% Carlos Lazo

% ECE 503

% Homework #5

% Due: 2/22/10

function [X\_k] = HW05\_dft\_idft (x\_n, N, S)

syms k;

% With the function being passed N, develop function from n = 0..N

n = 0:(N-1);

% If selection input S = 0, perform the DFT.

% Else, perform the IDFT.

if (S == 0)

% Develop the expression for the DFT:

X\_k = sum( x\_n .\* exp((-j\*2\*pi\*k\*n)/N) );

% Substitute k for k = 0..N-1, which is the n vector:

X\_k = subs(X\_k, 'k', n);

else

% Develop the expression for the IDFT:

X\_k = (1/N) \* sum( x\_n .\* exp((j\*2\*pi\*k\*n)/N) );

% Substitute k for k = 0..N-1, which is the n vector:

X\_k = subs(X\_k, 'k', n);

end

%% 1) The DFT and IDFT

clear all; close all; clc;

% b. P&M 7.6

N = 64;

n = 0 : N-1;

k = n;

% Given the equation for w\_n, find the DFT W\_n:

w\_n = 0.42 - (0.5) \* cos ((2\*pi\*n) / (N-1)) + (0.08) \* cos ((4\*pi\*n) / (N-1));

X\_k = HW05\_dft\_idft (w\_n, N, 0);

% Plot the magnitude and phase response of the system from k = 0..N-1.

figure

subplot(2,1,1);

stem(k, abs(X\_k));

xlabel({'k'; ' '; ['Y(k) = ' num2str(abs(X\_k))]; });

ylabel('Magnitude');

title('|X(k)|');

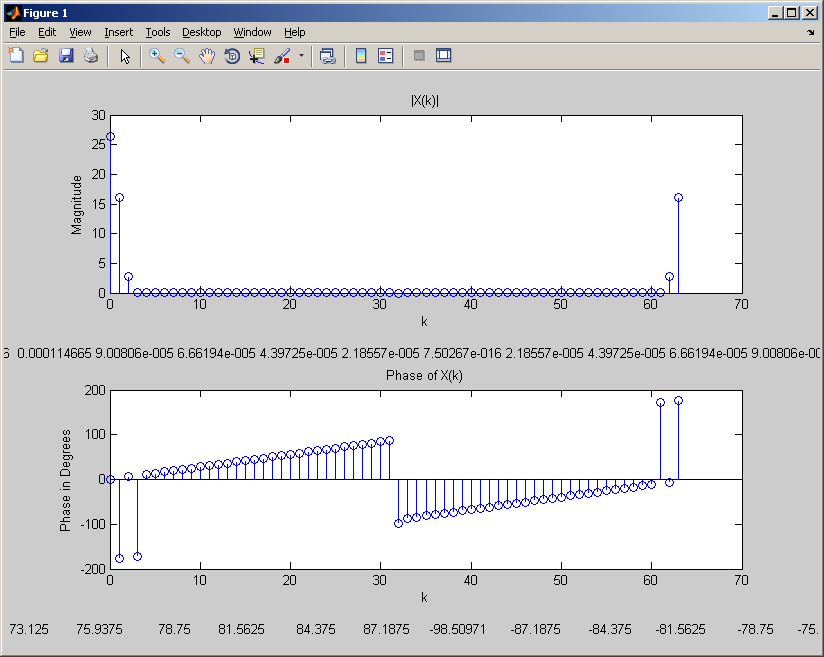
subplot(2,1,2);

stem(k, angle(X\_k)\*180/pi);

xlabel({'k'; ' '; ['Y(k) = ' num2str(angle(X\_k)\*180/pi)]; });

ylabel('Phase in Degrees');

title('Phase of X(k)');



%% 1) The DFT and IDFT

clear all; close all; clc;

% c. P&M 7.12: b) & c)

N = 6;

n = 0 : N-1;

k = n;

% Given the equation for wx\_n, find the DFT X\_n:

x\_n = [0 1 2 3 4 0]

X\_k = HW05\_dft\_idft (x\_n, N, 0);

% Setup the DFTs according to the problem description:

Y\_k = real(X\_k);

V\_k = imag(X\_k);

% Take the IDFTs and print the sequences:

y\_n = HW05\_dft\_idft (Y\_k, N, 1)

v\_n = HW05\_dft\_idft (V\_k, N, 1)

% Plot the magnitude and phase response of the system from k = 0..N-1.

