EE 473 HW 1 (Fall 2019)

- Homework is due **October 17, Thursday!**

1: *Reading.* So far we have covered Chapter 2 in Oppenheim and Schafer. Note that these are essentially EE 373 material, and all we did was a quick overview of the more important topics. If you don't feel confident about your current level of knowledge, do read the book.

2: *Math and Matlab.* The impulse response of the moving-average (MA) system is

$$h[n] = \frac{1}{M_1 + M_2 + 1}, \; n = -M_1, \ldots, -1, 0, 1, \ldots, M_2.$$

(a) Derive the frequency response. Your answer should contain only one complex exponential!

(b) Plot the magnitude response for $M_1 = 0$ and $M_2 = 4$. What sort of spectral behavior do you observe? Explain how this frequency-domain behavior agrees with impulse response of MA.

(c) Plot the phase response for $M_1 = 0$ and $M_2 = 4$. Is MA a phase-distorting system?

3: *Math and Matlab.* Consider the following system:

$$y[n] - 1.8\cos\left(\frac{\pi}{16}\right) y[n-1] + 0.81 y[n-2] = x[n] + \frac{1}{2}x[n-1]. \tag{1}$$

(a) Using Matlab, generate and plot the impulse response that corresponds to eq. (1) in the range $n = -10, \ldots, 100$.

(b) Determine the impulse response analytically and confirm your results.

(c) Compute (Matlab) the response of the system to $x_1[n] = e^{j\pi n/3}u[n]$. What is the output as $n \to \infty$?

(d) Let $H_{\text{ss}}(e^{j\omega})$ be the steady-state frequency response of the system to $x_1[n]$ given in (c). In other words,

$$\lim_{n\to\infty} \left(y[n] - H_{\text{ss}}(e^{j\omega})e^{j\omega n} \right) = 0. \tag{2}$$

Using eq. (2) and <u>without</u> taking the discrete-time Fourier transform, derive $H_{\text{ss}}(e^{j\omega})$. Note that since all transients die out in the steady-state, $H_{\text{ss}}(e^{j\omega}) = H(e^{j\omega})$, i.e., $H_{\text{ss}}(e^{j\omega})$ is the good old frequency response as we know it.

(e) Plot the magnitude and phase of $H(e^{j\omega})$.

(f) Determine the transient response, and plot it for $n = 0, \ldots, 30$. Does it really look transient based on the first 31 values?

Lesson Learned: When dealing with an unknown system, one experimental approach to finding the frequency response is to let the system run long enough, collect steady-state measurements at different frequencies, and then plot the data.