Program-1

Aim

Write MATLAB code for the following discrete-time signals:

i. Impulse Sequence

ii. Step Sequence

iii. Ramp Sequence

iv. Real Exponential Sequence

v. Sinusoidal Sequence

Software used

MATLAB/GNU Octave/SciLab

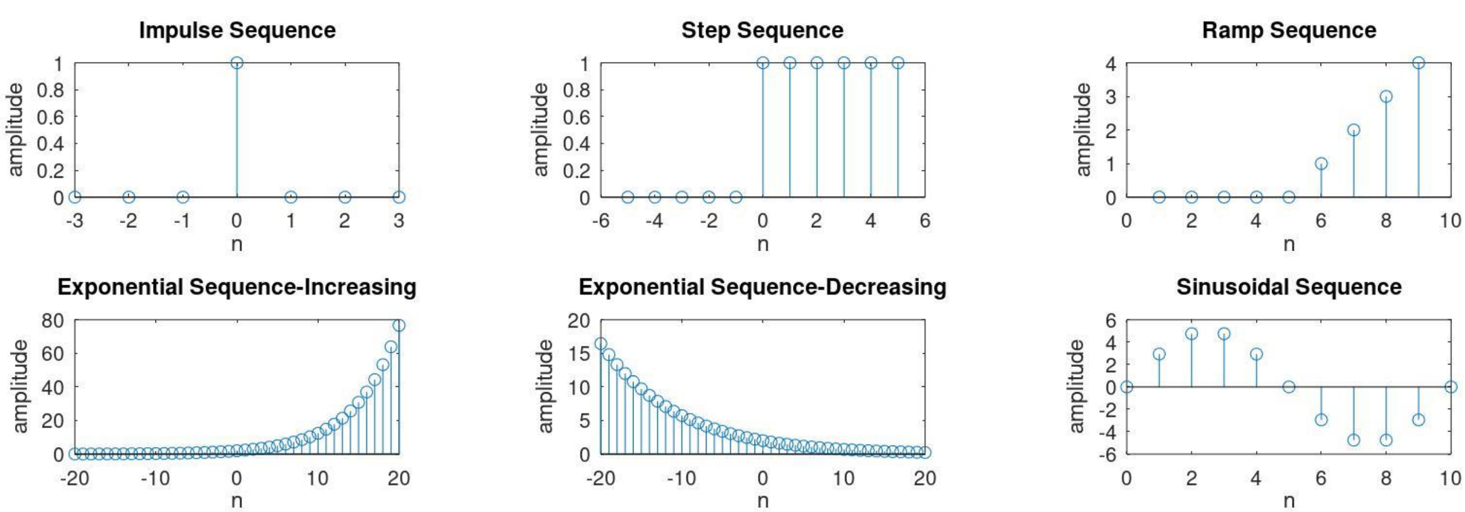
Code

```
%IMPULSE SEQUENCE

clc;

n=-3:3;

subplot(3,3,1);

impulse= (n==0);

stem(n,impulse);

ylabel('amplitude');

xlabel('n');

title('Impulse Sequence')
```

```
%STEP SEQUENCE
n=-5:5;
subplot(3,3,2);
unit_step = (n>=0);
stem(n,unit_step);
ylabel('amplitude');
xlabel('n');
title('Step Sequence')
%RAMP SEQUENCE
n=-4:4;
subplot(3,3,3);
ramp_function = n.*(n>=0);
stem(ramp_function);
ylabel('amplitude');
xlabel('n');
title('Ramp Sequence')
%REAL EXPONENTIAL SEQUENCE
n=-20:20; %increasing exponential
subplot(3,3,4);
x_n=2.*(1.2.^n);
stem(n,x_n);
ylabel('amplitude');
xlabel('n');
title('Exponential Sequence-Increasing')
```

```
n=-20:20; %decaying exponential
subplot(3,3,5);
x_n=2.*(0.9.^n);
stem(n,x_n);
ylabel('amplitude');
xlabel('n');
title('Exponential Sequence-Decreasing')
%SINUSOIDAL SEQUENCE
A=5;
f=0.1;
n=0:1:10;
subplot(3,3,6);
xt=A*sin(2*pi*f*n);
stem(n,xt);
ylabel('amplitude');
xlabel('n');
title('Sinusoidal Sequence')
```

Output



Program-2

Aim

Write a MATLAB code for the addition of discrete time signal.

Software used

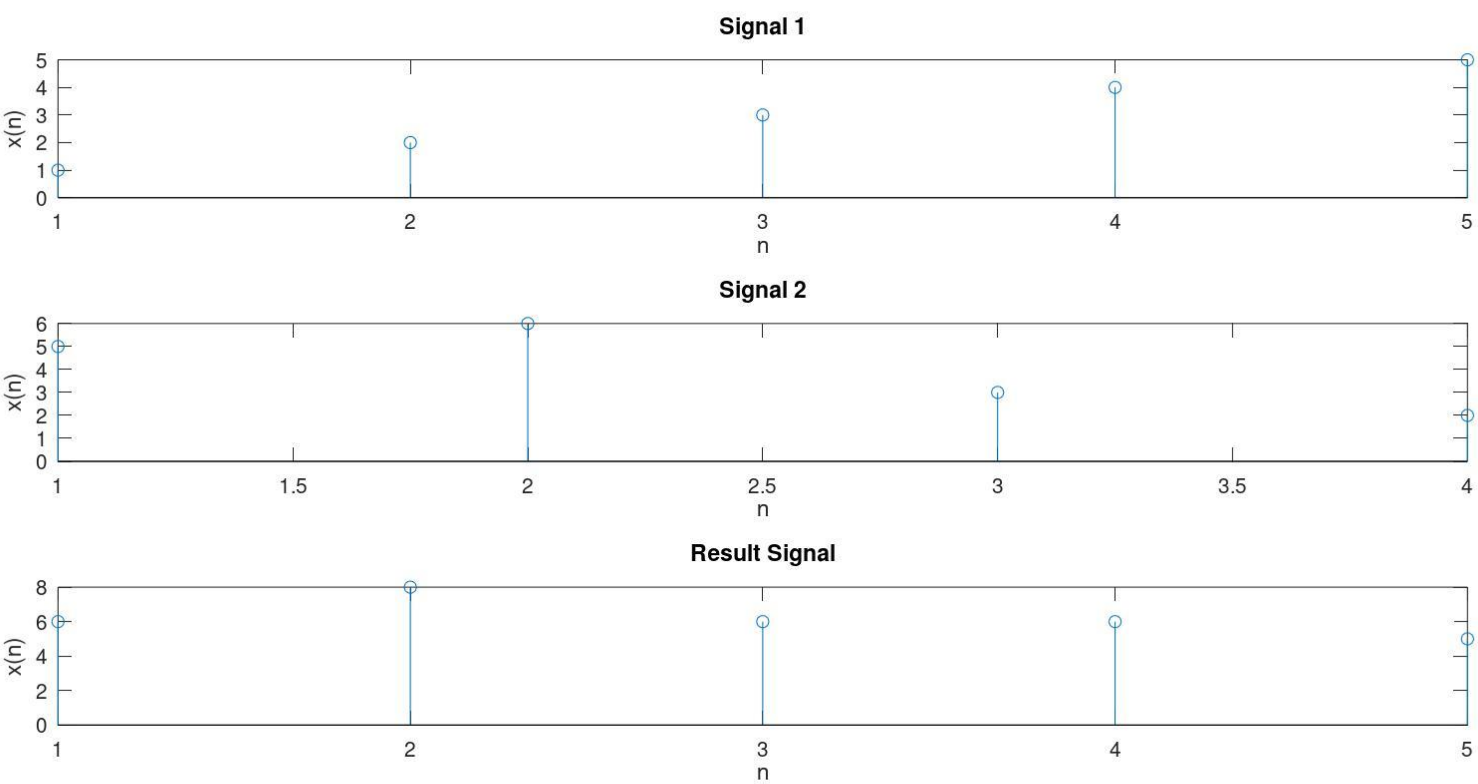
MATLAB/GNU Octave/SciLab

Code

```
x1 = [1,2,3,4,5];
n1 = [1:5];
x2 = [5,6,3,2];
n2 = [1:4];
subplot(3,1,1);
stem(n1,x1);
title("Signal 1");
xlabel("n");
ylabel("x(n)");
subplot(3,1,2);
stem(n2,x2);
title("Signal 2");
xlabel("n");
ylabel("x(n)");
subplot(3,1,3);
```

```
[y,n] = sigadd(x1,n1,x2,n2);
stem(n,y);
title("Result Signal");
xlabel("n");
ylabel("x(n)");
```

Output



Program-3

Aim

Write a MATLAB code for the multiplication of discrete time signal.

