```
%ECG680 DSP
%MATLAB Assignment 2
%Submisison by Minsung Cho
%Date: 10/10/2020

% 1.a.i
clearvars
xa = [1 1 1 1 1];
nxa = 0:4;
[y1, ny1] = convolve(xa, nxa, xa, nxa);

figure(1)
subplot(3,1,1)
stem(ny1,y1)
axis([min(ny1)-1 , max(ny1)+1, min(y1)-1, max(y1)+1])
grid on
title('y_1[n]=x[n]*x[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,2)
stem(nxa,xa)
axis([min(ny1)-1 , max(ny1)+1, min(y1)-1, max(y1)+1])
grid on
title('x[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,3)
stem(nxa,xa)
axis([min(ny1)-1 , max(ny1)+1, min(y1)-1, max(y1)+1])
grid on
title('x[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

% 1.a.ii
[xaii, nxaii] = shift (xa, -1, nxa);
[y2, ny2] = convolve(xaii, nxaii, xaii, nxaii);


figure(2)
subplot(3,1,1)
stem(ny2,y2)
axis([min(ny2)-1 , max(ny2)+1, min(y2)-1, max(y2)+1])
grid on
title('y_2[n]=x[n-1]*x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize',
 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,2)
```

```
stem(nxaii,xaii)
axis([min(ny2)-1 , max(ny2)+1, min(y2)-1, max(y2)+1])
grid on
title('x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,3)
stem(nxaii,xaii)
axis([min(ny2)-1 , max(ny2)+1, min(y2)-1, max(y2)+1])
grid on
title('x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

% 1.a.iii
[xaiii, nxaiii] = shift (xa, 1, nxa);
[y3, ny3] = convolve(xaiii, nxaiii, xaiii, nxaiii);


figure(3)
subplot(3,1,1)
stem(ny3,y3)
axis([min(ny3)-1 , max(ny3)+1, min(y3)-1, max(y3)+1])
grid on
title('y_3[n]=x[n-1]*x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize',
 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,2)
stem(nxaiii,xaiii)
axis([min(ny3)-1 , max(ny3)+1, min(y3)-1, max(y3)+1])
grid on
title('x[n+1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,3)
stem(nxaiii,xaiii)
axis([min(ny3)-1 , max(ny3)+1, min(y3)-1, max(y3)+1])
grid on
title('x[n+1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

% 1.a.iv
[y4, ny4] = convolve(xaiii, nxaiii, xaii, nxaii);

figure(4)
subplot(3,1,1)
stem(ny4,y4)
axis([min(ny4)-1 , max(ny4)+1, min(y4)-1, max(y4)+1])
grid on
```

```
title('y_4[n]=x[n+1]*x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize',
 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,2)
stem(nxaiii,xaiii)
axis([min(ny4)-1 , max(ny4)+1, min(y4)-1, max(y4)+1])
grid on
title('x[n+1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,1,3)
stem(nxaii,xaii)
axis([min(ny4)-1 , max(ny4)+1, min(y4)-1, max(y4)+1])
grid on
title('x[n-1]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%1.b.i
yb1 = convolution(y1);
nyb1 = 1:length(yb1);

figure(5)
subplot(2,1,1)
stem(nyb1,yb1)
axis([min(nyb1)-1 , max(nyb1)+1, min(yb1)-1, max(yb1)+1]);
grid on
title('y_bi[n]=impulse response of y_1[n]', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%1.b.ii

yb2 = convolution(y2);
nyb2 = 1:length(yb2);

subplot(2,1,2)
stem(nyb2,yb2)
axis([min(nyb2)-1 , max(nyb2)+1, min(yb2)-1, max(yb2)+1])
grid on
title('y_bii[n]=impulse response of y_2[n]', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%1.c.i
yc1 = conv(xa, xa);
nyc1 = 1:length(yc1);

%1.c.ii
```

```
yc2 = conv(xaii, xaii);
nyc2 = -5:3;

figure(6)
subplot(2,1,1)
stem(nyc1,yc1)
axis([min(nyc1)-1 , max(nyc1)+1, min(yc1)-1, max(yc1)+1]);
grid on
title('y_ci[n]=x[n]*x[n] using conv funciton', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(2,1,2)
stem(nyc2,yc2)
axis([min(nyc2)-1 , max(nyc2)+1, min(yc2)-1, max(yc2)+1]);
grid on
title('y_cii[n]=x[n-1]*x[n-1] using conv funciton', 'fontname', 'Comic
 Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

clearvars

%2.b.i
wu = pi/4;
wl = 0;
Ni = 15;

[y2bi, ny2bi] = FIRdesign(wl, wu, Ni);
[y2b1, w1] = freqz(y2bi, 1, ny2bi);

figure(7)
subplot(3,2,1)
stem(ny2bi,y2bi)
axis([min(ny2bi) , max(ny2bi), min(y2bi), max(y2bi)]);
grid on
title('y through FIR filter with N = 15', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,2,2)
plot(w1/pi,20*log10(abs(y2b1)))
axis([0, 2, -30, 30])
grid on
title('Frequency & Magnitude', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('Frequency (\times\pi rad/sample)', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
ylabel('magnitude(dB)', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.b.ii
Nii = 33;
```

