DEPARTMENT OF ECE

BAPATLA ENGINEERING COLLEGE

BAPATLA

Signals and Systems Lab

(EC-263) Lab Manual

Prepared by

Sameeulla Khan Md, Lecturer

List of Experiments

1. Write a program to generate the discrete sequences (i) unit step (ii) unit impulse (iii) ramp (iv) periodic sinusoidal sequences. Plot all the sequences.
2. Find the Fourier transform of a square pulse .Plot its amplitude and phase spectrum.
3. Write a program to convolve two discrete time sequences. Plot all the sequences. Verify the result by analytical calculation.
4. Write a program to find the trigonometric Fourier series coefficients of a rectangular periodic signal. Reconstruct the signal by combining the Fourier series coefficients with appropriate weightings.
5. Write a program to find the trigonometric and exponential fourier series coefficients of a periodic rectangular signal. Plot the discrete spectrum of the signal.
6. Generate a discrete time sequence by sampling a continuous time signal. Show that with sampling rates less than Nyquist rate, aliasing occurs while reconstructing the signal.
7. The signal x (t) is defined as below. The signal is sampled at a sampling rate of 1000 samples per second. Find the power content and power spectral density for this signal.

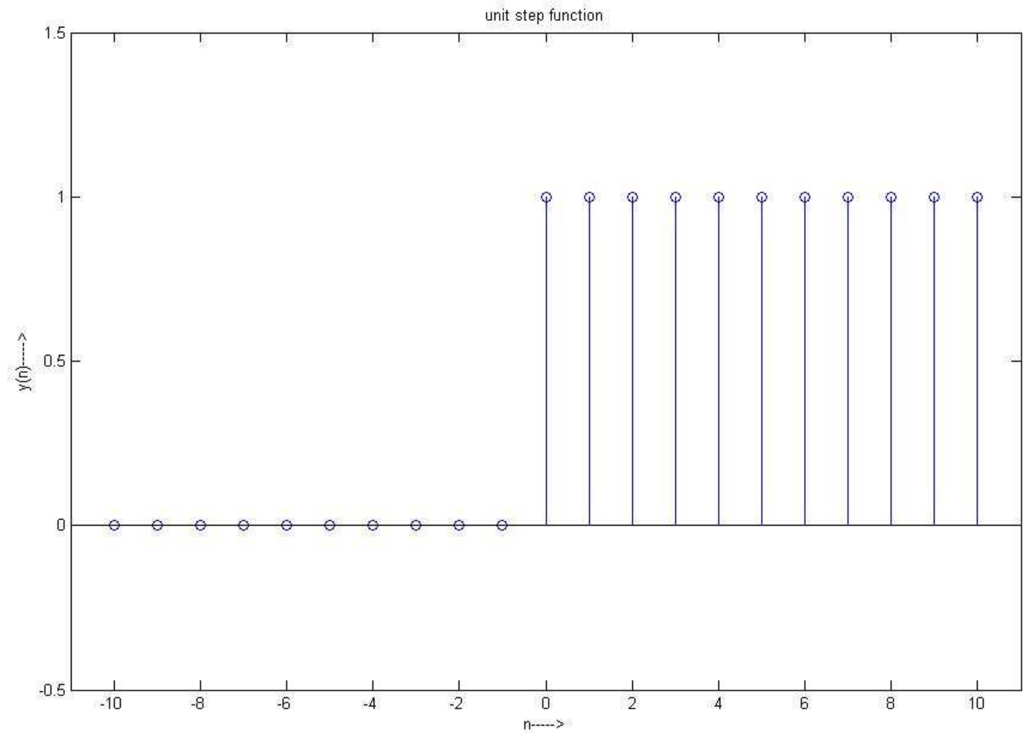
$$x(t) = \begin{cases} \cos(2\pi \times 47t) + \cos(2\pi \times 219t), & 0 \le t \le 10 \\ 0, & otherwise \end{cases}$$

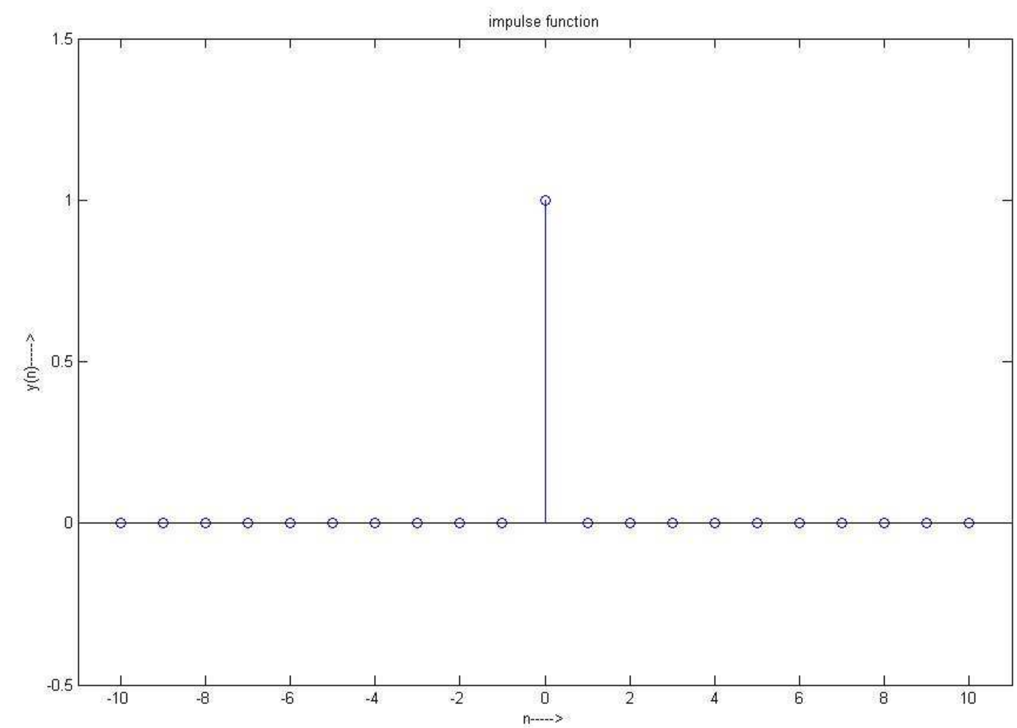
8. Write a program to find the magnitude and phase response of first order low pass and high pass filter. Plot the responses in logarithmic scale.
9. Write a program to find the response of a low pass filter and high pass filter, when a speech signal is passed through these filters.
10. Write a program to find the autocorrelation and cross correlation of sequences.
11. Generate a uniformly distributed length 1000 random sequence in the range (0,1). Plot the histogram and the probability function for the sequence. Compute the mean and variance of the random signal.
12. Generate a Gaussian distributed length 1000 random sequence . Compute the mean and variance of the random signal by a suitable method.
13. Write a program to generate a random sinusoidal signal and plot four possible realizations of the random signal.
14. Generate a discrete time sequence of N=1000 i.i.d uniformly distributed random numbers in the interval (-0.5,-0.5) and compute the autocorrelation of the sequence.
15. Obtain and plot the power spectrum of the output process when a white random process is passed through a filter with specific impulse response .

