Signals & Systems Laboratory

CSE- 301L

Lab # 08

OBJECTIVES OF THE LAB

This lab aims at the understanding of:

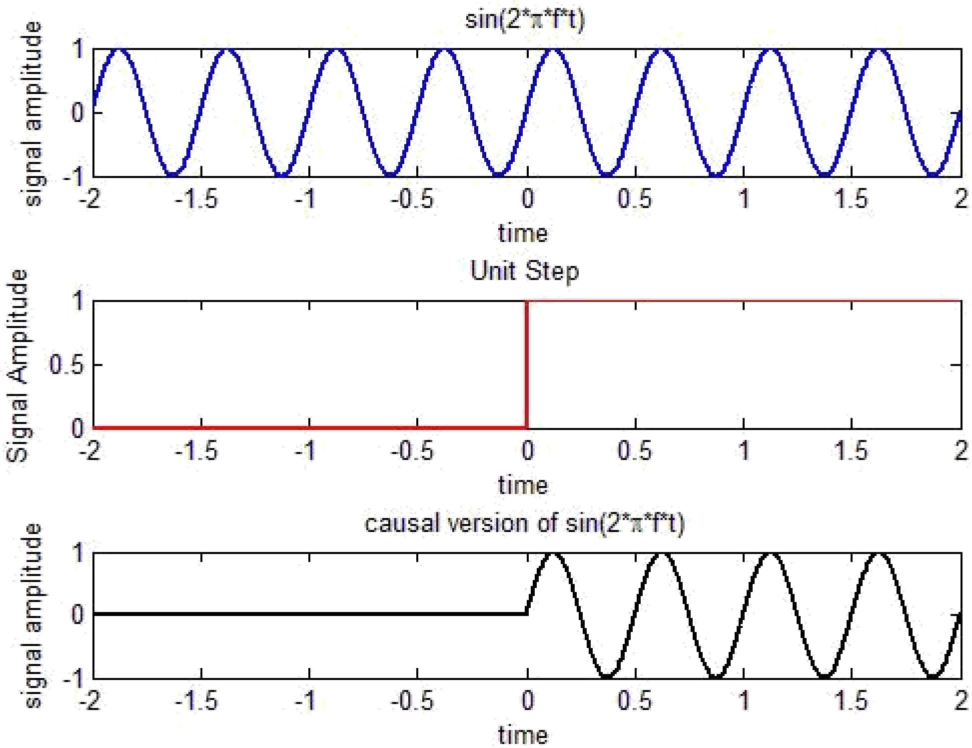
- *Making Signals Causal and Non-Causal*
- *Convolution*
- *Properties of Convolution*

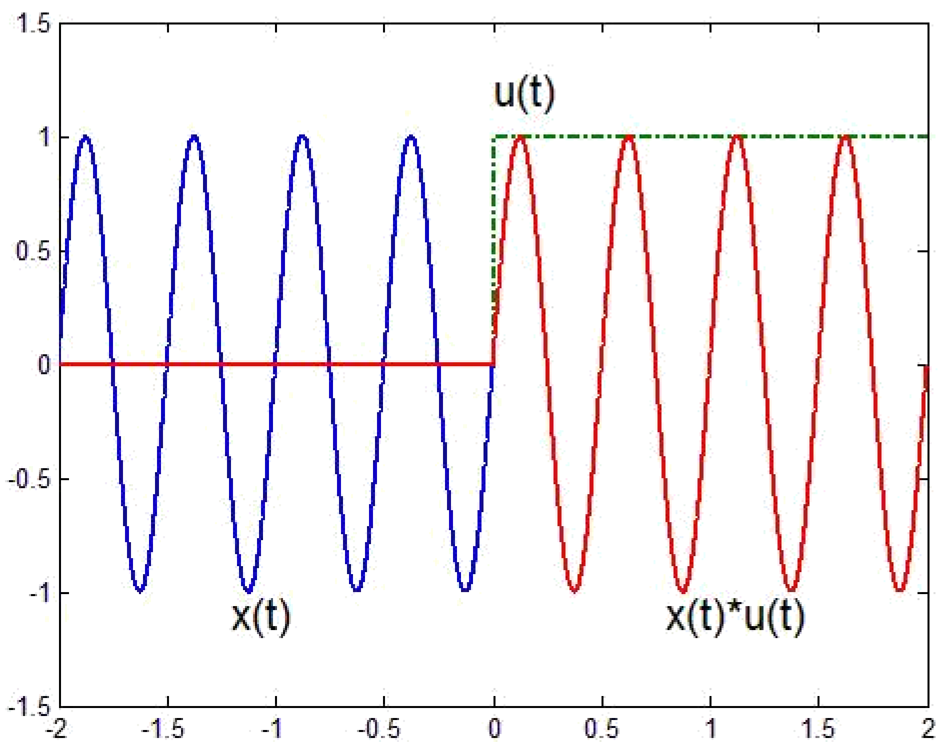
8.1 MAKING SIGNALS CAUSAL AND NON-CAUSAL