Software used

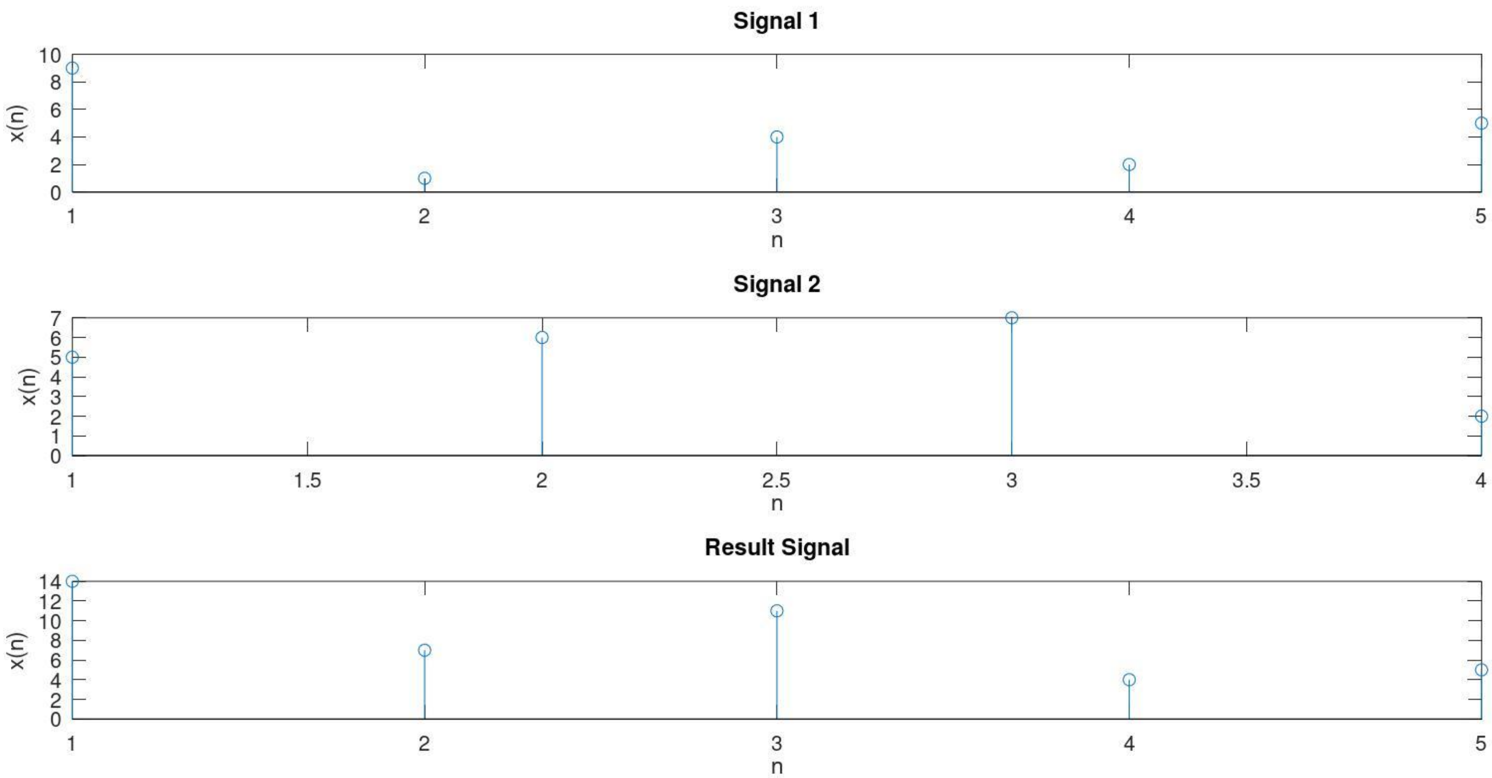
MATLAB/GNU Octave/SciLab

Code

```
x1 = [9,1,4,2,5];
n1 = [1:5];
x2 = [5,6,7,2];
n2 = [1:4];
subplot(3,1,1);
stem(n1,x1);
title("Signal 1");
xlabel("n");
ylabel("x(n)");
subplot(3,1,2);
stem(n2,x2);
title("Signal 2");
xlabel("n");
ylabel("x(n)");
subplot(3,1,3);
```

```
[y,n] = sigmult(x1,n1,x2,n2);
stem(n,y);
title("Result Signal");
xlabel("n");
ylabel("x(n)");
```

Output



<u>Program-4</u>

Aim

Write a MATLAB code for the shifting and folding of discrete time signal.