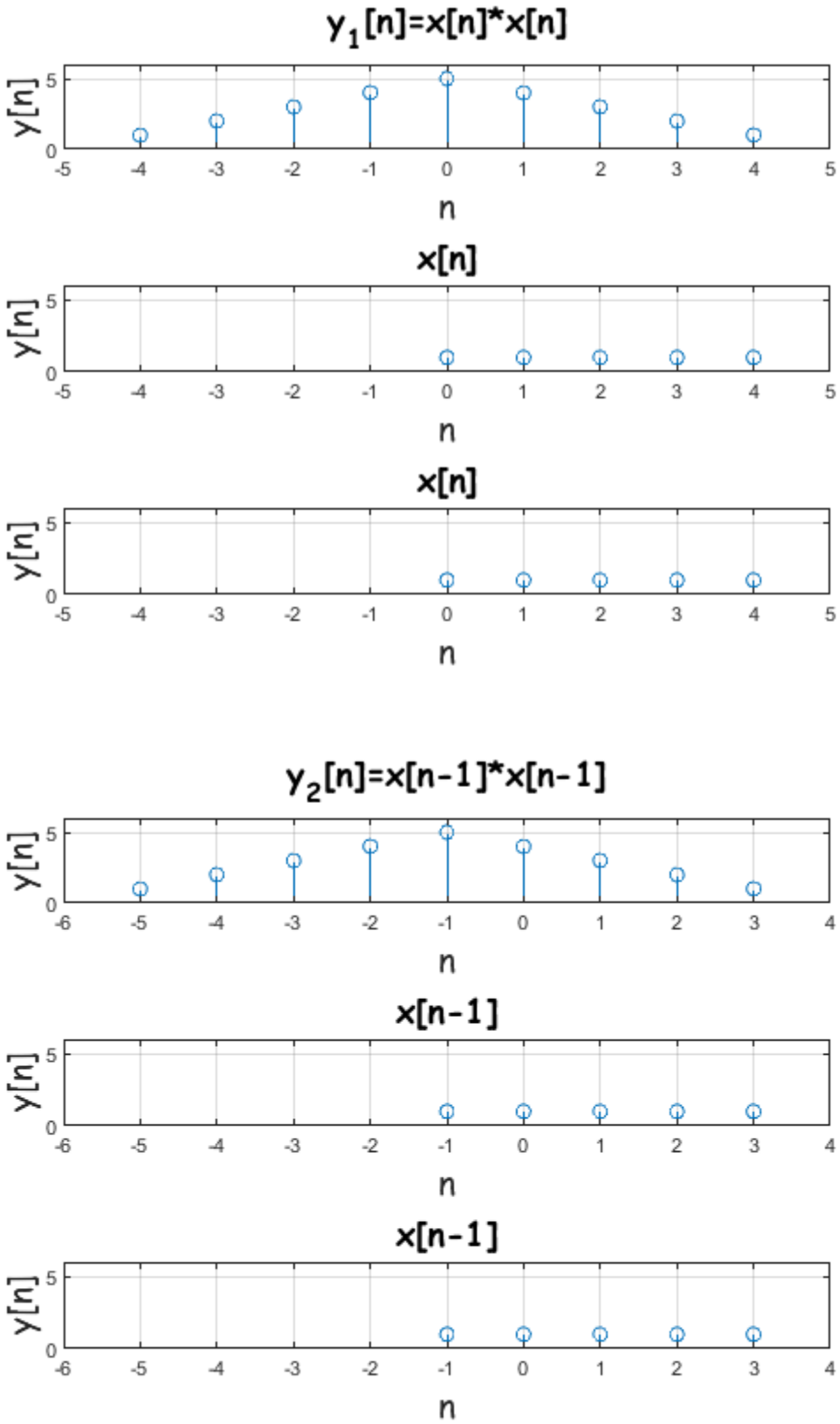
```
[y2bii, ny2bii] = FIRdesign(wl, wu, Nii);
[y2b2, w2] = freqz(y2bii, 1, ny2bii);

subplot(3,2,3)
stem(ny2bii,y2bii)
axis([min(ny2bii) , max(ny2bii), min(y2bii), max(y2bii)]);
grid on
title('y through FIR filter with N = 33', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,2,4)
plot(w2/pi,20*log10(abs(y2b2)))
axis([0, 2, -50, 30])
grid on
title('Frequency & Magnitude', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('Frequency (\times\pi rad/sample)', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
ylabel('magnitude(dB)', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.b.iii
Niii = 99;

[y2biii, ny2biii] = FIRdesign(wl, wu, Niii);
[y2b3, w3] = freqz(y2biii, 1, ny2biii);

subplot(3,2,5)
stem(ny2biii,y2biii)
axis([min(ny2biii) , max(ny2biii), min(y2biii), max(y2biii)]);
grid on
title('y through FIR filter with N = 99', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

subplot(3,2,6)
plot(w3/pi,20*log10(abs(y2b3)))
axis([0, 2, -40, 30])
grid on
title('Frequency & Magnitude', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('Frequency (\times\pi rad/sample)', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
ylabel('magnitude(dB)', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.c.i
clearvars
for n = 1:101
    a(n) = cos(n*(pi/8));
end
n = [1:101];
```

