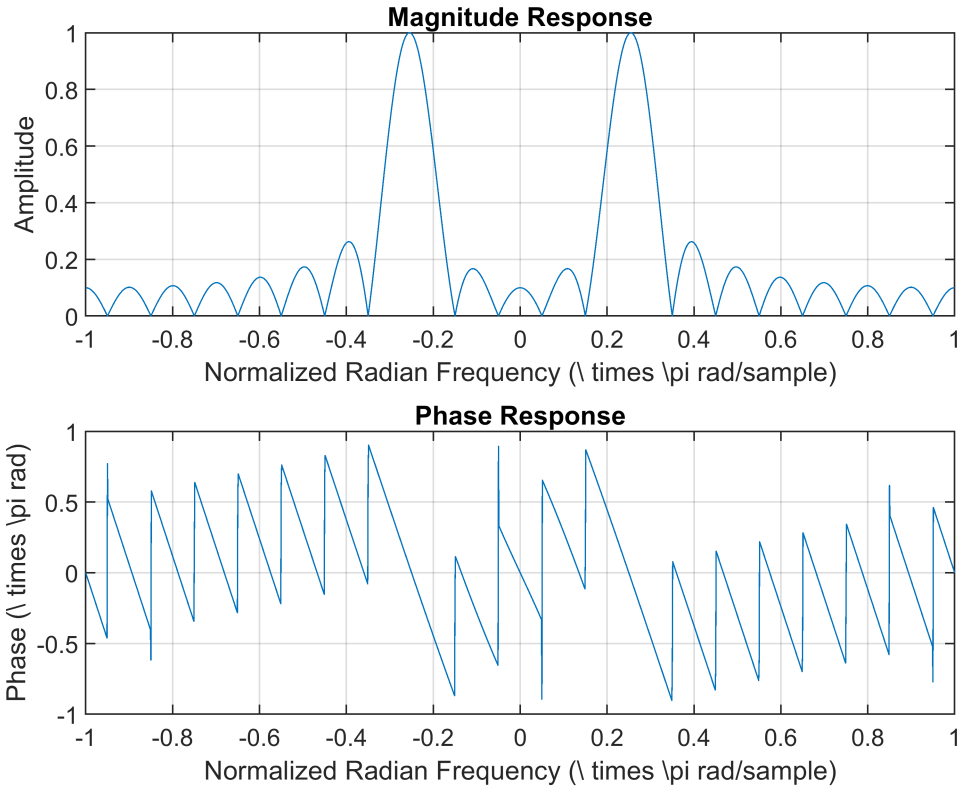
```
%%3.1
%a
w0 = pi/4;
w = -pi:pi/1000:pi;
L = 20;
%a
type freq_resp.m
```

```
function H = freq_resp(b, w)
H = 0;
    [r,c] = size(b);
    for i = 0:c-1
        H = H + b(i+1)*exp((-j*i).*(w));
    end
end
```

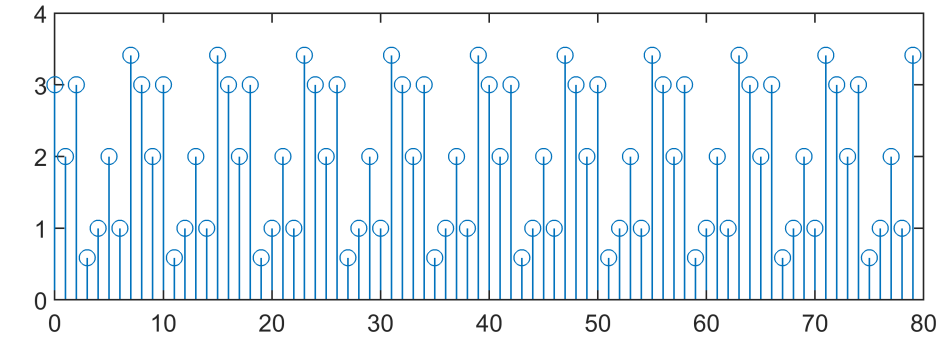
```
%b
type gen_filter.m
```

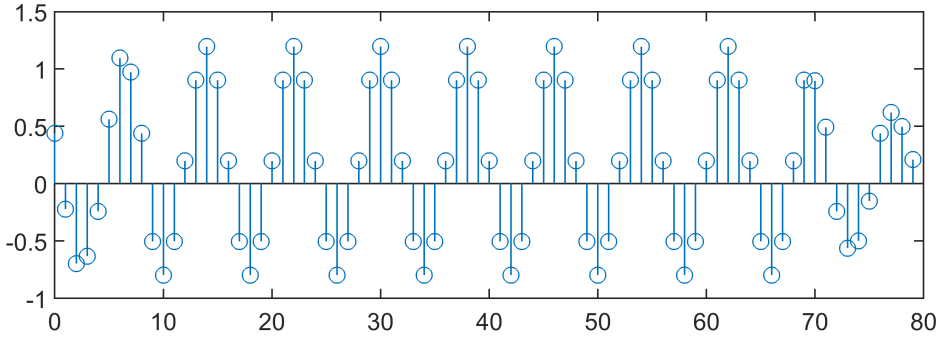
```
function b = gen_filter(w0, L)
    w = -pi:pi /1000: pi;
    b_unit_gain = zeros(1,L);

    for k = 0:L-1;
        b_unit_gain(k+1) = cos(w0*k);
    end;

    H = freq_resp(b_unit_gain, w);
    max_mag = max(abs(H));
    b = b_unit_gain / max_mag;
end
```

```
%c
b = gen_filter(w0, L);
H = freq_resp(b, w);
