EXPERIMENT 9

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Write a MATLAB Script to find the phase angle, phase delay and phase response of the designed IIR filters Lab6.

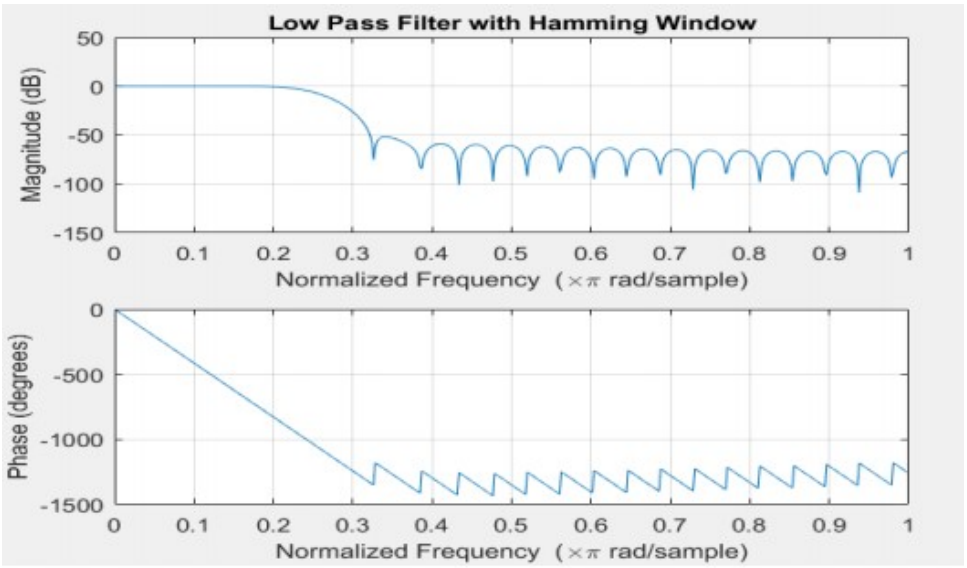
Code:

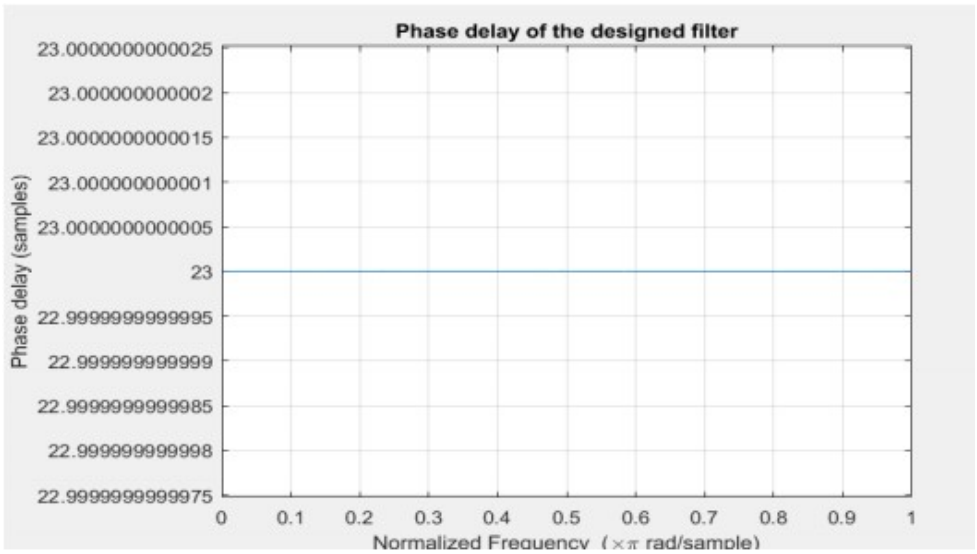
```
clc
clear
disp('The type of Windows are: 1.Rectangular 2.Hamming 3.Hann 4.Kaiser')
c=input('Choose the type of Window: ');
disp('Enter the type of filter')
disp('1. Low pass 2.High Pass 3. Bandpass filter 4. Bandstop filter')
d=input('Choose the filter type: ');
n=input('Enter the order of the filter: ');
wn=input('Enter the frequency: ');
n1=input('Enter the number of evaluation points: ');
nm=mod(n,2);
if nm==1
 n=n+1;
end
if c==1
 if d==1
 b = fir1(n ,wn,'low',rectwin(n+1));
 freqz(b,1,n1);
 title('Low Pass Filter with Rectangular Window');
 elseif d==2
 b = fir1(n ,wn,'high',rectwin(n+1));
 freqz(b,1,n1);
 title('High Pass Filter with Rectangular Window');
 theta = angle(z);
 elseif d==3
 b = fir1(n ,wn,'pass',rectwin(n+1));
 freqz(b,1,n1);
 title('Bandpass Filter with Rectangular Window');
 elseif d==4
 b = fir1(n ,wn,'stop',rectwin(n+1));
 freqz(b,1,n1);
 title('Bandstop Filter with Rectangular Window');
 end
elseif c==2
 if d==1
 b= fir1(n,wn,'low',hamming(n+1));
 freqz(b,1,n1);
 title('Low Pass Filter with Hamming Window');
 elseif d==2
 b= fir1(n,wn,'high',hamming(n+1));
 freqz(b,1,n1);
 title('High Pass Filter with Hamming Window');
 elseif d==3
 b= fir1(n,wn,'pass',hamming(n+1));
 freqz(b,1,n1);
 title('Bandpass Filter with Hamming Window');
 elseif d==4
 b= fir1(n,wn,'stop',hamming(n+1));
 freqz(b,1,n1);
 title('Bandstop Filter with Hamming Window');
 end
```

