National Tsing Hua University

Department of Electrical Engineering

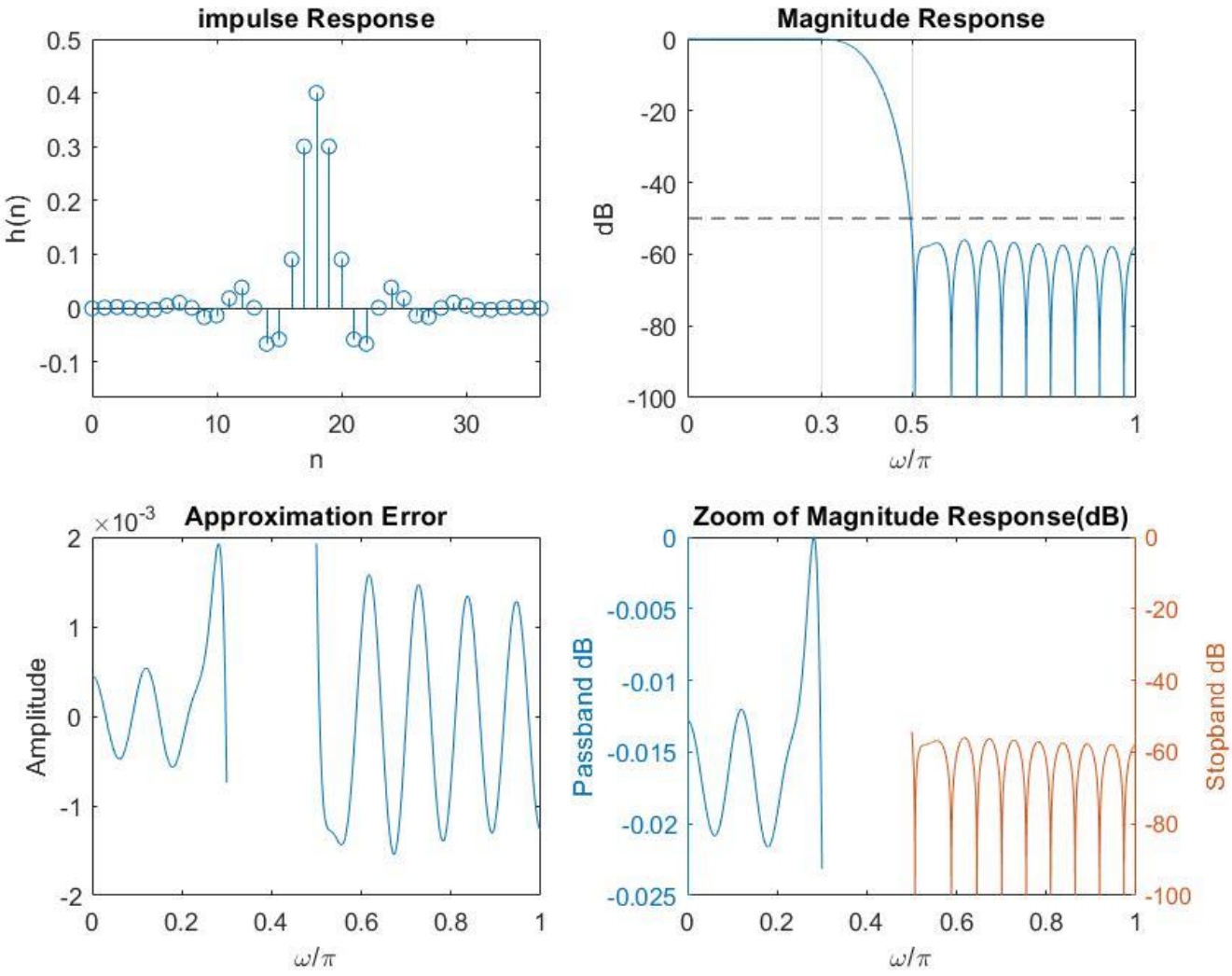
EE3660 Intro. to Digital Signal Processing, Spring 2020

