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EE 274 Digital Signal Processing 1 Lab Activity 1

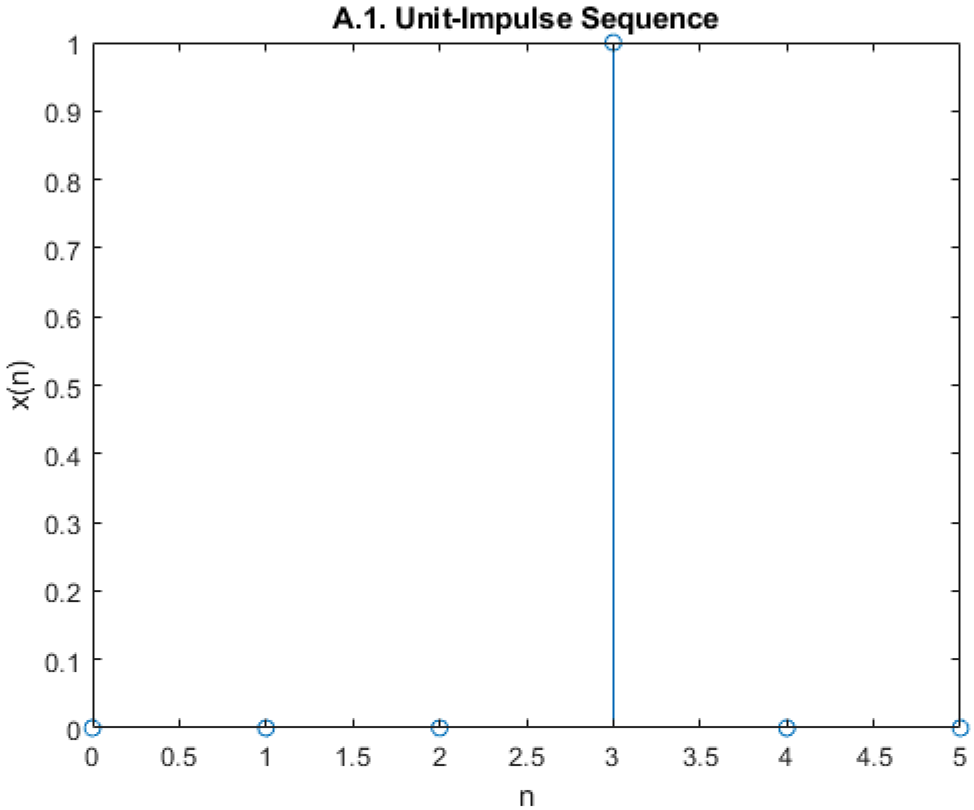
A. Signal Generation

In this exercise, you will demonstrate your coding skills in MATLAB by generating the following signals:

1. [y,n] = impseq(n0,a,b)
2. [y,n] = stepseq(n0,a,b)
3. [y,n] = sigadd(x1,n1,x2,n2)
4. [y,n] = sigmult(x1,n1,x2,n2)
5. [y,n] = sigshift(x1,n1,n0)
6. [y,n] = sigfold(x1,n1)
7. [xe,xo,n] = evenodd(x1,n1)

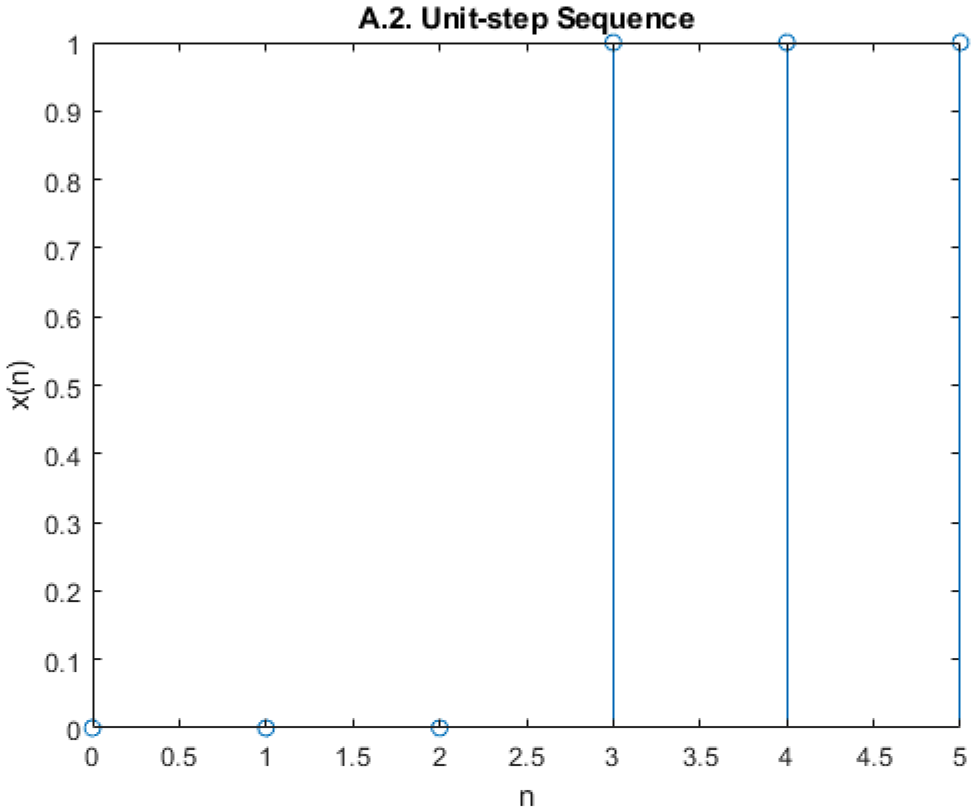
- Demo of impseq function **[y,n] = impseq(n0,a,b)**

```
[y,n] = impseq(3,0,5)
figure
stem (n,y)
title('A.1. Unit-Impulse Sequence')
xlabel('n')
ylabel('x(n)')
```



- Demo of Unit-step sequence function **[y,n] = stepseq(n0,a,b)**

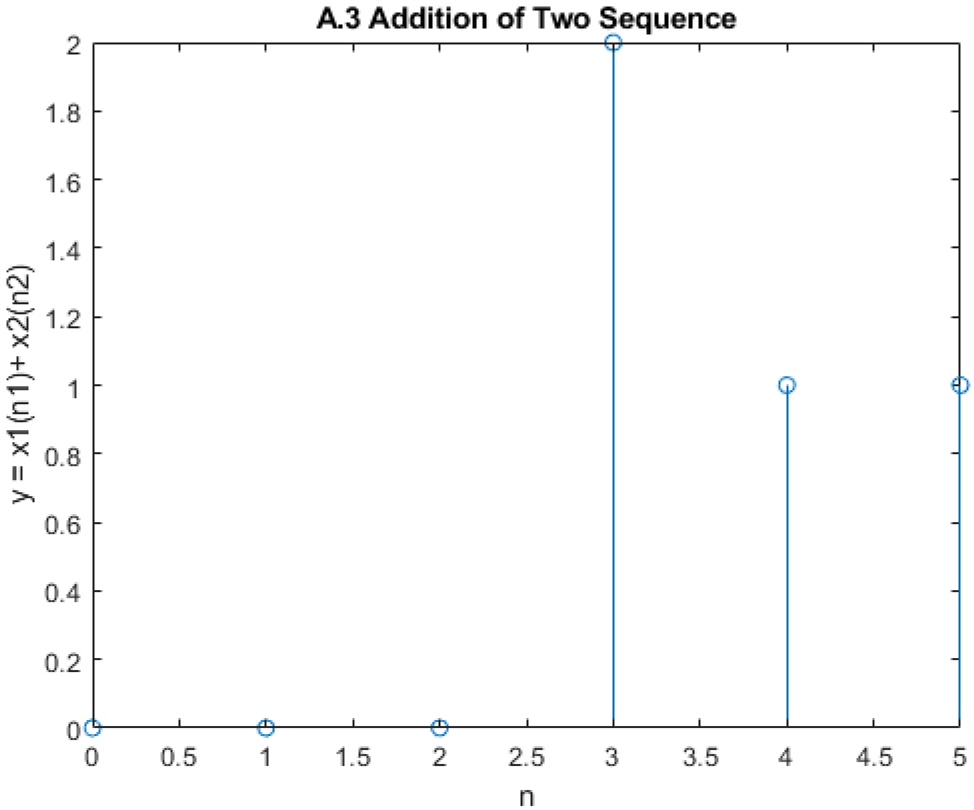
```
[y,n]  = stepseq(3,0,5)
figure
stem(n,y)
title('A.2. Unit-step Sequence')
xlabel('n')
ylabel('x(n)')
```