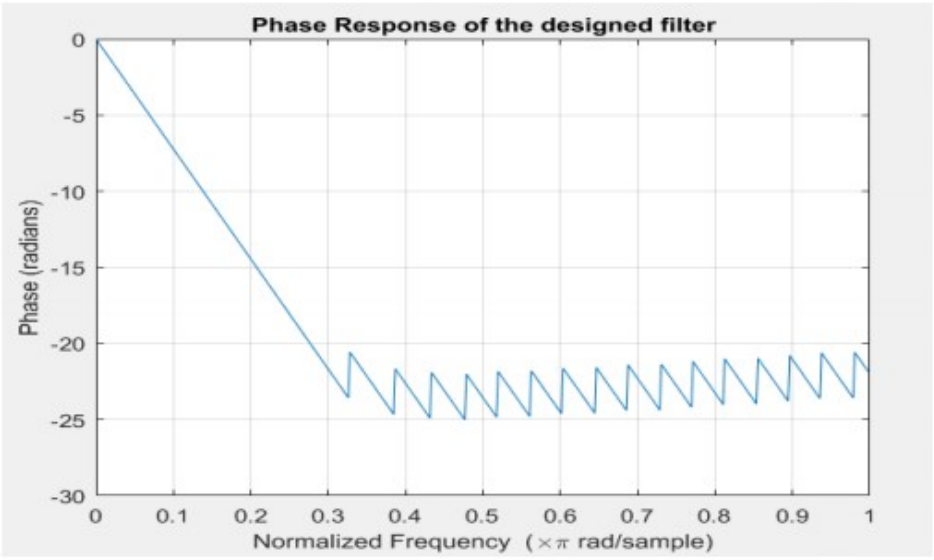
```
elseif c==3
 if d==1
 b= fir1(n,wn,'low',hann(n+1));
 freqz(b,1,n1);
 title('Low Pass Filter with Hann Window');
 elseif d==2
 b= fir1(n,wn,'high',hann(n+1));
 freqz(b,1,n1);
 title('High Pass Filter with Hann Window');
 elseif d==3
 b= fir1(n,wn,'pass',hann(n+1));
 freqz(b,1,n1);
 title('Bandpass Filter with Hann Window');
 elseif d==4
 b= fir1(n,wn,'stop',hann(n+1));
 freqz(b,1,n1);
 title('Bandstop Filter with Hann Window');
 end
elseif c==4
 if d==1
 b= fir1(n,wn,'low',kaiser(n+1));
 freqz(b,1,n1);
 title('Low Pass Filter with Kaiser Window');
 elseif d==2
 b= fir1(n,wn,'high',kaiser(n+1));
 freqz(b,1,n1);
 title('High Pass Filter with Kaiser Window');
 elseif d==3
 b= fir1(n,wn,'pass',kaiser(n+1));
 freqz(b,1,n1);
 title('Bandpass Filter with Kaiser Window');

 elseif d==4
 b= fir1(n,wn,'stop',kaiser(n+1));
 freqz(b,1,n1);
 title('Bandstop Filter with Kaiser Window');
else
 disp('Invalid input');
 end

end
figure(2);
phasedelay(b,512);
title('Phase delay of the designed filter');
figure(3);
phasez(b);
title('Phase Response of the designed filter');
z = freqz(b,1);
theta = angle(z);
theta = theta';
disp('Phase of designed filter: ');
disp(theta);
```

