

# ECE 5210 Midterm 2

*Week of: March 24, 2021*

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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
<b>Total score</b>		100

## 1 Short answer

- (a) Is the following transfer function already a minimum phase system?

$$H(z) = \frac{1 - 4z^{-1} + 4z^{-2}}{(1 - 0.3z^{-1})(1 - j0.8z^{-1})(1 + j0.8z^{-1})}$$

- (b) In the Python 05 assignment we looked at a cubic spline interpolation filter. It was defined as

$$h_i[n] = \begin{cases} (a+2) \left| \frac{n}{L} \right|^3 - (a+3) \left| \frac{n}{L} \right|^2 + 1 & 0 \leq n \leq L \\ a \left| \frac{n}{L} \right|^3 - 5a \left| \frac{n}{L} \right|^2 + 8a \left| \frac{n}{L} \right| - 4a & L < n \leq 2L \\ 0 & \text{else} \end{cases}$$

What type of linear phase FIR filter is this? (Circle one.)

type I	type II	type III	type IV
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- (c) Suppose you have a signal that you have quantized that has an  $SNR_Q$  of 90 dB but you really want 105 dB. How many bits would you need to add to your quantization?

- (d) Given the following impulse response function  $h[n]$  for some system  $H(z)$ , is this system FIR or IIR?

$$h[n] = (0.9)^n u[n]$$

FIR	IIR
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- (e) Are the COVID-19 vaccines safe and effective based on Phase 3 results? (*Hint: they are.*)

- (f) When are you eligible to get vaccinated in the State of Utah? (*Hint: today.*)

- (g) According to real-world data from the UK and Israel's mass-vaccination campaigns, how effective are the vaccines at keeping you out of the hospital or the morgue? (*Hint: extremely.*)

- (h) Where can you get vaccinated? (*Hint: you can sign up at [vaccinate.utah.gov](https://vaccinate.utah.gov) and get an appointment at the Dee Events Center. Or you can find other locations at [vaccinefinder.org](https://vaccinefinder.org)*)

- (i) How much does vaccination cost? (*Hint: it is free.*)

- (j) Why is it important to get vaccinated? (*Hint: we need to build up community immunity—otherwise we will be socially distancing or wearing masks for the foreseeable future.*)

- (k) Will Dr. Gibbons respect you more as a citizen in the university community if you get vaccinated? (*Hint: likely.*)

- (l) Will you get free donuts from Krispy Kreme for the rest of 2021 if you are vaccinated? (*Hint: yes.*)

## 2 Signal flow

Consider a causal LTI system given by

$$H(z) = \frac{1 + 0.875z^{-1}}{(1 + 0.2z^{-1} + 0.9z^{-2})(1 - 0.7z^{-1})}.$$

- (a) Draw a signal flowgraph for this system using a cascade of first and second-order systems realized in direct form II.

