EEN - 521 Digital Signal and Image Processing

Lab Report 2

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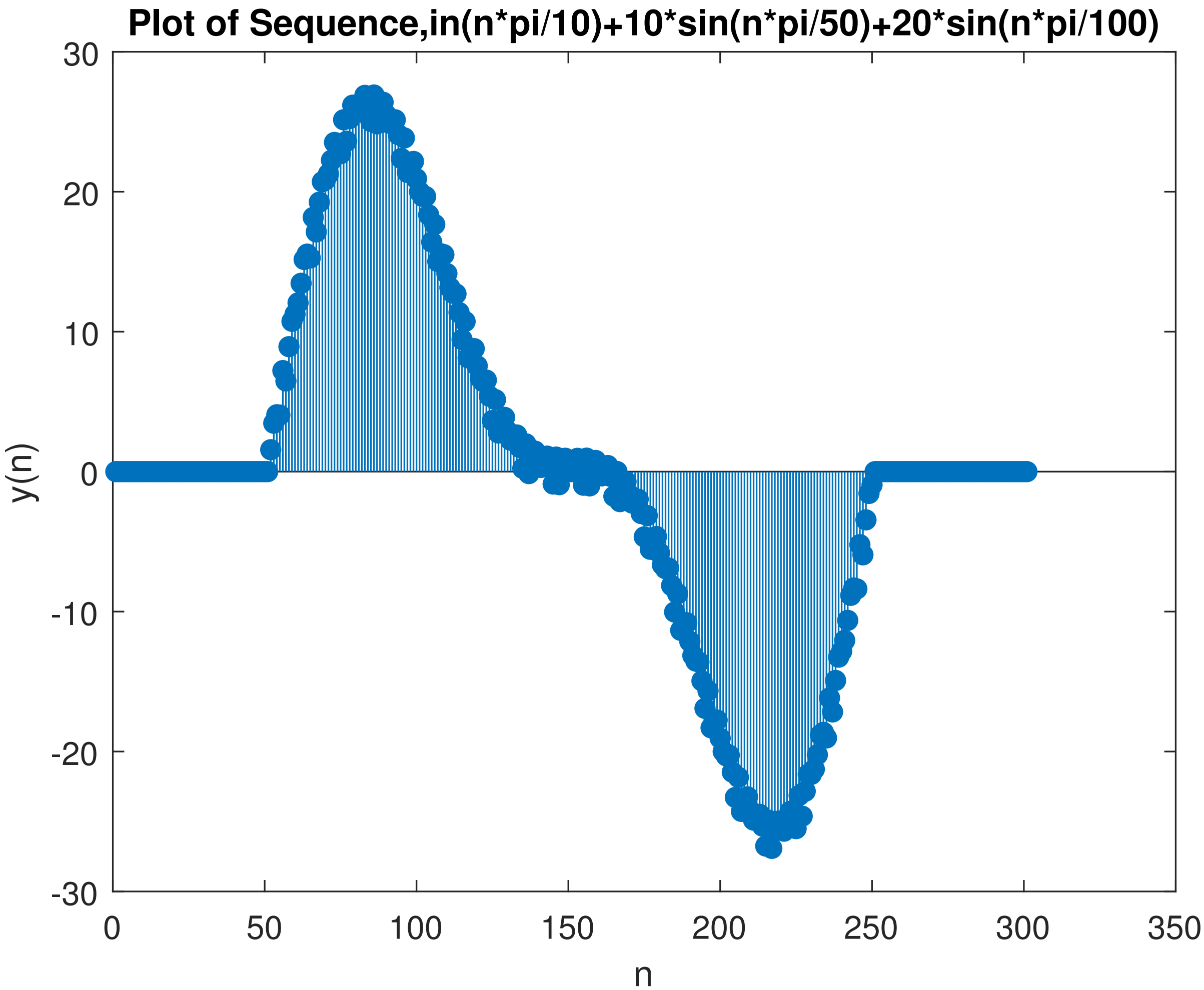
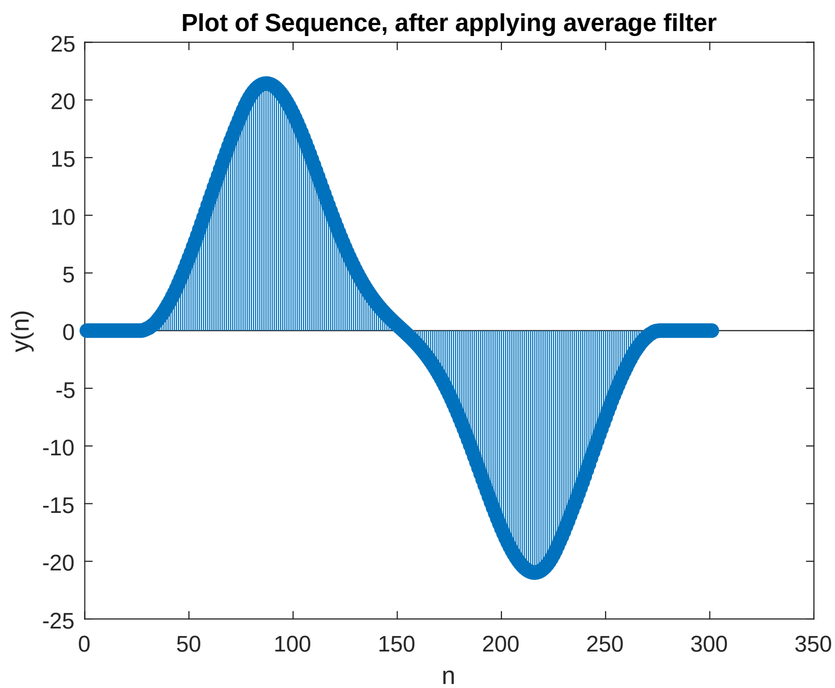
1) Construct a signal
$y = \sin((n\pi/10)n) + 10\sin(n\pi/50) + 20\sin(n\pi/100)$, for $n = 0, 1, 2, , ...200$. Add 50 zeros at both of the ends of signal sample. Construct an averaging window of 50 length and unity strength throughout. Further, impose this averaging window to the mentioned signal, and plot the input and output of the signal.

```
clc; % clearing screen
clear; % clearing previos variables
close all % closing previos windows


n=0:200; % Indices
yn=sin(n.*n*pi/10)+10*sin(n*pi/50)+20*sin(n*pi/100); % Input Sequence
y1n=[zeros(1,50) yn zeros(1,50)]; % Padding Zeros
filterd_Seq=movmean(y1n,50); % Filtering

figure
stem(y1n,'filled'); % plotting Input Sequence
xlabel('n');
ylabel('y(n)');
title('Plot of Sequence,in(n*pi/10)+10*sin(n*pi/50)+20*sin(n*pi/100)');
```



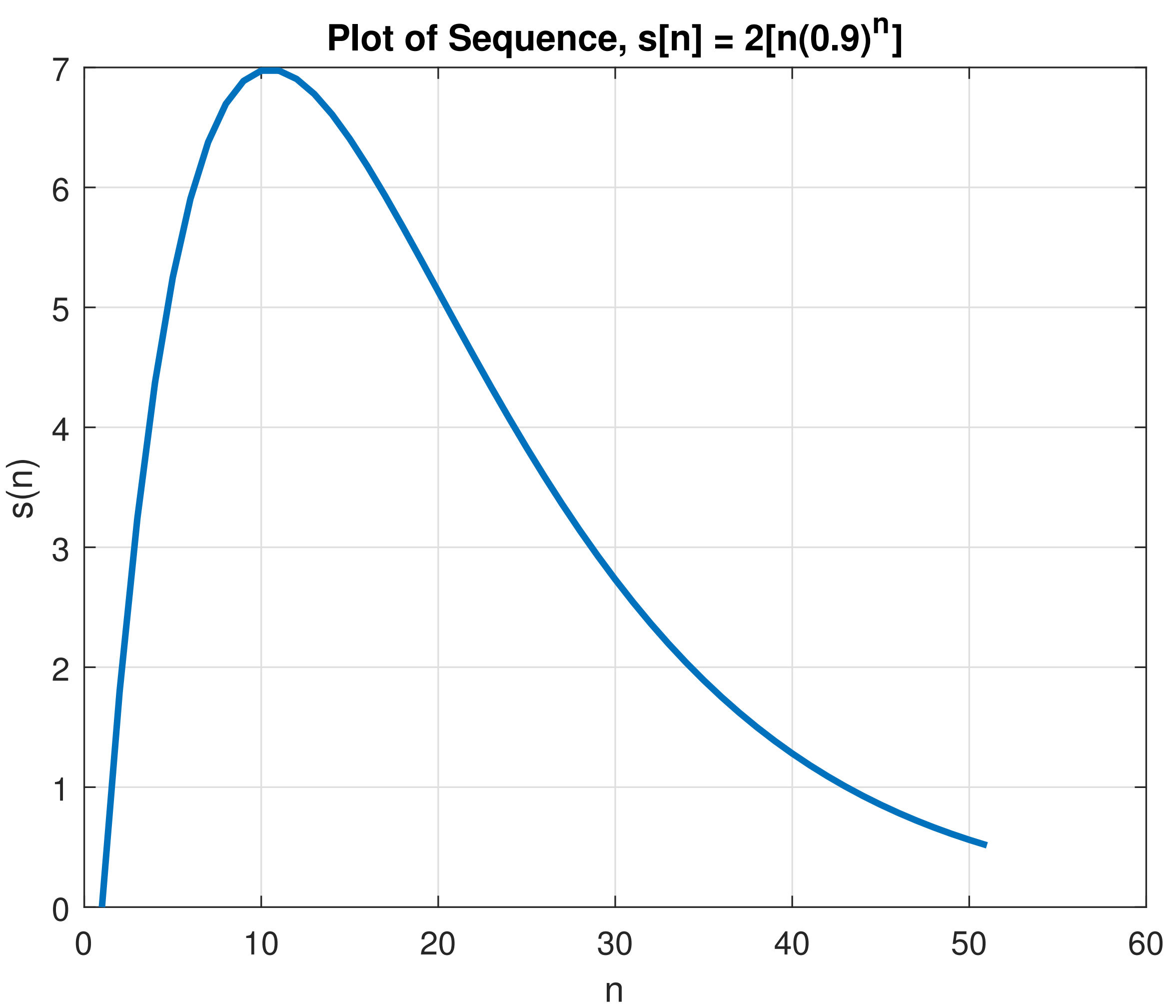

```
figure
stem(filterd_Seq,'filled'); % Plotting Filtered Sequence
xlabel('n');
ylabel('y(n)');
title('Plot of Sequence, after applying average filter');
```