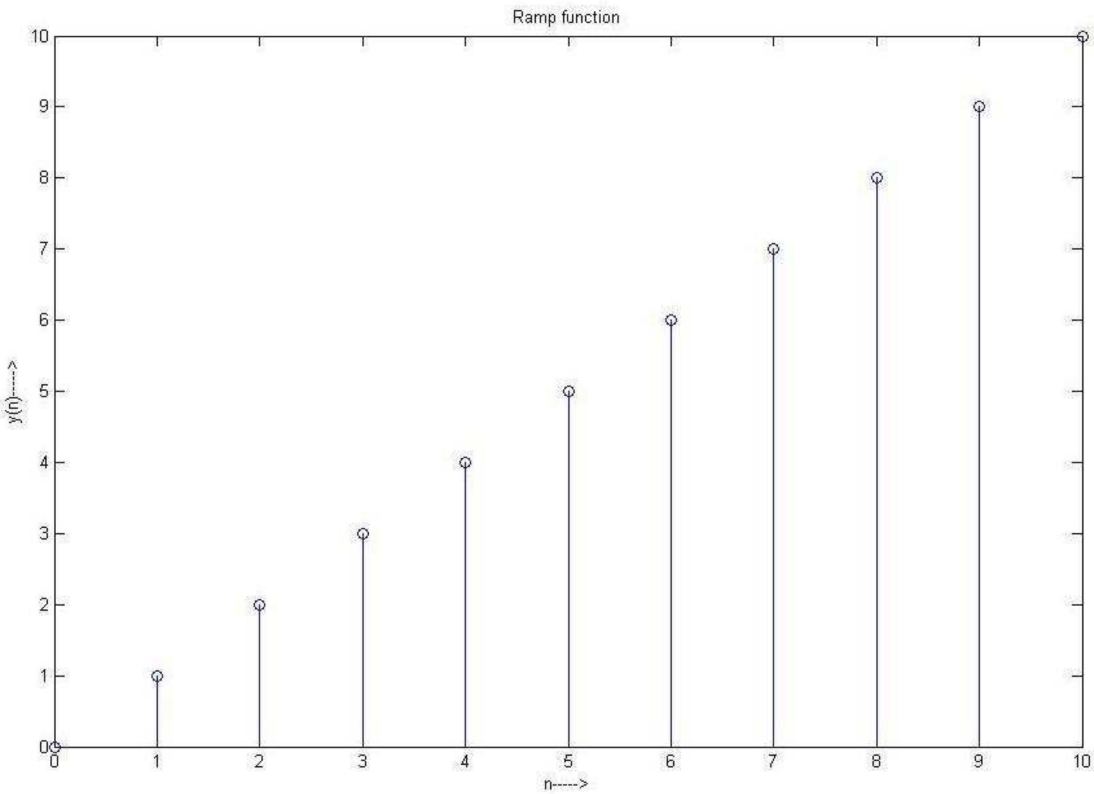
1. Write a program to generate the discrete sequences (i) unit step (ii) unit impulse (iii) ramp (iv) periodic sinusoidal sequences. Plot all the sequences.

