<u>Instrumentation and Measurement</u>

Assignment

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SC code: SC15B148

Roll no: 8

<u>Step input response of a second order system</u>

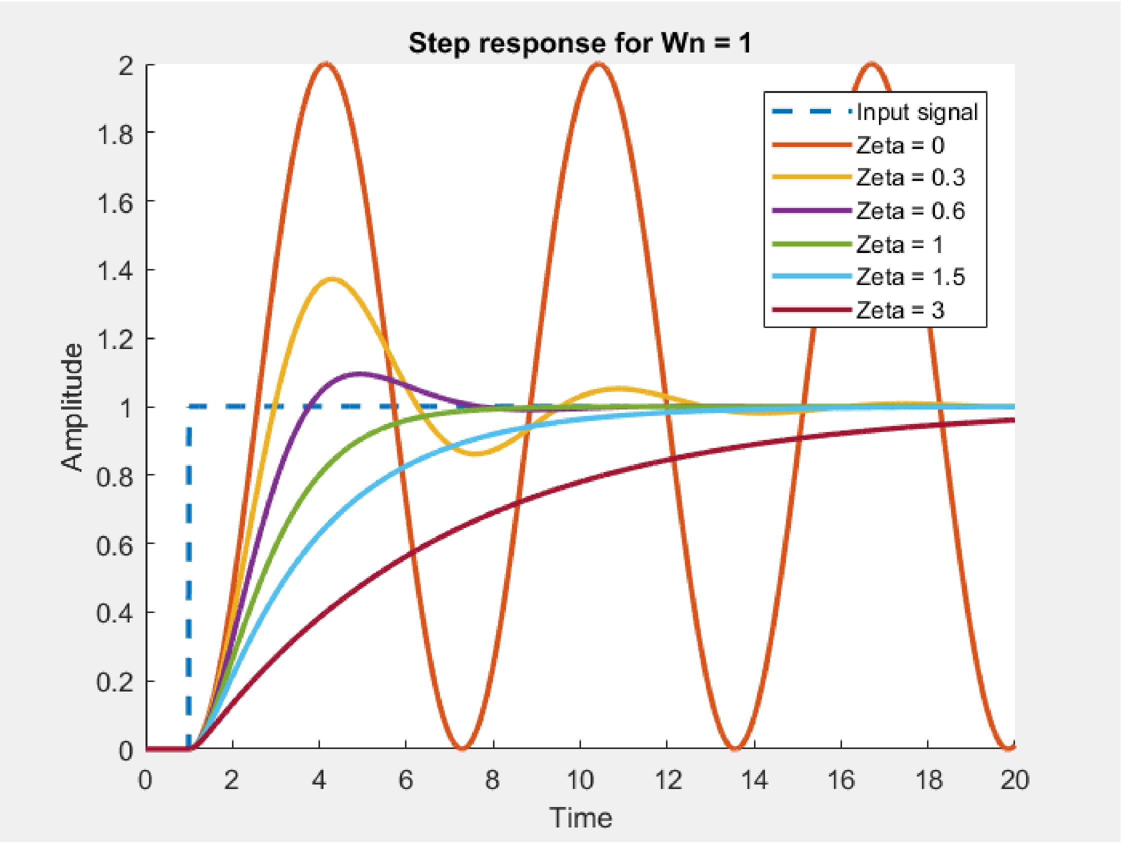
Code:

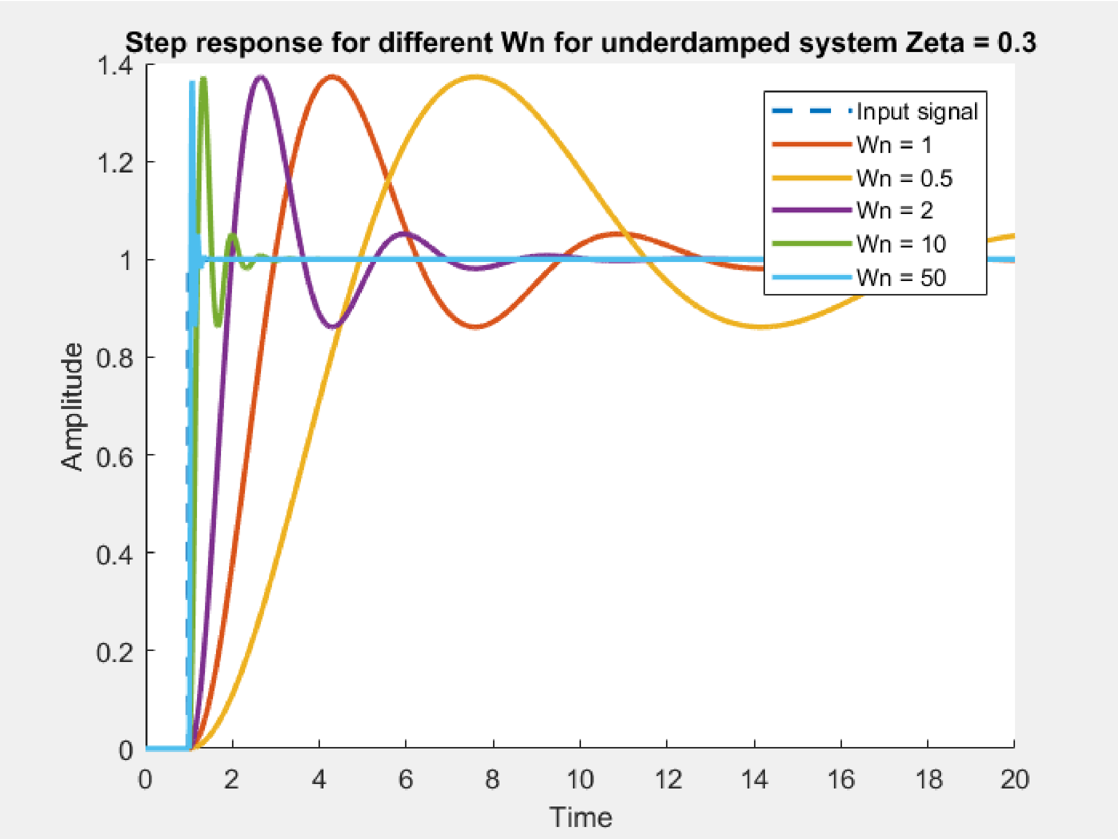
```
clear
clc

t = 0:0.01:20;
u = 1*double(t>=1);
s = tf('s');
w = [1 0.5 2 10 50] ;
z = [0 0.3 0.6  1 1.5 3];
figure(1)
hold()
plot(t,u,'--','Linewidth',2)
for i = 1:numel(z)
    G = (w(1)^2)/(s^2 + w(1)^2 + 2*z(i)*w(1)*s);
    y = lsim(G,u,t);
    plot(t,y,'Linewidth',2)
end

legend('Input signal','Zeta = 0','Zeta = 0.3','Zeta = 0.6','Zeta = 1','Zeta = 1.5','Zeta =
3')
title('Step response for Wn = 1')
xlabel('Time')
ylabel('Amplitude')

figure(2)
hold()
plot(t,u,'--','Linewidth',2)
z1 = 0.3;
for i = 1 : numel(w)
    G = (w(i)^2)/(s^2 + w(i)^2 + 2*z1*w(i)*s);
    y = lsim(G,u,t);
    plot(t,y,'Linewidth',2)
end
legend('Input signal','Wn = 1','Wn = 0.5','Wn = 2','Wn = 10','Wn = 50')
title('Step response for different Wn for underdamped system Zeta = 0.3')
xlabel('Time')
ylabel('Amplitude')

figure(3)
hold()
plot(t,u,'--','Linewidth',2)
z1 = 1;
for i = 1 : numel(w)
```

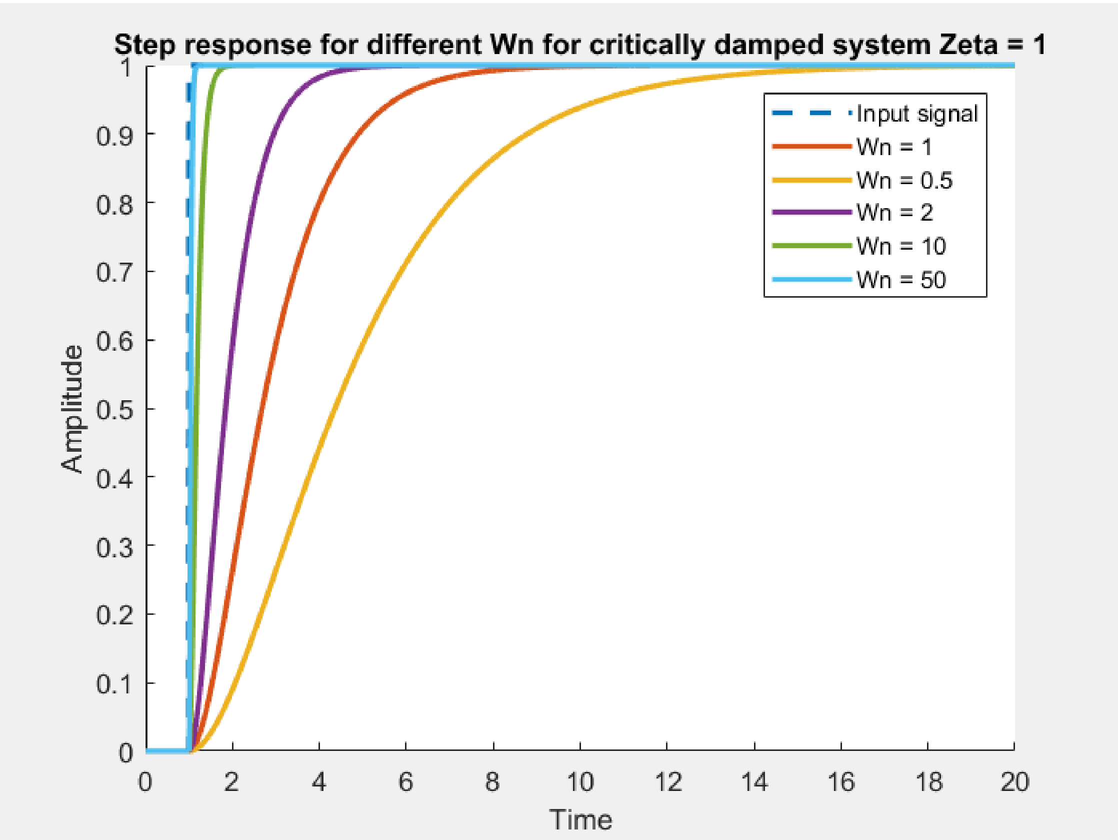
```
    G = (w(i)^2)/(s^2 + w(i)^2 + 2*z1*w(i)*s);
    y = lsim(G,u,t);
    plot(t,y,'Linewidth',2)
end
legend('Input signal','Wn = 1','Wn = 0.5','Wn = 2','Wn = 10','Wn = 50')
title('Step response for different Wn for critically damped system Zeta = 1')
xlabel('Time')
ylabel('Amplitude')
```