2) Generate a signal s[n] = 2[n(0.9)n], for n = {0, 1, 2, ...50}. Corrupt s[n] with an

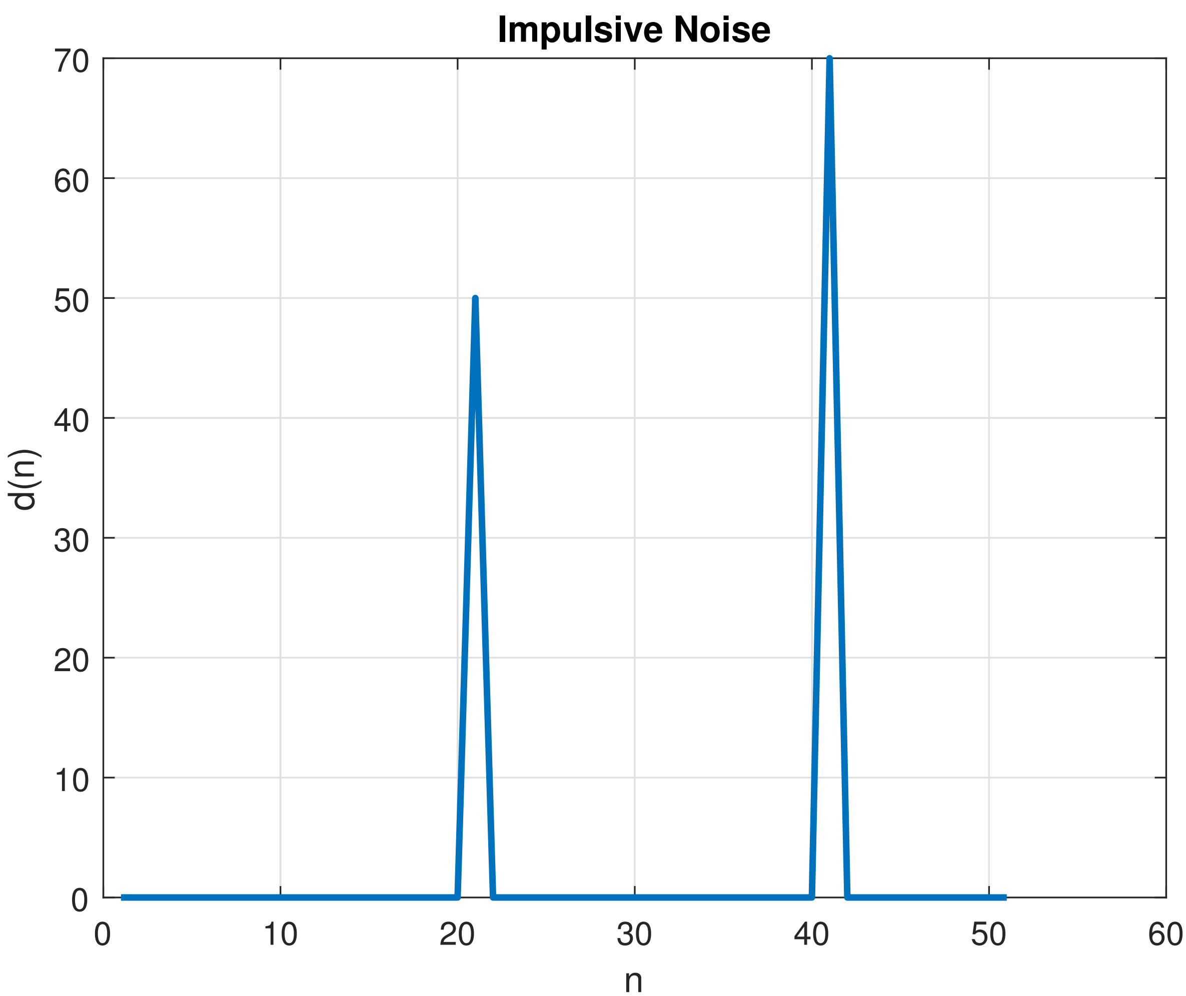
impulse noise d[n]. Apply a median filter of length-3 to the corrupted signal s[n] + d[n] and plot the median filtered signal. Increase the median filter length to 5 and 7 and comment on your results.

```
n = 0:50; % Indices
sn = 2*(n.*(0.9).^n); % Sequence
dn = 50*[n-20==0]+70*[n-40==0]; % Creating Impulsive Noise
xn = sn + dn; % Adding Sequence
mfs3=movmedian(xn,3);
mfs5=movmedian(xn,5);
mfs7=movmedian(xn,7);

figure
plot(sn,'linewidth',2); grid; % Plotting Sequence
xlabel('n');
ylabel('s(n)');
title('Plot of Sequence, s[n] = 2[n(0.9)^n]');
```



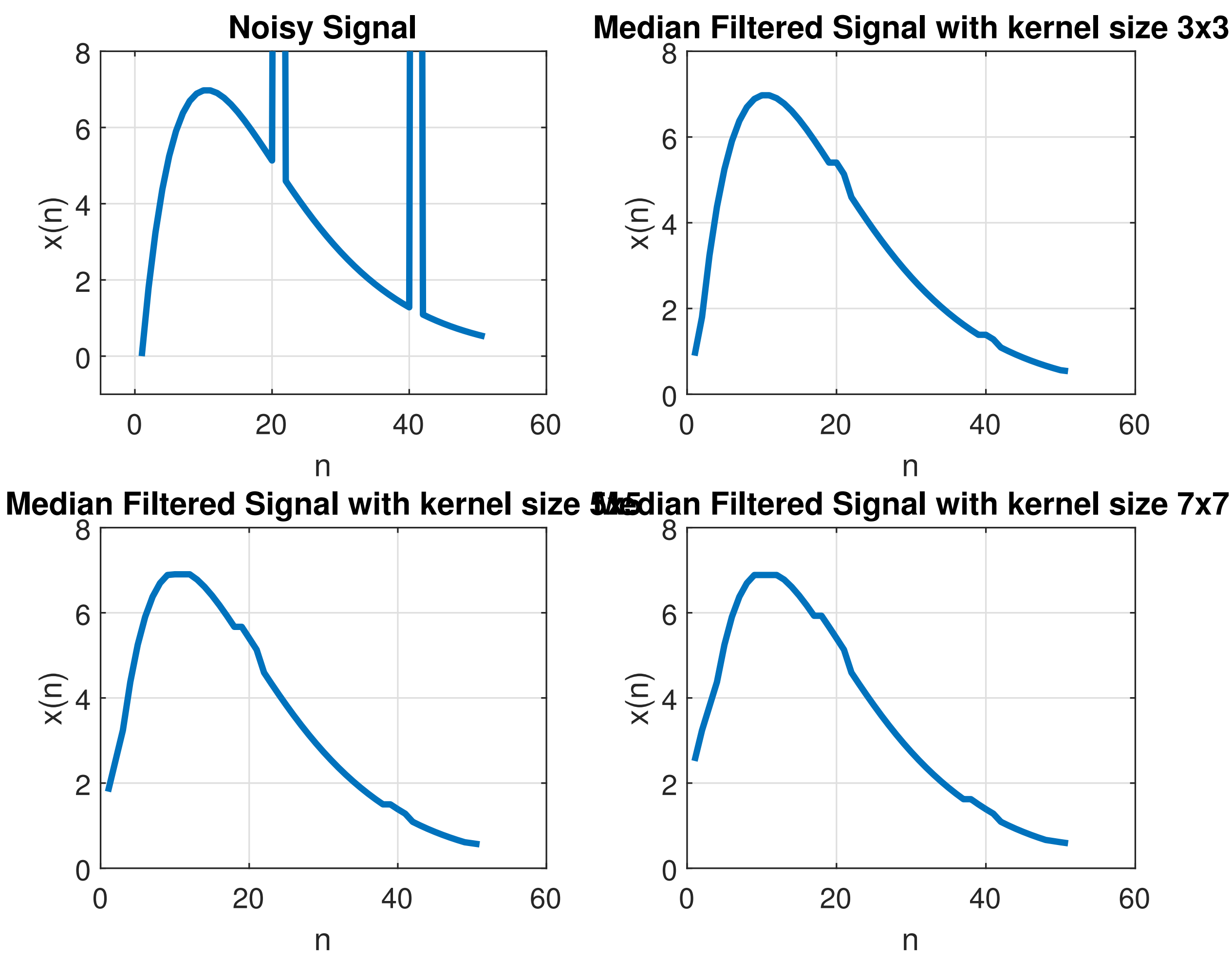

```
figure
```

```
plot(dn,'linewidth',2); grid; % Plotting Noise
xlabel('n');
ylabel('d(n)');
title('Impulsive Noise');
```




```
figure;
subplot(221)
plot(xn,'linewidth',2); grid; % Plotting Noisey Sequence
xlabel('n');
ylabel('x(n)');
title('Noisy Signal');
axis([-5 60 -1 8]);
subplot(222);
plot(mfs3,'linewidth',2); grid; % Plotting Filterd Sequence with kernal 3x3.
xlabel('n');
ylabel('x(n)');
title('Median Filtered Signal with kernel size 3x3');
subplot(223);
plot(mfs5,'linewidth',2); grid; % Plotting Filterd Sequence with kernal 5x5.
```

