ECE 5210 Midterm 2

Week of: March 20, 2023

Student's name: ____

Instructor:
Eric Gibbons
ericgibbons@weber.edu
801-626-6861

You have 2 hours for 5 problems.

- Show enough (neat) work in the clear spaces on this exam to convince us that you derived, not guessed, your answers.
- Put your final answers in the boxes at the bottom of the page.

You are allowed TWO pages of notes (front and back) for this exam. You may use a graphing calculator of your choice. Consulting with any third party is considered cheating.

Problem	Score	Possible Points
1		20
2		20
3		20
4		20
5		20
Total score		100

1 Short answer

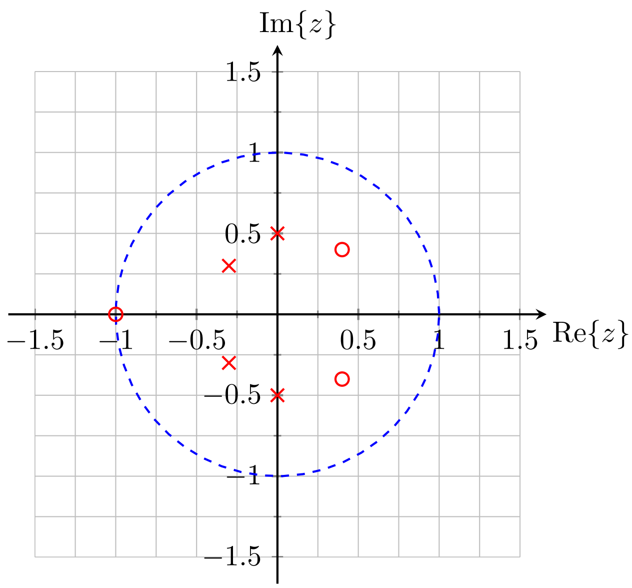
(a) The signal

$$x_c(t) = \sin(2\pi(200)t)$$

was sampled with a sampling period $T = 1/400\,\mathrm{s}$ to obtain a discrete-time signal $x[n]$. What is the resulting sequence $x[n]$?

$x[n] =$

(b) Consider the pole-zero plot for some system $H(z)$.



(i) Is the system stable?

yes no

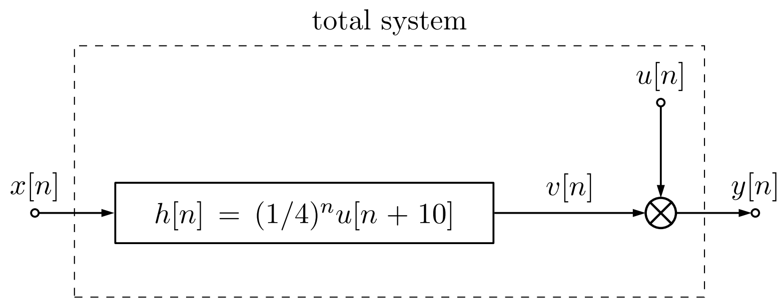
(ii) Does the system have minimum phase?

yes no

(iii Does the system have linear phase?

yes no

(a) Consider the system illustrated below. The output of an LTI system response $h[n] = \left(\frac{1}{4}\right)^n u[n+10]$ is multiplied by a unit step function $u[n]$ to yield the output of the overall system (enclosed in dashed line).



(i) Is the overall system LTI?

yes	no

(ii) Is the overall system causal?

yes	no

(iii) Is the overall system BIBO stable?

