Full Name: Zexi Lin 55314399

EEL 4750 / EEE 5502 (Fall 2019) – Exam #03

ExamID: 010001

Date: Dec. 4, 2019

Question	# of Points Possible	# of Points Obtained	Grader
# 1	20	20	IK
# 2	18	18	MS
# 3	20	16	JBH
# 4	22	18	Y.B
# 5	20	18	JBM
Total	100	90	Y.B

For full credit when sketching: remember to label axes and make locations and amplitudes clear.

Before starting the exam, read and sign the following agreement.

By signing this agreement, I agree to solve the problems of this exam while adhering to the policies and guidelines of the University of Florida and EEL 4750 / EEE 5502 and without additional external help. The guidelines include, but are not limited to,

- The University of Florida honor pledge: "On my honor, I have neither given nor received unauthorized aid in doing this assignment."
- Only one 8.5 by 11 inch cheat sheet (double-sided) may be used
- No calculators or computers may be used
- No textbooks or additional notes may be used
- No collaboration is allowed
- No cheating is allowed

Zexi Lin

Student

12.4.2019.

Date

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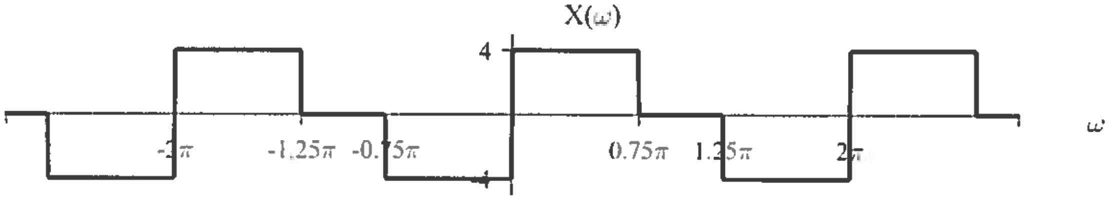
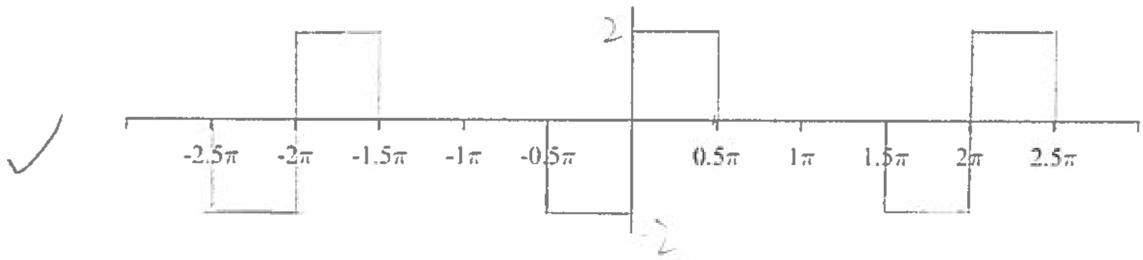
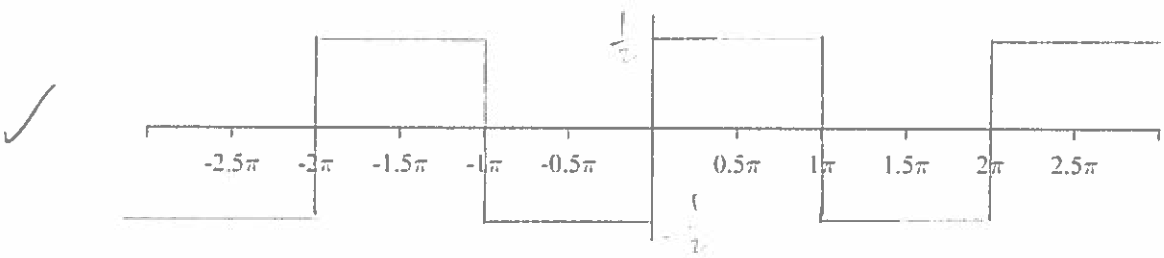
Question #1: Consider the DTFT of the signal $x[n]$ (i.e., $X(\omega)$) shown below.



(a) *(10 pts)* Sketch the DTFT (from $\omega = -3\pi$ to $\omega = 3\pi$) of $x[n]$ after downsampling by 2 **(with no anti-aliasing filter)**. Remember to label important locations / values.