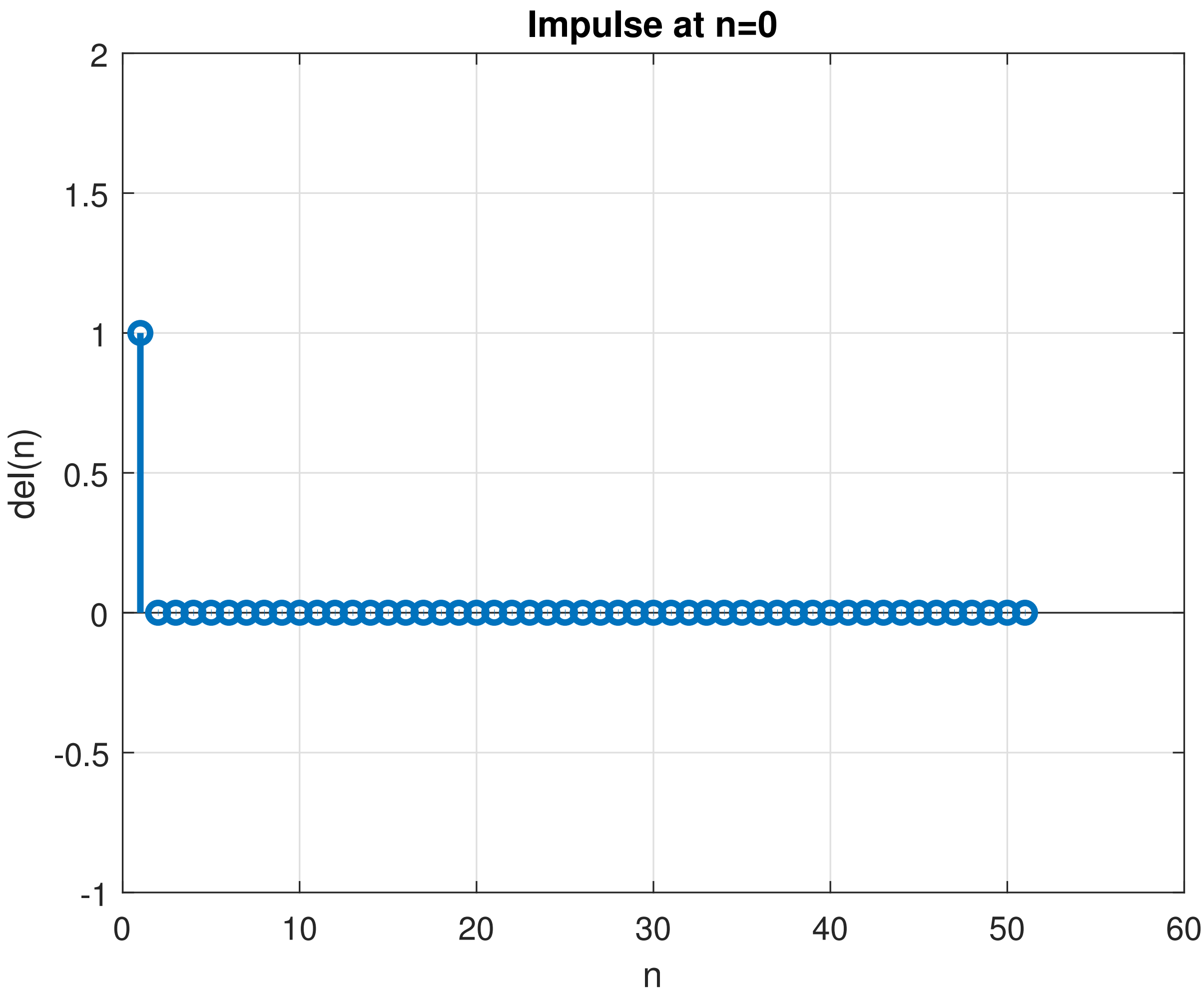
```
xlabel('n');
ylabel('x(n)');
title('Median Filtered Signal with kernel size 5x5');
subplot(224);
plot(mfs7,'linewidth',2); grid; % Plotting Filterd Sequence with kernal 7x7.
xlabel('n');
ylabel('x(n)');
title('Median Filtered Signal with kernel size 7x7');
```



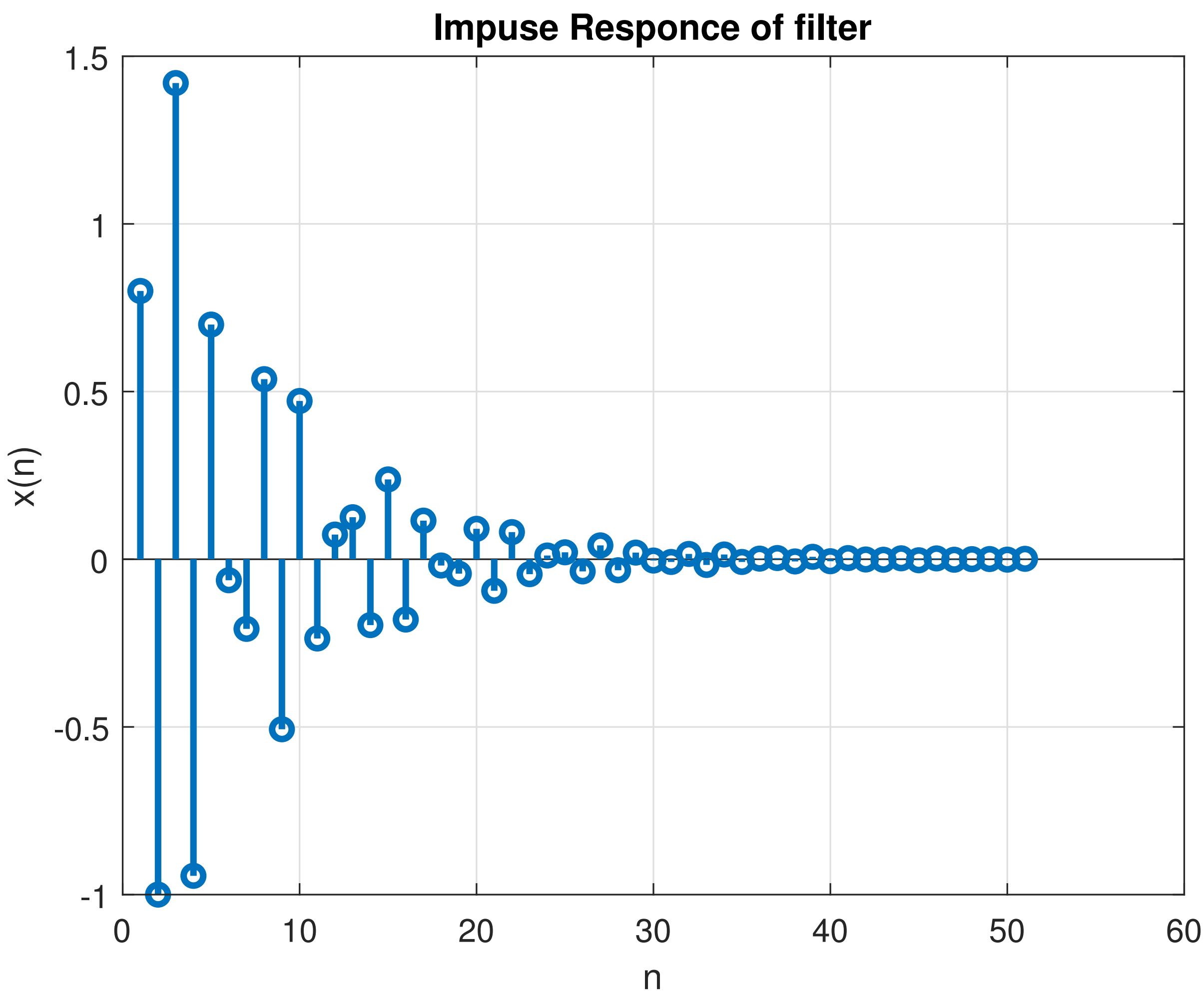
3) Determine the impulse and step responses of the causal LTI system given by y[n] + 0.7y[n-1]-0.45y[n-2]-0.6y[n-3] = 0.8x[n]-0.44x[n-1 + 0.36x[n-2] + 0.02x[n-3]

```
% filter Designing
n=0:50; % Indices
b=[0.8,-0.44,0.36,0.02]; % Filter's Numerator's Coefficients
a=[1,0.7,-0.45,-0.6]; % Filter's Denomonators's Coefficients

imp=[n==0]; % Impuse
imp_resp=filter(b,a,imp); % Impuse Responce
u = [n>=0]; % Unit Step fuction
```

