ECG680 DSP Lab 6

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1. Correlation: Assume N = 50. Plot r[n] and $\varphi_{tr}(n)$ for each of the received signals.

Code:

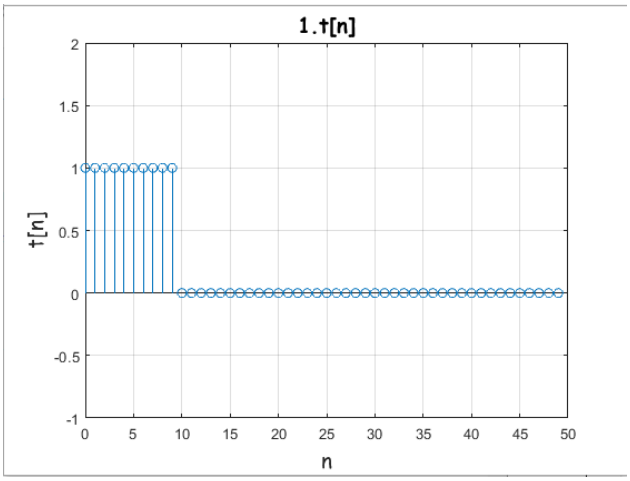
```
%1.



N = 50;
t = [ones(1,10),zeros(1,N-10)];
nt = [0:N-1];

stem(nt, t)
title({'1.t[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('t[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])
```

Plot:



i. S[n] = t[n-20] and n[n] = 0

Code:

```
%1.i.

[s, ns] = shift (t, 20, nt);
n = [zeros(1,N)];
```

```
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;

stem(ns, s)
title({'1.i.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
title({'1.i.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

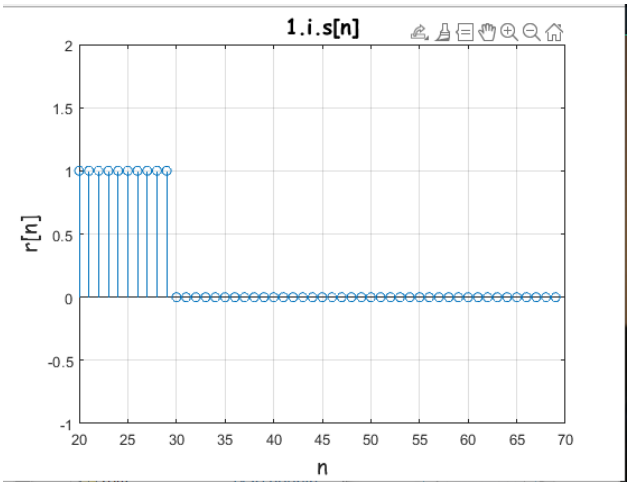
stem(nr, r)
title({'1.i.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

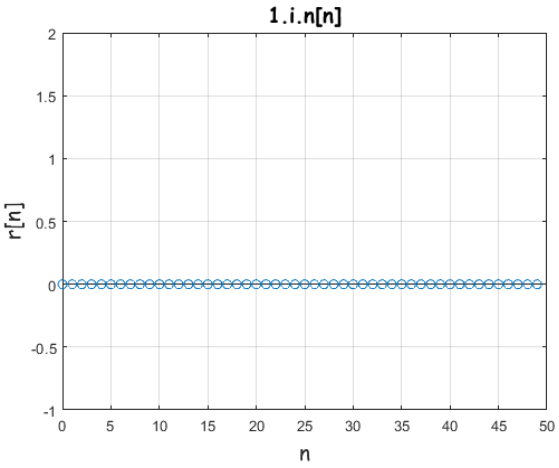
[revt, revnt] = reverse (t, nt);

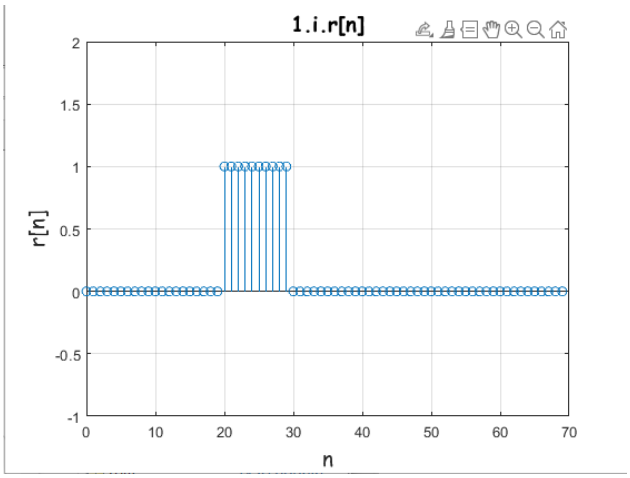
phi = conv(revt, r);
nphi = [1-N:length(phi)-N];

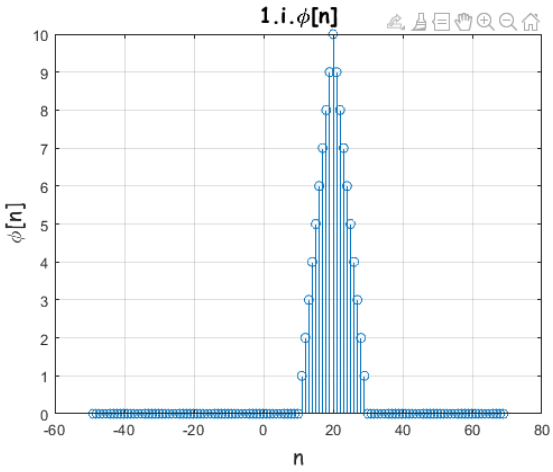
stem(nphi, phi)
title({'1.i.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:









ii. S[n] = 0.5t[n-20] and n[n] = 0

Code:

```
[s, ns] = shift (t, 20, nt);
s = 0.5.*s;
n = [zeros(1,N)];
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;

stem(ns, s)
title({'1.i.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
```