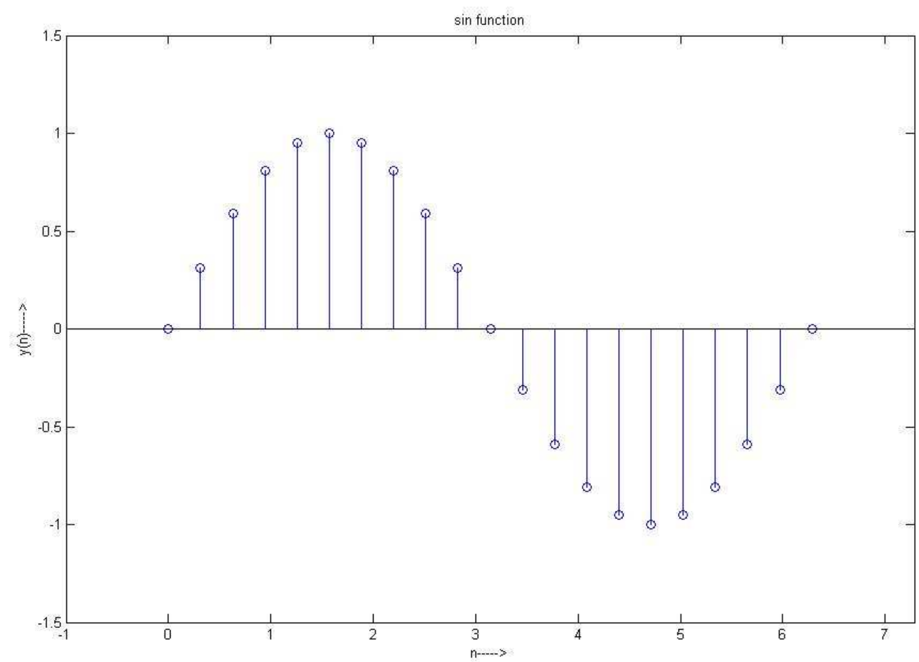
```
      % Unit Step Function
function y=unit_step(n)
l=length(n);
for i=1:l
    if (n(i)<0)
        y(i)=0;
    else
        y(i)=1;
    end
end
figure, stem(n,y), axis([n(1)-1 n(l)+1 -0.5 1.5])
xlabel('n----->'), ylabel('y(n)----->')
title('unit step function')


    %Unit Impulse Function
function y=impuls(n)
l=length(n);
for i=1:l
    if (n(i)~=0)
        y(i)=0;
    else
        y(i)=1;
    end
end
figure, stem(n,y), axis([n(1)-1 n(l)+1 -0.5 1.5])
xlabel('n----->'), ylabel('y(n)----->')
title('impulse function')


    %Ramp Function
function y=ramp(n)
l=length(n);
for i=1:l
    y(i)=n(i);
end
figure, stem(n,y),
xlabel('n----->'), ylabel('y(n)----->')
title('Ramp function')


    %Sin Function
function y=sine(n)
l=length(n);
y=sin(n);
figure, stem(n,y), axis([n(1)-1 n(l)+1 -1.5 1.5])
xlabel('n----->'), ylabel('y(n)----->'),title('sin function')
```

Plots:


unit step function
y(n)----->
n----->


impulse function
y(n)----->
n----->

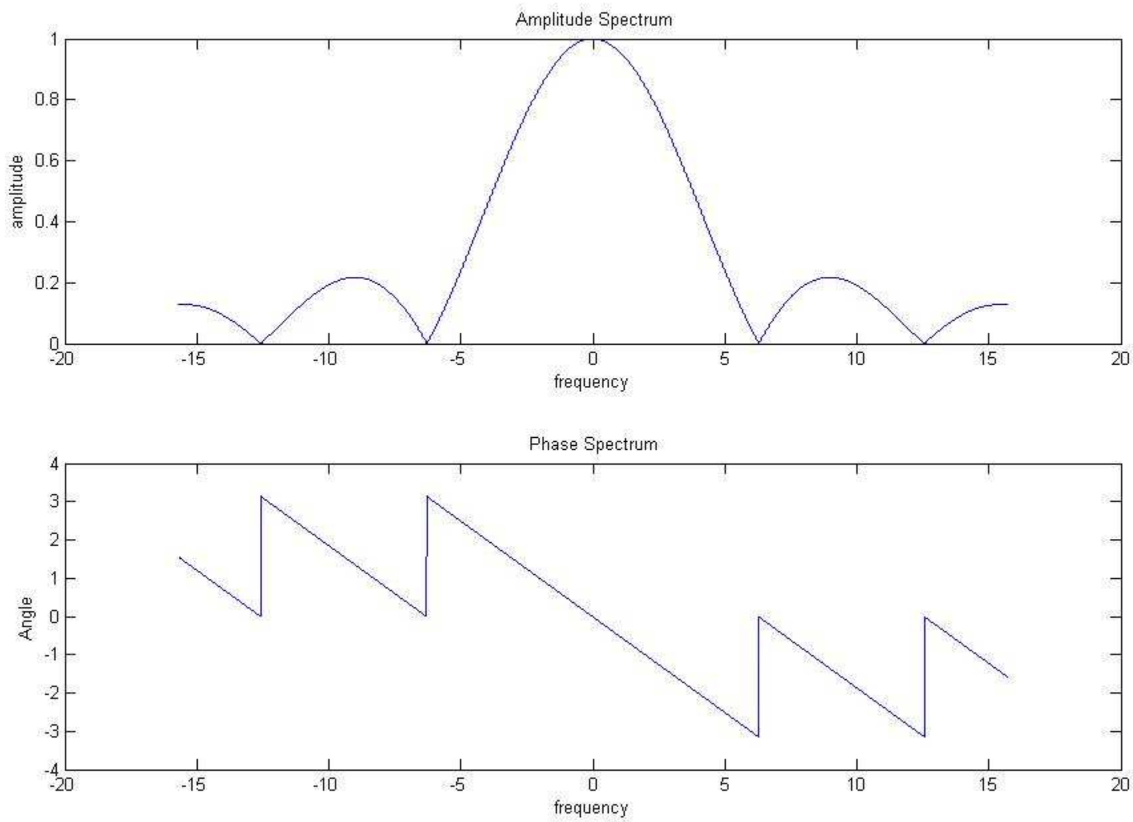




2. Find the Fourier transform of a square pulse .Plot its amplitude and phase spectrum.

```
      %Fourie Transform Of Square Pulse
function [F, A, P]= ft_sqr(w,T)
j=sqrt(-1);
F=(1-exp(-j*w*T))./(j*w); % Fourier Transform of squre pulse
A=abs(F);                 % Amplitue Spectrum
P=angle(F);               % Phase Spectrum
subplot(2,1,1), plot(w,A), xlabel('frequency'), ylabel('amplitude'),
title(' Amplitude Spectrum')
subplot(2,1,2), plot(w,P), xlabel('frequency'), ylabel('Angle')
title(' Phase Spectrum')
```