- Demo of addition of two sequence **[y,n] = sigadd(x1,n1,x2,n2)**

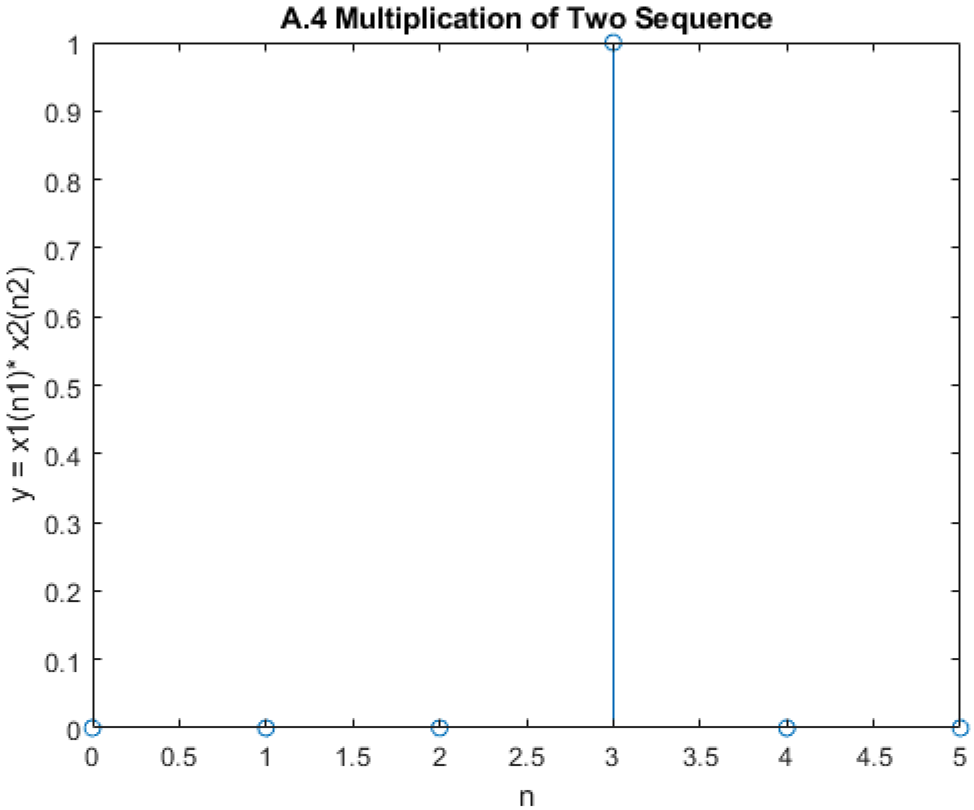
```
[y1,n1] = impseq(3,0,5) %generate impulse sequence
[y2,n2]  = stepseq(3,0,5) %generate unit-step sequence
[y,n] = sigadd(y1,n1,y2,n2) % add the unit step and unit impulse
 sequence
figure
stem(n,y)
title('A.3 Addition of Two Sequence')
ylabel('y = x1(n1)+ x2(n2)')
xlabel('n')
```

```
y2 =

  1×6 logical array

...
```



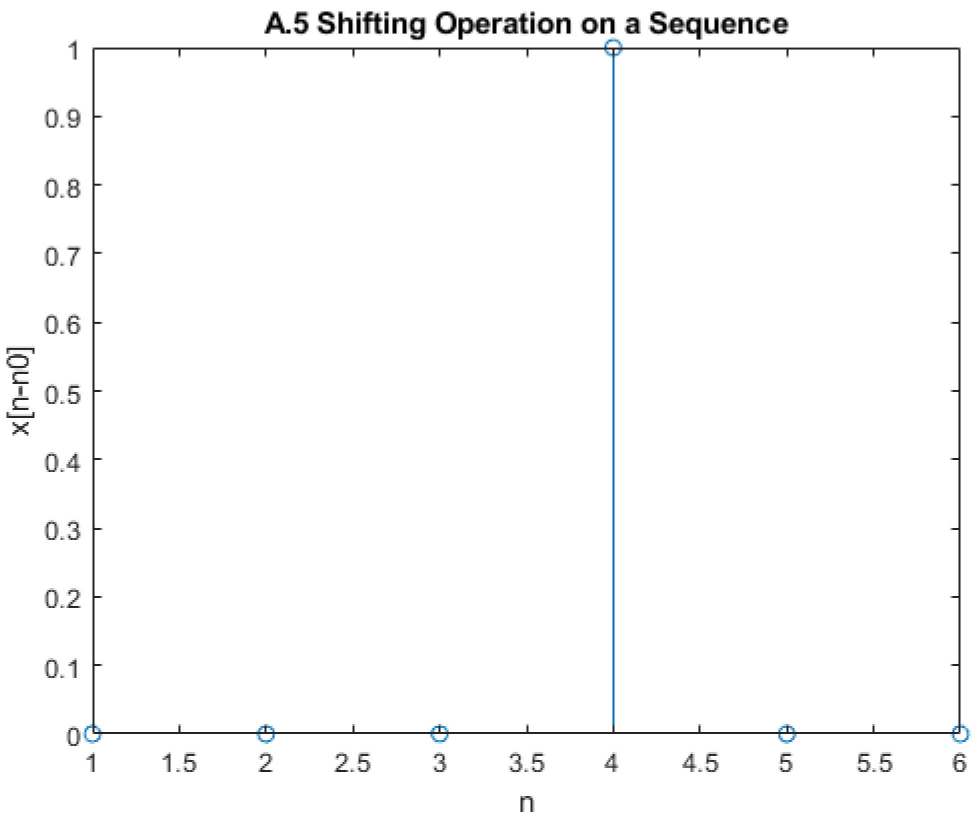
- Demo of multiplication of two sequence **[y,n] = sigmult(x1,n1,x2,n2)**

```
[y1,n1] = impseq(3,0,5) %generate impulse sequence
[y2,n2]  = stepseq(3,0,5) %generate unit-step sequence
[y,n] = sigmult(y1,n1,y2,n2) % add the unit step and unit impulse
 sequence
figure
stem(n,y)
title('A.4 Multiplication of Two Sequence')
ylabel('y = x1(n1)* x2(n2)')
xlabel('n')
```



