Glasgow College, UESTC


# Digital Signal Processing

# Homework 4

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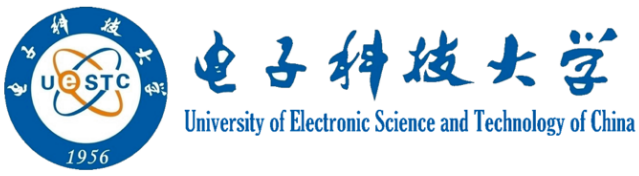

# HOMEWORK 4

CHANGGANG ZHENG[1]

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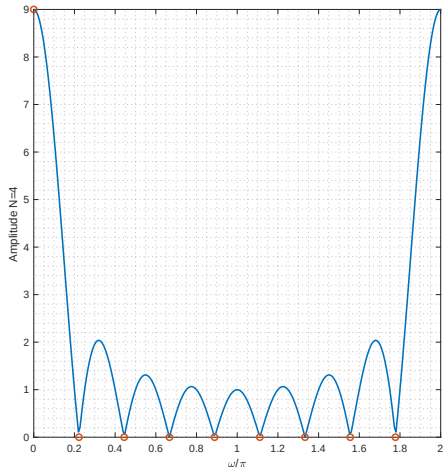
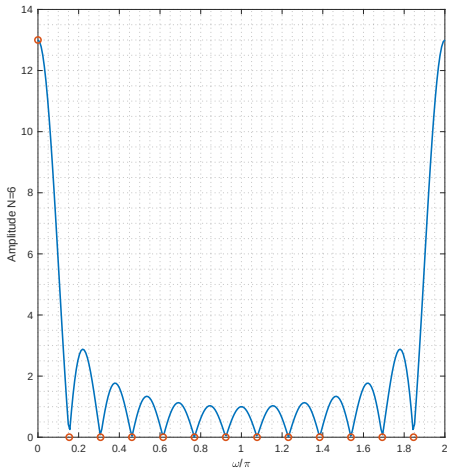
# 1 PROBLEM 5.1

