Title: DFT and IDFT

AIM: To perform DFT and IDFT operations on a given pair of sequences.

Objective: To perform DFT and IDFT operations on a given pair of sequences using DFT and IDFT in MATlab.

DFT : The discrete Fourier transform (DFT) is the primary transform used for numerical computation in digital signal processing. It is very widely used for spectrum analysis, fast convolution, and many other applications. The DFT transforms N discrete-time samples to the same number of discrete frequency samples, and is defined as

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-\left(i\frac{2\pi nk}{N}\right)}$$

The **Inverse DFT (IDFT)** transforms N discrete-frequency samples to the same number of discrete-time samples. The IDFT has a form very similar to the DFT,

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

Write a function in MATLAB to calculate DFT and IDFT of a sequence.

Matlab function to perform DFT

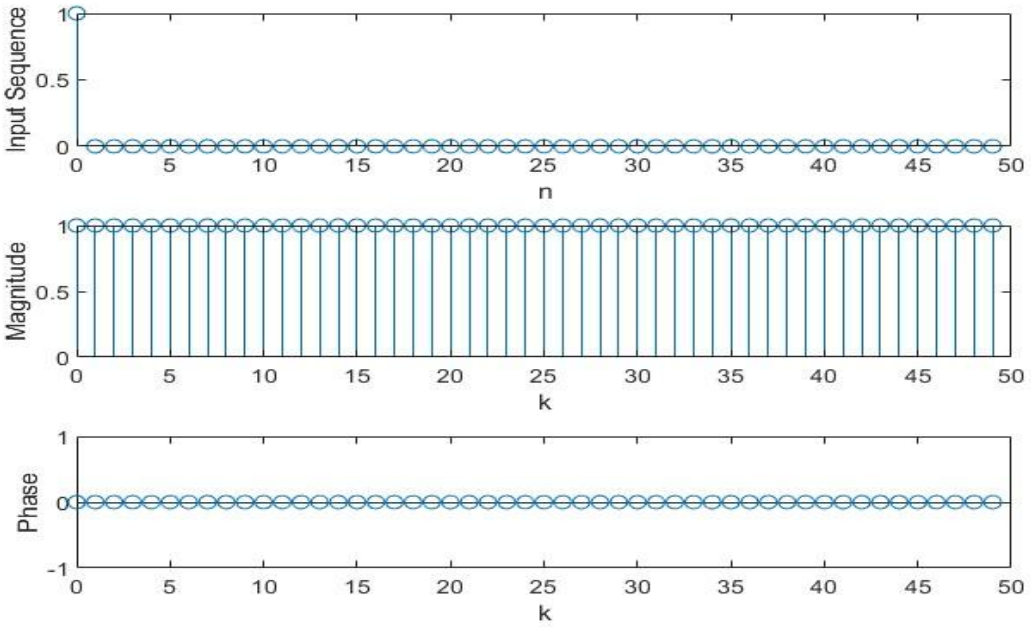
```
%{
      To Calculate the DFT of given sequence
      Author : Sudip Biswas
%}
function xk = DFTFun(x)
N = length(x);
n1=0:N-1;
for k =1:N
   xk(k)=0;
   for n=1:N
       W = (-1i*2*pi*(n-1)*(k-1))/N;
       xk(k) = xk(k)+ x(n)*exp(W);
   end
 End
% For Plotting input and output sequence
subplot(3,1,1);
stem(idflen,x);
ylabel("Input Sequence");
xlabel("k");
subplot(3,1,2);
stem(idflen,abs(xn));
ylabel("Magnitude");
```

