ECE 5210 Final

Week of: April 27, 2023

Student's name: ____________________

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You have 3 hours for 6 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.

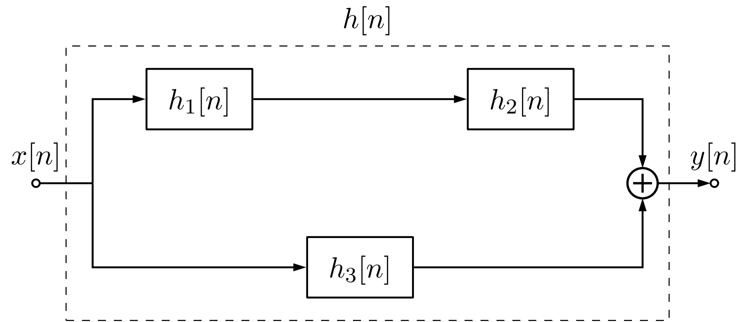
You are allowed THREE pages of notes (front and back) for this exam. You may use a graphing calculator of your choice. Consulting with any third party is considered cheating.

Problem	Score	Possible Points
1		20
2		20
3		20
4		20
5		25
6		20
Total score		125

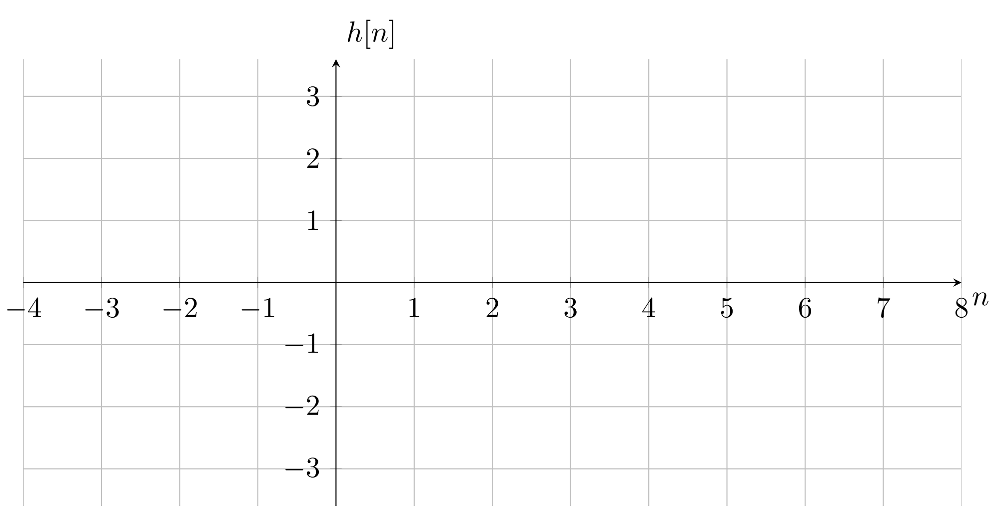
1 Parallel and cascade systems

Consider the system below. Each subsystem is defined as

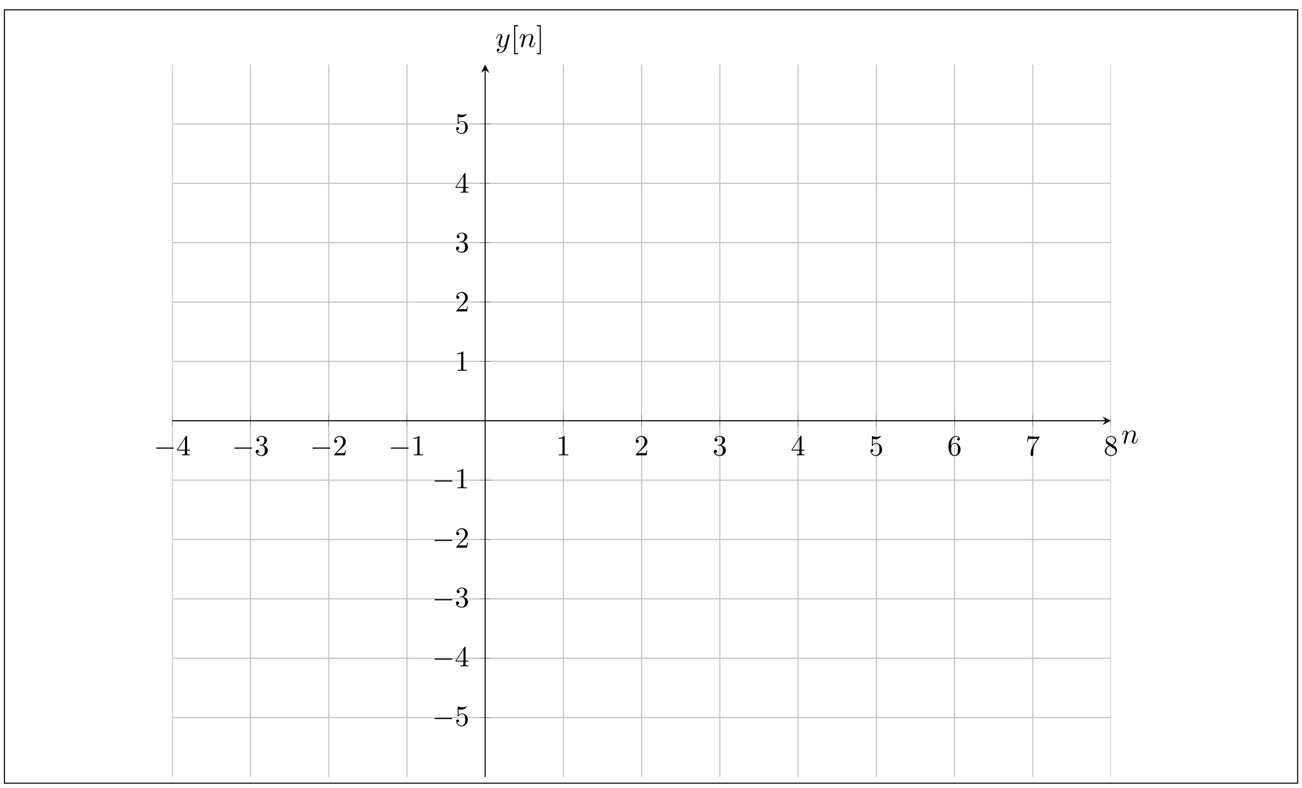
