جامعة بيرزيت

BIRZEIT UNIVERSITY

Faculty of Engineering & Technology

Electrical & Computer Engineering Department

ENCS4310

Digital Signal Processing | Assignment 1

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Part1 Solution

Q1

Part 1

Q1. Generate and plot each of the following sequences over the indicated interval.

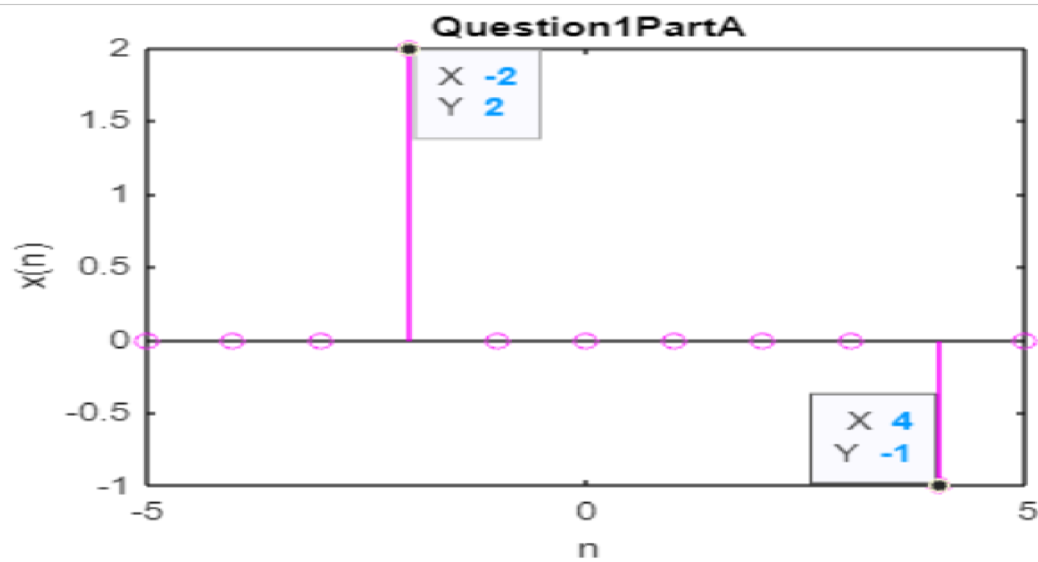
A) $x[n]=2\delta(n+2)-\delta(n-4),\ -5\le n\le 5.$

B) $y[n]=\cos(0.04\pi n)+0.2w(n),\ 0\le n\le 50.$ where w(n) is a Gaussian random sequence with zero mean and unit variance

C) $z[n]=\{...,5,4,3,2,1,\underline{5},4,3,2,1,5,4,3,2,1,...\};\ -10\le n\le 9,$

A) Code & Figure

```
clear all
close all
clc
n=-5:1:5;
[delta1,n]=delta(-2,-5,5);
[delta2,n]=delta(4,-5,5);
x=2*delta1-delta2
stem(n,x,'m')
size(n)
title('Question1PartA')
xlabel('n');
ylabel('x(n)');
```



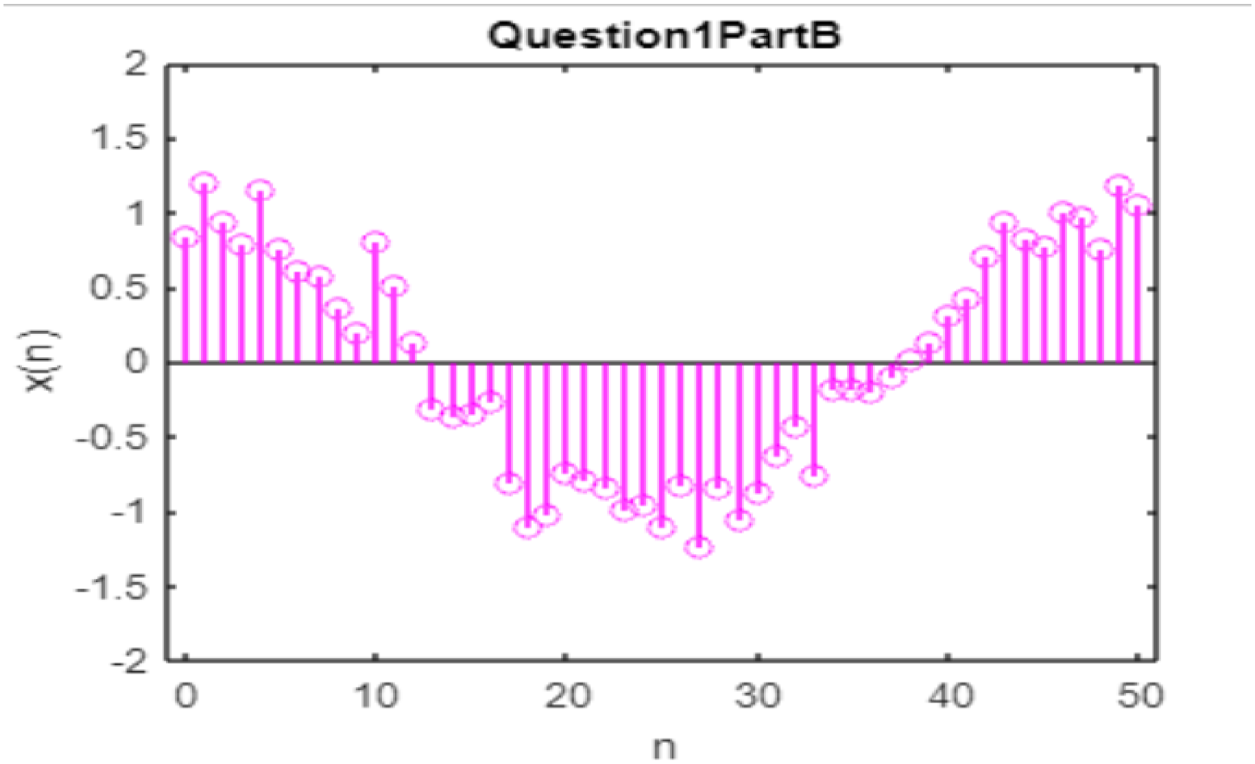
--Unit impulse step sequence code (delta) –function

```
function [x,n]=delta(no,n1,n2)
n=[n1:n2];
x=[(n-no) == 0];
```