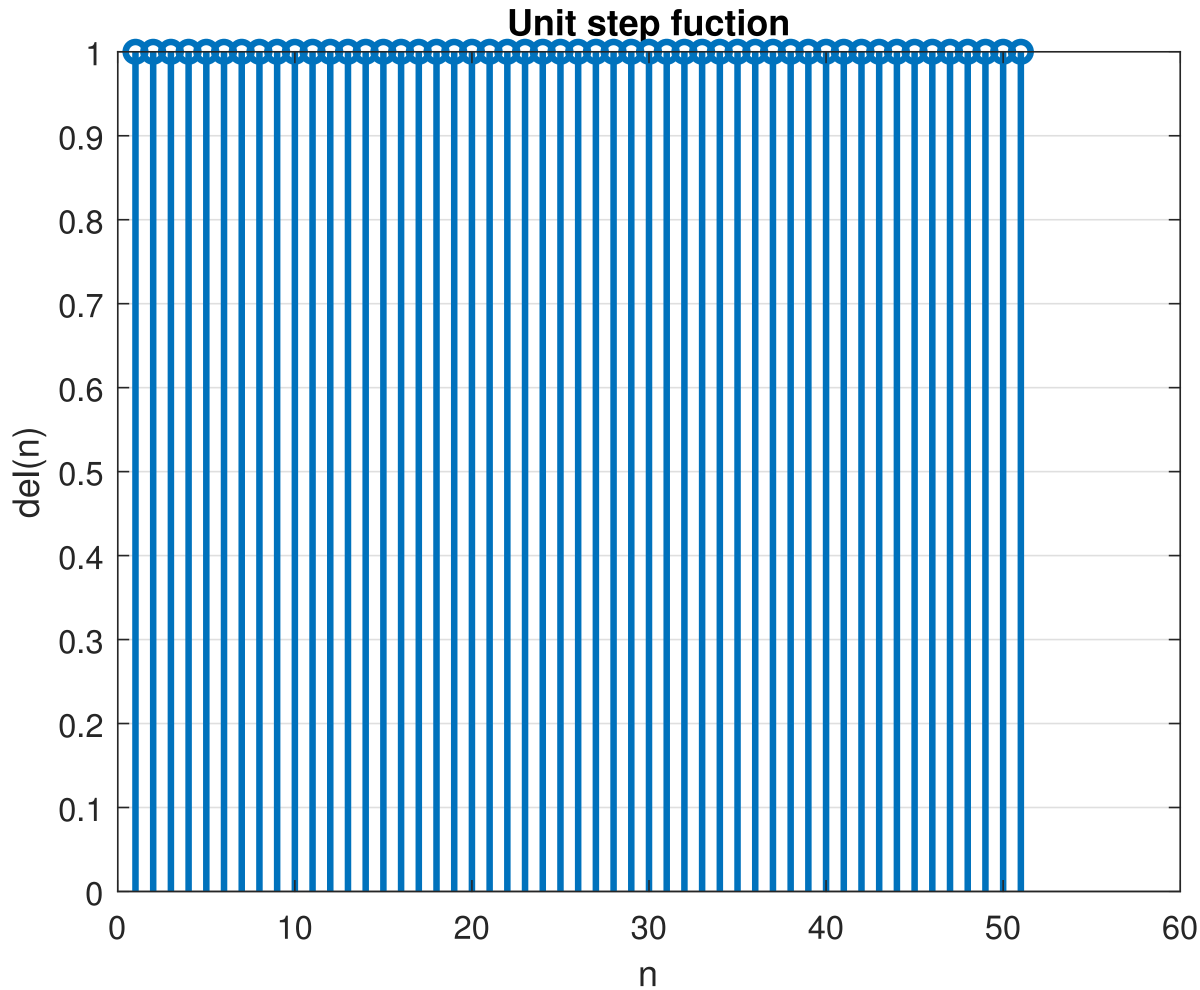
```
step_resp=filter(b,a,u); % Step responce

figure; stem(imp,'linewidth',2); grid; ylim([-1 2]); % Plotting Impulse
xlabel('n'); ylabel('del(n)'); title('Impulse at n=0');
```



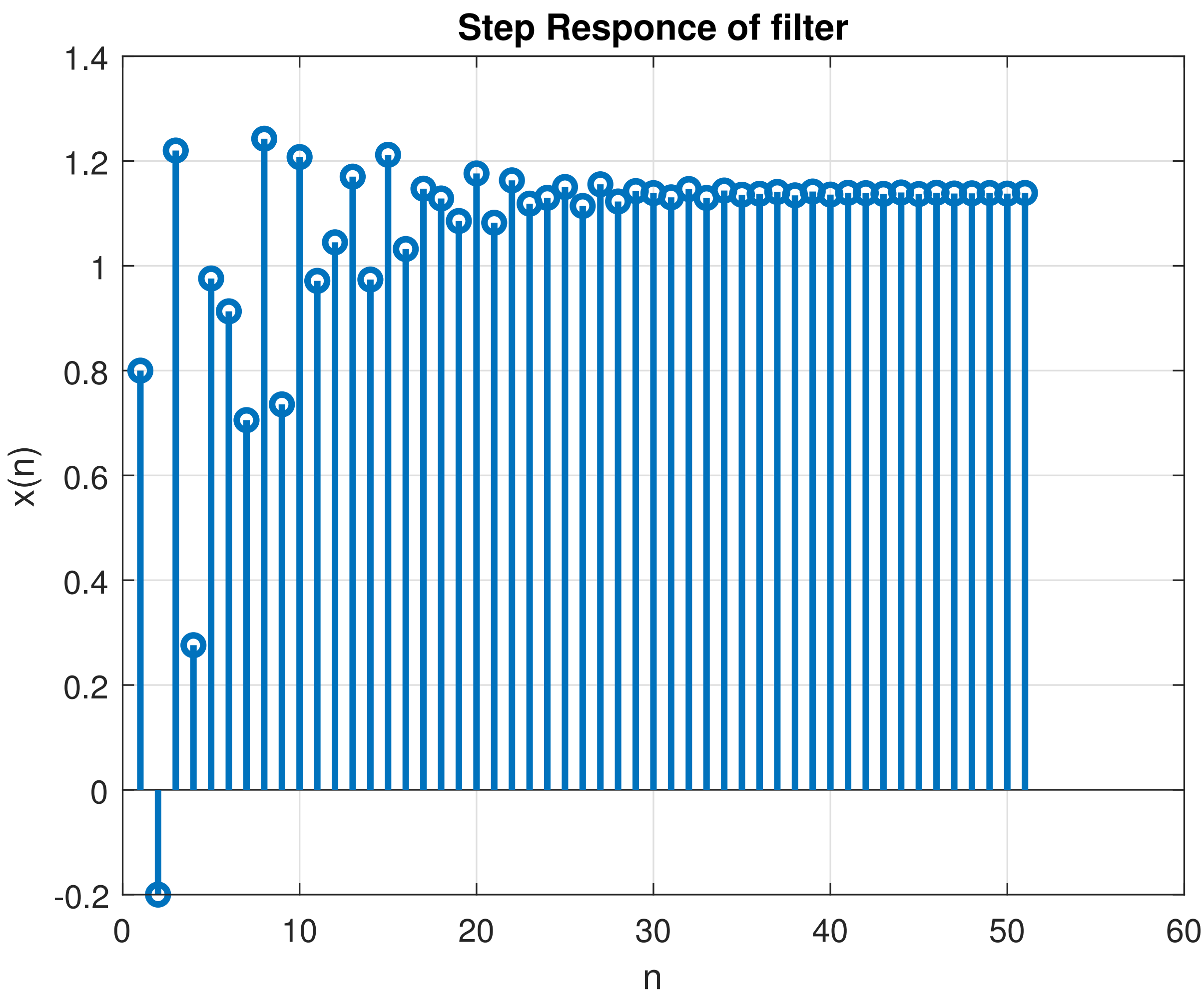

```
figure;stem(imp_resp,'linewidth',2); grid; % Plotting Impulse Responce
xlabel('n'); ylabel('x(n)'); title('Impuse Responce of filter');
```




```
figure; stem(u,'linewidth',2); grid; % Plotiing Unit Step Function
xlabel('n'); ylabel('del(n)'); title('Unit step fuction');
```



