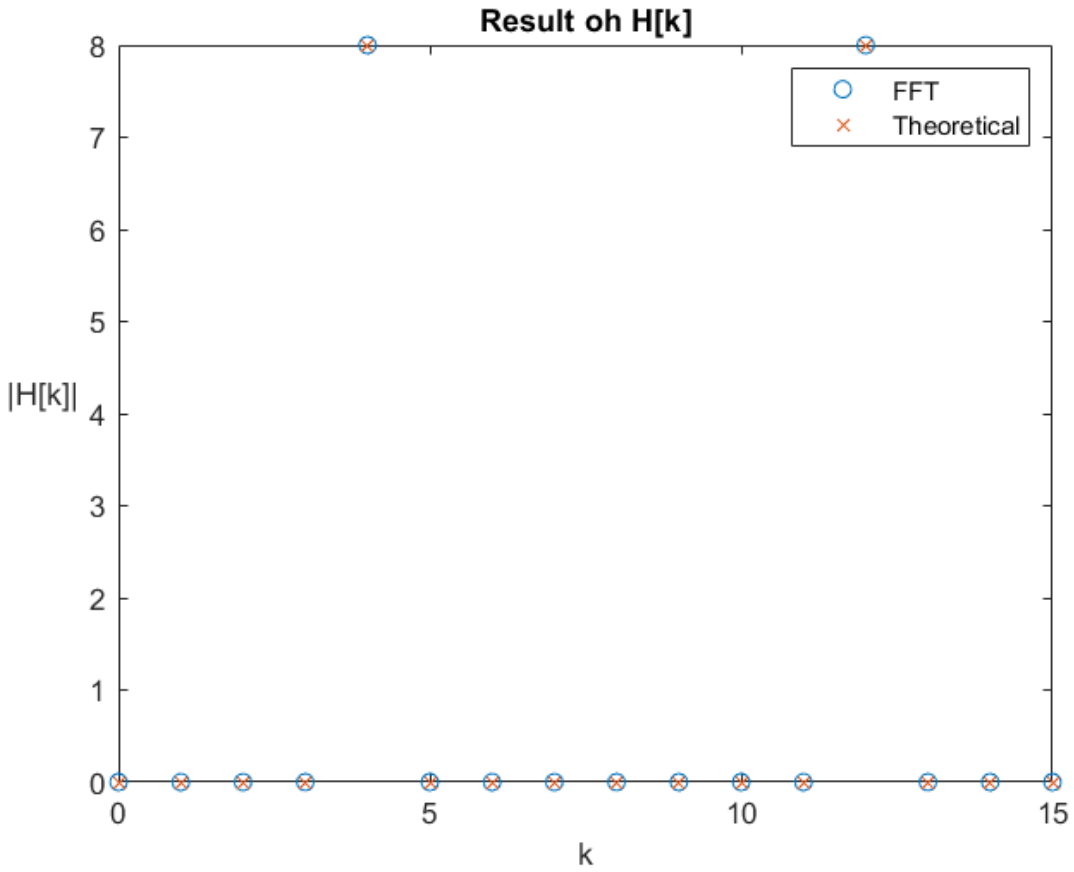
HW5 MATLAB code

1.

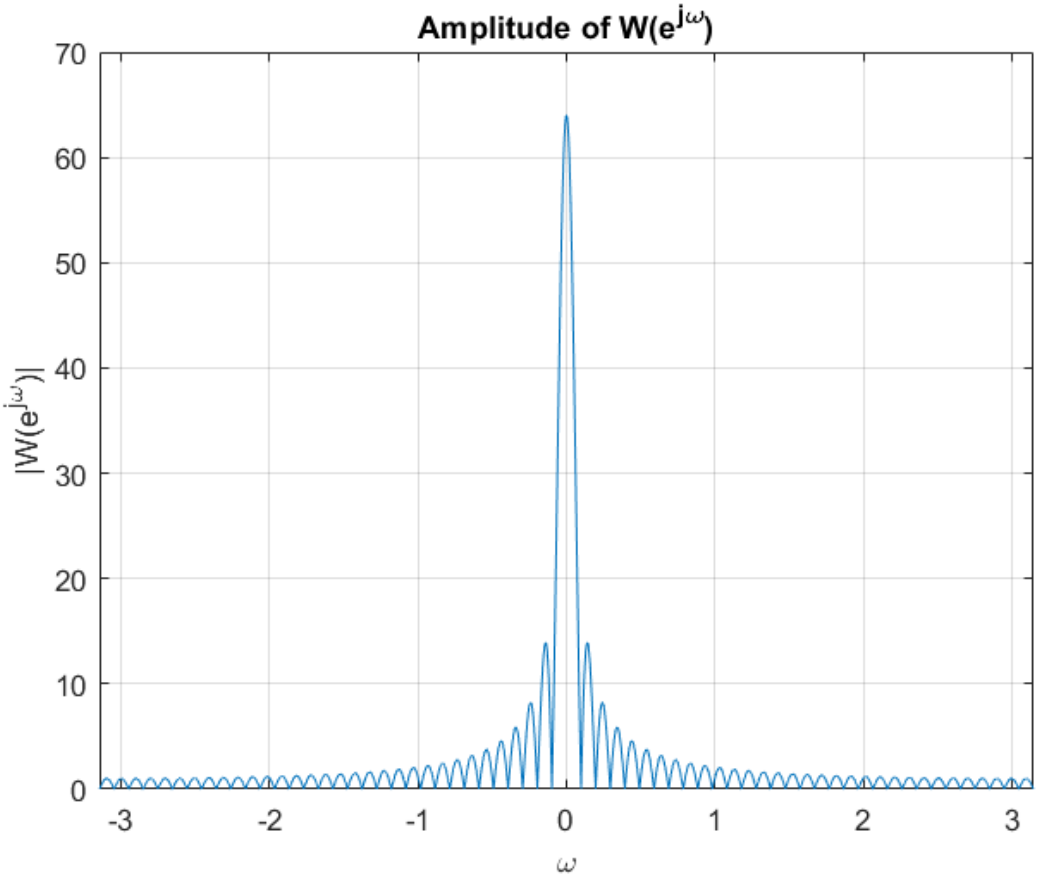
```
T = 1/4;
N = 16;
n = 0:N-1;
hn = cos(2*pi*n*T);
wr = ones(1,N);
Hk = fft(hn.*wr);
W = @(f) exp(1j*pi*(N-1)*T*f).*sinc(N*T*f)./sinc(T*f)*N; %
sinc(x)=sin(pi*x)/(pi*x) in MATLAB
Hk_theo = 1/2*W(n/(N*T)-1) + 1/2*W(n/(N*T)+1);
plot(n,abs(Hk),'o',n,abs(Hk_theo),'x');
title('Result oh H[k]');
xlabel('k'); ylabel('|H[k]|');
legend('FFT','Theoretical');
```