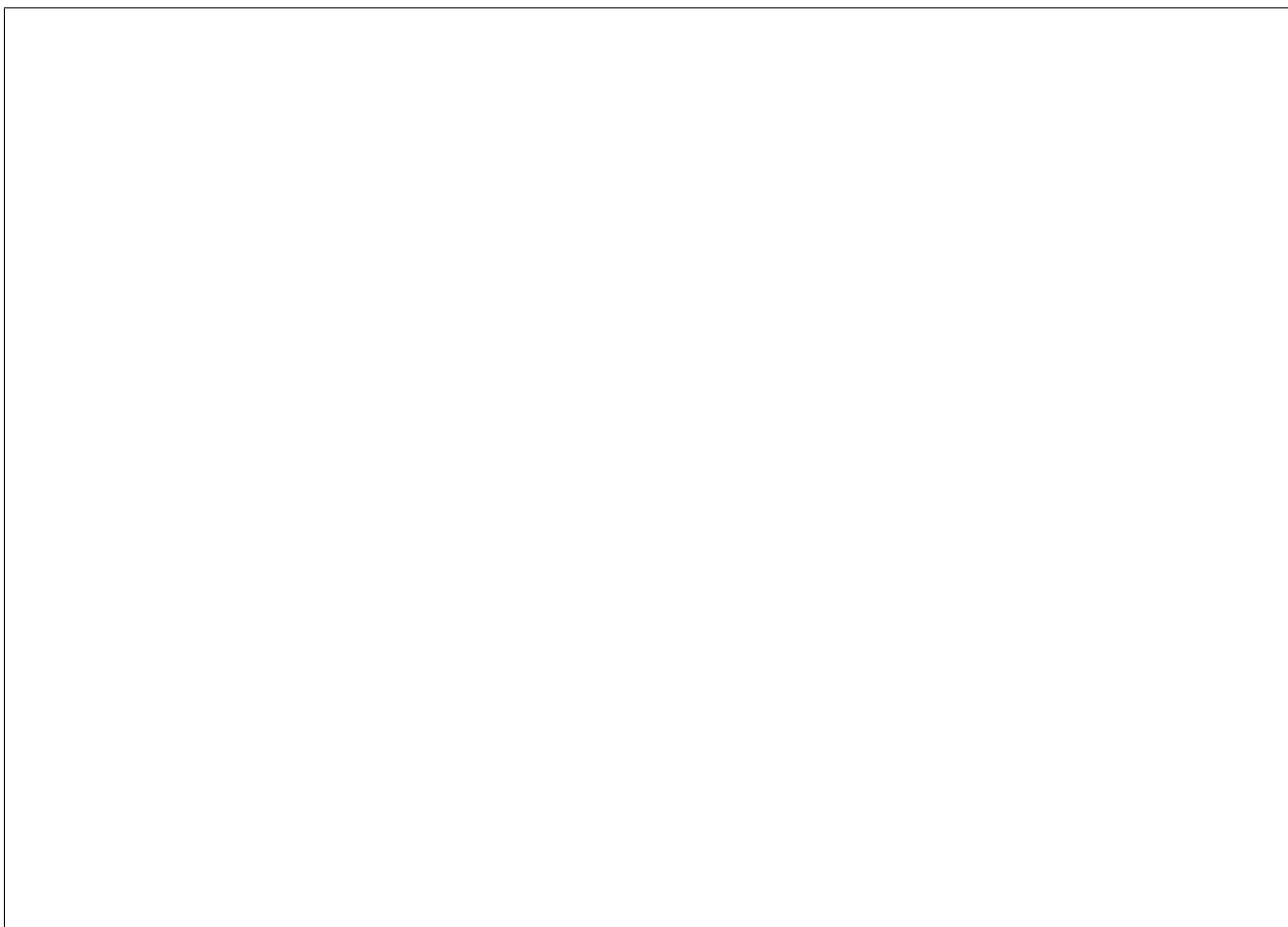
- (b) Draw a signal flowgraph for this system using a parallel connection of first and second-order systems realized in direct form II.

### 3 Frequency response

Consider the following system function  $H(z)$ .

$$H(z) = \frac{(1 + 3z^{-1})(1 - 0.5z^{-1})}{z^{-1}(1 + 0.4z^{-1})}.$$

- (a) Sketch the poles and zeros on the  $z$ -plane.



- (b) Find the decomposition of  $H(z)$  such that

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

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

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

#### 4 FIR linear phase filters

An FIR linear phase filter has a unit sample response that is real with  $h[n] = 0$  for  $n < 0$  and  $n > 7$ . If  $h[0] = 1$  and the system has a zero at  $z = 0.4e^{j\pi/3}$  and a zero at  $z = 3$ , what is  $H(z)$ ?

Your work, continued...

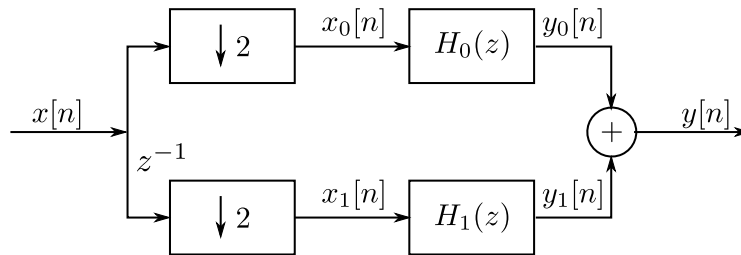
$H(z) =$

## 5 Decimation

Consider the decimation filter structure shown below where  $y_0[n]$  and  $y_1[n]$  are generated according to the following difference equations

$$y_0[n] = \frac{1}{4}y_0[n-1] - \frac{1}{3}x_0[n] + \frac{1}{8}x_0[n-1]$$

$$y_1[n] = \frac{1}{4}y_1[n-1] - \frac{1}{12}x_1[n].$$

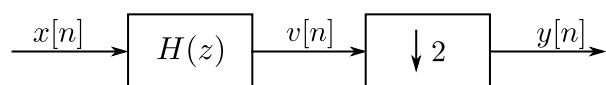


- (a) Find expressions for  $H_0(z)$  and  $H_1(z)$ .

$H_0(z) =$

$H_1(z) =$

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



$$H(z) =$$

- (c) In the implementation above,  $v[n] = av[n-1] + bx[n] + cx[n-1]$ . Determine  $a$ ,  $b$ , and  $c$ .

$$a =$$

$$b =$$

$$c =$$