B) Code and figure

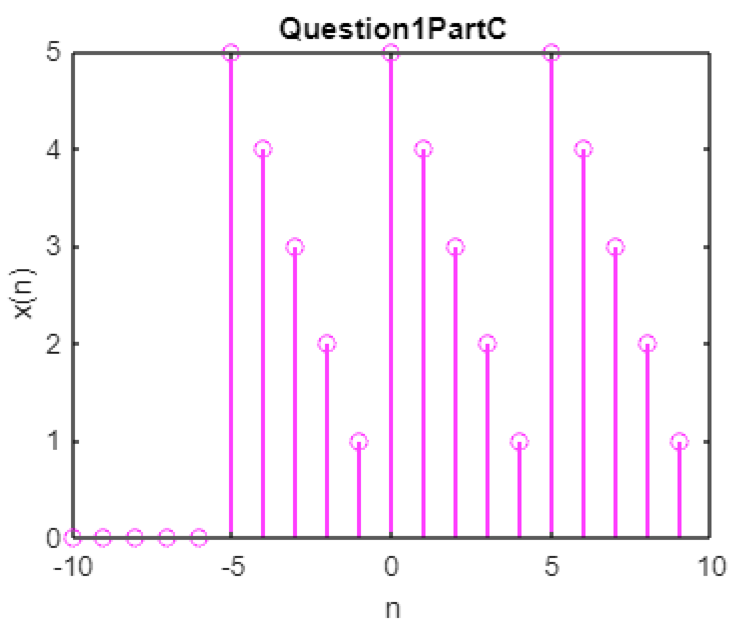
Q1b.m   Figure 1

```
n=[0:50];
p1=cos(0.04*pi*n);
p2=0.2*randn(1,51);
s=p1+p2;
stem(n,s,'m');
axis([-1 51 -2 2])
size(n)
title('Question1PartB')
xlabel('n');
ylabel('x(n)');
```



C) Code & figure

```
n=[-10,-9,-8,-7,-6,-5,-4,-3,-2,-1,0,1,2,3,4,5,6,7,8,9]
x=[zeros(1,5),5,4,3,2,1,5,4,3,2,1,5,4,3,2,1]
stem(n,x,'m');
title('Question1PartC')
xlabel('n');
ylabel('x(n)');
```



Q2:

Q2. Generate and plot each of the following sequences over the indicated interval.

$g(t) = \cos(2\pi F_1 t) + 0.125\cos(2\pi F_2 t), F_1 = 5Hz, F_2 = 15,$, plot g[n] for one second.