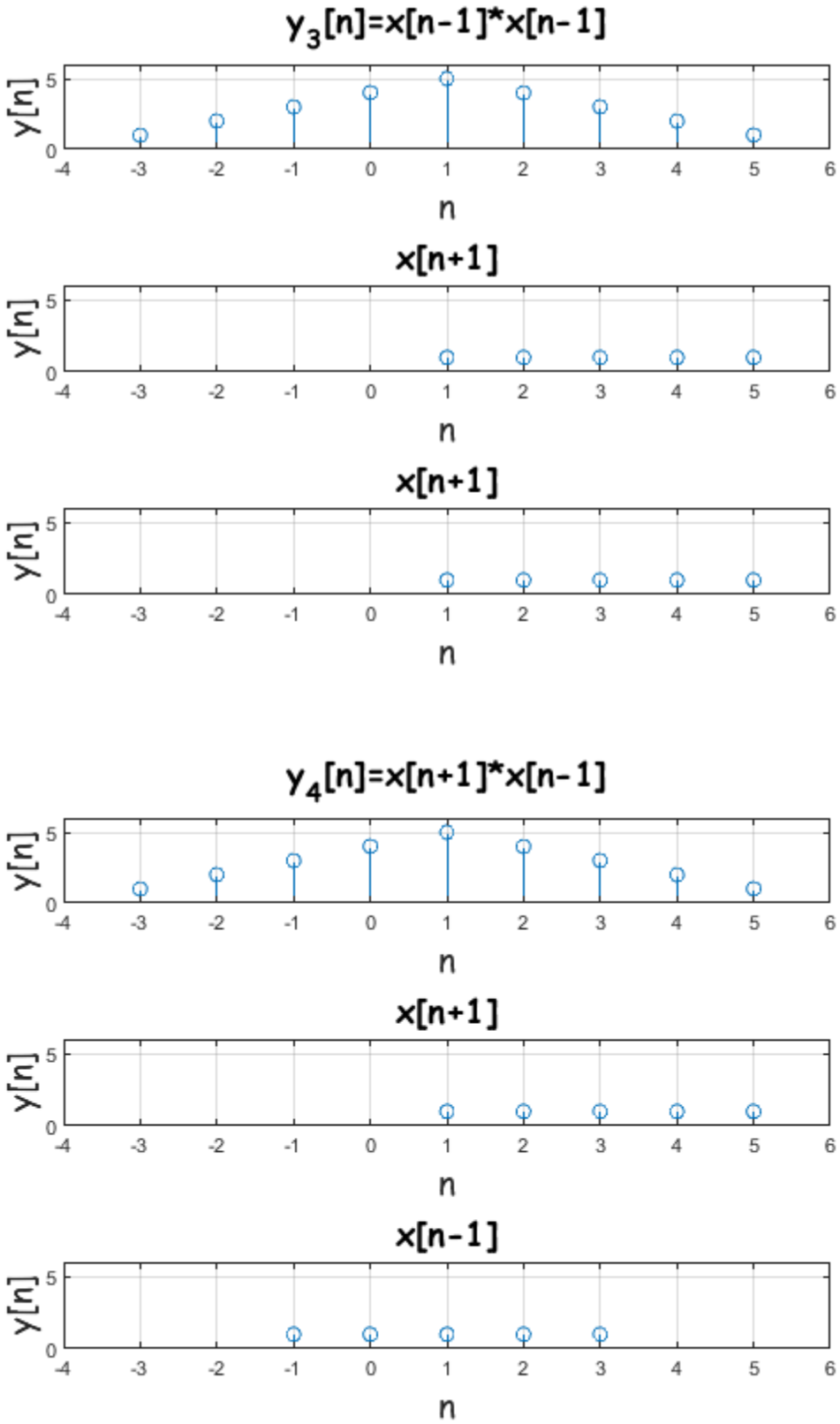
```
figure(8)
subplot(3,1,1)
stem(n, a)
axis([min(n) , max(n), min(a), max(a)]);
grid on
title('a[n]=cos[(pi/8)n]u[n]', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('a[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[ya, nya] = FIRdesign(0, pi/4, 33);

subplot(3,1,2)
stem(nya, ya)
axis([min(nya) , max(nya), min(ya), max(ya)]);
grid on
title('FIR with N = 33', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[y_f, ny_f] = convolve(a, n, ya, nya);

subplot(3,1,3)
stem(ny_f, y_f)
axis([min(ny_f) , max(ny_f), min(y_f), max(y_f)]);
grid on
title('filtered a[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('a[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.c.iI

for nb = 1:101
    b(nb) = cos(nb*(pi/3));
end
nb = [1:101];

figure(9)
subplot(3,1,1)
stem(nb, b)
axis([min(n) , max(n), min(b), max(b)]);
grid on
title('b[n]=cos[(pi/3)n]u[n]', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('b[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[yb, nyb] = FIRdesign(0, pi/4, 33);

subplot(3,1,2)
stem(nyb, yb)
axis([min(nyb) , max(nyb), min(yb), max(yb)]);
grid on
```

