DSAP LAB4

1. In the given LTI system of fig above, if the coefficients 'b' & 'a' are specified as

   b0=0.0663, b1= 0.1989, b2=0.1989, b3=0.0663
   a0=1, a1= -0.9349, a2=0.5668, a3= -0.1015,

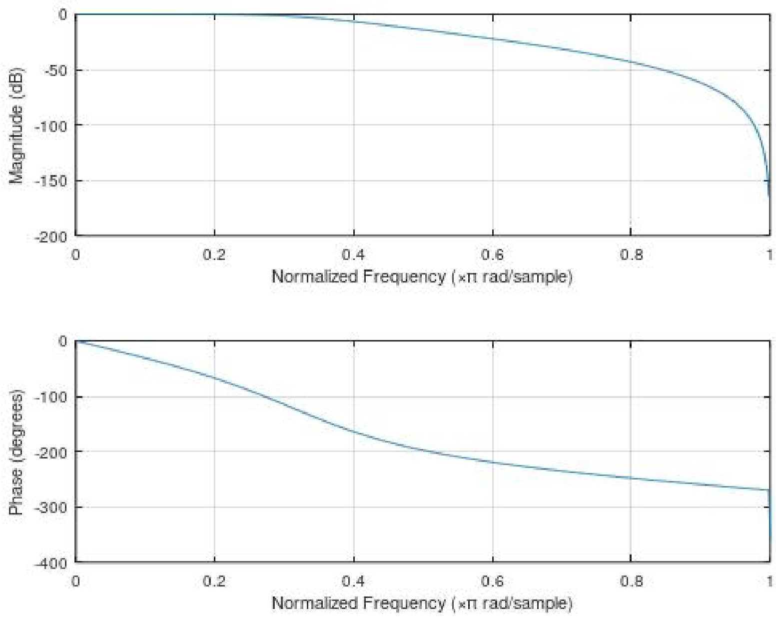
   then the order of the system is 3 i.e. N=3.

a. Plot the frequency response of the system.

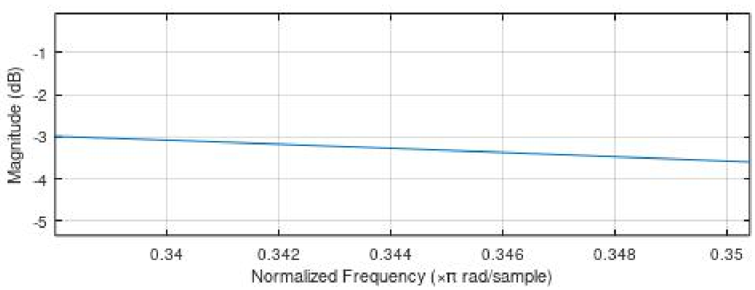
Code:

```
b= [0.0663, 0.1989, 0.1989, 0.0663];
a= [1, -0.9349, 0.5668, -0.1015];
freqz(b,a);
```

Output:

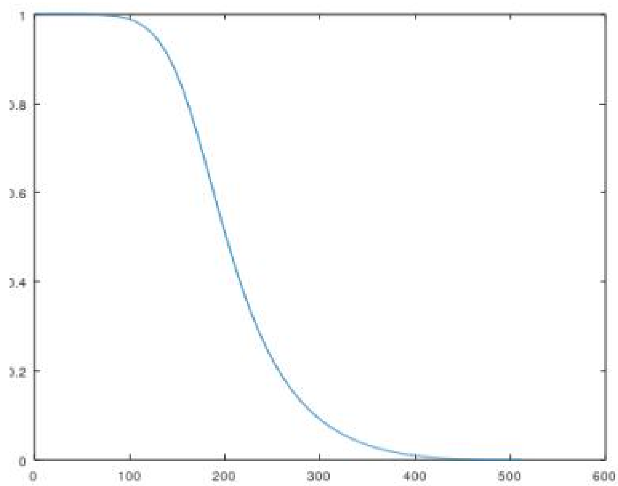


b. From the magnitude response of the system, find out the cut-off frequency.



From the magnitude response, it can be observed that the cutoff frequenct corresponding to magnitude of -3dB is 0.338 pi rad/sample.

c. Identify the nature of the system analyzing its frequency response.



Analyzing the frequency response, it is clear that it is similar to that of a low pass filter, as it passes only lower frequency components (f<=fc).

