# Homework 1

ELEN0071 University of Lige, Spring 2019

Due: Wednesday 06/03/2019 11:59pm

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*Instructions:* Name your homework report `LastName1_LastName2_LastName3_homework1.pdf` (in alphabetical order). Submit your homework report on the Montefiore submission platform (`http://submit.montefiore.ulg.ac.be`).

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**1. Magnitude response of a filter.** Consider a filter with the transfer function

$$H(z) = \frac{b_0}{[1 - 2r\cos(\omega_0)z^{-1} + r^2 z^{-2}]^K}$$

with $K = 8$, $r = 0.9$, $b_0 = 5.3936 \times 10^{-7}$.

(a) Plot the magnitude response $|H(e^{j\omega})|$ for $\omega_0 = \frac{\pi}{3}$.

(b) Plot the magnitude response $|H(e^{j\omega})|$ for $\omega_0 = \frac{2\pi}{3}$.

(c) Explain clearly the main effect of the variation of $\omega_0$ to the magnitude response.

In your plots, the magnitude response should be expressed in dB and the normalized angular frequency should be scaled by $\pi$ and expressed in ($\times\pi$ rad/sample).

**Hint:** $H(z)$ could be treated as a cascade of $K$ second-order filters.

**2. Autocorrelation of a single echo.** A single echo $y[n]$ is generated using the FIR filter

$$y[n] = x[n] + ax[n - D], \qquad -1 < a < 1,$$

where $x[n]$ is the original sound, $D$ is the round-trip delay, and $a$ is the attenuation factor due to propagation and reflection.

Develop an expression for the autocorrelation $r_y[l]$ in terms of the autocorrelation $r_x[l]$, $D$ and $a$.

**3. Echo cancelation.** The file `hw1_echo.wav` contains a single echo (see exercice 2).

(a) Play the sound, plot its corresponding autocorrelation function, find the delay $D$ expressed in number of sampling intervals and the equivalent delay $\tau$ expressed in seconds.

(b) Assume the amplitude of the reflected sound is sixty percent of the emitted one ($a = 0.6$). Design a filter to remove the echo from the signal, then test your filter. Explain clearly the design procedure.

Your answer should include the filter coefficients (numerator and denominator), e.g. a or b = [1, zeros(1,d-1), +alpha].