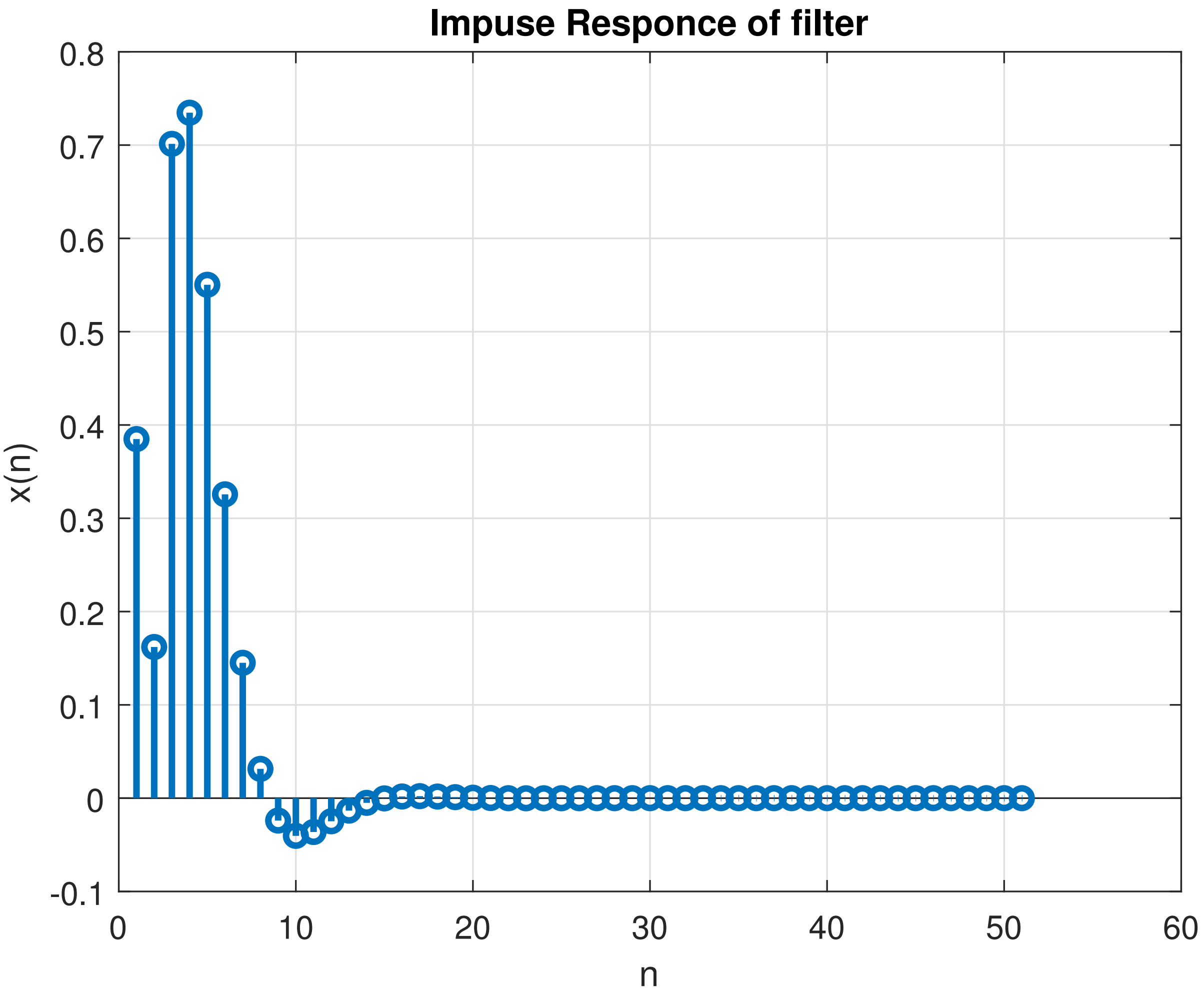

```
figure; stem(step_resp,'linewidth',2); grid; % Plotting Step Responce
xlabel('n'); ylabel('x(n)'); title('Step Responce of filter');
```



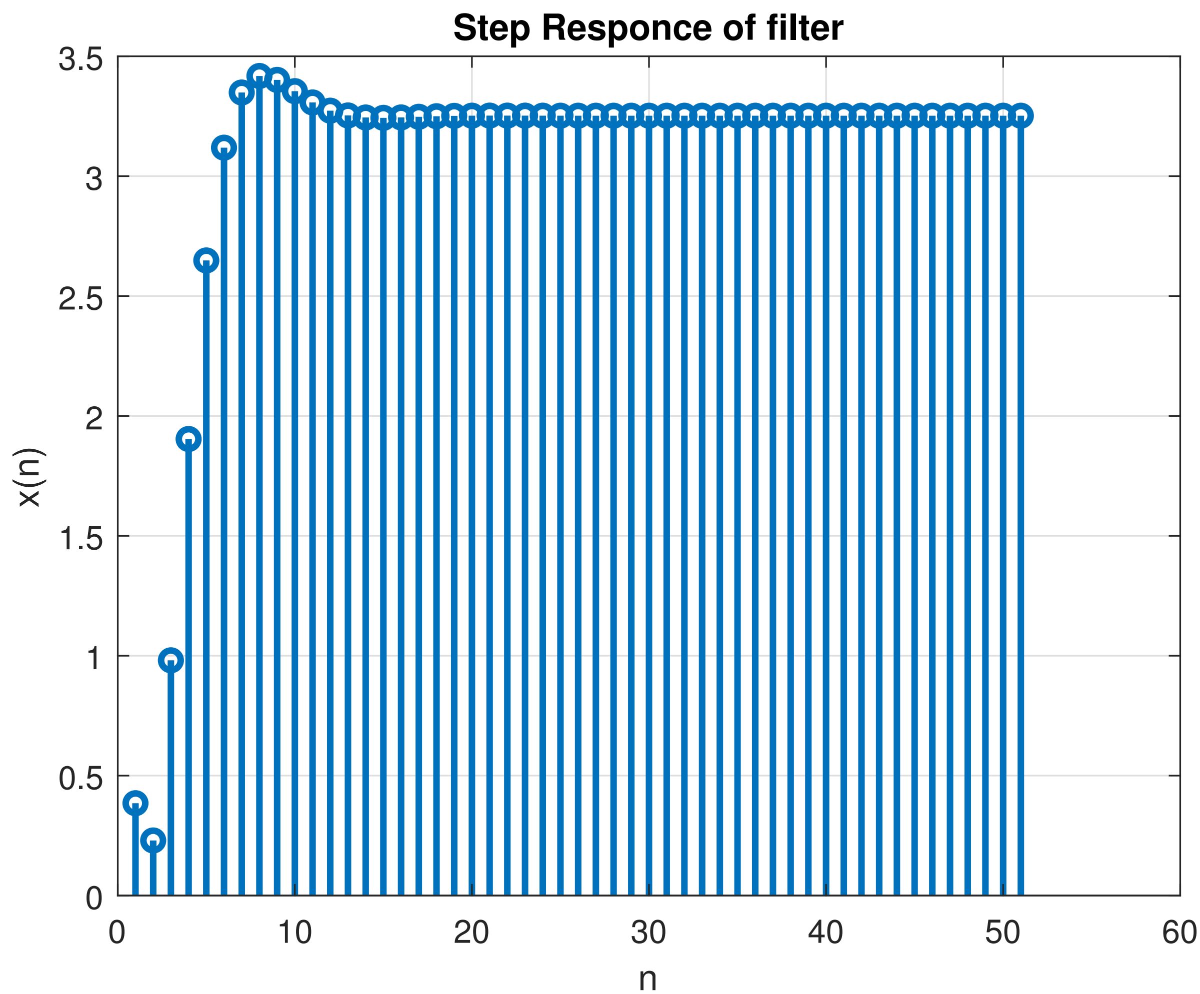
4) Use MATLAB function "filter" & "filtic", to obtain system response for a difference equation y[n] - 1.143y[n - 1] + 0.4128y[n - 2] = 0.0675x[n] + 0.1349x[n - 1] + 0.675x[n - 2] Initial conditions y[-1] = 1; y[-2] = 2.

```
% Filter Designing
b=[0.0675, 0.1349, 0.675];  % Filter's Numerator's Coefficients
a=[1,-1.143, 0.4128]; % Filter's Denomonators's Coefficients
yn=[1,2]; % Initial Values
ic = filtic(b,a,yn); % Inicial Conditions

imp=[n==0]; % Impuse
imp_resp = filter(b,a,imp,ic) % Impuse Responce
```

```
u = [n>=0]; % Unit Step fuction
step_resp = filter(b,a,double(u),ic); % Step responce

figure;stem(imp_resp,'linewidth',2); grid; % Plotting Impulse Responce
xlabel('n'); ylabel('x(n)');title('Impuse Responce of filter');
```