%d
figure;
subplot(2, 1, 1)
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
subplot(2, 1, 2)
plot(w/pi , angle(H)/pi);
grid on;
title('Phase Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Phase (\\ times \\pi rad)');
```




```
%d
%{
    To find the expression of y[n] analytically, you must convolve x and b.
%}
n = 0:1:79;
x = 2 + cos((pi/4)*n) + cos((3*pi/4)*n + pi/2);
y = conv(x, b, "same");
%e
figure;
subplot(2, 1, 1);
stem(n, x);
subplot(2,1, 2);
stem(n, y);
```



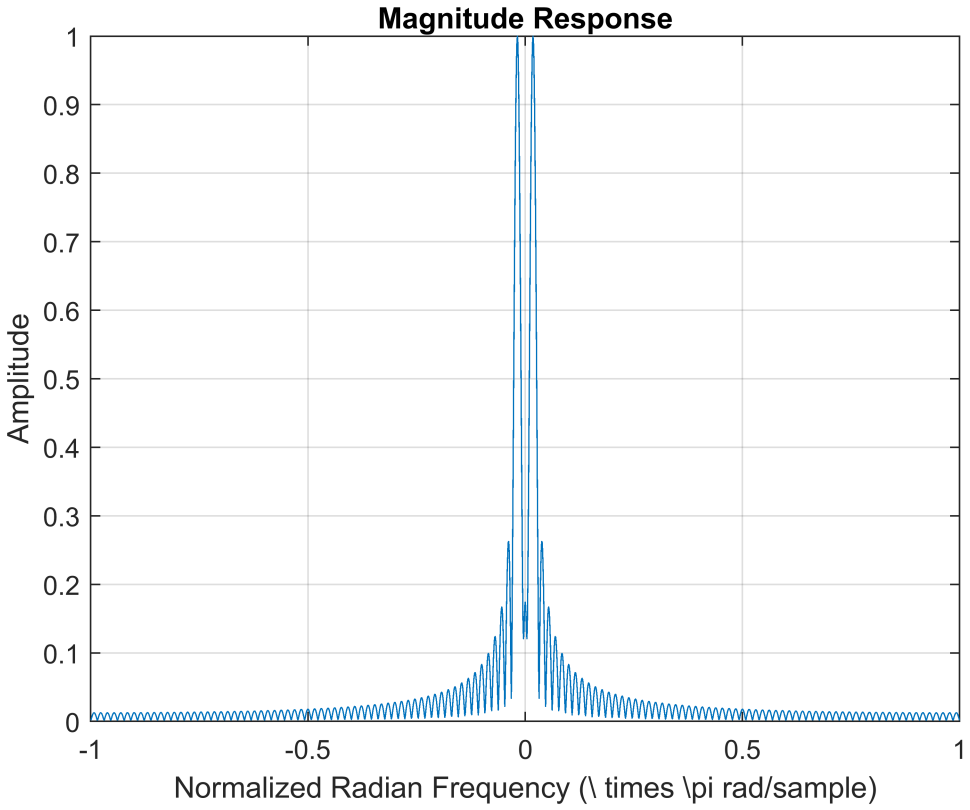



```
%%3.2
%a
type gen_filter_w_info.m
```

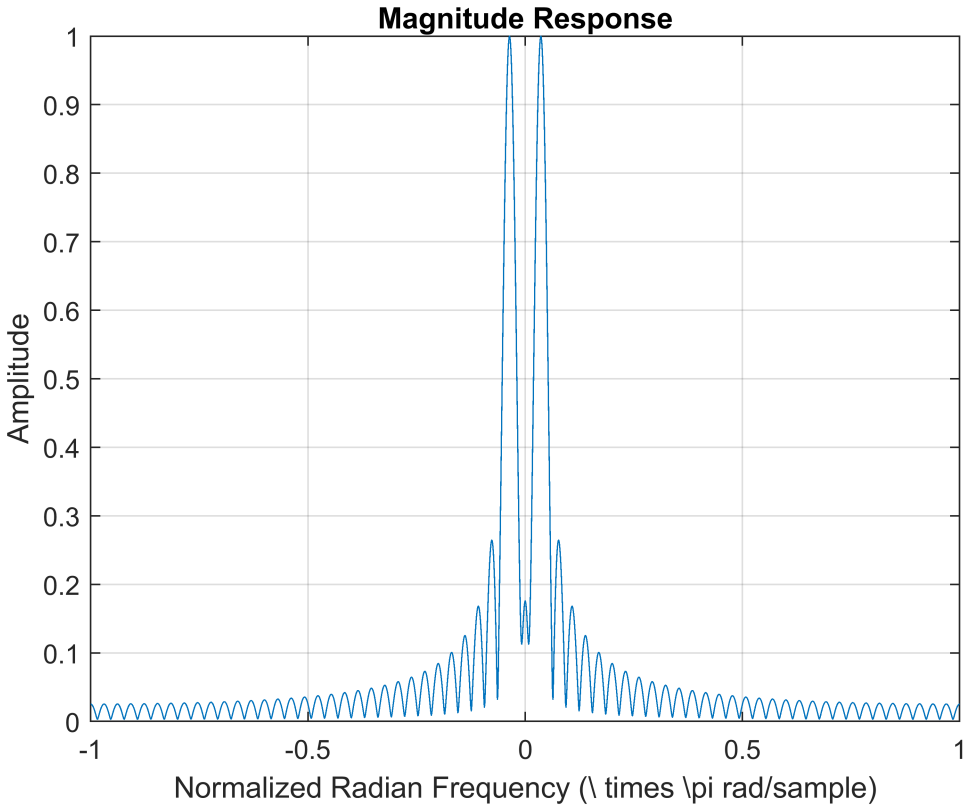
```
function [b, f_start , f_end , bw] = gen_filter_w_info(w0, L);