Output :

```
The type of Windows are: 1.Rectangular 2.Hamming 3.Hann 4.Kaiser
Choose the type of Window: 2
Enter the type of filter
1. Low pass 2.High Pass 3. Bandpass filter 4. Bandstop filter
Choose the filter type: 1
Enter the order of the filter: 46
Enter the frequency: 0.3
Enter the number of evaluation points: 1024
```


Low Pass Filter with Hamming Window
Magnitude (dB)
50
0
-50
-100
-150
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)
Phase (degrees)
0
-500
-1000
-1500
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)


Phase delay of the designed filter
Phase delay (samples)
23.0000000000025
23.000000000002
23.0000000000015
23.000000000001
23.0000000000005
23
22.9999999999995
22.999999999999
22.9999999999985
22.999999999998
22.9999999999975
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)


Phase Response of the designed filter
Phase (radians)
0
-5
-10
-15
-20
-25
-30
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Normalized Frequency (×π rad/sample)

Write a MATLAB Script to find the phase angle, phase delay and phase response of the designed IIR filters Lab7.

Code:

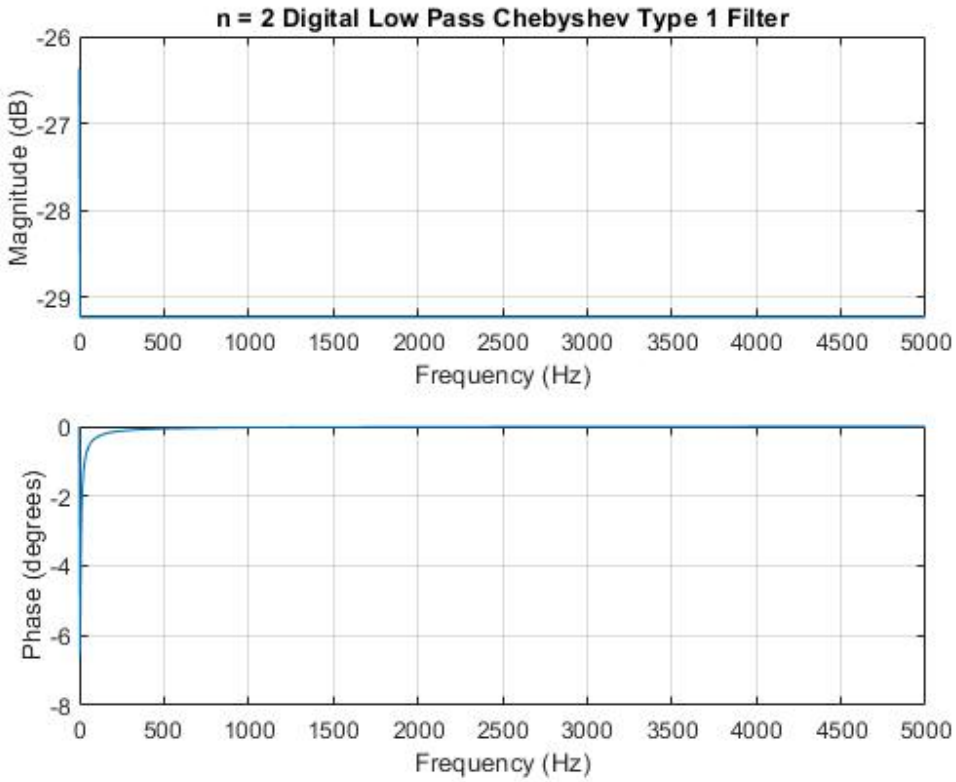
```
clc;
clear;
close all;
type = input('Enter the type of filter(1. Low Pass, 2. High Pass, 3. Band Pass, 4. Band
Stop): ');
g = input('Enter the design of filter(1.Butterworth , 2.Chebyshev type1 , 3. Chebyshev
type2 , 4. Elliptic): ');
k = input('Enter the type of Filter discretization functions(1. Bilinear, 2. Impulse
Invariant): ');
rp = input('Enter the pass band ripple: ');
rs = input('Enter the stop band attenuation: ');
wp = input('Enter the pass band frequency(Hz): ');
ws = input('Enter the stop band frequency(Hz): ');
fs = input('Enter the sampling frequency(Hz): ');
wp = wp/(fs/2);
ws = ws/(fs/2);
if(type == 1)
 if(g == 1)
 [n,wn] = buttord(wp,ws,rp,rs);
 [b,a] = butter(n,wn,'low');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Low Pass Butterworth Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Low Pass Butterworth Filter',n));
 elseif(g == 2)
 [n,wp] = cheb1ord(wp,ws,rp,rs);
 [b,a] = cheby1(n,rp,wp,'low');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Low Pass Chebyshev Type 1 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Low Pass Chebyshev Type 1 Filter',n));

 elseif(g == 3)
 [n,ws] = cheb2ord(wp,ws,rp,rs);
 [b,a] = cheby2(n,rs,ws,'low');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Low Pass Chebyshev Type 2 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Low Pass Chebyshev Type 2 Filter',n));
```