$$h_1[n] = \delta[n] + \delta[n-1] + \delta[n-2]$$
$$h_2[n] = \delta[n+1] - \delta[n-1]$$
$$h_3[n] = \delta[n-3].$$



(a) Find the equivalent impulse response of the system, $h[n]$.



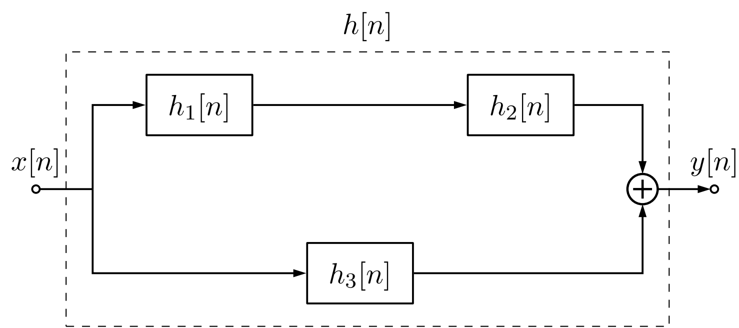
(b) Find the system response, $y[n]$, to input $x[n] = \delta[n+1] + 2\delta[n] + \delta[n-1]$



2 Parallel and cascade systems

Consider the stable system below. Each subsystem is defined as

$$h_1[n] = \left(\frac{1}{6}\right)^n u[n]$$
$$h_2[n] = \frac{1}{6}\delta[n-1]$$
$$h_3[n] = \left(\frac{2}{3}\right)^n u[n].$$



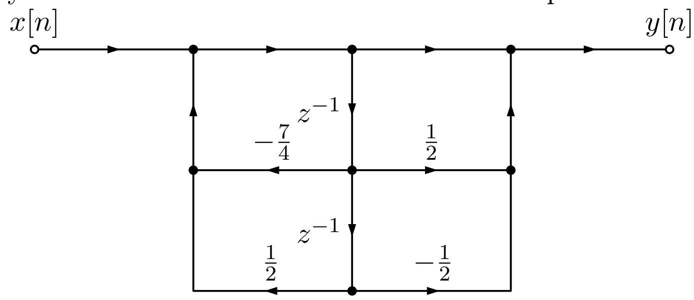
(a) Find $H(z)$, including the region of convergence.