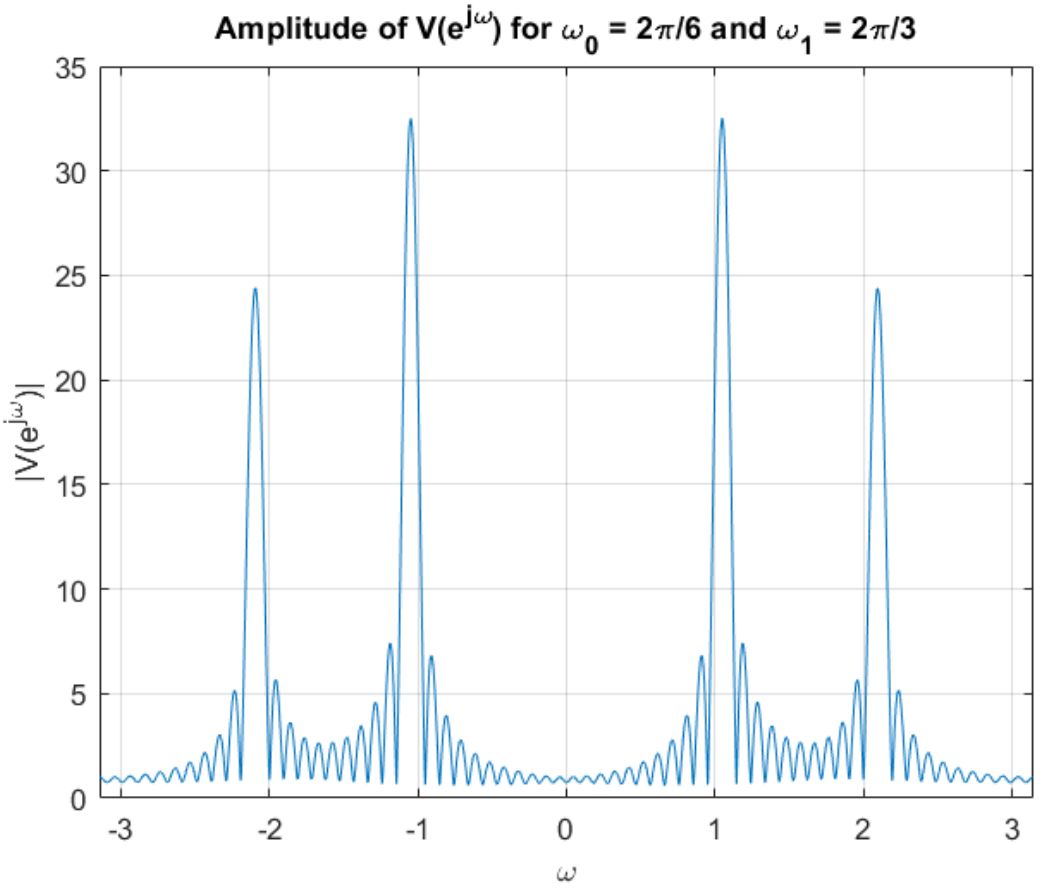


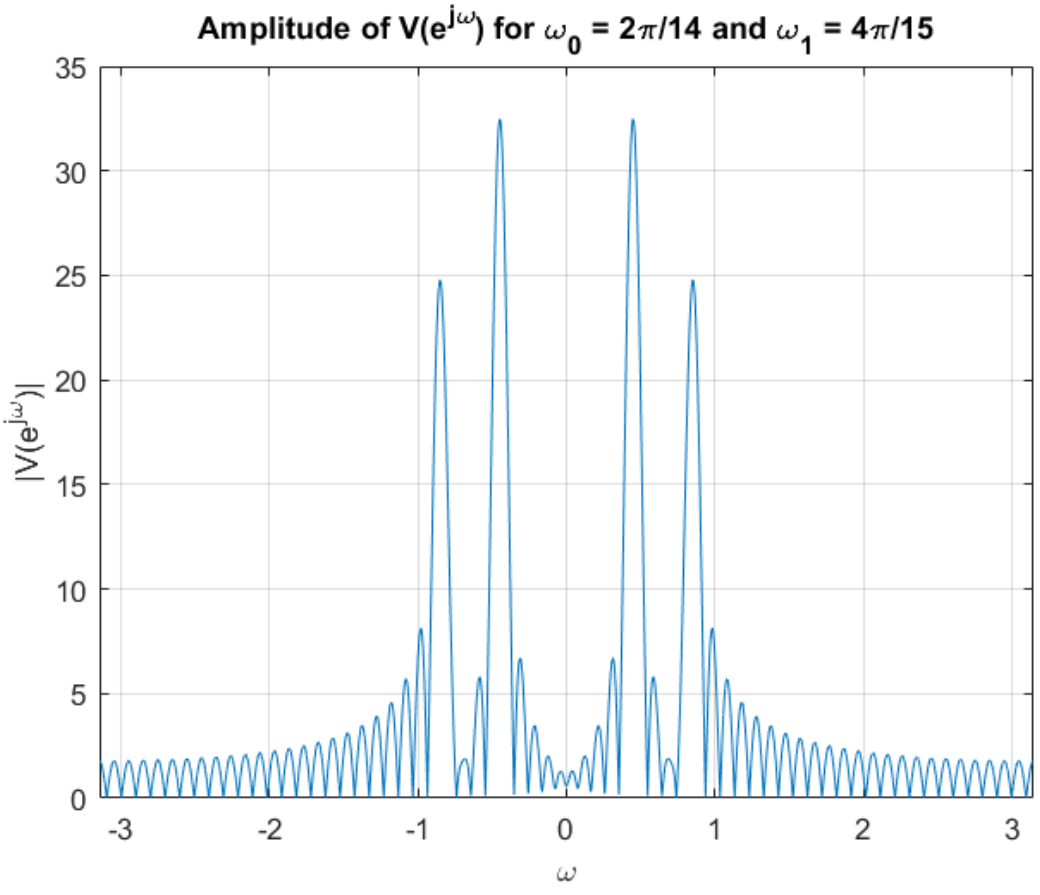
2.

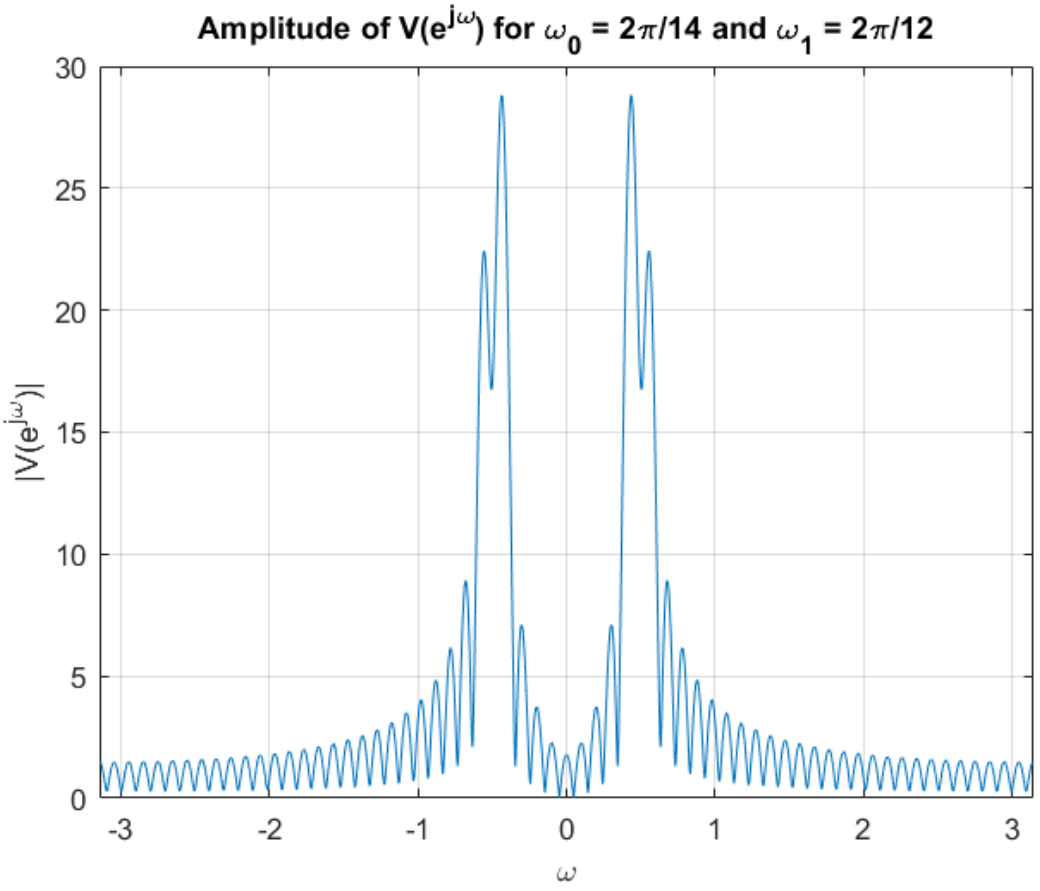
```
%(a)
L = 64;
W = @(w) exp(-1j*w*(L-1)/2).*sin(w*L/2)./sin(w/2);
fs = 10000;
w = -pi:1/fs:pi;
W_a = W(w);
figure(1);
plot(w,abs(W_a));
xlim([-pi pi]);
title('Amplitude of W(e^{j\omega})');
xlabel('\omega'); ylabel('|W(e^{j\omega})|');
grid on

%(b)
A0 = 1;
A1 = 0.75;
theta0 = 0;
theta1 = 0;
w0 = 2*pi/6;
w1 = 2*pi/3;
V_b = A0/2*exp(1j*theta0)*W(w-w0)+A0/2*exp(-
1j*theta0)*W(w+w0)+A1/2*exp(1j*theta1)*W(w-w1)+A1/2*exp(-
1j*theta1)*W(w+w1);
figure(2);
plot(w,abs(V_b));
title('Amplitude of V(e^{j\omega}) for \omega_0 = 2\pi/6 and \omega_1 =
2\pi/3');
xlabel('\omega'); ylabel('|V(e^{j\omega})|');
xlim([-pi pi]);
grid on

%(c)
w0 = 2*pi/14;
w1 = 4*pi/15;
V_c = A0/2*exp(1j*theta0)*W(w-w0)+A0/2*exp(-
1j*theta0)*W(w+w0)+A1/2*exp(1j*theta1)*W(w-w1)+A1/2*exp(-
1j*theta1)*W(w+w1);
figure(3);
plot(w,abs(V_c));
title('Amplitude of V(e^{j\omega}) for \omega_0 = 2\pi/14 and \omega_1 =
4\pi/15');
xlabel('\omega'); ylabel('|V(e^{j\omega})|');
xlim([-pi pi]);
grid on

%(d)
w0 = 2*pi/14;
w1 = 2*pi/12;
V_d = A0/2*exp(1j*theta0)*W(w-w0)+A0/2*exp(-
1j*theta0)*W(w+w0)+A1/2*exp(1j*theta1)*W(w-w1)+A1/2*exp(-
1j*theta1)*W(w+w1);
figure(4);
plot(w,abs(V_d));
title('Amplitude of V(e^{j\omega}) for \omega_0 = 2\pi/14 and \omega_1 =
2\pi/12');
xlabel('\omega'); ylabel('|V(e^{j\omega})|');
xlim([-pi pi]);
grid on
```

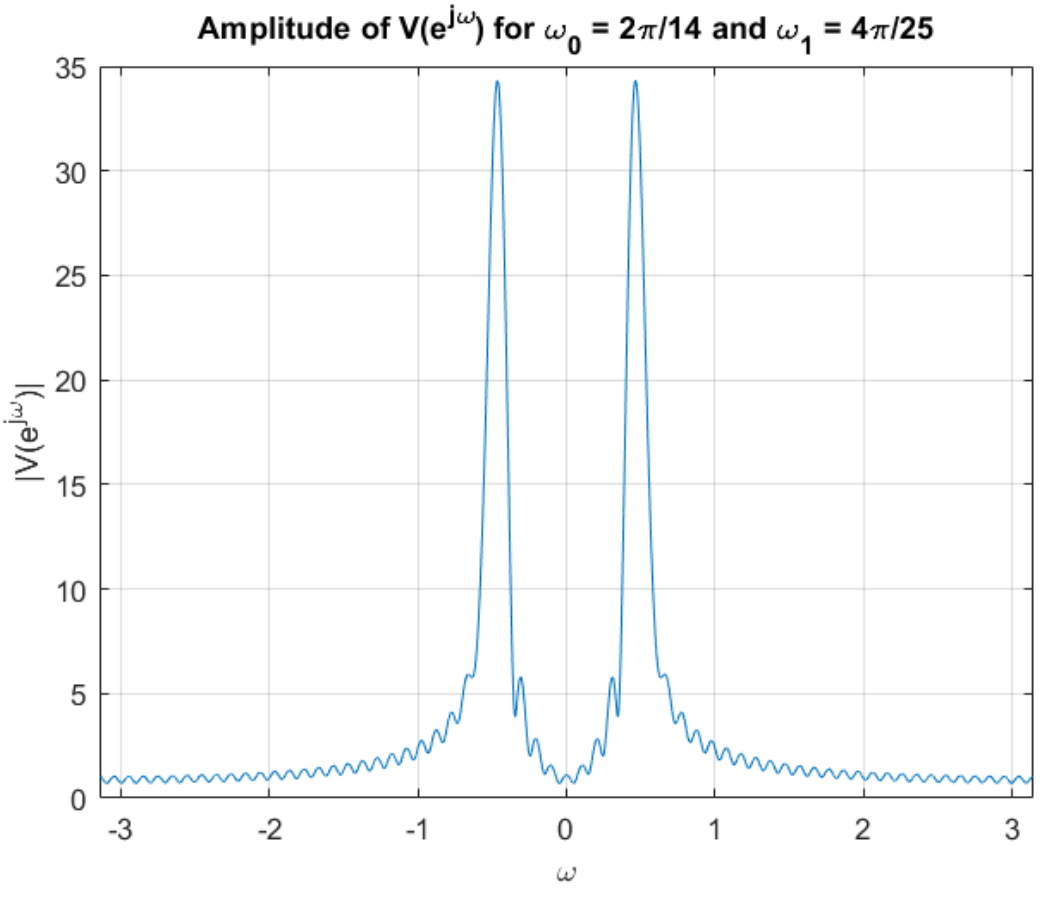
```
%(e)
w0 = 2*pi/14;
w1 = 4*pi/25;
V_e = A0/2*exp(1j*theta0)*W(w-w0)+A0/2*exp(-
1j*theta0)*W(w+w0)+A1/2*exp(1j*theta1)*W(w-w1)+A1/2*exp(-
1j*theta1)*W(w+w1);
figure(5);
plot(w,abs(V_e));
title('Amplitude of V(e^{j\omega}) for \omega_0 = 2\pi/14 and \omega_1 =
4\pi/25');
xlabel('\omega'); ylabel('|V(e^{j\omega})|');
xlim([-pi pi]);
grid on
```