Software used

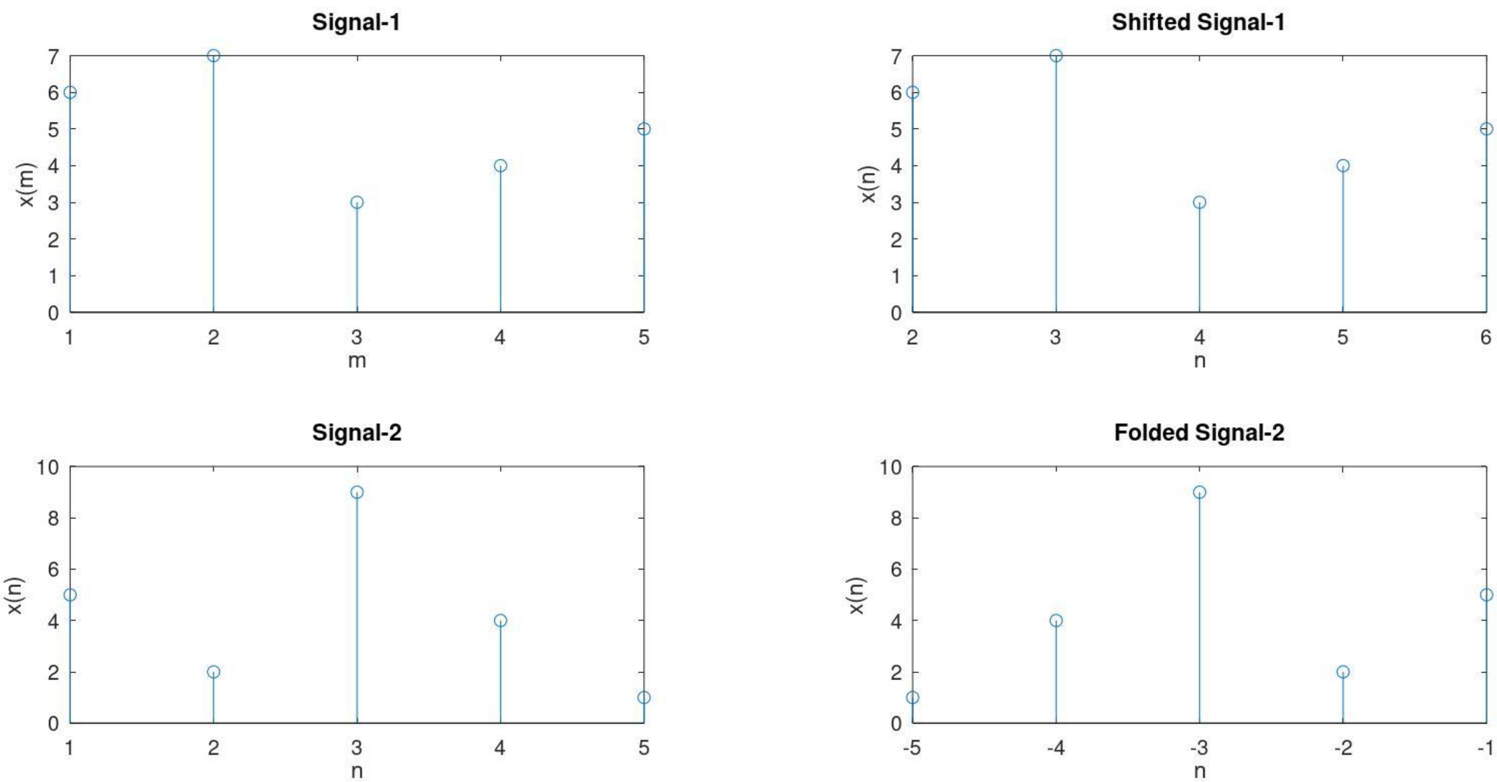
MATLAB/GNU Octave/SciLab

Code

```
%sigshift
x = [6,7,3,4,5];
m = [1:5];
k = 1;
subplot(2,2,1);
stem(m,x);
title("Signal-1");
xlabel("m");
ylabel("x(m)");
subplot(2,2,2);
stem(n,y);
[y,n] = sigshift(x,m,k);
```

```
stem(n,y);
title("Shifted Signal-1");
xlabel("n");
ylabel("x(n)");

%sigfold
x = [5,2,9,4,1];
n = [1:5];
subplot(2,2,3);
stem(n,x);
title("Signal-2");
xlabel("n");
ylabel("x(n)");
subplot(2,2,4);
stem(n,x);
[y,n] = sigfold(x,n);
stem(n,y);
title("Folded Signal-2");
xlabel("n");
ylabel("x(n)");
```

Output



Signal-1
x(m)
m
Shifted Signal-1
x(n)
n
Signal-2
x(n)
n
Folded Signal-2
x(n)
n

Program-5

Aim

Write a MATLAB code for the following question:

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) $x(n) = n[u(n)-u(n-10)]+10e-0.3(n-10)[u(n-10)-u(n-20)]$,

$0 \le n \le 20$.

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

d) $\tilde{x}(n) = \{\ldots, 5, 4, 3, 2, 1, 5 , 4, 3, 2, 1, 5, 4, 3, 2, 1, \ldots\}$; $-10 \le n \le 9$.

Software used

MATLAB/GNU Octave/SciLab

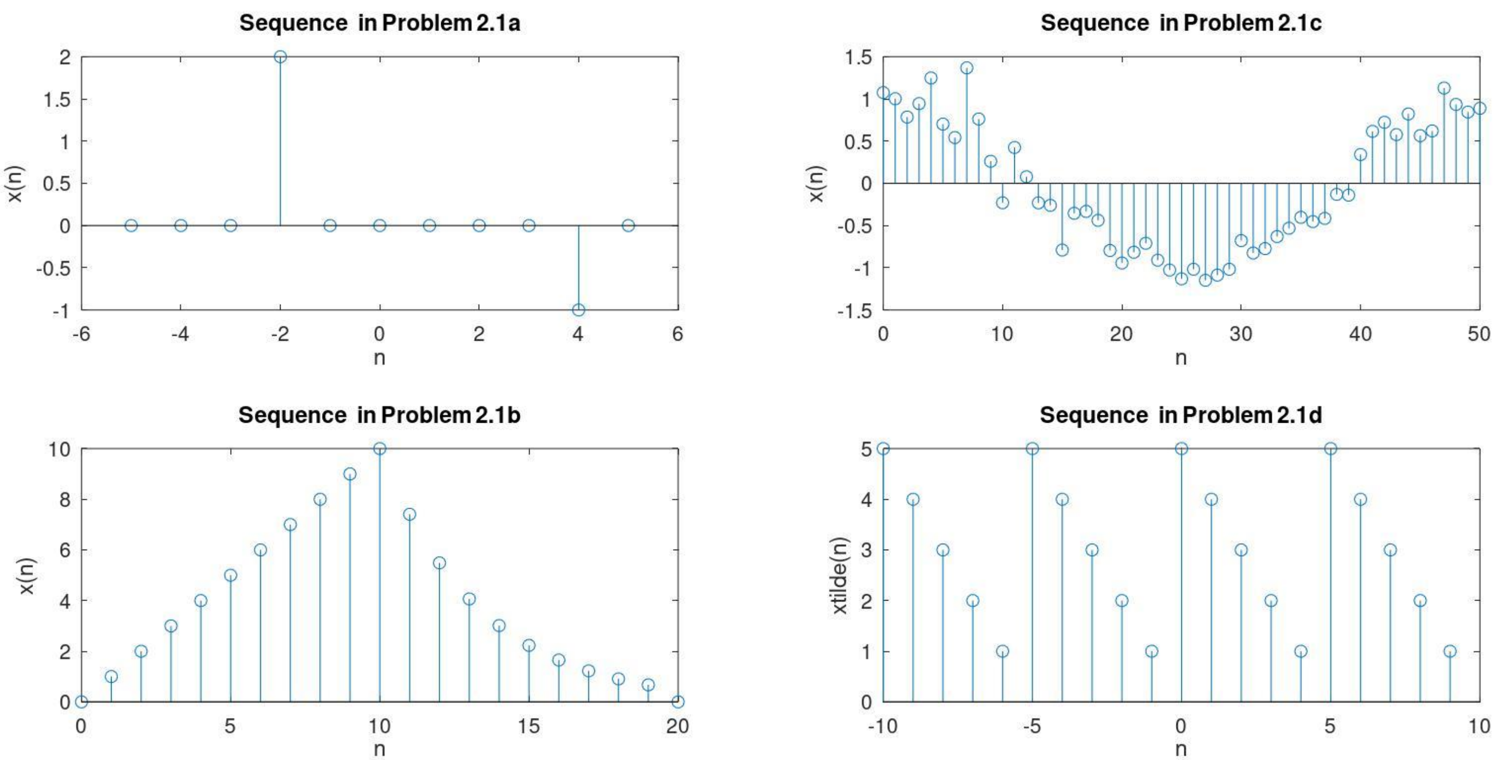
Code

```
n=[-5:5];
x=2*impseq(-2,-5,5)-impseq(4,-5,5);
subplot(2,2,1);
stem(n,x);
```

```
title('Sequence in Problem 2.1a');
xlabel('n');
ylabel('x(n)');
n=[0:20];
x1=n.*(stepseq(0,0,20)-stepseq(10,0,20));
x2=10*exp(-0.3*(n-10)).*(stepseq(10,0,20)-
stepseq(20,0,20));
x=x1+x2;
subplot(2,2,3);
stem(n,x);
title('Sequence in Problem 2.1b');
xlabel('n');
ylabel('x(n)');
n=[0:50];
x=cos(0.04*pi*n)+0.2*randn(size(n));
subplot(2,2,2);
stem(n,x);
title('Sequence in Problem 2.1c');
xlabel('n');
ylabel('x(n)');
n=[-10:9];
x=[5,4,3,2,1];
xtilde=x'* ones(1,4);
xtilde=(xtilde(:))';
```

```
subplot(2,2,4);
stem(n,xtilde);
title('Sequence in Problem 2.1d');
xlabel('n');
ylabel('xtilde(n)');
```

Output



Program-6

Aim

Write a MATLAB code for the following question:

Let x(n) = u(n) − u(n − 10). Decompose x(n) into even and odd components.