Homework Assignment #5: Chap10 Answer

Problem 5.

```
close all; clc; clear all;
M=36; L=M+1; wp=0.3*pi; ws=0.5*pi;
As=50;

h=fir2(M,[0, wc/pi, wc/pi, 1],[1, 1, 0, 0 ]);
w=linspace(0,1,10000)*pi;
H=freqz(h,1,w);
Hmag=abs(H);
Hdb=20*log10(Hmag./max(Hmag));
[Ha,w2, P2, L2] =amplresp(h,w);
aperr = nan(1,length(w));
magz1 = nan(1,length(w));
magz2 = nan(1,length(w));
ind= w<=wp;
aperr(ind) =Ha(ind)-1;
magz1(ind) =Hdb(ind);
ind = w>=ws;
aperr(ind) =Ha(ind);
magz2(ind) =Hdb(ind);
%% plot
subplot(2,2,1);
stem(0:M,h);
xlim([0,M])
ylim([min(h)-0.1,max(h)+0.1]);
xlabel('n');
ylabel('h(n)');
title('impulse Response');

subplot(2,2,2);
plot(w/pi,Hdb);hold on
plot(w/pi,-As*ones(1,length(w)),'--','color','k');
ylim([-100,0]);
set(gca,'XTick',[0 0.3 0.5 1],'Xgrid','on');
xlabel('\omega/\pi');
ylabel('dB');
title('Magnitude Response');
```

```
subplot(2,2,3);
plot(w/pi,aperr);
xlabel('\omega/\pi');
ylabel('Amplitude');
title('Approximation Error');

subplot(2,2,4);
[AX,hf1,hf2] =plotyy(w/pi,magz1,w/pi,magz2);
xlabel('\omega/\pi');
title('Zoom of Magnitude Response(dB)');
set(get(AX(1),'Ylabel'),'string','Passband dB')
set(get(AX(2),'Ylabel'),'string','Stopband dB')
set(AX(2),'Ylim',[-100 0],'YTick',-100:20:0)
```

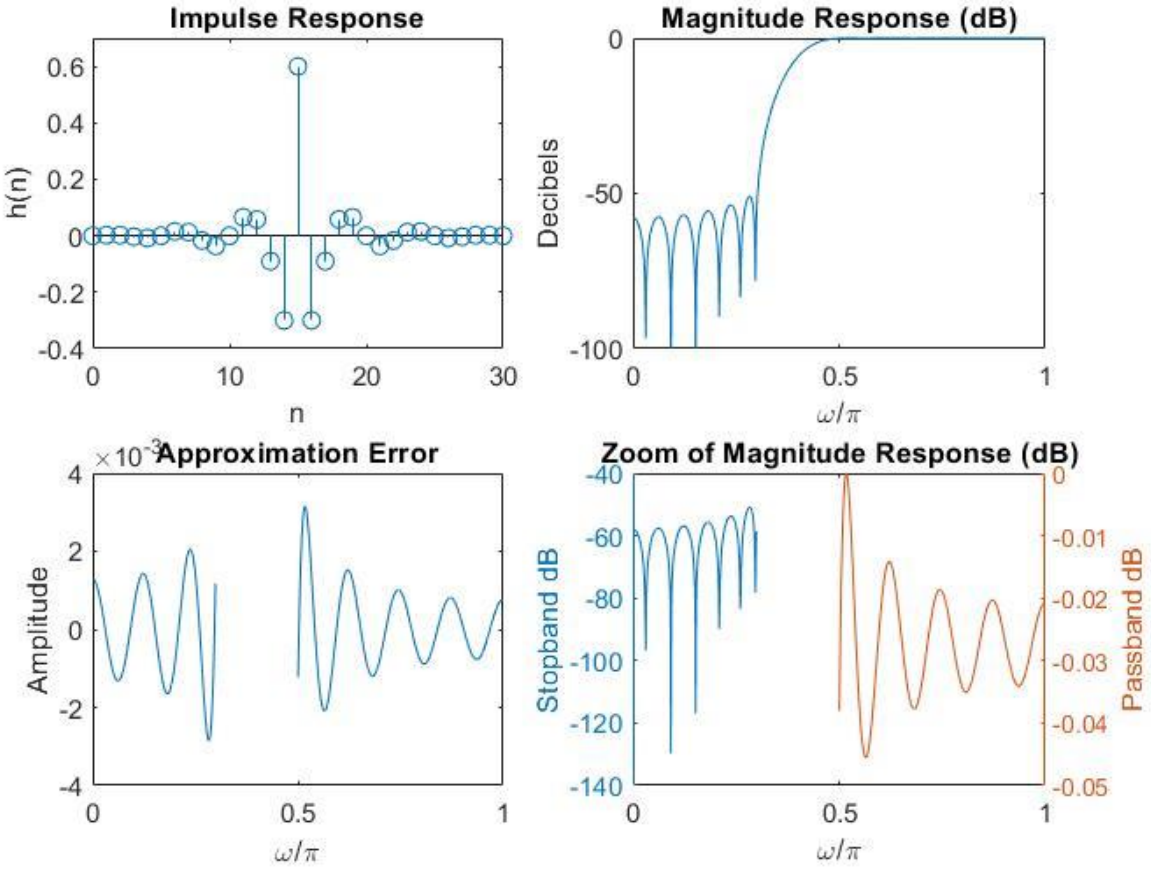


Problem 6.