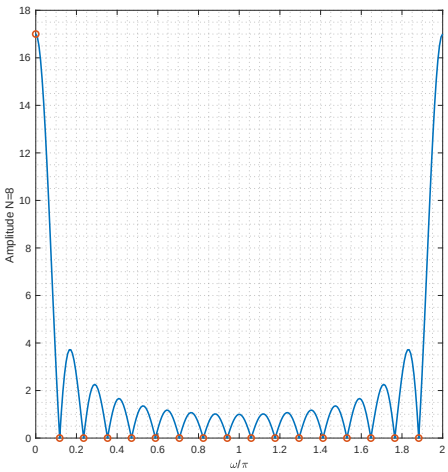



N=4

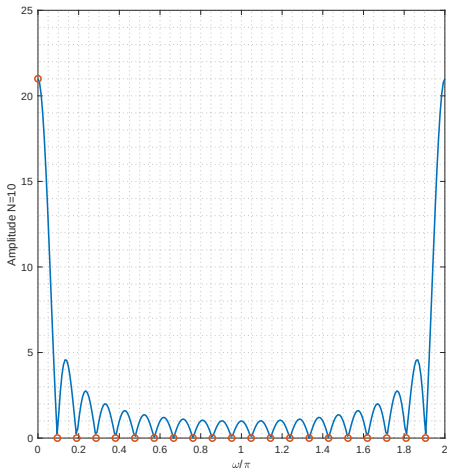



N=6

**Figure 1:** DFT and DTFT of y1[n]



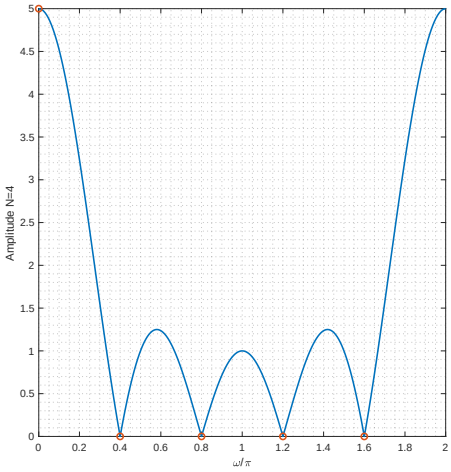

N=8

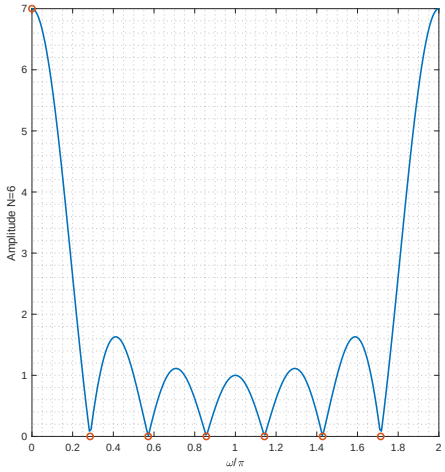



N=10

**Figure 2:** DFT and DTFT of y1[n]

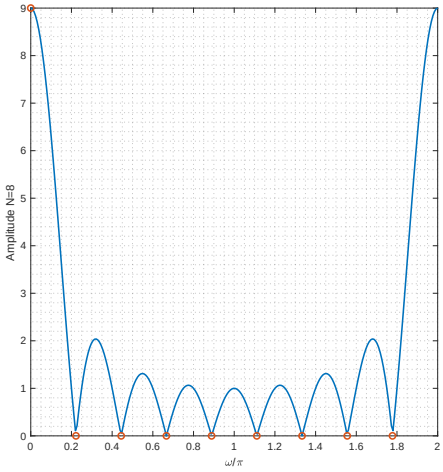
```
clear
clc
for N=[4 6 8 10]
  %% Program M5.1 (a)
  % N = input('The value of N = ');
```

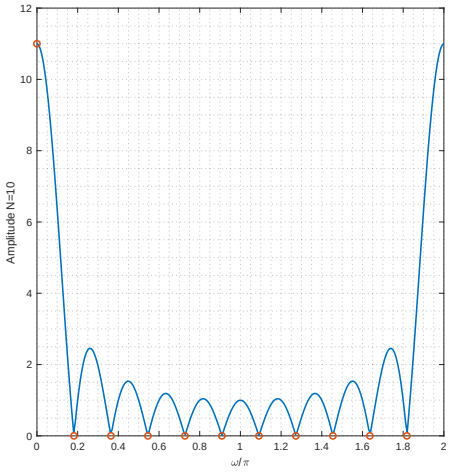



N=4 N=6

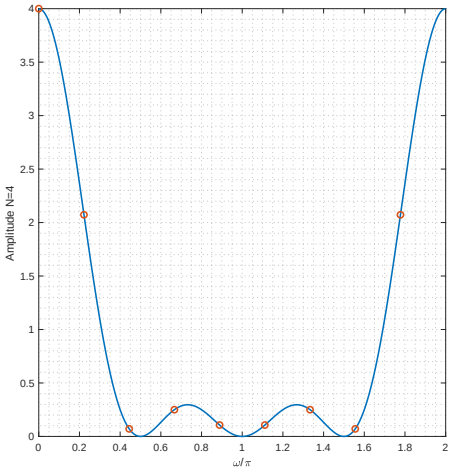
**Figure 3:** DFT and DTFT of y2[n]

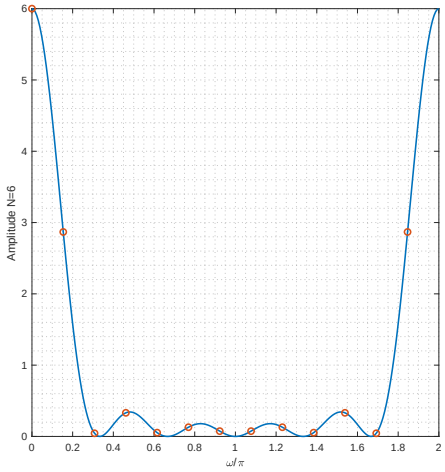



N=8 N=10

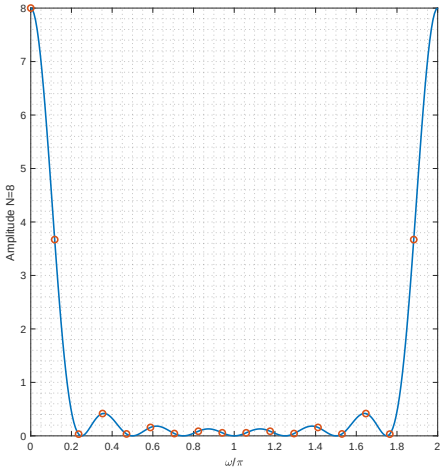
**Figure 4:** DFT and DTFT of y2[n]