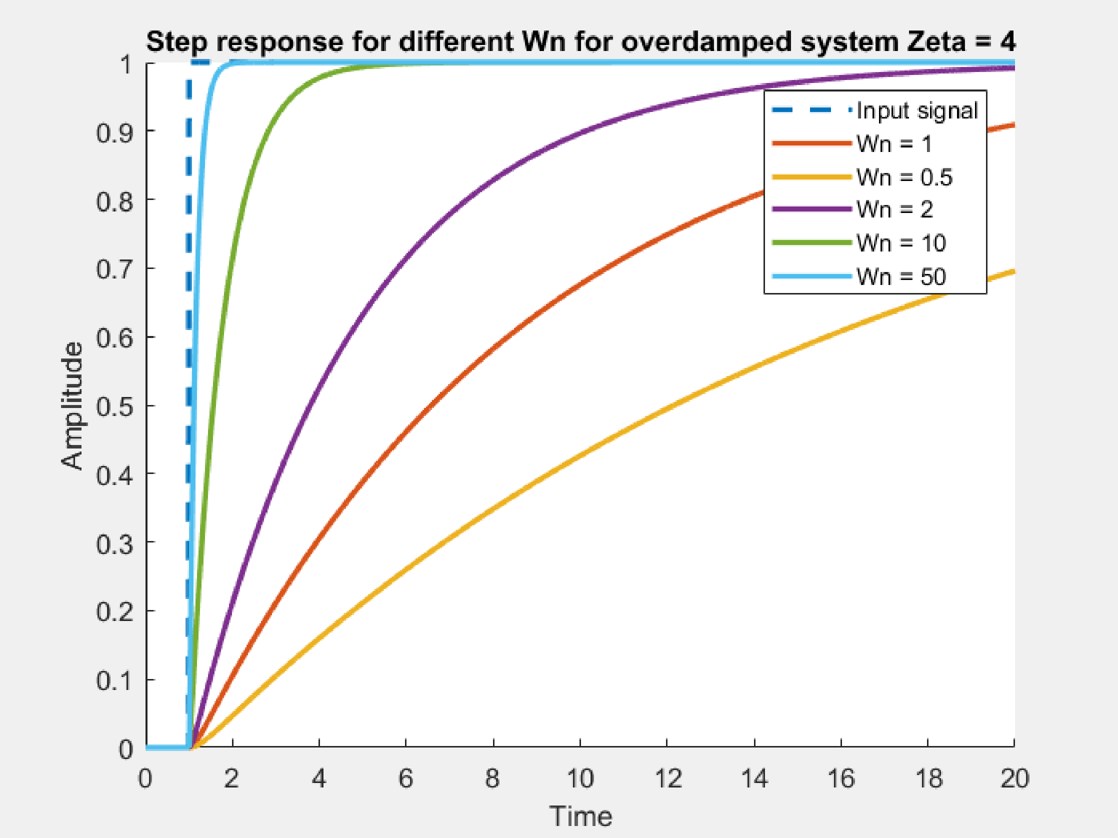
```
figure(4)
hold()
plot(t,u,'--','Linewidth',2)
z1 = 4;
for i = 1 : numel(w)
    G = (w(i)^2)/(s^2 + w(i)^2 + 2*z1*w(i)*s);
    y = lsim(G,u,t);
    plot(t,y,'Linewidth',2)
end
legend('Input signal','Wn = 1','Wn = 0.5','Wn = 2','Wn = 10','Wn = 50')
title('Step response for different Wn for overdamped system Zeta = 4')
xlabel('Time')
ylabel('Amplitude')
```

```
clear
clc
```