Software used

MATLAB/GNU Octave/SciLab

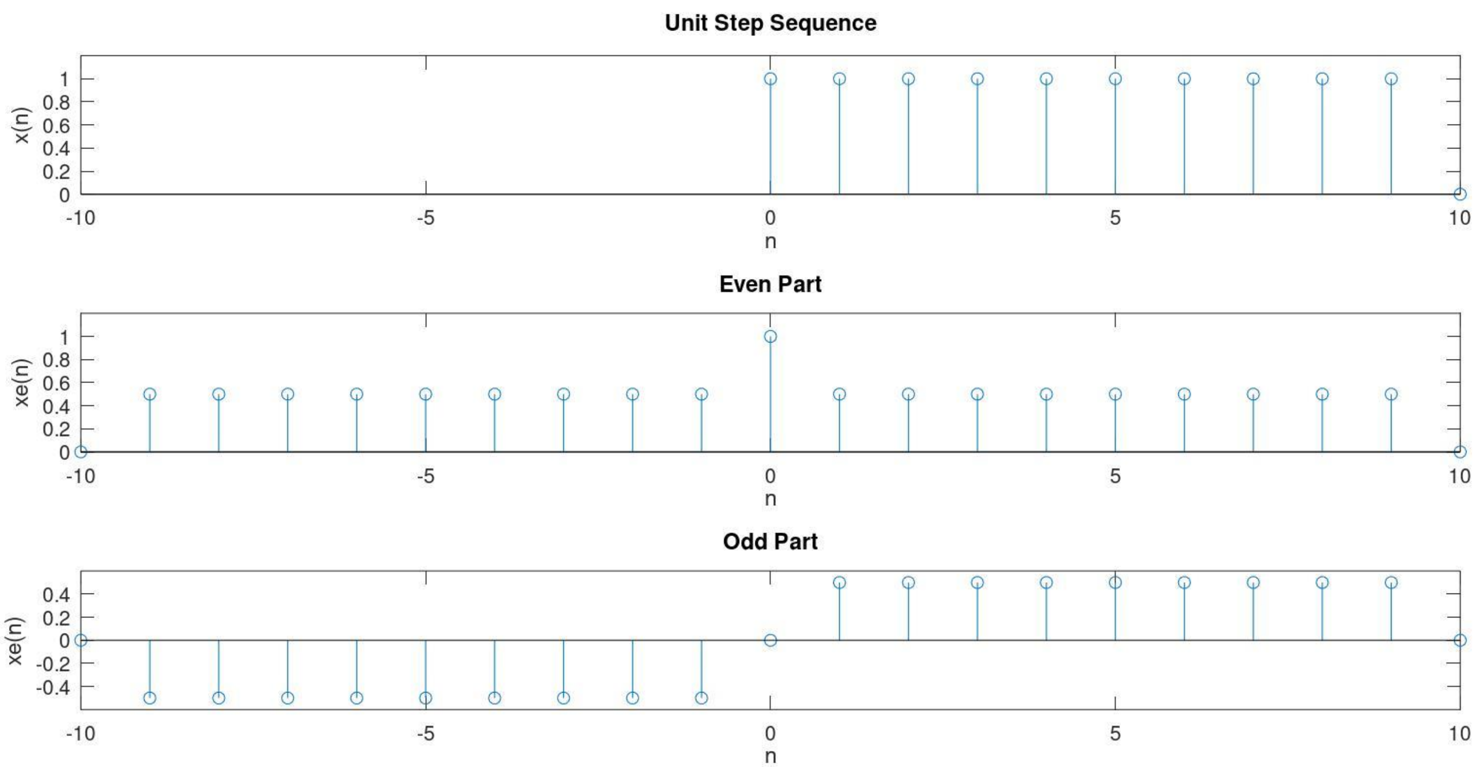
Code

```
function [x,n] = stepseq(n0,n1,n2)
% Generates x(n) = u(n-n0); n1 <= n <= n2
% ------------------------------------------
% [x,n] = stepseq(n0,n1,n2)
%
n = [n1:n2]; x = [(n-n0) >= 0];
end

function [x,n] = impseq(n0,n1,n2)
% Generates x(n) = delta(n-n0); n1 <= n <= n2
% ----------------------------------------------
```

```
% [x,n] = impseq(n0,n1,n2)
%
n = [n1:n2]; x = [(n-n0) == 0];
end

%MATLAB CODE
clc;
clear all;
close all;
n=[0:10];
x=stepseq(0,0,10)-stepseq(10,0,10);
[xe,xo,m]=evenodd(x,n);
subplot(3,1,1); stem(n,x);
title('Unit Step Sequence')
xlabel('n'); ylabel('x(n)');
axis([-10,10,0,1.2])
subplot(3,1,2);
stem(m,xe);
title('Even Part')
xlabel('n');
ylabel('xe(n)');
axis([-10,10,0,1.2])
subplot(3,1,3);
```

```
stem(m,xo);
title('Odd Part')
xlabel('n');
ylabel('xe(n)');
axis([-10,10,-0.6,0.6])
```

Output



Program-7

Aim

Write a MATLAB code for the following question:

Given the following two sequences

a) $x(n) = [3, 11, 7, 0, -1, 4, 2], -3 \le n \le 3;$
b) $h(n) = [2, 3, 0, -5, 2, 1], -1 \le n \le 4.$

Determine the convolution $y(n) = x(n) * h(n)$.

Software used

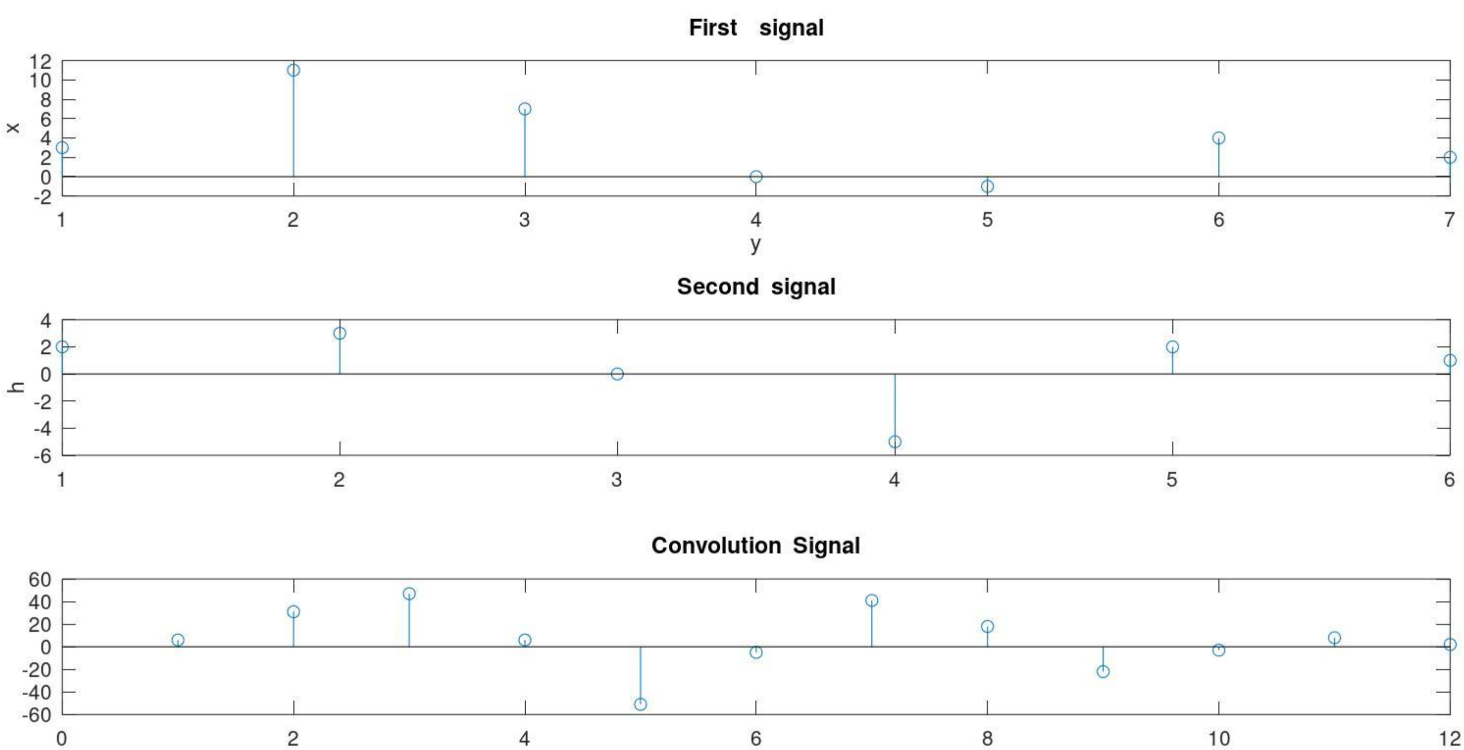
MATLAB/GNU Octave/SciLab

Code

```
clc;
x=[3    11  7   0   -1  4   2];
h=[2    3   0   -5  2   1];
y=conv(x,h);
subplot(3,1,1);
stem(x);
title('First signal');
xlabel('y');
```

```
ylabel('x');
subplot(3,1,2);
stem(h);
title('Second  signal');
ylabel('h');
subplot(3,1,3);
stem(y)
title('Convolution Signal');
```

Output



Program-8

Aim

Write a MATLAB code for the following question:

Given the following difference equation

$y(n) - y(n-1) + 0.9y(n-2) = x(n); \forall n$

a) Calculate and plot the impulse response h(n) at n = −20,…, 120.

b) Calculate and plot the unit step response s(n) at n = −20,…, 120.