```
title({'1.i.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

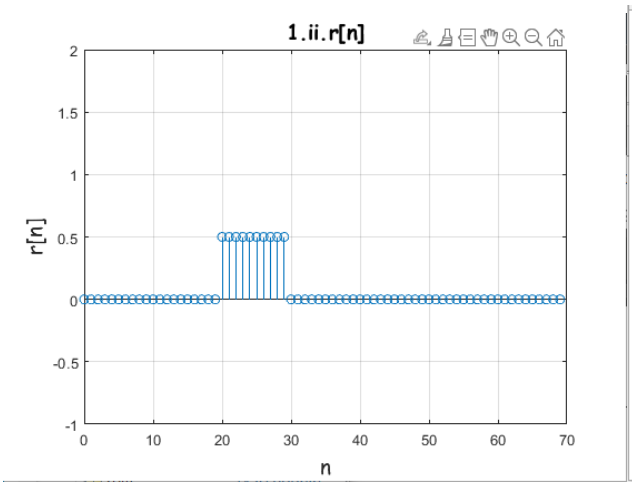
stem(nr, r)
title({'1.i.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

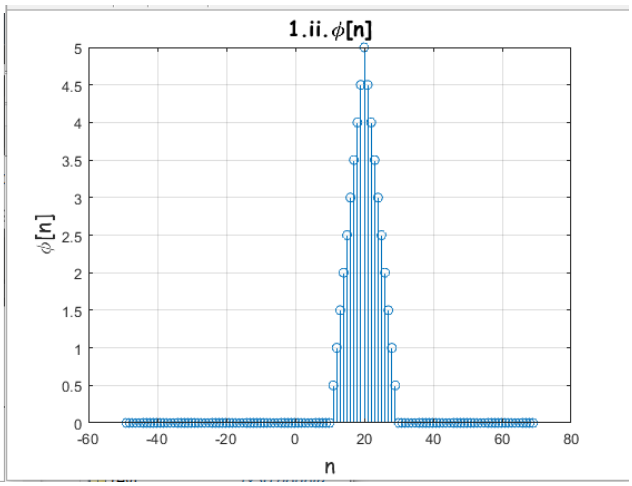
[revt, revnt] = reverse (t, nt);

phi = conv(revt, r);
nphi = [1-N:length(phi)-N];

stem(nphi, phi)
title({'1.i.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:





iii. S[n] = t[n-20] and n[n] = 2*(rand(n)-0.5 where rand is set to rand('uniform')

Code:

```
[s, ns] = shift (t, 20, nt);
n = 2.*rand(1,N);
```

```
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;

stem(ns, s)
title({'1.iii.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
title({'1.iii.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

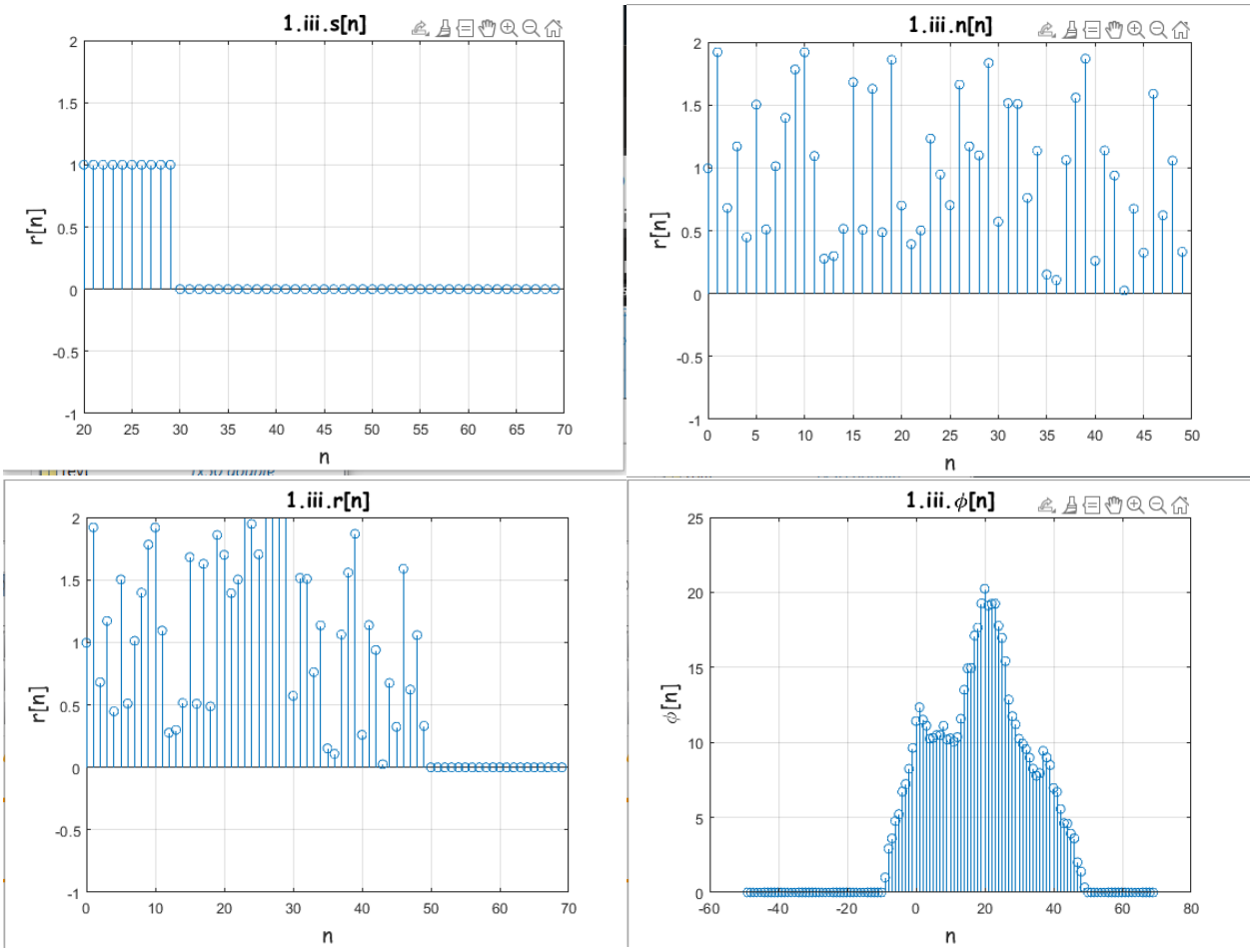
stem(nr, r)
title({'1.iii.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

[revt, revnt] = reverse (t, nt);

phi = conv(revt, r);
nphi = [1-N:length(phi)-N];

stem(nphi, phi)
title({'1.iii.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:



iv. S[n] = t[n-20] and n[n] = 4*(rand(n)-0.5 where rand is set to rand('uniform')

Code:

```
[s, ns] = shift (t, 20, nt);
n = 4.*rand(1,N);
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;

stem(ns, s)
title({'1.iv.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
title({'1.iv.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
```

```
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

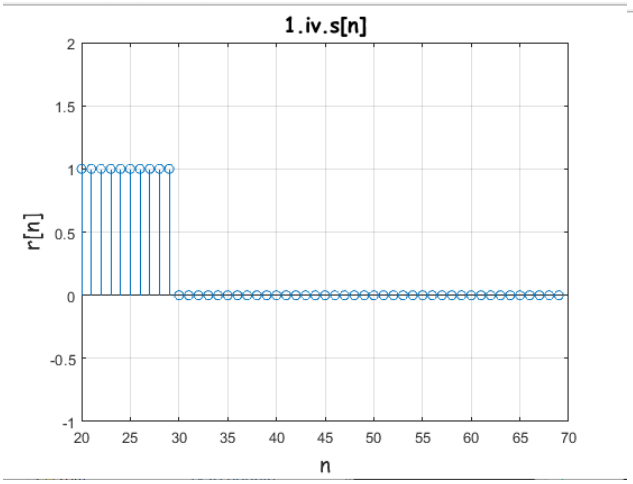
stem(nr, r)
title({'1.iv.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

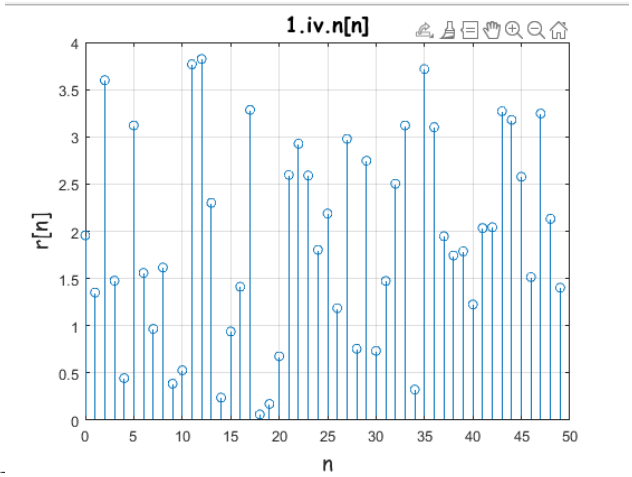
[revt, revnt] = reverse (t, nt);

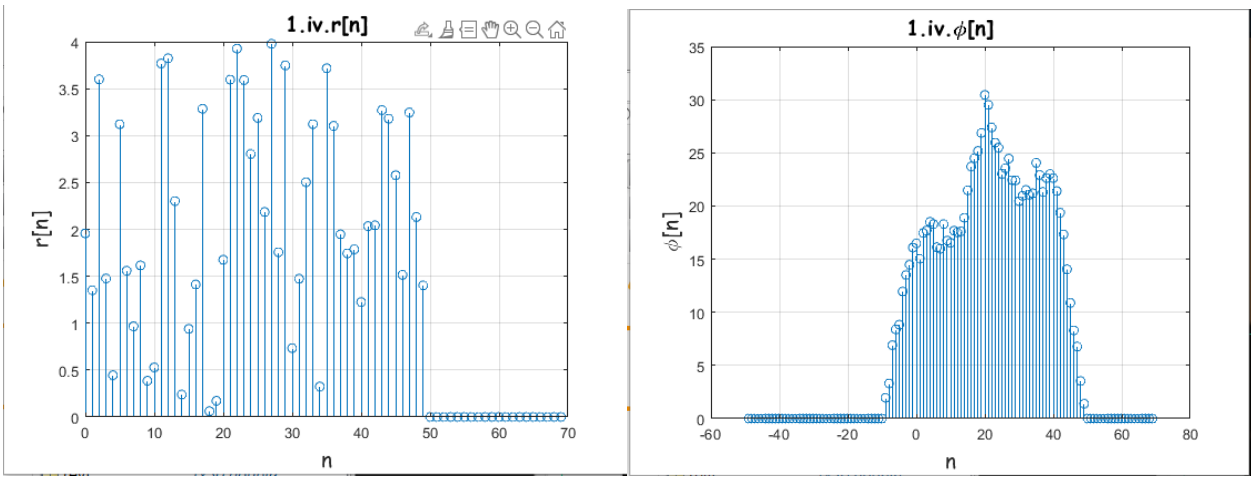
phi = conv(revt, r);
nphi = [1-N:length(phi)-N];

stem(nphi, phi)
title({'1.iii.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:







v. S[n] = t[n-20] and n[n] = 0.5*(rand(n) where rand is set to rand('normal')