% Part b)

format short;

figure

stem(n, y\_n);

xlabel({'n'; ' '; ['y(n) = ' num2str(y\_n)]; });

ylabel('y(n)');

title('Plot of y(n) vs. n');

% Part c)

figure

subplot(2,1,1);

stem(n, real(v\_n));

xlabel({'n'; ' '; ['Re[v(n)] = ' num2str(real(v\_n))]; });

ylabel('Re[v(n)]');

title('Plot of Re[v(n)] vs. n');

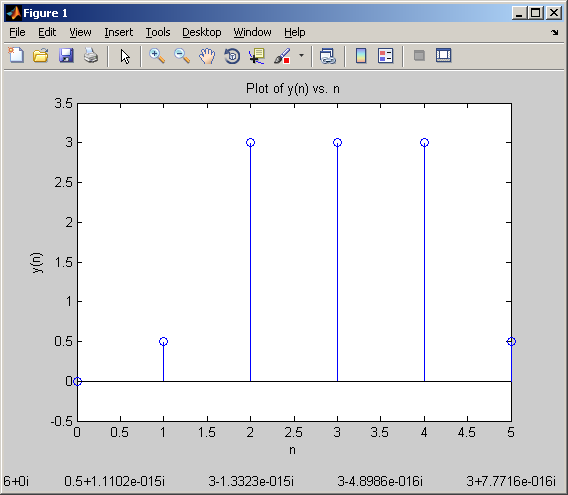
subplot(2,1,2);

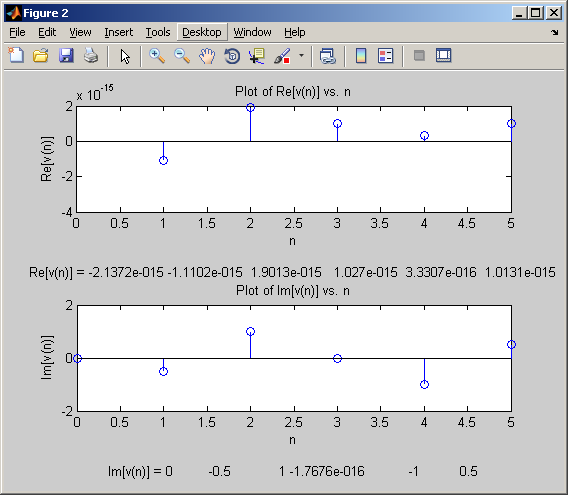
stem(k, imag(v\_n));

xlabel({'n'; ' '; ['Im[v(n)] = ' num2str(imag(v\_n))]; });

ylabel('Im[v(n)]');

title('Plot of Im[v(n)] vs. n');





%% 1) The DFT and IDFT

clear all; close all; clc;

% d. P&M 7.22

N = 10;

n = 0 : N-1;

k = n;

% Given the equation for x\_n, find the DFT X\_n:

x\_n = cos ((2\*pi\*n) / 10);

X\_k = HW05\_dft\_idft (x\_n, N, 0);

% Plot the magnitude and phase response of the system from k = 0..N-1.

figure

subplot(2,1,1);

stem(k, abs(X\_k));

xlabel({'k'; ' '; ['Y(k) = ' num2str(abs(X\_k))]; });

ylabel('Magnitude');

title('|X(k)|');