Software used

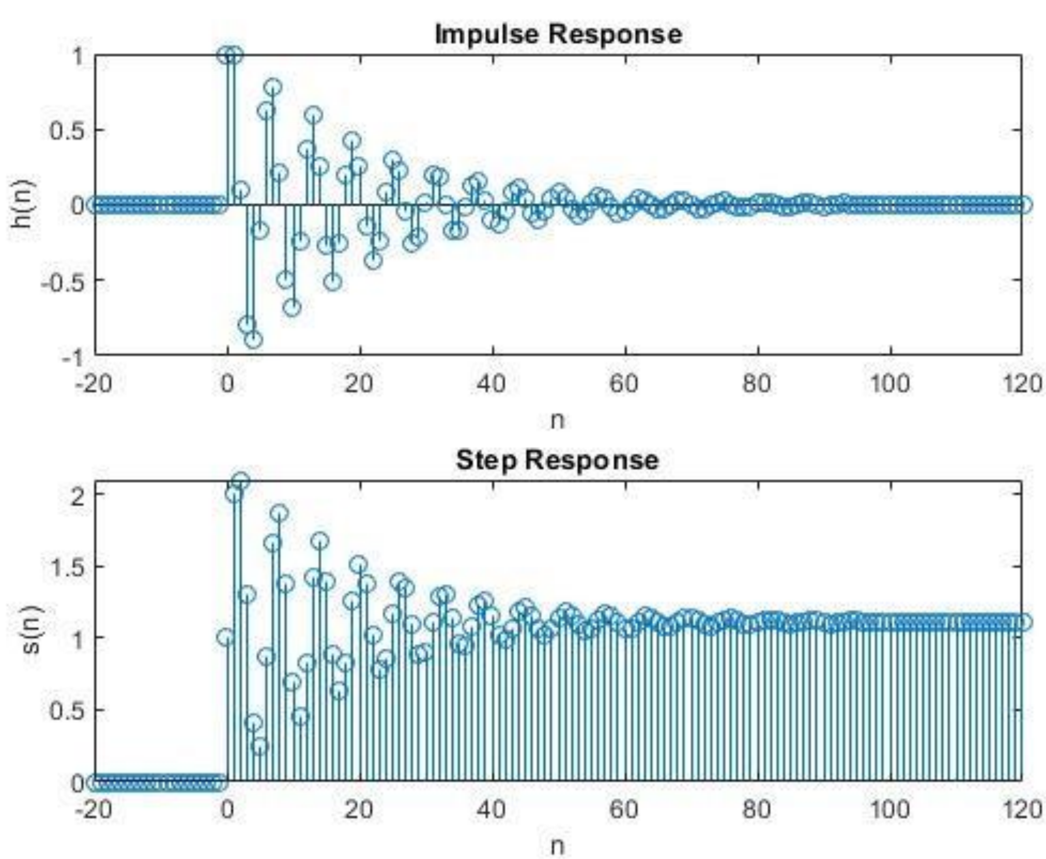
MATLAB/GNU Octave/SciLab

Code

```
clc;
b= [1];
a= [1, -1, 0.9];
b= [1];
a= [1, -1, 0.9];
n= [-20:120];
h= impz(b, a, n);
subplot(2,1,1);
```

```
stem(n, h);
title('Impulse Response');
xlabel('n');
ylabel('h(n)');
x= stepseq(0, -20,120);
s= filter(b, a, x);
subplot(2,1,2);
stem(n, s);
title('Step Response');
xlabel('n');
ylabel('s(n)');
```

Output



Program-9

Aim

Write a MATLAB code for the following question:

Determine the discrete-time Fourier transform of $x(n) = (0.5)^n u(n)$ and also evaluate X(ejω) at 501 equispaced points between [0, π] and plot its magnitude, angle, real, and imaginary parts.

Software used

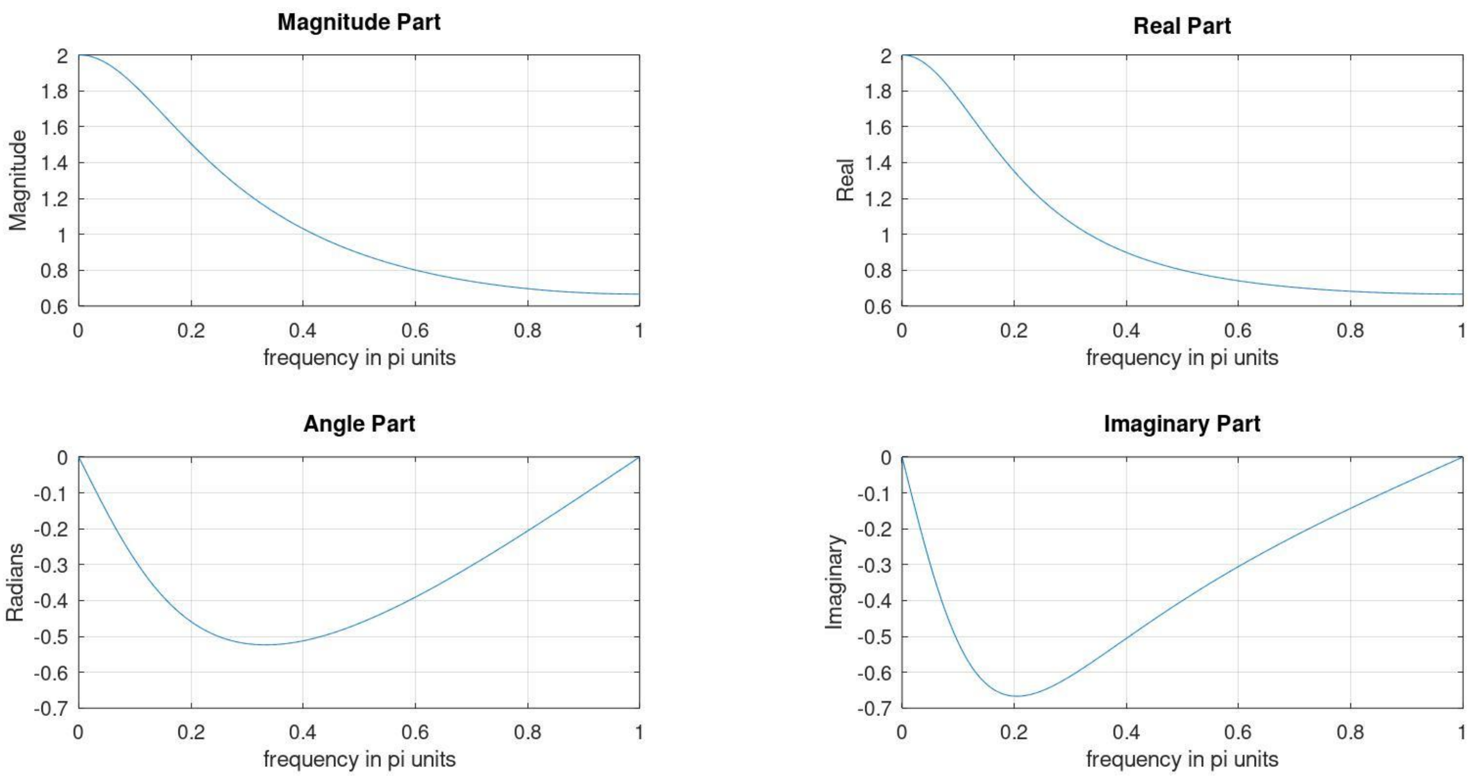
MATLAB/GNU Octave/SciLab

Code

```
clc;
clear all;
close all;
w= [0:1:500]*pi/500;
%[0, pi] axis divided into 501 points.
X= exp(1i*w)./ (exp(1i*w) - 0.5*ones(1,501));
magX= abs(X); angX = angle(X);
realX= real(X);
imagX= imag(X);
subplot(2,2,1);
```

```
plot(w/pi,magX); grid
xlabel('frequency in pi units');
ylabel('Magnitude');
title('Magnitude Part');
subplot(2,2,3);
plot(w/pi,angX); grid
xlabel('frequency in pi units') ;
ylabel('Radians');
title('Angle Part');
subplot(2,2,2);
plot(w/pi,realX); grid
xlabel('frequency in pi units');
ylabel('Real');
title('Real Part');
subplot(2,2,4);
plot(w/pi,imagX); grid
xlabel('frequency in pi units');
ylabel('Imaginary')
title('Imaginary Part');
```