Step response for different Wn for underdamped system Zeta = 0.3
Amplitude
Time
Input signal
Wn = 1
Wn = 0.5
Wn = 2
Wn = 10
Wn = 50
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18
20

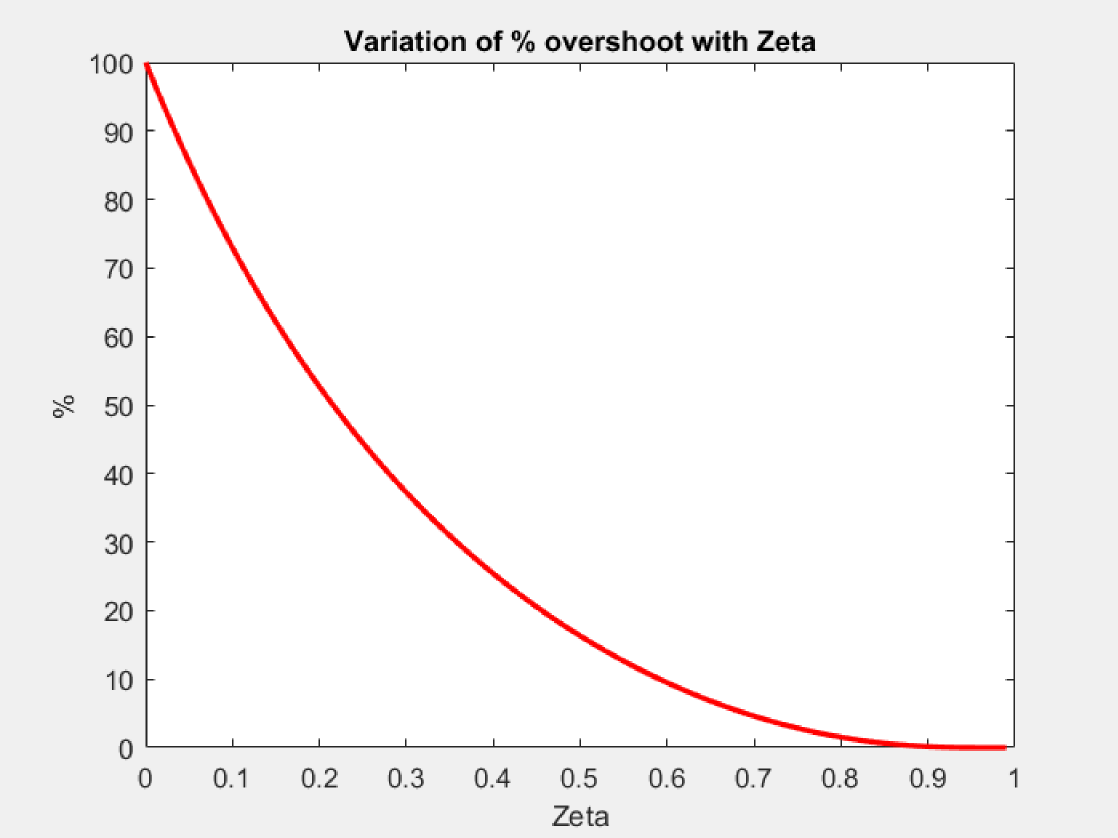

Step response for different Wn for critically damped system Zeta = 1
Amplitude
Time
Input signal
Wn = 1
Wn = 0.5
Wn = 2
Wn = 10
Wn = 50
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
18
20



Variation of overshoot with Zeta in step response

Code:

```
clear
clc

z = 0:0.01:1-0.01;
mp = exp(-z.*pi./((1-z.^2).^0.5));
plot(z,mp*100,'r','Linewidth',2)
title('Variation of % overshoot with Zeta')
xlabel('Zeta')
ylabel('%')
%title()
```



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Frequency and Phase responses of second order system

Code:

```
clear
clc
```

```
w = 0:0.01:20;
w = 1j*w;
z = [3 1.5 1 0.8 0.6 0.4 0.2];
```

```
Wn = 1;
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),abs(H),'Linewidth',2)

end
xlabel('Frequency')
ylabel('Gain')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Frequency response for Wn = 1')
```