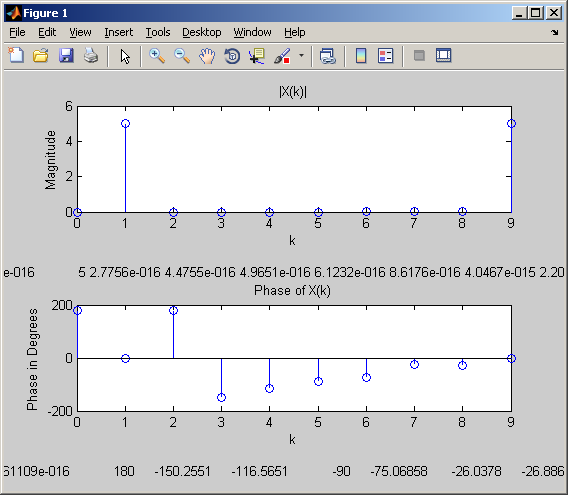
subplot(2,1,2);

stem(k, angle(X\_k)\*180/pi);

xlabel({'k'; ' '; ['Y(k) = ' num2str(angle(X\_k)\*180/pi)]; });

ylabel('Phase in Degrees');

title('Phase of X(k)');



%% 2) DFT Properties

clear all; close all; clc;

% c. P&M 7.9

N = 4;

n = 0 : N-1;

k = n;

% Given the equation for x\_n1 & x\_n2, find the DFT X\_n1 & X\_n2:

x\_n1 = [1 2 3 1];

x\_n2 = [4 3 2 2];

X\_k1 = HW05\_dft\_idft (x\_n1, N, 0)

X\_k2 = HW05\_dft\_idft (x\_n2, N, 0)

% In the frequency domain, convolution become multiplication:

X\_k3 = X\_k1 .\* X\_k2

% Perform the IDFT and take the real components to find x\_n3:

x\_n3 = real(HW05\_dft\_idft (X\_k3, N, 1))

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% \*\*\* OUTPUT \*\*\*

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% X\_k1 =

%

% 7.0000 -2.0000 - 1.0000i 1.0000 + 0.0000i -2.0000 + 1.0000i

%

%

% X\_k2 =

%

% 11.0000 2.0000 - 1.0000i 1.0000 - 0.0000i 2.0000 + 1.0000i

%

%

% X\_k3 =

%

% 77.0000 -5.0000 + 0.0000i 1.0000 - 0.0000i -5.0000

%

%

% x\_n3 =

%

% 17 19 22 19

%% 2) DFT Properties

clear all; close all; clc;

% e. P&M 7.14, Part a.

N = 5;

n = 0 : N-1;

k = n;

% Given the equation for x\_n1 & x\_n2, find the DFT X\_n1 & X\_n2:

x\_n1 = [0 1 2 3 4];

x\_n2 = [0 1 0 0 0];

X\_k1 = HW05\_dft\_idft (x\_n1, N, 0)

X\_k2 = HW05\_dft\_idft (x\_n2, N, 0)

% In the frequency domain, convolution become multiplication:

Y\_k = X\_k1 .\* X\_k2

% Perform the IDFT and take the real components to find x\_n3:

y\_n = real(HW05\_dft\_idft (Y\_k, N, 1))

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% \*\*\* OUTPUT \*\*\*

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% X\_k1 =

%

% 10.0000 -2.5000 + 3.4410i -2.5000 + 0.8123i -2.5000 - 0.8123i -2.5000 - 3.4410i

%

%

% X\_k2 =

%

% 1.0000 0.3090 - 0.9511i -0.8090 - 0.5878i -0.8090 + 0.5878i 0.3090 + 0.9511i

%

%

% Y\_k =

%

% 10.0000 2.5000 + 3.4410i 2.5000 + 0.8123i 2.5000 - 0.8123i 2.5000 - 3.4410i

%

%

% y\_n =

%

% 4.0000 0.0000 1.0000 2.0000 3.0000

%% 2) DFT Properties

clear all; close all; clc;

% e. P&M 7.14, Part b.

