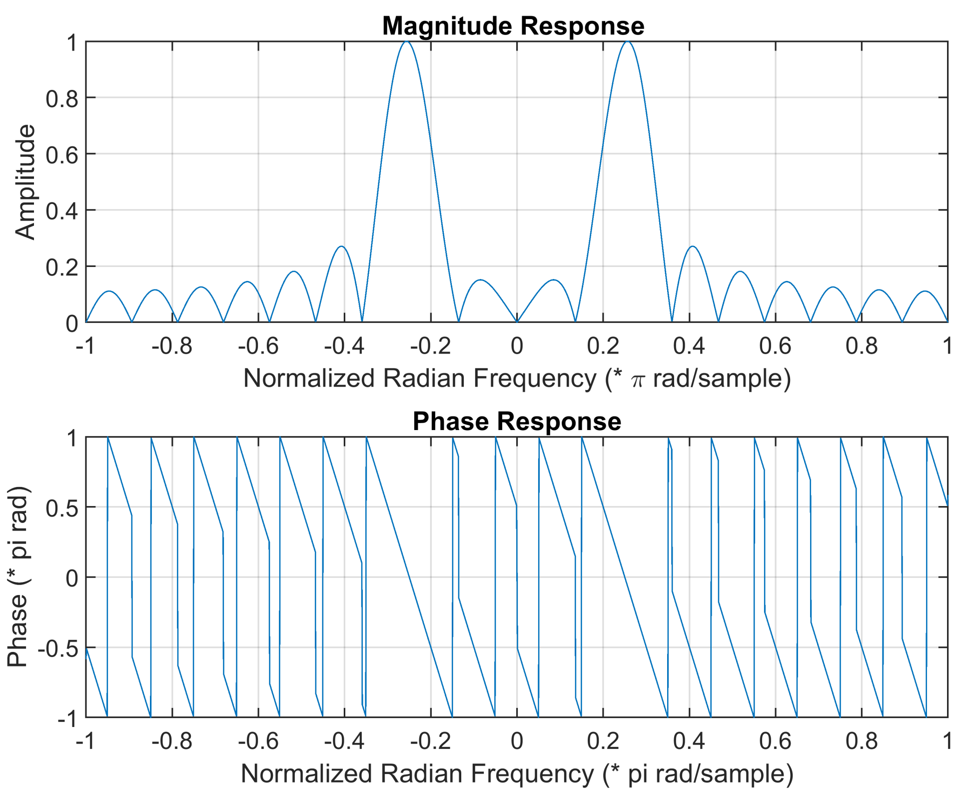
Exercise 5.1

Part A defined as a function freq_resp() below

Part B defined as function gen_filter() below

Part C

```
w = -pi:pi/1000:pi;
w0 = pi/4;
L = 20;
b = gen_filter(w0,L);
H = freq_resp(b,w);
figure(1);
subplot(2, 1, 1)
plot(w/pi , abs(H));
grid on;
title("Magnitude Response ")
xlabel("Normalized Radian Frequency (* \pi rad/sample)");
ylabel("Amplitude");
subplot(2, 1, 2)
plot(w/pi , angle(H)/pi);
grid on;
title("Phase Response")
xlabel("Normalized Radian Frequency (* pi rad/sample)");
ylabel("Phase (* pi rad)");
```