- Demo of signal shifting **[y,n] = sigshift(x1,n1,n0)**

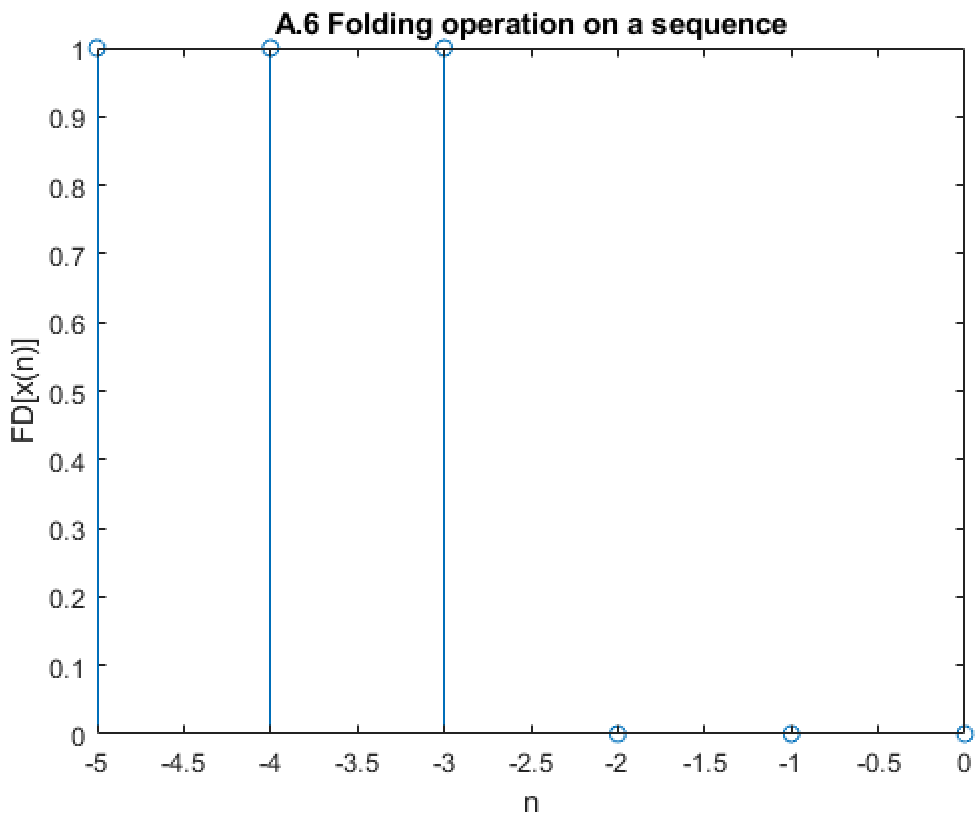
```
[y1,n1] = impseq(3,0,5) % generate impulse sequence
[y,n] = sigshift(y1,n1,1) % shift impulse sequence by 1
figure
stem(n,y)
title('A.5 Shifting Operation on a Sequence')
ylabel('x[n-n0]')
xlabel('n')
```



1. Demo of signal folding **[y,n] = sigfold(x1,n1)**

```
[y1,n1]  = stepseq(3,0,5)
[y,n]= sigfold(y1,n1)
figure
stem(n,y)
title('A.6 Folding operation on a sequence')
ylabel('FD[x(n)]')
xlabel('n')
```

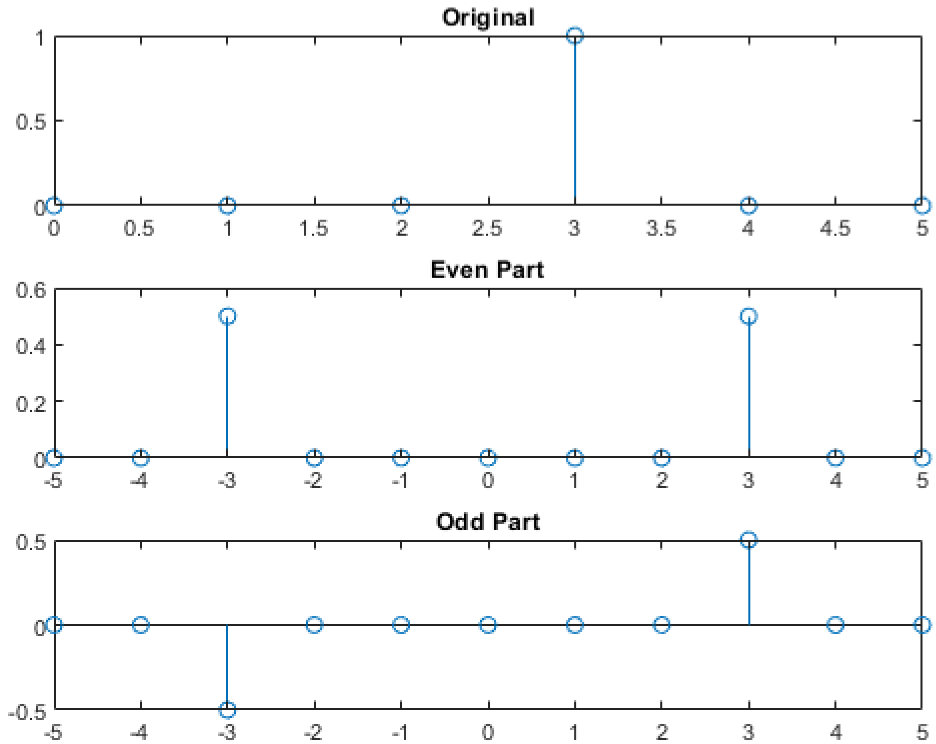
```
y1 =

  1×6 logical array

...
```



- Demo of odd even signal decomposition **[xe,xo,m] = evenodd(x,n)**

```
[y1,n1] = impseq(3,0,5) %generate impulse sequence
[y2,n2]  = stepseq(3,0,5) %generate unit-step sequence
[y,n] = sigmult(y1,n1,y2,n2) % add the unit step and unit impulse
 sequence
[xe,xo,m] = evenodd(y,n)
subplot(311)
stem(n,y)
title('Original')
subplot(312)
stem(m,xe)
title('Even Part')
subplot(313)
stem(m,xo)
title('Odd Part')
```

```
y2 =

  1×6 logical array

...
```



B. SIGNAL REPRESENTATION

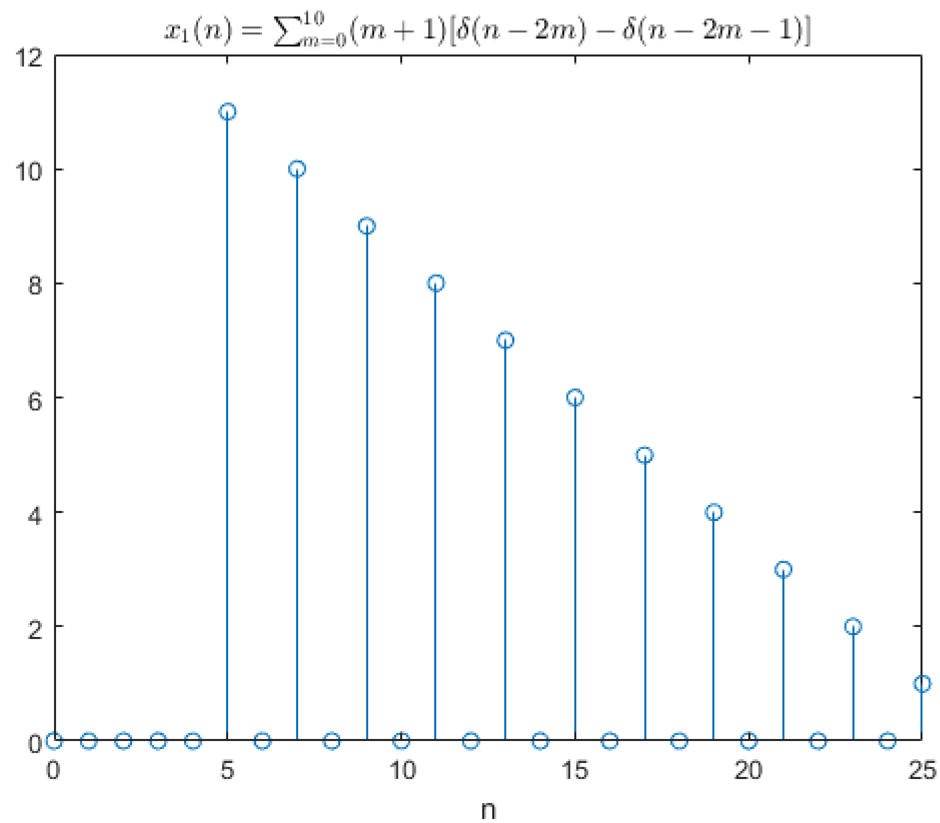
Generate and Plot the following signals. You may use your functions in Part A.