N = 5;

n = 0 : N-1;

k = n;

% Given the equation for x\_n1 & x\_n2, find the DFT X\_n1 & X\_n2:

x\_n1 = [0 1 2 3 4];

x\_n2 = [0 1 0 0 0];

s\_n = [1 0 0 0 0];

X\_k1 = HW05\_dft\_idft (x\_n1, N, 0)

X\_k2 = HW05\_dft\_idft (x\_n2, N, 0)

S\_k = HW05\_dft\_idft (s\_n , N, 0)

% In the frequency domain, convolution become multiplication:

X\_k3 = S\_k ./ X\_k1

% Perform the IDFT and take the real components to find x\_n3:

x\_n3 = real(HW05\_dft\_idft (X\_k3, N, 1))

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% \*\*\* OUTPUT \*\*\*

% \*\*\*\*\*\*\*\*\*\*\*\*\*\*

% X\_k1 =

%

% 10.0000 -2.5000 + 3.4410i -2.5000 + 0.8123i -2.5000 - 0.8123i -2.5000 - 3.4410i

%

% X\_k2 =

%

% 1.0000 0.3090 - 0.9511i -0.8090 - 0.5878i -0.8090 + 0.5878i 0.3090 + 0.9511i

%

% X\_k3 =

%

% 0.1000 -0.1382 - 0.1902i -0.3618 - 0.1176i -0.3618 + 0.1176i -0.1382 + 0.1902i

%

% x\_n3 =

%

% -0.1800 0.2200 0.0200 0.0200 0.0200

%% 3) More DFT Stuff with MATLAB

clear all; close all; clc;

% a. X(ejw) = (1-a2) / (1 - 2 a cos(w) + a2).

syms k;

% Define all variables based on what we're looking for:

N1 = 5;

N2 = 40;

N3 = 1000;

n1 = 0:N1-1;

n2 = 0:N2-1;

n3 = 0:N3-1;

k1 = n1;

k2 = n2;

k3 = n3;

w1 = (2\*pi\*k)./N1;

w2 = (2\*pi\*k)./N2;

w3 = (2\*pi\*k)./N3;

a = 0.8;

% Define the DFT equations:

X\_K1 = (1 - a^2) ./ (1 - 2\*a\*cos(w1) + a^2);

X\_K2 = (1 - a^2) ./ (1 - 2\*a\*cos(w2) + a^2);

X\_K3 = (1 - a^2) ./ (1 - 2\*a\*cos(w3) + a^2);

x\_n1 = HW05\_dft\_idft (X\_K1, N1, 1);

x\_n2 = HW05\_dft\_idft (X\_K2, N2, 1);

x\_n3 = HW05\_dft\_idft (X\_K3, N3, 1);

% Plot all figures:

X\_K1 = subs(X\_K1, 'k', k1);

figure;

stem(n1, x\_n1);

xlabel('n');

ylabel('x(n)');

title('x(n), N = 5');

figure;

stem(n2, x\_n2);

xlabel('n');

ylabel('x(n)');

title('x(n), N = 40');

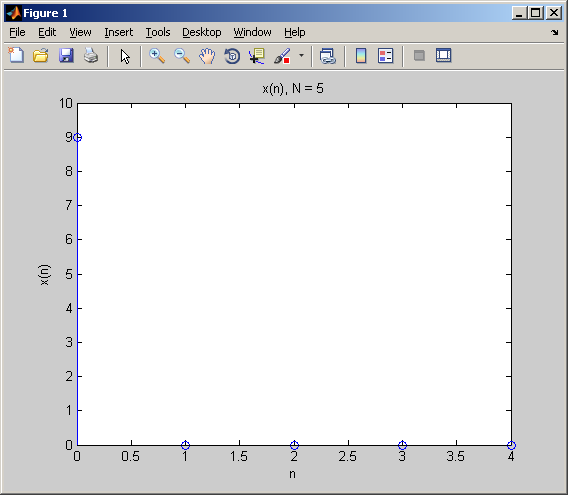
figure;