A) For $Fs = 50Hz$

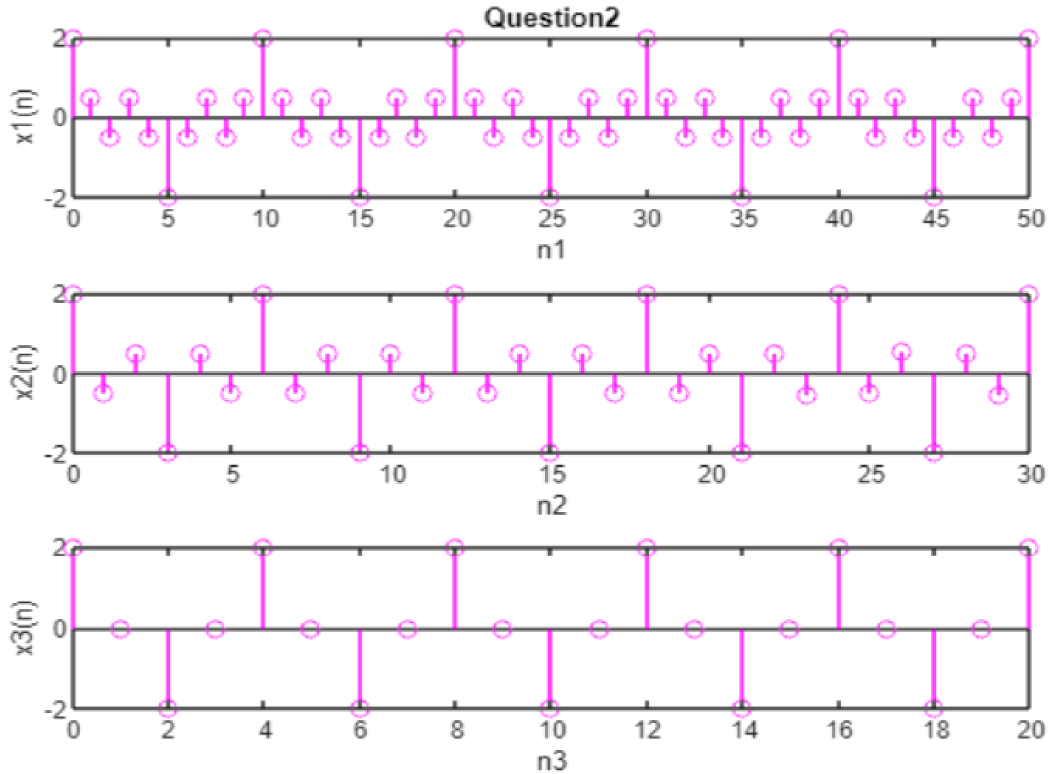
B) For $Fs = 30Hz$

C) For $Fs = 20Hz$

A, B, C) all of them in the figure in the order

Q2.m × | Figure 1 ×

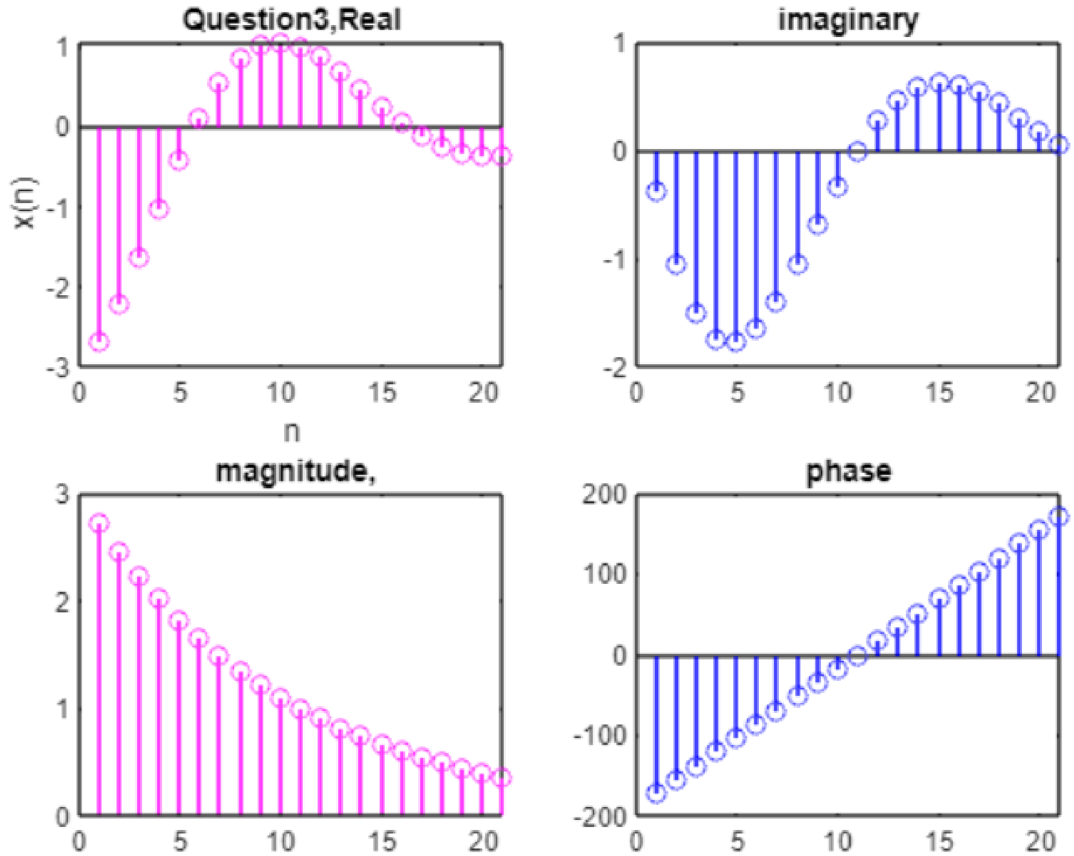
```
%when Fs=50Hz ----A-------------
%w1=2*pi*5khz/50khz=0.2*pi
%w2=2*pi*15khz/50khz=0.6*pi
n=[0:50]
x=cos(0.2*pi*n)+cos(0.6*pi*n)
subplot(3,1,1)
stem(n,x,'m')
title('Question2')
xlabel('n');
ylabel('x(n)');
%when Fs=30Hz --B--------------
n2=[0:30]
x2=cos(0.333*pi*n2)+cos(pi*n2)
subplot(3,1,2)
stem(n2,x2,'m')
xlabel('n');
ylabel('x(n)');
%when Fs=20Hz --C--------------
n3=[0:20]
x3=cos(0.5*pi*n3)+cos(1.5*pi*n3)
subplot(3,1,3)
stem(n3,x3,'m')
xlabel('n');
ylabel('x(n)');
```



Q3:

Q3.m | Figure 1

```
clc
n=[-10:10];
x4=exp(-0.1+0.3i).^n;
axis([-11 12 -3 3])
subplot(2,2,1)
stem(real(x4),'m');
title('Question3,Real')
xlabel('n');
ylabel('x(n)');
subplot(2,2,2)
stem(imag(x4),'b');
title('imaginary')
subplot(2,2,3)
stem(abs(x4),'m');
title(' magnitude,')
subplot(2,2,4)
stem((180/pi)*angle(x4),'b');
title('phase')
```


Question3,Real
x(n)
n
imaginary
magnitude,
phase

Part2 Solution

Q5. For

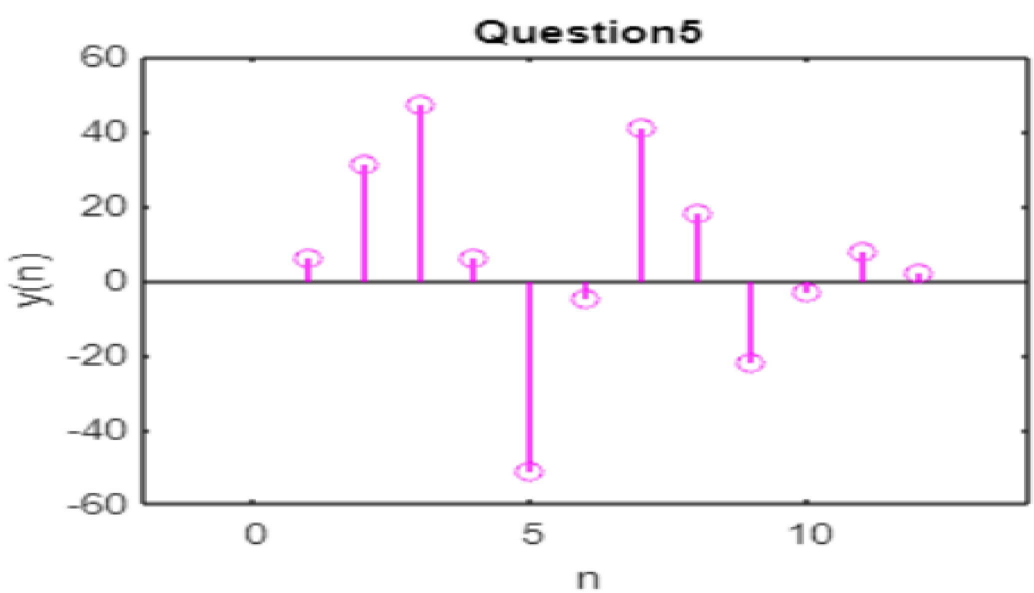
$x[n] = [3, 11, 7, 0 , -1, 4, 2], \ -3 \le n \le 3;$

$h[n] = [2, 3 , 0, -5, 2, 1], \ -1 \le n \le 4$

Find and plot y[n].

- Y[n]=X[n]*H[n]

```
rangeOfx=-3:3;
rangeOfH=-1:4;
x=[3,11,7,0,-1,4,2];
h=[2,3,0,-5,2,1];
y=conv_m(x,rangeOfx,h,rangeOfH)
stem(y,'m')
axis([-2 14 -60 60]);
title('Question5')
xlabel('n');
ylabel('y(n)');
```