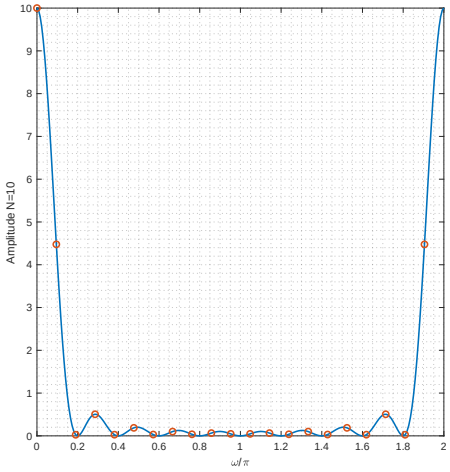



N=4 N=6

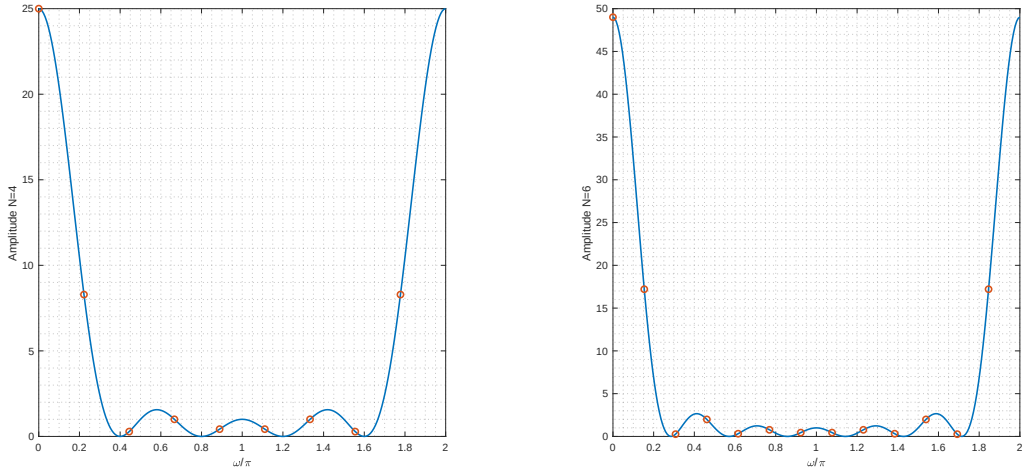
**Figure 5:** DFT and DTFT of y3[n]