Code:

```
[s, ns] = shift (t, 20, nt);
n = 0.5.*normrnd(0,1,[1,N]);
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;

stem(ns, s)
title({'1.v.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
title({'1.v.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)

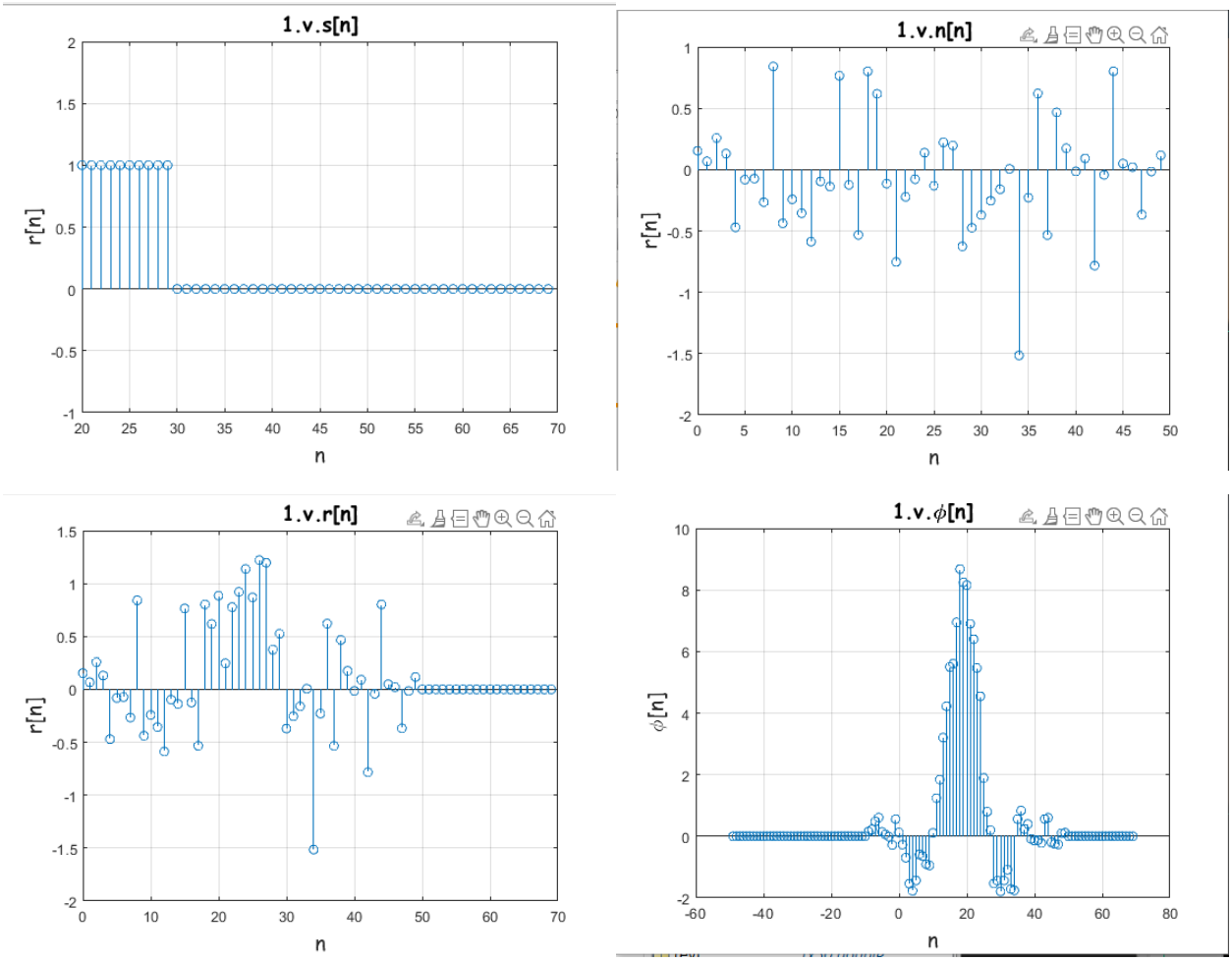
stem(nr, r)
title({'1.v.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)

[revt, revnt] = reverse (t, nt);

phi = conv(revt, r);
nphi = [1-N:length(phi)-N];
```

```
stem(nphi, phi)
title({'1.v.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:



vi. S[n] = t[n-20] and n[n] = rand(n) where rand is set to rand('normal')

Code:

```
[s, ns] = shift (t, 20, nt);
n = normrnd(0,1,[1,N]);
nn = [0:N-1];
[s1, n1, nr] = compsig(s, ns, n, nn);
r = s1 + n1;
```

```
stem(ns, s)
title({'1.vi.s[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(t)-1 max(t)+1])

stem(nn, n)
title({'1.vi.n[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)

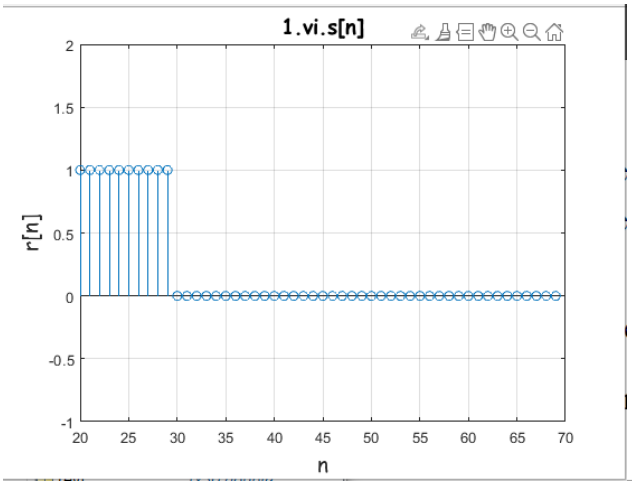
stem(nr, r)
title({'1.vi.r[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('r[n]','fontname', 'Comic Sans MS', 'fontsize',14)