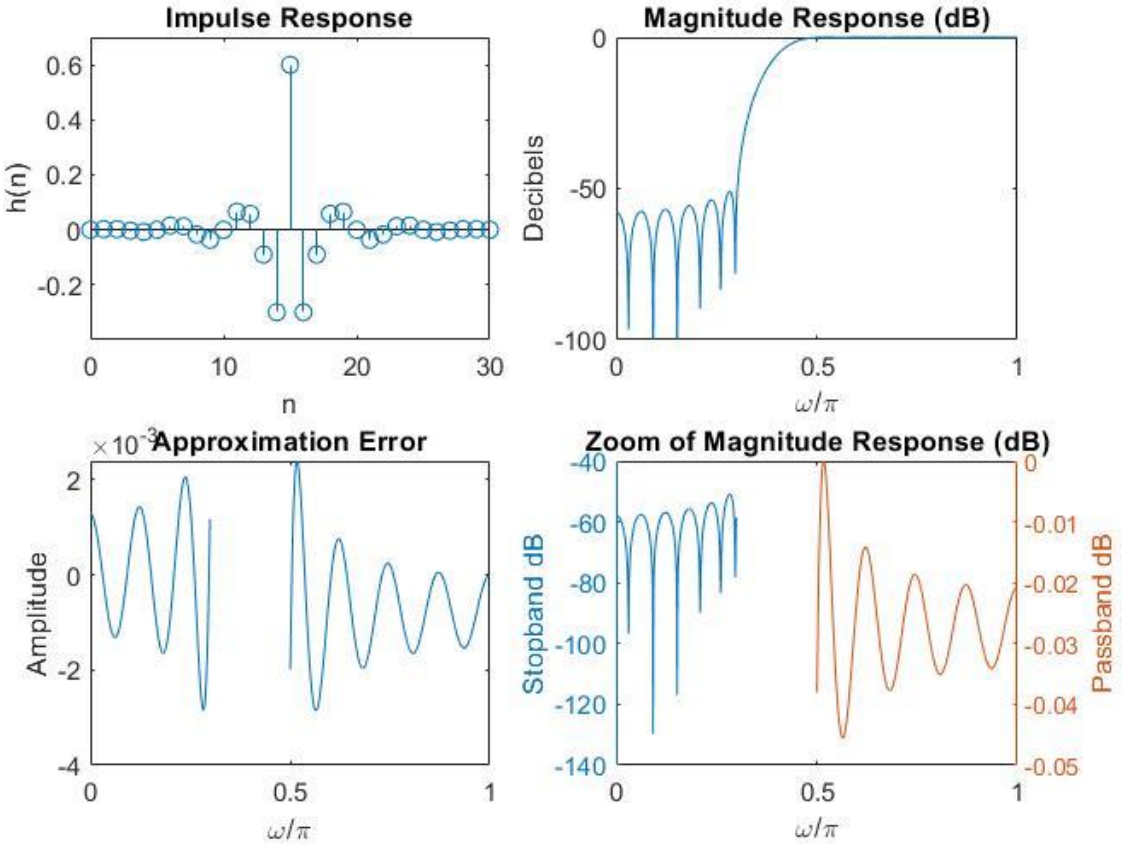
```
close all; clc; clear all;
ws = 0.3*pi; wp = 0.5*pi;
As = 50; delta = 10^(-1*(As/20));
[M,wn,beta,ftype] = kaiserord([0.3 0.5],[0 1],[delta,delta]);
%% Part (a)
wc = (ws+wp)/2;
h = ideallp(pi,M) - ideallp(wc,M);
h = h.*kaiser(M+1,beta);
%% Part (b)
%h = fir1(M,wn,ftype,kaiser(M+1,beta));

w = linspace(0,1,1000)*pi;
H = freqz(h,1,w);
Hmag = abs(H);
Hdb = 20*log10(Hmag./max(Hmag));
[Ha, w2, P2, L2] = amplresp(h(:)',w);
aperr = nan(1,length(w));
magz1 = nan(1,length(w));
magz2 = nan(1,length(w));
ind = w <= ws;
aperr(ind) = Ha(ind);
magz1(ind) = Hdb(ind);
ind = w >= wp;
aperr(ind) = Ha(ind) - 1;
magz2(ind) = Hdb(ind);

%%  Plot:
subplot(2,2,1)
stem(0:M,h);
xlim([0 M])
ylim([min(h)-0.1 max(h)+0.1])
xlabel('n')
ylabel('h(n)')
title('Impulse Response')

subplot(2,2,2)
plot(w/pi,Hdb);
ylim([-100 0])
xlabel('\omega/\pi')
ylabel('Decibels')
title('Magnitude Response (dB)')
```

```
subplot(2,2,3)
plot(w/pi,aperr);
xlabel('\omega/\pi')
ylabel('Amplitude')
title('Approximation Error')

subplot(2,2,4)
[AX, hf1, hf2] = plotyy(w/pi,magz1,w/pi,magz2);
xlabel('\omega/\pi')
title('Zoom of Magnitude Response (dB)')
set(get(AX(1),'Ylabel'),'string','Stopband dB')
set(get(AX(2),'Ylabel'),'string','Passband dB')
```