    w = -pi:pi /1000: pi;
    b = gen_filter(w0, L);
    H = freq_resp(b, w);


    index_passband = find(abs(H) >= 0.7071);
    w_passband = w(index_passband);

    w_passband_positive = w_passband(find(w_passband >= 0));
    f_start = min(w_passband_positive);
    f_end = max(w_passband_positive);
    bw = f_end - f_start;
end
```

```
%b
[b, f_start , f_end , bw] = gen_filter_w_info(w0, 20);
[b_2, f_start_2 , f_end_2 , bw_2] = gen_filter_w_info(w0, 40);
%{
Each time the Lis doubled the bandwidth is halved exponetially
%}

%c
```

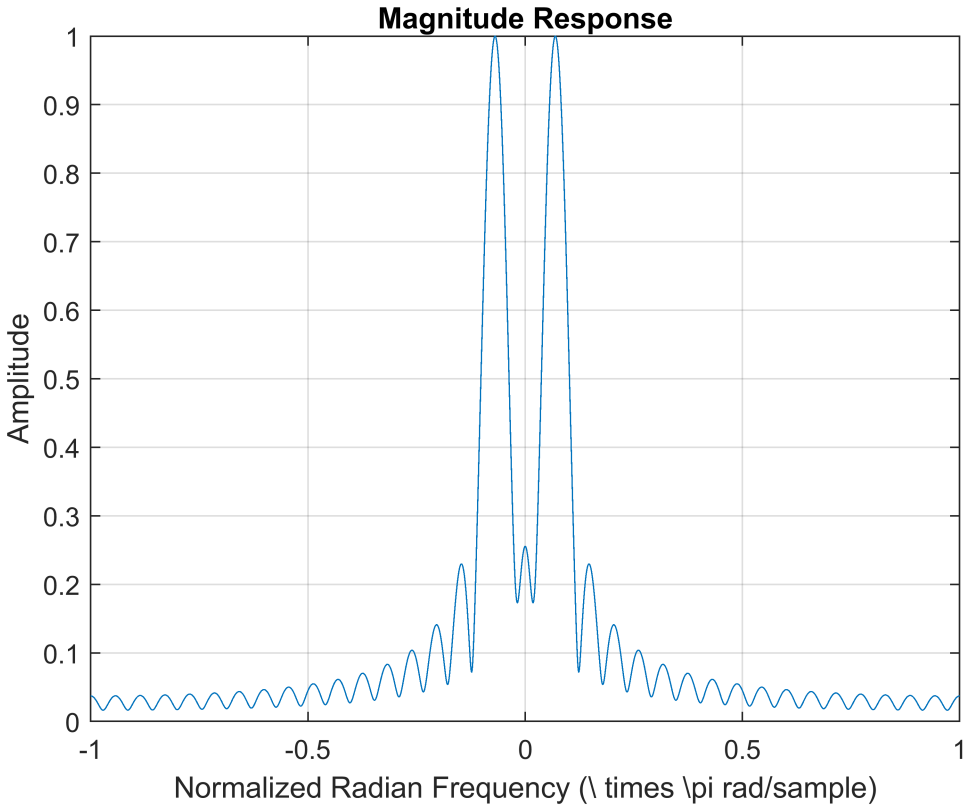
```
% Octave : 2 3 4 5 6 7
% Start key # : 36 48 60 72 84 96
% End key # : 47 59 71 83 95 107