<u>Plot:</u>



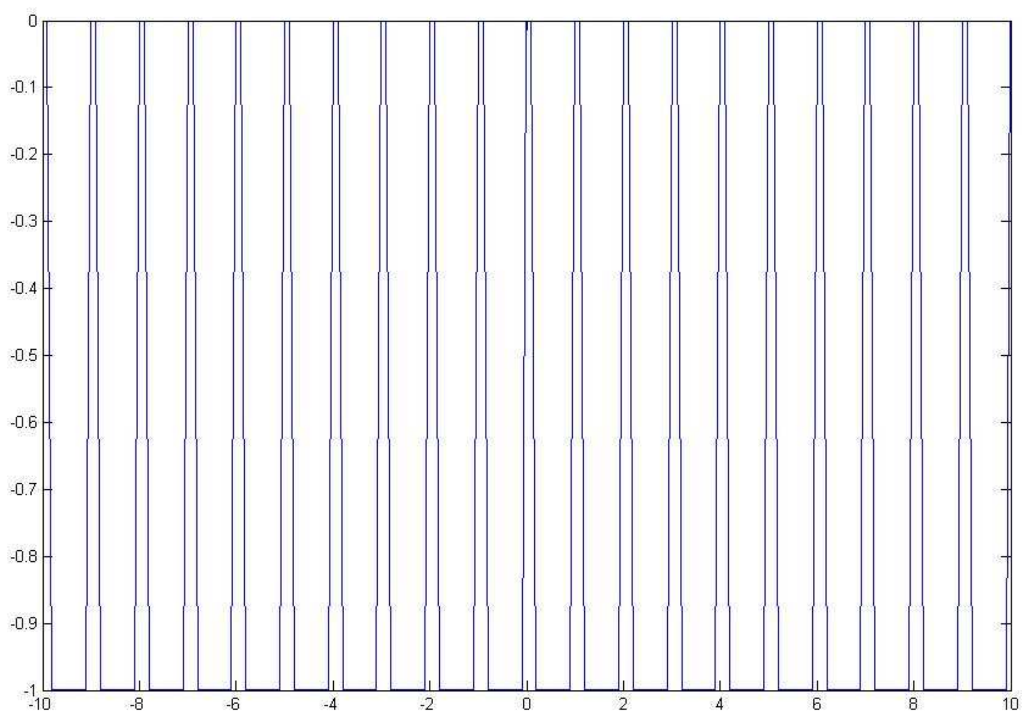
3. Write a program to convolve two discrete time sequences. Plot all the sequences. Verify the result by analytical calculation.

```
    %Discrete Convolution
function f=cnv(a,b)
la=length(a);
lb=length(b);
n=la+lb-1;
b=[b zeros(1,la-1)];
a=[a zeros(1,lb-1)];
for i=1:n
    f(i)=0;
    for j=1:i
        f(i)=f(i)+a(j)*b(i-j+1);
    end
end
```

4. Write a program to find the trigonometric Fourier series coefficients of a rectangular periodic signal. Reconstruct the signal by combining the Fourier series coefficients with appropriate weightings.

```
    % Trignometric Fourier Series
function f=four_rect(n,t,T,k)
wo=(2*pi/T);
for i=1:n
   a(i)=2*sin(2*pi*i*t/T)/(pi*i);
   end
disp('Trignometric coefficients:')
ao=(2*t/T);
%signal reconstruction
for j=1:length(k)
    f(j)=ao;
    for i=1:n
    f(j)=f(j)+a(i)*cos(i*wo*k(j));
    end
end
plot(k,f)
```

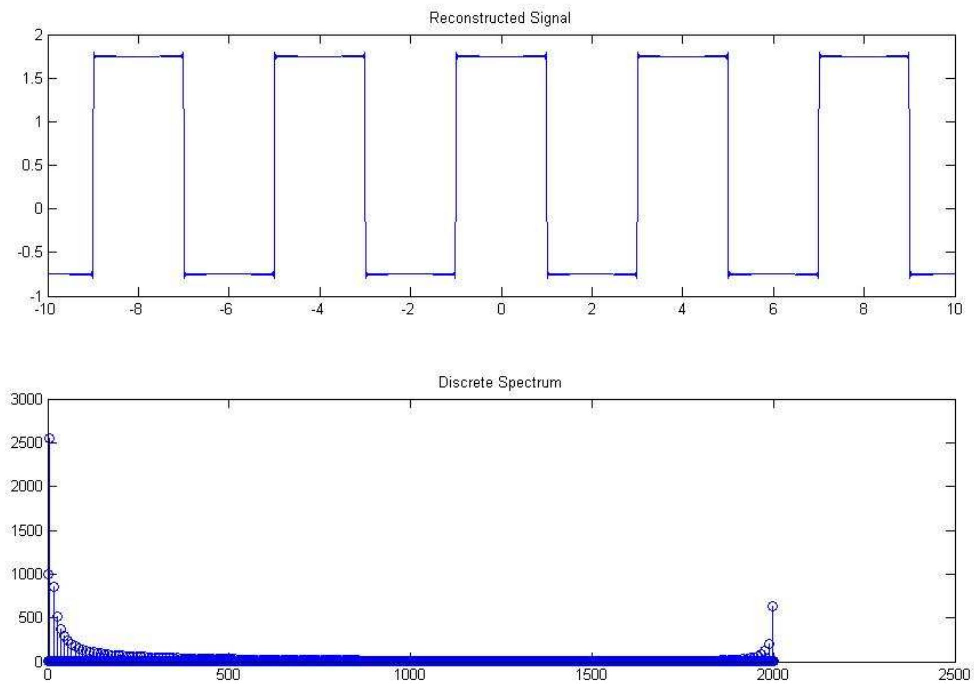
Plot:



5. Write a program to find the trigonometric and exponential fourier series coefficients of a periodic rectangular signal. Plot the discrete spectrum of the signal.

```
% Exponential Fourier Series
function y=exp_four_rect(n,t,T,k,w)
wo=2*pi/T;
for i=1:n
    f(i)=(2*t*sinc(2*i*t/T)/T);
    f1(i)=(2*t*sinc(2*(-i)*t/T));
end
fo=(2*t/T);
j=sqrt(-1);
for l=1:length(k)
    y(l)=fo;
    for m=1:n
        y(l)=y(l)+f(m)*exp(-j*m*wo*k(l));
    end
    for m=n+1:2*n
        y(l)=y(l)+f1(m-n)*exp(j*(m-n)*wo*k(l));
    end
end
F=fft(y);
subplot(2,1,1), plot(k,y), title('Reconstructed Signal')
subplot(2,1,2), stem(abs(F)), title('Discrete Spectrum')
```

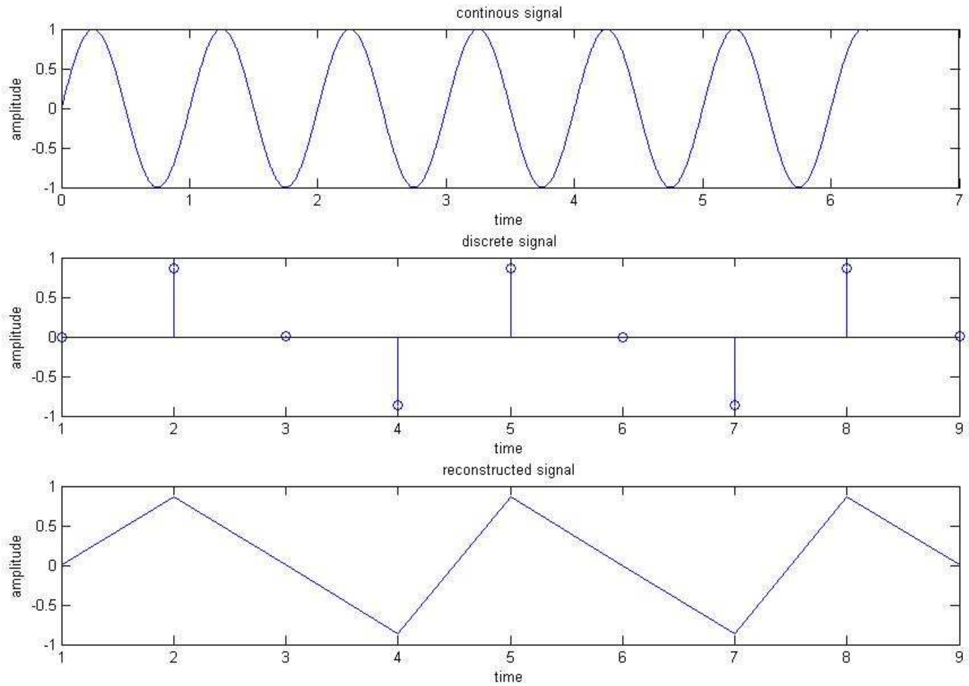
Plot:



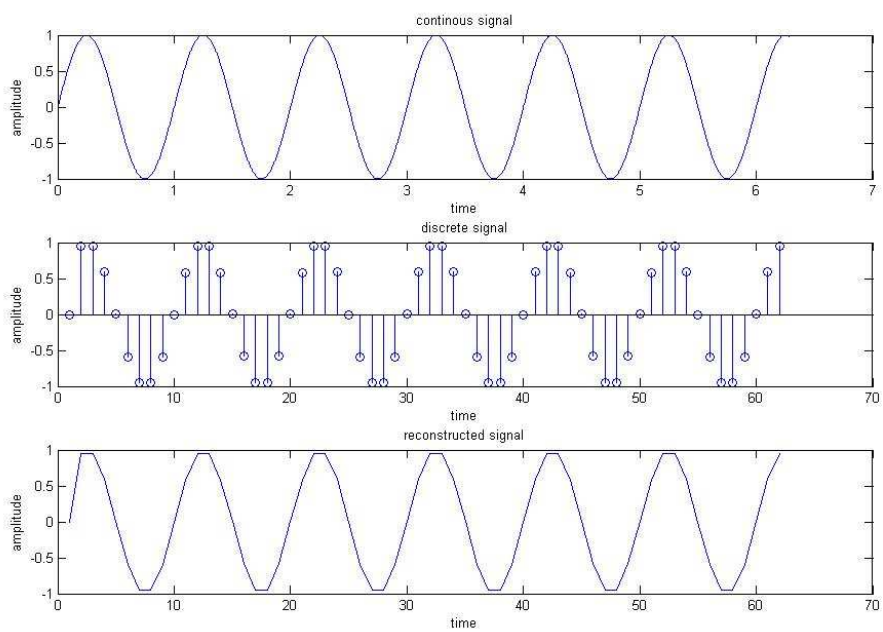
6. Generate a discrete time sequence by sampling a continuous time signal. Show that with sampling rates less than Nyquist rate, aliasing occurs while reconstructing the signal.

```
    %Sampling Function
function y=sa(f,fs)
T=1/f;
Ts=1/fs;
t=0:(pi/1000):2*pi;
d=pi/1000;
x=sin(2*pi*f*t);
l=length(t);
j=1;
for i=1:l

    if (t(i)/Ts==round(t(i)/Ts))
        y(j)=x(i);
        j=j+1;
    elseif (abs(t(i)-j*Ts)<d)

        if ((abs(t(i)-j*Ts))<=abs(t(i+1)-j*Ts))

            y(j)=x(i);
            j=j+1;
        elseif ((abs(t(i)-j*Ts))>abs(t(i+1)-j*Ts))
            y(j)=x(i+1);
            j=j+1;
        end
    end
end
subplot(3,1,1), plot(t,x), xlabel('time'), ylabel('amplitude')
title('continous signal')
subplot(3,1,2), stem(y), xlabel('time'), ylabel('amplitude')
title('discrete signal')
subplot(3,1,3), plot(y), xlabel('time'), ylabel('amplitude')
title('reconstructed signal')
```