(a)



(b)

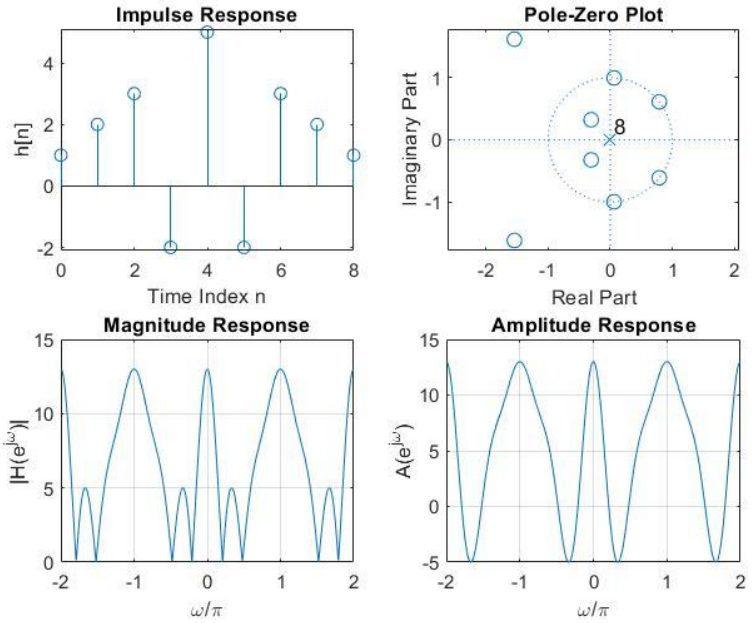

Impulse Response
h(n)
n
Magnitude Response (dB)
Decibels
ω/π
Approximation Error
×10^-3
Amplitude
ω/π
Zoom of Magnitude Response (dB)
Stopband dB
Passband dB
ω/π

Problem 7.

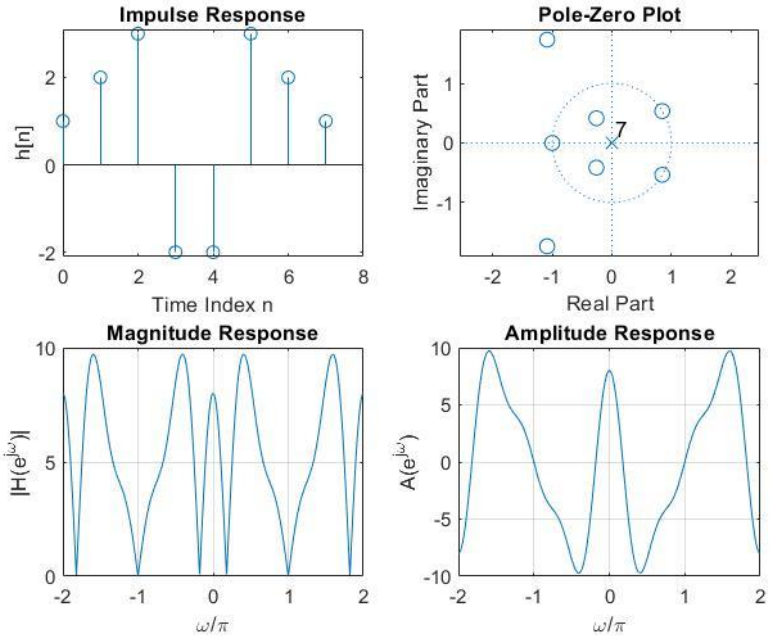
```
close all; clc
%% Part a: Type-I
% hn = [1 2 3 -2 5 -2 3 2 1];
% w = linspace(-2,2,1000)*pi;
%% Part b: Type-II
% hn = [1 2 3 -2 -2 3 2 1];
% w = linspace(-2,2,1000)*pi;
%% Part c: Type-III
% hn = [1 2 3 -2 0 2 -3 -2 -1];
% w = linspace(-2,2,1000)*pi;
%% Part d: Type-IV
hn = [1 2 3 -2 2 -3 -2 -1];
w = linspace(-2,2,1000)*pi;

H = freqz(hn,1,w);
Hmag = abs(H);
Hangle = angle(H);
n = 0:length(hn)-1;
[Hr, w, P, L] = amplresp(hn,w);

%% Plot:
subplot(2,2,1)
stem(n,hn);
ylim([min([hn 0])-.1 max(hn)+.1])
xlabel('Time Index n')
ylabel('h[n]')
title('Impulse Response')

subplot(2,2,2)
zplane(hn,1)
xlabel('Real Part')
ylabel('Imaginary Part')
title('Pole-Zero Plot')

subplot(2,2,3)
plot(w/pi,Hmag); grid on
xlabel('\omega/\pi')
ylabel('|H(e^{j\omega})|')
title('Magnitude Response')
```

```
subplot(2,2,4)
plot(w/pi,Hr); grid on
xlabel('\omega/\pi')
ylabel('A(e^{j\omega})')
title('Amplitude Response')
```

