"Well, don't come and look at the rainbow then, you big ape!"

EE 311 **Feb. 1, 2019**
Notes – Eighth Day

Chapter 3

Do Difference Equation Plot in class

Do Wav File Filter in class

Do HeartbeatFreq plot in class

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Difference Equation Frequency Plot

1. For the difference equation given by:

$$y(n) = b_0 x(n) + \_ b_1 x(n-1) + b_2 x(n-2) + b_3 x(n-3) + b_4 x(n-4) + b_5 x(n-5) + b_6 x(n-6)$$
$$- a_1 y(n-1) - a_2 y(n-2) - a_3 y(n-3) - a_4 y(n-4) - a_5 y(n-5) - a_6 y(n-6)$$

Where

b_0 = 0.017476594979571
b_1 = -0.038920031694642
b_2 = 0.064334049527568
b_3 = -0.066334158266463
b_4 = 0.064334049527568
b_5 = -0.038920031694643
b_6 = 0.017476594979571

a_1 = -4.280268819697845
a_2 = 8.253138737990916
a_3 = -8.997394058724847
a_4 = 5.814086612755390
a_5 = -2.102290903814148
a_6 = 0.332371933872886

Take the sample frequency to be 1KHz

A) Find the transfer function in z
B) Use MATLAB® to find and plot the impulse response for 50 terms.
C) Use MATLAB® to find and plot the magnitude response.
D) Use MATLAB® to plot the poles and zeros in the z-plane

```
%EllipticPlot.m
fs = 1000;
b0 =  0.017476594979571;
b1 = -0.038920031694642;
b2 =  0.064334049527568;
b3 = -0.066334158266463;
b4 =  0.064334049527568;
b5 =  -0.038920031694643;
b6 =  0.017476594979571;
a1 = -4.280268819697845;
a2 =  8.253138737990916;
a3 = -8.997394058724847;
a4 =  5.814086612755390;
a5 = -2.102290903814148;
a6 =  0.332371933872886;
num = [b0 b1 b2 b3 b4 b5 b6];
den = [1 a1 a2 a3 a4 a5 a6];
[h n] = impz(num, den, 50, fs);
figure(1);clf;
stem(n, h);
xlabel('Time in seconds');
ylabel('amplitude');
title('Impulse Response');
[H f] = freqz(num, den, 1024, fs);
figure(2);clf;
subplot(2, 1, 1);
plot(f, abs(H));
axis([0 fs/2 0 1.2]);
xlabel('frequency in Hz');
ylabel('Gain');
title('Magnitude Response');
subplot(2, 1, 2);
plot(f, angle(H)*180/pi);
xlabel('frequency in Hz');
ylabel('Phase in degrees');
title('Phase Response');
figure(3);clf;
zplane(num, den);
```

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Wave File Filter

1. Create a low pass filter using the following coefficients:

```
b0 = 0.009796066019321;
b1 = -0.035891832463444;
b2 = 0.052346221563431;
b3 = -0.035891832463444;
b4 = 0.009796066019321;
a1 = -3.779213428634376;
a2 = 5.373825951039081;
a3 = -3.406809372185889;
a4 = 0.812353100968238;
```

Take the sample frequency to be 22050 Hz

A) Use MATLAB® to find and plot the magnitude response.

B) Use MATLAB® to plot the poles and zeros in the z-plane

C) Read the wav file named 'beet9th.wav' like this:

```
[y fs] = audioread('beet9th.wav');
```

D) Pass the wav file through the filter like this

```
yf = filter(num, den, y);
```

E) Play the original wave file and the filtered version.

```
player = audioplayer(y, fs);
play(player);
player2 = audioplayer(yf, fs);
play(player2);
```

```
%FilterBeet9th.m
[y fs] = audioread('beet9th.wav');
b0 = 0.009796066019321;
b1 = -0.035891832463444;
b2 = 0.052346221563431;
b3 = -0.035891832463444;
b4 = 0.009796066019321;
a1 = -3.779213428634376;
a2 = 5.373825951039081;
a3 = -3.406809372185889;
a4 = 0.812353100968238;
num = [b0 b1 b2 b3 b4];
den = [1 a1 a2 a3 a4];
[H f] = freqz(num, den, 1024, fs);
figure(1);clf;
subplot(2, 1, 1);
plot(f, abs(H));
axis([0 fs/2 0 1.2]);
xlabel('frequency in Hz');
ylabel('Gain');
title('Magnitude Response');
subplot(2, 1, 2);
plot(f, angle(H)*180/pi);
xlabel('frequency in Hz');
ylabel('Phase in degrees');
title('Phase Response');
yf = filter(num, den, y);
player = audioplayer(y, fs);
play(player);
pause;
player = audioplayer(yf, fs);
play(player);
```

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Wav Frequency Plot

Read the wav file "Heartbeat.wav" into MATLAB® and plot the data against time. Using the time domain plot estimate what the frequency domain plot will look like – what are the dominant frequencies.

Use MATLAB® to plot the FFT of the wav file and verify your time domain observations.

```
%HeartbeatFreq.m
[y fs] = audioread('Heartbeat.wav');
T = 1/fs;
t = 0:T:T*(length(y)-1);
figure(1);clf;
subplot(2, 1, 1);
plot(t, y);
xlabel('time in seconds');
ylabel('amplitude');
title('Heartbeat.wav in time');
axis([0 3 -1 1]);
%
X = fft(y);
X = X/max(abs(X));
subplot(2,1,2)
k = 1:length(y);
plot(k*fs/length(y), abs(X))  %Plot X in frequency
axis([0 200 0 1]);
xlabel('frequency in Hz');
ylabel('gain');
title('Heartbeat.wav in frequency');
player = audioplayer(y, fs);
play(player);
```