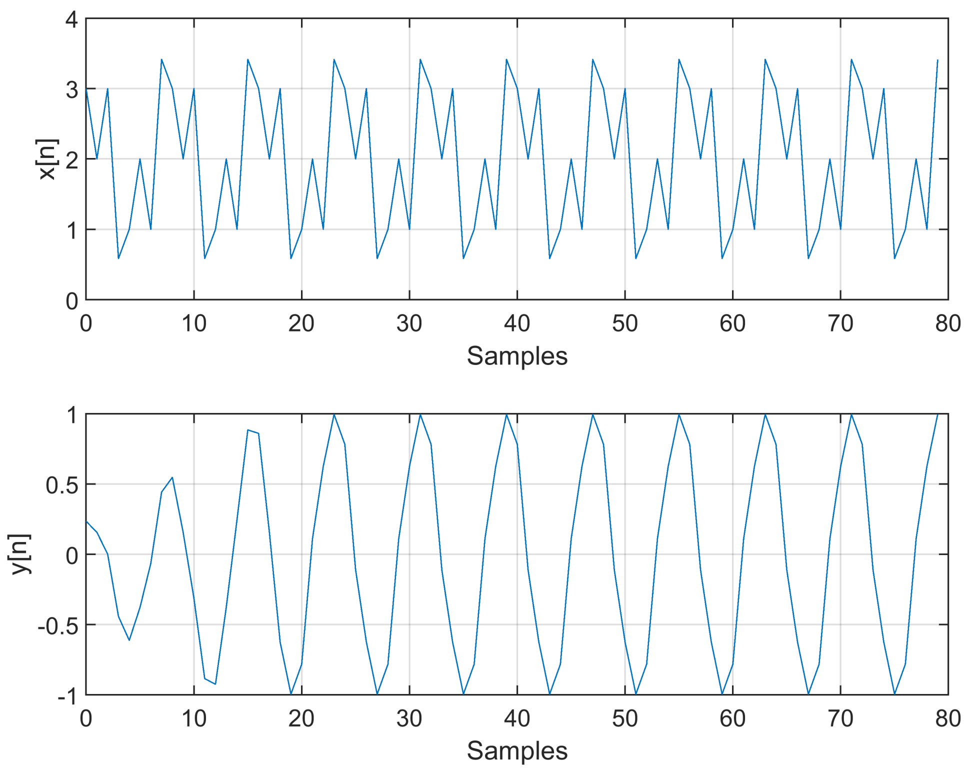
Part D

x[n] = 2 + cos((pi*n)/4)+ cos((3*pi*n)/4 + pi/2)

y[n] = 0 + cos(n * pi/4) (1/10)*cos((3*pi*n)/4 - pi)

Part E

```
n = 0:79;
x = 2 + cos((n*pi)/4) + cos((n*3*pi)/4 + (pi/2));
y = filter(b, 1, x);
figure(2);
subplot(2, 1, 1)
plot(n , x);
grid on;
xlabel("Samples");
ylabel("x[n]");
subplot(2, 1, 2)
plot(n , y);
grid on;
xlabel("Samples");
ylabel("y[n]");
```



EXERCISE 5.2

Part B

```
b = gen_filter_w_info(pi/4, 20);
b = gen_filter_w_info(pi/4, 40);
```

Response: Bandwidth goes up as length goes down

Part C

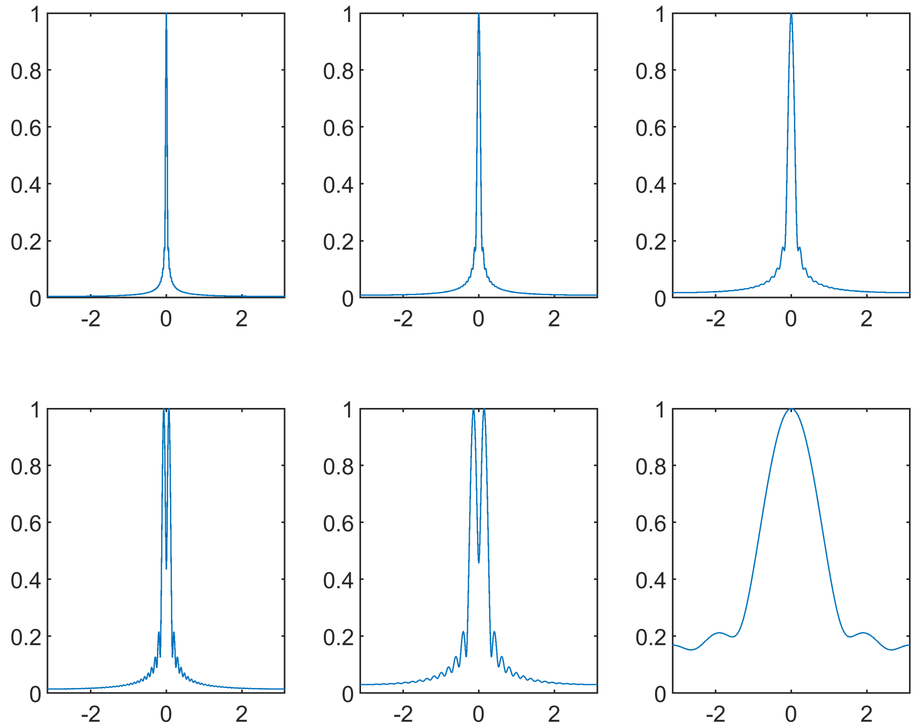
```
fs = 11025;
s_norm_freq = [65.4 130.8 261.6 523.3 1046.5 2093.0] / fs;
e_norm_freq = [123.5 246.9 493.9 987.8 1987.5 3951.1] / fs;
c_norm_freq = [94.4 188.9 379.2 755.5 1551.0 3022.0] / fs;

sdif = zeros(1,6) + 100;
edif = zeros(1,6) + 100;
bis = zeros(1,6);
bie = zeros(1,6);
for i = 1:size(c_norm_freq,2)
    for L = 3:200
        [band, f_s, f_e, bandw] = gen_filter_w_info(c_norm_freq(i),L);
        %Next 8 lines of code identify which value of L results in the
       %smallest difference of frequency from given values
       if (abs(f_s - s_norm_freq(i)) < sdif(i))
           sdif(i) = f_s - s_norm_freq(i);
           bis(i) = L;
       end
       if (abs(f_e - e_norm_freq(i)) < edif(i))
           edif(i) = f_e - e_norm_freq(i);
           bie(i) = L;
       end
    end
end
```