$$x_1(n) = \sum_{m=0}^{10}(m+1)[\delta(n-2m) - \delta(n-2m-1)]$$

```
y=0
N=25
nn=0:N
for n =0:N
for m =0:10
    temp=(m+1) .*( impseq(n-2*m,0,N) - impseq(n-(2*m)-1,0,N))
    y=y+temp
end
end
figure
stem(nn,y)
xlabel('n')
title('$x_1(n) = \sum_{m=0}^{10}(m+1)[\delta(n-2m) -
 \delta(n-2m-1)]$','interpreter','latex')
```

y =

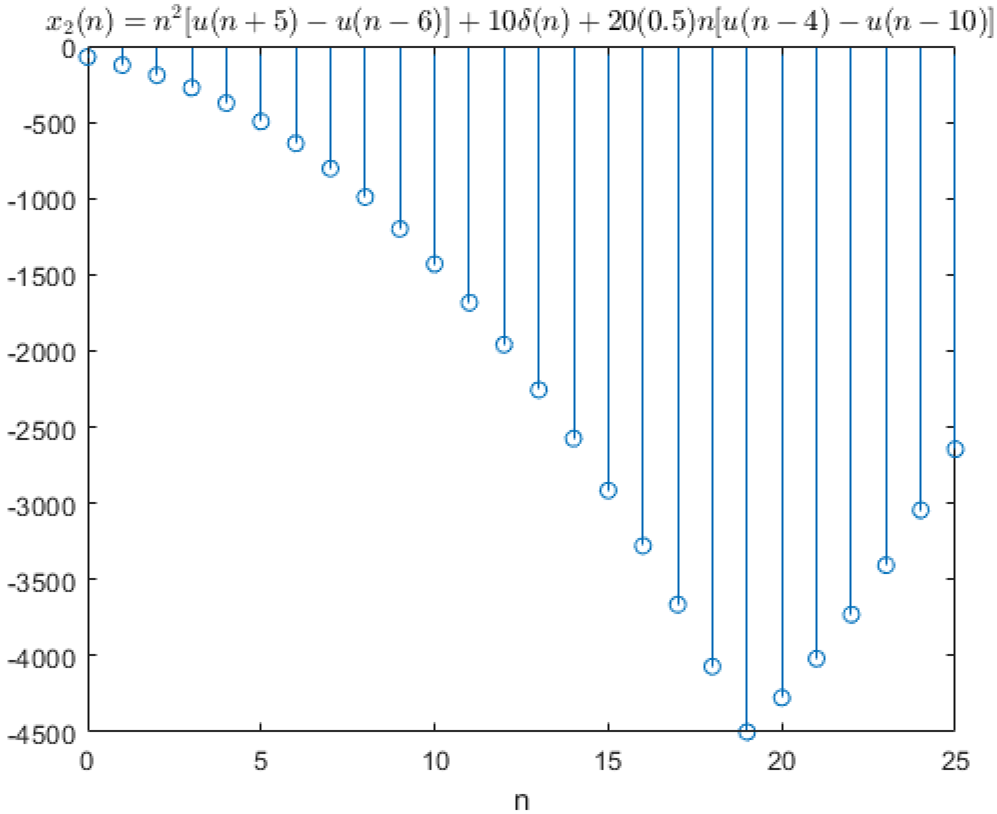
```
    0

...
```



$x_2(n) = n^2[u(n+5) - u(n-6)] + 10\delta(n) + 20(0.5)n[u(n-4) - u(n-10)]$

```
y=0
N=25
nn=0:N
for n=0:25
temp = n^2 .* (stepseq(n+5,0,N) - stepseq(n-6,0,N)) + (10 .*
 impseq(n,0,N)) + 20*(0.5)^n .*(stepseq(n-4,0,N) - stepseq(n-1,0,N))
y=y+temp
end
figure
stem(nn,y)
xlabel('n')
title('$x_2(n) = n^2[ u(n+5) - u(n-6)] + 10\delta(n) +20(0.5)n[u(n-4)-
u(n-10)]$','interpreter','latex')
```

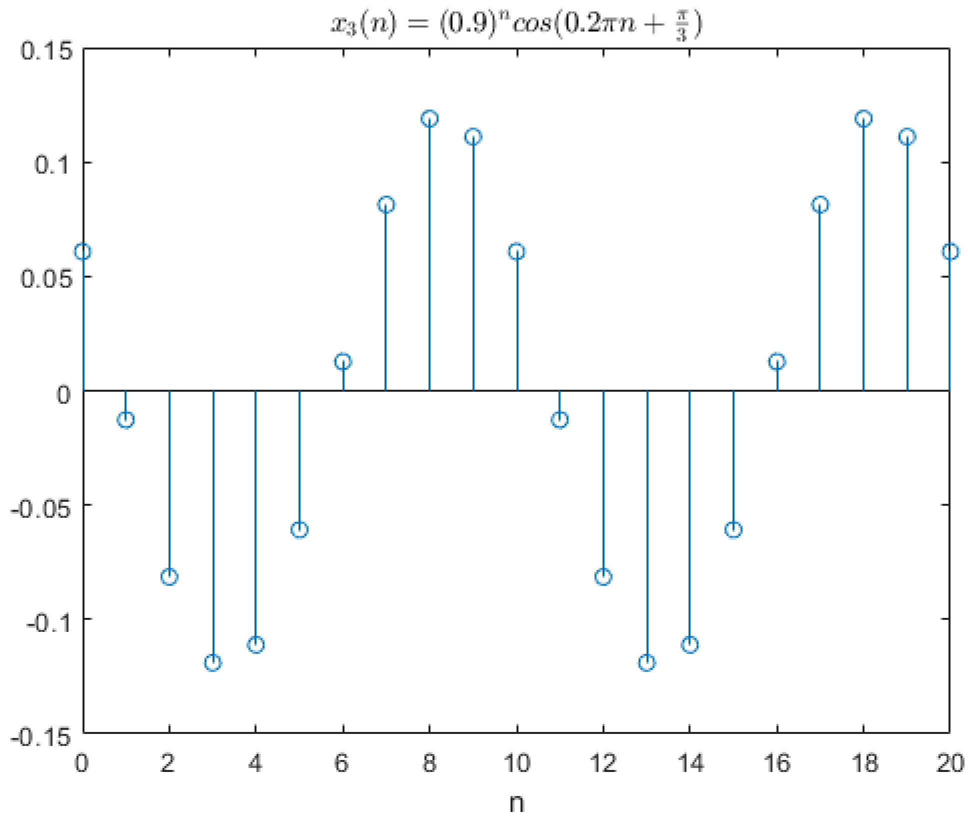
```
y =

    0

...
```



$x_3(n) = (0.9)^n cos(0.2\pi n + \frac{\pi}{3})$

```
N=20
n = 0:N;
x0 = 0.9;
x = (0.9^N)*cos(0.2*pi*n+(pi/3));
figure
stem(n,x)
xlabel('n')
title(' $x_3(n)= (0.9)^n cos(0.2\pi n + \frac{\pi}
{3})$','interpreter','latex')
```