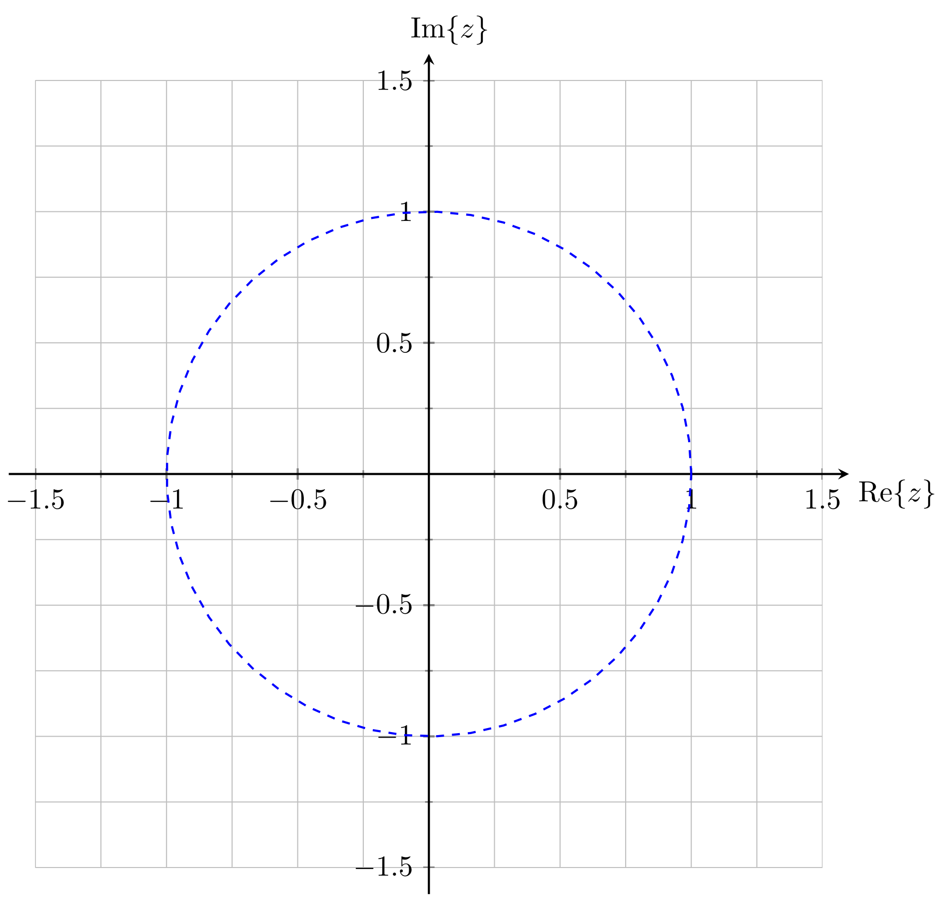
yes	no

2 Minimum phase and all-pass systems

Consider the FIR system

$$H(z) = (1 + z^{-1}) \left(1 - 1.6 \cos\left(\frac{\pi}{4}\right) z^{-1} + 0.64 z^{-2}\right) \left(1 - 2.5 \cos\left(\frac{\pi}{3}\right) z^{-1} + 1.5625 z^{-2}\right).$$

(a) On the complex plane below, plot every pole as an "×" and every zero as an "∘".



(b) If this is a linear phase system, indicate which type.

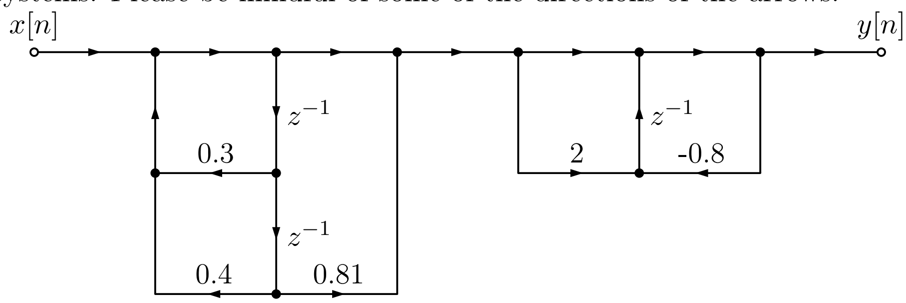
Type I	Type II	Type III	Type IV	Not linear phase

(c) Decompose this system to a minimum phase system $H_{\text{min}}(z)$ and an all-pass system $H_{\text{ap}}(z)$.

$H_{\text{min}}(z) =$	$H_{\text{ap}}(z) =$

3 Signal flow

A causal LTI system is define by the signal flow graph shown below, which represents the system as a cascade of systems. Please be mindful of some of the directions of the arrows.



(a) What is the transfer function $H(z)$ of the overall cascade system?

$H(z) =$

(b) Is the overall system stable? Justify your answer.

Circle one: stable unstable

(c) Is the overall system a minimum-phase system? Justify your answer

Circle one:	minimum phase	not minimum phase

(d) Draw the signal flow graph of the direct form II implementation.

4 Interpolation

Consider the system below where $y_0[n]$ and $y_1[n]$ are generated by the difference equations

$$y_0[n] = x[n] - 2x[n-1] + x[n-2]$$
$$y_1[n] = 1.5x[n] + 1.5x[n-1]$$

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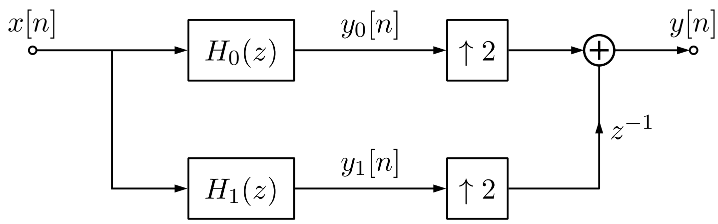
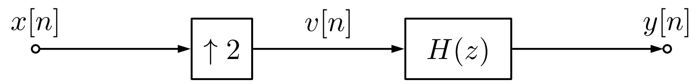


(a) Find expressions for $H_0(z)$ and $H_1(z)$.

$H_0(z) =$ $H_1(z) =$

(b) The decimation filter can also be implemented as shown below. Find $H(z)$.



$H(z) =$

(c) In the implementation above, $v[n] = a_0 x[n] + a_1 x[n-1] + a_2 x[n-2] + a_3 x[n-3] + a_4 x[n-4]$. Find a_k for $k = 0, 1, \ldots, 4$

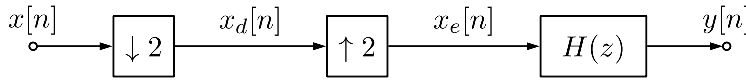
$a_0 =$ $a_1 =$ $a_2 =$ $a_3 =$ $a_4 =$

(d) For the systems in parts (a) and (b), how many multiplies will the systems require to process one input sample?

a: b:

5 Decimation and interpolation

Consider the system below. For each of the following input signals $x[n]$ determine $y[n]$.



The system $H(z)$ has a frequency response from $-\pi < \omega \leq \pi$

$$H\left(e^{j\omega}\right) = \begin{cases} 2 & |\omega| < \pi/2 \\ 0 & \text{else.} \end{cases}$$

Hint: It might be helpful to think about what the DTFT $X(e^{j\omega})$ of each of the signals.

(a) $x[n] = \cos\left(\frac{\pi n}{4}\right)$

$y[n] =$

(b) $x[n] = \cos\left(\frac{5\pi n}{4}\right)$

$y[n] =$

(c) $x[n] = \frac{\sin\left(\frac{\pi n}{3}\right)}{\pi n}$

$y[n] =$