Test Function

a) Unit Impulse

```
% Unit Impulse
x = [1,zeros(1,49)];
DFTFun(x);
```

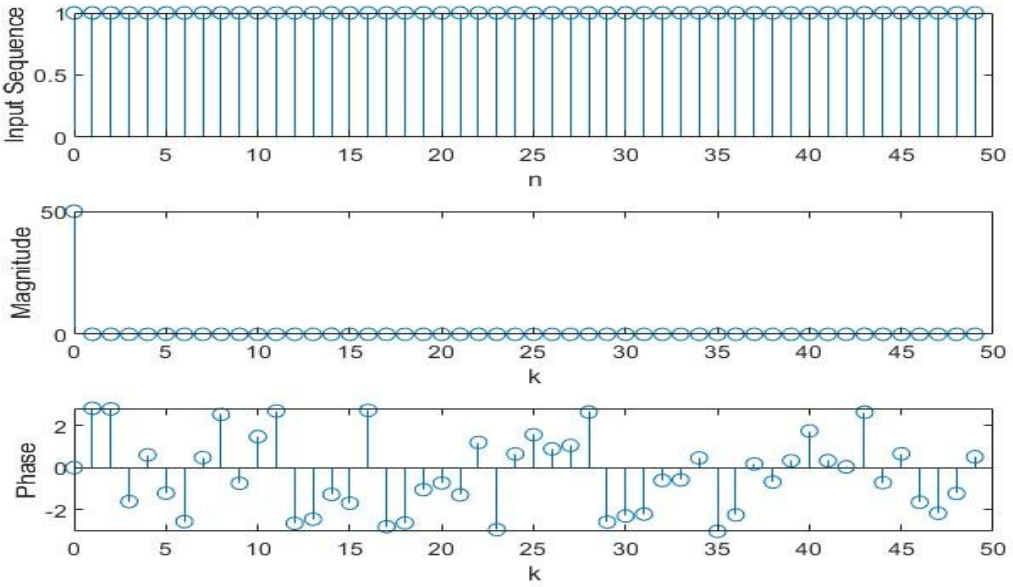
Output of Program



b) Unit step

```
% Unit Step
x = ones(1,50);
DFTFun(x);
```

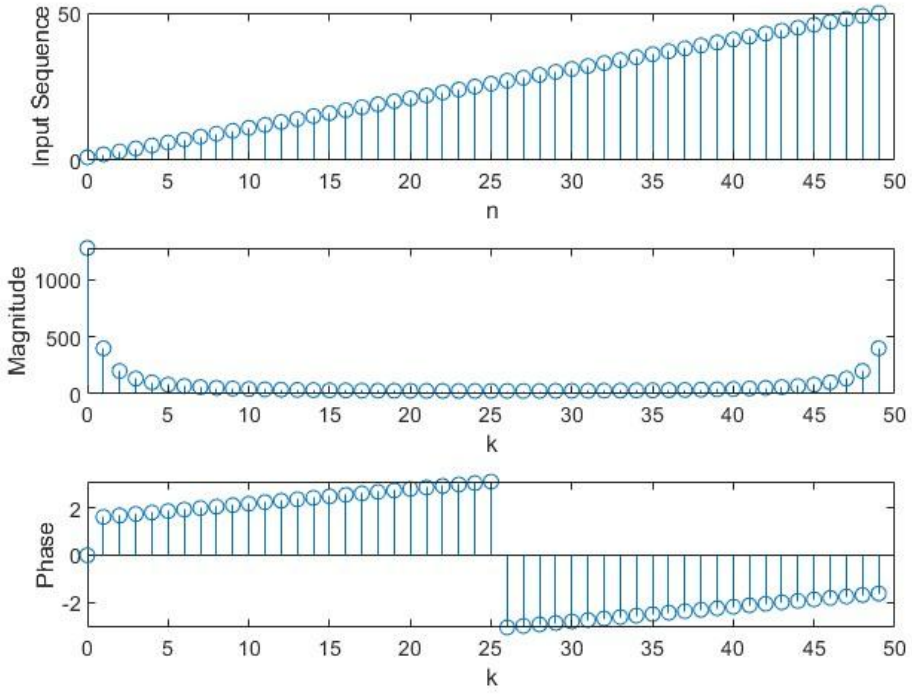
Output of Program



c) Unit ramp

```
% Unit Ramp
x = [1:50];
DFTFun(x);
```

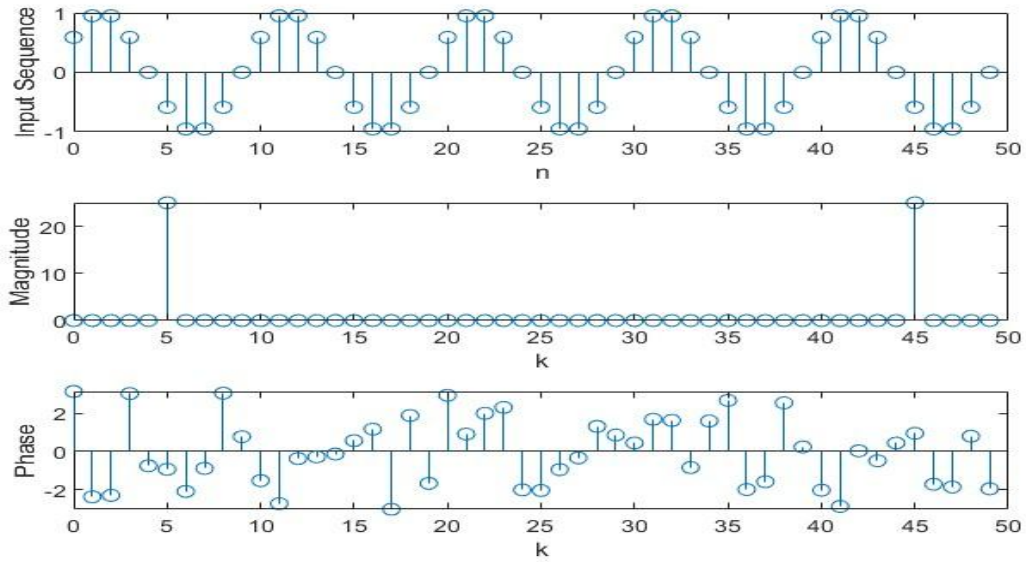
Output of Program



d) Sine

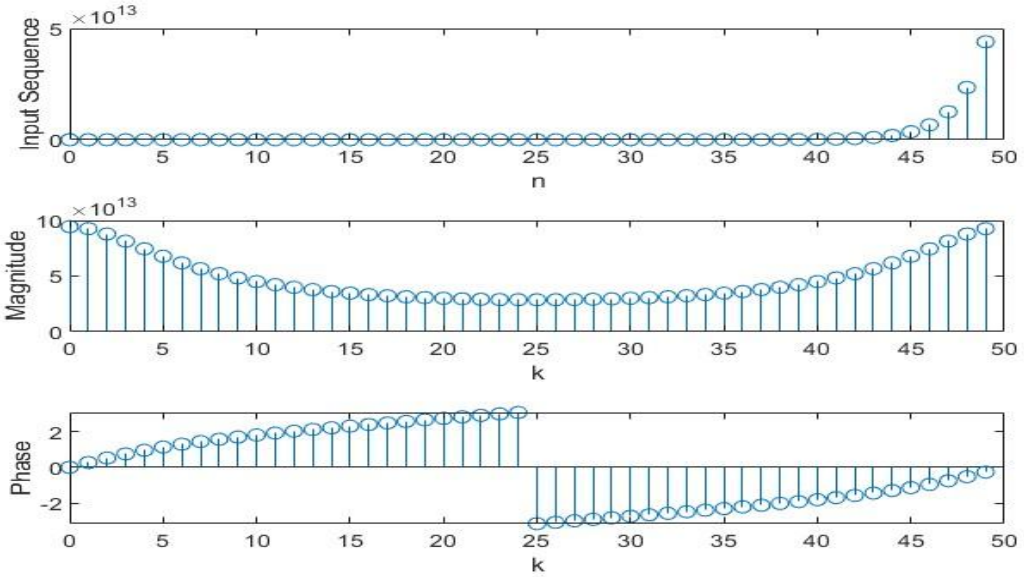
```
% sine
x = 1:50;
y=sin(2*pi*x/10);
DFTFun(y);
```