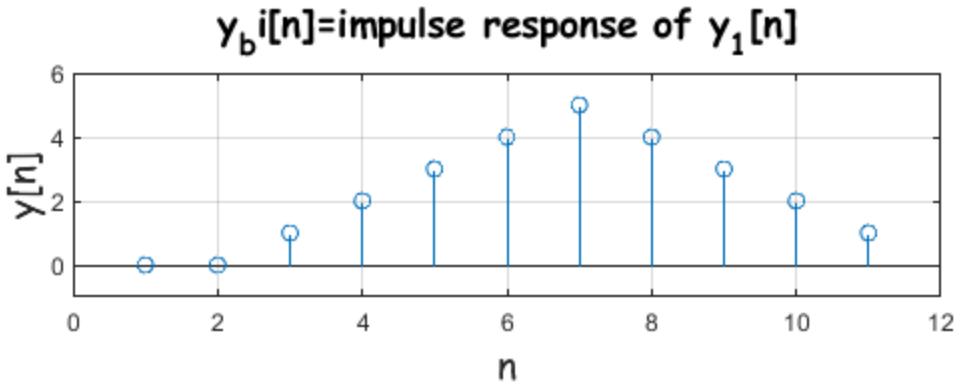
```
title('FIR with N = 33', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[y_fb, ny_fb] = convolve(b, n, ya, nya);

subplot(3,1,3)
stem(ny_fb, y_fb)
axis([min(ny_fb) , max(ny_fb), min(y_fb), max(y_fb)]);
grid on
title('filtered a[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('b[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.c.iii

for nc = 1:101
    c(nc) = cos(nc*(pi/3))*cos(nc*(pi/8));
end
nc = [1:101];

figure(10)
subplot(3,1,1)
stem(nc, c)
axis([min(nc) , max(nc), min(c), max(c)]);
grid on
title('c[n]=cos[(pi/3)n]*cos[(pi/8)n]u[n]', 'fontname', 'Comic Sans
 MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('c[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[yc, nyc] = FIRdesign(0, pi/4, 33);

subplot(3,1,2)
stem(nyc, yc)
axis([min(nyc) , max(nyc), min(yc), max(yc)]);
grid on
title('FIR with N = 33', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('y[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

[y_fc, ny_fc] = convolve(c, nc, yc, nyc);

subplot(3,1,3)
stem(ny_fc, y_fc)
axis([min(ny_fc) , max(ny_fc), min(y_fc), max(y_fc)]);
grid on
title('filtered c[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)
xlabel('n', 'fontname', 'Comic Sans MS', 'fontsize', 14)
ylabel('c[n]', 'fontname', 'Comic Sans MS', 'fontsize', 14)

%2.a
%finite impulse response frequency selective filter function
function [y, ny] = FIRdesign(wl, wu, N)
```