% Start freq (Hz) : 65.4 130.8 261.6 523.3 1046.5 2093.0
% End freq (Hz) : 123.5 246.9 493.9 987.8 1987.5 3951.1
% Center freq (Hz): 94.4 188.9 379.2 755.5 1551.0 3022.0

fs = 11025;
O_Start_f = [65.4 130.8 261.6 523.3 1046.5 2093.0];
O_end_f = [123.5 246.9 493.9 987.8 1987.5 3951.1];
O_center_f = [94.4 188.9 379.2 755.5 1551.0 3022.0];

%{
for i = 1:6
    O_Start_f(i) = (2*pi*O_Start_f(i))/fs;
    O_end_f(i) = (2*pi*O_end_f(i))/fs;
    O_center_f(i) = (2*pi*O_center_f(i))/fs;
end;
%}
O_end_f = O_end_f.*(2*pi)/fs;
O_Start_f = O_Start_f.*(2*pi)/fs;
O_center_f = O_center_f.*(2*pi)/fs;
%%

%d
[b2, f_start2 , f_end2 , bw2] = gen_filter_w_info(O_center_f(1), 130);
figure;
H = freq_resp(b2, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```



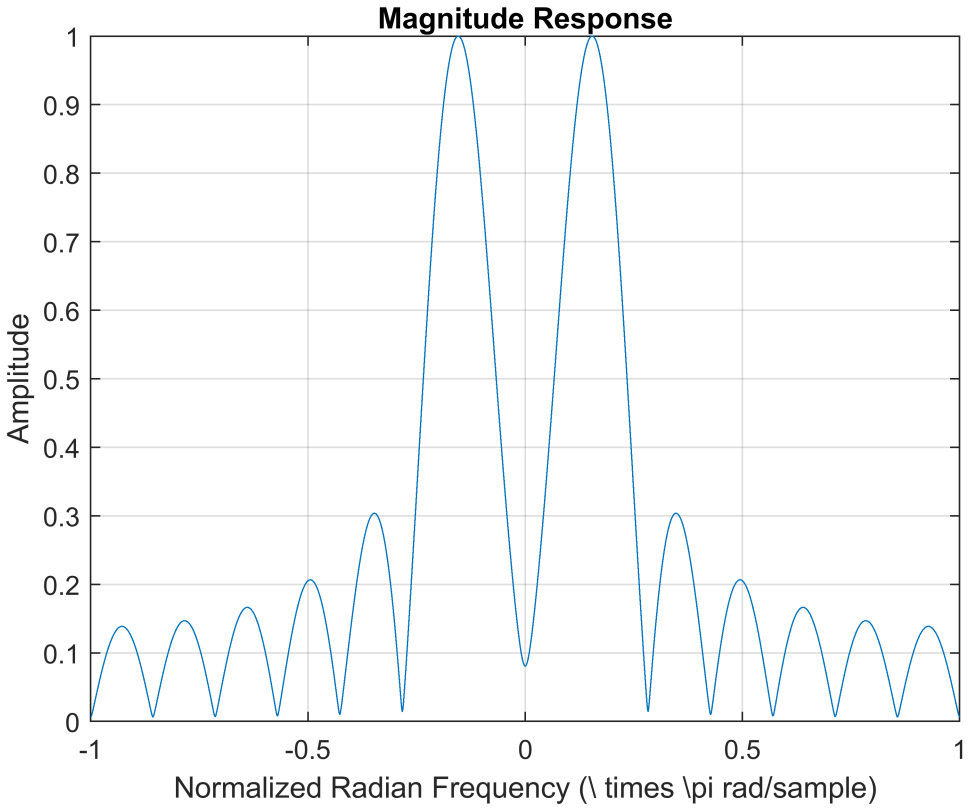

```
[b3, f_start3 , f_end3 , bw3] = gen_filter_w_info(O_center_f(2), 65);
figure;
H = freq_resp(b3, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```



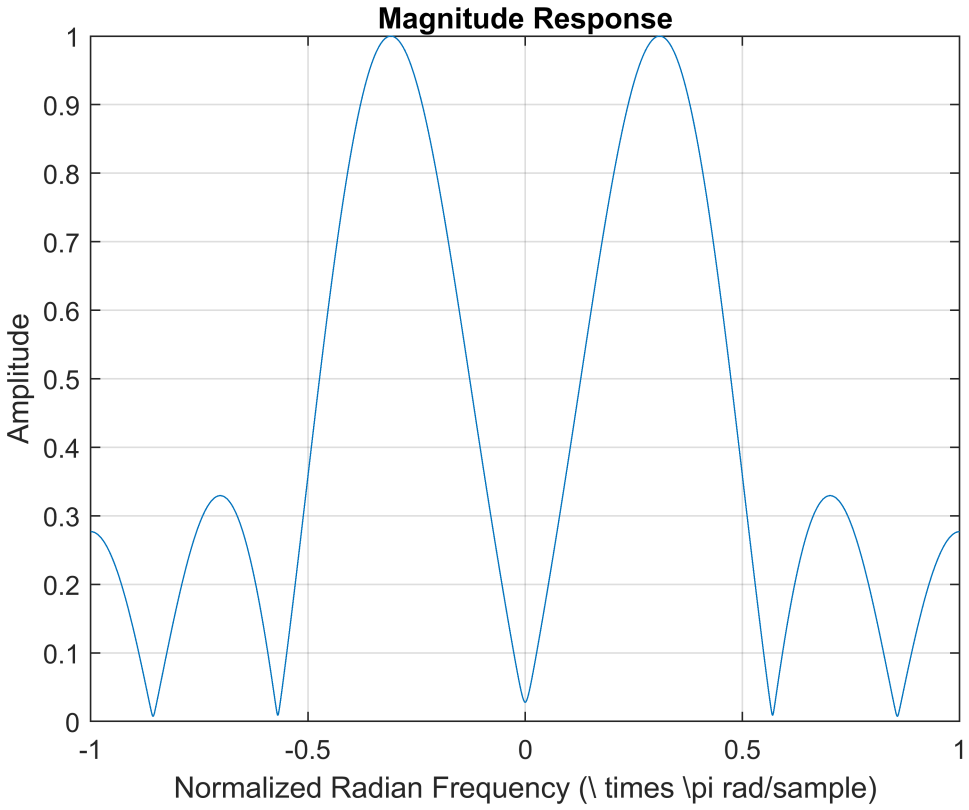

```
%
[b4, f_start4 , f_end4 , bw4] = gen_filter_w_info(O_center_f(3), 35);
%
figure;
H = freq_resp(b4, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```



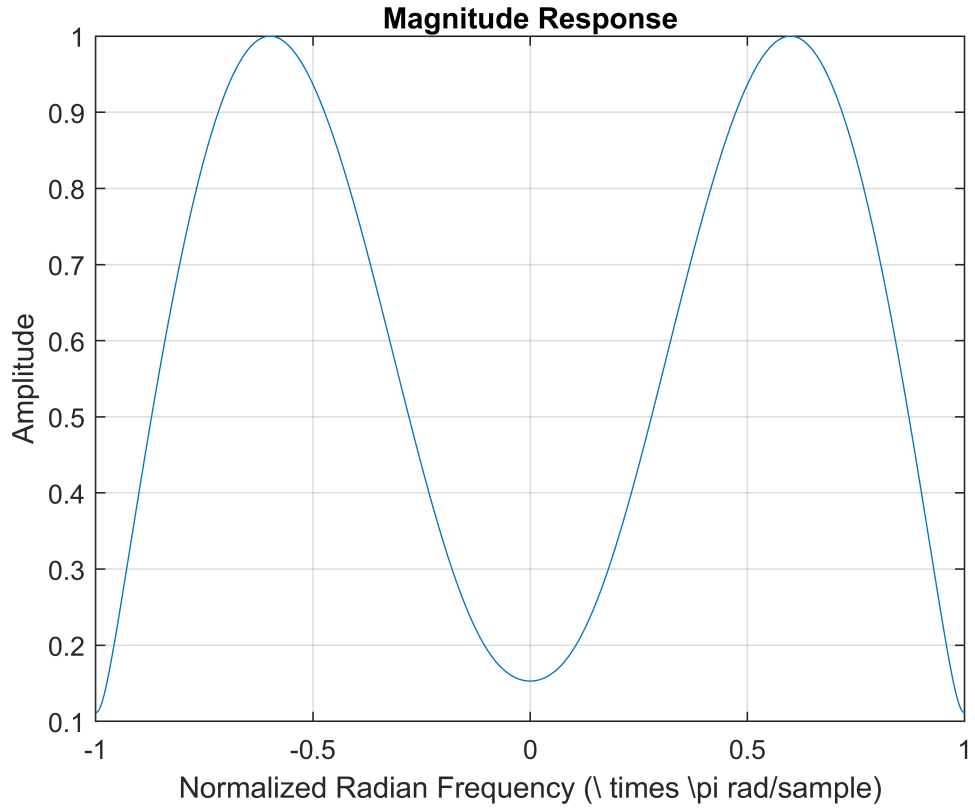

```
[b5, f_start5 , f_end5 , bw5] = gen_filter_w_info(O_center_f(4), 14);
figure;
H = freq_resp(b5, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```




```
[b6, f_start6 , f_end6 , bw6] = gen_filter_w_info(O_center_f(5), 7);
figure;
H = freq_resp(b6, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```




```
[b7, f_start7 , f_end7 , bw7] = gen_filter_w_info(O_center_f(6), 4);
figure;
H = freq_resp(b7, w);
plot(w/pi , abs(H));
grid on;
title('Magnitude Response')
xlabel('Normalized Radian Frequency (\\ times \\pi rad/sample)');
ylabel('Amplitude');
```




```
%e
%{
 Octive 3 filters out the high frequncies while octive 7
 filters out the low frequencies.
%}
[Y, FS] = audioread('x-file.wav');
O3 = conv(b3, Y);
audiowrite('x-file-octave3.wav',O3,FS);
O7 = conv(b7, Y);
audiowrite('x-file-octave7.wav',O7,FS);
```