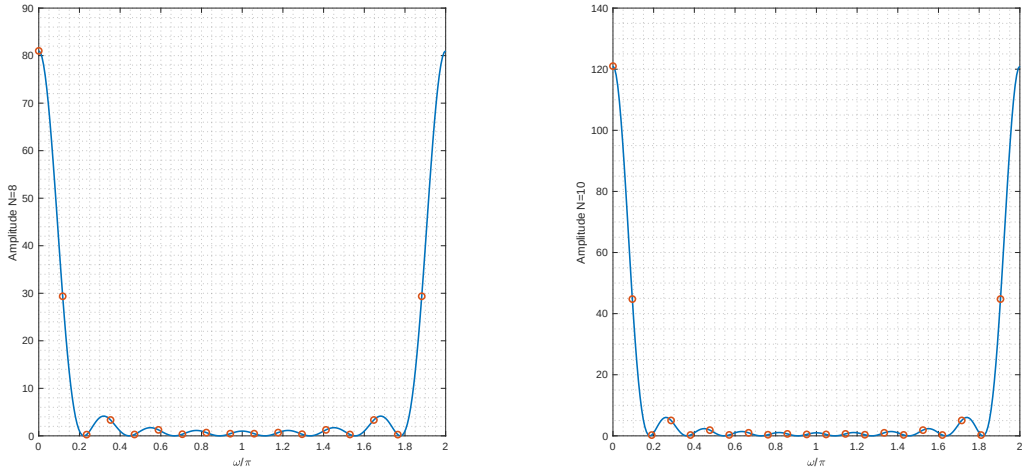

N=8 N=10

**Figure 6:** DFT and DTFT of y3[n]



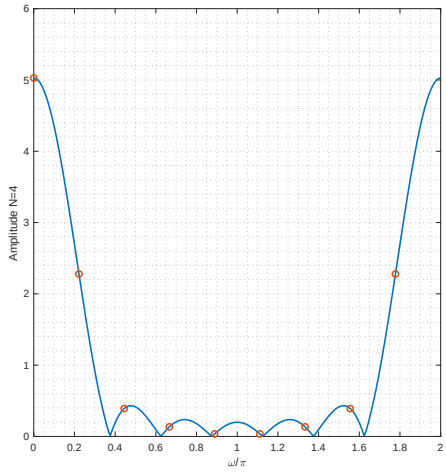

N=4 N=6

**Figure 7:** DFT and DTFT of y4[n]

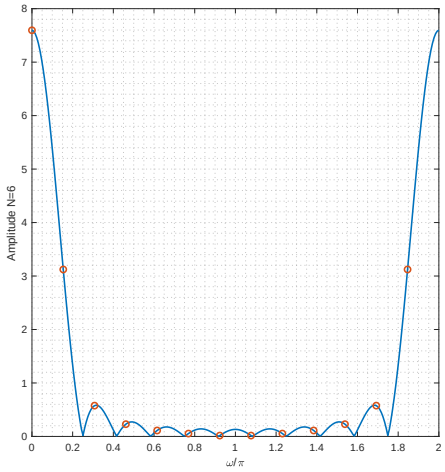



N=8 N=10

**Figure 8:** DFT and DTFT of y4[n]

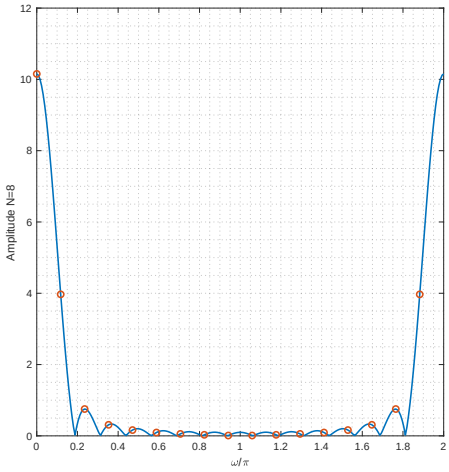



N=4

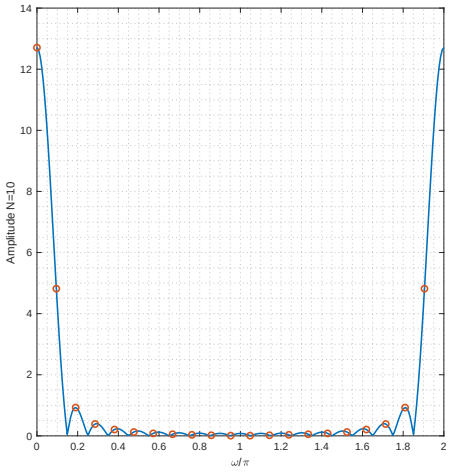



N=6

**Figure 9:** DFT and DTFT of y5[n]




N=8




N=10

**Figure 10:** DFT and DTFT of y5[n]

```
k = -N:N;
y = ones(1,2*N+1);
w = 0:2*pi/255:2*pi;
Y = freqz(y, 1, w);
Ydft = fft(y);
n = 0:1:2*N;
sequence_a = figure;
plot(w/pi,abs(Y),'LineWidth',1.5)
hold on
plot(n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
xlabel('\omega/\pi');
ylabel(['Amplitude N=',num2str(N)]);
grid minor
set(sequence_a, 'PaperPosition', [0.05 0.05 7 7]);
set(sequence_a, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(sequence_a,['sequence_a',num2str(N),'.pdf'],'pdf')
%% Program M5.1 (b)
% N = input('The value of N = ');
k = 0:N;
y = ones(1,N+1);
w = 0:2*pi/255:2*pi;
Y = freqz(y, 1, w);
Ydft = fft(y);
sequence_b = figure;
n = 0:N;
plot(w/pi,abs(Y),n*2/(N+1),abs(Ydft),'o','LineWidth',1.5);
xlabel('\omega/\pi');
ylabel(['Amplitude N=',num2str(N)]);
grid minor
set(sequence_b, 'PaperPosition', [0.05 0.05 7 7]);
set(sequence_b, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(sequence_b,['sequence_b',num2str(N),'.pdf'],'pdf')
%% Program M5.1 (c)
% N = input('The value of N = ');
k = -N:N;
y = ones(1,2*N+1);
y = y - abs(k)/N;
w = 0:2*pi/255:2*pi;
Y = freqz(y, 1, w);
Ydft = fft(y);
sequence_c = figure;
n = 0:1:2*N;
plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
xlabel('\omega/\pi');
ylabel(['Amplitude N=',num2str(N)]);
grid minor
set(sequence_c, 'PaperPosition', [0.05 0.05 7 7]);
set(sequence_c, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(sequence_c,['sequence_c',num2str(N),'.pdf'],'pdf')
%% Program M5.1 (d)
% N = input('The value of N = ');
k = -N:N;
y = N + ones(1,2*N+1) - abs(k);
```