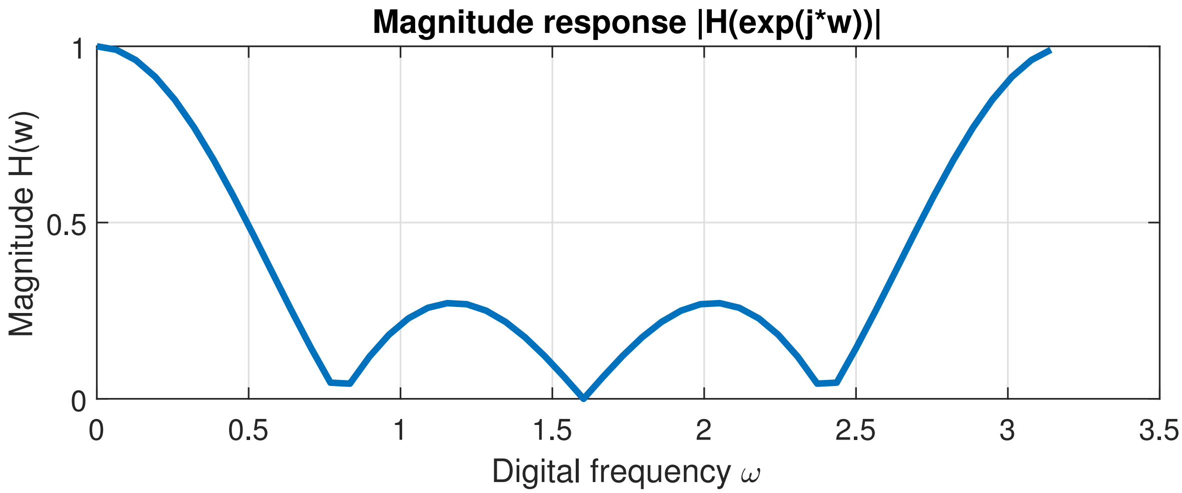

```
figure;stem(step_resp,'linewidth',2); grid;  % Plotting Step Responce
xlabel('n'); ylabel('x(n)');title('Step Responce of filter');
```

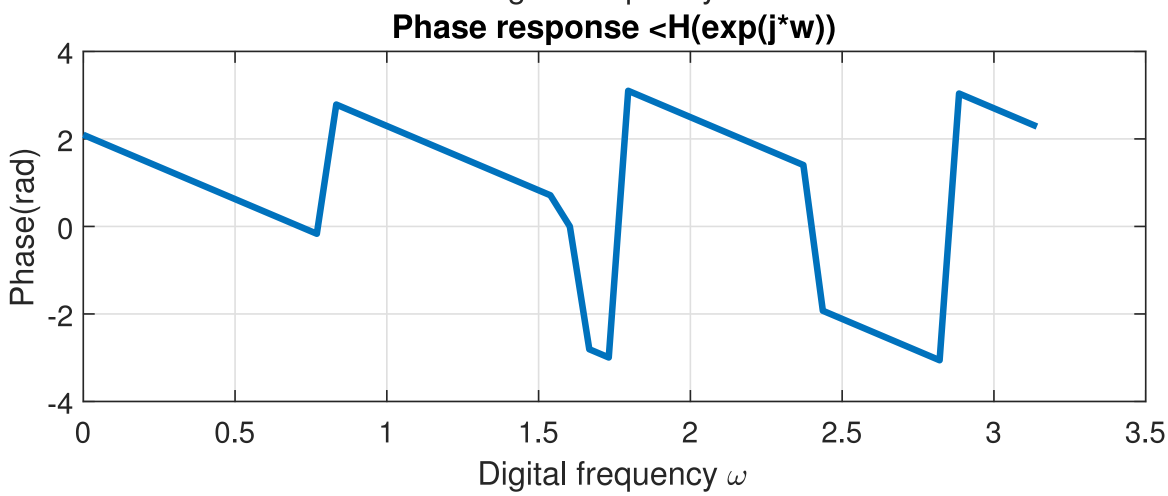


5) Evaluate the frequency response at the frequency $\omega = \pi/3$ and 50 values of the steady state output in response to a complex sinusoidal input of frequency $\omega = \pi/3$ for the moving average system with impulse response $h[n] = (1/4 \quad if \ 0 \leq n \leq 3, \quad 0 \ otherwise$

```
n=0:49; % Indices
len=length(n);
hn=[ones(1,4)/4 zeros(1,len-4)]; % Impulse Responce
xn=exp(j*len*pi/3); % Complex sinosoidal Input
len2=length(xn);

Xw=conv(xn,hn); % Concolving the input sequence with impulse responce.
Yw=fft(Xw); % Calculating fourier transform of convolved sequence.
w=0:pi/49:pi; % frequency range

figure; subplot(2,1,1);
plot(w,abs(Yw),'linewidth',2); grid; % plotting magnitude of spectrum of convolved sequenc
ylabel('Magnitude H(w)'); xlabel('Digital frequency \omega');
title('Magnitude response |H(exp(j*w))|');
subplot(2,1,2);
plot(w,angle(Yw),'linewidth',2); grid; % plotting phase of spectrum of convolved sequence.
```

```
ylabel('Phase(rad)'); xlabel('Digital frequency \omega');
title('Phase response <H(exp(j*w))');
```

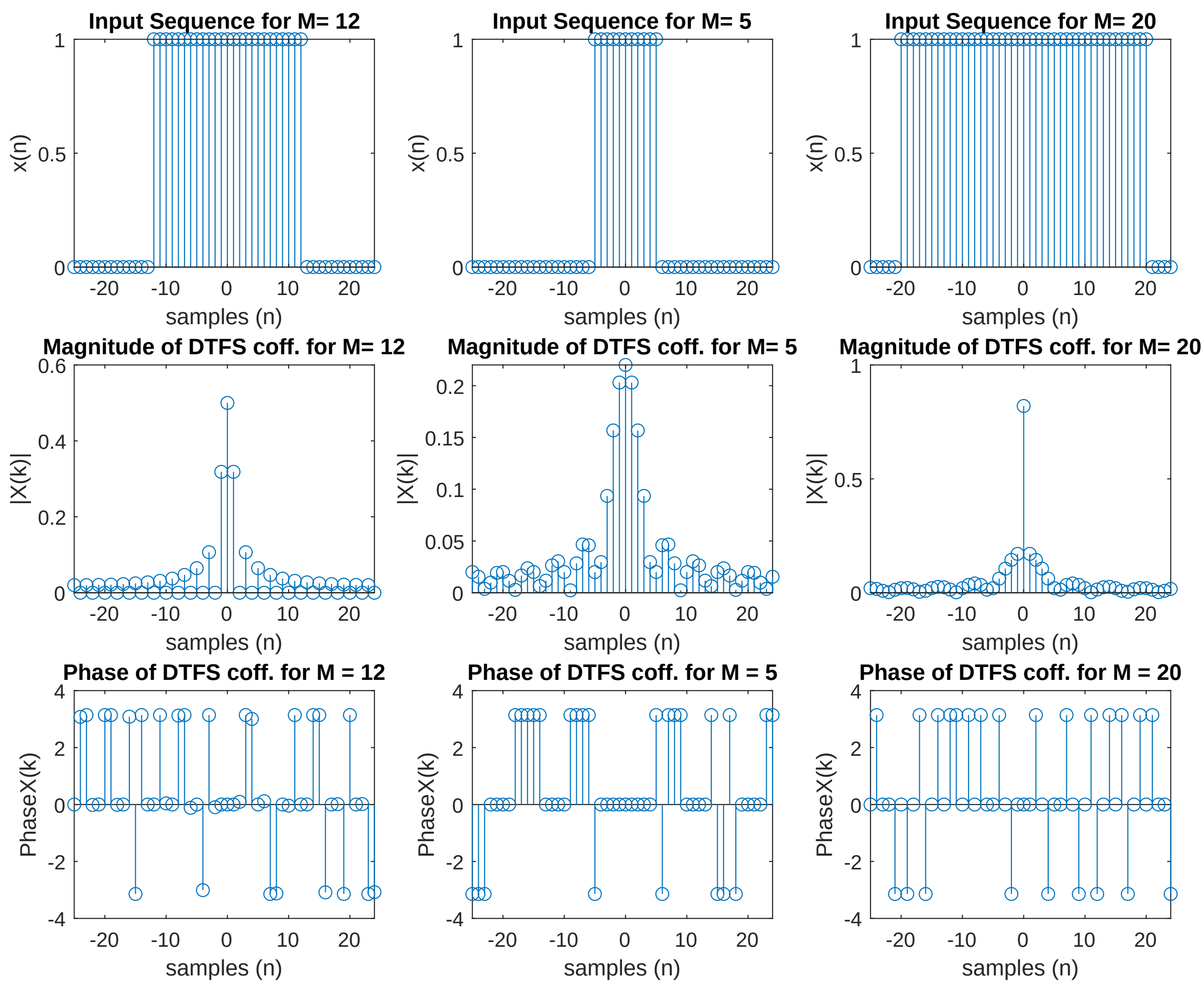




6) Use MATLAB to determine the DTFS coefficients of N- periodic square wave. For period N = 50 and (a) M = 12 (b) M = 5 (c) M = 20 x[n] = (1 if -M < n < M 0 if M < n < N - M