Plot:



Under Sampling

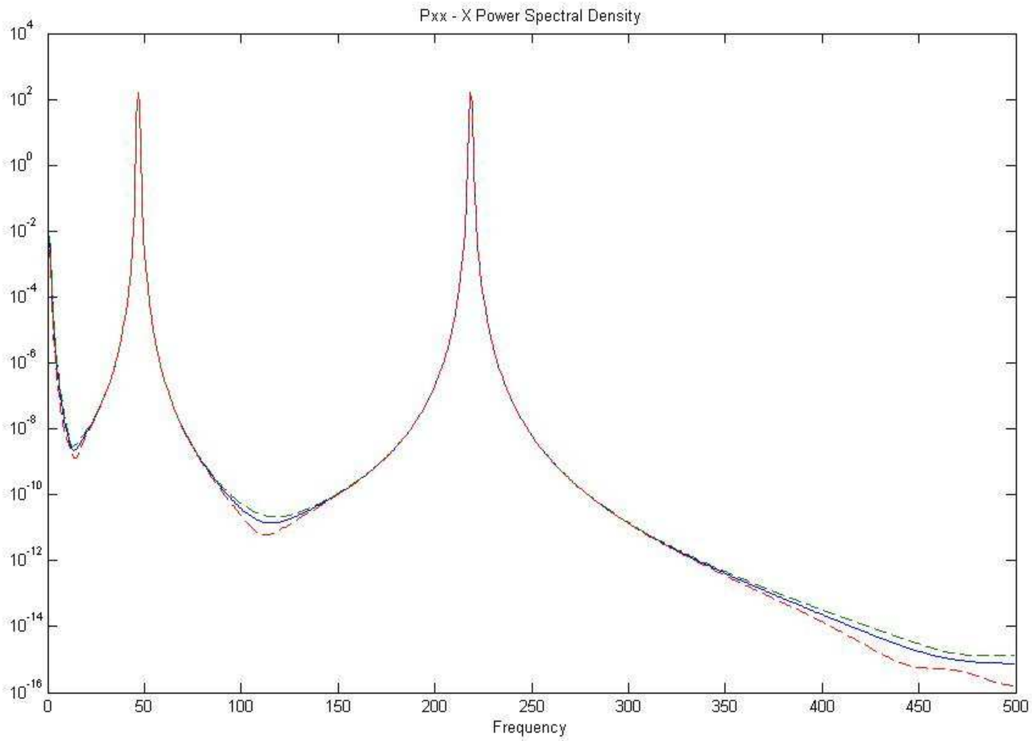


Greater Than Nyquist Rate

7. The signal x (t) is defined as below. The signal is sampled at a sampling rate of 1000 samples per second. Find the power content and power spectral density for this signal.

$$x(t) = \begin{cases} \cos(2\pi \times 47t) + \cos(2\pi \times 219t), & 0 \le t \le 10 \\ 0, & otherwise \end{cases}$$

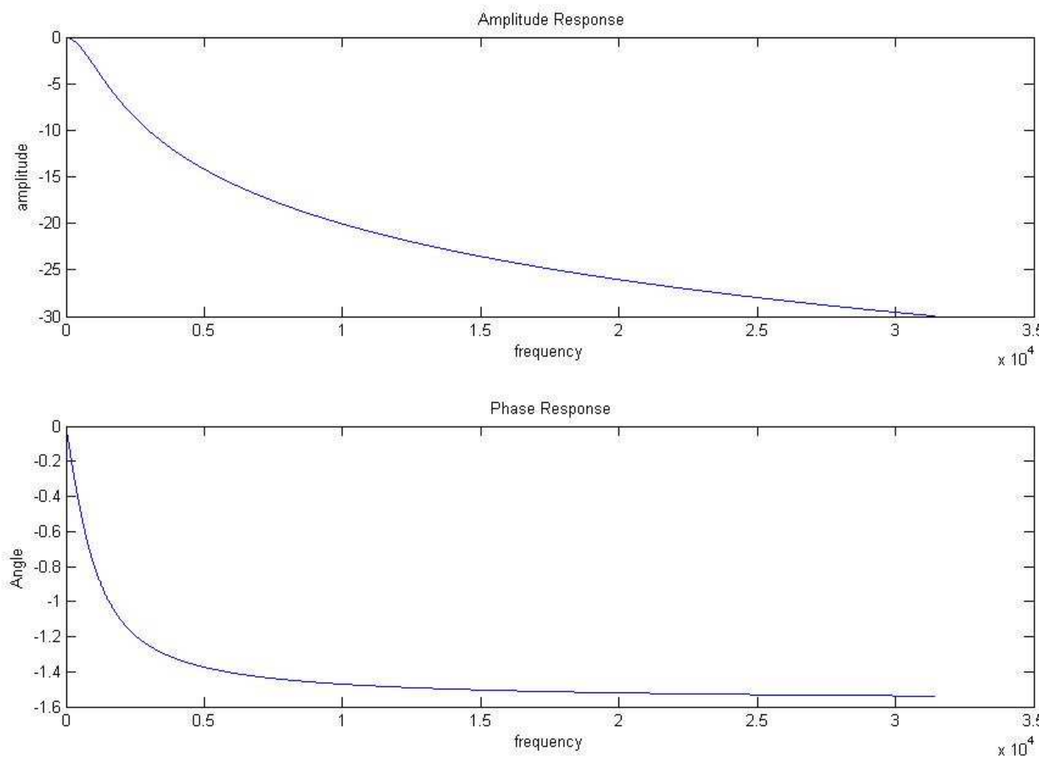
```
function p=psd()
t=0:(1/1000):10;
x=cos(2*pi*47*t)+cos(2*pi*219*t);
l=length(x);
p=(norm(x)^2)/l;
ps=spectrum(x,1024);
specplot(ps,1000)
```



8. Write a program to find the magnitude and phase response of first order low pass and high pass filter. Plot the responses in logarithmic scale.

