Full Name: _____

EEL 4750 / EEE 5502 (Fall 2018) – HW #07 **Due Date: Oct. 12, 2018**

Homework learning objectives: By the end of this homework, you should be able to:

- Compute the DFT of a signal
- Solve for the magnitude and phase of a transfer function
- Obtain the output for a system

Question #1: *(1 pts)* How many hours did you spend on this homework?

Question #2: *(16 pts)* Consider the length-4 signal $x[n]$ with values

$$[1 \quad 1 \quad 0 \quad 0]$$

Also, consider the length-4 signal $y[n]$ with values

$$[1 \quad 0 \quad 0 \quad 1]$$

(a) Sketch the length-4 signals $x[n]$ and $y[n]$.

(b) Sketch $x[n] \circledast y[n]$.

(c) Compute the length-4 discrete Fourier transform (DFT) of $x[n]$ to get $X[k]$.

(d) Sketch the length-4 magnitude of the DFT $|X[k]|$.

(e) Sketch the length-4 phase of the DFT $\angle X[k]$.

(f) Compute the length-4 discrete Fourier transform (DFT) of $y[n]$ to get $Y[k]$.

(g) Sketch the length-4 magnitude of the DFT $|Y[k]|$.

(h) Sketch the length-4 phase of the DFT $\angle Y[k]$.

(i) Explain the similarities and difference between $|X[k]|$, $|Y[k]|$, $\angle X[k]$, and $\angle Y[k]$.

Question #3: *(18 pts)* Consider the length-4 signal $x[n]$ with values

$$[1 \quad -1 \quad 1 \quad -1]$$

(a) Compute the length-4 discrete Fourier transform (DFT) of $x[n]$ to get $X[k]$

(b) Compute the length-2 DFT of the even values of $x[n]$ (i.e., $x[2n]$) to get $X_e[k]$.

(c) Compute the length-2 DFT of the odd values of $x[n]$ (i.e., $x[2n+1]$) to get $X_o[k]$.

(d) Show that $X[k]$ is periodic with a fundamental period of 4.

(e) Show that $X_e[k]$ and $X_o[k]$ are periodic with a fundamental periods of 2.

(f) Show that for $X_e[k]$ and $X_o[k]$ above that $X[k] = X_e[k] + e^{-j(2\pi/4)k} X_o[k]$ and is now periodic with a fundamental period of 4. This is the basic building block of the fast Fourier transform.

Question #4: *(20 pts)* Consider $y[n] = x[n] - x[n-1]$, representing a causal LTI system.

(a) Determine the systems poles and zeros. Sketch the pole-zero plot for the system.

(b) Compute the z-transform of the system impulse response $H(z)$.

(c) Sketch the [frequency] magnitude response $|H(\omega)|$ for the system for $4\pi \leq \omega \leq 4\pi$.

(d) Compute the [frequency] [phase] response $\angle H(\omega)$ for the system.

(e) Sketch the [frequency] phase response for the system for $4\pi \leq \omega \leq 4\pi$.

(f) Would you describe this filter as a low pass, bandpass, high pass, or all pass filter?

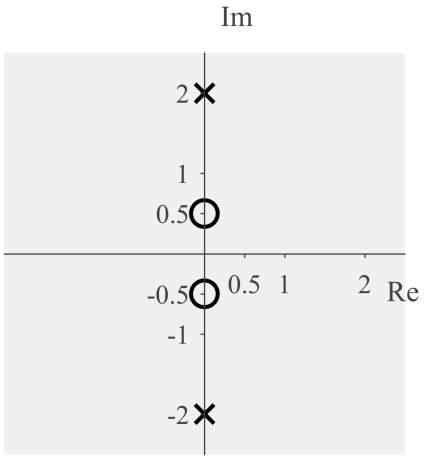
(g) Is this system invertible (i.e., is the inverse stable?)?

(h) Is this a minimum phase system?

(i) Compute the output of $x[n] = 10$.

(j) Compute the output of $x[n] = 10 + 5\cos(\pi/3n) + 13\cos(\pi)$.

Question #5: *(14 pts)* Consider the following pole-zero plot, representing a causal LTI system.



(a) Compute the DTFT of the system impulse response $H(\omega)$.

(b) Sketch the [frequency] magnitude response $|H(\omega)|$ for the system for $4\pi \leq \omega \leq 4\pi$.

(c) Would you describe this filter as a low pass, bandpass, high pass, or all pass filter?

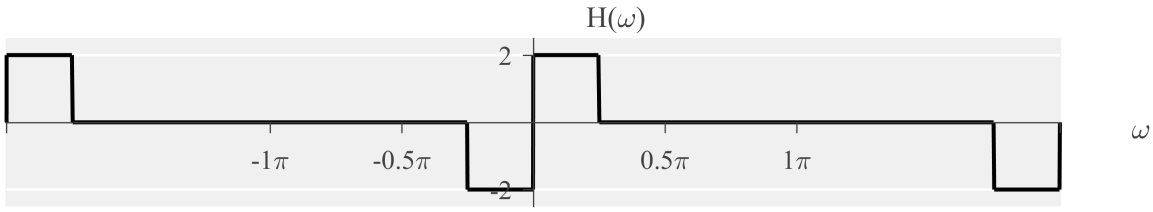
(d) Is this system invertible (i.e., is the inverse stable?)?

(e) Is this a minimum phase system?

(f) Compute the output of $x[n] = 10$.

(g) Compute the output of $x[n] = 5\cos(\pi/3n + \pi/2)$.

Question #6: *(16 pts)* Consider the following DTFT frequency response $H(\omega)$, representing a causal LTI system.



(a) Sketch the [frequency] magnitude response for the system for $2\pi \leq \omega \leq 2s\pi$.

(b) Sketch the [frequency] phase response for the system for $2\pi \leq \omega \leq 2\pi$.

(c) Would you describe this filter as a low pass, bandpass, high pass, or all pass filter?

(d) Compute the output of $x[n] = 5\cos(\pi/3n + \pi/2)$.

(e) Compute the output of $x[n] = 10 + 5\cos(\pi/3n + \pi/2) + 13\cos(\pi)$. Assume $H(0) = 2$.

(f) Is this system invertible (i.e., is the inverse stable?)?

(g) Sketch the magnitude response for $g[n] = h[n]\cos(\pi n)$. Would you describe this filter as a low pass, bandpass, high pass, or all pass filter?

(h) Sketch the magnitude response for $g[n] = h[n]\cos((\pi/2)n)$. Would you describe this filter as a low pass, bandpass, high pass, or all pass filter?

Question #7: *(5 pts) Project (EEE 5502 only)*

(a) For students in EEE 5502 whom are pursuing advanced degrees, I want to ensure you experience and learn about some modern signal processing trends and techniques. Therefore, your final project report will discuss a "hot" topic in signal processing and its relationship to our class. To identify a "hot" topic, identify one paper from the IEEE Signal Processing Magazine's top 50 articles (`http://ieeexplore.ieee.org/xpl/topAccessedArticles.jsp?punumber=79`). This paper will serve as the foundation for your report. The IEEE Signal Processing Magazine publishes papers on hot signal processing topics that are geared toward an audience with a good, but not necessarily expert, knowledge of digital signal processing. As a result, it is a good place to start to come up with ideas for your report.

In the comments to your homework submission on Canvas, provide a link to your chosen paper from the IEEE Signal Processing Magazine's top 50 articles.