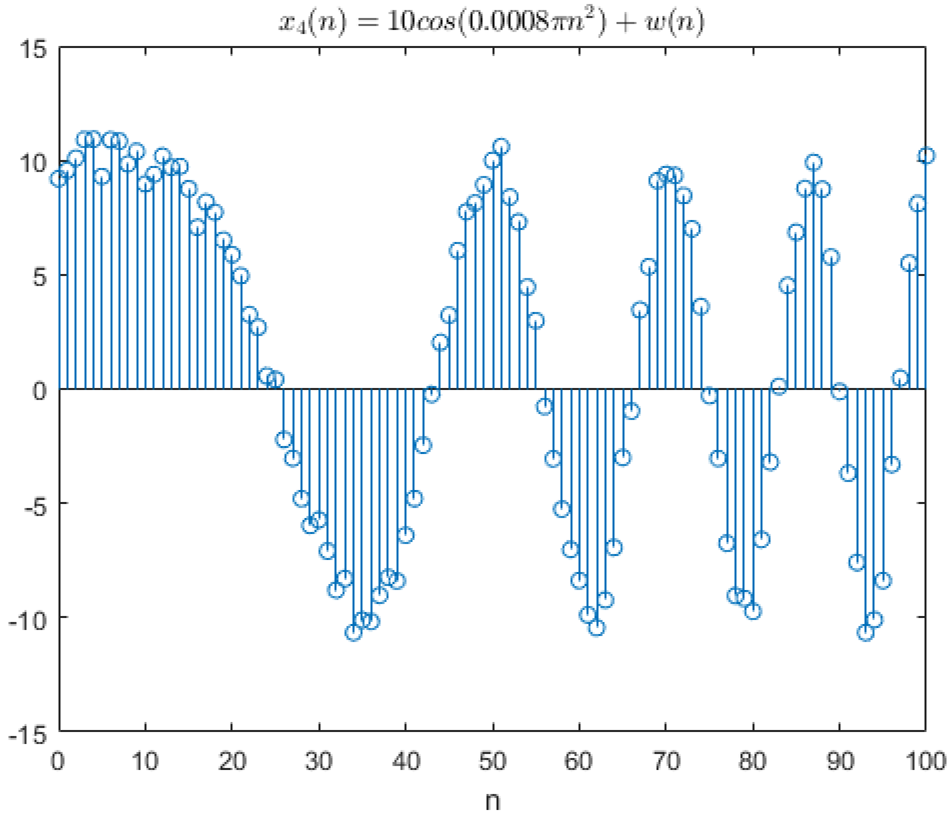
```
N =

    20
```



$x_4(n) = 10cos(0.0008\pi n^2) + w(n)$

```
N=100
n=0:N;
x0=10;
w = -1+2*rand(1,N+1);
x =(x0*cos(0.0008*pi*(n.^2))) + w
figure
stem(n,x)
xlabel('n')
title(' $x_4(n) = 10cos(0.0008\pi n^2) + w(n)$','interpreter','latex')
```

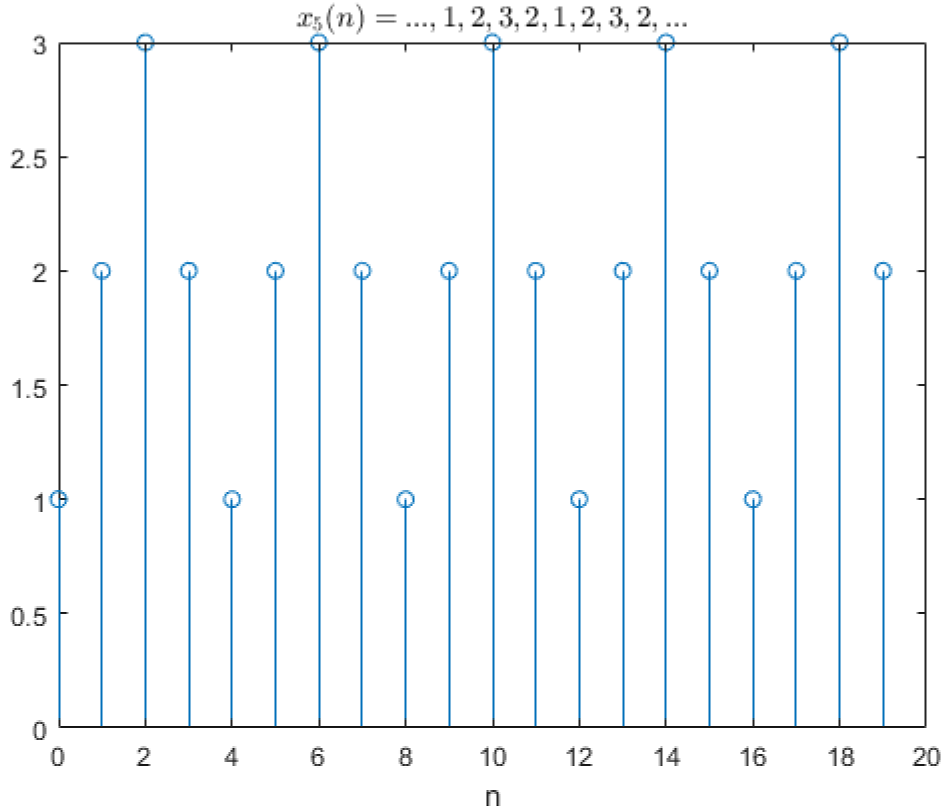
```
N =

   100

...
```



$x_5(n) = ..., 1, 2, 3, 2, 1, 2, 3, 2, ...$

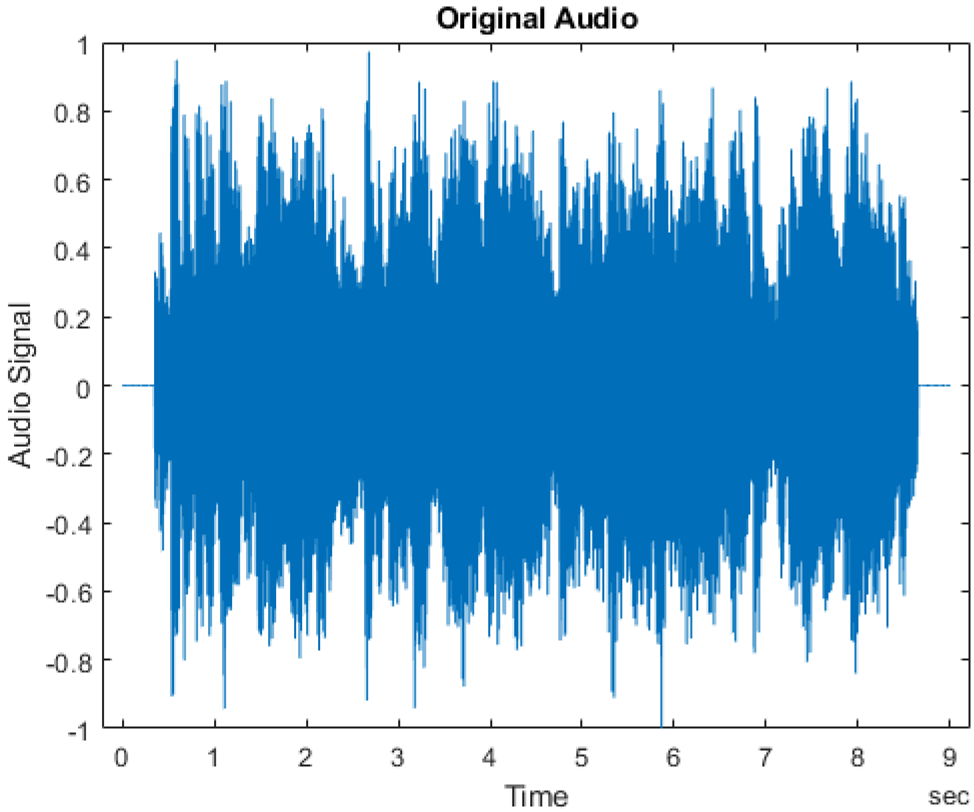
```
N=20
n=0:N-1
x=[1 2 3 2]
x= [x x x x x]
figure
stem(n,x)
xlabel('n')
title(' $x_5(n) = {...,1,2,3,2,1,2,3,2,...}$','interpreter','latex')
```

```
N =

    20

...
```