Output of Program



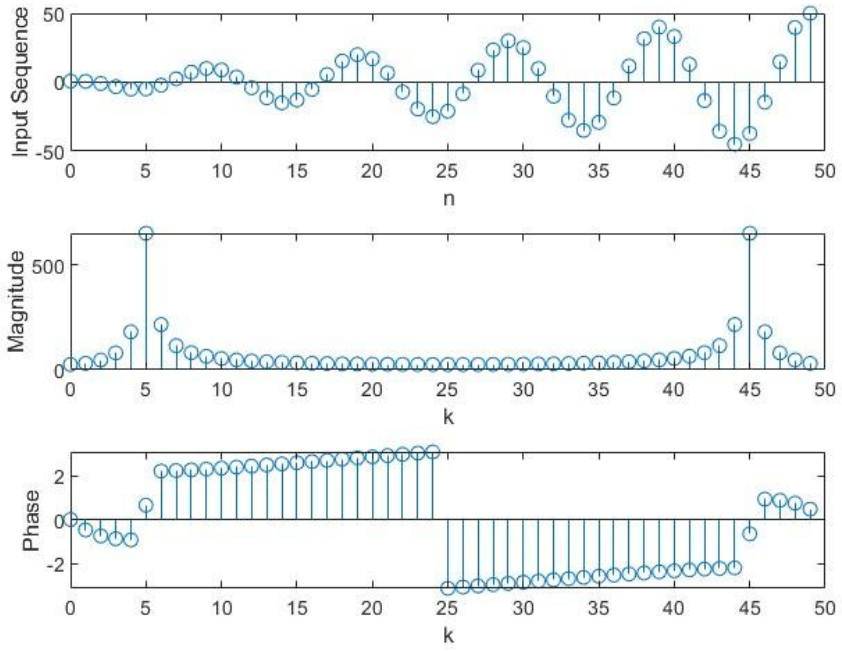
e) Exponential

```
% exponential
x = 1:50;
y=exp(2*pi*x/10);
DFTFun(y);
```



f) Modulation with Ramp

```
% modulation with ramp
x = 1:50;
y=cos(2*pi*x/10);
z=x.*y;
DFTFun(z);
```



Matlab function to perform IDFT

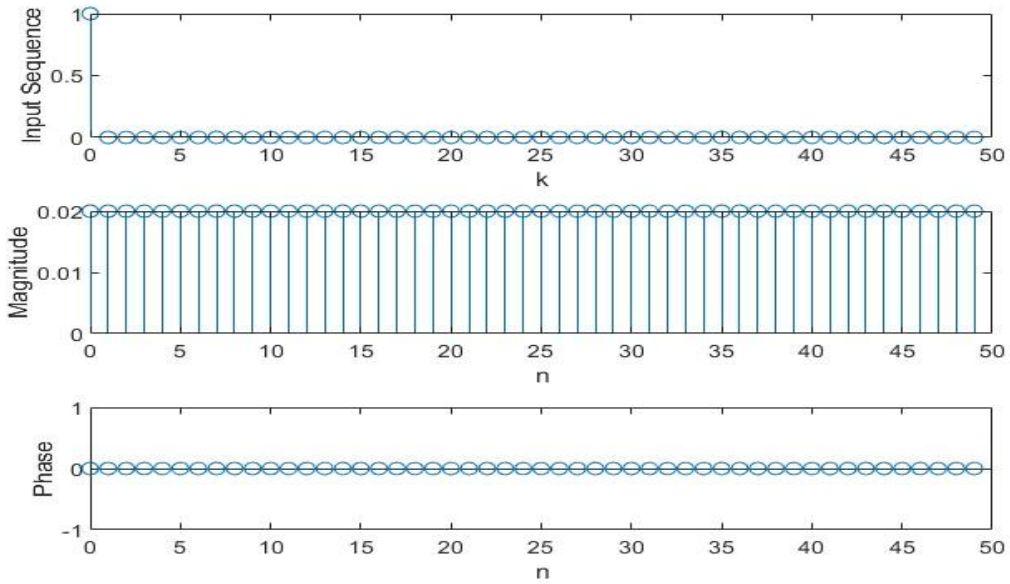
```
%{
To Calculate the inverse DFT of given sequence
Author : Sudip Biswas
%}
function xn = iDFTFun(x)
N = length(x);
idflen=0:N-1;
for k =1:N
   xn(k)=0;
   for n=1:N
       W = (1i*2*pi*(n-1)*(k-1))/N;
       xn(k) = xn(k)+ x(n)*exp(W);
   end
   xn(k) = xn(k)/N;

end

% For Plotting input and output sequence
stem(idflen,abs(xn));
ylabel("Magnitude");
subplot(3,1,1);
stem(idflen,x);
ylabel("Input Sequence");
xlabel("k");
subplot(3,1,2);
stem(idflen,abs(xn));
ylabel("Magnitude");
xlabel("n");
subplot(3,1,3);
stem(idflen,angle(xn));
ylabel("Phase");
xlabel("n");
```

