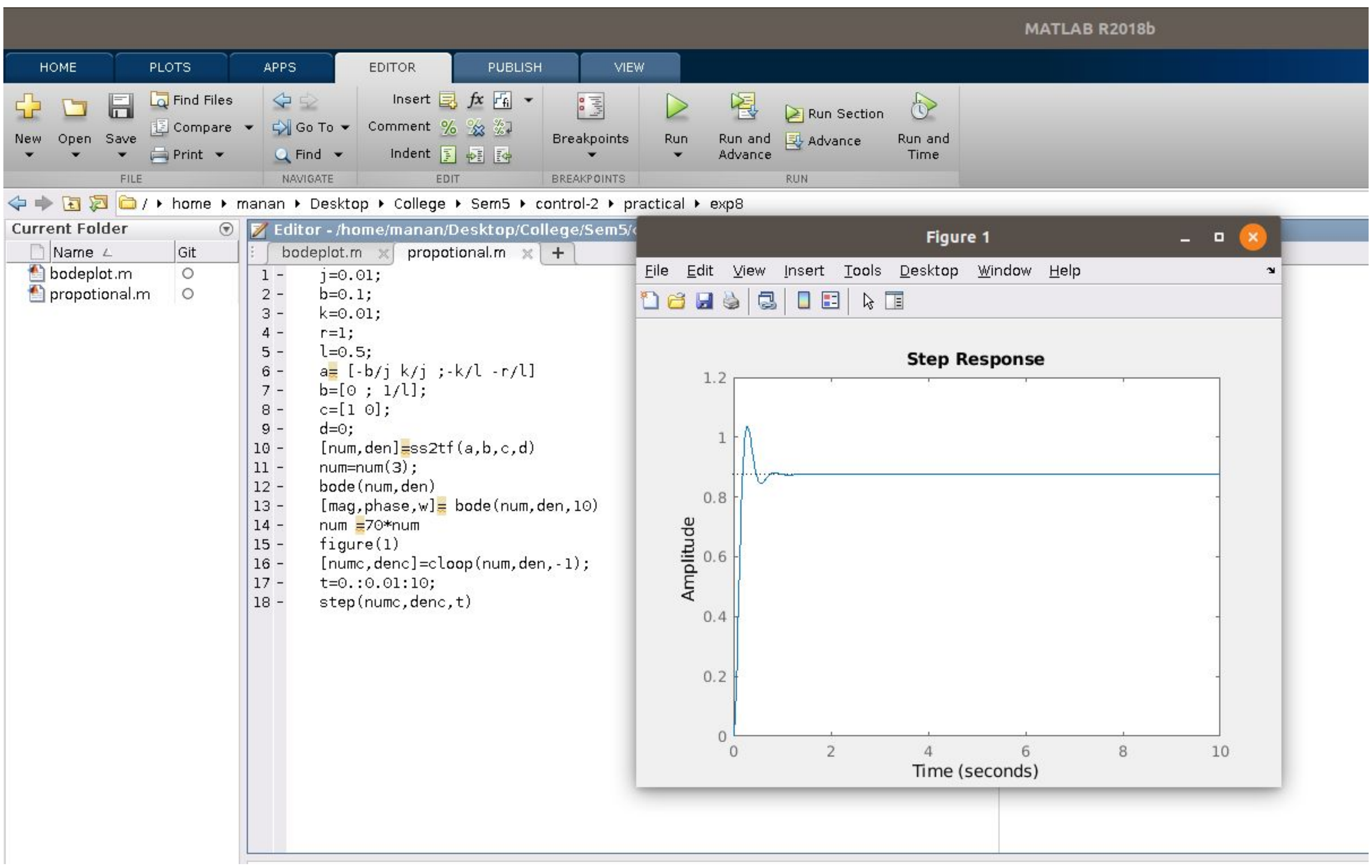
MATLAB R2018b
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/exp7/dampingfactor.m
dampingfactor.m
s = tf('s');
w = 5;
hold on
for i = 0.00:0.08:1.30
zeta = i;
sys = w^2 / (s^2 + 2*zeta*w*s + w^2);
[y,t]=impulse(sys); % impulse response
plot_t = t(1:100)
plot_y = y(1:100)
plot(plot_t,plot_y)
end
Command Window
0.4688
0.4589
0.4493
0.4399
0.4307
0.4216
0.4128
0.4041
0.3956
0.3873
0.3791
Figure 1

The Frequency design method of DC motor using MATLAB.