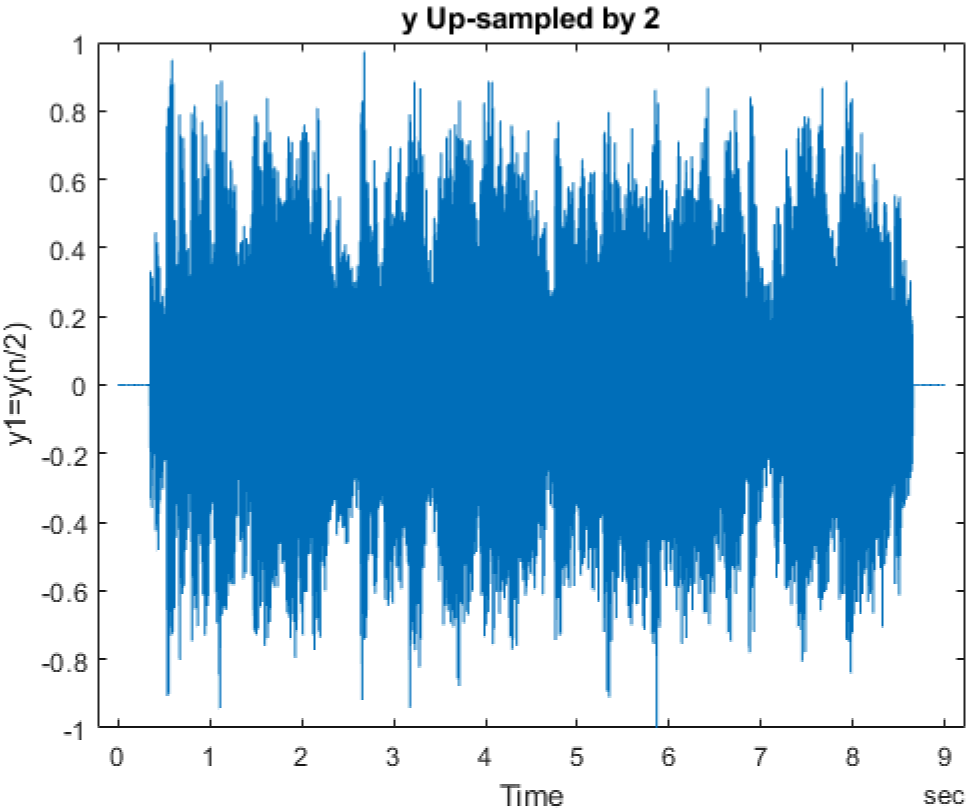
C. Sampling

```
%Sampling is done by periodically obtaining samples from a continuous
 time
%signal. The period also known as the sampling period is the
 reciprocal of
%sampling frequency $F_s$. Using up-sampling and down-sampling,
 information
%can be added or removed from a discrete time signal.
%
% # Load *signal1.wave* file in your workspace
% # Using *[y,fs] = audioread()*, import the audio and sampling rate
% information in your workspace.
%
[y,fs] = audioread('signal1.wav');
info=audioinfo('signal1.wav');
t = 0:seconds(1/fs):seconds(info.Duration);
t = t(1:end-1);

plot(t,y)
title('Original Audio')
xlabel('Time')
ylabel('Audio Signal')
soundsc(y,fs)
```



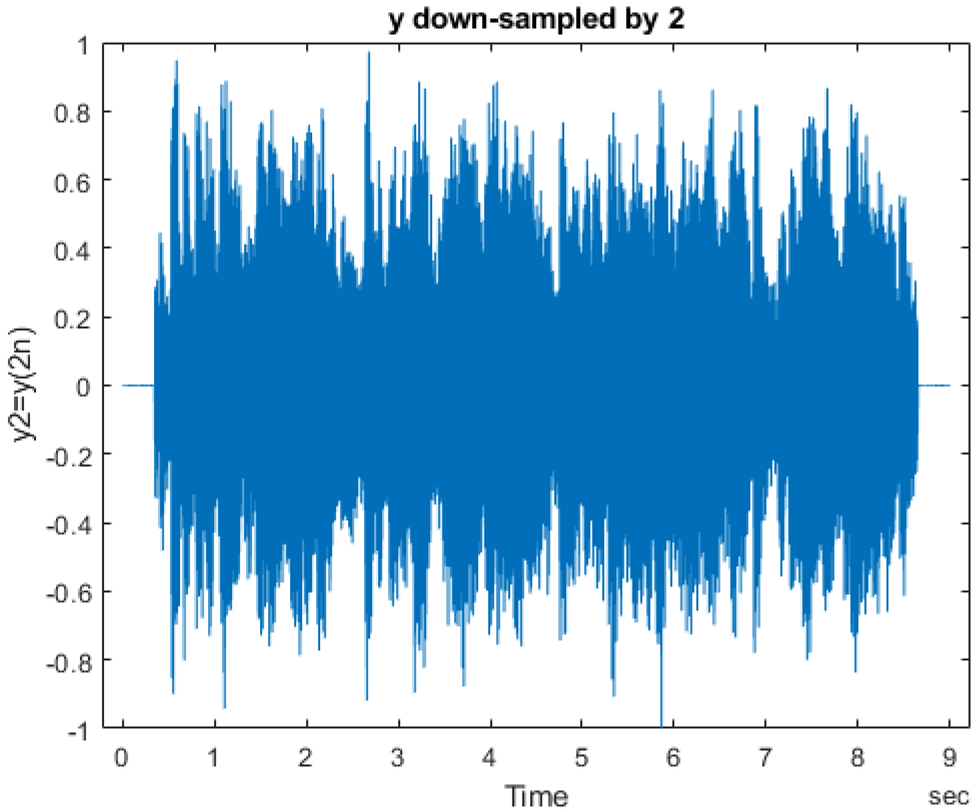

```
%y up-sampled by 2
M=2
y1= upsample(y,M)
t1 = 0:seconds(1/(M*fs)):seconds(info.Duration);
t1 = t1(1:end-1);
figure
plot(t1,y1)
title('y Up-sampled by 2')
xlabel('Time')
ylabel('y1=y(n/2)')
soundsc(y1,fs)
```

```
M =

     2

...
```



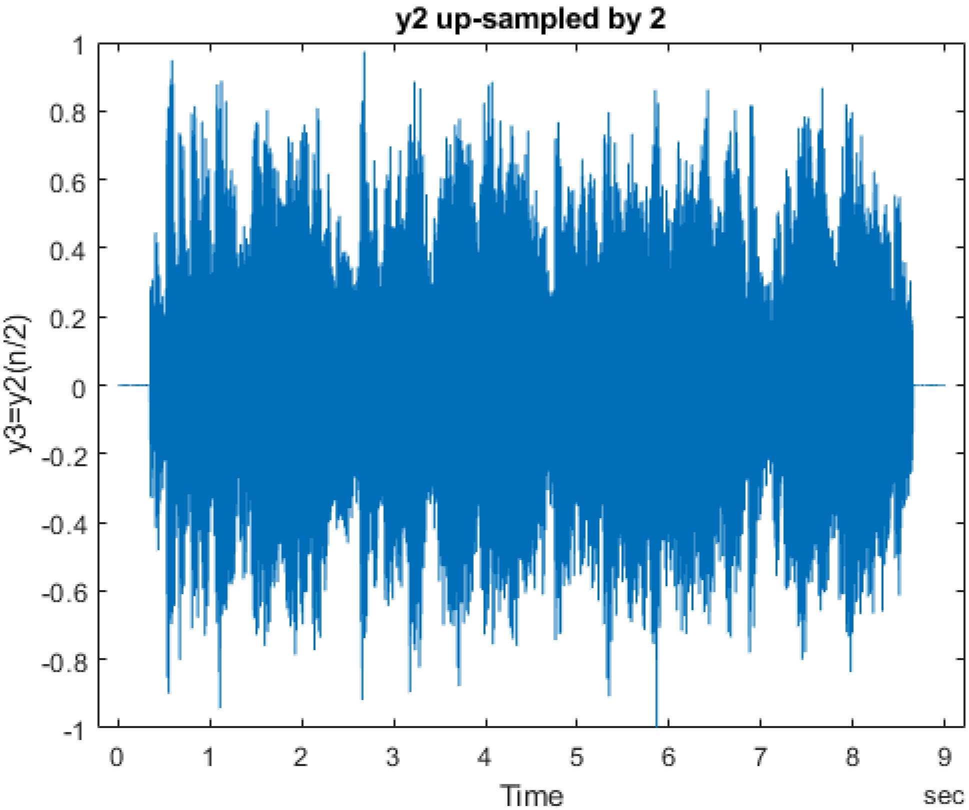

```
%y down-sampled by 2
M=2
y2= downsample(y,M)
t2 = 0:seconds(1/(fs/M)):seconds(info.Duration);
t2 = t2(1:end-1);
figure
plot(t2,y2)
title('y down-sampled by 2')
xlabel('Time')
ylabel('y2=y(2n)')
soundsc(y2,fs)
```

```
M =

     2

...
```