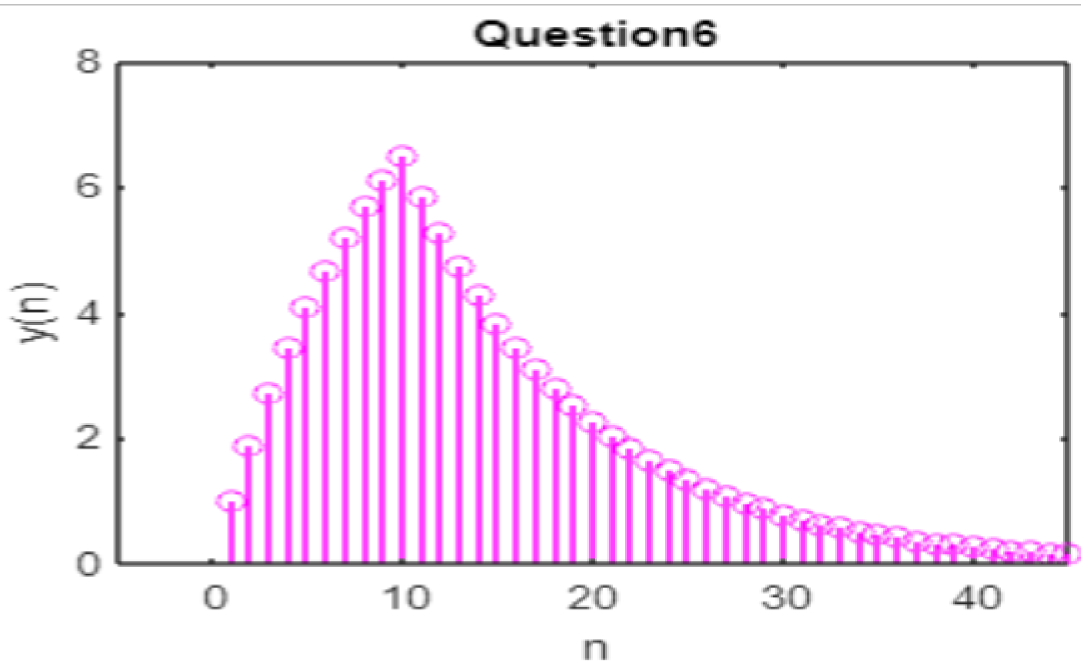
Q6:

Q6. Let the rectangular pulse $x(n) = u(n) - u(n-10)$ be an input to an LTI system with impulse response $h[n] = (0.9)^n u(n)$

Plot x{n], h[n], Find and plot the output y(n). Consider the interval [-5, 45].

Code and Figure

```
n=-5:45
[a,n]=stepseq(0,0,45);
[b,n]=stepseq(10,0,45);
x=a-b;
h=(0.9).^n .*a;
y=conv(x,h)
stem(y,'m')
axis([-5 45  0 8]);
title('Question6')
xlabel('n');
ylabel('y(n)');
```



Q7.Part2

Q7. To demonstrate one application of the crosscorrelation sequence.

Let $x[n] = [3, 11, 7, \underline{0}, -1, 4, 2]$ be a prototype sequence,

A) let y(n) be its noise-corrupted-and-shifted version

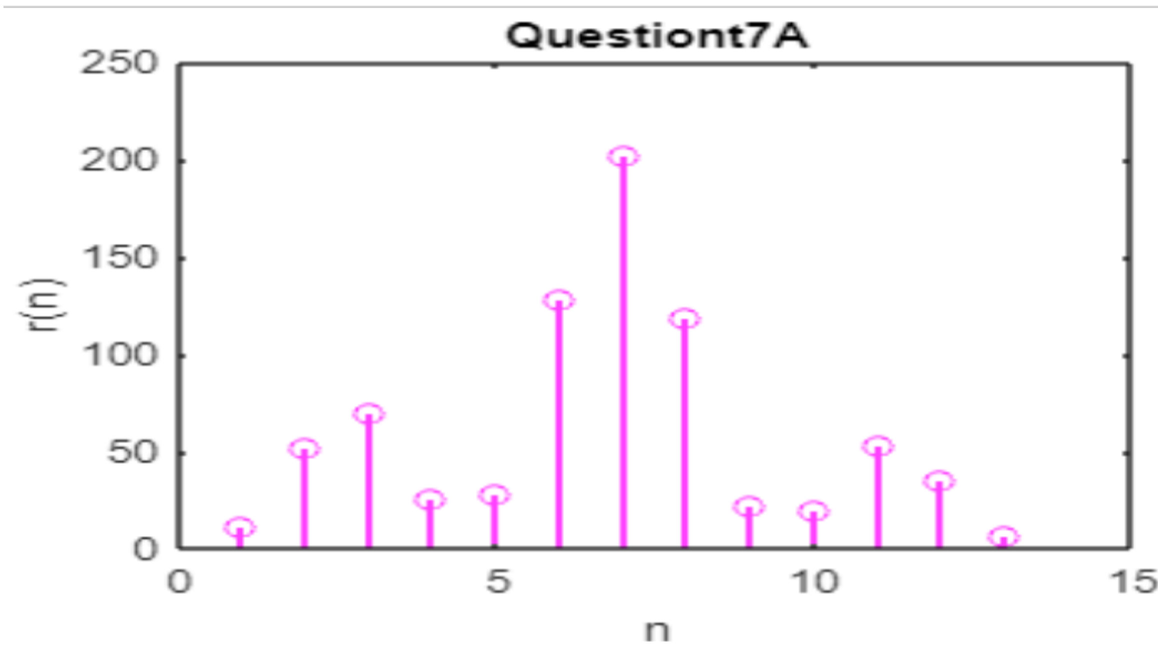
$$y[n]=x[n-2]+w[n]$$

where w[n] is Gaussian sequence with mean 0 and variance 1. Compute the crosscorrelation between y[n] and x[n] and comment on the results.