- **Bode Plot:**


MATLAB R2018b
Editor - /home/manan/Desktop/College/Sem5/control-2/practical/exp8/bodeplot.m
j=0.01;
b=0.1;
k=0.01;
r=1;
l=0.5;
a= [-b/j k/j ;-k/l -r/l]
b=[0 ; 1/l];
c=[1 0];
d=0;
[num,den]=ss2tf(a,b,c,d)
num=num(3);
bode(num,den)
Figure 1
Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)
Command Window
New to MATLAB? See resources for Getting Started.

- For Proportional Gain:



- For Lag Controller

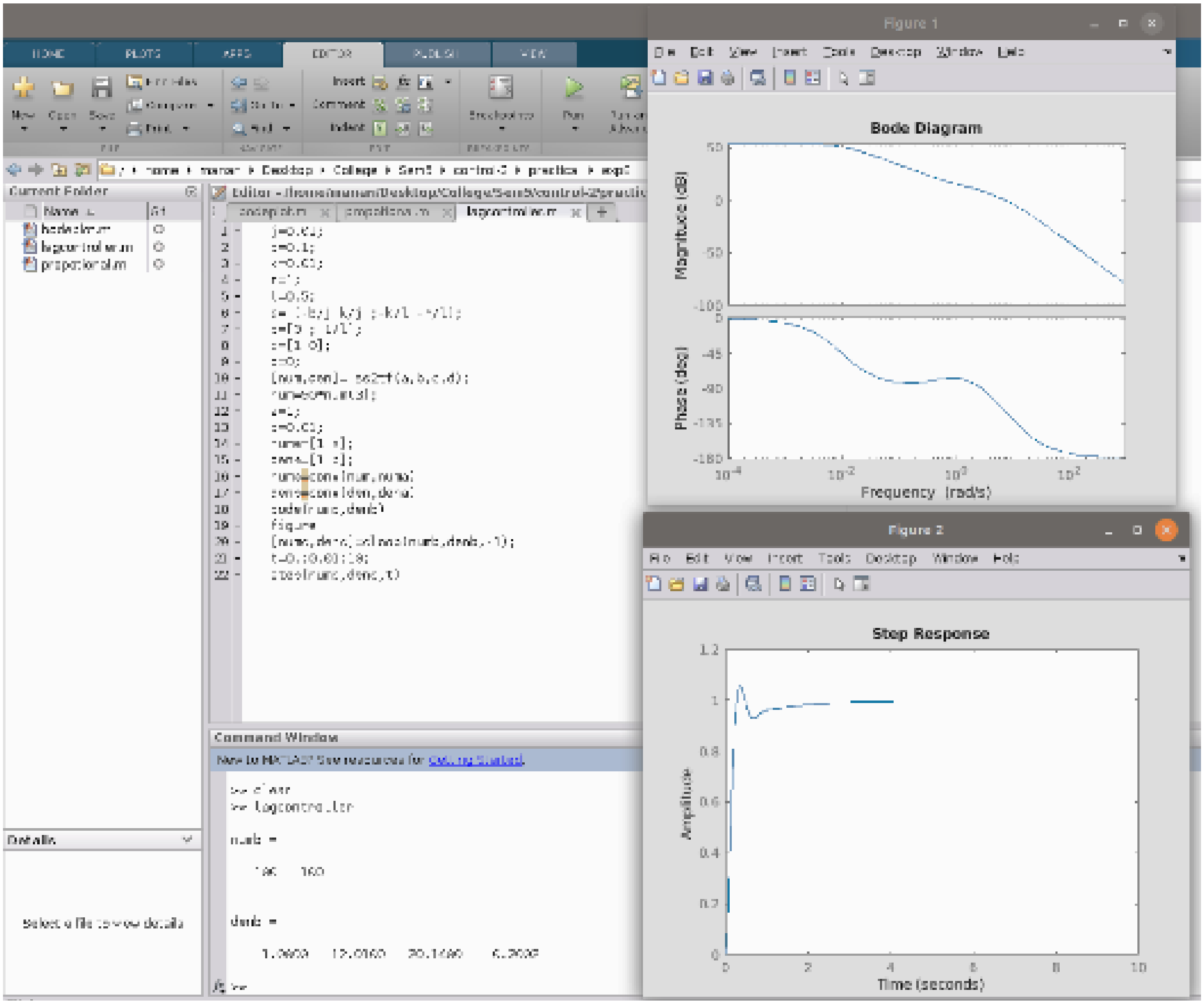


Figure 1
Bode Diagram
Magnitude (dB)
Phase (deg)
Frequency (rad/s)
Figure 2
Step Response
Amplitude
Time (seconds)
Current Folder
Command Window
Details