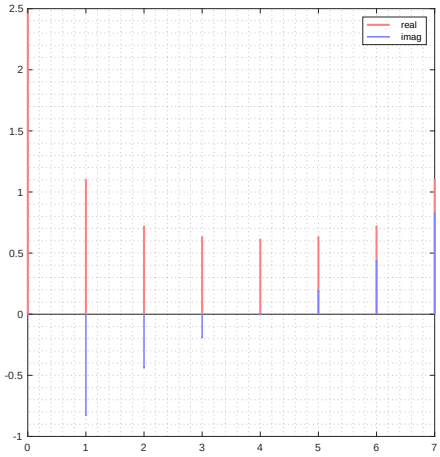
```
  w = 0:2*pi/255:2*pi;
  Y = freqz(y, 1, w);
  Ydft = fft(y);
  sequence_d = figure;
  n = 0:1:2*N;
  plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
  xlabel('\omega/\pi');
  ylabel(['Amplitude N=',num2str(N)]);
  grid minor
  set(sequence_d, 'PaperPosition', [0.05 0.05 7 7]);
  set(sequence_d, 'PaperSize', [7.05 7.05]); %Keep the same paper size
  saveas(sequence_d,['sequence_d',num2str(N),'.pdf'],'pdf')
  %% Program M5.1 (e)
  % N = input('The value of N = ');
  k = -N:N;
  y = cos(pi*k/(2*N));
  w = 0:2*pi/255:2*pi;
  Y = freqz(y, 1, w);
  Ydft = fft(y);
  n = 0:1:2*N;
  sequence_e = figure;
  plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
  xlabel('\omega/\pi');
  ylabel(['Amplitude N=',num2str(N)]);
  grid minor
  set(sequence_e, 'PaperPosition', [0.05 0.05 7 7]);
  set(sequence_e, 'PaperSize', [7.05 7.05]); %Keep the same paper size
  saveas(sequence_e,['sequence_e',num2str(N),'.pdf'],'pdf')
end
```

## 2 PROBLEM 5.3

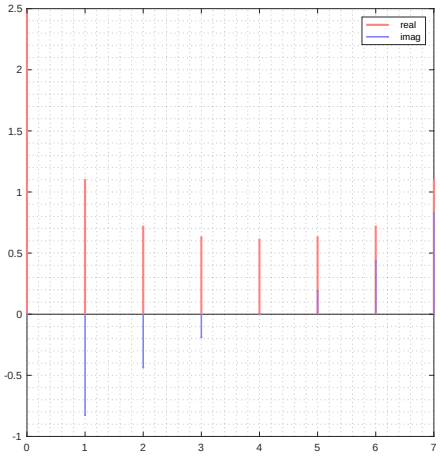
```
N = 8; % sequence length
gamma = 0.5;
k = 0:N-1;
x = exp(-gamma*k);
X = fft(x);
range = k;
%% Property 1
X1 = fft(conj(x));
G1 = conj([X(1) X(N:-1:2)]);

% Verify X1 = G1

p1_1=figure;
stem(range,real(X1),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(X1),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
```