B) Repeat part (a) for $y[n]=x[n-4]+w[n]$

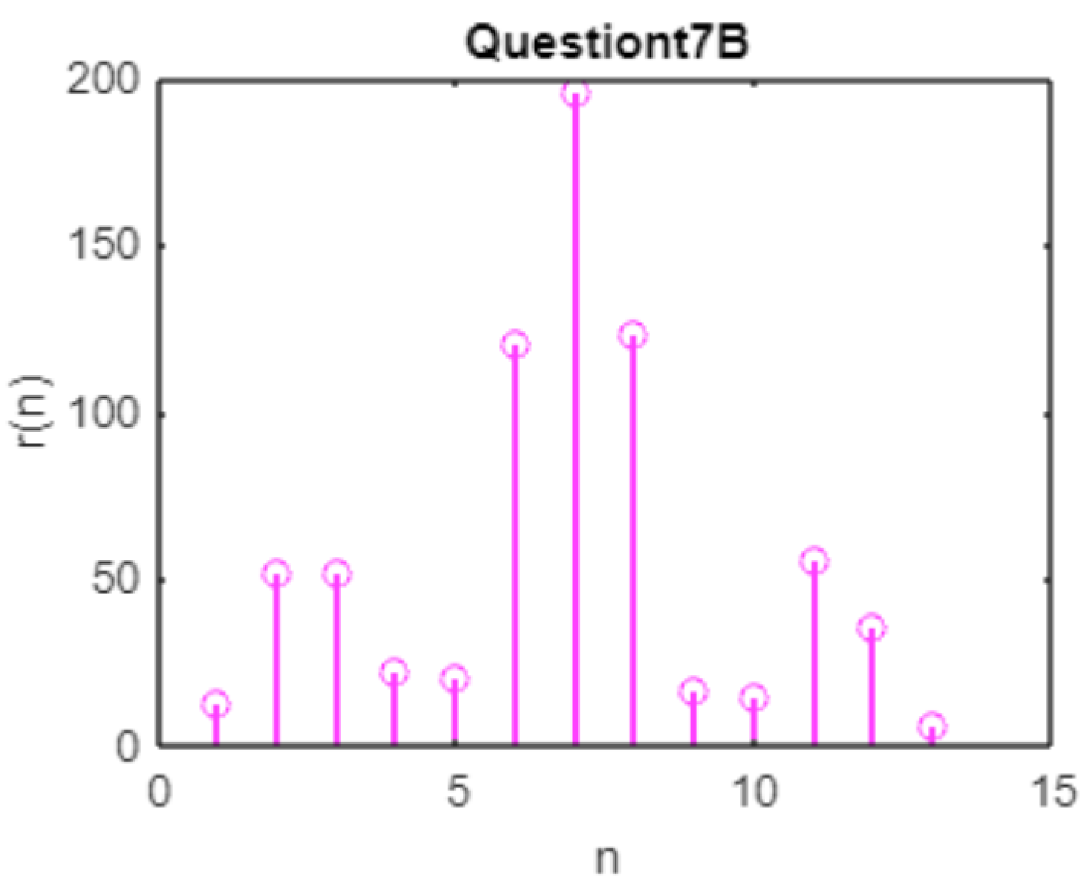
A) Code & Figure

```
n=[-3,-2,-1,0,1,2,3]
x=[3 11 7 0 -1 4 2];
y=randn(1,7)+sigshift(x,n,2);
r=xcorr(x,y)
stem(r,'m');
xlabel('n');
ylabel('r(n)');
```



B) Code & Figure

```
n=[-3,-2,-1,0,1,2,3]
x=[3 11 7 0 -1 4 2];
y=randn(1,7)+sigshift(x,n,4);
r=xcorr(x,y)
stem(r,'m');
title('Question7B');
xlabel('n');
ylabel('r(n)');
```



Q8, Part4

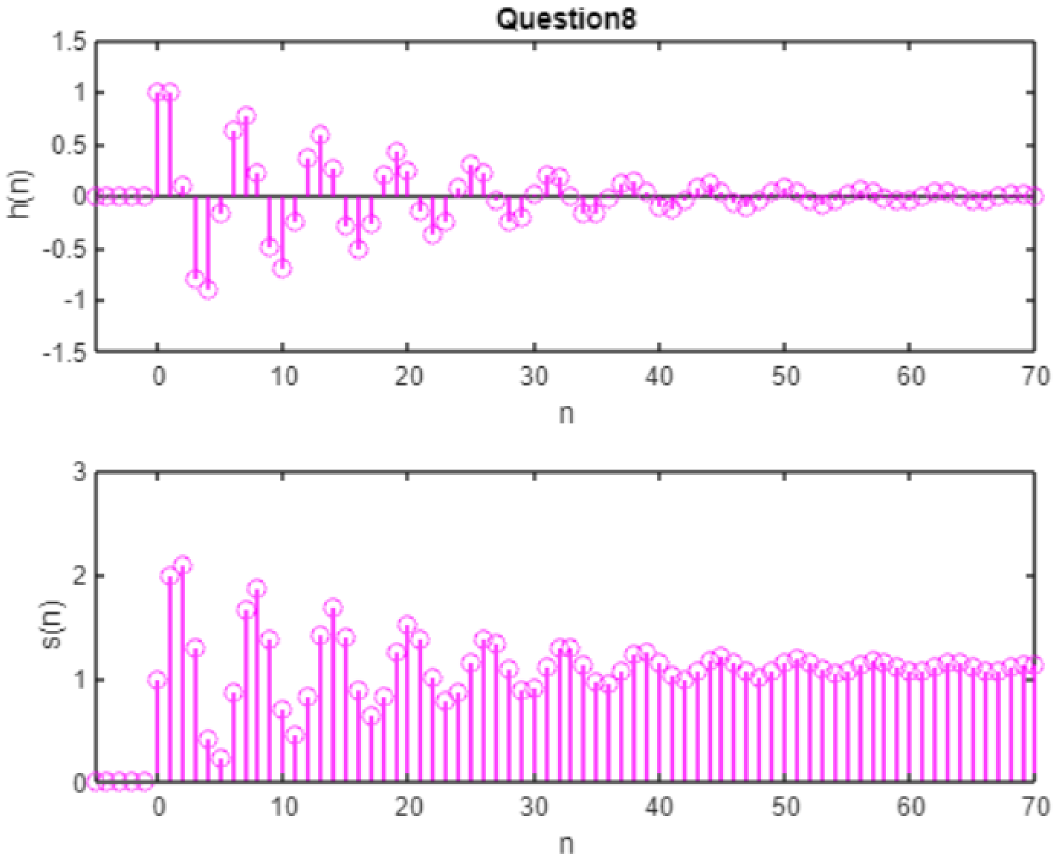
Q8. Given the following difference equation

$$y[n]-y[n-1]+0.9y[n-2] = x[n]$$

A) Calculate and plot the impulse response h(n) at n = −5,..., 120.
B) Calculate and plot the unit step response s(n) at n = −5,..., 120.
C) Is the system specified by h(n) stable?

A, B) Code and Figure

```
[x,n]=delta(0,-5,120);
b=1;
a=[1 -1 0.9];
h=filter(1,a,x)
subplot(2,1,1)
stem(n,h,'m');
title('Question8')
axis([-5 70 -1.5 1.5]);
xlabel('n');
ylabel('h(n)');
[x,n]=stepseq(0,-5,120);
a=[1 -1 0.9];
s=filter(1,a,x)
subplot(2,1,2)
stem(n,s,'m');
axis([-5 70  0 3]);
xlabel('n');
ylabel('s(n)');
```



C)

Yes, Stable hence the value of h[n]=0 for all n <0 from the figure.

Q9)

Q9. A “simple” digital differentiator is given by

$$y[n] = x[n] - x[n-1]$$

which computes a backward first-order difference of the input sequence. Implement this differentiator on the following sequences, and plot the results. Comment on the appropriateness of this simple differentiator.