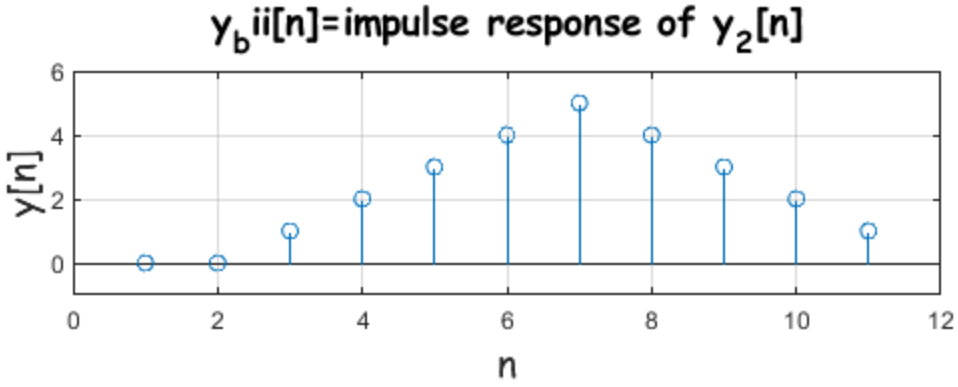
```
    %make one-sided h
    for n = 1:2*N
        h(n) = (sin(wu*n)-sin(wl*n))/(pi*n);
    end



    %the h is finite with the double the length of the window
    n = [1:2*N];

    %the process of making h hermitian even
    [h_r, n_r] = reverse(h, n);
    [h_comp, h_r_comp, n_comp] = compsig(h, n, h_r, n_r);
    h_comp = h_comp + h_r_comp;

    %the process to make the box to sweep
    for n = 1:N
        box(n) = 1;
    end
    n_box = -(N-1)/2:(N-1)/2;

    %colvolution of the h and the window
    [y, ny] = convolve(h_comp, n_comp, box, n_box);
end

%impulse convolution funciton
function y = convolution(h)
    prompt = 'Enter your impulse response: ';
    x = 3;
    xt = 1:x;
    x = [zeros(1, length(xt)-1)];
    y = [x h];
end

%convolution function
function [y, ny] = convolve(h, nh, x, nx)
    [x_r, nx_r] = reverse (x, nx);
    k = length(nh);
    x_r = [x_r zeros(1,k-1)];
    y = zeros(1, length(x_r));
    n = 0;
    while(k>=0)
            y = y + x_r.*h(find(h,1,'first')+n);
            k = k-1;
            x_r = circshift(x_r, 1);
            x_r(1) = 0;
            if(find(h, 1, 'first')+n == find(h, 1, 'last'));
                k = -1;
            end
            n = n + 1;
    end
    ny = min(nh)-length(x)+1:max(nh);
end
```