Test Function

(a) Unit Impulse

```
% Unit Impulse
x = [1,zeros(1,49)];
iDFTFun(x);
```

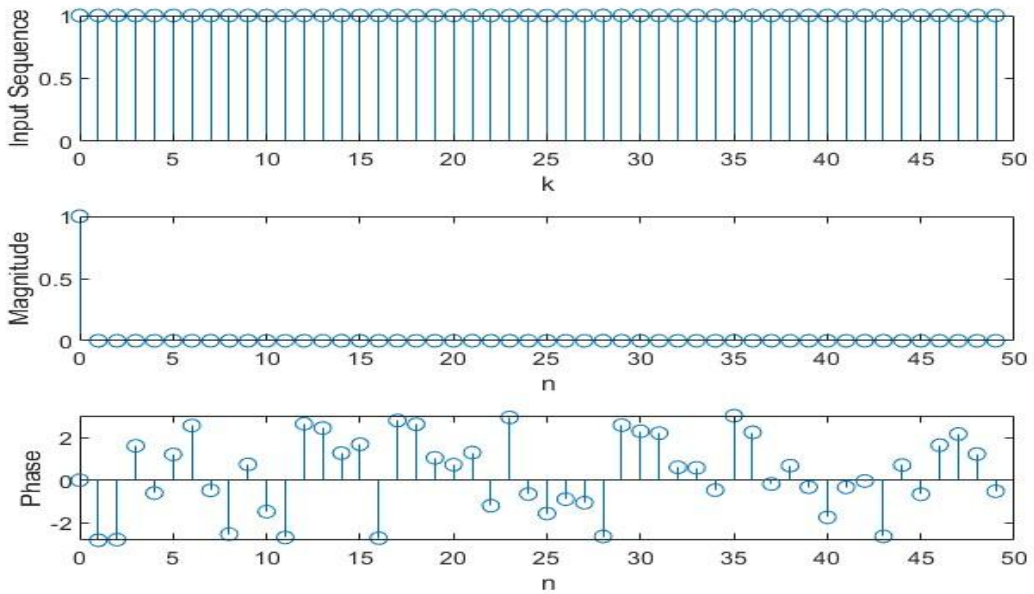
Output of Program



(b) Unit Impulse

```
% Unit Step
x = ones(1,50);
iDFTFun(x);
```

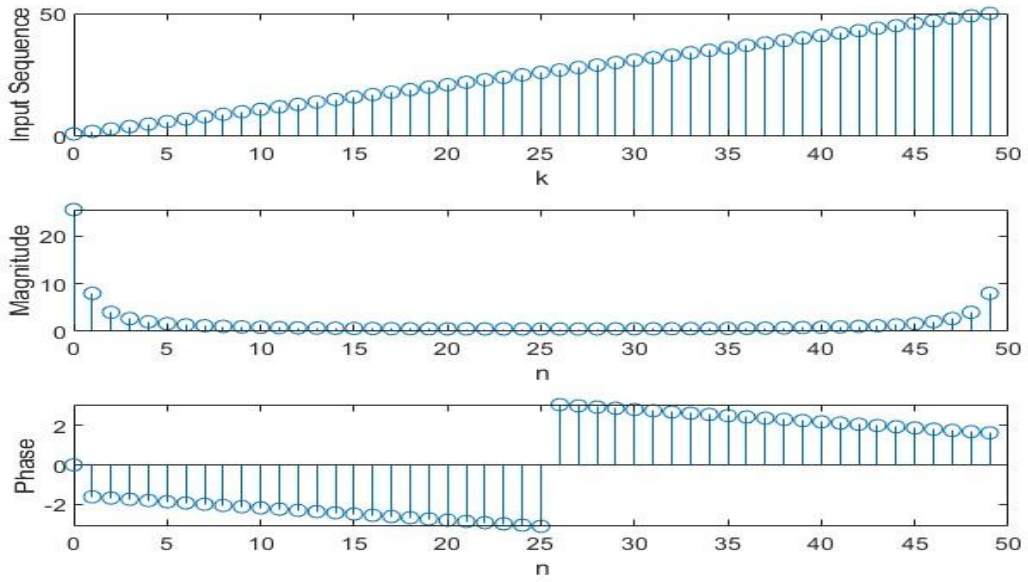
Output of Program



(c) Unit Ramp

```
% Unit Ramp
x = [1:50];
iDFTFun(x);
```

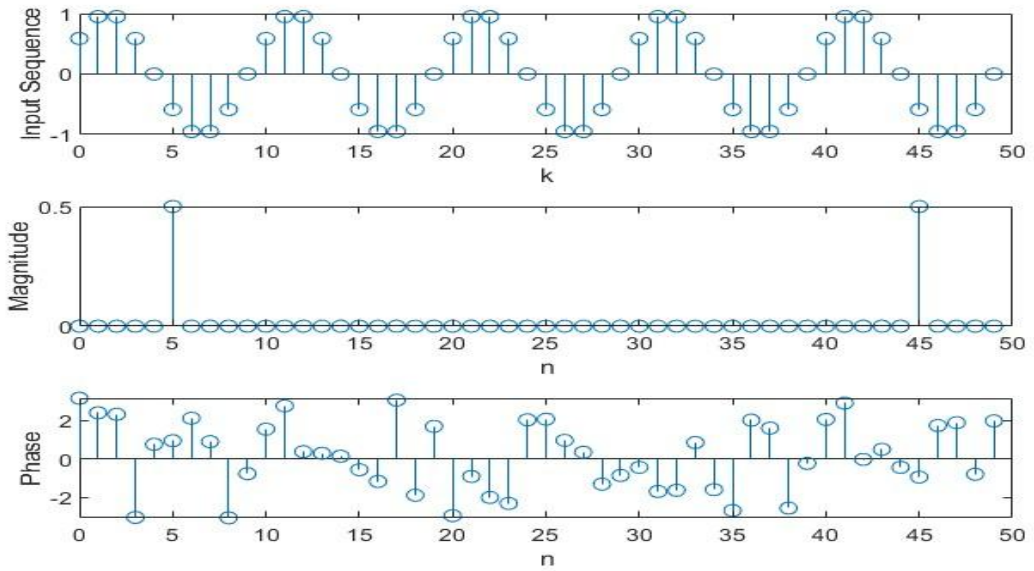
Output of Program



(d) Sin

```
%sin
x = 1:50;
y=sin(2*pi*x/10);
iDFTFun(y);
```