Causal Signals: A signal is said to be causal if it is zero for time t<0. A signal can be made causal by multiplying it with unit step.

Example

```
clc
clear all
close all

t= -2:1/1000:2;
x1 = sin(2*pi*2*t);

subplot(3,1,1);
plot(t,x1,'LineWidth',2);
xlabel('time');
ylabel('signal amplitude');
title('sin(2*\pi*f*t)');

u = (t>=0);
x2 = x1.*u;

subplot(3,1,2);
plot(t,u, 'r','LineWidth',2);
xlabel('time');
ylabel('Signal Amplitude');
title('Unit Step');

subplot(3,1,3);
plot(t,x2, 'k','LineWidth',2);
xlabel('time'); ylabel('signal
amplitude');
title('causal version of sin(2*\pi*f*t)');

figure;
plot(t,x1,t,u,'-.',t,x2,'LineWidth',2);
text(0,1.2,'u(t)','FontSize',16);
text(-1.2,-1.1,'x(t)','FontSize',16);
text(0.8,-1.1,'x(t)*u(t)','FontSize',16);
axis([-2 2 -1.5 1.5]);
```


sin(2*π*f*t)
signal amplitude
time
Unit Step
Signal Amplitude
time
causal version of sin(2*π*f*t)
signal amplitude
time


u(t)
x(t)
x(t)*u(t)

----------------------------TASK 1---------------------------

Sample the signal given in above example to get its discrete-time counterpart (take 10 samples/sec as sampling rate). Make the resultant signal causal. Display the lollipop plot of each signal.

----------------------------TASK 2---------------------------

A signal is said to be anti-causal if it exists for values of n<0. Make the signal given in above example anti-causal.

----------------------------TASK 3---------------------------

Create a function by name of **sig_causal** in matlab that has two input arguments: (i) a discrete-time signal, and (ii) a position vector. The function should make the given signal causal and return the resultant signal to the calling program.