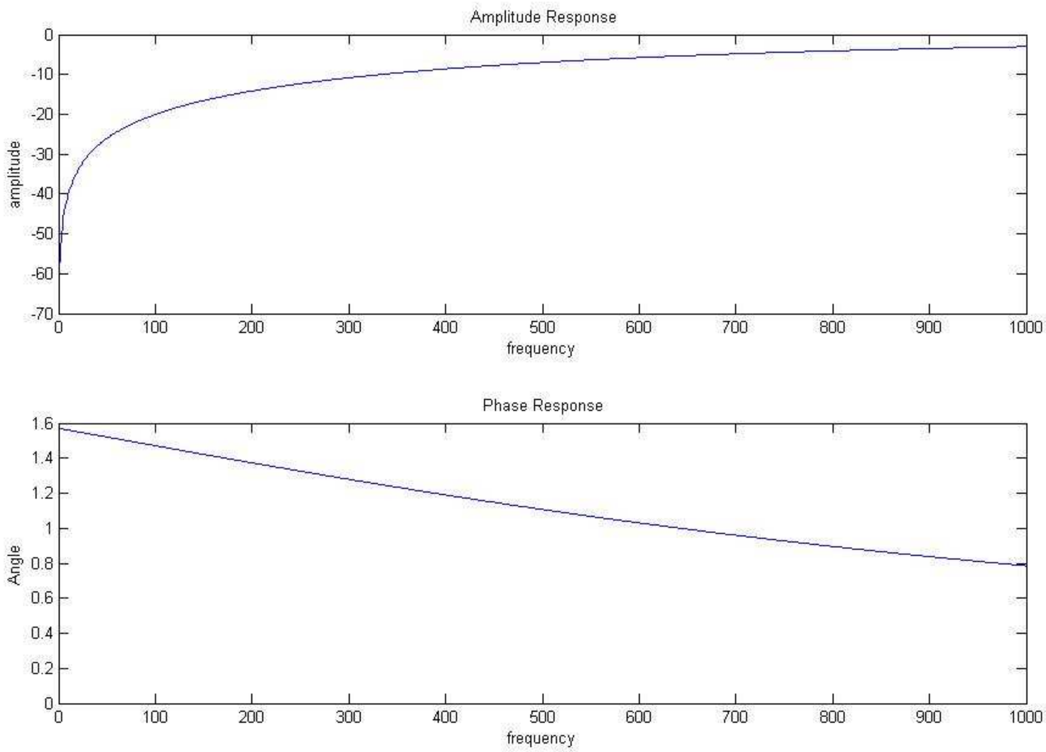
```
    % First Order Low Pass Filter
function [H, A, P]=lpf(r,c,w)
j=sqrt(-1);
w1=1/(r*c);             % Cut-off frequency
H=1./(1+j*(w/w1));       % Frequency Response of First Order RC LPF
A=abs(H);               % Amplitude Response
P=angle(H);             % Phase Response
Ad=20*log10(A);         % Amplitude Response in decibels
subplot(2,1,1), plot(w,Ad), xlabel('frequency'), ylabel('amplitude'),
title(' Amplitude Response')
subplot(2,1,2), plot(w,P), xlabel('frequency'), ylabel('Angle')
title(' Phase Response')
```

<u>Plot:</u>



```
    % First Order High Pass Filter
function [H, A, P]=hpf(r,c,w)
j=sqrt(-1);
w1=1/(r*c);             % Cut-off frequency
H=w./(w-j*w1);     % Frequency Response of First Order RC HPF
A=abs(H);               % Amplitude Response
P=angle(H);             % Phase Response
Ad=20*log10(A);         % Amplitude Response in decibels
subplot(2,1,1), plot(w,Ad), xlabel('frequency'), ylabel('amplitude'),
title(' Amplitude Response')
subplot(2,1,2), plot(w,P), xlabel('frequency'), ylabel('Angle')
title(' Phase Response')
```

<u>Plot:</u>



9. Write a program to find the response of a low pass filter and high pass filter, when a speech signal is passed through these filters.

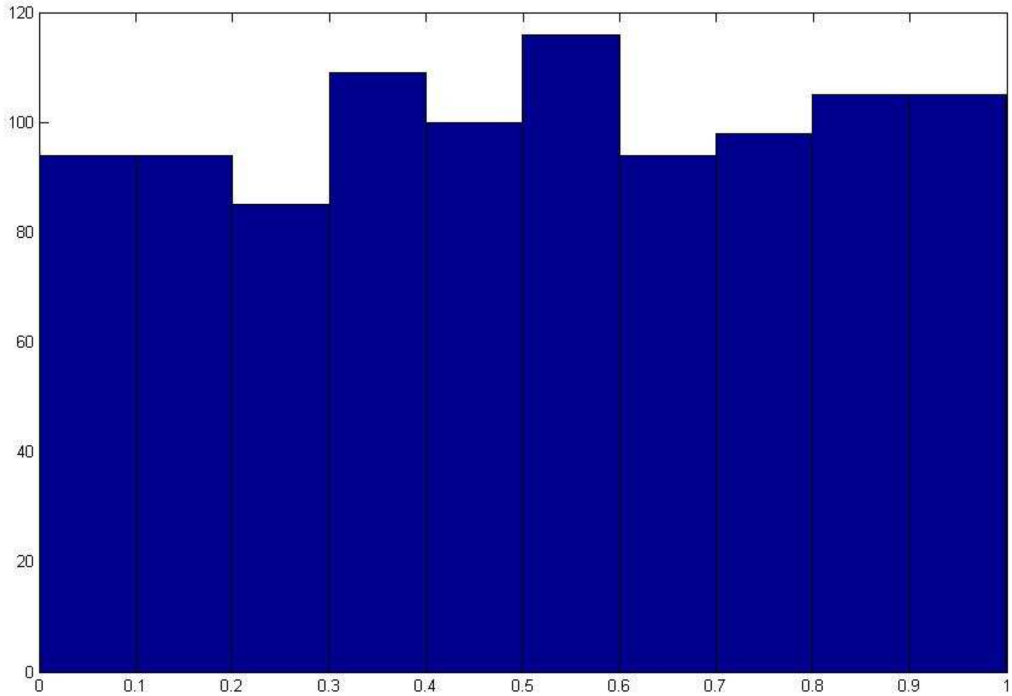
```
function [Y1 Y2]=speech_response(x,w,w1)
j=sqrt(-1);
H1=1./(1+j*(w/w1));   %Impulse response of lPF
H2=w./(w-j*w1);     %Impulse response of HPF
X=fft(x);
Y1=X.*H1;
Y2=X.*H2;
subplot(2,1,1), plot(Y1,w)
subplot(2,1,2), plot(Y2,w)
```