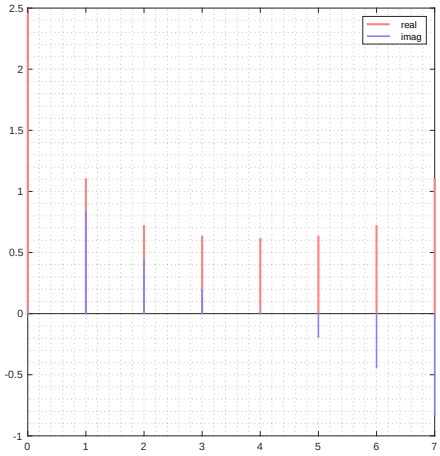



$X^*[n]$ real part

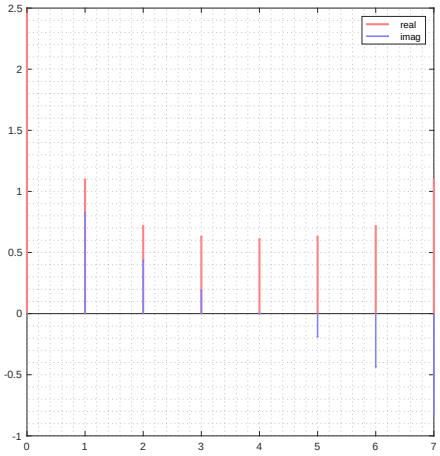



$X^*[< -k >_N]$ real part

**Figure 11:** Property 1

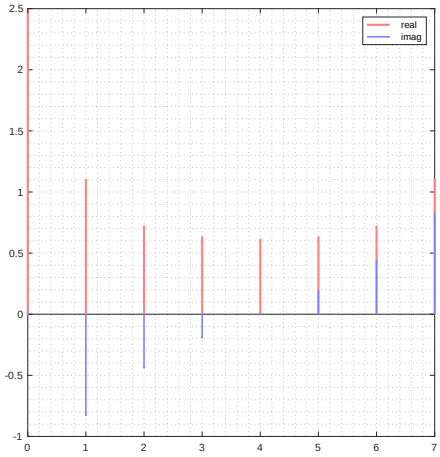



$X^*[< k >_N]$ real part

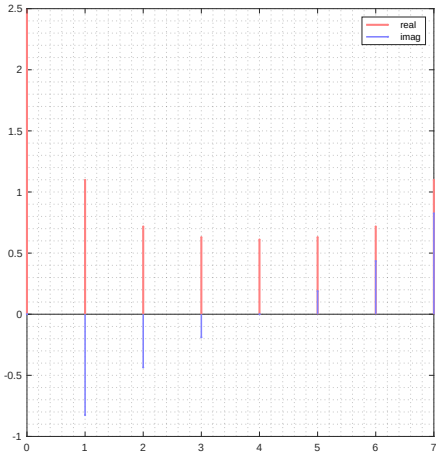



$X^*[k]$ real part

**Figure 12:** Property 2

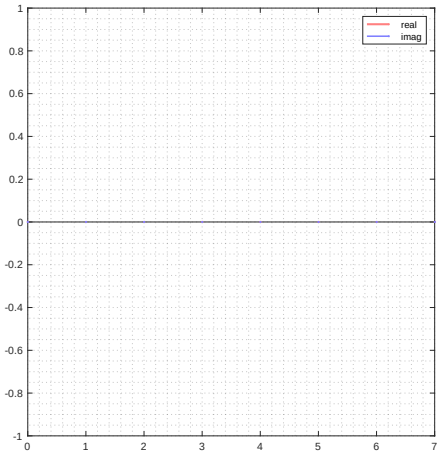



$X_{re}[k]$ real part

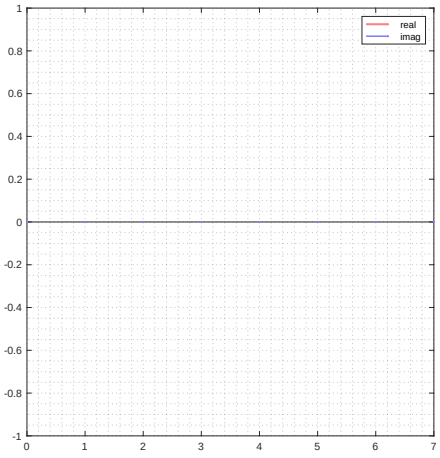



$X_{cs}[k]$ real part

**Figure 13:** Property 3

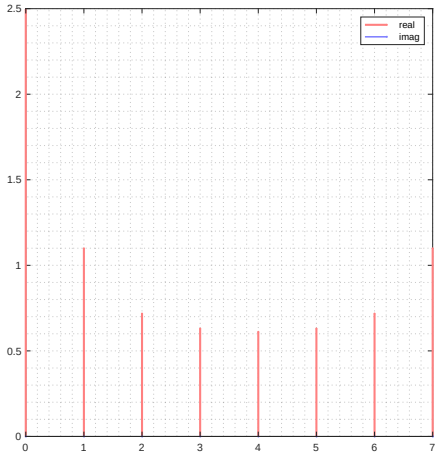



$jX_{im}[k]$ imag part

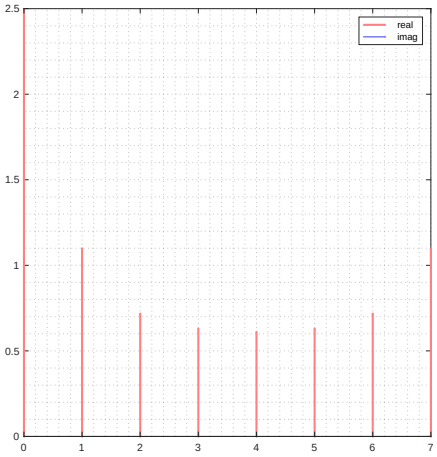



$X_{ca}[k]$ imag part

**Figure 14:** Property 4

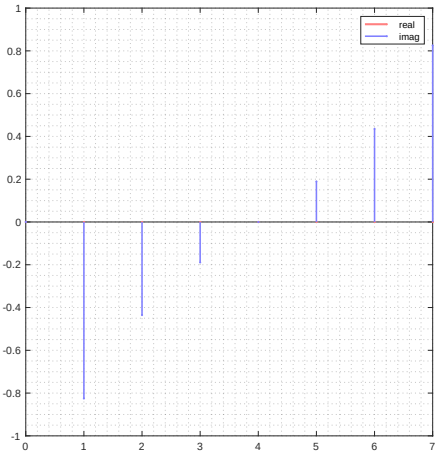



$X_{cs}[k]$ real part

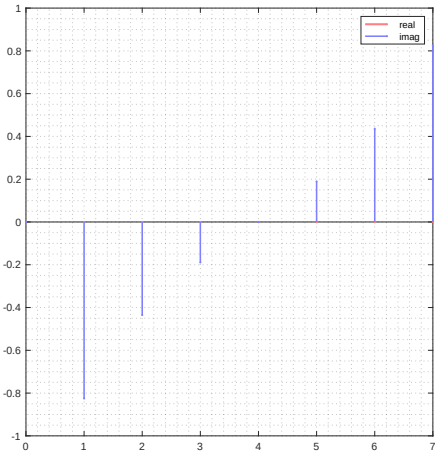



$X_{re}[k]$ real part

**Figure 15:** Property 5




$X_{ca}[k]$ real part




$X_{ca}[k]$ real part

**Figure 16:** Property 6

```
grid minor
legend('real','imag')
set(p1_1, 'PaperPosition', [0.05 0.05 7 7]);
set(p1_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p1_1,['p1_1.pdf'],'pdf')

p1_2=figure;
stem(range,real(G1),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(G1),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p1_2, 'PaperPosition', [0.05 0.05 7 7]);
set(p1_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p1_2,['p1_2.pdf'],'pdf')
%% Property 2
x2 = conj([x(1) x(N:-1:2)]);
X2 = fft(x2);
% Verify X2 = conj(X)
p2_1=figure;
stem(range,real(X2),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(X2),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p2_1, 'PaperPosition', [0.05 0.05 7 7]);
set(p2_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p2_1,['p2_1.pdf'],'pdf')

p2_2=figure;
stem(range,real(conj(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(conj(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p2_2, 'PaperPosition', [0.05 0.05 7 7]);
set(p2_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p2_2,['p2_2.pdf'],'pdf')
%% Property 3
x3 = real(x);
X3 = fft(x3);
G3 = 0.5*(X+conj([X(1) X(N:-1:2)]));

% Verify X3 = G3
p3_1=figure;