$H(z) =$ ROC:

(b) Find the difference equation that relates $y[n]$ to the input $x[n]$.

3 System realization

Consider a stable system draw below in its Direct Form II implementation.



(a) What is $H(z)$?

$H(z) =$

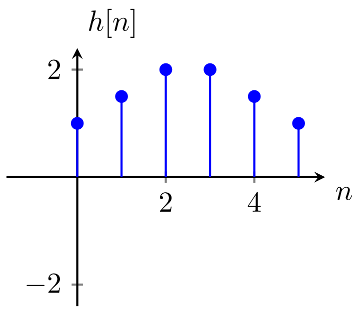
(b) Sketch $H(z)$ as a cascade of one or more first-order sections or say why this cannot be done.

(c) Sketch $H(z)$ as a parallel combination of sections or say why this cannot be done.

4 FIR filters

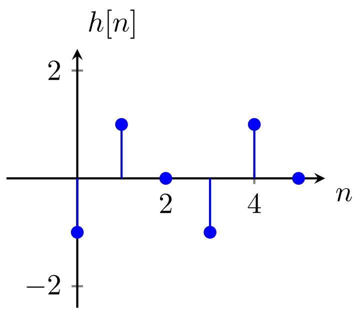
For each $h[n]$ FIR filters (which are non-zero only where indicated) determine whether $H(e^{j\omega})|_{\omega=0} = 0$ and $H(e^{j\omega})|_{\omega=\pi} = 0$.

(a)



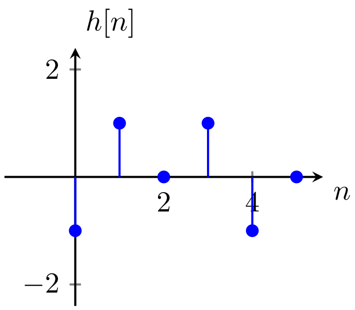
$H(e^{j\omega})\|_{\omega=0} = 0$:	True	False
$H(e^{j\omega})\|_{\omega=\pi} = 0$:	True	False

(b)



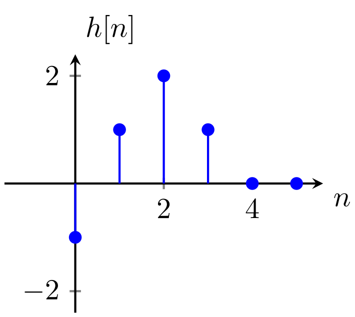
$H(e^{j\omega})\|_{\omega=0} = 0$:	True	False
$H(e^{j\omega})\|_{\omega=\pi} = 0$:	True	False

(c)



$H(e^{j\omega})\|_{\omega=0} = 0$:	True	False
$H(e^{j\omega})\|_{\omega=\pi} = 0$:	True	False

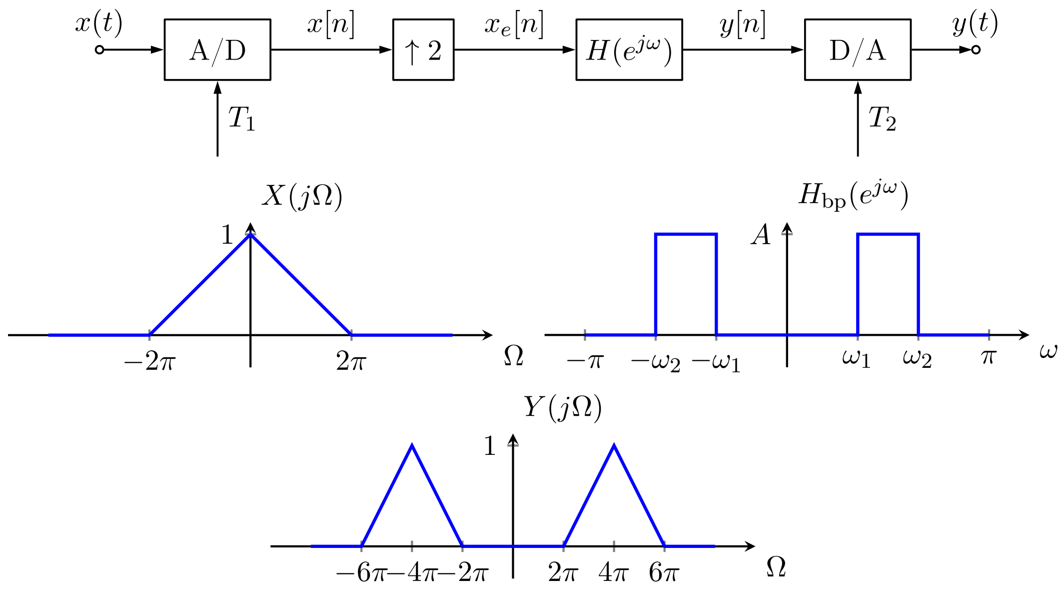
(d)