Output



Magnitude Part
Magnitude
frequency in pi units
Real Part
Real
frequency in pi units
Angle Part
Radians
frequency in pi units
Imaginary Part
Imaginary
frequency in pi units

Program-10

Aim

Write a MATLAB code for the following question:

To study the effect of sampling on the frequency-domain quantities, we will sample xa(t) = $e^{-1000|t|}$ at 2 different sampling frequencies.

a)Sample $x_a(t)$ at F_s = 5000 sam/sec to obtain $x_1(n)$. Determine and plot $X_1(e^{j\omega})$.

b) Sample xa(t) at F_s = 1000 sam/sec to obtain $x_2(n)$. Determine and plot $X_2(e^{j\omega})$.

Software used

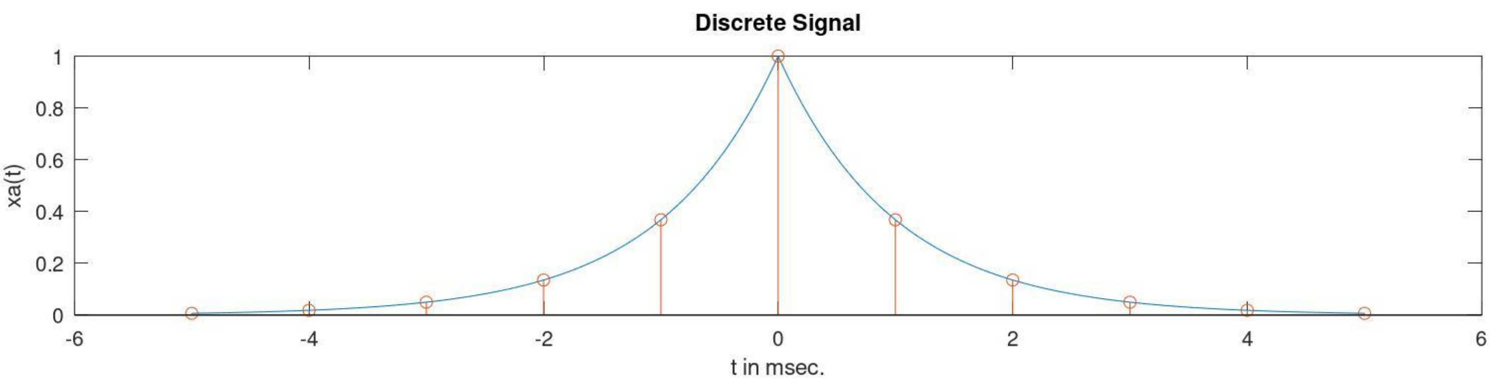
MATLAB/GNU Octave/SciLab

Code

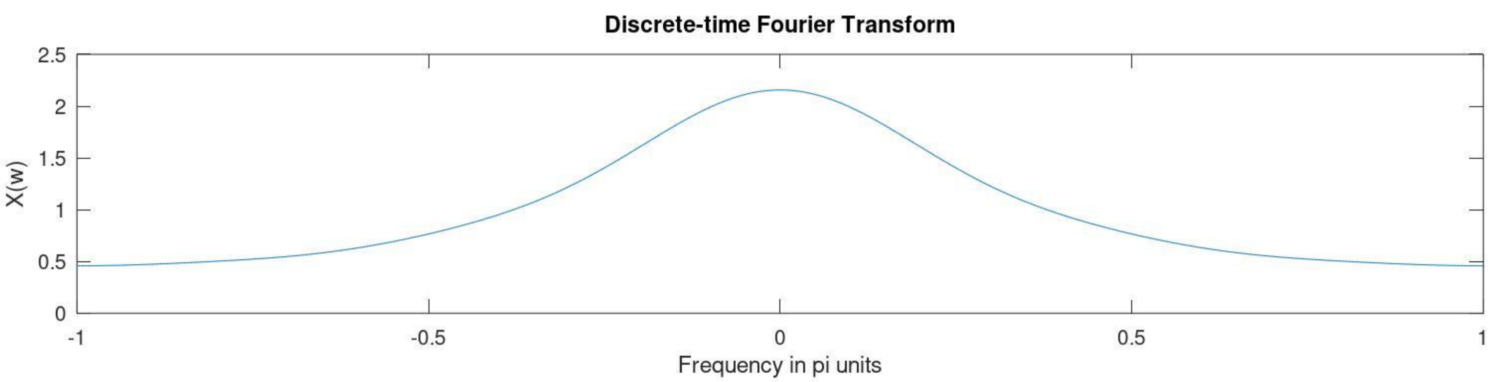
```
clc;
clear all;
% Analog Signal
Dt = 0.00005;
t = -0.005:Dt:0.005;
xa = exp(-1000*abs(t));
% Discrete-time Signal
```

```
Ts = 0.001; n = -5:1:5;
x = exp(-1000*abs(n*Ts));
% Discrete-time Fourier transform
K = 500; k = 0:1:K;
w = pi*k/K;
X = x * exp(-j*n'*w);
X = real(X);
w = [-fliplr(w), w(2:K+1)];
X = [fliplr(X), X(2:K+1)];
subplot(1,1,1)
subplot(2,1,1);plot(t*1000,xa);
xlabel('t in msec.');
ylabel('xa(t)');
title('Discrete Signal'); hold on
stem(n*Ts*1000,x); hold off
subplot(2,1,2);plot(w/pi,X);
xlabel('Frequency in pi units');
ylabel('X(w)');
title('Discrete-time Fourier Transform');
```

Output



Discrete Signal
xa(t)
t in msec.
1
0.8
0.6
0.4
0.2
0
-6
-4
-2
0
2
4
6



Discrete-time Fourier Transform
X(w)
Frequency in pi units
2.5
2
1.5
1
0.5
0
-1
-0.5
0
0.5
1

Program-11

Aim

Write a MATLAB code for the following question:

Reconstruct $x_a(t)$ from the sample $x_2(n)$ obtained in Experiment-10(b), by sampling $x_a(t) = e^{-1000|t|}$ at F_S = 1000 sam/sec.