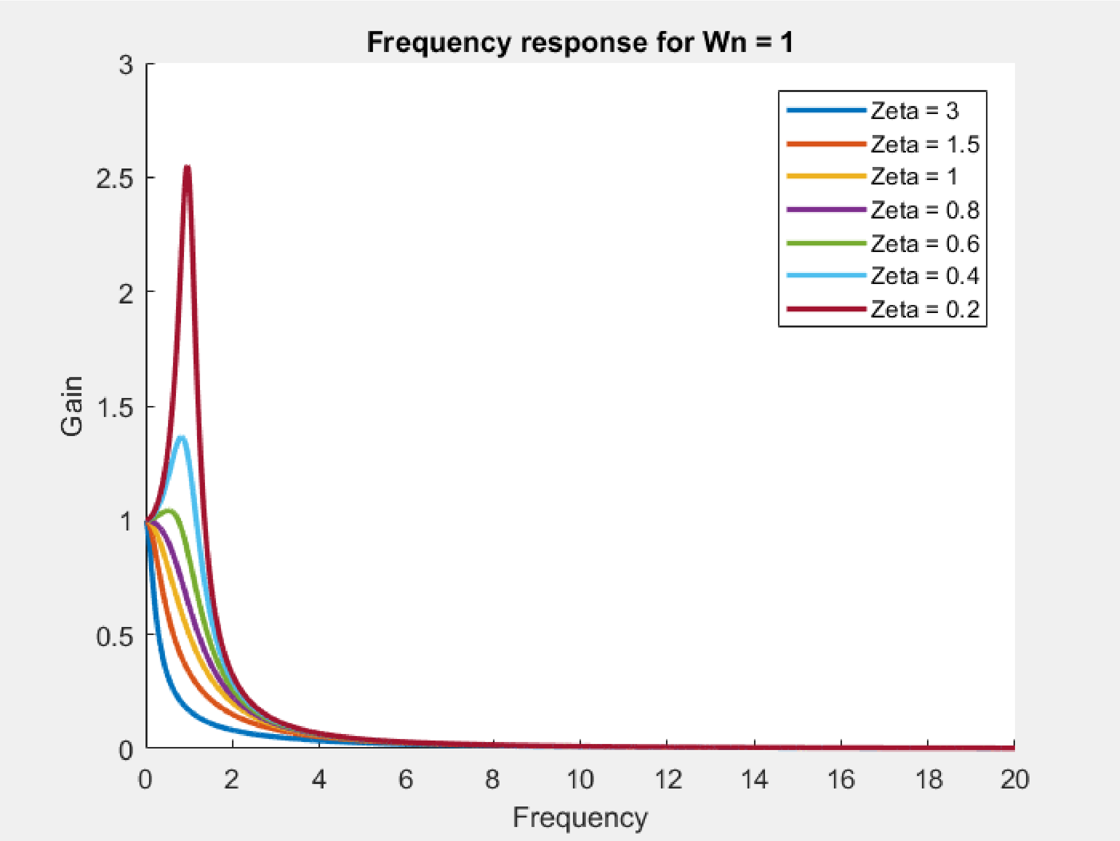
```
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),phase(H)*180/pi,'Linewidth',2)

end
xlabel('Frequency')
ylabel('Phase')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Phase response for Wn = 1')
```

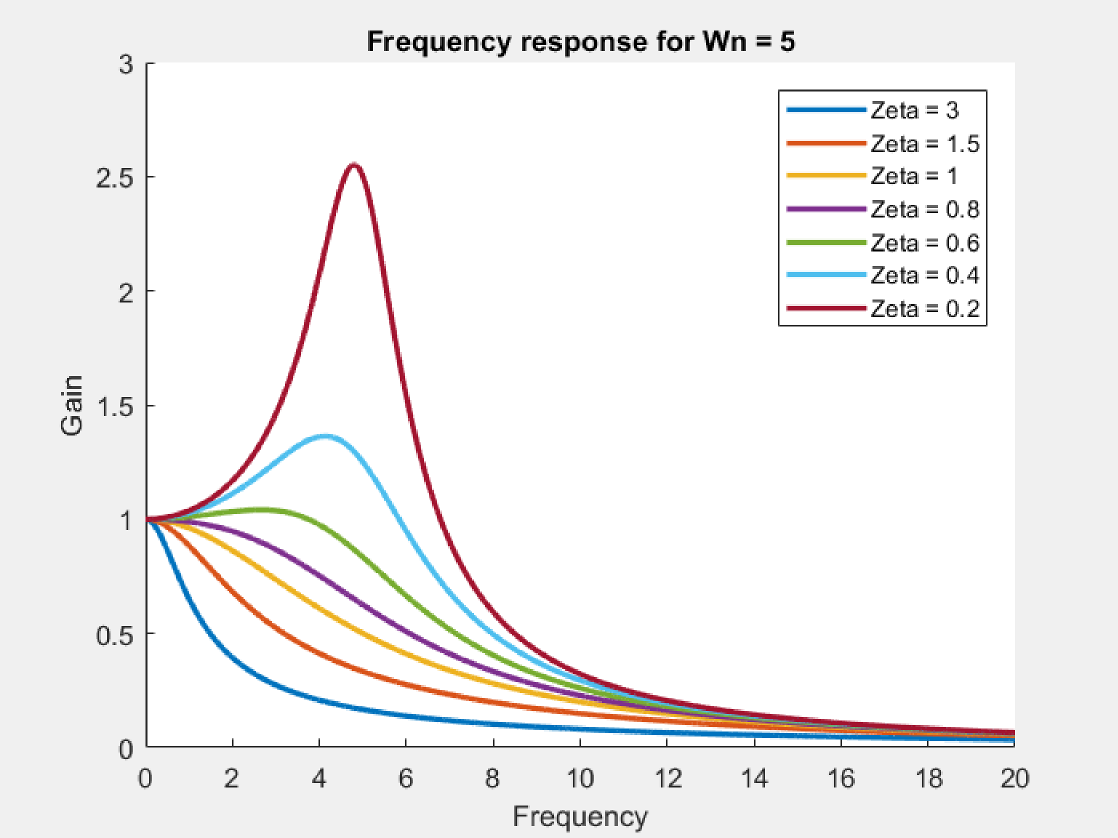
```
Wn = 5;
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),abs(H),'Linewidth',2)

end
xlabel('Frequency')
ylabel('Gain')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Frequency response for Wn = 5')
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),phase(H)*180/pi,'Linewidth',2)
end
xlabel('Frequency')
ylabel('Phase')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Phase response for Wn = 5')
```