2. The transfer function of the fourth-order discrete time system is given as:

$$H(z) = \frac{0.0018 + 0.0073\, z^{-1} + 0.011\, z^{-2} + 0.007\, z^{-3} + 0.008\, z^{-4}}{1 - 3.0544\, z^{-1} + 3.8291\, z^{-2} - 2.2925\, z^{-3} + 0.55072\, z^{-4}}$$

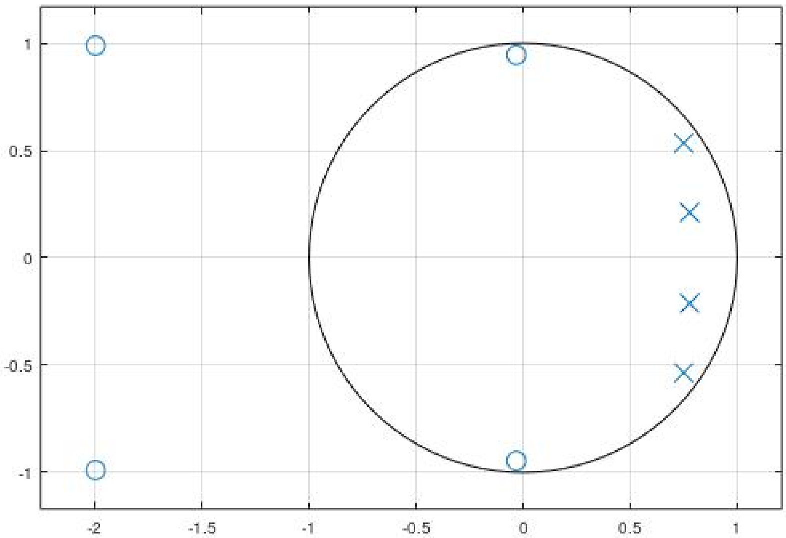
Using MATLAB-

a. Find out the poles and zeros of the system and plot them in the z- plane.

Code:

```
pkg load signal
b = [0.0018, 0.0073, 0.011, 0.007, 0.008];
a = [1, -3.0544, 3.8291, -2.2925, 0.55072];
%a
[zeros, poles, gain] = tf2zp(b,a);
zeros
poles
gain
zplane(b,a);
```

Output:




```
zeros =

 Column 1:

  -1.9962 + 0.9892i
  -1.9962 - 0.9892i
  -0.0316 + 0.9458i
  -0.0316 - 0.9458i

poles =

 Column 1:

   0.7498 + 0.5349i
   0.7498 - 0.5349i
   0.7774 + 0.2118i
   0.7774 - 0.2118i

gain = 1.8000e-03
>> |
```

b. Use them to determine the second order sections in the cascaded form.

Code:

```
pkg load signal
b = [0.0018, 0.0073, 0.011, 0.007, 0.008];
a = [1, -3.0544, 3.8291, -2.2925, 0.55072];
%b
[zeros, poles, gain] = tf2zp(b,a);
[sos, g] = zp2sos(zeros, poles, gain);
sos
g
```

Output:

```
sos =

   1.000000   3.992323   4.963185   1.000000  -1.499648   0.848364
   1.000000   0.063232   0.895482   1.000000  -1.554752   0.649155

g = 1.8000e-03
>>
```

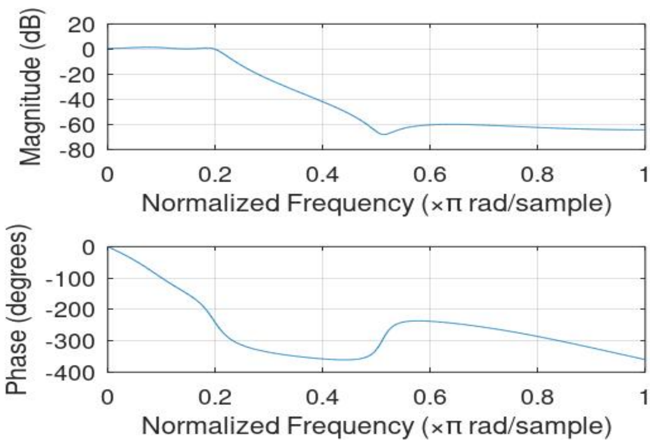
first row(section1) and second row(section2) with b's coefficients being the first three and a's coefficients being the final three respectively.

c. Plot the frequency response of the system and comment on the nature of the system.

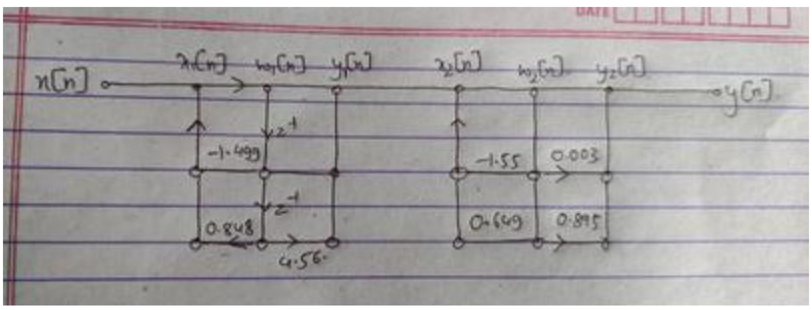
Code:

```
pkg load signal
b = [0.0018, 0.0073, 0.011, 0.007, 0.008];
a = [1, -3.0544, 3.8291, -2.2925, 0.55072];
%c
freqz(b,a);
```

Output:



d. After knowing the numerator and denominator coefficients of each second order section, draw the signal flow graph to represent the cascaded structure.