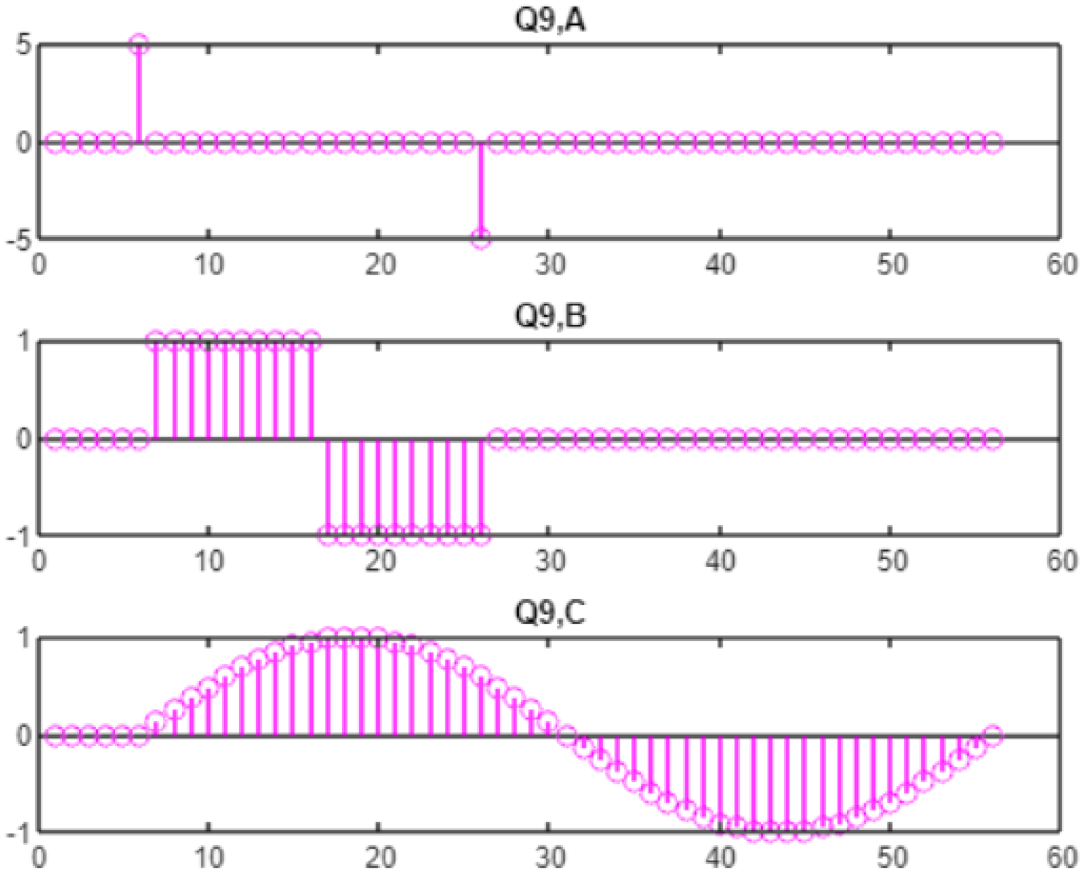
A) Rectangular pulse: $x[n] = 5[u(n) - u(n-20)]$

B) Triangular pulse: $x[n] = n\,(u[n] - u[n-10]) + (20-n)\,(u[n-10] - u[n-20])$

C) Sinusoidal pulse: $x[n] = sin\left(\frac{\pi n}{25}\right)(u[n] - u[n-100])$

A, B, C) Code and Figure

```
%A
n = -5:1:50;
unit1= (n >=0 );
unit2 = (n >= 20);
unit4 = (n >=10);
unit3 = (n >= 100);
x1 = 5 * ( unit1 - unit2 )
a=1;
b=[1 -1];
res=filter(b,a,x1)
subplot(3,1,1)
stem(res,'m')
title("Q9,A")
% B
x2 = n.*( unit1 - unit4 ) +  ( (20 - n ) .* ( unit4 - unit2) );
res2=filter(b,a,x2)
subplot(3,1,2)
stem(res2,'m')
title("Q9,B")
%C
res3 = sin((1/25)*pi*n).*(unit1 - unit3);
subplot(3,1,3)
stem(res3,'m')
title("Q9,C")
```



Q9,A
Q9,B
Q9,C

Q10)

Q10. For $x[n] = (0.5)^n\ u[n]$. The corresponding DTFT is $X(e^{j\omega}) = \dfrac{e^{j\omega}}{e^{j\omega} - 0.5}$.

Evaluate $X(e^{j\omega})$ at 501 equispaced points between $[0,\pi]$ and plot its magnitude, angle, real, and imaginary parts.