Amplitude of V(e^jω) for ω0 = 2π/6 and ω1 = 2π/3
|V(e^jω)|
ω
0
5
10
15
20
25
30
35
-3
-2
-1
0
1
2
3

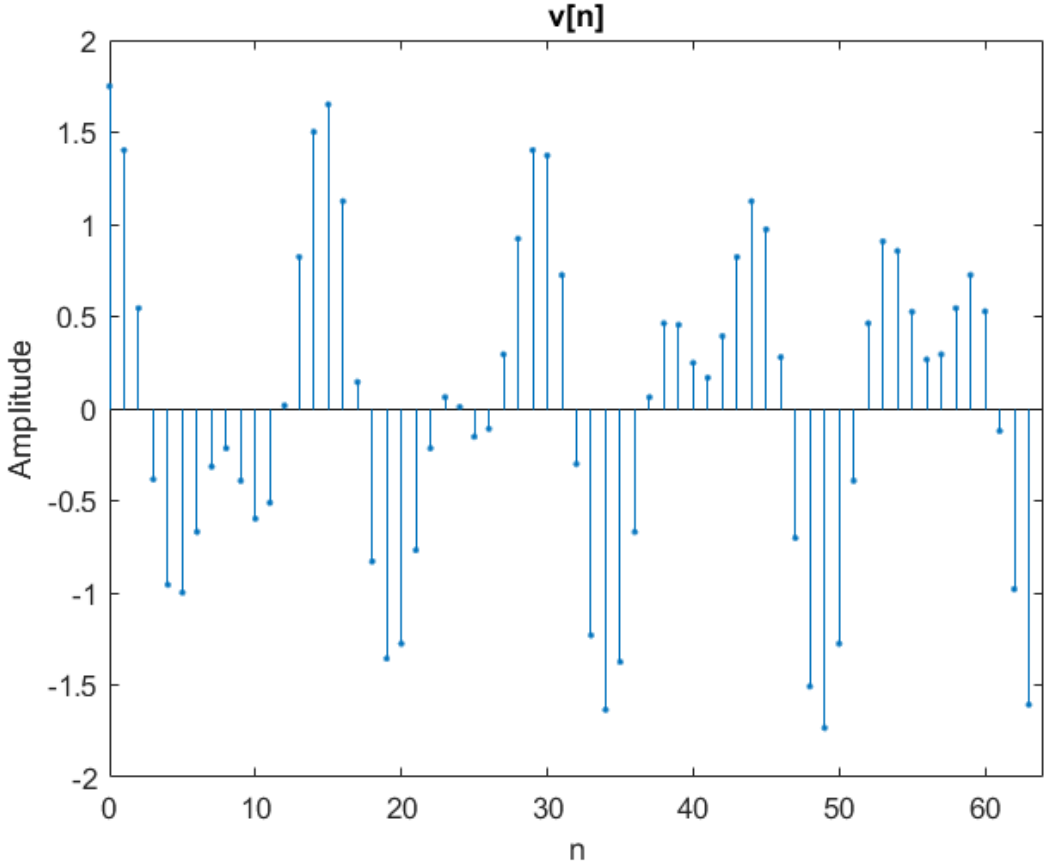

Amplitude of V(e^jω) for ω0 = 2π/14 and ω1 = 4π/15
|V(e^jω)|
ω
0
5
10
15
20
25
30
35
-3
-2
-1
0
1
2
3

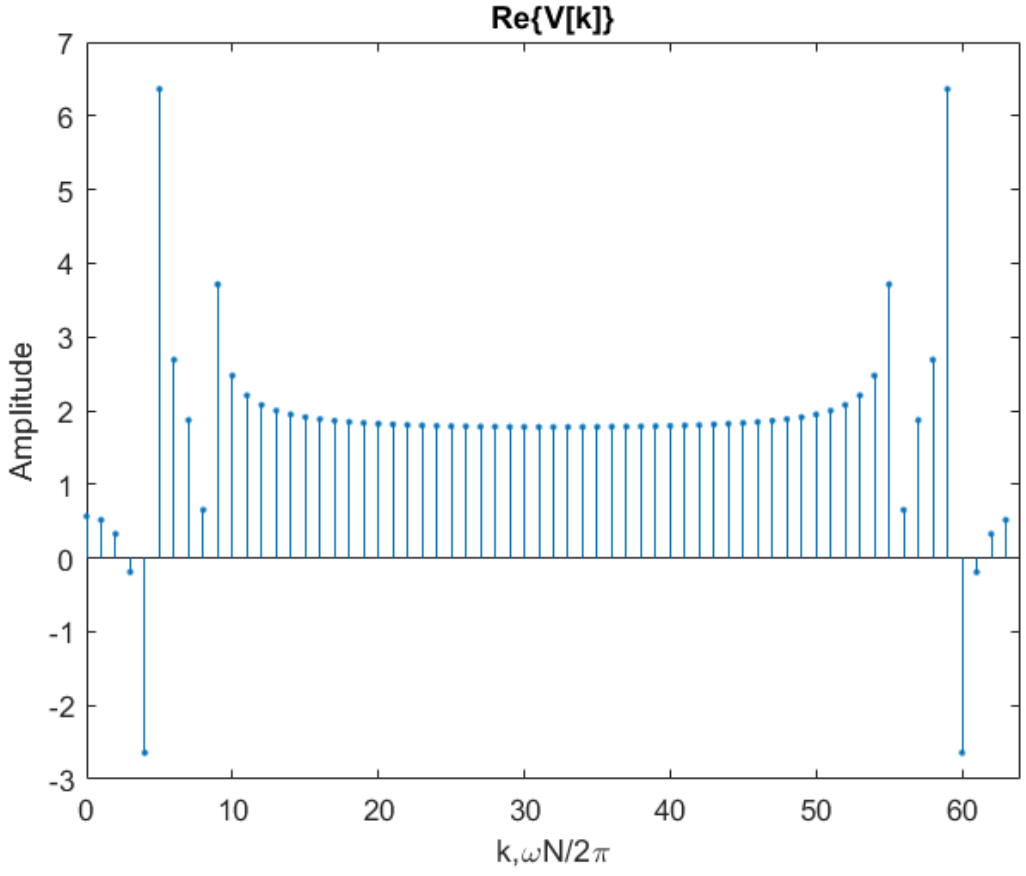

Amplitude of V(e^jω) for ω0 = 2π/14 and ω1 = 2π/12
|V(e^jω)|
ω
0
5
10
15
20
25
30
-3
-2
-1
0
1
2
3

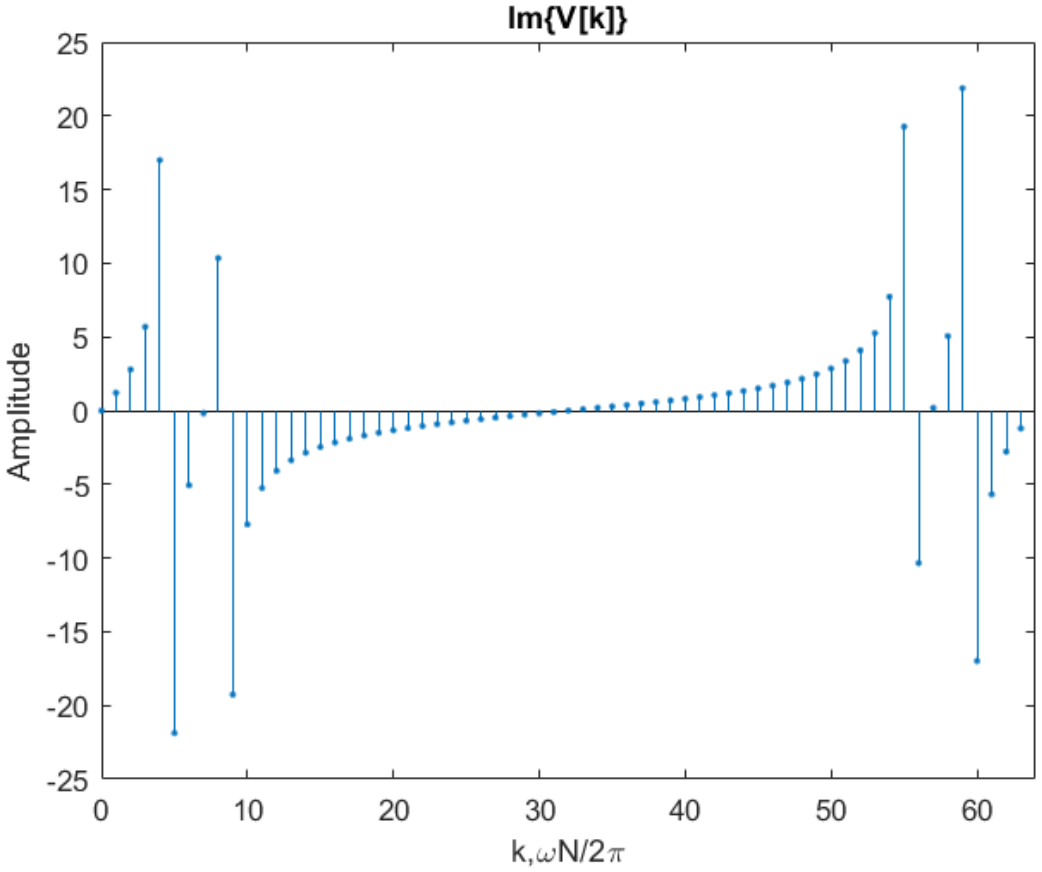

Amplitude of V(e^jω) for ω0 = 2π/14 and ω1 = 4π/25
|V(e^jω)|
ω
0
5
10
15
20
25
30
35
-3
-2
-1
0
1
2
3