3. Let a discrete time system be implemented by cascading of the following three second order sections:

Section 1: $$\frac{0.0007378\,(1 + 2z^{-1} + z^{-2})}{(1 - 1.2686\,z^{-1} + 0.7051\,z^{-2})}$$

Section 2: $$\frac{1 + 2z^{-1} + z^{-2}}{1 - 1.0106\,z^{-1} + 0.3583\,z^{-2}}$$

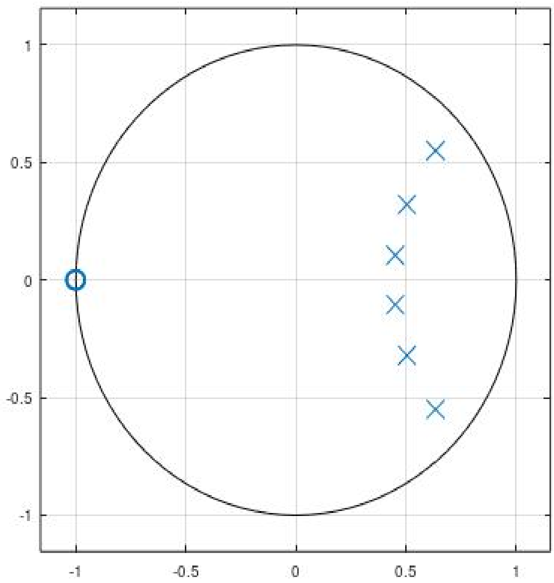
Section 3: $$\frac{1 + 2z^{-1} + z^{-2}}{1 - 0.9044\,z^{-1} + 0.2155\,z^{-2}}$$

a. Using above three second order sections in cascaded form determine the poles and zeros of the system and plot them in z-plane.

Code:

```
        b1 = [1,2,1];
a1 = [1, -1.2686,0.7051];
a2 = [1, -1.0106, 0.3583];
a3 = [1, -0.9044, 0.2155];

a = conv(a1, conv(a2,a3));
b = conv(0.0007378*b1, conv(b1,b1));
figure, zplane(b,a);
[zeros, poles, k] = sos2zp([[0.0007278*b1,a1];[b1,a2];[b1,a3]]);
zeros
poles
K
```

Output:



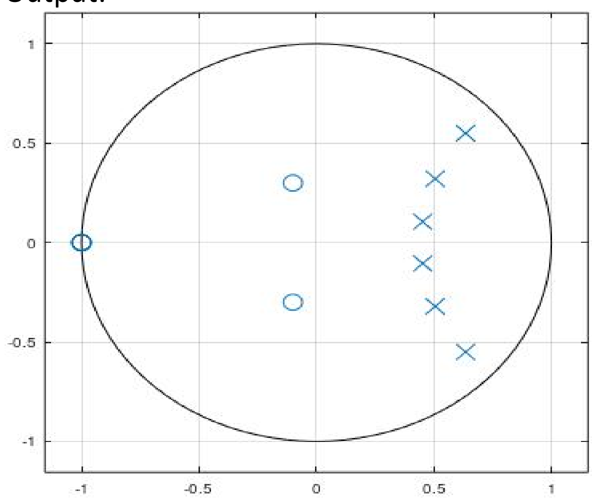

```
zeros =

  -1
  -1
  -1
  -1
  -1
  -1

poles =

 Column 1:

   0.6343 + 0.5502i
   0.6343 - 0.5502i
   0.5053 + 0.3209i
   0.5053 - 0.3209i
   0.4522 + 0.1050i
   0.4522 - 0.1050i

k = 7.2780e-04
>>
```

b. Determine the transfer function of the system, formed by cascading of the above three sections. Determine the poles and zeros from this transfer function and plot them in z-plane. Your result should match with that from 3(a).

Code:

```
sos = [0.007378, 2* 0.0007378, 0.0007378, 1 , -1.2686, 0.7051;
1,2,1,1,-1.0106,0.3583;
1,2,1,1,-0.9044,0.2155];
[b,a] = sos2tf(sos);
b
a
[z,p,k] = tf2zp(b,a);
z
p
k
zplane(b,a);
```

Output:




```
>> q3b
b =

   7.3780e-03   3.0988e-02   5.0908e-02   4.1317e-02   1.7707e-02   4.4268e-03   7.3780e-04

a =

   1.000000  -3.183600   4.622256  -3.779503   1.813619  -0.479998   0.054443

z =

  -1.0002 +      0i
  -1.0000 + 0.0002i
  -1.0000 - 0.0002i
  -0.9998 +      0i
  -0.1000 + 0.3000i
  -0.1000 - 0.3000i

p =

   0.6343 + 0.5502i
   0.6343 - 0.5502i
   0.5053 + 0.3209i
   0.5053 - 0.3209i
   0.4522 + 0.1050i
   0.4522 - 0.1050i

k = 7.3780e-03
>> |
```