8.2 CONVOLUTION

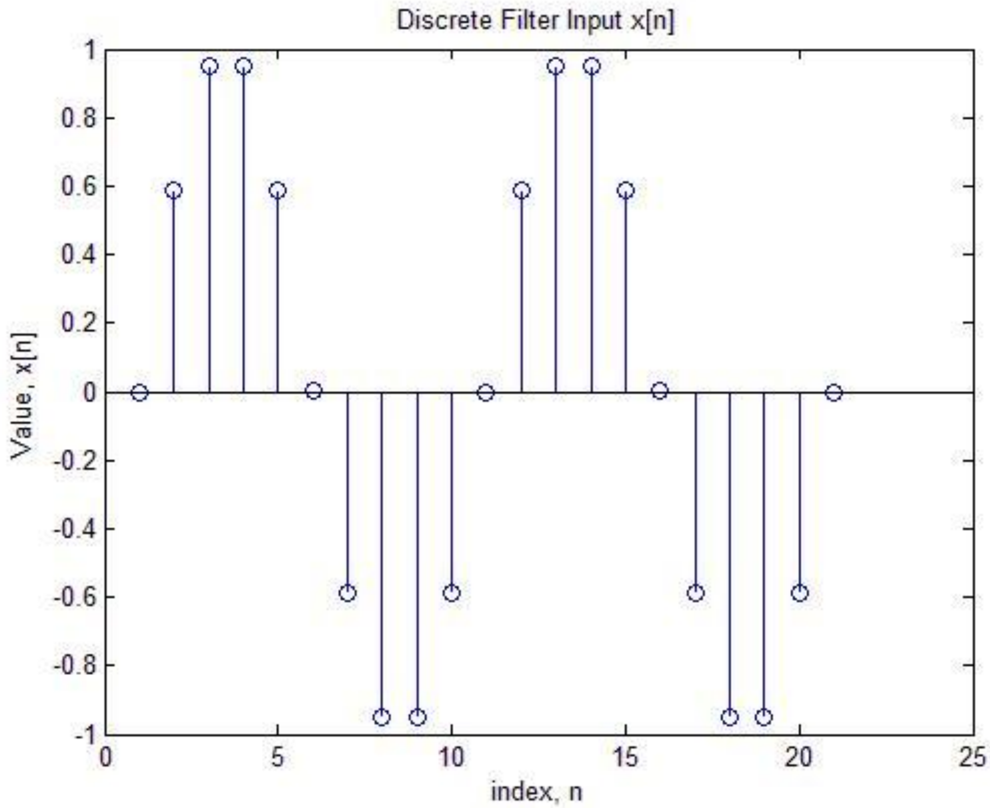
Use the matlab command conv(h, x) to find convolution where