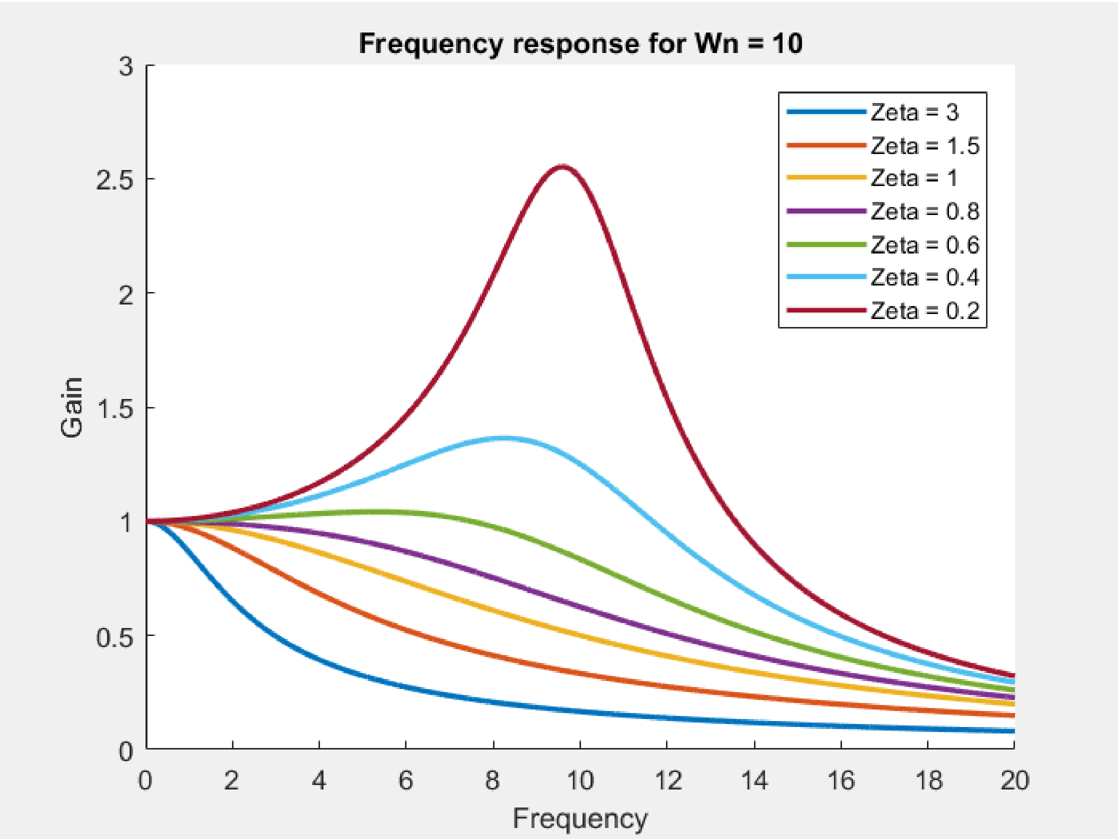
```
Wn = 10;
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),abs(H),'Linewidth',2)

end
xlabel('Frequency')
ylabel('Gain')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Frequency response for Wn = 10')
figure()
hold()
for i = 1:numel(z)
    H = (Wn^2)./(w.*w + Wn^2 + w.*2*z(i)*Wn);
    plot(real(w/1j),phase(H)*180/pi,'Linewidth',2)

end
xlabel('Frequency')
```