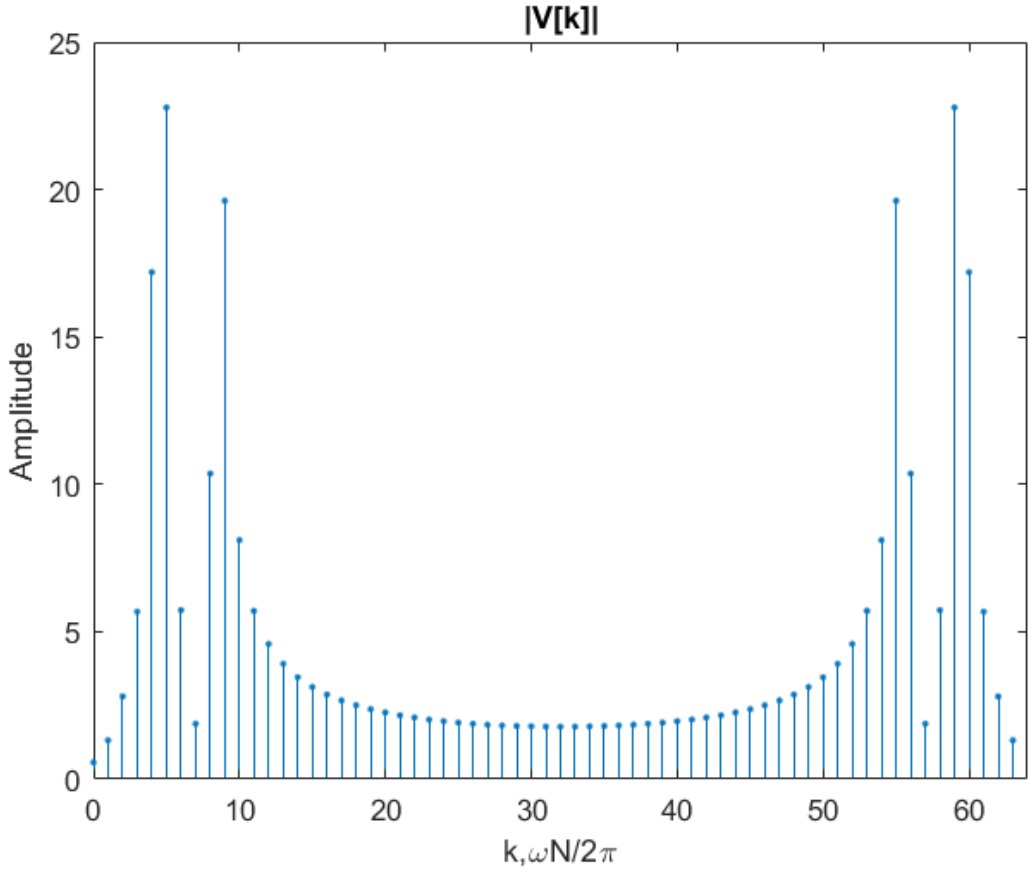
3.

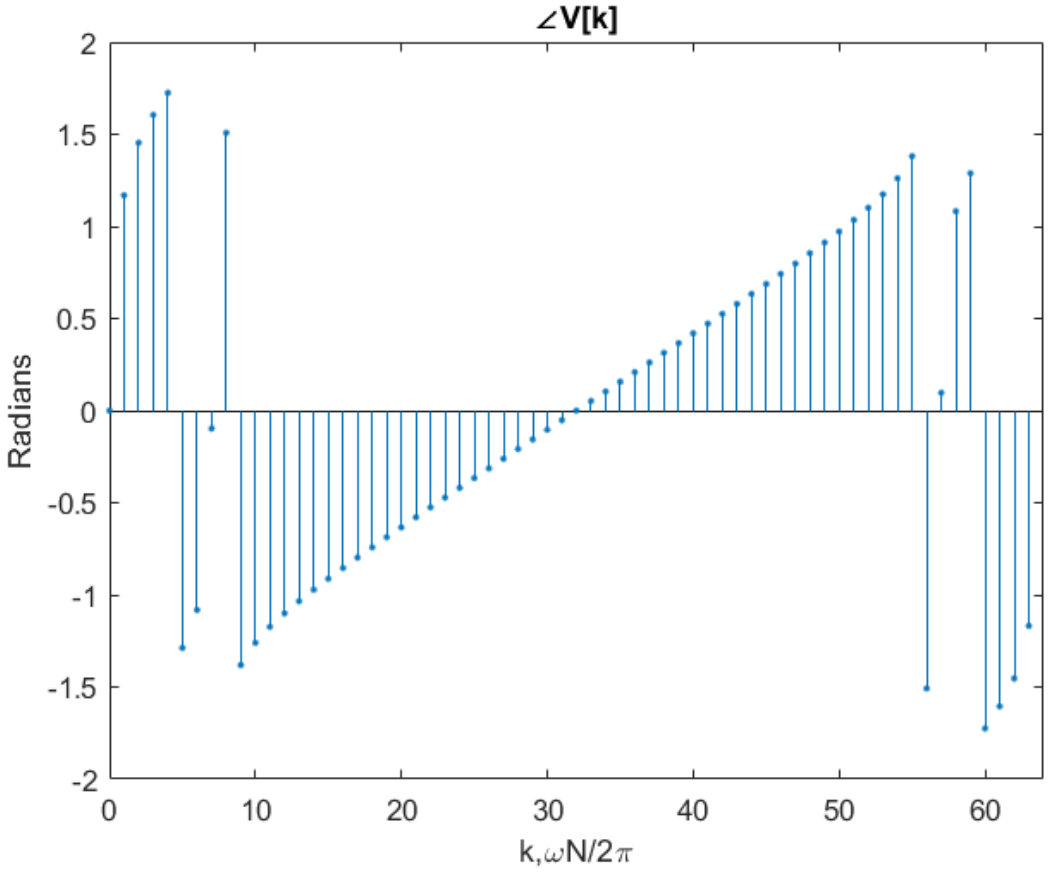
```
%(a)
N = 64;
A0 = 1;
A1 = 0.75;
w0 = 2*pi/14;
w1 = 4*pi/15;
theta0 = 0;
theta1 = 0;
n = 0:N-1;
v = A0*cos(w0*n+theta0)+A1*cos(w1*n+theta1);
figure(1);
stem(n,v,'.');
title('v[n]');
xlabel('n'); ylabel('Amplitude');
xlim([0 N]);

%(b)
V = fft(v);
figure(2);
stem(n,real(V),'.');
title('Re\{V[k]\}');
xlabel('k,\omegaN/2\pi'); ylabel('Amplitude');
xlim([0 N]);

%(c)
figure(3);
stem(n,imag(V),'.');
title('Im\{V[k]\}');
xlabel('k,\omegaN/2\pi'); ylabel('Amplitude');
xlim([0 N]);

%(d)
figure(4);
stem(n,abs(V),'.');
title('|V[k]|');
xlabel('k,\omegaN/2\pi'); ylabel('Amplitude');
xlim([0 N]);

%(e)
figure(5);
stem(n,angle(V),'.');
title('\angleV[k]');
xlabel('k,\omegaN/2\pi'); ylabel('Radians');
xlim([0 N]);

%(f)
figure(6);
plot((0:1023)*2*pi/1024,abs(fft(v,1024)));
title('|V(e^{j\omega})|');
xlabel('\omega'); ylabel('Amplitude');
xlim([0 2*pi]);
```

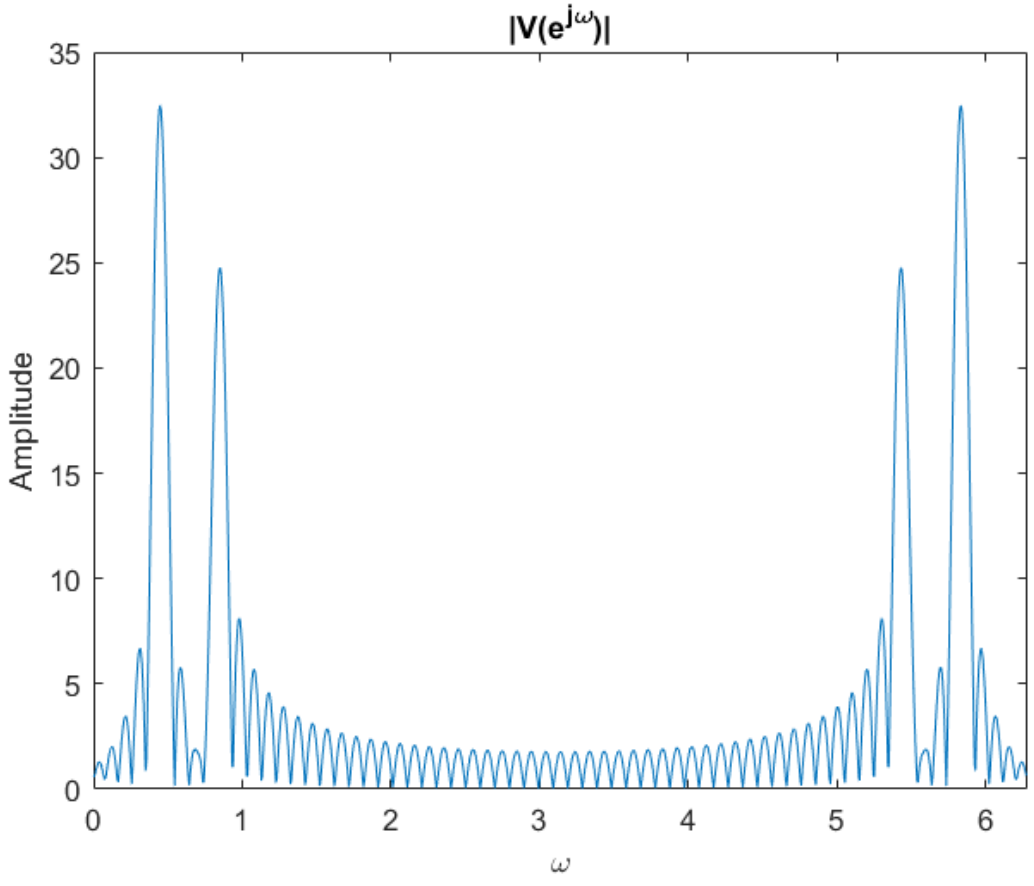

v[n]
Amplitude
n
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
10
20
30
40
50
60