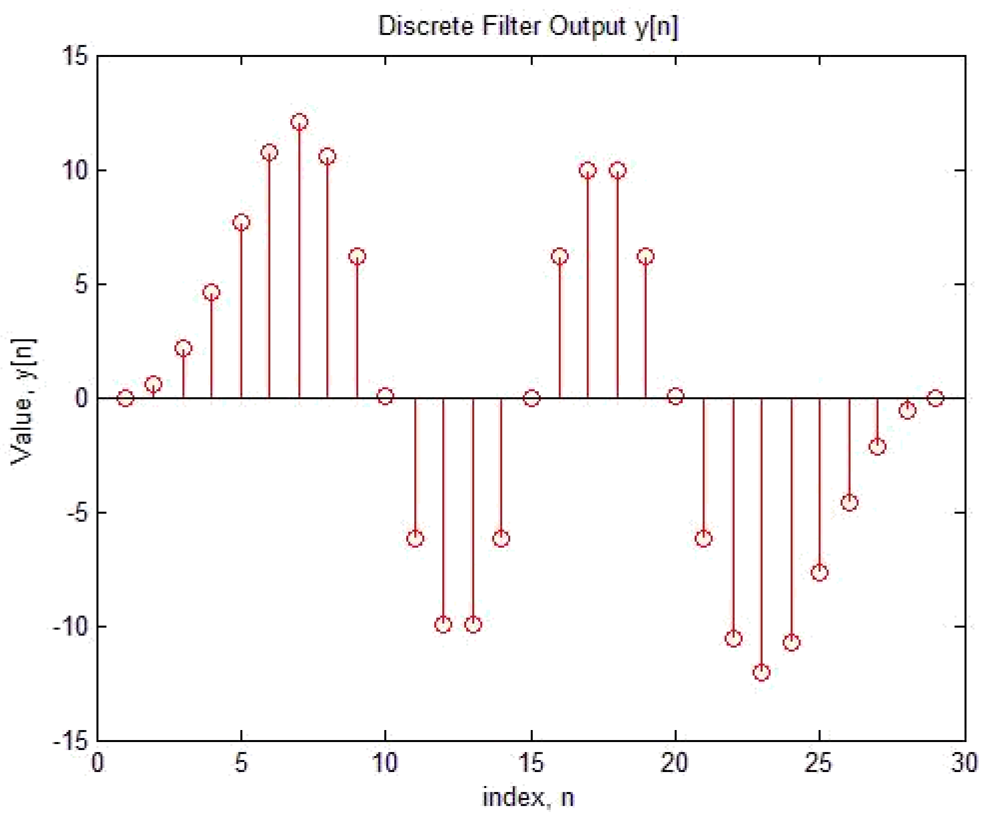
h – impulse response

x – input signal

Example

```
clc clear all close all

        h = [1 2 3 4 5 4 3 2 1];
        x = sin(0.2*pi*[0:20])
y = conv(h, x);

figure(1);

stem(x);

title('Discrete Filter Input x[n]'); xlabel('index, n');
ylabel('Value, x[n]');

figure(2); stem(y, 'r');
title('Discrete Filter Output y[n]'); xlabel('index, n');
ylabel('Value, y[n]');
```


Discrete Filter Input x[n]
Value, x[n]
index, n
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
20
25


Discrete Filter Output y[n]
Value, y[n]
index, n
15
10
5
0
-5
-10
-15
0
5
10
15
20
25
30

Even though there are only 21 points in the x array, the conv function produces 8 more points because it uses the convolution summation and assumes that x[n] = 0 when n>20.

----------------------------TASK 4---------------------------

Convolve the following

signals: x =[2 4 6 4 2];

h =[3 -1 2 1];

Plot the input signal as well as the output signal.

----------------------------TASK 5---------------------------

Convolution is associative. Given the three signal $x_1[n]$, $x_2[n]$, and $x_3[n]$

as: $x_1[n]$= [3 1 1]

$x_2[n]$= [4 2 1]

$x_3[n]$=[3 2 1 2 3]

Show that $(x_1[n] * x_2[n]) * x_3[n] = x_1[n] * (x_2[n] * x_3[n])$.

----------------------------TASK 6---------------------------

Convolution is commutative. Given x[n] and h[n] as:

X[n]=[1 3 2 1]

H[n]=[1 1 2]

Show that $x[n] * h[n] = h[n] * x[n]$.

----------------------------TASK 7---------------------------

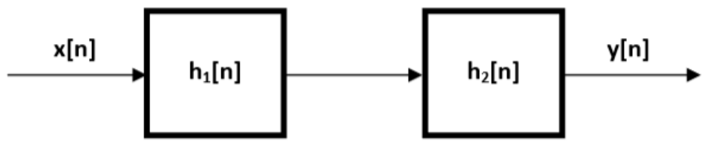
Given the impulse response of the systems as:

$$h[n]= 2\delta[n] + \delta[n-1]+ 2\delta[n-2]+ 4\delta[n-3]+ 3\delta[n-4]$$

If the input $x[n] = \delta[n]+ 4\delta[n-1] +3\delta[n-2] + 2\delta[n-3]$ is applied to the system, determine the output of the system.

----------------------------TASK 8---------------------------

Two systems are connected in cascade:



$h_1[n]$=[1 3 2 1]

$h_2[n]$=[1 1 2]

If the input x[n] = δ[n]+ 4δ[n-1] +3δ[n-2] +2δ[n-3] is applied, determine the output.

---------------------------TASK 9-------------------------

Given the signals:

$x_1[n]$= 2δ[n] -3δ[n-1]+ 3δ[n-2] +4δ[n-3] -2δ[n-4]

$x_2[n]$= 4δ[n]+ 2δ[n-1]+ 3δ[n-2] - δ[n-3] -2δ[n-4]

$x_3[n]$= 3δ[n]+ 5δ[n-1]-3δ[n-2] +4 δ[n-3]

Verify that

$x_1[n] * (x_2[n] * x_3[n]) = (x_1[n] * x_2[n]) * x_3[n]$

$x_1[n] * x_2[n]= x_2[n] * x_1[n]$