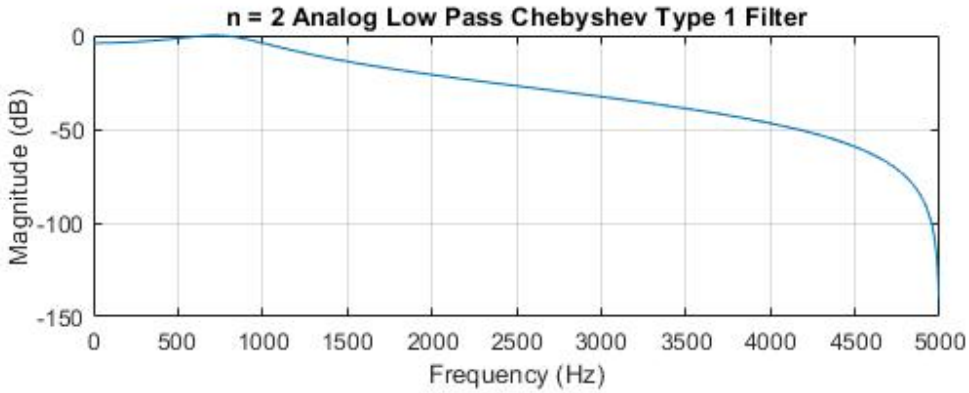
```
 elseif(g == 4)
 [n,wp] = ellipord(wp,ws,rp,rs);
 [b,a] = ellip(n,rp,rs,wp,'low');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Low Pass Elliptic Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Low Pass Elliptic Filter',n));
 end
elseif(type == 2)
 if(g == 1)
 [n,wn] = buttord(wp,ws,rp,rs);
 [b,a] = butter(n,wn,'high');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital High Pass Butterworth Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog High Pass Butterworth Filter',n));

 elseif(g == 2)
 [n,wp] = cheb1ord(wp,ws,rp,rs);
 [b,a] = cheby1(n,rp,wp,'high');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital High Pass Chebyshev Type 1 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog High Pass Chebyshev Type 1 Filter',n));

 elseif(g == 3)
 [n,ws] = cheb2ord(wp,ws,rp,rs);
 [b,a] = cheby2(n,rs,ws,'high');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital High Pass Chebyshev Type 2 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog High Pass Chebyshev Type 2 Filter',n));

 elseif(g == 4)
 [n,wp] = ellipord(wp,ws,rp,rs);
 [b,a] = ellip(n,rp,rs,wp,'high');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
```