10. Write a program to find the autocorrelation and cross correlation of sequences.

```
% Auto Correlation

function c=cor(a)
l=length(a);
n=2*l-1;
a=[a zeros(1,l-1)];
d(1:l)=a(l:-1:1);% sequence time reverse
d=[d zeros(1,l-1)];
for i=1:n
    c(i)=0;
    for j=1:i
        c(i)=c(i)+a(j)*d(i-j+1);  % performing convolution to given sequence
                                  % and time reversed gives correlation
    end
end


 %Cross correlation

function c=xcor(a,b)
la=length(a);
lb=length(b);
n=la+lb-1;
a=[a zeros(1,lb-1)];
d(1:lb)=b(lb:-1:1);% sequence time reverse
d=[d zeros(1,la-1)];
for i=1:n
    c(i)=0;
    for j=1:i
        c(i)=c(i)+a(j)*d(i-j+1);  % performing convolution to given sequence
                                  % and time reversed gives cross correlation
    end
end
```

11. Generate a uniformly distributed length 1000 random sequence in the range (0,1). Plot the histogram and the probability function for the sequence. Compute the mean and variance of the random signal.

```
function [a m v X]=rand_gen(N)
X=rand(1,N);
hist(X);
a=hist(X);
m=mean(X);
v=var(X);
```

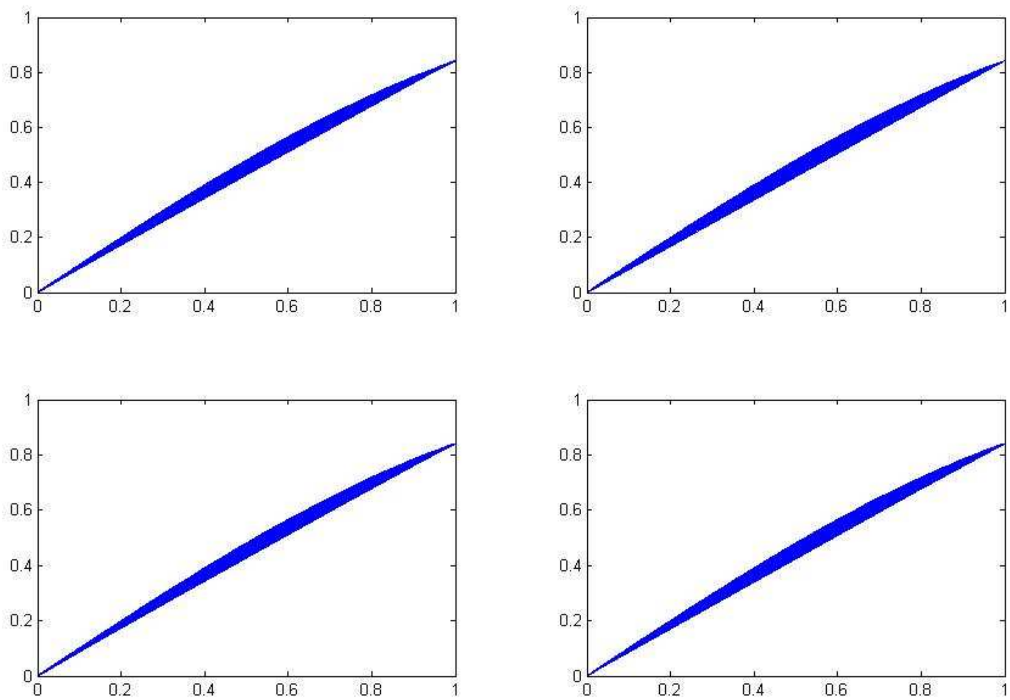


12. Generate a Gaussian distributed length 1000 random sequence . Compute the mean and variance of the random signal by a suitable method.

```
function [x m v]=rand_gauss(n)
x=rand(1,n);
m=mean(x);
v=var(x);
```

13. Write a program to generate a random sinusoidal signal and plot four possible realizations of the random signal.

```
function [y1 y2 y3 y4]=rand_sin(n)
x1=rand(1,n);
x2=rand(1,n);
x3=rand(1,n);
x4=rand(1,n);
y1=sin(x1);
y2=sin(x2);
y3=sin(x3);
y4=sin(x4);
subplot(2,2,1), plot(x1,y1)
subplot(2,2,2), plot(x2,y2)
subplot(2,2,3), plot(x3,y3)
subplot(2,2,4), plot(x4,y4)
```



14. Generate a discrete time sequence of N=1000 i.i.d uniformly distributed random numbers in the interval (-0.5,-0.5) and compute the autocorrelation of the sequence.

```
function [x rx]=randseq(n)
x=rand(1,n)-0.5;
rx=cor(x);
```

15. Obtain and plot the power spectrum of the output process when a white random process is passed through a filter with specific impulse response .

```
function sy=white_rand(w,H)
sy=abs(H).^2;
plot(w,sy)
```