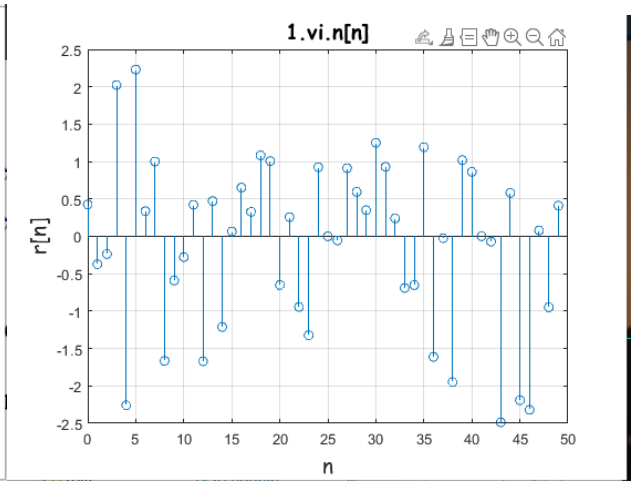
[revt, revnt] = reverse (t, nt);

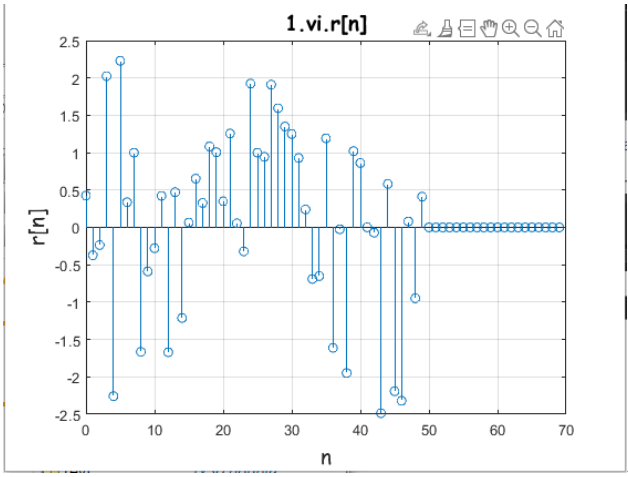
phi = conv(revt, r);
nphi = [1-N:length(phi)-N];

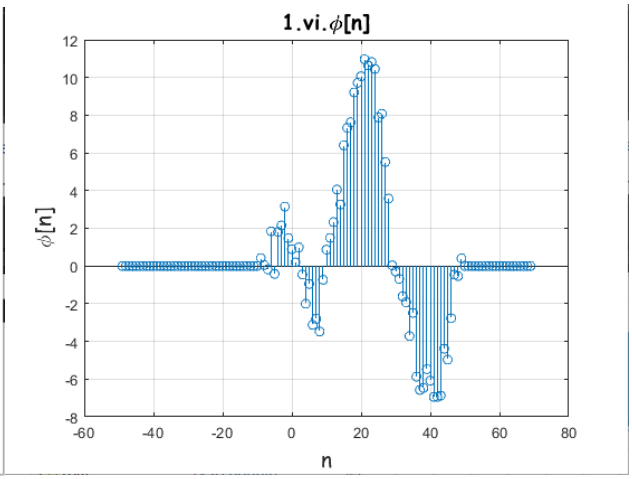
stem(nphi, phi)
title({'1.vi.\phi[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('\phi[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:









2. 2 Real FFT's (DFT's) Simulataneously
    a.

Let N be a power of 2 $\quad N = 2^l \quad l \in I$

$$X(k) = \sum_{n=0}^{N-1} x(n)\, e^{-j\frac{2\pi}{N}kn}$$

$$= \sum_{\substack{n=0 \\ n \text{ even}}}^{N-1} x(n)\, e^{-j\frac{2\pi}{N}kn} + \sum_{\substack{n=0 \\ n \text{ odd}}}^{N-1} x(n)\, e^{-j\frac{2\pi}{N}kn}$$

$$= \sum_{n=0}^{\frac{N}{2}-1} x(2n)\, e^{-j\frac{2\pi}{N}k2n} + \sum_{n=0}^{\frac{N}{2}-1} x(2n+1)\, e^{-j\frac{2\pi}{N}k(2n+1)}$$

$$e^{-j\frac{2\pi}{N}k2n} = e^{-j\frac{2\pi}{N/2}kn}$$

$$\Rightarrow X(k) = \underbrace{\sum_{n=0}^{\frac{N}{2}-1} x(2n)\, e^{-j\frac{2\pi}{N/2}kn}}_{N/2 \text{ point DFT}} + e^{-j\frac{2\pi}{N}k} \underbrace{\sum_{n=0}^{\frac{N}{2}-1} x(2n+1)\, e^{-j\frac{2\pi}{N/2}kn}}_{N/2 \text{ point DFT}}$$

$$= G(k) + e^{-j\frac{2\pi}{N}k} H(k)$$

Because $G(k)$ and $H(k)$ are $\frac{N}{2}$ point DFT's they are periodic with period $N/2$.

$$G(k) = G\left(k + \tfrac{N}{2}\right)$$
$$H(k) = H\left(k + \tfrac{N}{2}\right)$$

b. generating 2 distinct real sequences, x[n] and y[n], of length N where 64 <= N <= 1024