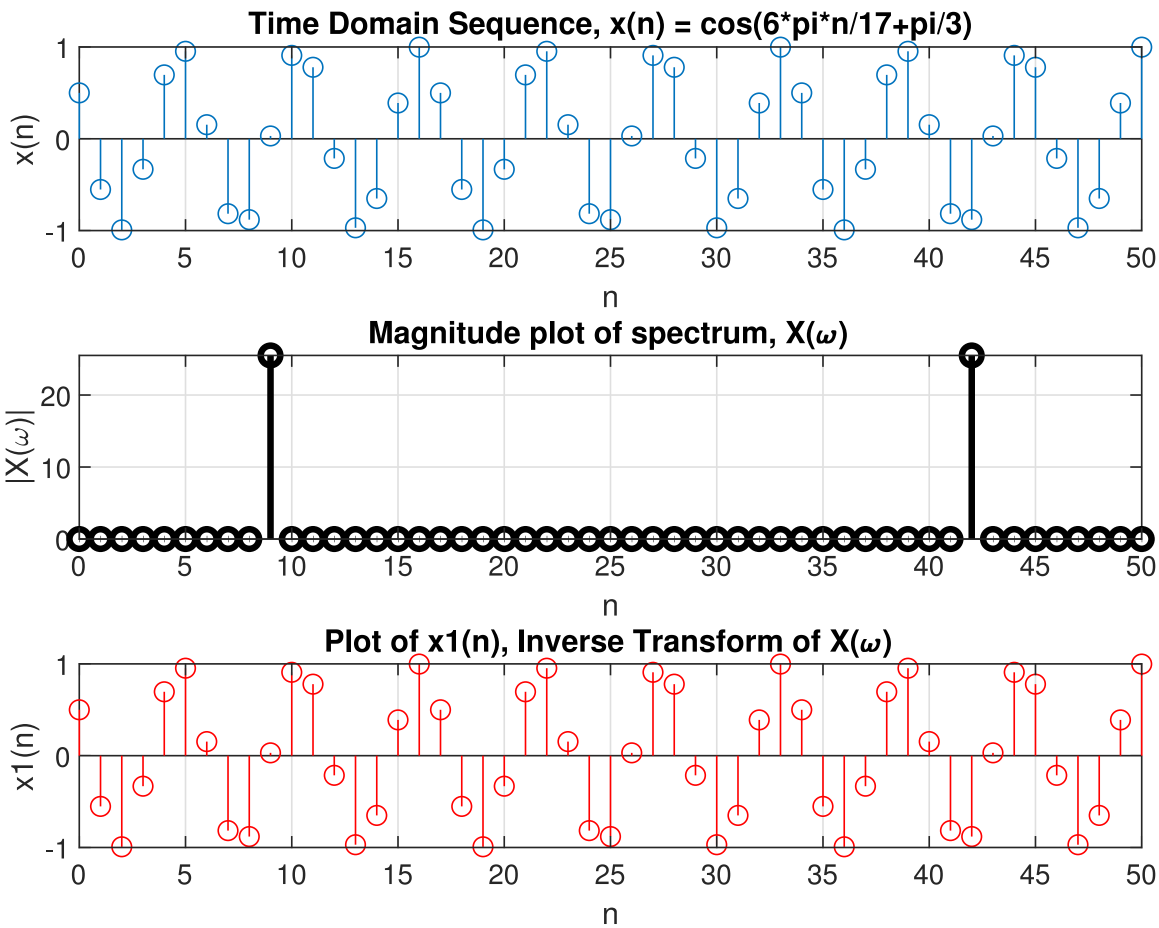
```
N=50; % period
n=-N/2:N/2-1; % Range for time indices
k=-N/2:N/2-1; % Range of frequency indices
M=[12,5,20]; % Length of sequences for the different cases.

figure
for i=1:3
len1=2*M(i)+1; % length of ones
len0=N/2-M(i); % length of zeros
xn=[zeros(1,len0) ones(1,len1) zeros(1,len0-1)]; % Sequence
Xk=(1/N)*xn*exp(-1j*2*pi.*k.*n'/N); % DTFS of sequence.

subplot(3,3,i);
```

```
stem(n,xn); % plotting time domain sequence
xlabel('samples (n)');
ylabel('x(n)');
title(['Sequence in time domain for M= ' num2str(M(i))]);

subplot(3,3,i+3);
stem(k,abs(Xk)); % plotting magnitude of spectrum
xlabel('samples (n)');
ylabel('|X(k)|');
title(['Magnitude plot of DTFS coefficients for M= ' num2str(M(i))]);
subplot(3,3,i+6)
stem(k,angle(Xk)); % plotting phase of spectrum
xlabel('samples (n)');
ylabel('Phase{X(k)}');
title(['Phase plot of DTFS coefficients for M = ' num2str(M(i))]);
end
```


Input Sequence for M= 12
Input Sequence for M= 5
Input Sequence for M= 20
x(n)
samples (n)
Magnitude of DTFS coff. for M= 12
Magnitude of DTFS coff. for M= 5
Magnitude of DTFS coff. for M= 20
|X(k)|
samples (n)
Phase of DTFS coff. for M = 12
Phase of DTFS coff. for M = 5
Phase of DTFS coff. for M = 20
PhaseX(k)
samples (n)

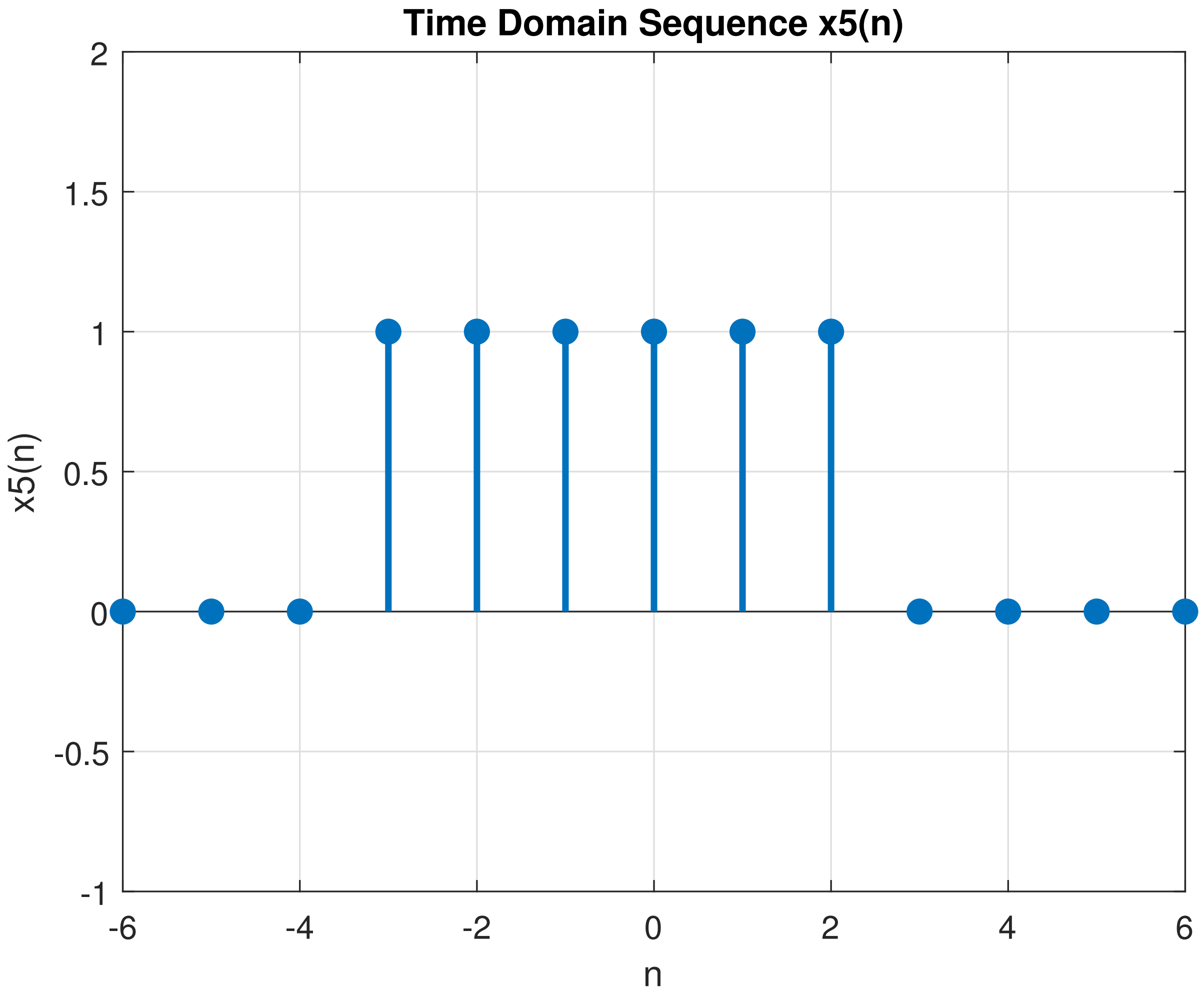
7) Use MATLAB's "fft" & "ifft" commands to evaluate DTFS coefficients & time-domain signal of the following
(a) $\mathbf{x[n] = \cos((6\pi/17)n + \pi/3)}$, (b) $\mathbf{X[k] = \cos(8\pi k/21)}$

```
n=0:50; % indices
xn=cos(6*pi*n/17+pi/3); % Time domain Sequence, x(n).
Xw=fft(xn); % Fourier Transform of sequence x(n).
xn1=ifft(Xw); % Inverse Fourier Transform of X(w).

figure; subplot(311)
stem(n,xn); grid; % plotting the time domain sequence
xlabel('n'); ylabel('x(n)');
title('Time Domain Sequence, x(n) = cos(6*pi*n/17+pi/3)');
subplot(312); k=0:50;
stem(k,abs(Xw), 'k', 'lineWidth',2); grid; % Magnitude plot of spectrum.
xlabel('n'); ylabel('|X(\omega)|');
title('Magnitude plot of spectrum, X(\omega)')
subplot(313);
stem(n,xn1, 'r'); grid; % plotting Inverse fourier transform.
xlabel('n'); ylabel('x1(n)');
title('Plot of x1(n), Inverse Transform of X(\omega)');
```