Re{V[k]}
Amplitude
k,ωN/2π
7
6
5
4
3
2
1
0
-1
-2
-3
0
10
20
30
40
50
60


Im{V[k]}
Amplitude
k,ωN/2π


|V[k]|
Amplitude
k,ωN/2π


∠V[k]
Radians
k,ωN/2π

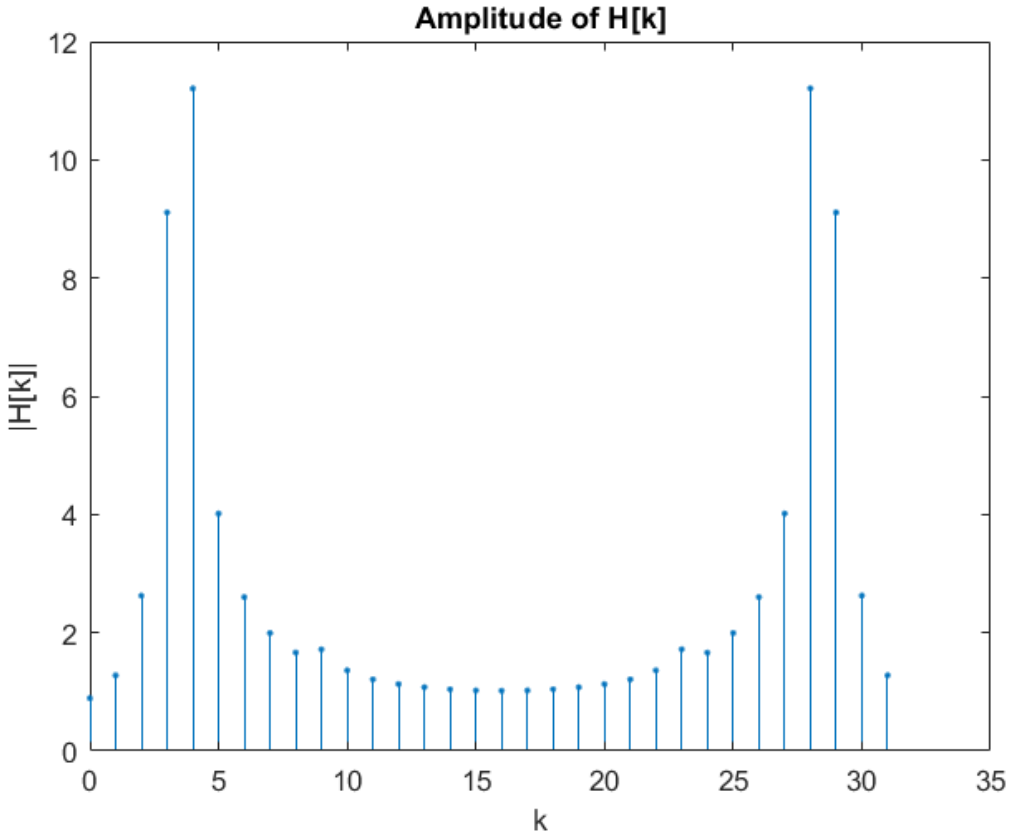

|V(e^jω)|
Amplitude
ω

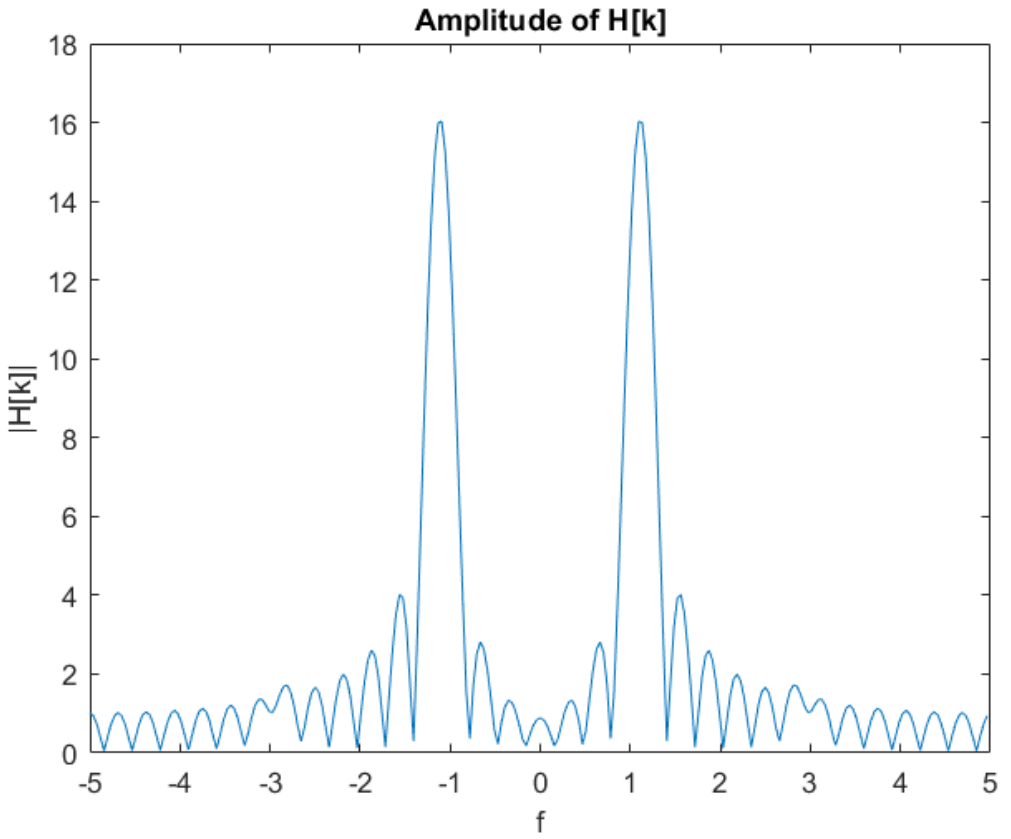
4.

```
T = 0.1;
N = 32;
n = (0:N-1)';
hn = cos(2*pi*n*T*1.1) + 0.07*cos(2*pi*n*T*2.9);
fs = 1/T;
N_fft = 256;
f = (-N_fft/2:N_fft/2-1)*fs/N_fft;
w_r = rectwin(N);
H = fft(hn.*w_r);
figure(1);
stem(n,abs(H),'.');
title('Amplitude of H[k]');
xlabel('k'); ylabel('|H[k]|');
figure(2);
plot(f,abs(fftshift(fft(hn.*w_r,N_fft))));
title('Amplitude of H[k]');
xlabel('f'); ylabel('|H[k]|');

w_hm = hamming(N);
figure(3);
subplot(2,2,1);
stem(n,hn,'.');
title('h[n]');
xlabel('n'); ylabel('h[n]');
subplot(2,2,2);
stem(n,w_hm,'.');
title('w_{hm}[n]');
xlabel('n'); ylabel('w_{hm}[n]');
subplot(2,2,3:4);
stem(n,hn.*w_hm,'.');
title('h[n]w_{hm}[n]');
xlabel('n'); ylabel('h[n]w_{hm}[n]');
H = fft(hn.*w_hm);
figure(4);
stem(n,abs(H),'.');
title('Amplitude of H[k]');
xlabel('k'); ylabel('|H[k]|');
figure(5);
plot(f,abs(fftshift(fft(hn.*w_hm,N_fft))));
title('Amplitude of H[k]');
xlabel('f'); ylabel('|H[k]|');

w_b = blackman(N);
figure(6);
subplot(2,2,1);
stem(n,hn,'.');
title('h[n]');
xlabel('n'); ylabel('h[n]');
subplot(2,2,2);
stem(n,w_b,'.');
title('w_b[n]');
xlabel('n'); ylabel('w_b[n]');
subplot(2,2,3:4);
stem(n,hn.*w_b,'.');
title('h[n]w_b[n]');
xlabel('n'); ylabel('h[n]w_b[n]');
H = fft(hn.*w_b);
figure(7);
stem(n,abs(H),'.');
```