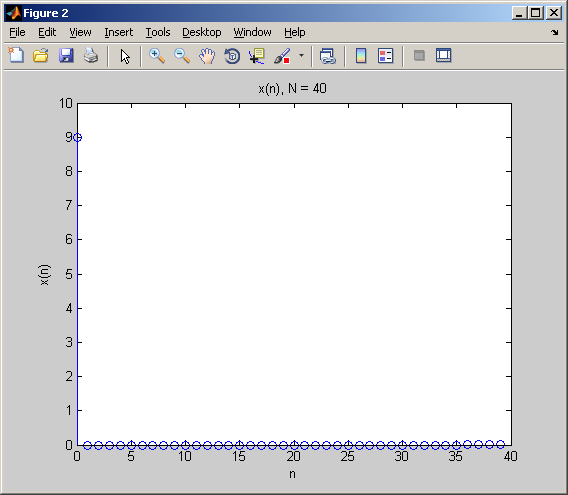
stem(n3, x\_n3);

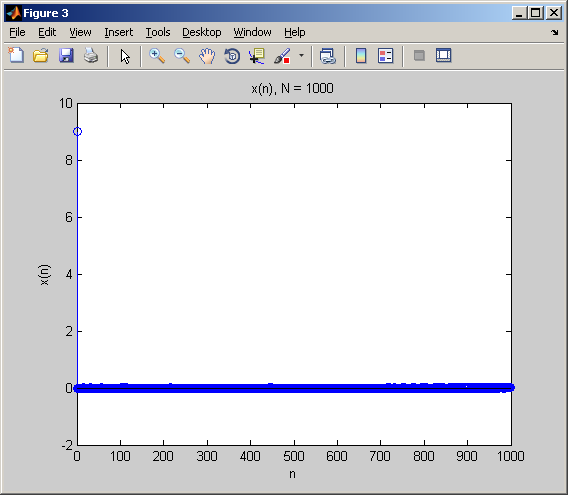
xlabel('n');

ylabel('x(n)');

title('x(n), N = 1000');







%% More DFT Stuff with MATLAB

clear all; close all; clc;

% b. P&M 7.30, part a)

% Define all variables and their equations:

f1 = (1/18);

f2 = (5/128);

fc = (50/128);

n = 0:255;

x\_n = cos(2\*pi\*f1\*n) + cos(2\*pi\*f2\*n);

x\_c = cos(2\*pi\*fc\*n);

x\_am = x\_n .\* x\_c;

subplot(3,1,1);

stem(n,x\_n);

xlabel('n');

ylabel('x(n)');

subplot(3,1,2);

stem(n,x\_c);

xlabel('n');

