Full Name: ____

EEL 4750 / EEE 5502 (Fall 2021) – HW #5 **Due: 4:00 PM ET, Sept. 27, 2021**

Concept Questions 5

Question #1: Complete the Canvas questions here: `https://ufl.instructure.com/courses/437179/assignments/4812578/`

Theory Questions 5

Question #1: Consider an impulse response $h[n]$ for an FIR system.

(a) Let the coefficients of $h[n]$ be **even** symmetric around some value of n (i.e., it does not have to be symmetric around $n = 0$). Show that this system has a linear phase.

(b) Let the coefficients of $h[n]$ be **odd** symmetric around some value of n (i.e., it does not have to be symmetric around $n = 0$). Show that this system has a linear phase. (Note: you can just explain how your previous proof changes)

Question #2: For the transfer functions or frequency responses below, **sketch** the magnitude response and phase response over $-\pi \le \omega \le \pi$ for the following frequency responses.

(a) $H(z) = z^{-3}$

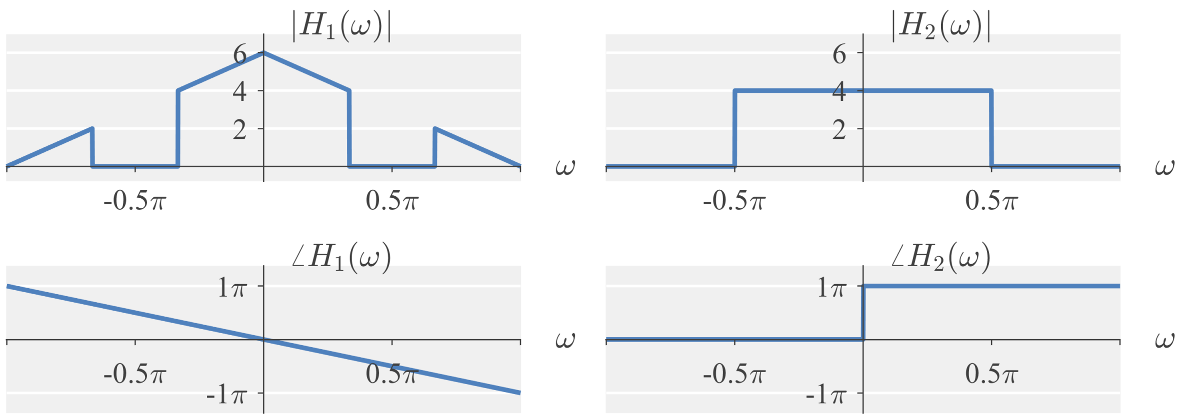
(b) $H(\omega) = \left[\sum_{k=-\infty}^{\infty} u(\omega + \pi/4 - 2\pi k) - u(\omega - \pi/4 - 2\pi k)\right] e^{-j3\omega} + e^{+j3\omega}$

Question #3: For the magnitude and phase responses of $H_1(\omega)$ and $H_2(\omega)$ shown below, **sketch** the magnitude response and phase response over $-\pi \le \omega \le \pi$ for the following frequency responses.

(a) $H(\omega) = H_1(\omega)H_2(\omega)$

(b) $H(\omega) = H_2(\omega)\, e^{-j\omega}$

(c) $H(\omega) = -H_1(\omega)$



Implementation Questions 5

Question #1: Use functions from previous assignments to plot the impulse response, magnitude response, phase response, and pole-zero plot for the transfer functions below (Note: `DTFT` and `pzplot` functions are provided). Let n be defined by `m` and ω be defined in the template script.

(a) $H_a(z) = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4}$

(b) $H_b(z) = 1 - z^{-1}$

(c) $H_c(z) = \dfrac{1}{1 + 0.75z^{-1}}$

(d) $H_d(z) = \dfrac{1}{\left(1 - 0.75e^{-j(\pi/4)}z^{-1}\right)\left(1 - 0.75e^{+j(\pi/4)}z^{-1}\right)}$

(e) $H(z) = H_a(z)H_b(z)H_d(z)$ [1]

Question #2: Use your knowledge of pole-zero plots and transfer functions to design the following types of filters. You may design them however you want (assuming you satisfy the requirements).

(a) Design the pole and zero locations for a high-pass filter with a cut-off frequency at approximately $\omega_c = \pi/4$ (i.e., where we transition from stop-band to pass-band) and a small transition band. (If your transition band is not small enough, your solution may not give you a full score).

(b) Design the pole and zero locations for a band-pass filter that passes frequencies around $\omega_1 = \pi/6$ and $\omega_2 = \pi/2$.

(c) Design the pole and zero locations for an all-pass filter such that $\angle H(z) \neq 0$.

Question #3: (*Finding a hidden signal buried in a frequency*) Oftentimes we want to find small signals (e.g., a face) buried in larger signals (e.g., a picture). The correlation operation gives us the tools to accomplish this. And sometimes, these small signals are buried in **huge** amounts of interference (e.g., 60 Hz interference from electrical systems).

Use the `load` command to load a noisy signal called `messsage` with a smaller signal called `code`, which is found somewhere in the message. The `message` variable is corrupted by several strong frequencies. Use filtering (from this HW) followed by correlation (from HW #2) to find at which index the code begins in the message (Note: you have to determine the interfering frequencies).

Find at which index the code begins in the message

[1] Note: You do not need to do math – remember what multiplication in Z-domain represents. Also, we have included two functions at the end of the template that may help you: `ba2pz` and `pz2ba`.