code:

```
%2.b.i
```

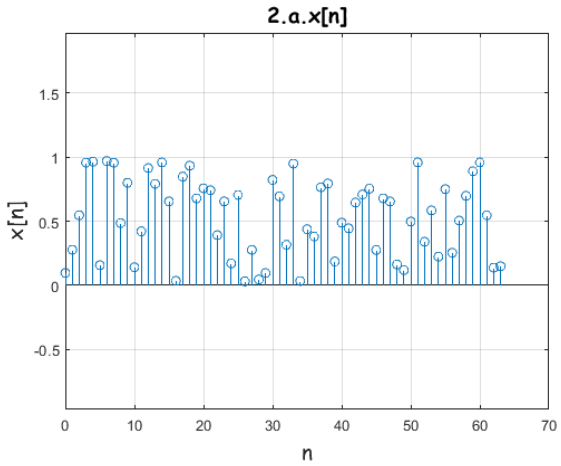
```
N = 64;

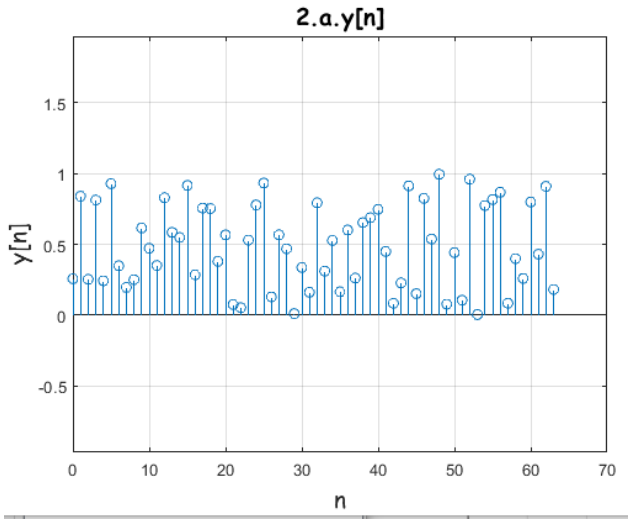
n = [0:N-1];
x = rand(1,N);
y = rand(1,N);

stem(n, x)
title({'2.a.x[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('x[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(x)-1 max(x)+1])

stem(n, y)
title({'2.a.y[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('y[n]','fontname', 'Comic Sans MS', 'fontsize',14)
ylim([min(x)-1 max(x)+1])
```

Plots:





c. performing an FFT on x[n] and y[n] (plot the magnitude of X(k) and Y(k)),

code:

```
%2.b.ii.

xf = fft(x);
stem(n, xf)
title({'2.b. FFT of x[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
```

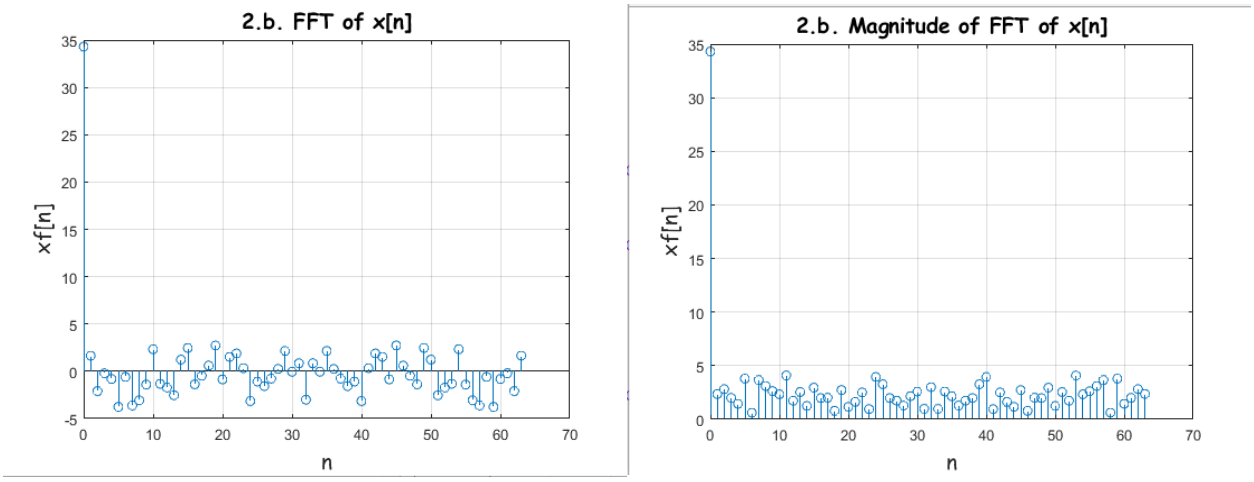
```
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('xf[n]','fontname', 'Comic Sans MS', 'fontsize',14)

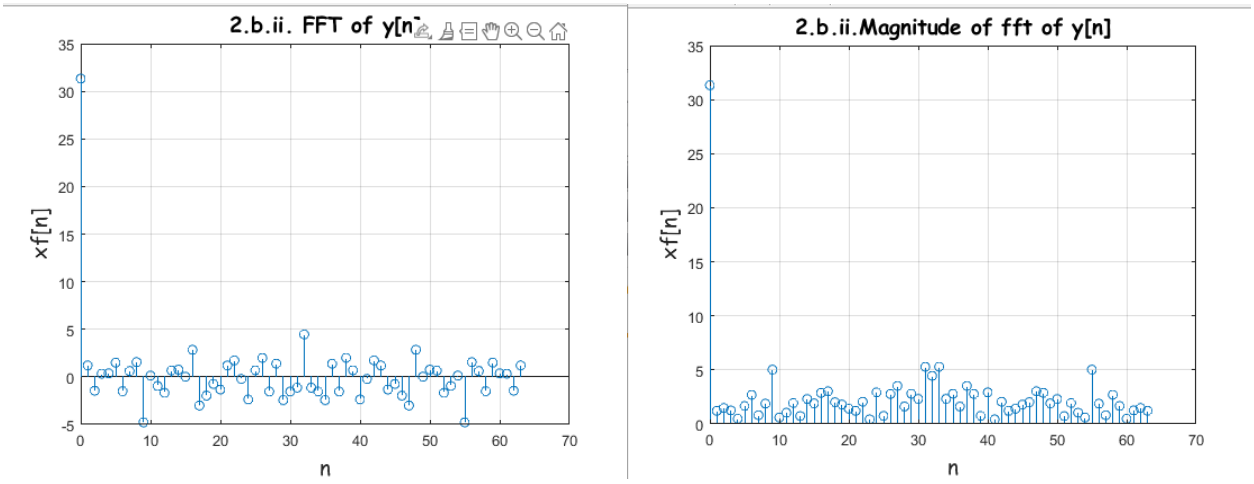
stem(n, abs(xf))
title({'2.b. Magnitude of FFT of x[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('xf[n]','fontname', 'Comic Sans MS', 'fontsize',14)

yf = fft(y);
stem(n, yf)
title({'2.b.ii. FFT of y[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('xf[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, abs(yf))
title({'2.b.ii.Magnitude of fft of y[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('xf[n]','fontname', 'Comic Sans MS', 'fontsize',14)
```