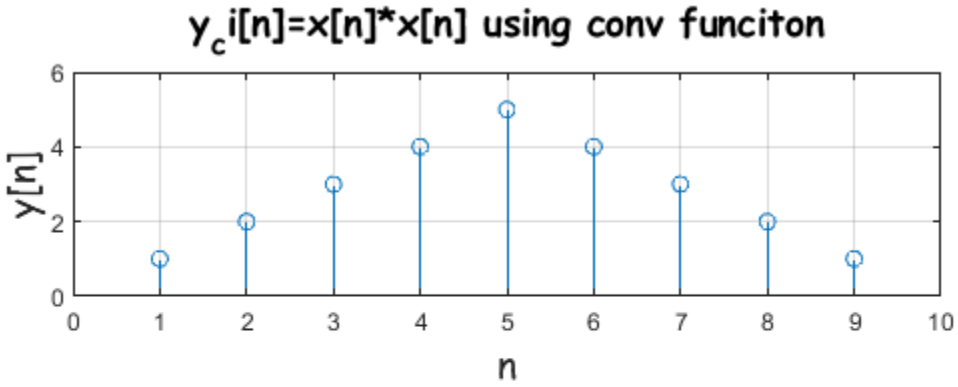
```
%shift function

function [s, n] = shift (x, N, nx)
s = x;
n = nx + N;
end

%reverse function
function [r, k] = reverse (x, nx)
r = fliplr(x);
k = -fliplr(nx);
end

% compsig function
function [s1, s2, n] = compsig(x1, n1, x2, n2)
    nmin = min([min(n1), min(n2)]);     %determines the minimum time
 index.
    nmax = max([max(n1), max(n2)]);     %determines the maximum time
 index.
    n = nmin:nmax;                      %time indices are set.

    nsize = size(n, 2);                 %size to be
    [s1, s2] = deal(zeros(1, nsize));   %s1 and s2 are initialized
 with size n.

    x1size = size(x1,2);                %determines the size of x1.
    x2size = size(x2,2);                %determines the size of x2.
    x1first = find(n == n1(1));         %finds the
    x2first = find(n == n2(1));

    switch (n1(1) < n1(2))              %as long as the index is
 incremental
        case true                       %the right index for x1 is
 transferred.
            s1(x1first : x1first + x1size - 1) = x1;
        otherwise                       %this is when the order is
 flipped.
            s1(x1first - x1size + 1 : x1first) = fliplr(x1);
    end

    switch (n2(1) < n2(2))
        case true
            s2(x2first : x2first + x2size - 1) = x2;
        otherwise
            s2(x2first - x2size + 1 : x2first) = fliplr(x2);
    end
end
```

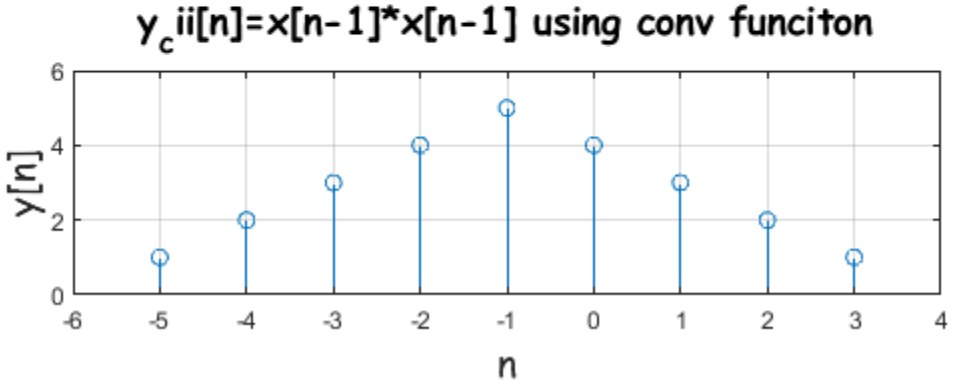

y1[n]=x[n]*x[n]
y[n]
n
x[n]
y[n]
n
x[n]
y[n]
n
y2[n]=x[n-1]*x[n-1]
y[n]
n
x[n-1]
y[n]
n
x[n-1]
y[n]
n