Part D

```
figure(3);
b2 = gen_filter_w_info(c_norm_freq(1), bie(1));
H2 = freq_resp(b2, w);
subplot(2,3,1)
plot(w,abs(H2));
b3 = gen_filter_w_info(c_norm_freq(2), bie(2));
H3 = freq_resp(b3, w);
subplot(2,3,2)
plot(w,abs(H3));
b4 = gen_filter_w_info(c_norm_freq(3), bie(3));
H4 = freq_resp(b4, w);
subplot(2,3,3)
plot(w,abs(H4))
b5 = gen_filter_w_info(c_norm_freq(4), bie(4));
H5 = freq_resp(b5, w);
subplot(2,3,4)
plot(w,abs(H5));
b6 = gen_filter_w_info(c_norm_freq(5), bie(5));
H6 = freq_resp(b6, w);
subplot(2,3,5)
plot(w,abs(H6));
```

```
b7 = gen_filter_w_info(c_norm_freq(6), bie(6));
H7 = freq_resp(b7, w);
subplot(2,3,6)
plot(w,abs(H7));
```



Part E

```
[data_x, fs_x] = audioread("x-file.wav");
y = conv(b3, data_x);
soundsc(y, fs_x);
audiowrite("x-file-octave3.wav", y,fs_x);
```

Sounds much more muffled than the original

```
pause(15);
y = conv(b7, data_x);
soundsc(y, fs_x);
audiowrite("x-file-octave7.wav", y,fs_x);
```

Unable to distinguish from original

FUNCTION DECLARATIONS

EXERCISE 5.1

PART A

```
function H = freq_resp(b, w)
    H = 0;
    for k = 1:size(b,1)
        H = H + b(k) * exp(-1j*w*k);
    end
end
```

PART B

```
function b = gen_filter(w0,L)
   M = L-1;
   b_unit_gain = zeros(M,1);
   for k = 1:M
        b_unit_gain(k) = cos(w0 * k);
   end
   w = -pi:pi/1000:pi;
   H = freq_resp(b_unit_gain, w);
   max_mag = max(abs(H));
   b = b_unit_gain / max_mag;
end
```

EXERCISE 5.2

Part A

```
function [b, f_start, f_end, bw] = gen_filter_w_info(w0, L)
   M = L-1;
   b_unit_gain = zeros(M,1);
   for k = 1:M
        b_unit_gain(k) = cos(w0 * k);
   end
   w = -pi:pi/1000:pi;
   H = freq_resp(b_unit_gain, w);
   max_mag = max(abs(H));
   b = b_unit_gain / max_mag;
   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
```