stem(range,real(X3),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(X3),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p3_1, 'PaperPosition', [0.05 0.05 7 7]);
set(p3_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p3_1,['p3_1.pdf'],'pdf')
```

```
70
71 p3_2=figure;
72 stem(range,real(G3),'.','LineWidth',2,'color',[1,0.5,0.5]);
73 hold on;
74 stem(range,imag(G3),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
75 legend('real','imag')
76 grid minor
77 set(p3_2, 'PaperPosition', [0.05 0.05 7 7]);
78 set(p3_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
79 saveas(p3_2,['p3_2.pdf'],'pdf')
80 %% Property 4
81 x4 = j*imag(x);
82 X4 = fft(x4);
83 G4 = 0.5*(X-conj([X(1) X(N:-1:2)]));
84 % Verify X4 = G4
85 p4_1=figure;
86 stem(range,real(X4),'.','LineWidth',2,'color',[1,0.5,0.5]);
87 hold on;
88 stem(range,imag(X4),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
89 legend('real','imag')
90 grid minor
91 set(p4_1, 'PaperPosition', [0.05 0.05 7 7]);
92 set(p4_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
93 saveas(p4_1,['p4_1.pdf'],'pdf')
94
95 p4_2=figure;
96 stem(range,real(G4),'.','LineWidth',2,'color',[1,0.5,0.5]);
97 hold on;
98 stem(range,imag(G4),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
99 legend('real','imag')
100 grid minor
101 set(p4_2, 'PaperPosition', [0.05 0.05 7 7]);
102 set(p4_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
103 saveas(p4_2,['p4_2.pdf'],'pdf')
104 %% Property 5
105 x5 = 0.5*(x+conj([x(1) x(N:-1:2)]));
106 X5 = fft(x5);
107 % Verify X5 = real(X)
108 p5_1=figure;
109 stem(range,real(X5),'.','LineWidth',2,'color',[1,0.5,0.5]);
110 hold on;
111 stem(range,imag(X5),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
112 legend('real','imag')
113 grid minor
114 set(p5_1, 'PaperPosition', [0.05 0.05 7 7]);
115 set(p5_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
116 saveas(p5_1,['p5_1.pdf'],'pdf')
117
118 p5_2=figure;
119 stem(range,real(real(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
120 hold on;
121 stem(range,imag(real(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
122 legend('real','imag')
```

```
grid minor
set(p5_2, 'PaperPosition', [0.05 0.05 7 7]);