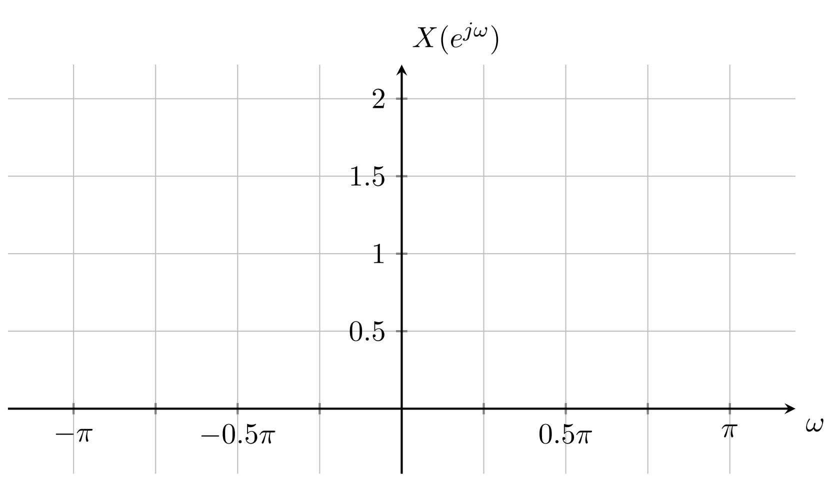
$H(e^{j\omega})\|_{\omega=0} = 0$:	True	False
$H(e^{j\omega})\|_{\omega=\pi} = 0$:	True	False

5 Bandpass upsampler

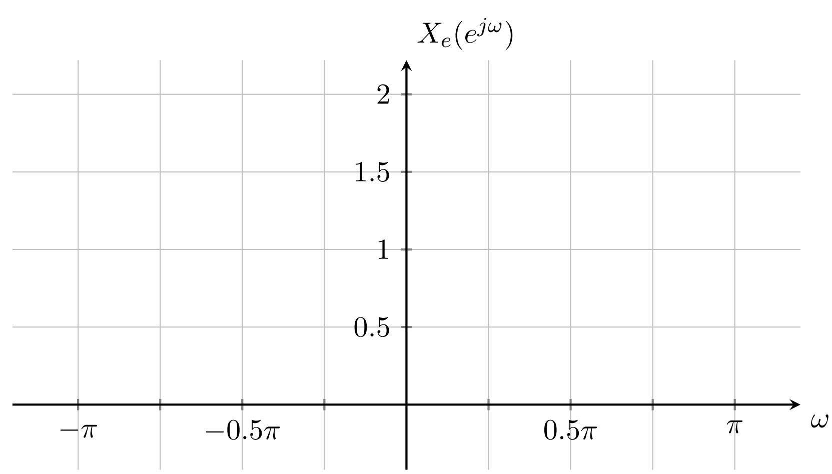
The discrete-time filtering scheme shown below comprises of an A/D converter sampling at rate $T_1 = 0.5\,\text{s}$, an upsampler followed by an ideal filter $H(e^{j\omega})$ with a gain of A, and a D/A converter operating with sampling rate of T_2. The spectra of the input and output of the complete system, $X(j\Omega)$ and $Y(j\Omega)$ are also shown.