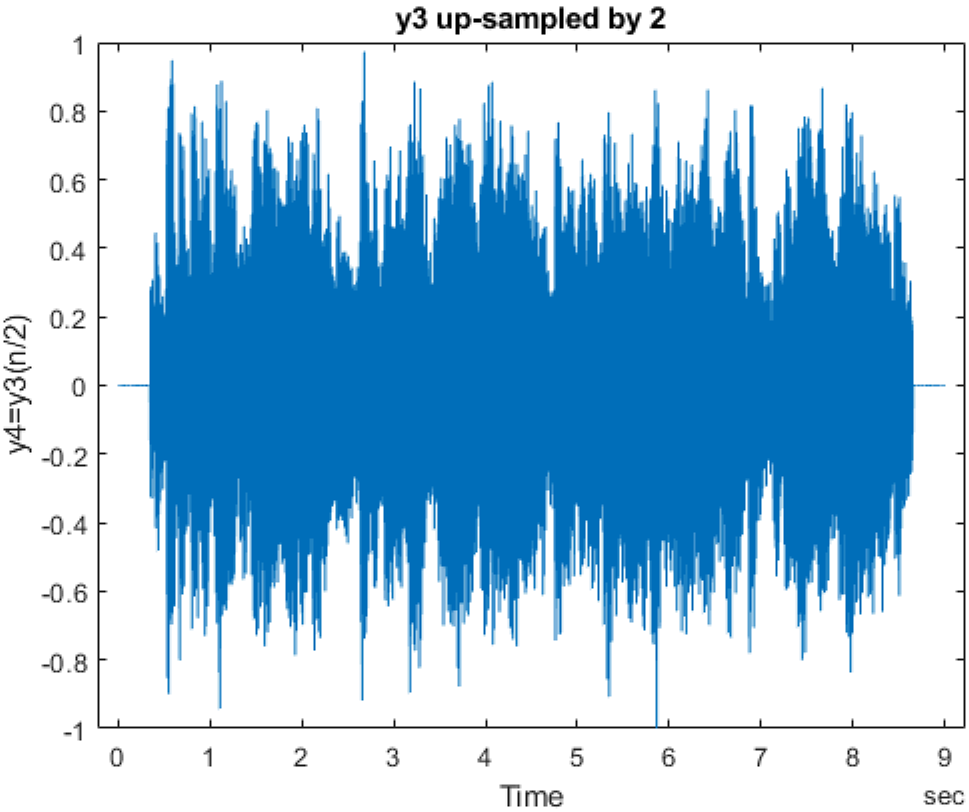

```
%y2 up-sampled by 2
M=2
y3 = upsample(y2,M)
t3 = 0:seconds(1/fs):seconds(info.Duration);
t3 = t3(1:end-1);
figure
plot(t3,y3)
title('y2 up-sampled by 2')
xlabel('Time')
ylabel('y3=y2(n/2)')
soundsc(y3,fs)
```

```
M =

     2

...
```




```
%y3, up-sampled by 2
M=2
y4 = upsample(y3,M)
t4 = 0:seconds(1/(fs*M)):seconds(info.Duration);
t4 = t4(1:end-1);
figure
plot(t4,y4)
title('y3 up-sampled by 2')
xlabel('Time')
ylabel('y4=y3(n/2)')
soundsc(y4,fs)

%yes however some information will be loss as the upsampler cannot
 predict
%the value inbetween the downsampled signales. In effect, there are
 loss
%information in the upsampled signals $y_3$ and $y_4$.
```

```
M =

     2

...
```

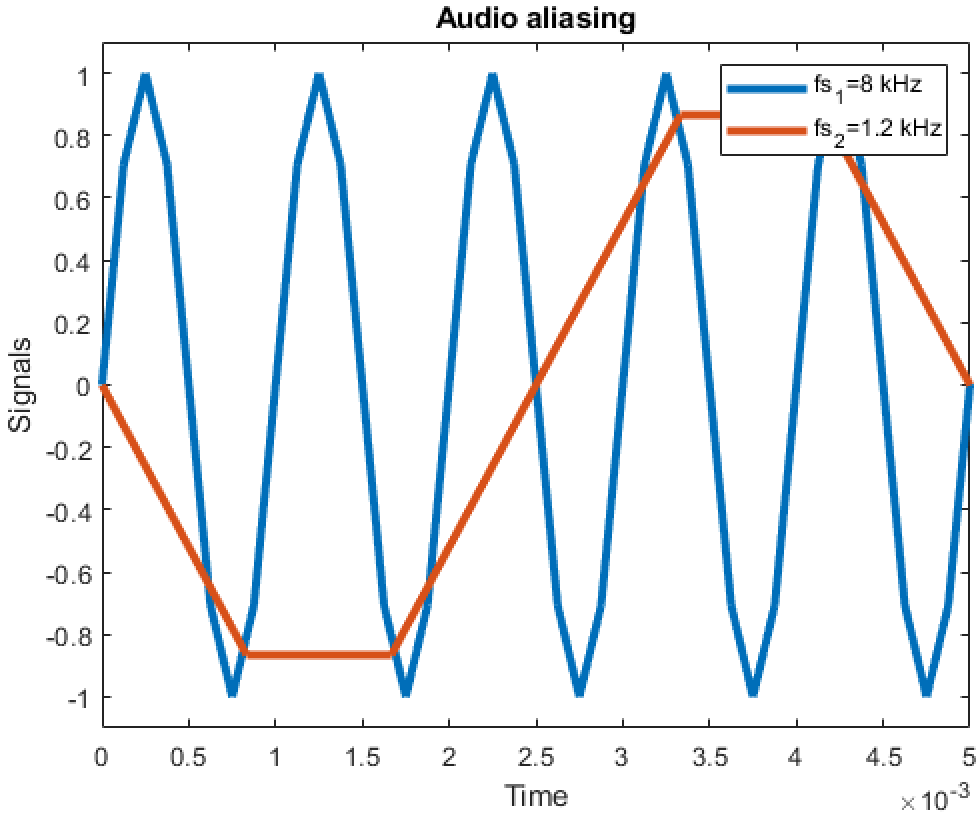


D. Aliasing

The following exercise investigates the effect of improper sampling.