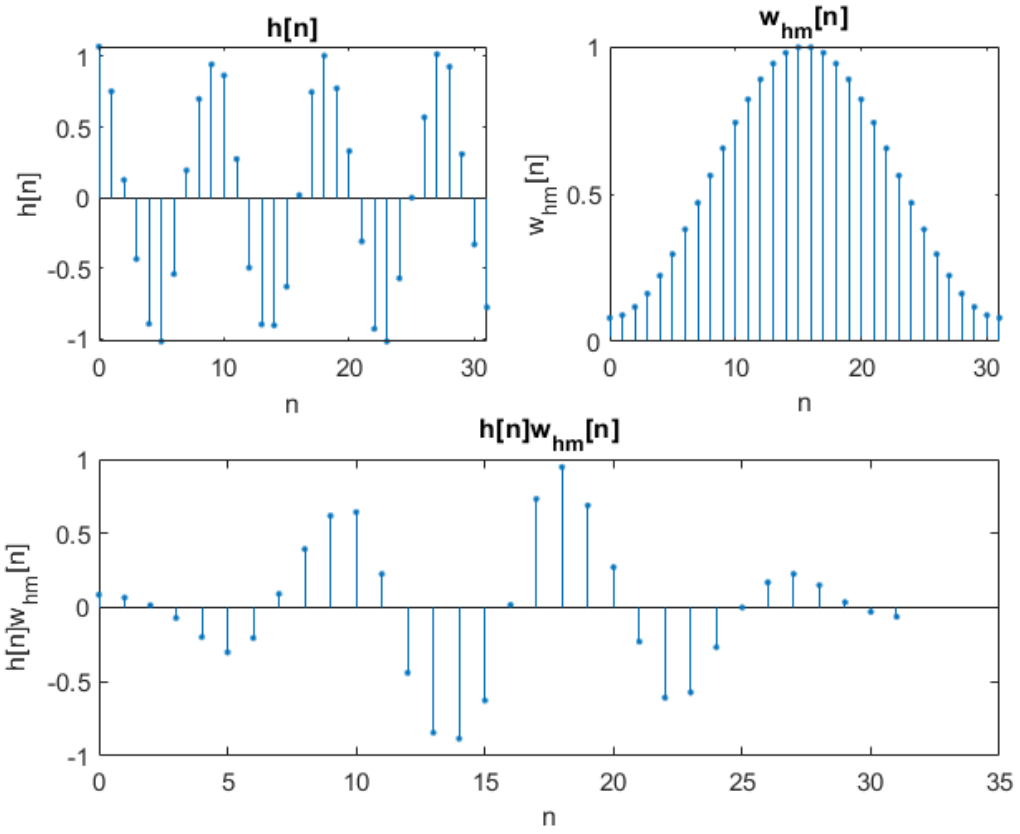
```
title('Amplitude of H[k]');
xlabel('k'); ylabel('|H[k]|');
figure(8);
plot(f,abs(fftshift(fft(hn.*w_b,N_fft))));
title('Amplitude of H[k]');
xlabel('f'); ylabel('|H[k]|');
```

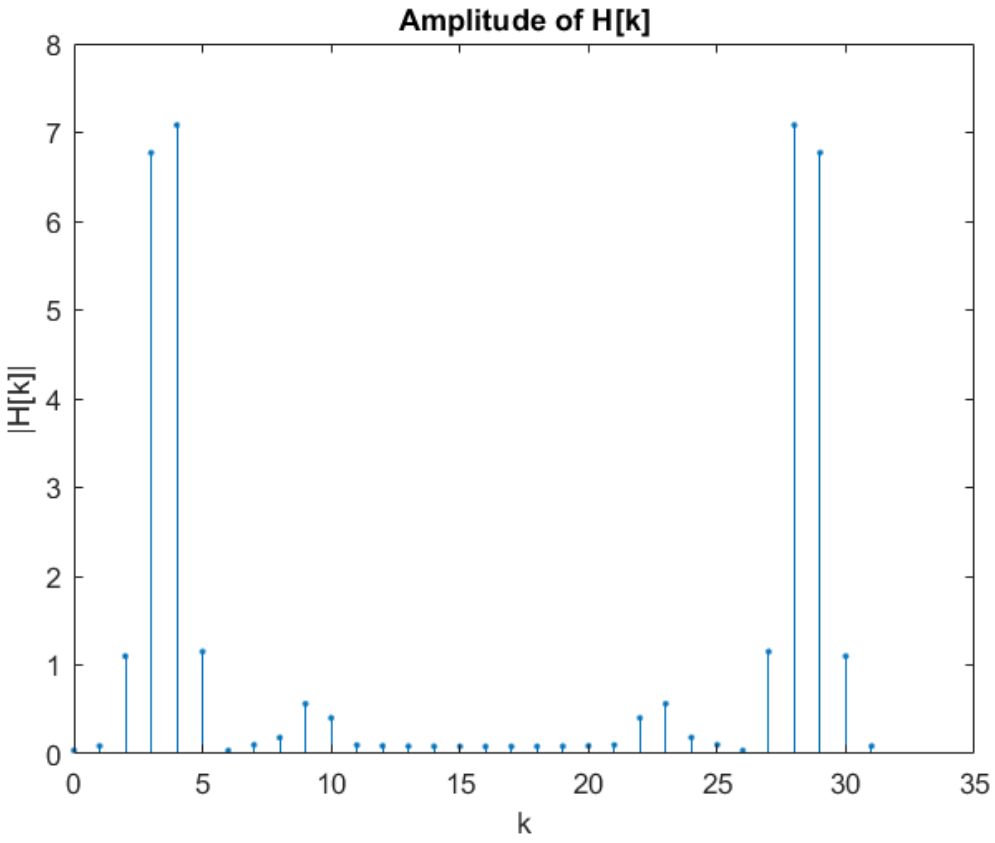
(a)

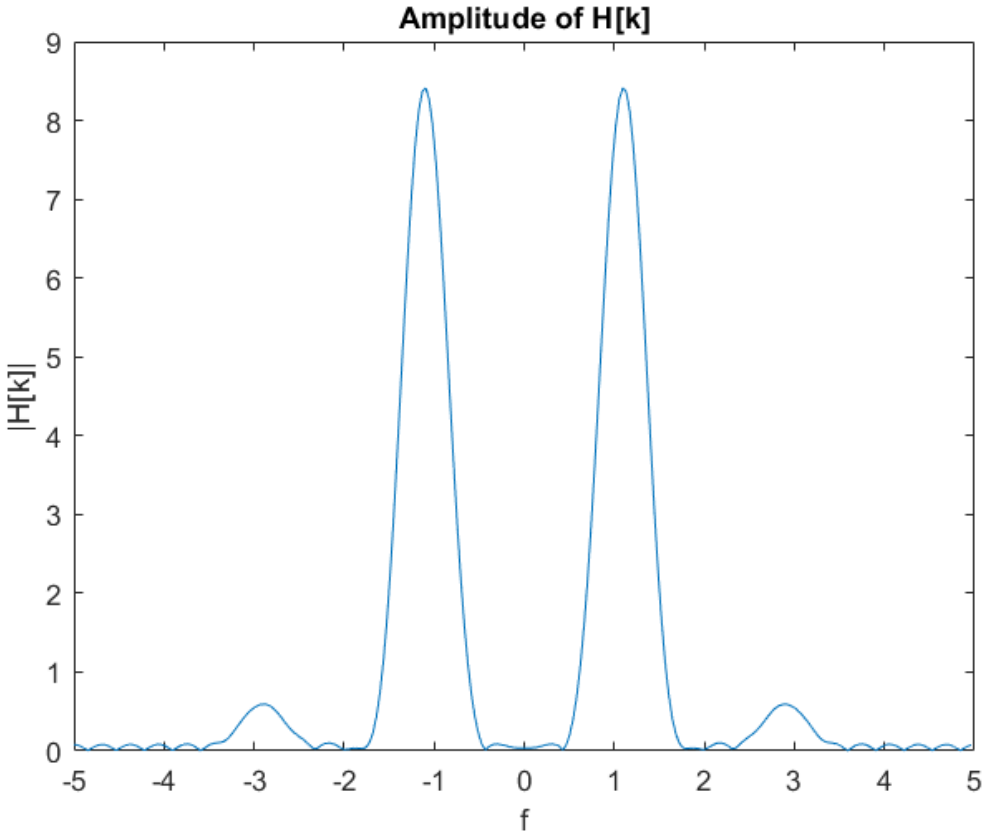

Amplitude of H[k]
|H[k]|
k
0
5
10
15
20
25
30
35
0
2
4
6
8
10
12


Amplitude of H[k]
|H[k]|
f
-5
-4
-3
-2
-1
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18

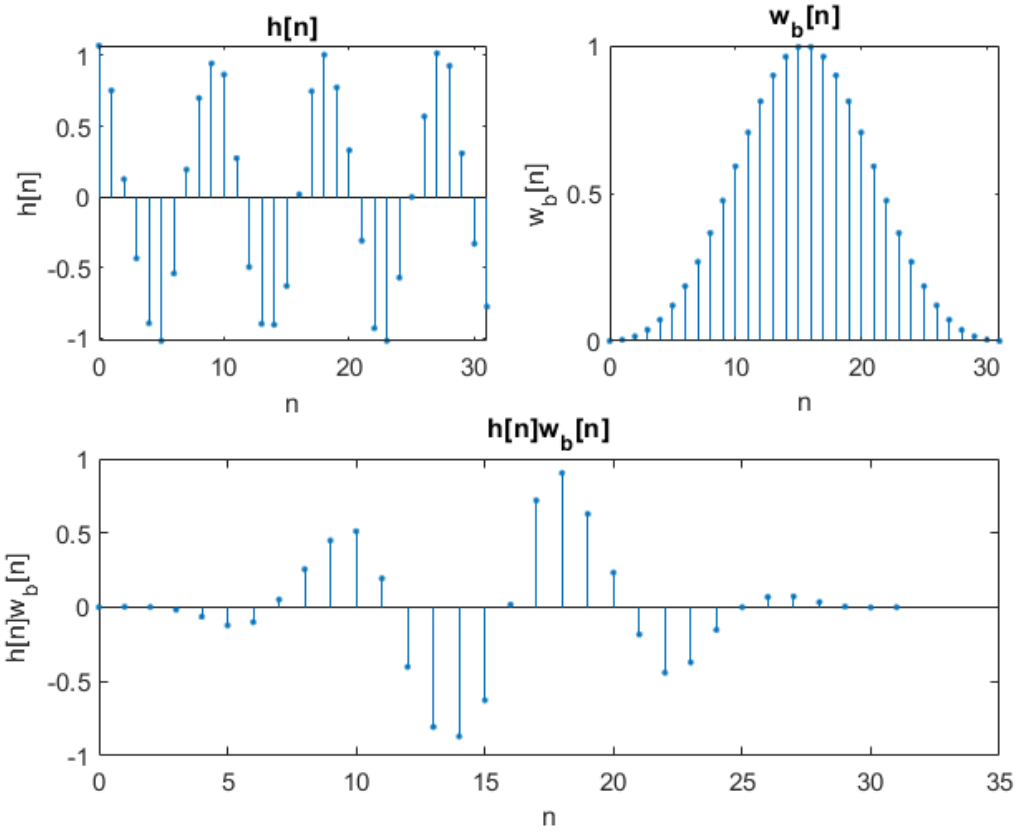
(b)

