Problem Set 3

1. A signal is sampled at 500 samples per second. Design a linear phase FIR filter in the least-mean-square sense (Hint: Matlab function `firls`)

$$f_p = 100 \text{ Hz}$$
$$f_s = 150 \text{ Hz}$$
$$\delta_p = 0.1$$
$$\delta_s = 0.001$$

   Plot its frequency response (with amplitude response in dB) , linear scale amplitude response, impulse response, group delay and zeros and poles. You can use `fdatool` if you want to (help `fdatool`).(1 *point*)

2. Design two linear phase FIR differentiators ($H(\omega) = \omega, \omega \in [0, \pi]$) in the least-mean-square sense. Use filter orders $N = 15$ and $N = 31$. Plot the frequency responses (with amplitude responses in dB), linear scale amplitude responses, impulse responses, group delays and zeros and poles. You can use `fdatool` if you want to. Plot also the errors between ideal and designed filter. Try to design differentiators with $N = 16$ and $N = 32$. What can you notice and why?(2 *points*)

3. Design two linear phase FIR Hilbert transformers, passband between 0.05π and 0.95π in the least-mean-square sense. Use filter orders $N = 7$ and $N = 8$. Plot the frequency responses (with amplitude responses in dB), linear scale amplitude responses, impulse responses, group delays and zeros and poles. You can use `fdatool` if you want to. Plot also the errors between ideal and designed filter.(1 *point*)

4. Design a linear phase FIR filter in least-mean-square sense. Filter specifications are:

$$H(\omega) = 1 - \omega \qquad \omega \in [0, \pi]$$

   Try different filter orders. Plot the frequency responses (with amplitude response in dB), linear scale amplitude response, impulse responses, group delays and zeros and poles. You can use `fdatool` if you want to. Plot also the errors between ideal and designed filter.(1 *point*)