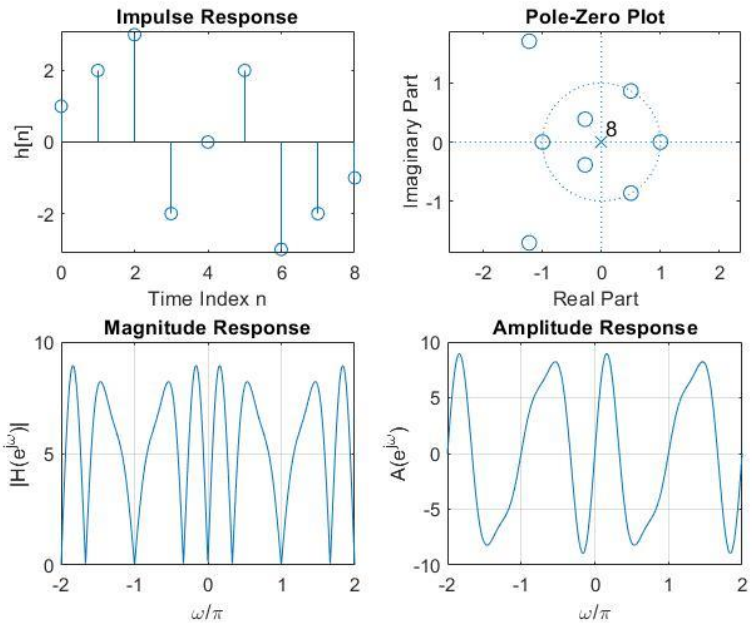
(a)



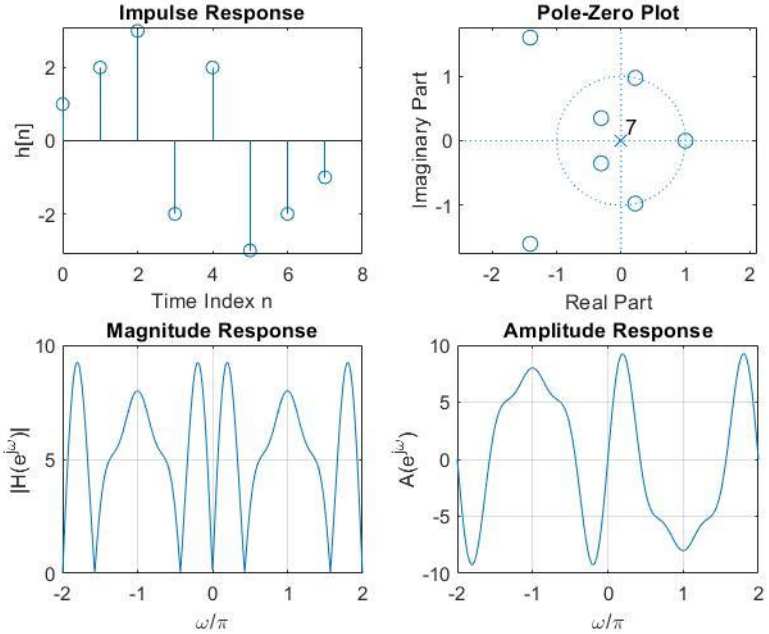
(b)



(c)


Impulse Response
h[n]
Time Index n
Pole-Zero Plot
Imaginary Part
Real Part
8
Magnitude Response
|H(e^jω)|
ω/π
Amplitude Response
A(e^jω)
ω/π