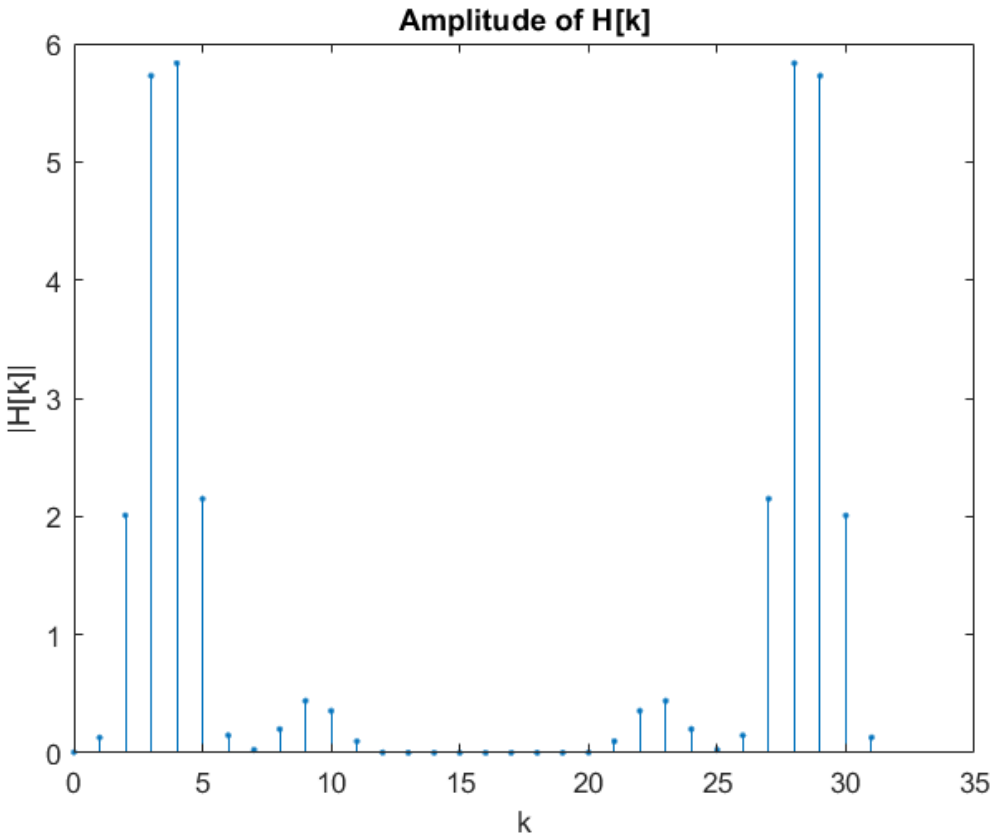


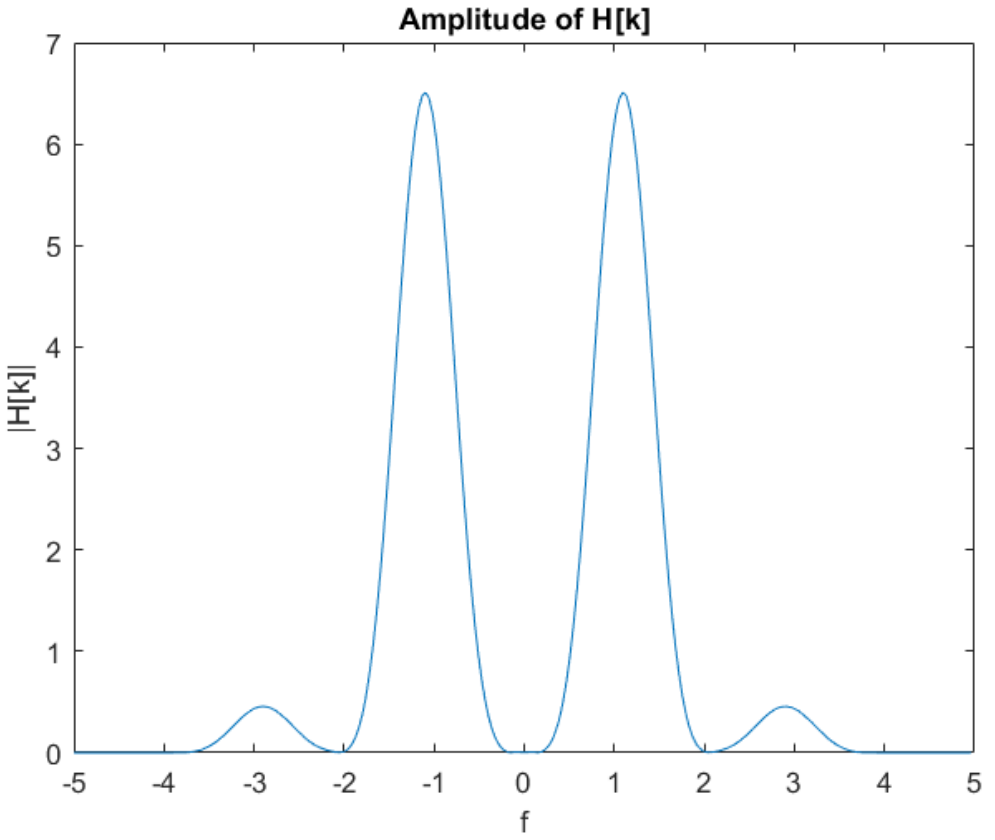




(c)