Software used

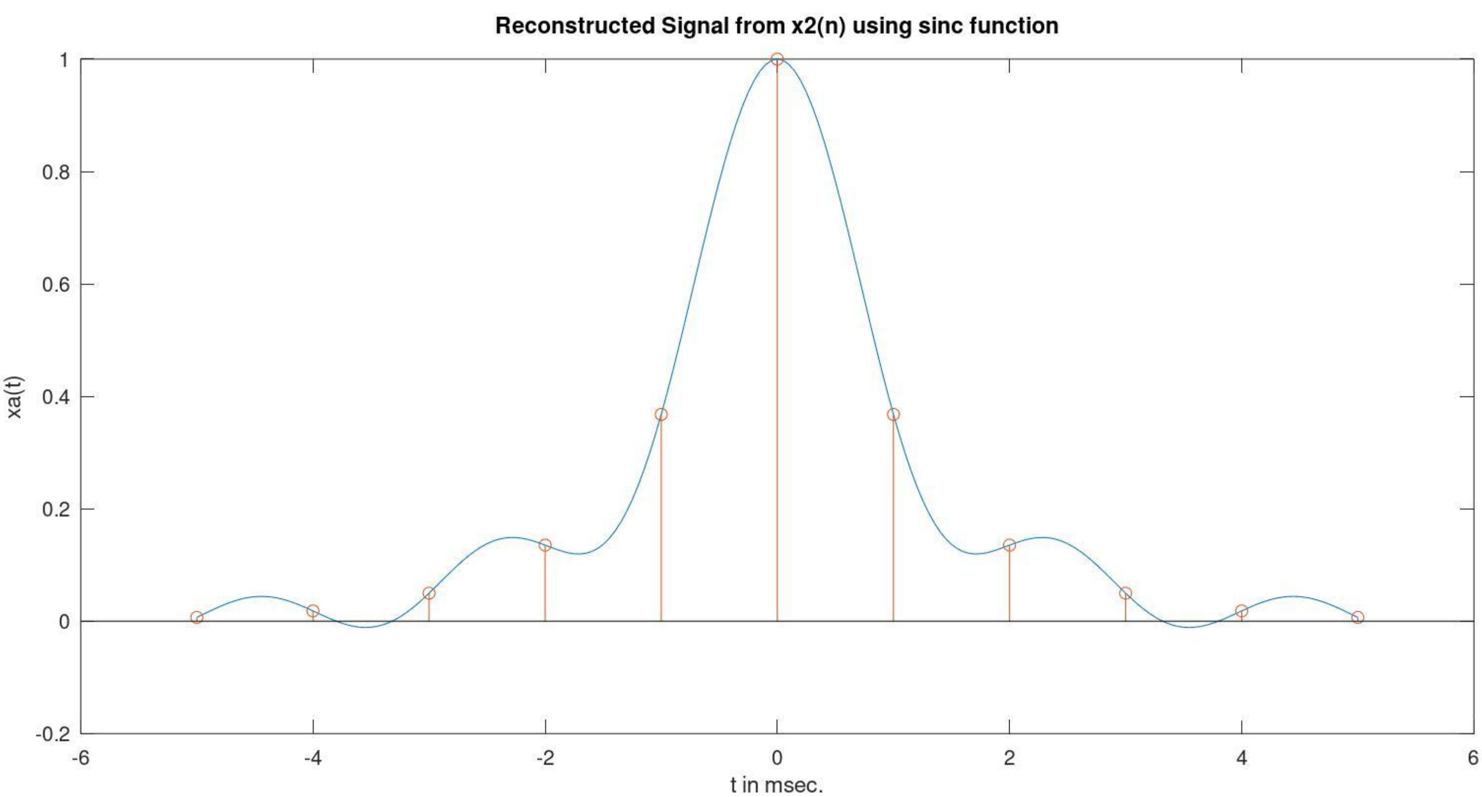
MATLAB/GNU Octave/SciLab

Code

```
clc;
clear all;
close all;
% Discrete-time Signal x2(n)
Ts = 0.001;
Fs = 1/Ts;
n = -5:1:5;
nTs = n*Ts;
x = exp(-1000*abs(nTs));
% Analog Signal reconstruction
Dt = 0.00005;
```

```
t = -0.005:Dt:0.005;
xa = x * sinc(Fs*(ones(length(nTs),1)*t-
nTs'*ones(1,length(t))));
% check
error = max(abs(xa - exp(-1000*abs(t))));
plot(t*1000,xa);
xlabel('t in msec.');
ylabel('xa(t)');
title('Reconstructed Signal from x2(n) using
sinc function'); hold on
stem(n*Ts*1000,x); hold off
```

Output



Program-12

Aim

Write a MATLAB code for the following question:

Given a causal system,

$$y(n)=0.9y(n-1)+x(n)$$

a) Determine H(z) and sketch its pole-zero plot.

b) Plot $|H(e^{j\omega})|$ and $\angle H(e^{j\omega})$.

Software used

MATLAB/GNU Octave/SciLab

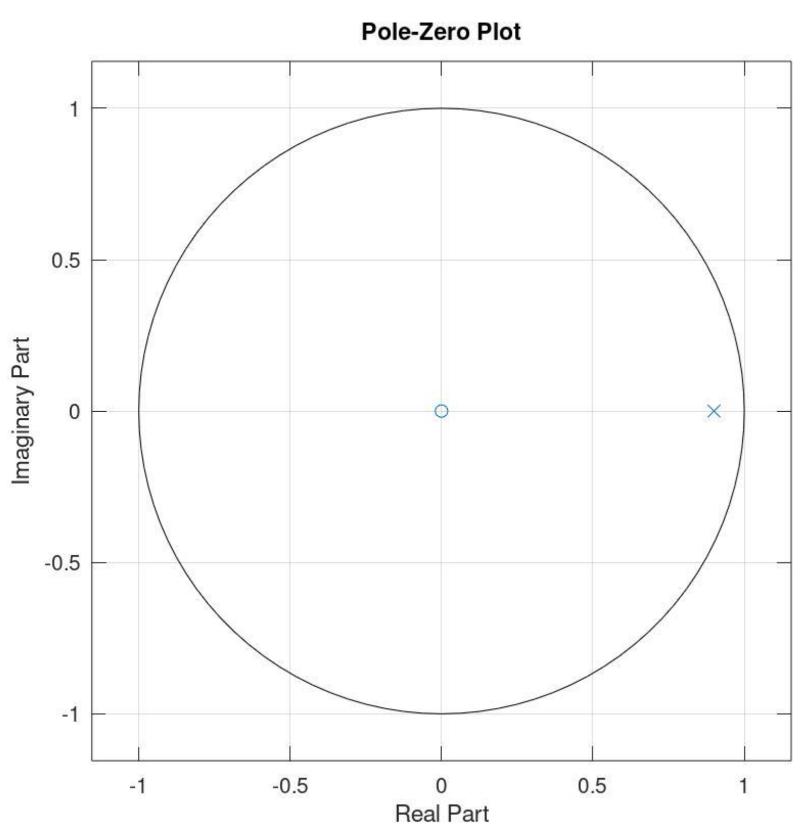
Code

```
b = [1, 0];
a = [1, -0.9];
zplane(b,a)
title('Pole-Zero Plot');
xlabel('Real Part');
ylabel('Imaginary Part');
[H,w] = freqz(b,a,100);
magH = abs(H);
```