Output of Program



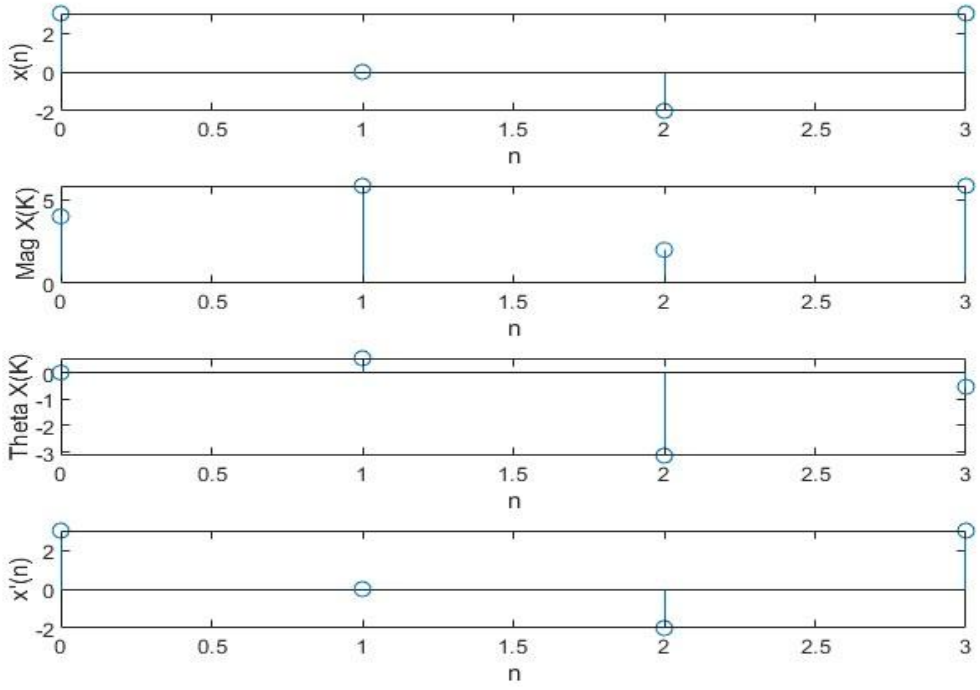
Calculate 4-point DFT of following sequences and thereby IDFT

(a) x[n]=3δ[n]-2δ[n-2]+3δ[n-3]

Matlab function to perform DFT

```
n =[0,1,2,3];
xn=[3,0,-2,3];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program

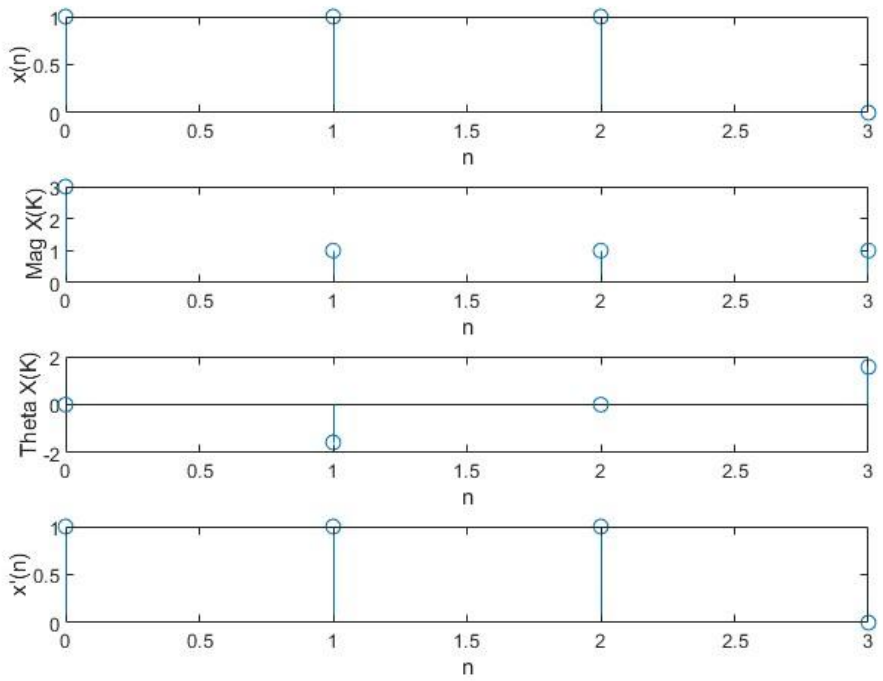


(b) x[n] = 1 for 0 ≤ n ≤ 2

Matlab function to perform DFT

```
n =[0,1,2,3];
xn=[1,1,1,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program