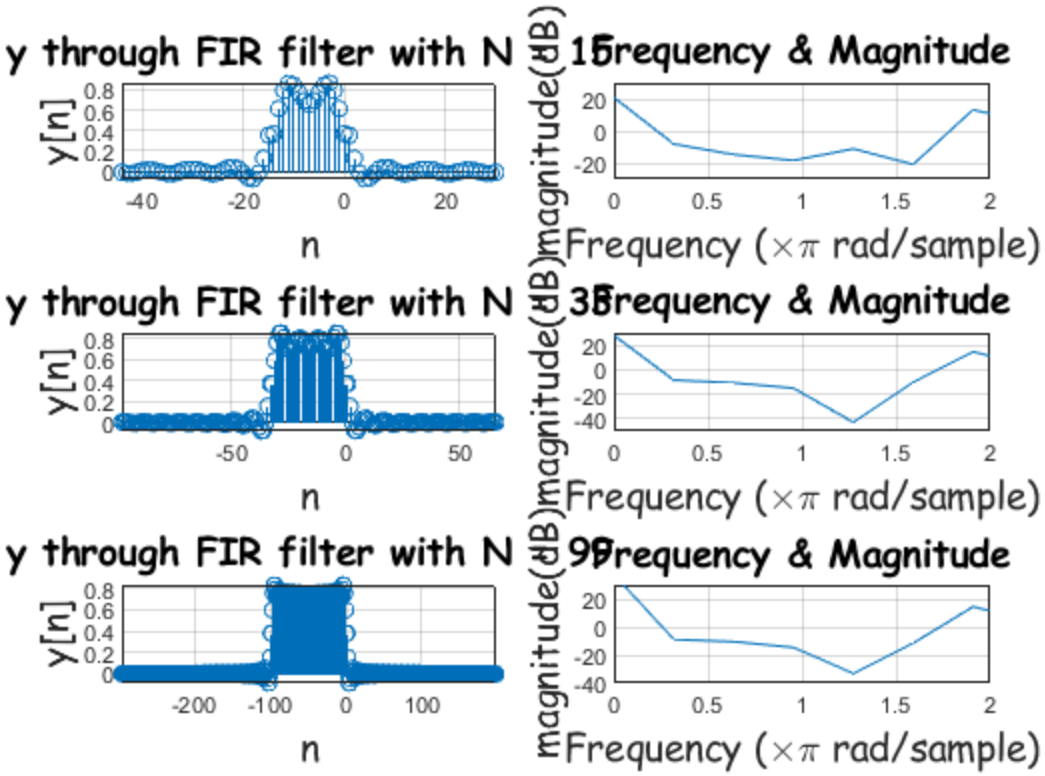

y3[n]=x[n-1]*x[n-1]
y[n]
n
x[n+1]
y[n]
n
x[n+1]
y[n]
n
y4[n]=x[n+1]*x[n-1]
y[n]
n
x[n+1]
y[n]
n
x[n-1]
y[n]
n