1. Generate two 1 kHz sine signals (2 seconds duration), first signal at 8 kHz sample frequency and second signal at 1.2 kHz sample frequency
2. On the same graph, use the plot function to display the two signals versus t in the range $0 \leq t \leq 5$ msec.
3. Listen to the two signals one after another using the function **soundsc (x, fs)**;
4. Compare the two signals. How does the sampling rate affect the digitized sound?

```
T = 2; %parameters
f0 = 1000; % 1kHz sine signal
fs1 = 8000; % Sampling frequencies
fs2 = 1200;
[x1, t1] = sin_NU(fs1,f0,T); % sine signal sampled at fs1
[x2, t2] = sin_NU(fs2,f0,T); % sine signal sampled at fs2
figure;
plot(t1,x1,t2,x2,'LineWidth',3.0),
axis([0, 0.005, -1.1, 1.1])
legend('fs_1=8 kHz','fs_2=1.2 kHz')
xlabel('Time')
ylabel('Signals')
title('Audio aliasing');
```




```
soundsc(x1,fs1)
```

```
soundsc(x2,fs2)
```

based from observation, the sine wave sampled at F_s2 does not completely recovered the original sine wave at $f_o =1$kHz as compared to F_s1 with frequency lower than $2F_max$, which leads to aliasing.

E. Quantization

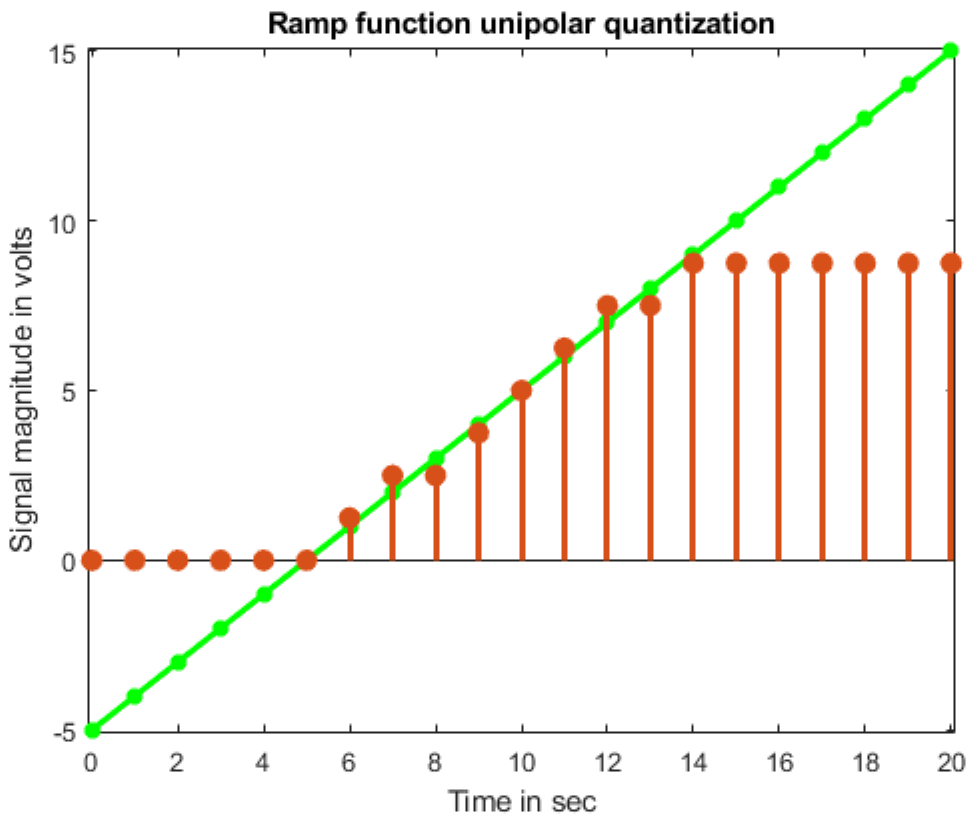
```
%Quantization is done by replacing each value of an analog signal
 $x(t)$ by
%the value of the nearest quantization level. To exemplify this
 oepration,
%let's simulate a unipolar ADC (Analog to Digital Converter) having
 the
%technical specifications: R= 10 Volts (full-scale range) and B =
 3(number
%of bits).
%
% # Write a MATLAB function y=adc_uni(x,R,B) where x and y are vectors
% containing the input signal and the quantized signal, respectively.
% # Test your function with an input ramp signal ranging from -5 to 15
% Volts (1 volt per step).
% # On the same graph, use the plot and stem functions to display the
 input
```

```
% signal and quantized signal respectively.
```

adc_uni function test

```
R = 10;
B = 3;
x = -5:15;
y = adc_uni(x,R,B);
t = 0:length(x)-1;
figure(11)
plot(t,x,t,y)
plot(t,x,'g-*','LineWidth',2.2)
hold on
stem(t,y,'filled','LineWidth',2.2)
hold off
title('Ramp function unipolar quantization')
xlabel('Time in sec')
ylabel('Signal magnitude in volts')
axis([-0.1,20.1,-5.1,15.1])

function y = adc_uni(x, R, B)
level = [0:R/(2^B):R-R/(2^B)];
temp = [-Inf,(level(2:end)-R/(2^(B+1))),Inf];
y = zeros(1,length(x));
i=1
y=(x >= temp(i)).*(x < temp(i+1)).*level(i)
for i = 2:length(level)
    y = y + (x >= temp(i)).*(x < temp(i+1)).*level(i);
end
end
```

```
i =

     1

...
```




```
function [x, t] = sin_NU(fs, f0, T) %function to generate sine signal
t = 0:1/fs:T; %the signal vector output
x = sin(2*pi*f0*t); %the time vector output
end

function [x,n]=impseq(n0,a,b)
% Generates x(n)= delta(n-n0); a<=n<=b
n=[a:b]; x=[(n-n0)==0];
end
```

```
y =

  1×6 logical array

...


y1 =

  1×6 logical array

...


y1 =
```

```
  1×6 logical array

...


y1 =

  1×6 logical array

...


y1 =

  1×6 logical array

...


temp =

  Columns 1 through 13

...
```

[y,n] = stepseq(n0,a,b)

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

```
y =

  1×6 logical array

...


y2 =

  1×6 logical array

...
```

[y,n] = sigadd(x1,n1,x2,n2)

```
function [y,n]=sigadd(x1,n1,x2,n2)
n=min(min(n1),min(n2)): max(max(n1),max(n2));
y1=zeros(1,length(n)); y2=y1;
y1(find((n>=min(n1))&(n<=max(n1))==1))=x1;
y2(find((n>=min(n2))&(n<=max(n2))==1))=x2;
y=y1+y2;
end
```

```
y =

     0     0     0     2     1     1

...
```

[y,n] = sigmult(x1,n1,x2,n2)

```
function [y,n] = sigmult(x1,n1,x2,n2)
% implements y(n) = x1(n)*x2(n)
n = min(min(n1),min(n2)):max(max(n1),max(n2)); % duration of y(n)
y1 = zeros(1,length(n)); y2 = y1; %
y1(find((n>=min(n1))&(n<=max(n1))==1))=x1; % x1 with duration of y
y2(find((n>=min(n2))&(n<=max(n2))==1))=x2; % x2 with duration of y
y = y1 .* y2; % sequence multiplication
end
```

```
y =

     0     0     0     1     0     0

...
```

```
y =

     0     0     0     1     0     0

...
```

```
function [y,n] = sigshift(x,n1,n0)
% implements y(n) = x(n-n0)
n = n1+n0; y = x;
end
```

```
y =

  1×6 logical array

...
```

```
function [y,n] = sigfold(x,n)
% implements y(n) = x(-n)
% -----------------------
% [y,n] = sigfold(x,n)
%
y = fliplr(x); n = -fliplr(n);
end
```

```
y =
```

```
  1×6 logical array

...
```

odd even decomposition function

```
function [xe,xo,m] = evenodd(x,n)
if any(imag(x)~=0)
    error('x is not real sequence ')
end
m = -fliplr(n);
m1 = min([m,n]);
m2 = max([m,n]);
m = m1:m2;
nm = n(1)-m(1);
n1 = 1:length(n);
x1 = zeros(1,length(m));
x1(n1+nm) = x;
x = x1;
xe = 0.5*(x+fliplr(x));
xo = 0.5*(x-fliplr(x));
end
```

```
xe =

  Columns 1 through 7

...
```

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