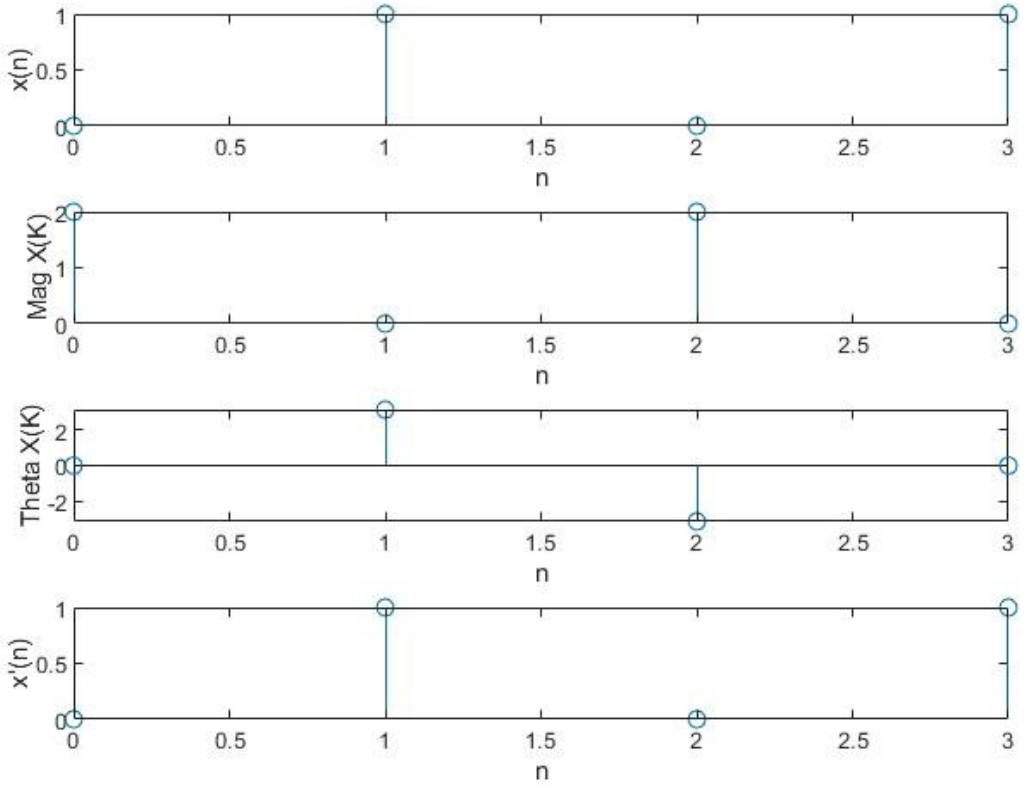


(c) x[n] = n, for n odd

Matlab function to perform DFT

```
n =[0,1,2,3];
xn=[0,1,0,1];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program



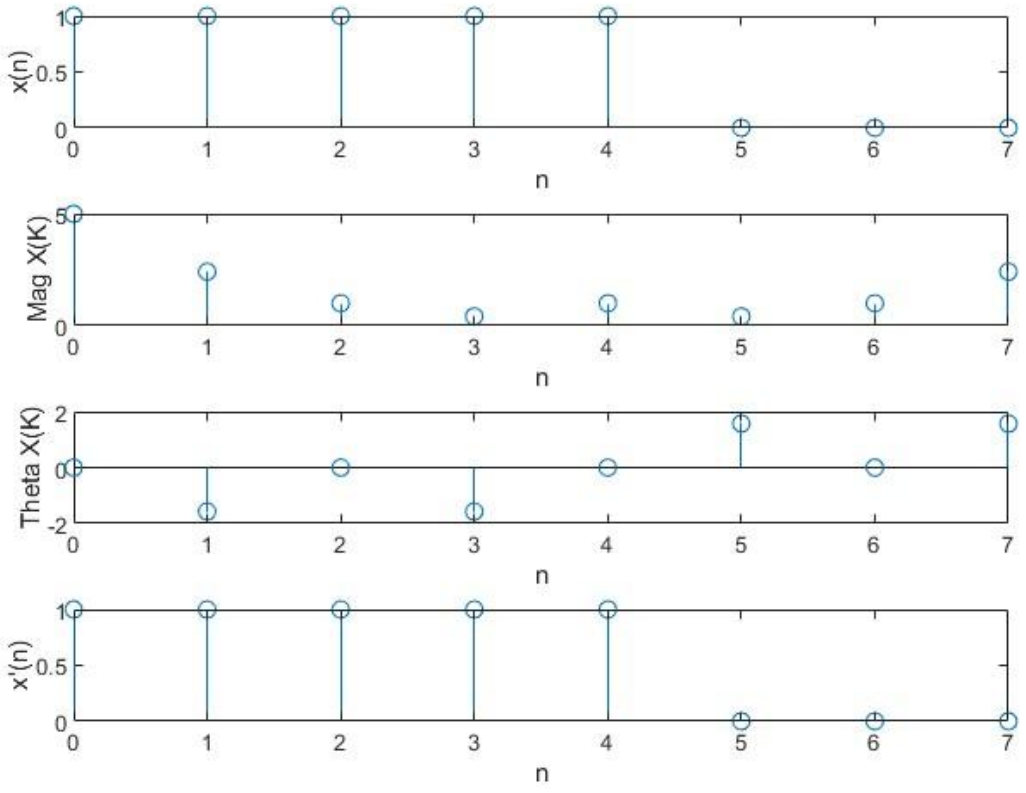
Calculate 8-point DFT of following sequences and thereby IDFT

(a) x[n] = 1 for 0 ≤ n ≤ N/2

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7];
xn=[1,1,1,1,1,0,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program

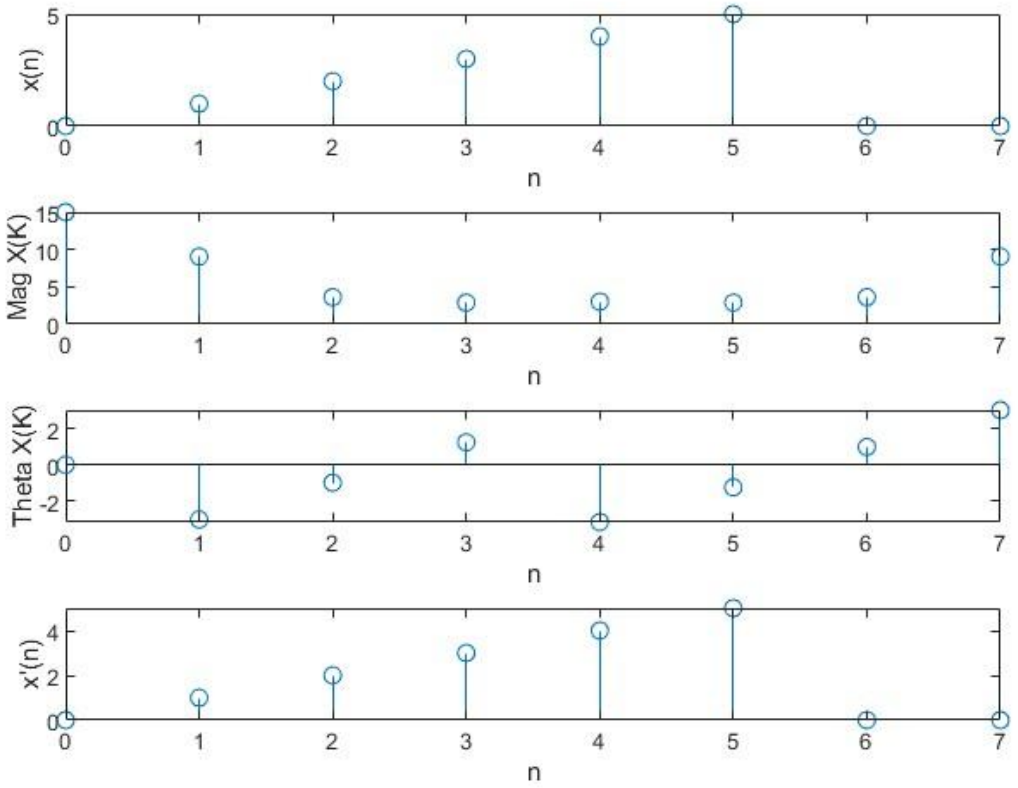


(b) x[n] = n for 0 ≤ n ≤ 5

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7];