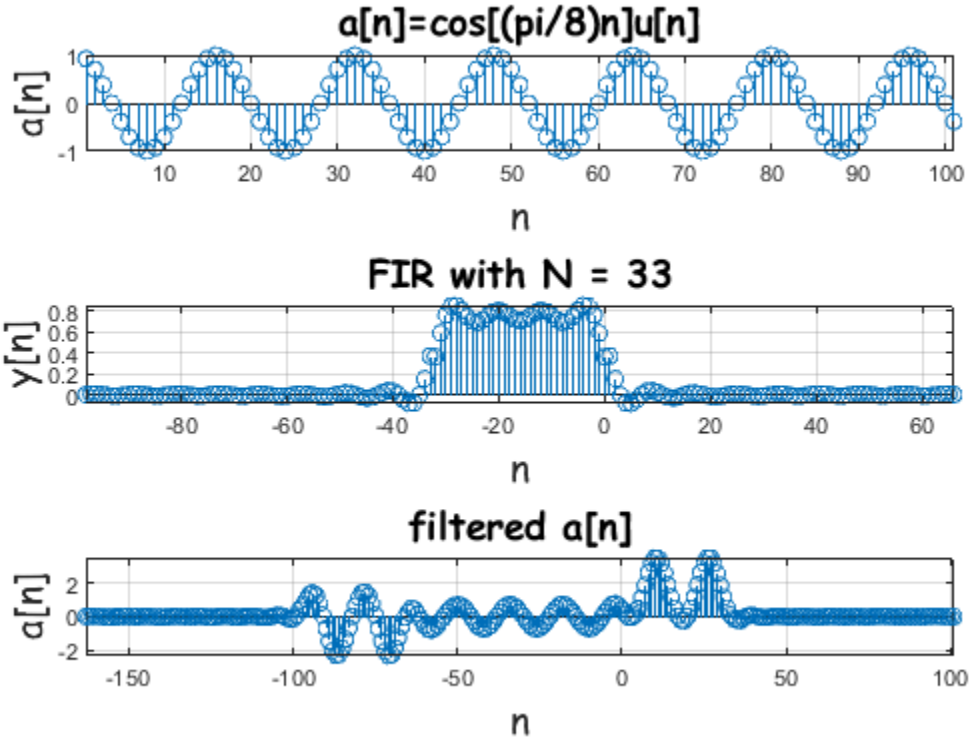

$y_b i[n]$=impulse response of $y_1[n]$
y[n]
n

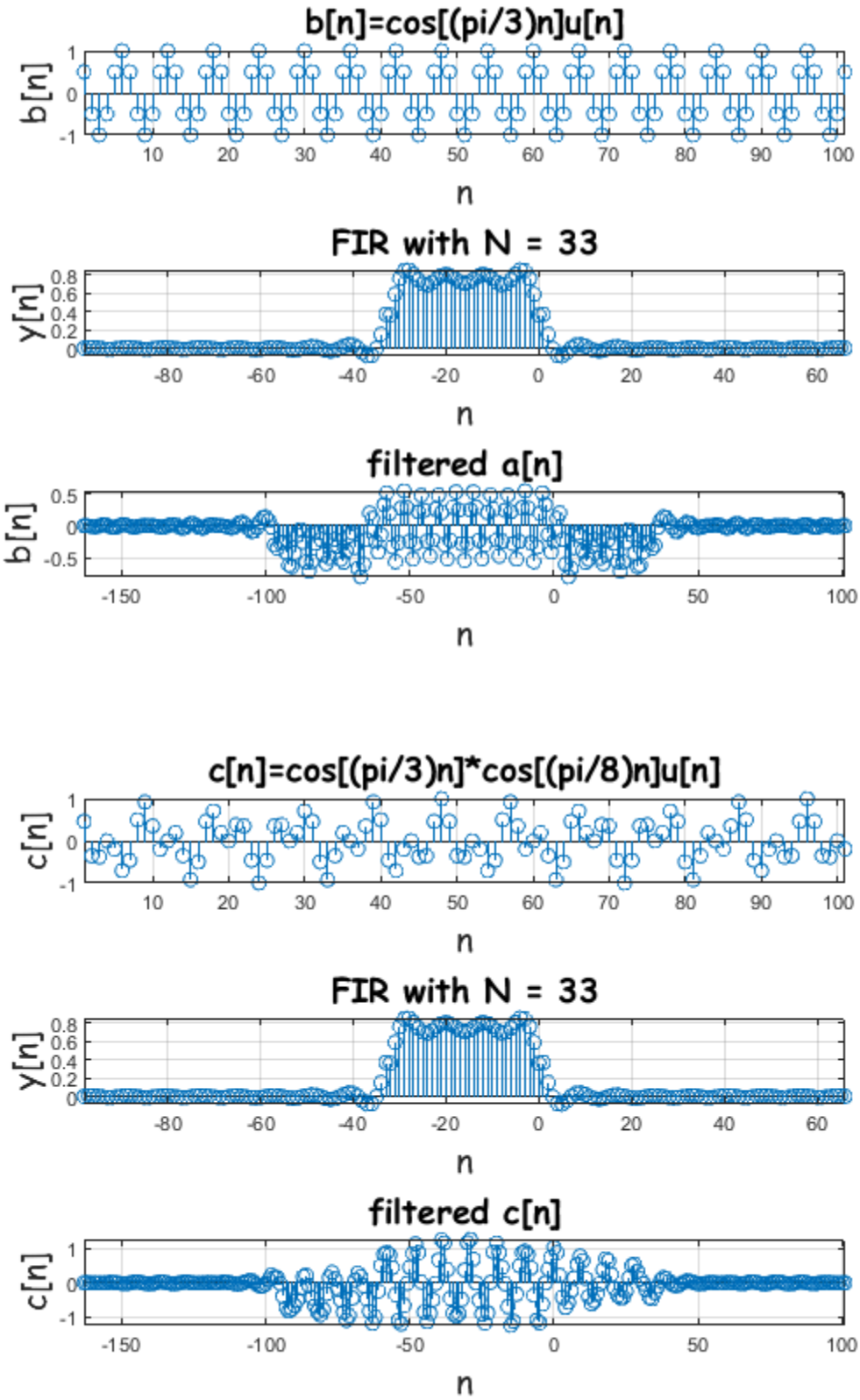

$y_b ii[n]$=impulse response of $y_2[n]$
y[n]
n


$y_c i[n]$=x[n]*x[n] using conv funciton
y[n]
n


$y_c ii[n]$=x[n-1]*x[n-1] using conv funciton
y[n]
n


y through FIR filter with N
y[n]
n
Frequency & Magnitude
magnitude(dB)
Frequency (×π rad/sample)
y through FIR filter with N
y[n]
n
Frequency & Magnitude
magnitude(dB)
Frequency (×π rad/sample)
y through FIR filter with N
y[n]
n
Frequency & Magnitude
magnitude(dB)
Frequency (×π rad/sample)


a[n]=cos[(pi/8)n]u[n]
a[n]
n
FIR with N = 33
y[n]
n
filtered a[n]
a[n]
n


b[n]=cos[(pi/3)n]u[n]
b[n]
n
FIR with N = 33
y[n]
n
filtered a[n]
b[n]
n
c[n]=cos[(pi/3)n]*cos[(pi/8)n]u[n]
c[n]
n
FIR with N = 33
y[n]
n
filtered c[n]
c[n]
n

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