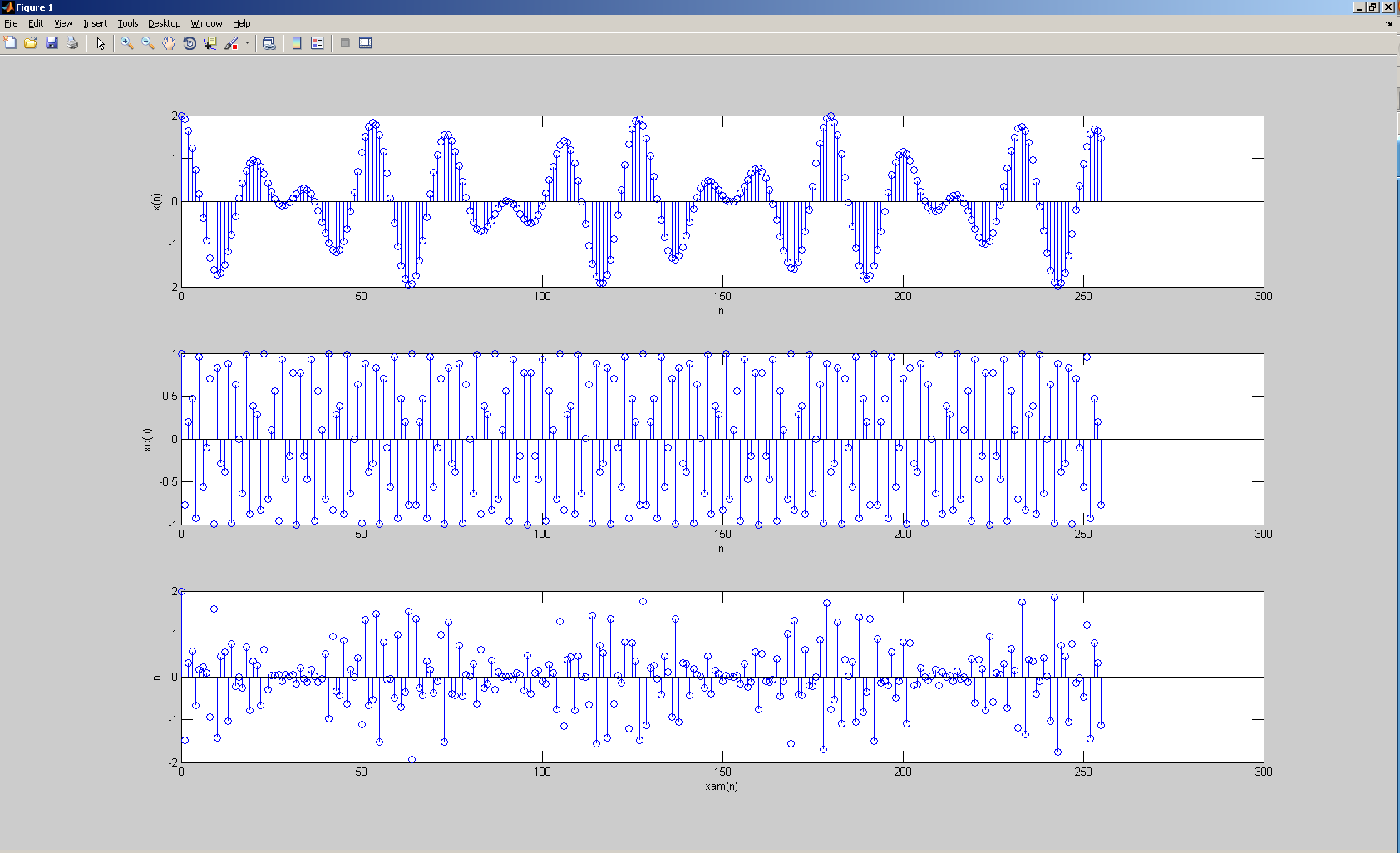
ylabel('xc(n)');

subplot(3,1,3);

stem(n,x\_am);

xlabel('xam(n)');

ylabel('n');



In order:

x(n)

xc(n)

xam(n)

%% More DFT Stuff with MATLAB

clear all; close all; clc;

% b. P&M 7.30, part b)

% Define all variables and their equations:

f1 = (1/18);

f2 = (5/128);

fc = (50/128);

n = 0:127;

x\_n = cos(2\*pi\*f1\*n) + cos(2\*pi\*f2\*n);

x\_c = cos(2\*pi\*fc\*n);

x\_am = x\_n .\* x\_c;

N = 128;

X\_k = HW05\_dft\_idft (x\_am, N, 0);

figure

subplot(2,1,1);

stem(n, abs(X\_k));

xlabel('k');

ylabel('Magnitude');

title('|X(k)|');

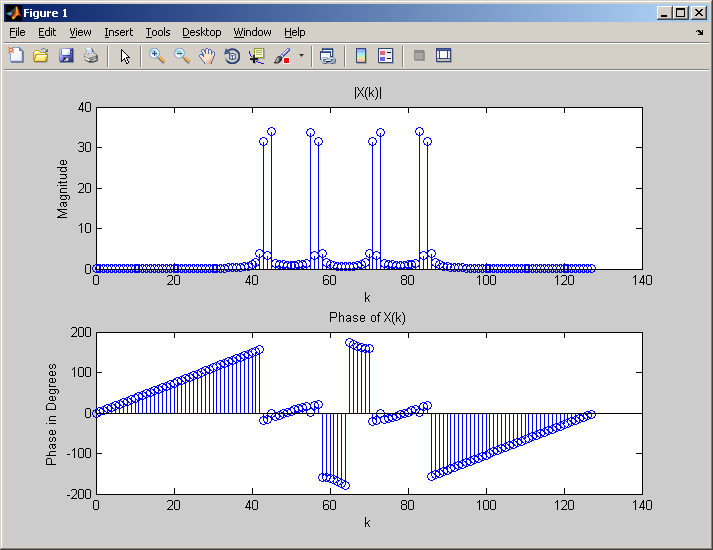
subplot(2,1,2);

stem(n, angle(X\_k)\*180/pi);

xlabel('k');

ylabel('Phase in Degrees');

title('Phase of X(k)');