Code, Figure

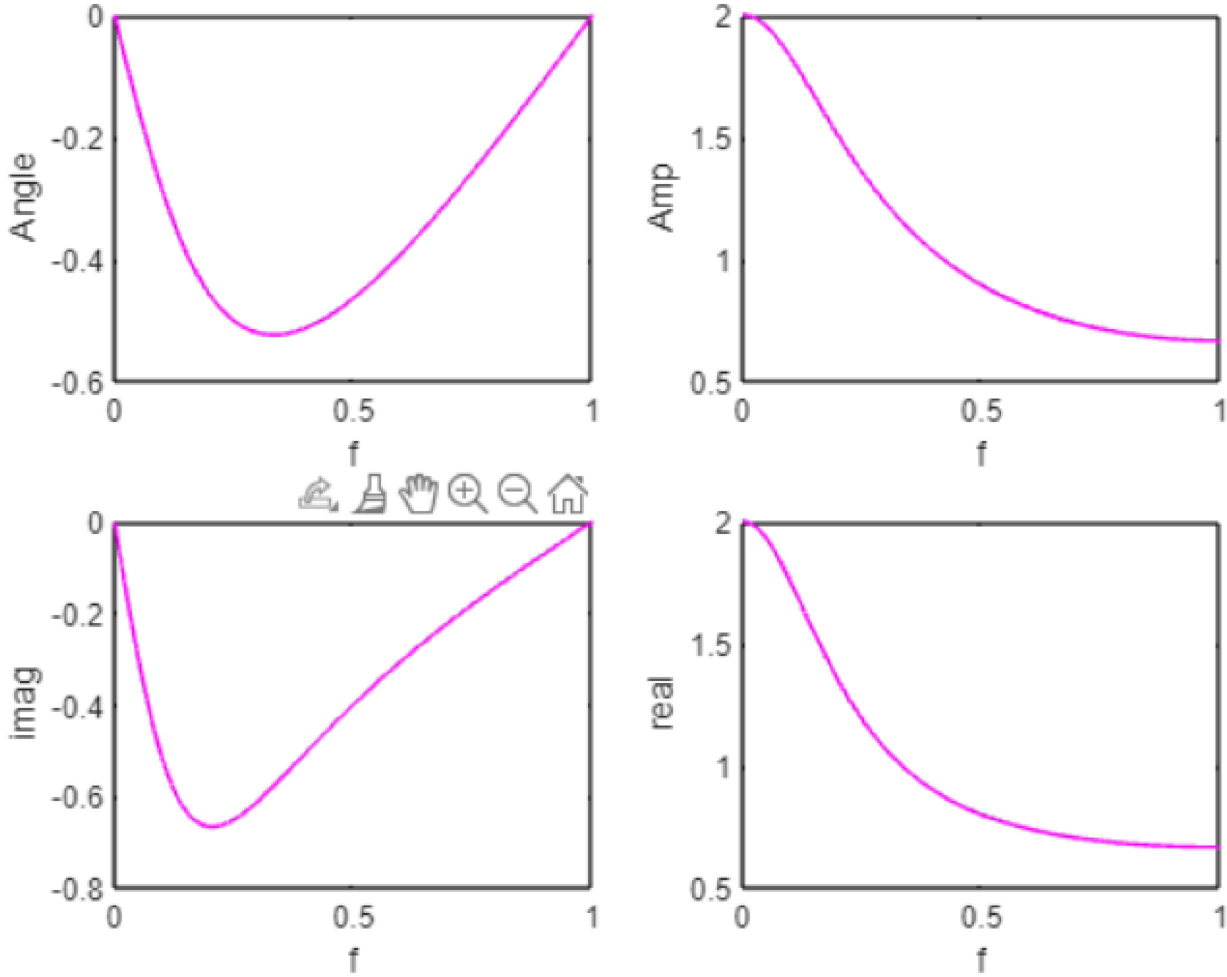
```
w=[0:1:500]*pi/500;
f=exp(j*w)./(exp(j*w)-0.5*ones(1,501));

subplot(2,2,1);
plot(w/pi,angle(f),'m');
xlabel('f');
ylabel('Angle');

subplot(2,2,2);
plot(w/pi,abs(f),'m');
xlabel('f');
ylabel('Amp');

subplot(2,2,3);
plot(w/pi,imag(f),'m');
xlabel('f');
ylabel('imag');

subplot(2,2,4);
plot(w/pi,real(f),'m');
xlabel('f');
ylabel('real');
```



Angle
Amp
imag
real
f
0
-0.2
-0.4
-0.6
-0.8
0.5
1
1.5
2

Q11)

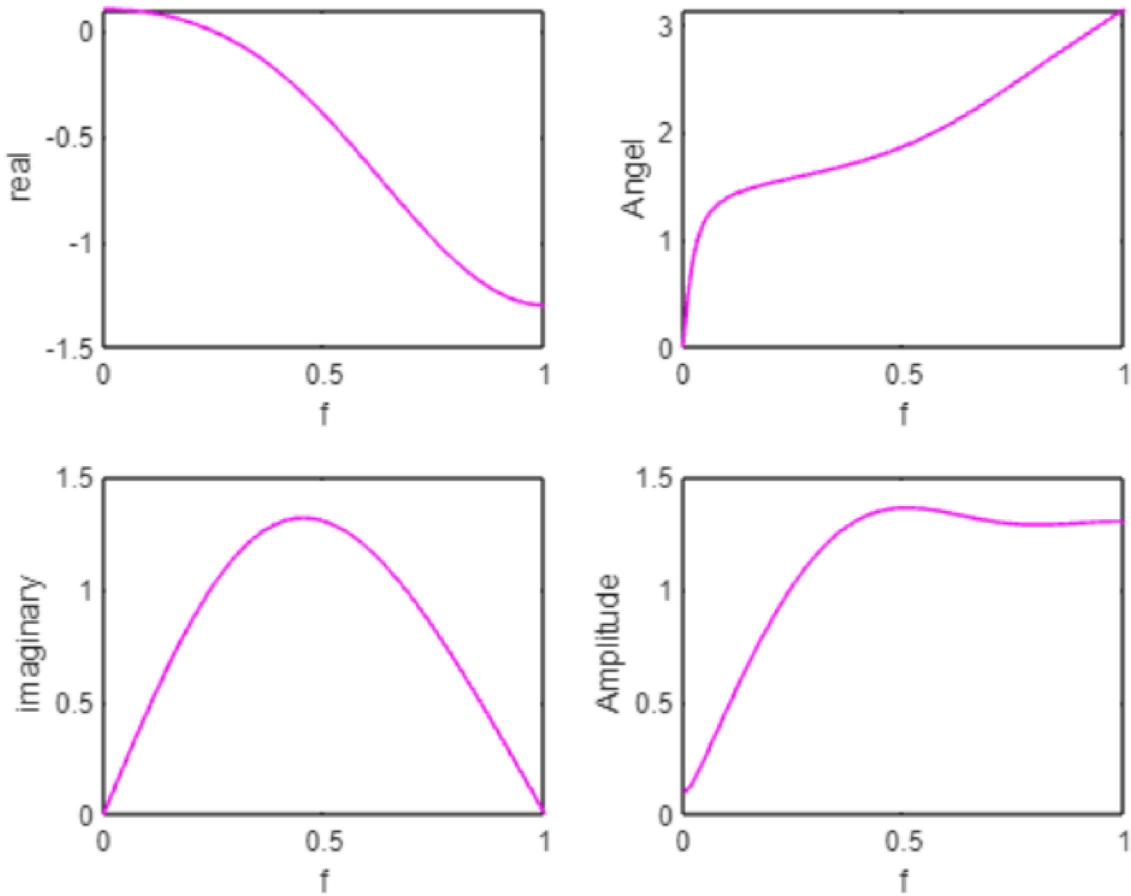
Q.11 Consider the sequence $x[n] = \{1, \underset{\uparrow}{-0.5}, -0.3, -0.1\}$

A) Numerically compute the discrete-time Fourier transform of at 501 equispaced frequencies between $[0,\pi]$.

B) plot its magnitude, angle, real, and imaginary parts.