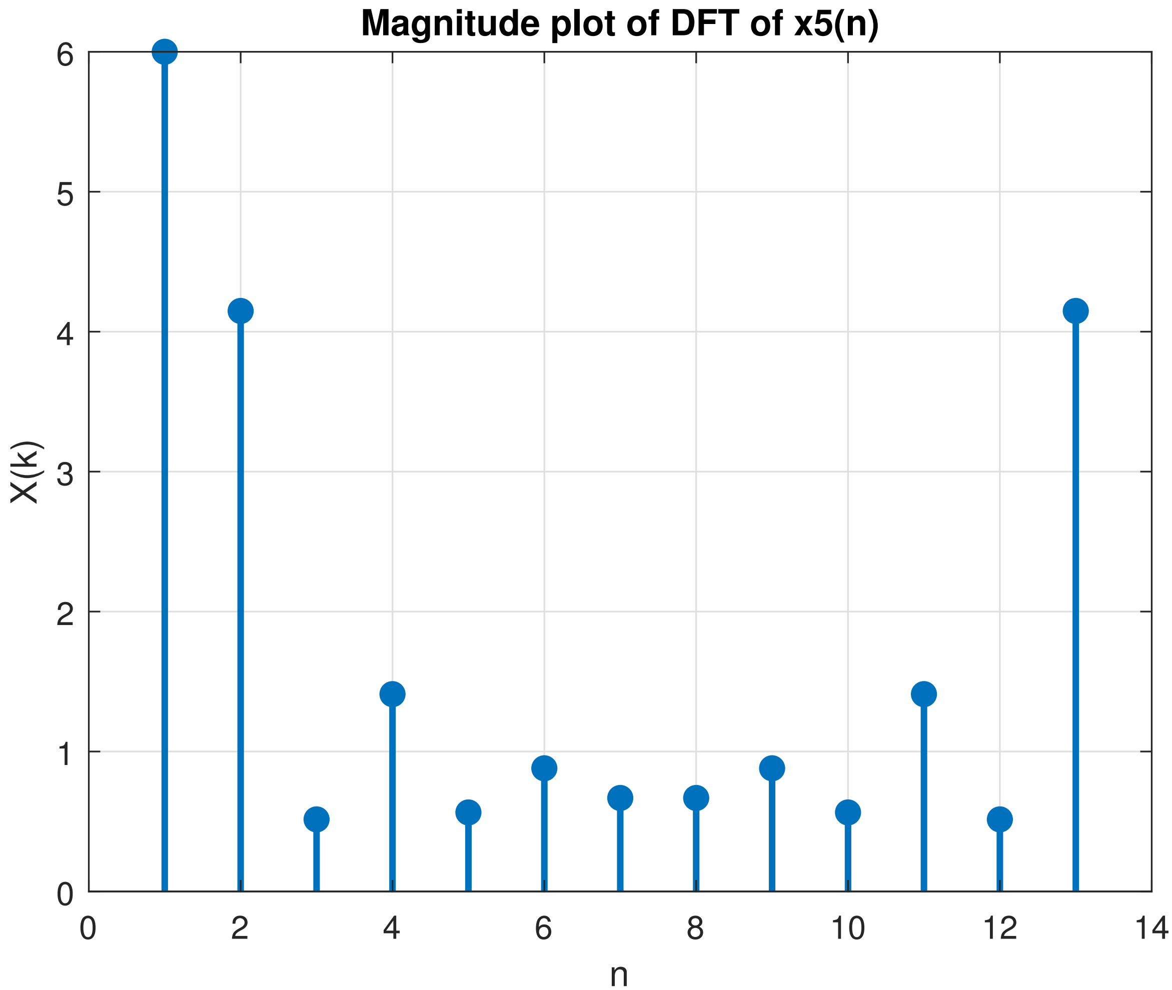


8) Find the DTFT of the discrete-time rectangular pulse $\mathbf{x[n] = (1 \text{ if } -4 < n < 4\ ;\ 0,}$ otherwise Using "fft"

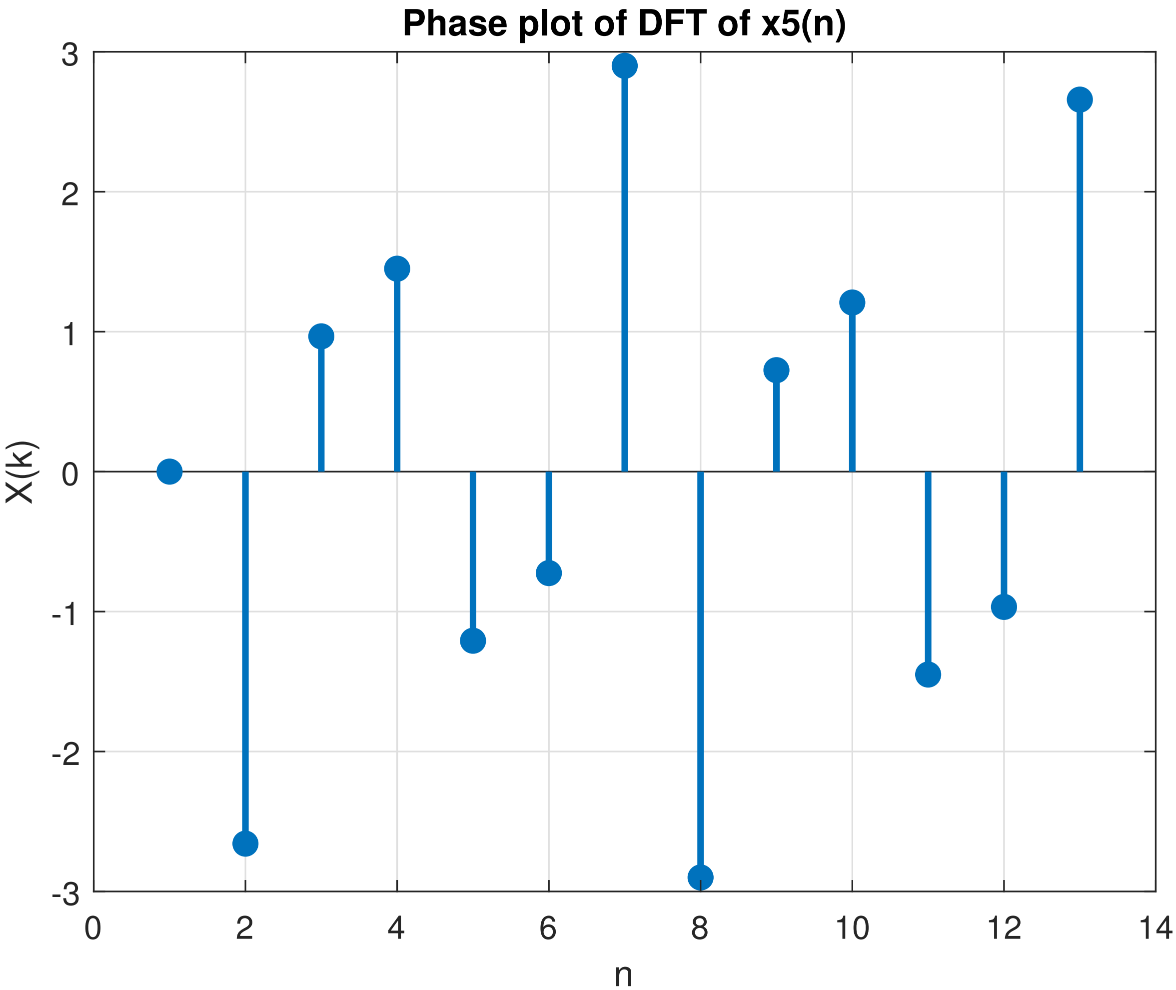
```
n=-6:6; % Indices
xn5= [(n+3) >= 0]-[(n-3) >= 0]; % Sequence
DTFT=fft(xn5);

figure;
stem(n,xn5,'filled','linewidth',2); grid; % plotting time domain sequence
xlabel('n'); ylabel('x5(n)'); axis([-6 6 -1 2])
title('Time Domain Sequence x5(n)');
```




```
figure;
stem(abs(DTFT),'filled','linewidth',2); grid
xlabel('n');
ylabel('X(k)');
title('Magnitude plot of DFT of x5(n)');
```




```
figure;
stem(angle(DTFT),'filled','linewidth',2); grid; % plotting phase spectrum
xlabel('n'); ylabel('X(k)');
title('Phase plot of DFT of x5(n)');
```


Phase plot of DFT of x5(n)
X(k)
n
3
2
1
0
-1
-2
-3
0
2
4
6
8
10
12
14