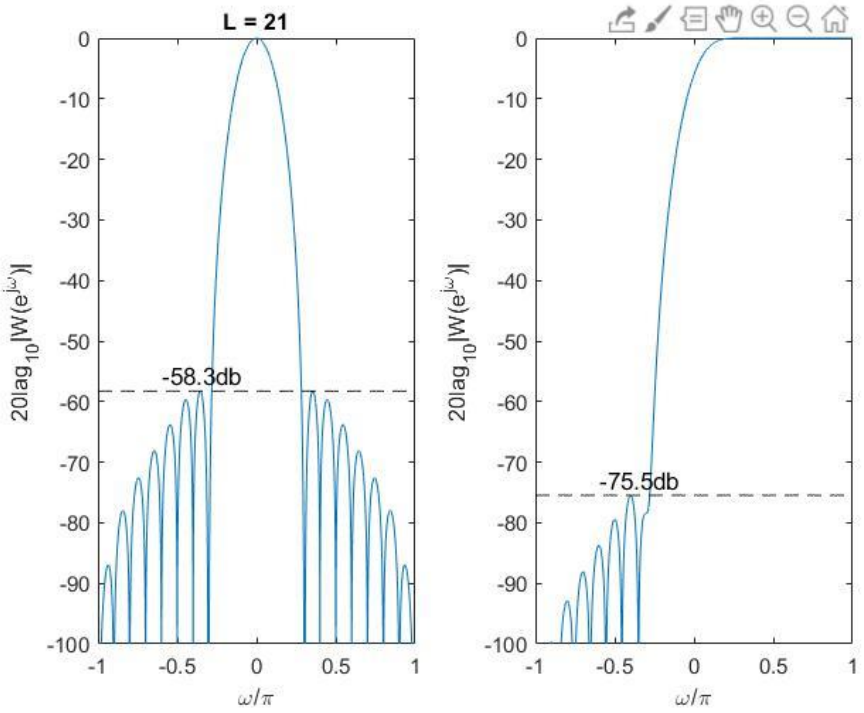
(d)


Impulse Response
h[n]
Time Index n
Pole-Zero Plot
Imaginary Part
Real Part
7
Magnitude Response
|H(e^jω)|
ω/π
Amplitude Response
A(e^jω)
ω/π

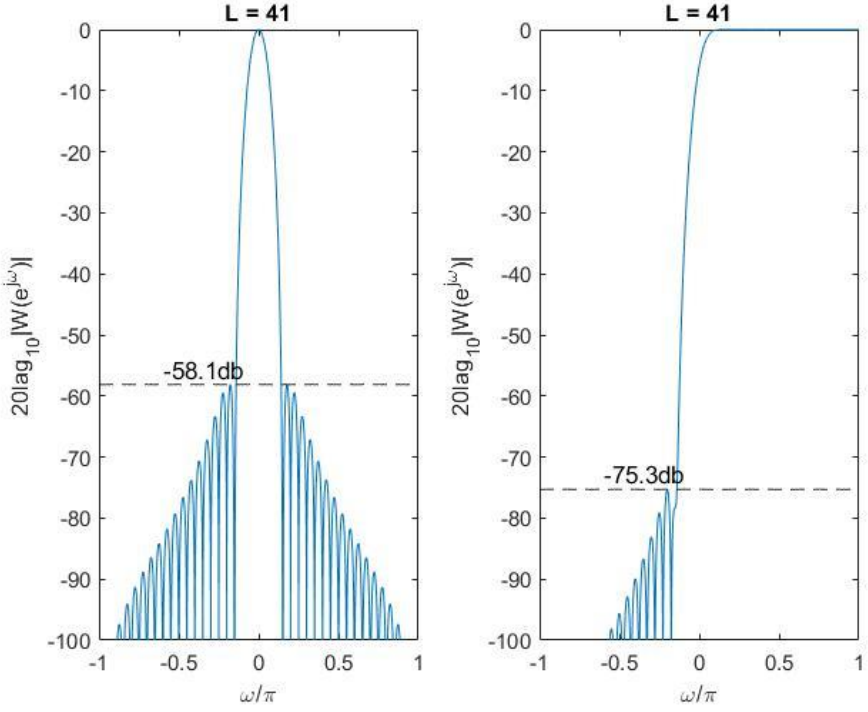
Problem 8.

```
L=21;   % part a
%L=41;  % part c
hw=blackman(L)';
Nw=10000;
w=linspace(-1,1,Nw)*pi;
H=freqz(hw,1,w);
Hmag=abs(H);
Hmagdb=20*log10(Hmag/max(Hmag));
[Ha,w2,P2,L2]=amplresp(hw,w);
Hac=abs(cumsum(Ha));  % part b
Hacdb=20*log10(Hac/max(Hac));

[peakH,peakHind]=findpeaks(Hmagdb);
[peakHac,peakHacind]=findpeaks(Hacdb);
Lshind=w(peakHind)<-1e-8;
sidelobeH =max(peakH(Lshind));
[temp,Lshind]=find(w(peakHacind)<0);
sidelobeHac=max(peakHac(Lshind));

subplot(1,2,1);
plot(w/pi,Hmagdb);hold on
plot(w/pi,sidelobeH*ones(1,Nw),'--k');
text(w(Nw/5)/pi,sidelobeH,[num2str(sidelobeH,3),'db'],'verticalalignment','bottom')
;
ylim([-100,0]);
xlabel('\omega/\pi');
ylabel('20lag_{10}|W(e^{j\omega})|');
title(['L = ',num2str(L)]);

subplot(1,2,2);
plot(w/pi,Hacdb); hold on
plot(w/pi,sidelobeHac*ones(1,Nw),'--k');
text(w(Nw/5)/pi,sidelobeHac,[num2str(sidelobeHac,3),'db'],'verticalalignment','bott
om');
ylim([-100,0]);
xlabel('\omega/\pi');
ylabel('20lag_{10}|W(e^{j\omega})|');
title(['L = ',num2str(L)]);
```