set(p5_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p5_2,['p5_2.pdf'],'pdf')
%% Property 6
x6 = 0.5*(x-conj([x(1) x(N:-1:2)]));
X6 = fft(x6);
% Verify X6 = j*imag(X)
p6_1=figure;
stem(range,real(X6),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(X6),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p6_1, 'PaperPosition', [0.05 0.05 7 7]);
set(p6_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p6_1,['p6_1.pdf'],'pdf')
p6_2=figure;
stem(range,real(1j*imag(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
hold on;
stem(range,imag(1j*imag(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
legend('real','imag')
grid minor
set(p6_2, 'PaperPosition', [0.05 0.05 7 7]);
set(p6_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
saveas(p6_2,['p6_2.pdf'],'pdf')
```

# 3 PROBLEM 5.8

**I got the output:**

```
>> problem_5_8
   6.4400 + 0.0000i -30.6600 + 0.0000i  62.9000 + 0.0000i -91.5000 ...
      - 0.0000i

   4.9134e+03
```

**From the following program:**

```
x = [6.29 8.11 -7.46 8.26 2.64 -8.04 -4.43 0.93 -9.15 9.29];
XF = fft(x);
k =0:9;
YF = exp(-i*2*pi*k/5).*XF;
output = [XF(1) XF(6) sum(XF) sum(YF)];
disp(output)
disp(sum(abs(XF).*abs(XF)))
```

# 4 SUMMARY

For this Homework, I understand more about Digital Signal Processing, as well as how to use the MATLAB to plot and analysis series and how to smooth the signals. I also understand what will be the effect if we use the filter to smooth the signal. I also know more about the property of the filter and how to generate the system to help us impliment some operation like square root.

# REFERENCES

[1] Changgang-Zheng/Signals-and-Systems/report.https://github.com/Changgang-Zheng/Signals-and-Systems

[2] Supplementary materials to the text book 'Digital Signal Processing: A Computer-Based Approach', 4th Edition. by S.K. Mitra, ISBN 0077320670. http://www.bb9.uestc.edu.cn/webapps/portal/frameset.jsp?tab_tab_group_id=_2_1&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_13014_1%26url%3D

[3] Digital Signal Processing: A Computer-Based Approach, 4th Edition. by S.K. Mitra, ISBN 0077320670.