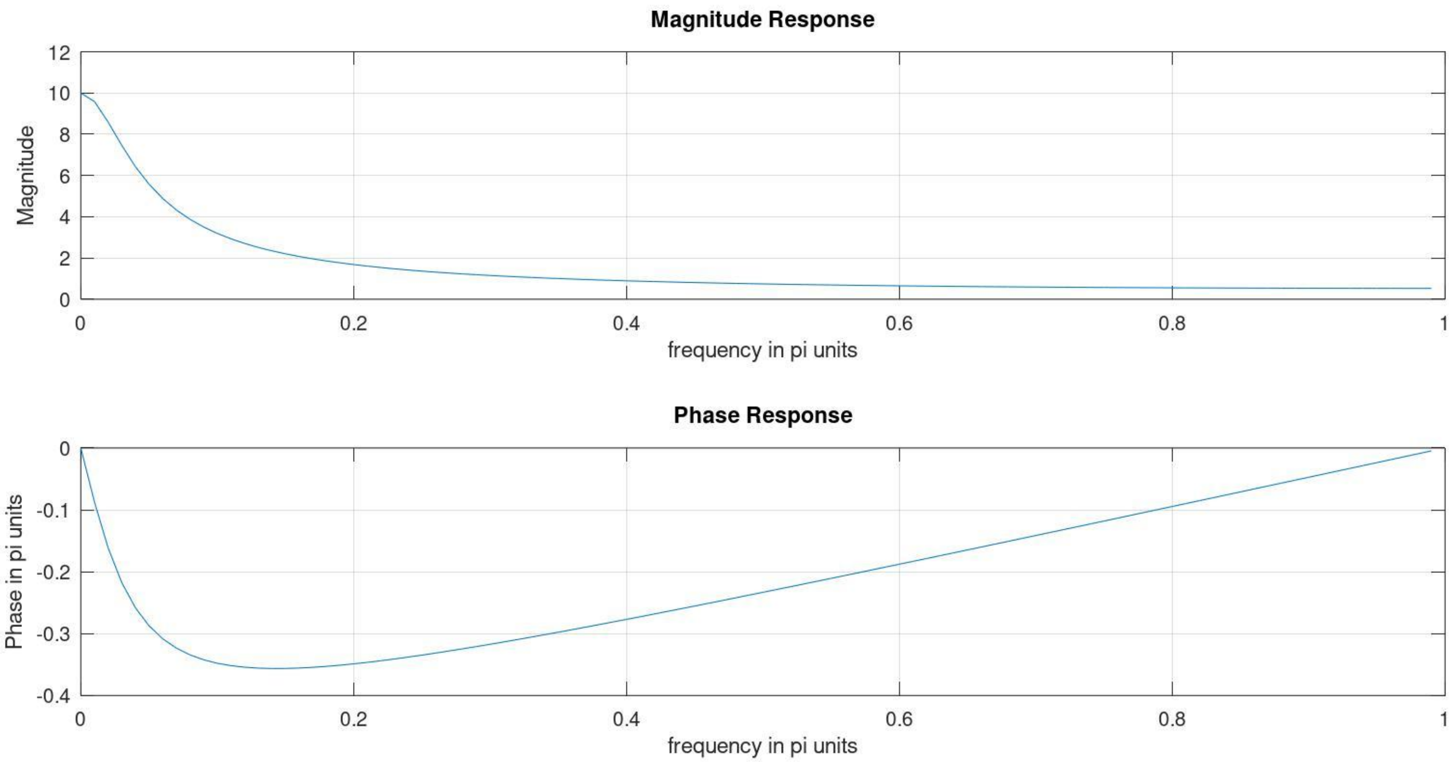
```
phaH = angle(H);
subplot(2,1,1);
plot(w/pi,magH);grid
xlabel('frequency in pi units');
ylabel('Magnitude');
title('Magnitude Response');
subplot(2,1,2);
plot(w/pi,phaH/pi);grid
xlabel('frequency in pi units');
ylabel('Phase in pi units');
title('Phase Response');
```

Output

a)



b)


Magnitude Response
Magnitude
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
frequency in pi units
Phase Response
Phase in pi units
0
-0.1
-0.2
-0.3
-0.4
0
0.2
0.4
0.6
0.8
1
frequency in pi units

Program-13

Aim

Write a MATLAB code for the following question:

A filter is described by the following difference equation:

$$16y(n) + 12y(n-1) + 2y(n-2) - 4y(n-3) - y(n-4)$$
$$= x(n) - 3x(n-1) + 11x(n-2) - 27x(n-3) + 18x(n-4)$$

Determine its cascaded form structure.

Software used

MATLAB/GNU Octave/SciLab

Code

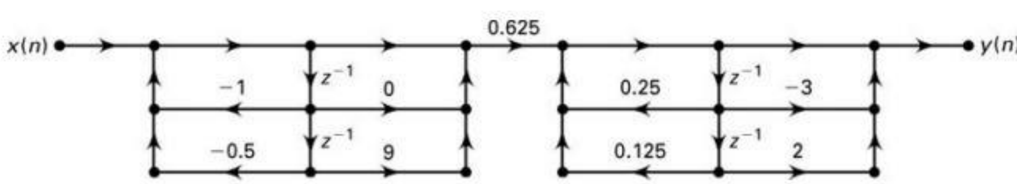
```
function [b0,B,A] = dir2cas(b,a);
%----DIRECT-form to CASCADE-form conversion-----
b0 = b(1); b = b/b0; a0 = a(1); a = a/a0;
b0 = b0/a0;
%
M = length(b);
N = length(a);
if N>M
```

```
b = [b zeros(1,N-M)];
elseif M>N
a = [a zeros(1,M-N)];
N = M;
else
NM = 0;
end
%
K = floor(N/2); B = zeros(K,3); A = zeros(K,3);
if K*2 == N;
b = [b 0];
a = [a 0];
end
%
broots = cplxpair(roots(b));
aroots = cplxpair(roots(a));
for i=1:2:2*K
Brow = broots(i:1:i+1,:);
Brow = real(poly(Brow));
B(fix((i+1)/2),:) = Brow;
Arow = aroots(i:1:i+1,:);
Arow = real(poly(Arow));
A(fix((i+1)/2),:) = Arow;
```

```
end
%
function y = casfiltr(b0,B,A,x);
%-----CASCADE form realization of IIR and FIR
%filters-----
[K,L] = size(B);
N = length(x);
w = zeros(K+1,N);
w(1,:) = x;
for i = 1:1:K
w(i+1,:) = filter(B(i,:),A(i,:),w(i,:));
end

%MATLAB CODE
b= [1 -3 11 -27 18];
a= [16 12 2 -4 -1];
[b0,B,A]= dir2cas(b,a)
delta = impseq(0,0,7)
format long
hcas= casfiltr(b0,B,A,delta)
hdir= filter(b,a,delta)
```

Output

```
b0 = 0.062500
B =

   1.0000e+00   9.9920e-16   9.0000e+00
   1.0000e+00  -3.0000e+00   2.0000e+00

A =

   1.0000   1.0000   0.5000
   1.0000  -0.2500  -0.1250

delta =

  1  0  0  0  0  0  0  0

hcas =

 Columns 1 through 6:

   6.250000000000000e-02  -2.343750000000001e-01   8.554687500000007e-01  -2.284179687500004e+00   2.676513671875005e+00  -1.522644042968753e+00

 Columns 7 and 8:

   2.898406982421875e-01   4.993171691894546e-01

hdir =

 Columns 1 through 6:

   6.250000000000000e-02  -2.343750000000000e-01   8.554687500000000e-01  -2.284179687500000e+00   2.676513671875000e+00  -1.522644042968750e+00

 Columns 7 and 8:

   2.898406982421875e-01   4.993171691894531e-01
```



Program-14

Aim

Write a MATLAB code for the following question:

Design a digital FIR lowpass filter with the following specifications:

$$\omega_p = 0.2\pi,\ R_p = 0.25 \text{ dB}$$

$$\omega_s = 0.3\pi,\ A_s = 50 \text{ dB}$$

Using Hamming Window function, determine the impulse response and provide a plot of the frequency response of the designed filter.

Software used

MATLAB/GNU Octave/SciLab

Code

```
wp = 0.2*pi; ws = 0.3*pi; tr_width = ws - wp;
M = ceil(6.6*pi/tr_width) + 1
n=[0:1:M-1];
wc = (ws+wp)/2 % Ideal LPF cutoff frequency
hd = ideal_lp(wc,M);
w_ham = (hamming(M))';
h = hd .* w_ham;
[db,mag,pha,grd,w] = freqz_m(h,[1]);
delta_w = 2*pi/1000;
```

```
Rp = -(min(db(1:1:wp/delta_w+1)))% Actual
%Passband Ripple

As = -round(max(db(ws/delta_w+1:1:501)))% Min
%Stopband attenuation

% plots

subplot(2,2,1); stem(n,hd);

title('Ideal Impulse Response');

axis([0 M-1 -0.1 0.3]);

xlabel('n');

ylabel('hd(n)');

subplot(2,2,2); stem(n,w_ham);

title('Hamming Window');

axis([0 M-1 0 1.1]); xlabel('n');ylabel('w(n)');

subplot(2,2,3); stem(n,h);

title('Actual Impulse Response');

axis([0 M-1 -0.1 0.3]);

xlabel('n');

ylabel('h(n)');

subplot(2,2,4);

plot(w/pi,db);

title('Magnitude Response in dB');grid

axis([0 1 -100 10]);

xlabel('frequency in pi units');

ylabel('Decibels');
```

Output

tr_width = 0.3142

M = 67

wc = 0.7854

Rp = 0.0394

As= 52