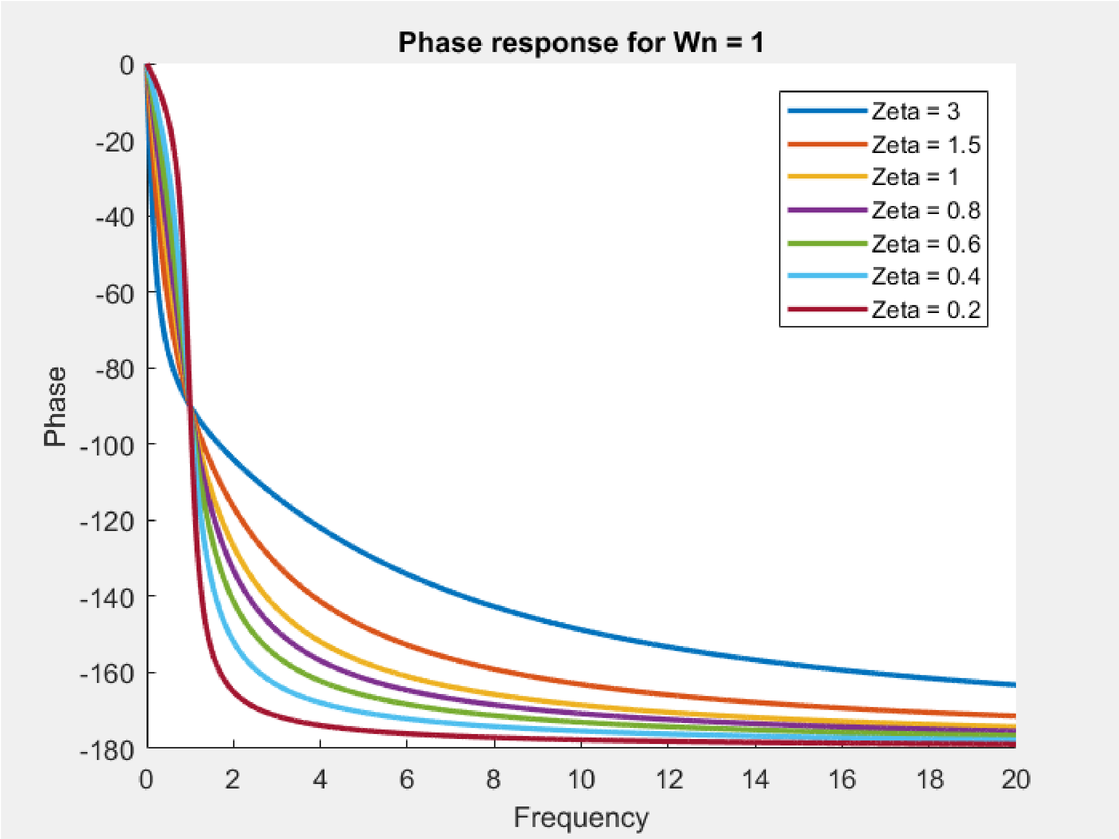
```
ylabel('Phase')
legend('Zeta = 3','Zeta = 1.5','Zeta = 1','Zeta = 0.8','Zeta = 0.6','Zeta = 0.4','Zeta =
0.2')
title('Phase response for Wn = 10')
```