(a) and (b)


L = 21
-58.3db
-75.5db
$20\log_{10}|W(e^{j\omega})|$
ω/π

(c)

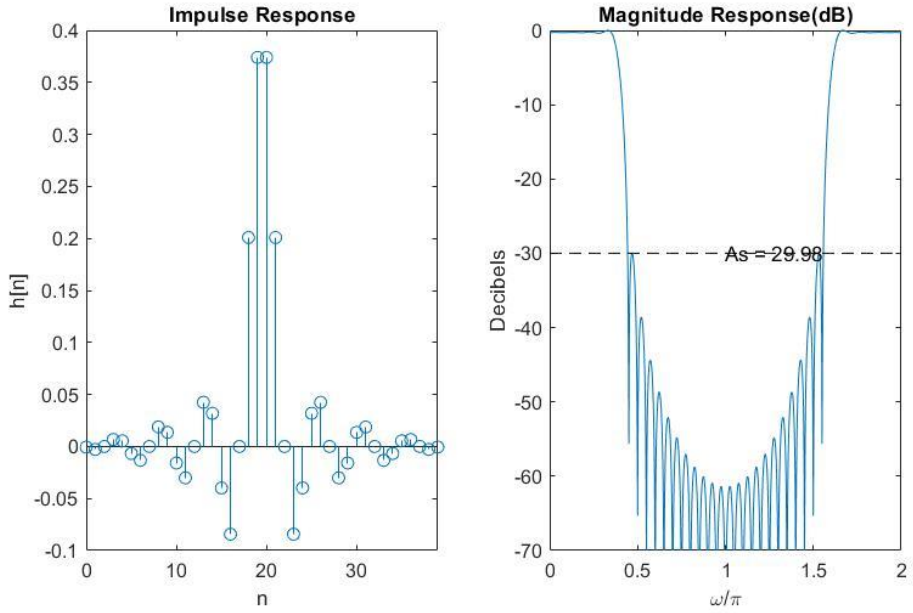

L = 41
L = 41
-58.1db
-75.3db
$20\log_{10}|W(e^{j\omega})|$
ω/π

Problem 9.