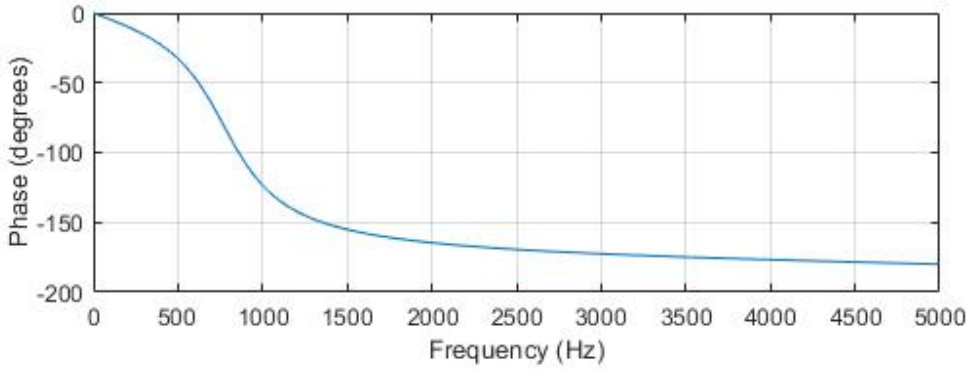
```
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital High Pass Elliptic Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog High Pass Elliptic Filter',n));
 end

elseif(type == 3)
 if(g == 1)
 [n,wn] = buttord(wp,ws,rp,rs);
 [b,a] = butter(n,wn,'bandpass');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandpass Butterworth Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandpass Butterworth Filter',n));

 elseif(g == 2)
 [n,wp] = cheb1ord(wp,ws,rp,rs);
 [b,a] = cheby1(n,rp,wp,'bandpass');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandpass Chebyshev Type 1 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandpass Chebyshev Type 1 Filter',n));

 elseif(g == 3)
 [n,ws] = cheb2ord(wp,ws,rp,rs);
 [b,a] = cheby2(n,rs,ws,'bandpass');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandpass Chebyshev Type 2 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandpass Chebyshev Type 2 Filter',n));

 elseif(g == 4)
 [n,wp] = ellipord(wp,ws,rp,rs);
 [b,a] = ellip(n,rp,rs,wp,'bandpass');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
```

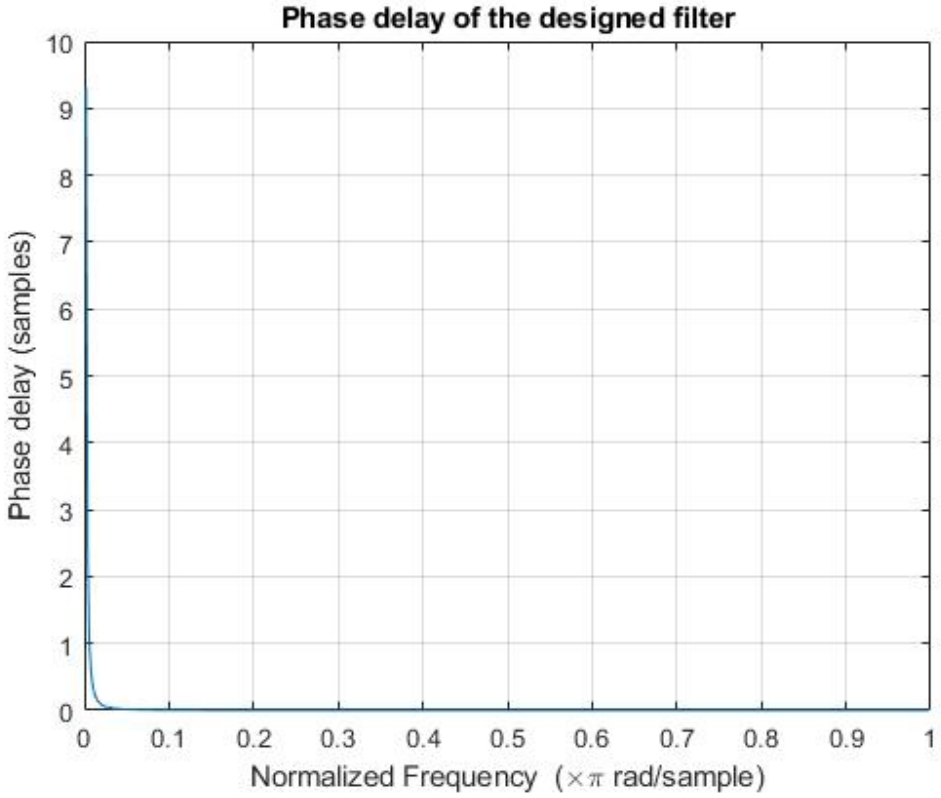
```
 title(sprintf('n = %d Digital Bandpass Elliptic Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandpass Elliptic Filter',n));
 end
elseif(type == 4)
 if(g == 1)
 [n,wn] = buttord(wp,ws,rp,rs);
 [b,a] = butter(n,wn,'stop');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandstop Butterworth Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandstop Butterworth Filter',n));

 elseif(g == 2)
 [n,wp] = cheb1ord(wp,ws,rp,rs);
 [b,a] = cheby1(n,rp,wp,'stop');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandstop Chebyshev Type 1 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandstop Chebyshev Type 1 Filter',n));

 elseif(g == 3)
 [n,ws] = cheb2ord(wp,ws,rp,rs);
 [b,a] = cheby2(n,rs,ws,'stop');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandstop Chebyshev Type 2 Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandstop Chebyshev Type 2 Filter',n));

 elseif(g == 4)
 [n,wp] = ellipord(wp,ws,rp,rs);
 [b,a] = ellip(n,rp,rs,wp,'stop');
 if(k ==1)
 [bz,az] = bilinear(b,a,fs);
 elseif(k==2)
 [bz,az] = impinvar(b,a,fs);
 end
 freqz(bz,az,1024,fs);
 title(sprintf('n = %d Digital Bandstop Elliptic Filter',n));
 figure(2);
 freqz(b,a,1024,fs);
 title(sprintf('n = %d Analog Bandstop Elliptic Filter',n));
 end
```