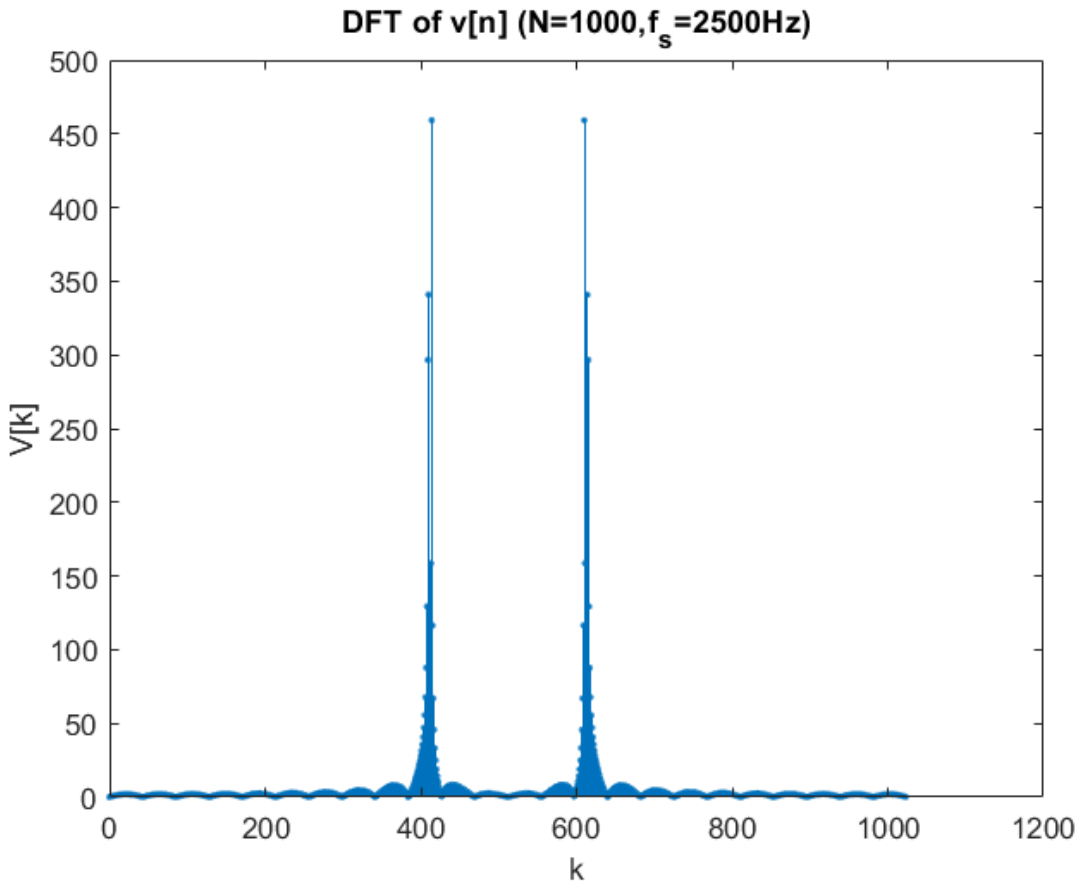


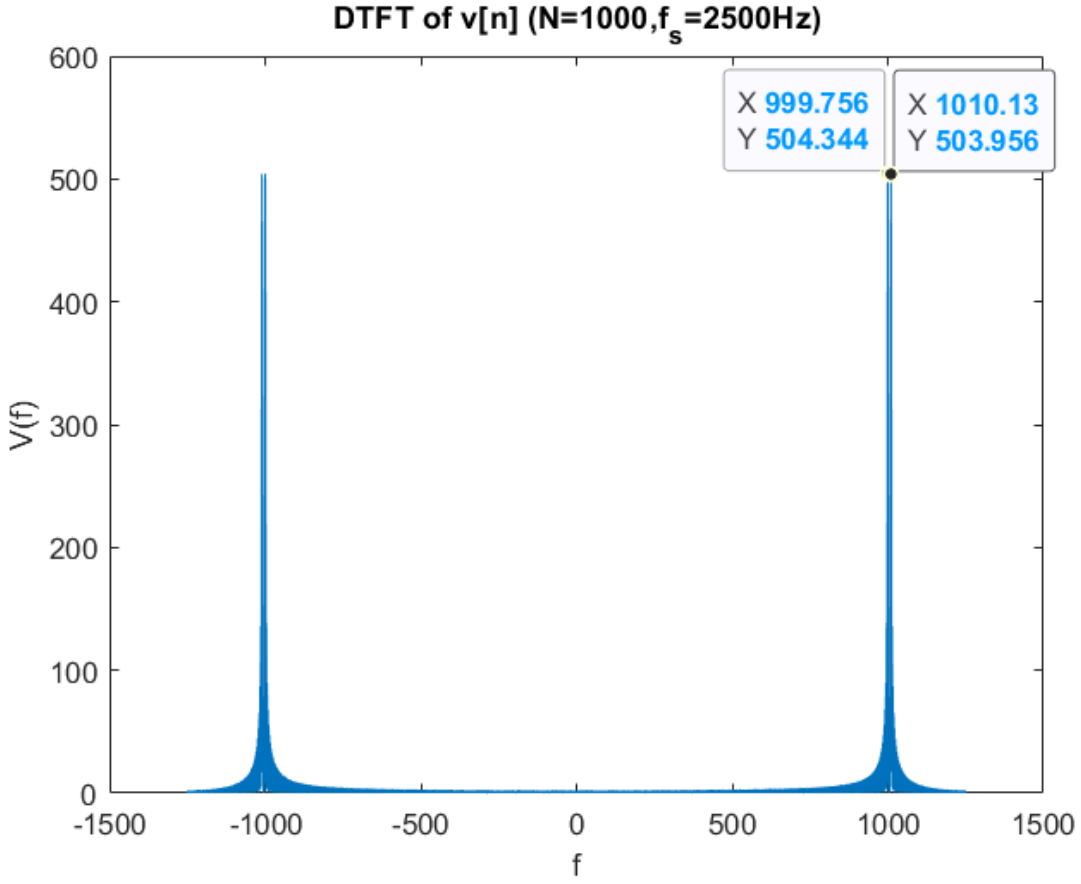

Amplitude of H[k]
|H[k]|
k
0
1
2
3
4
5
6
0
5
10
15
20
25
30
35

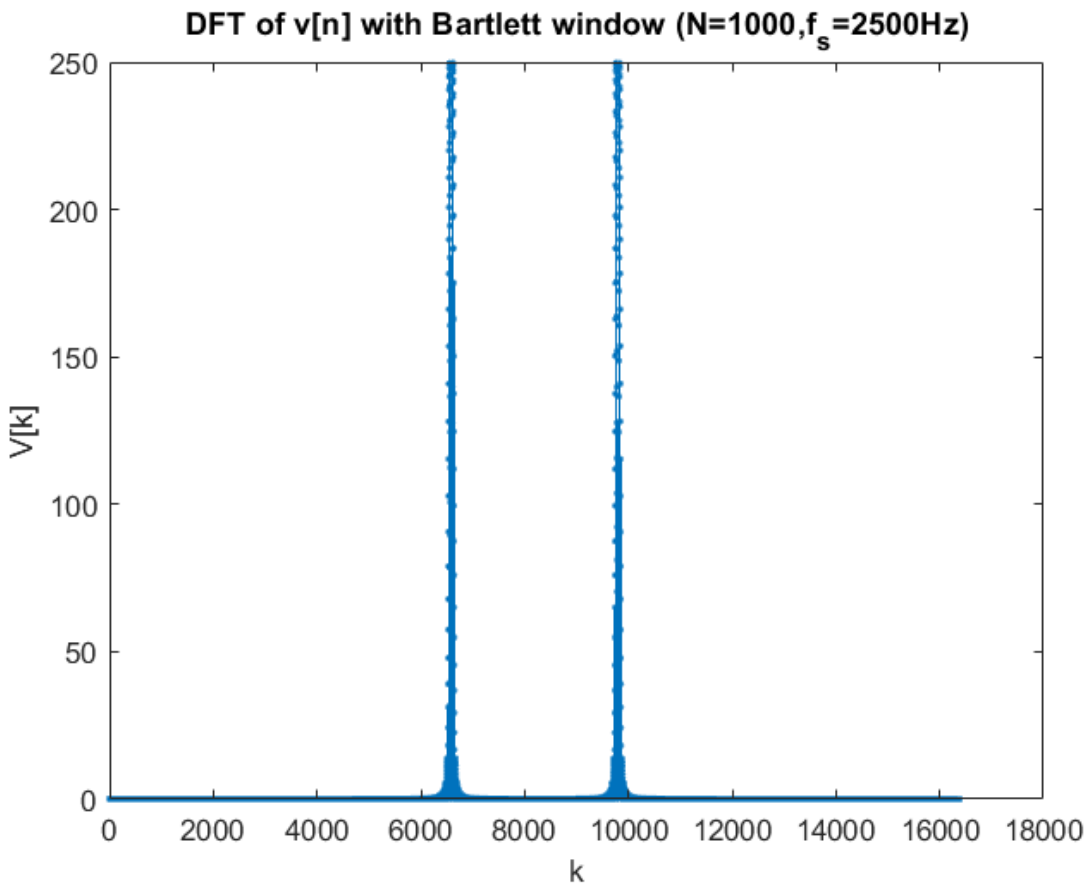

Amplitude of H[k]
|H[k]|
f
0
1
2
3
4
5
6
7
-5
-4
-3
-2
-1
0
1
2
3
4
5

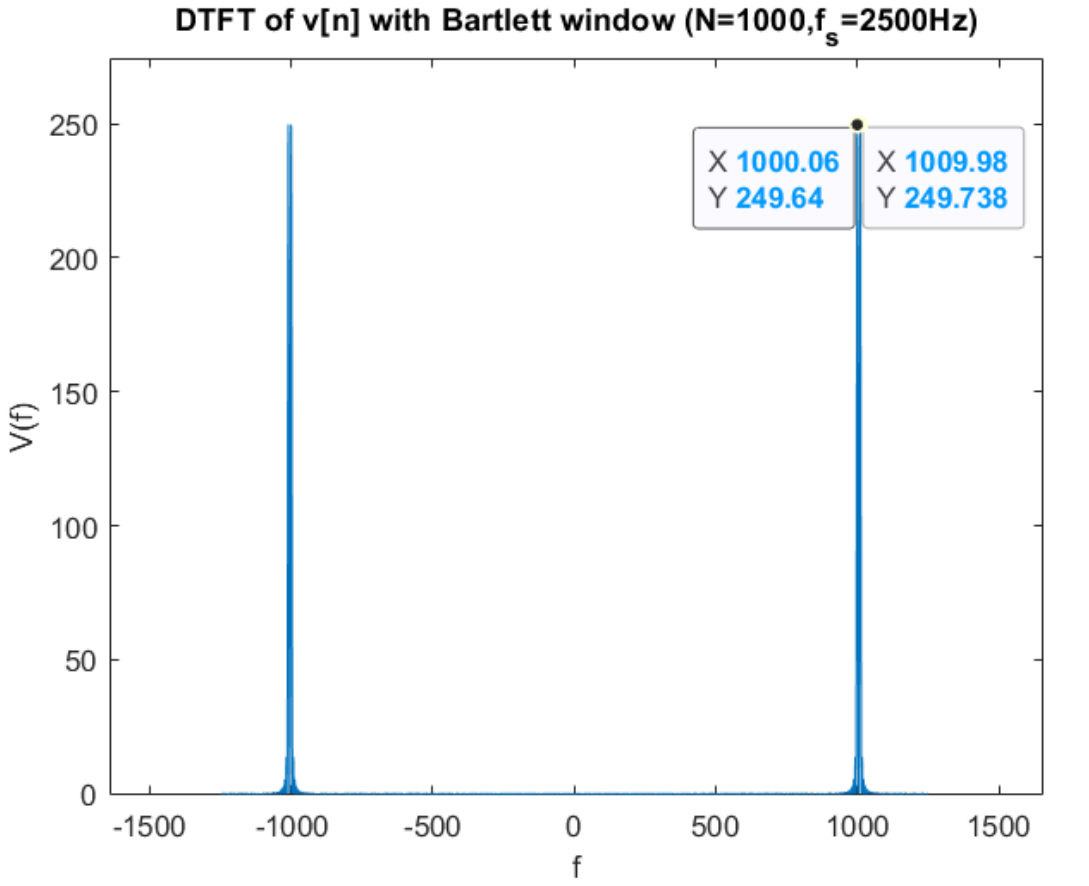
6.

```
f1 = 1*10^3;
f2 = 1.01*10^3;
fs = 2500;
T = 1/fs;
N = 1000;
n = 0:N-1;
vn = cos(2*pi*f1*n*T)+cos(2*pi*f2*n*T);
N_fft = 2^nextpow2(N);
V = fft(vn,N_fft);
figure(1);
stem(0:N_fft-1,abs(V),'.');
title('DFT of v[n] (N=1000,f_s=2500Hz)');
xlabel('k'); ylabel('V[k]');

N_fft = 16*2^nextpow2(N);
V = fft(vn,N_fft);
figure(2);
plot((-N_fft/2:N_fft/2-1)*fs/N_fft,abs(fftshift(V)));
title('DTFT of v[n] (N=1000,f_s=2500Hz)');
xlabel('f'); ylabel('V(f)');

w = bartlett(N)';
V_b = fft(vn.*w,N_fft);
figure(3);
stem(0:N_fft-1,abs(V_b),'.');
title('DFT of v[n] with Bartlett window (N=1000,f_s=2500Hz)');
xlabel('k'); ylabel('V[k]');

V_b = fft(vn.*w,N_fft);
figure(4);
plot((-N_fft/2:N_fft/2-1)*fs/N_fft,abs(fftshift(V_b)));
title('DTFT of v[n] with Bartlett window (N=1000,f_s=2500Hz)');
xlabel('f'); ylabel('V(f)');
```


DFT of v[n] (N=1000,f_s=2500Hz)
V[k]
k
0
50
100
150
200
250
300
350
400
450
500
0
200
400
600
800
1000
1200


DTFT of v[n] (N=1000,f_s=2500Hz)
X 999.756
Y 504.344
X 1010.13
Y 503.956
V(f)
f
0
100
200
300
400
500
600
-1500
-1000
-500
0
500
1000
1500


DFT of v[n] with Bartlett window (N=1000,f_s=2500Hz)
V[k]
k
0
50
100
150
200
250
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


DTFT of v[n] with Bartlett window (N=1000,f_s=2500Hz)
V(f)
f
X 1000.06
Y 249.64
X 1009.98
Y 249.738
0
50
100
150
200
250
-1500
-1000
-500
0
500
1000
1500