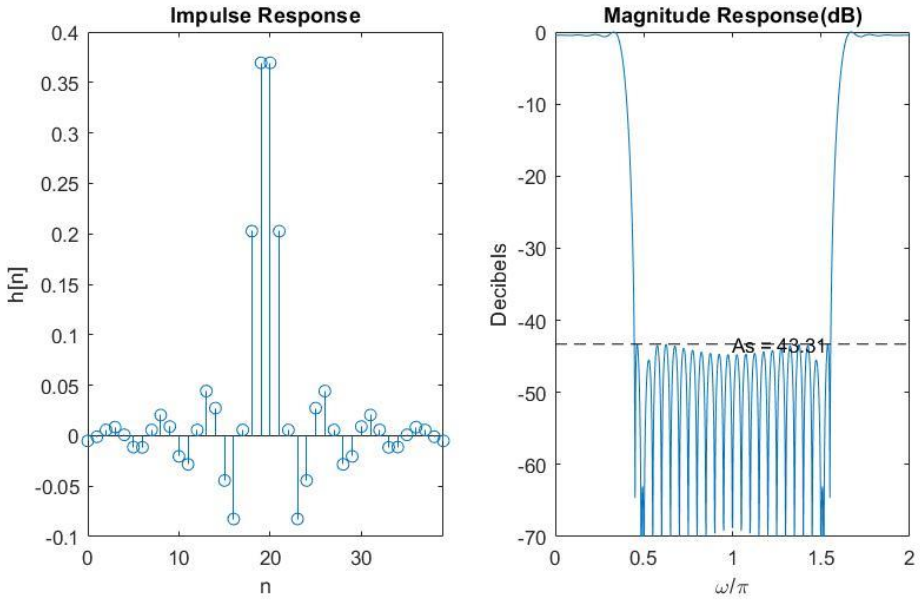
```
L=40; M=L-1;
wc=0.4*pi;Dw=2*pi/L;
om=(0:L-1)*Dw;
alpha = M/2; Q=floor(alpha);
psid = -alpha*Dw*[0:Q,-(L-(Q+1:M))];

%%  Part a
k=wc/Dw;
k_1 = floor(wc/Dw);
k_2 = ceil(wc/Dw);
%T=0.5;  %part a
T = 0.3871;   % part b
Ad =[ones(1,k_1),T,zeros(1,L-k_2*2-1),T,ones(1,k_1-1)];
Hd=Ad.*exp(j*psid);
hd =real(ifft(Hd));
h= hd.*rectwin(L)' ;

%% Part c
ind =om <pi;
h =fir2(M,[om(ind), pi]/pi,[Ad(ind),0]);

%% plot
w=linspace (0,2,1000)*pi;
H=freqz(h,1,w);
Hmag = abs(H);
Hdb =20*log10(Hmag/max(Hmag));

[Hdbpeak,Hdbpeakind] =findpeaks(Hdb);
ind = (w(Hdbpeakind)>wc & w(Hdbpeakind)<2*pi-wc);
[As,Asind]=max(Hdbpeak(ind));
Asloc =w(Asind);

subplot(1,2,2)
plot(w/pi,Hdb); hold on
plot(w/pi,As*ones(1,length(w)),'--','color','k')
text(w(500)/pi,As,['As = ',num2str(abs(As),'%.2f')])
ylim([-80,0])
xlabel('\omega/\pi')
ylabel('Decibels')
title('Magnitude Response(dB)')
```

```
subplot(1,2,1)
stem(0:M,h)
xlim([0,M])
xlabel('n')
ylabel('h[n]')
title('Impulse Response')
```

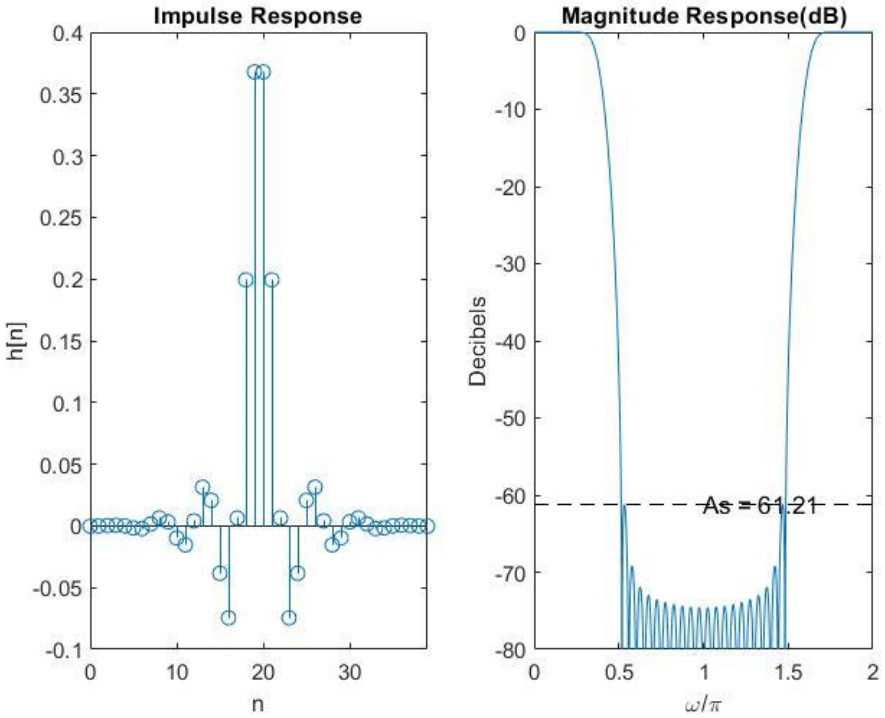
(a)



(b)



(c)


Impulse Response
h[n]
n
Magnitude Response(dB)
Decibels
As = 61.21
ω/π