Plots:





d. performing an FFT on x[n] and y[n] using the method described in part a) of this exercise(plot the magnitude of Z(k), X(k) and Y(k))

code:

```
%2.b.iii.

z = x + y*1i;
zc = conj(z);
fftz = fft(z);
fftx = (fft(z)+fft(zc))/2;
ffty = (fft(z)+fft(zc))/(2*1i);

stem(n, fftx)
title({'2.b.iii.fft of x[n] using 2.a.'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('fft x[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, ffty)
title({'2.b.iii.fft of y[n] using 2.a.'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('fft y[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, z)
title({'2.b.iii.fft of z[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('fft z[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, abs(fftx))
title({'2.b.iii.magnitude of fft of x[n] using 2.a.'},'fontname', 'Comic Sans MS', 'fontsize',14)
```

```
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('magnitude of fft x[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, abs(ffty))
title({'2.b.iii.magnitude of fft of y[n] using 2.a.'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('magnitude of fft y[n]','fontname', 'Comic Sans MS', 'fontsize',14)

stem(n, abs(z))
title({'2.b.iii.magnitude of fft of z[n]'},'fontname', 'Comic Sans MS', 'fontsize',14)
grid on
xlabel('n','fontname', 'Comic Sans MS', 'fontsize',14)
ylabel('magnitude of fft z[n]','fontname', 'Comic Sans MS', 'fontsize',14)
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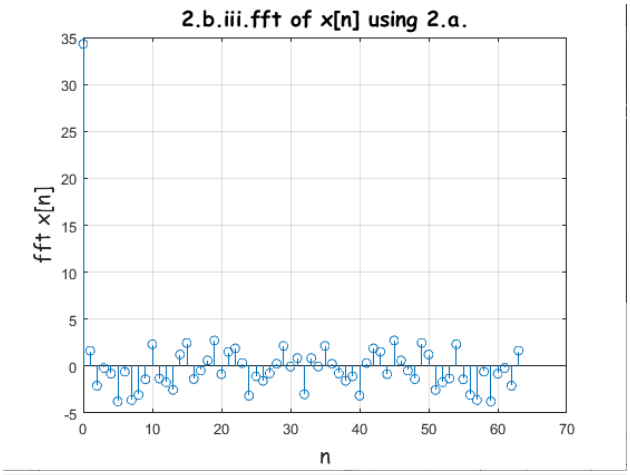
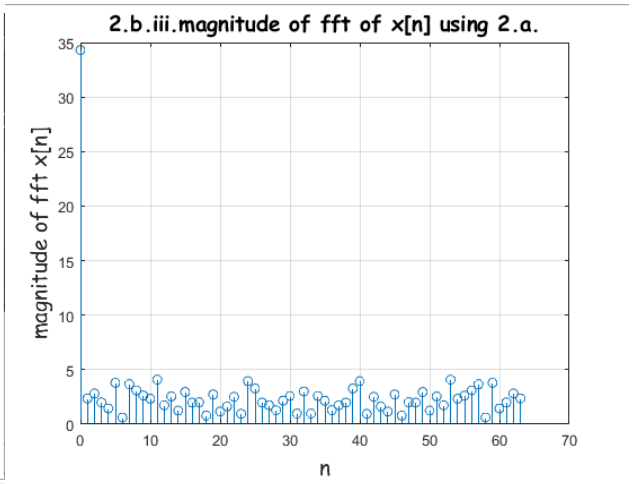
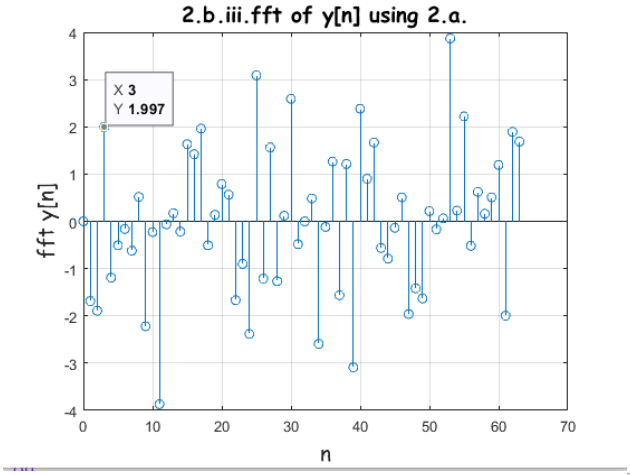
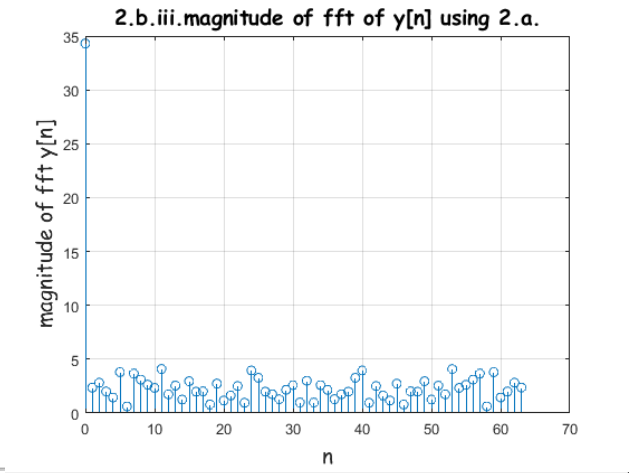
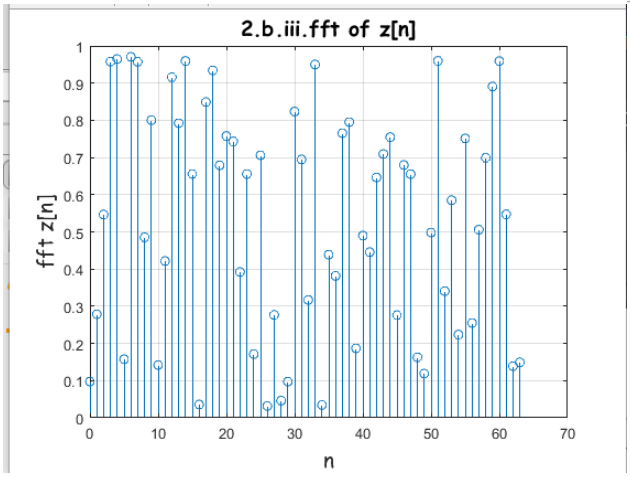
Plots:

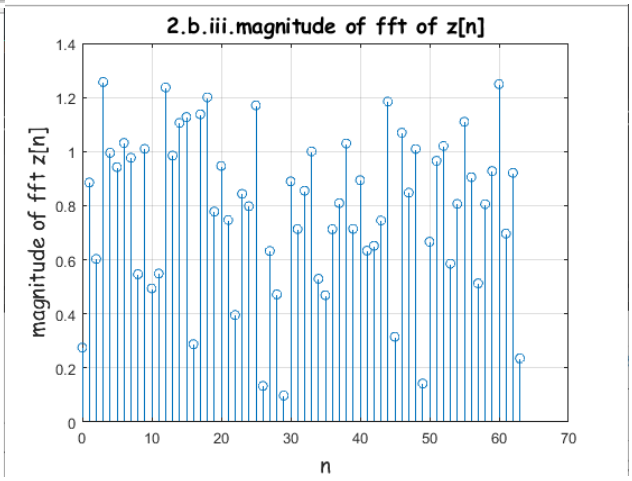




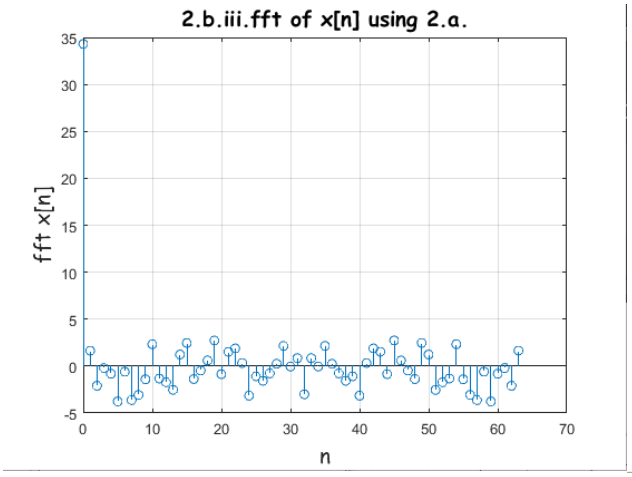


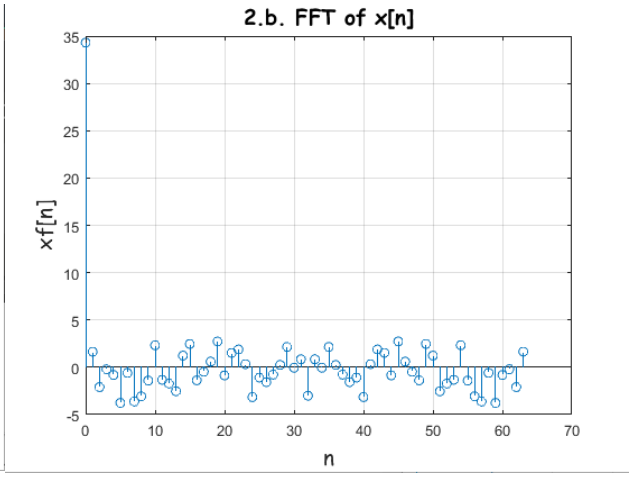


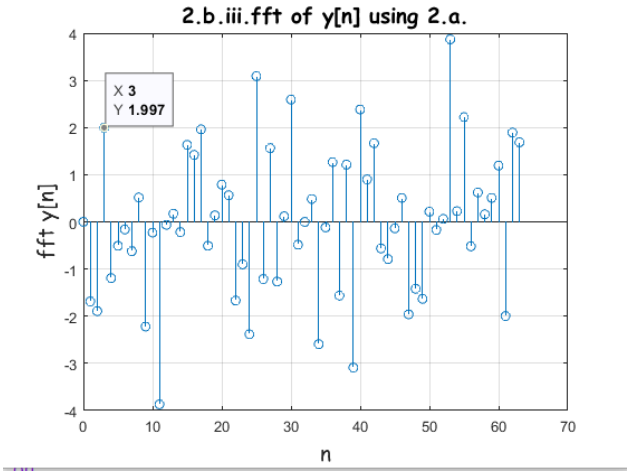


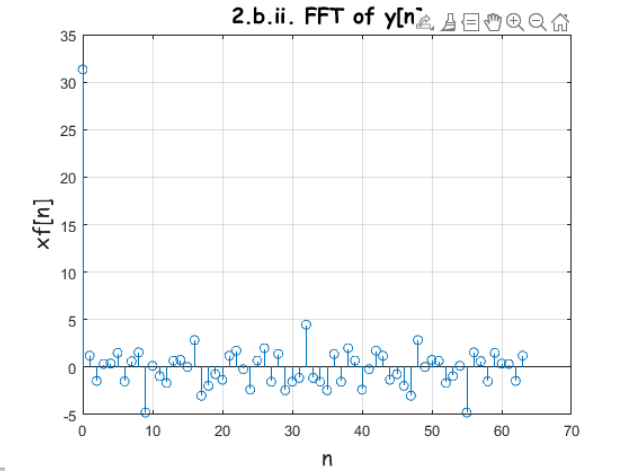


e. comparing your results (subtract your answers in part ii) from your answers in part iii)).









They are the same. Although y[n] might look different, it is the same.