Code, Figure

```
w=[0:1:500]*pi/500;
x=[1, -0.5,-0.3,-0.1];
y=zeros(1,length(w));
for i=1:length(w)
    for n=-1:2
        y(i)=y(i)+x(n+2)*exp(-j*w(i)*n);
    end
end
subplot(2,2,1);
plot(w/pi, real(y),'m');
xlabel('f');
ylabel('real');
subplot(2,2,2);
plot(w/pi, angle(y),'m');
xlabel('f');
ylabel('Angel');
subplot(2,2,3);
plot(w/pi, imag(y),'m');
xlabel('f');
ylabel('imaginary');
subplot(2,2,4);
plot(w/pi,abs(y),'m');
xlabel('f');
ylabel('Amplitude');
```



real
0
-0.5
-1
-1.5
0
0.5
1
f
Angel
3
2
1
0
0
0.5
1
f
imaginary
1.5
1
0.5
0
0
0.5
1
f
Amplitude
1.5
1
0.5
0
0
0.5
1
f

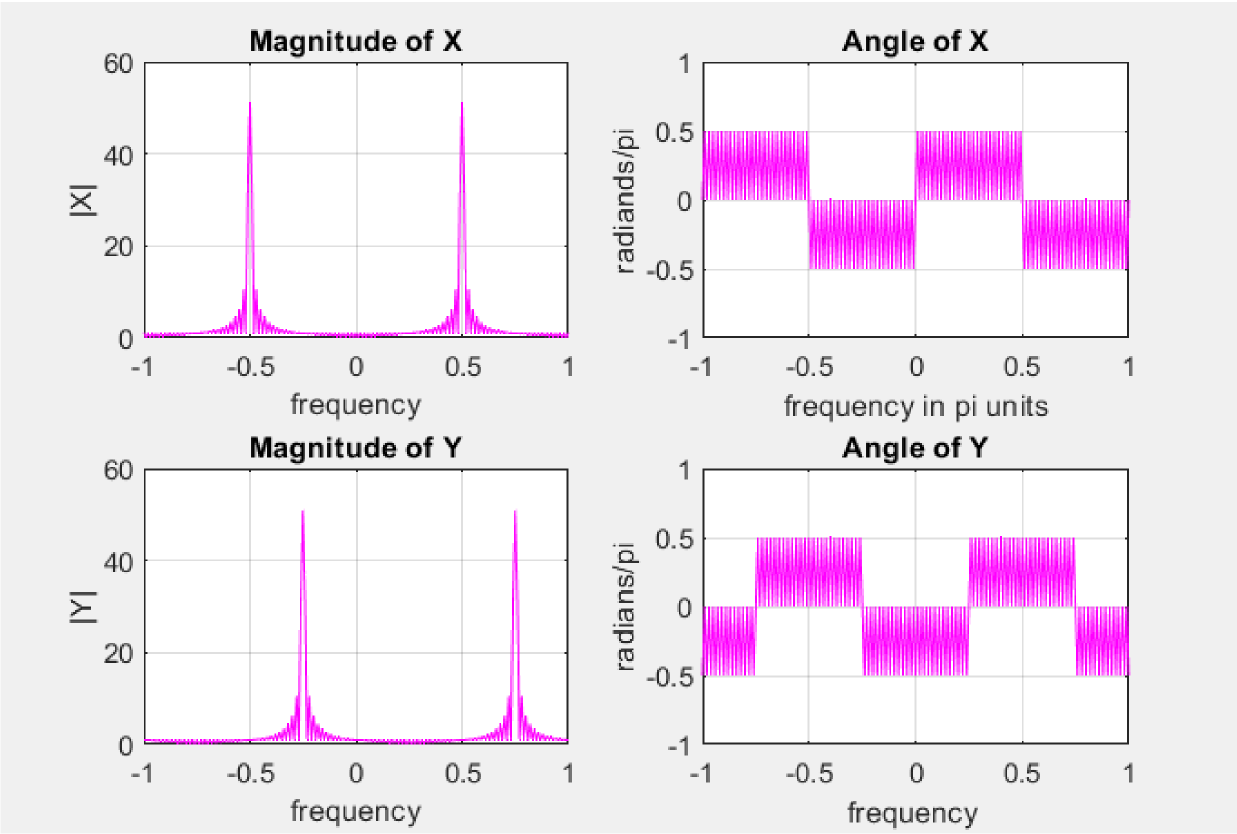
Q12)

Q.12 Let $x[n]=\cos(\frac{\pi n}{2}), \quad 0 \le n \le 100$ and $y[n]=e^{j\pi n/4}x[n]$

A) Numerically compute the discrete-time Fourier transform of at 401 equispaced frequencies between [-2π,2π].
B) plot its magnitude, angle spectrum.
C) Comment on the relation between x[n] and y[n].

Code, Figure

```
n = 0:100;x = cos(pi*n/2);
k = -100:100;
w = (pi/100)*k; % frequency between -pi and +pi
X = x * (exp(-j*pi/100)).^(n'.*k); % DTFT of x%
y = exp(j*pi*n/4).*x; % signal multiplied by exp(j*pi*n/4)
Y = y * (exp(-j*pi/100)).^(n'.*k); % DTFT of y
subplot(2,2,1);
plot(w/pi,abs(X),'m');
grid;
axis([-1,1,0,60])
xlabel('frequency');
ylabel('|X|')
title('Magnitude of X')
subplot(2,2,2);
plot(w/pi,angle(X)/pi,'m');
grid; axis([-1,1,-1,1])
xlabel('frequency in pi units');
ylabel('radiands/pi')
title('Angle of X')
subplot(2,2,3);
plot(w/pi,abs(Y),'m');
grid;
axis([-1,1,0,60])
xlabel('frequency');
ylabel('|Y|')
title('Magnitude of Y')
subplot(2,2,4);
plot(w/pi,angle(Y)/pi,'m');
grid;
axis([-1,1,-1,1])
xlabel('frequency ');
ylabel('radians/pi')
title('Angle of Y')
```



Magnitude of X
|X|
frequency
Angle of X
radiands/pi
frequency in pi units
Magnitude of Y
|Y|
frequency
Angle of Y
radians/pi
frequency

Functions:

```
function [y,ny] = conv_m(x,nx,h,nh) % Modified convolution routine for signal
processing
% -------------------------------------------------
% [y,ny] = conv_m(x,nx,h,nh)
% [y,ny] = convolution result
% [x,nx] = first signal
% [h,nh] = second signal
nyb = nx(1)+nh(1);
nye = nx(length(x)) + nh(length(h));
ny = [nyb:nye];
y = conv(x,h);
```

```
function [y,n]=sigshift(x,n,no)
n=n+no;
y=x;
```

```
% Function to generate x(n)=step(n-no), n1<=n<=n2
function [x,n]=stepseq(no,n1,n2)
n=[n1:n2];
x=[(n-no) >= 0];

function X = dtft(x)
    % Find the length of the input signal
    N = length(x);
    % Create an array of frequency values from -pi to pi
    w = (-pi:2*pi/N:pi-2*pi/N);
    X = x*exp(-1i*(0:N-1)'*w);
    X = sum(X,1);
```