%% More DFT Stuff with MATLAB

clear all; close all; clc;

% b. P&M 7.30, part c)

% Define all variables and their equations:

f1 = (1/18);

f2 = (5/128);

fc = (50/128);

n = 0:99;

x\_n = cos(2\*pi\*f1\*n) + cos(2\*pi\*f2\*n);

x\_c = cos(2\*pi\*fc\*n);

x\_am = x\_n .\* x\_c;

N = 100;

X\_k = HW05\_dft\_idft (x\_am, N, 0);

figure

subplot(2,1,1);

stem(n, abs(X\_k));

xlabel('k');

ylabel('Magnitude');

title('|X(k)|');

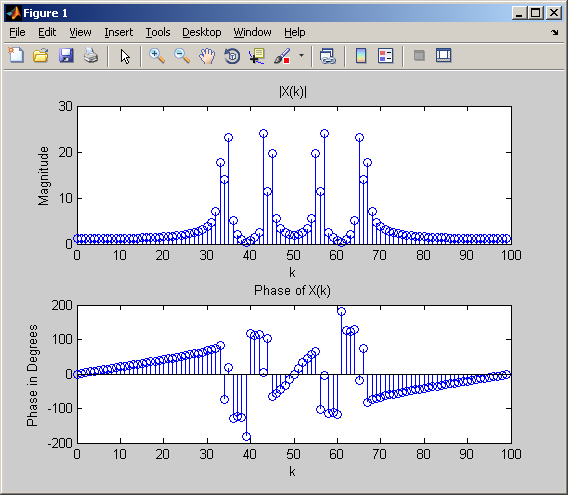
subplot(2,1,2);

stem(n, angle(X\_k)\*180/pi);

xlabel('k');

ylabel('Phase in Degrees');

title('Phase of X(k)');



%% More DFT Stuff with MATLAB

clear all; close all; clc;

% b. P&M 7.30, part c)

% Define all variables and their equations:

f1 = (1/18);

f2 = (5/128);

fc = (50/128);

n = 0:99;

x\_n = cos(2\*pi\*f1\*n) + cos(2\*pi\*f2\*n);

x\_c = cos(2\*pi\*fc\*n);

x\_am = x\_n .\* x\_c;

x\_am = [x\_am zeros(1,28)]

N = 128;

X\_k = HW05\_dft\_idft (x\_am, N, 0);

figure

subplot(2,1,1);

stem(N, abs(X\_k));

xlabel('k');

ylabel('Magnitude');

title('|X(k)|');

subplot(2,1,2);

stem(N, angle(X\_k)\*180/pi);

xlabel('k');

ylabel('Phase in Degrees');

title('Phase of X(k)');

% Could not get this to work right.

%% More DFT Stuff with MATLAB

clear all; close all; clc;

% b. P&M 7.30, part d)

% Define all variables and their equations:

f1 = (1/18);

f2 = (5/128);

fc = (50/128);

n = 0:179;

x\_n = cos(2\*pi\*f1\*n) + cos(2\*pi\*f2\*n);

x\_c = cos(2\*pi\*fc\*n);

x\_am = x\_n .\* x\_c;

x\_am = [x\_am zeros(1,(256-180))]

N = 256;

X\_k = HW05\_dft\_idft (x\_am, N, 0);

figure

subplot(2,1,1);

stem(N, abs(X\_k));

xlabel('k');

ylabel('Magnitude');

title('|X(k)|');

subplot(2,1,2);

stem(N, angle(X\_k)\*180/pi);

xlabel('k');

ylabel('Phase in Degrees');

title('Phase of X(k)');

% Could not get this to work right.