xn=[0,1,2,3,4,5,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program

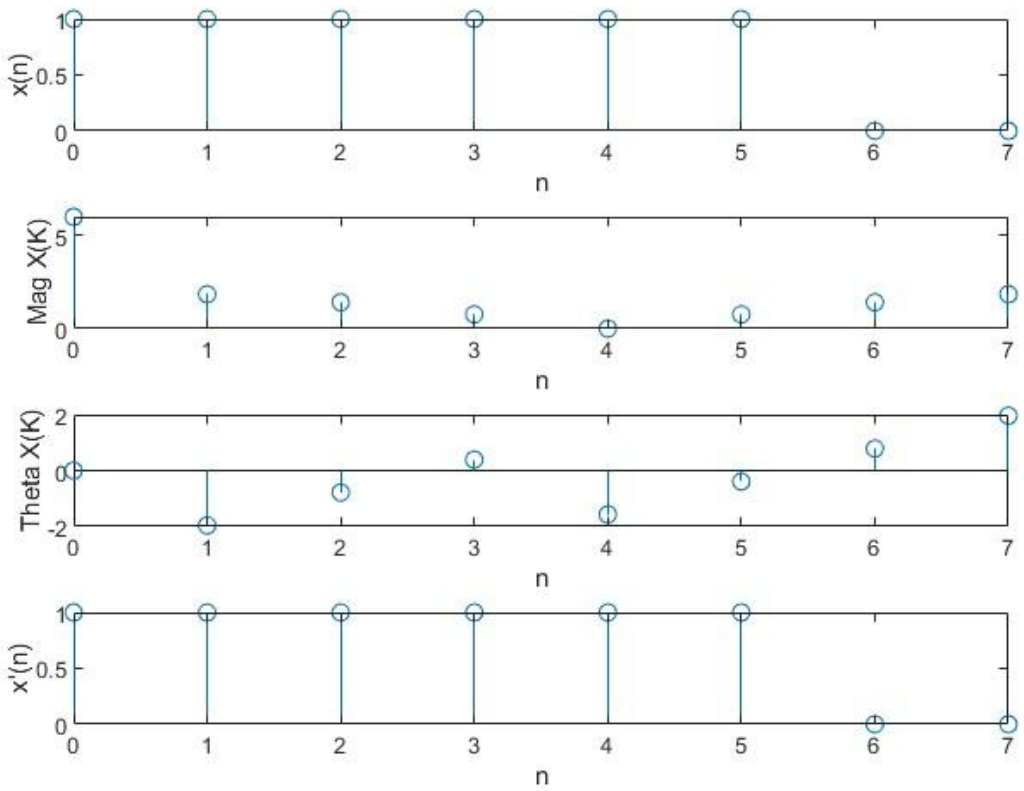


(c) x[n]=u[n]-u[n-5]

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7];
xn=[1,1,1,1,1,1,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program



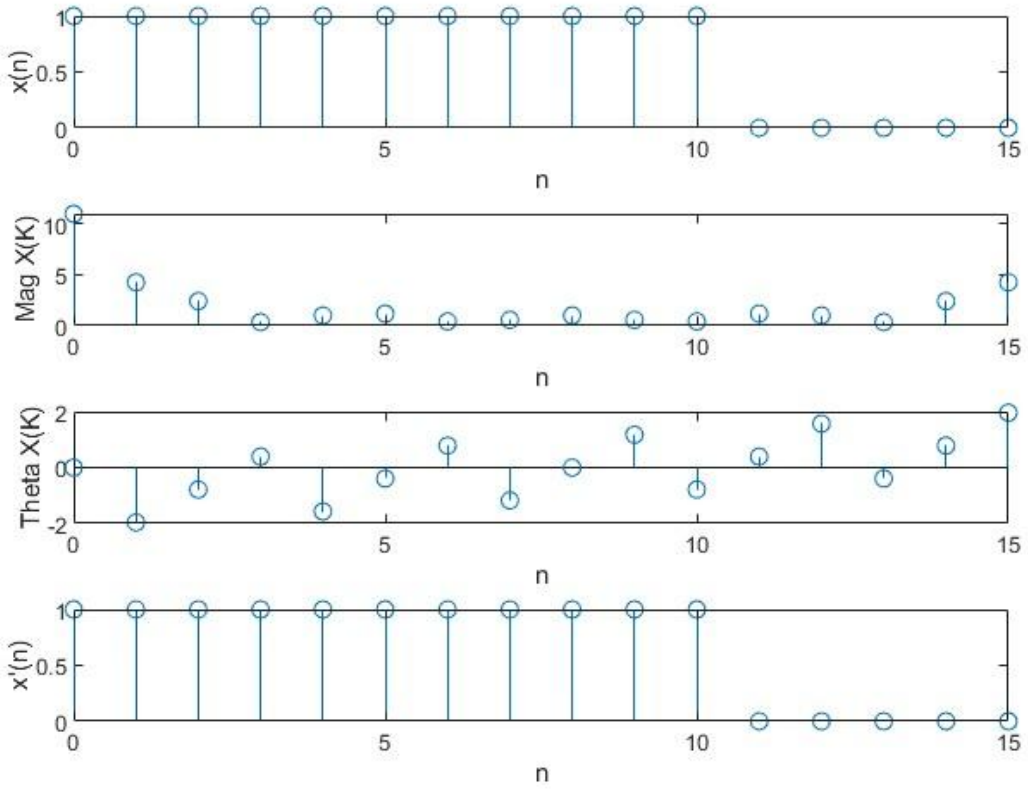
Calculate 16-point DFT of following sequences and thereby IDFT

(a) x[n] = 1 for 0 ≤ n ≤ 10

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15];
xn=[1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program

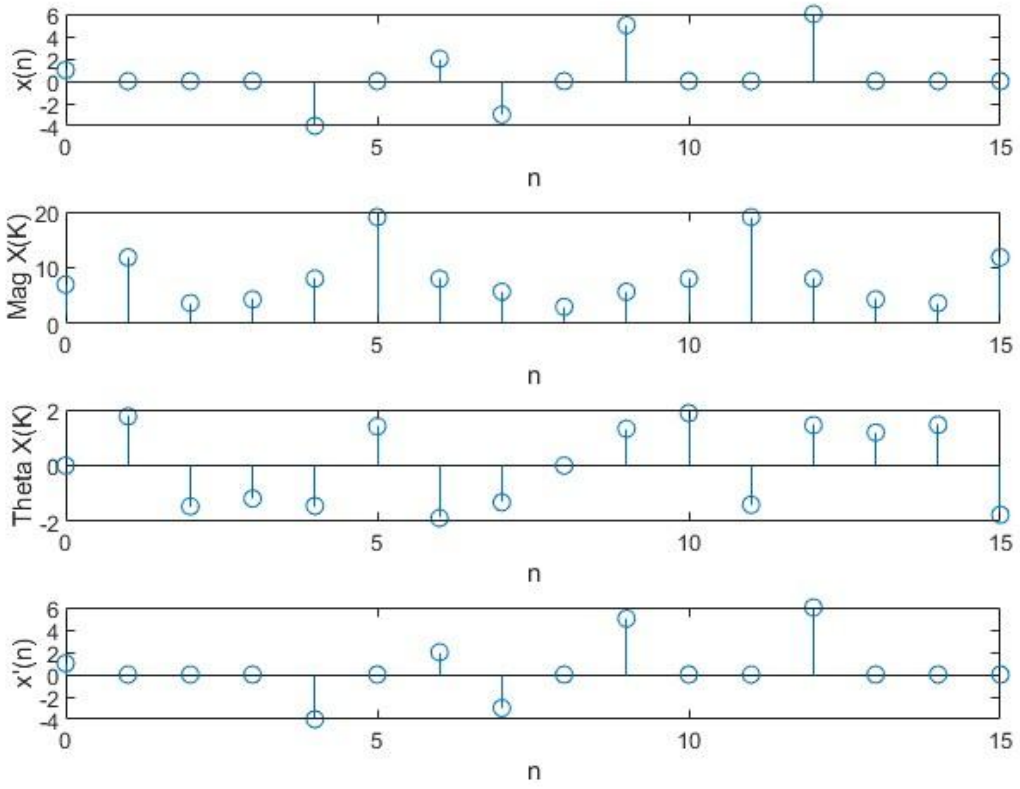


(b) x[n]=δ[n-1]-4δ[n-4]+2δ[n-6]-3δ[n-7]+5δ[n-9]+6δ[n-12]

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15];
xn=[1,0,0,0,-4,0,2,-3,0,5,0,0,6,0,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program



(c) x[n]=u[n-2]-u[n-10]

Matlab function to perform DFT

```
n =[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15];
xn=[0,0,1,1,1,1,1,1,1,1,1,0,0,0,0,0];
xk = DFTFun(xn);
subplot(4,1,1);
stem(n,xn);
xlabel("n");
ylabel("x(n)");
subplot(4,1,2);
stem(n,abs(xk));
xlabel("n");
ylabel("Mag X(K)");
subplot(4,1,3);
stem(n,angle(xk));
xlabel("n");
ylabel("Theta X(K)");
xn1 = iDFTFun(xk);
subplot(4,1,4);
stem(n,xn1);
xlabel("n");
ylabel("x'(n)");
```

Output of Program