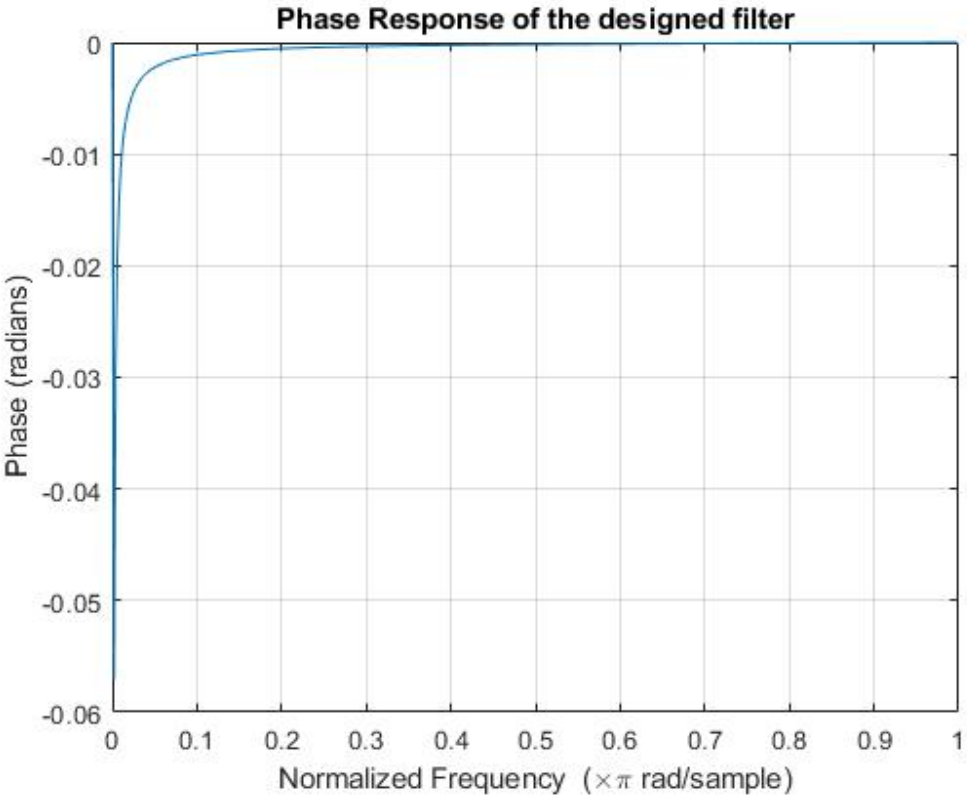
```
end
figure(3);
phasedelay(bz,az,512);
title('Phase delay of the designed filter');
figure(4);
phasez(bz,az);
title('Phase Response of the designed filter');
z = freqz(b,a,1024,fs);
theta = angle(z);
theta = theta';
disp('Phase of designed filter: ');
disp(theta);
```




n = 2 Analog Low Pass Chebyshev Type 1 Filter
Magnitude (dB)
0
-50
-100
-150
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Frequency (Hz)


Phase (degrees)
0
-50
-100
-150
-200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Frequency (Hz)


Phase delay of the designed filter
Phase delay (samples)
10
9
8
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Normalized Frequency (×π rad/sample)


Phase Response of the designed filter
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
Phase (radians)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Normalized Frequency (×π rad/sample)