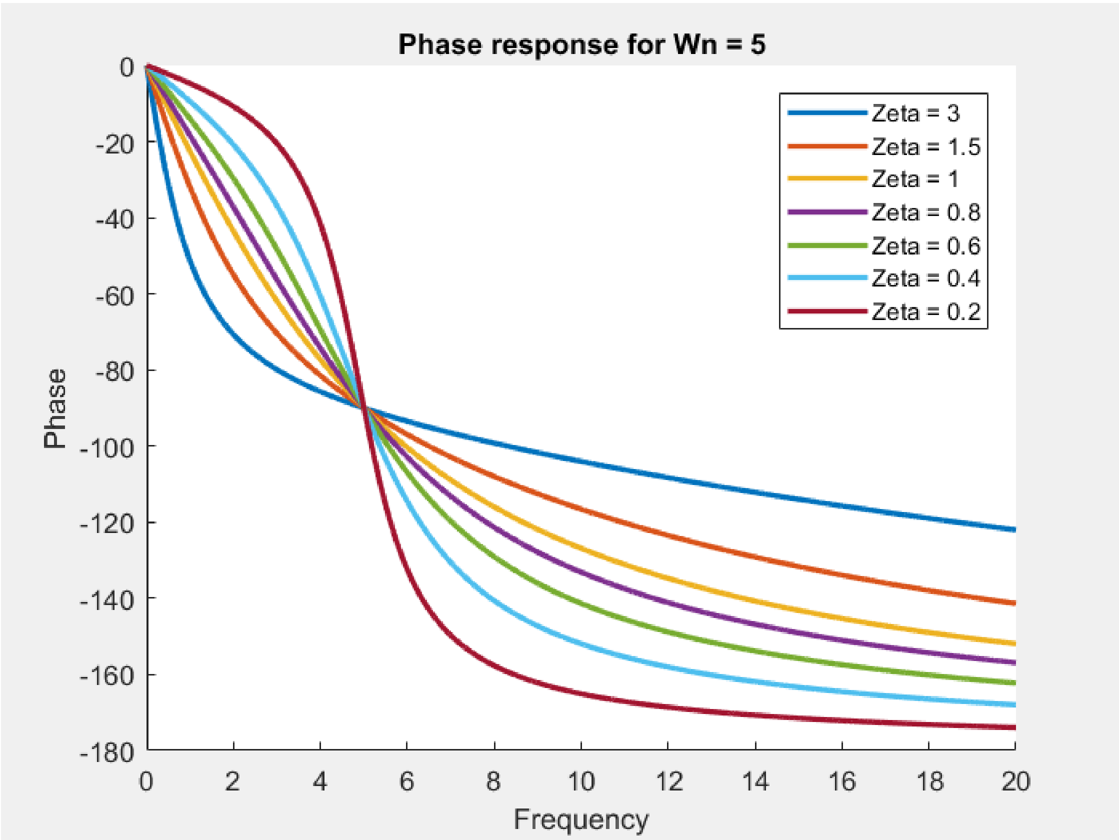
```
clear
clc
```

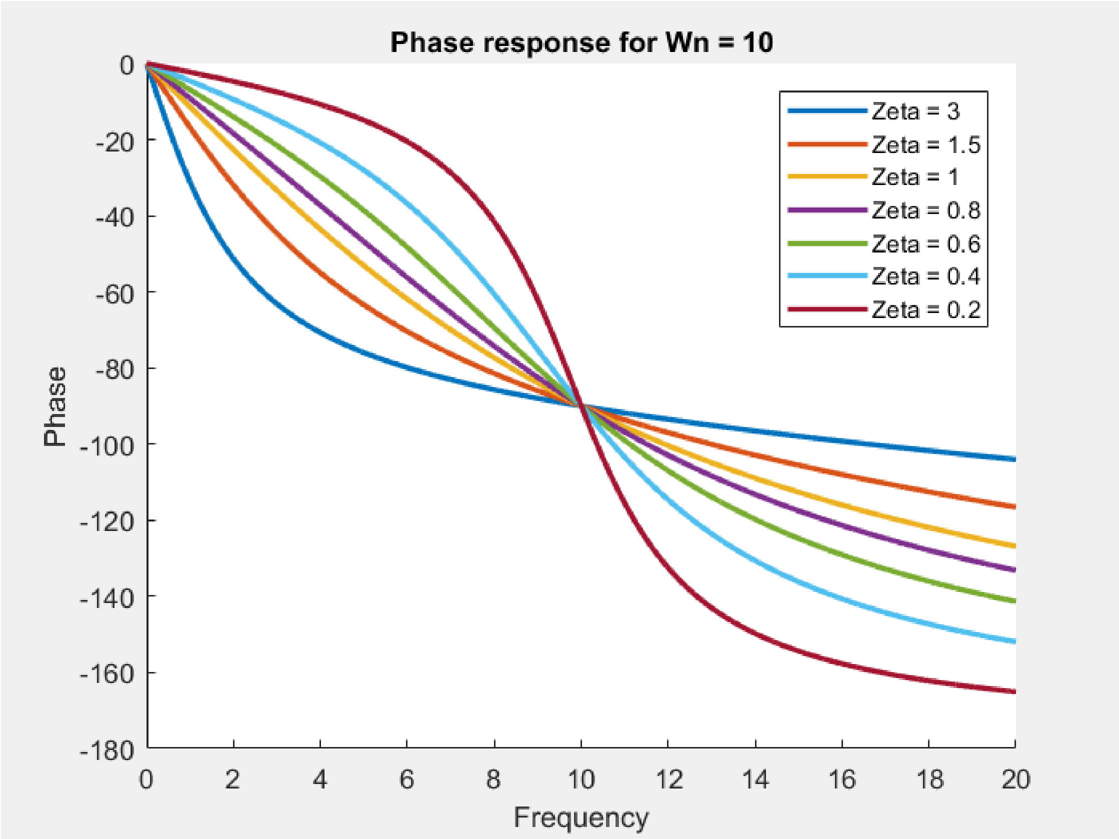



Frequency response for Wn = 5
Zeta = 3
Zeta = 1.5
Zeta = 1
Zeta = 0.8
Zeta = 0.6
Zeta = 0.4
Zeta = 0.2
Gain
Frequency
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14
16
18
20


Frequency response for Wn = 10
Zeta = 3
Zeta = 1.5
Zeta = 1
Zeta = 0.8
Zeta = 0.6
Zeta = 0.4
Zeta = 0.2
Gain
Frequency
0
0.5
1
1.5
2
2.5
3
0
2
4
6
8
10
12
14
16
18
20


Phase response for Wn = 1
Zeta = 3
Zeta = 1.5
Zeta = 1
Zeta = 0.8
Zeta = 0.6
Zeta = 0.4
Zeta = 0.2
Phase
Frequency
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
2
4
6
8
10
12
14
16
18
20


Phase response for Wn = 5
Zeta = 3
Zeta = 1.5
Zeta = 1
Zeta = 0.8
Zeta = 0.6
Zeta = 0.4
Zeta = 0.2
Phase
Frequency
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
2
4
6
8
10
12
14
16
18
20


Phase response for Wn = 10
Zeta = 3
Zeta = 1.5
Zeta = 1
Zeta = 0.8
Zeta = 0.6
Zeta = 0.4
Zeta = 0.2
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
Phase
0
2
4
6
8
10
12
14
16
18
20
Frequency