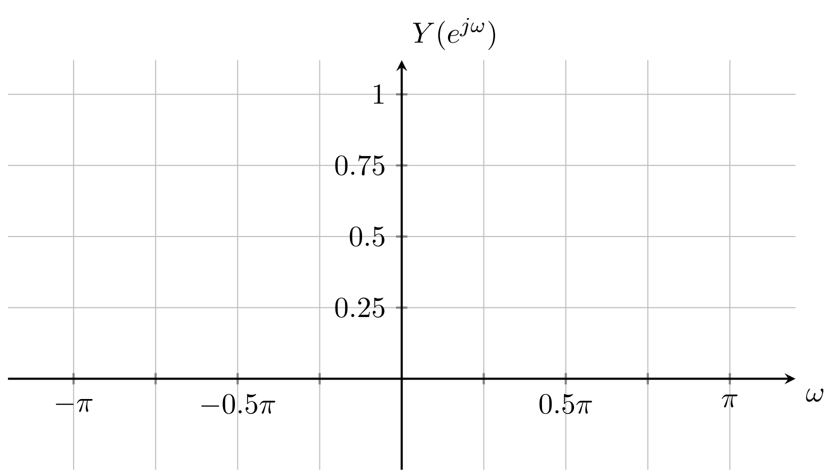
(a) Sketch $X(e^{j\omega})$.



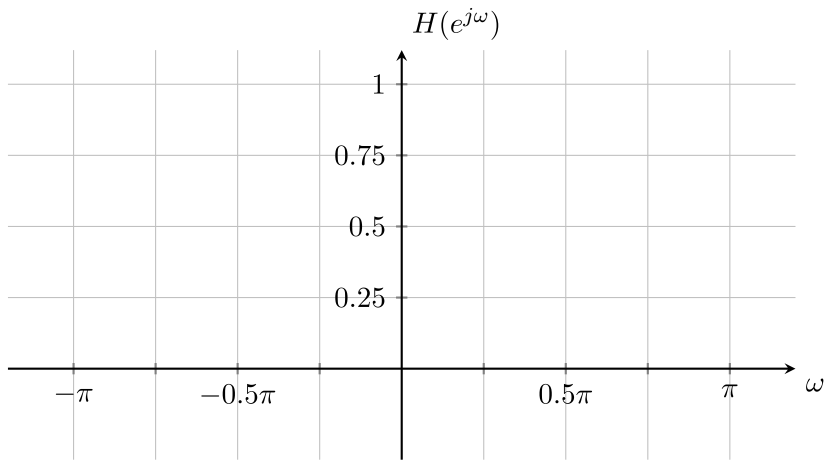
(b) Sketch $X_e(e^{j\omega})$.



(c) Sketch $Y(e^{j\omega})$.



(d) Sketch the frequency response of the digital filter $H(e^{j\omega})$.



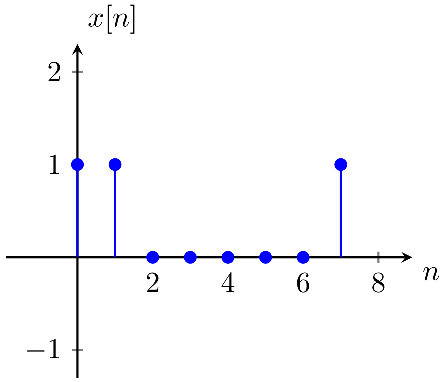
(e) Determine a suitable value for T_2 for the low-pass filter such that the system performs as shown. Recall that the reconstructed signal in an ideal D/A is just an analog low-pass filter $H_r(j\Omega)$ where

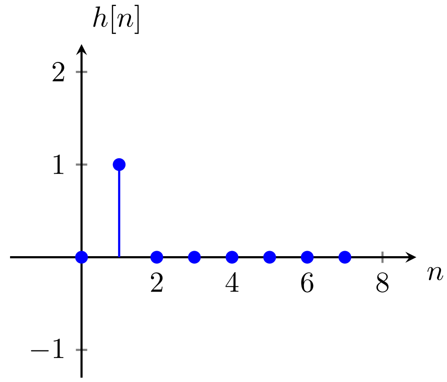
$$H_r(j\Omega) = \begin{cases} 1/T & |\Omega| < \pi/T \\ 0 & \text{else} \end{cases}$$

$T_2 =$

6 Discrete Fourier Transform

Two 8-sample sequences, $x[n]$ and $h[n]$, are shown below.





(a) Find the 8-point DFT of $x[n]$. You can solve this via brute force or it might helpful to remember what the relationship between the DTFT and DFT is.

...your work, continued.

$X[0] =$	$X[1] =$
$X[2] =$	$X[3] =$
$X[4] =$	$X[5] =$
$X[6] =$	$X[7] =$

(b) Sketch the sequence $y[n]$ defined as the inverse DFT of $Y[k] = X[k]H[k]$. You do not have to explicitly compute $Y[k]$ to solve this problem.