(b) *(10 pts)* Sketch the DTFT (from $\omega = -3\pi$ to $\omega = 3\pi$) of $x[n]$ after downsampling by 8 **(with an anti-aliasing filter)**. Remember to label important locations / values.



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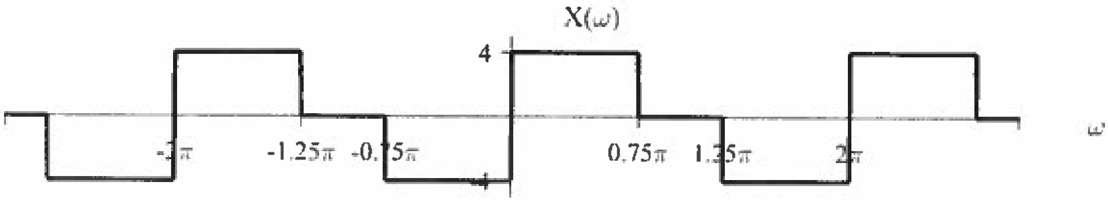
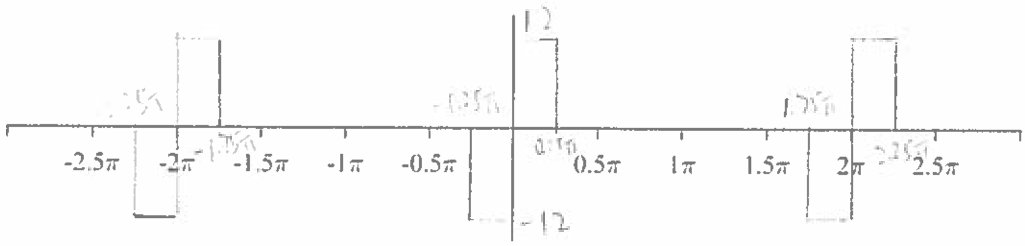
Question #2: Consider the DTFT of the signal $x[n]$ (i.e., $X(\omega)$) shown below.



(a) *(10 pts)* Sketch the DTFT (from $\omega = -3\pi$ to $\omega = 3\pi$) of $x[n]$ after upsampling by 3 (**with an interpolation filter**). Remember to label important locations / values.



10

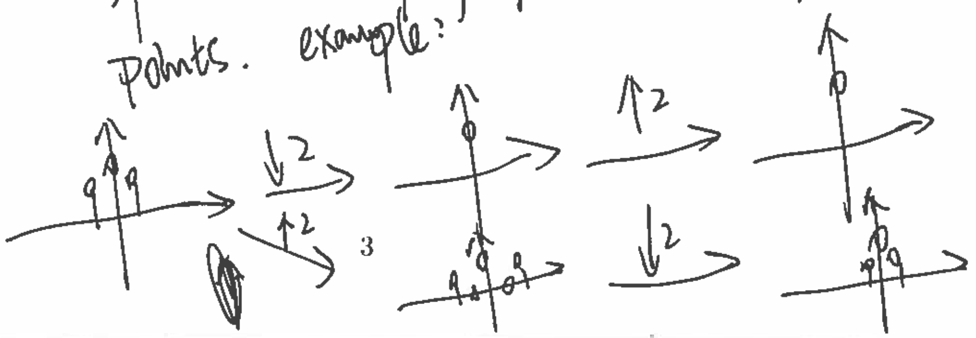
(b) *(8 pts)* **(True or False)** Upsampling by M followed by downsampling by N is equivalent to downsampling by N followed by upsampling by M. **Justify why.**

False.

Because downsampling may cause ~~this~~ aliasing and we may loss some information.

If we downsampling first. we may loss some points. example:

8



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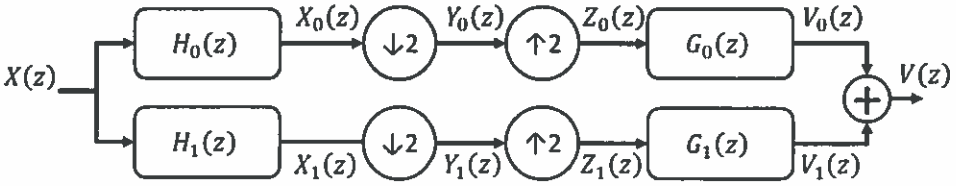
Question #3: Consider a 2-channel filter bank shown below.



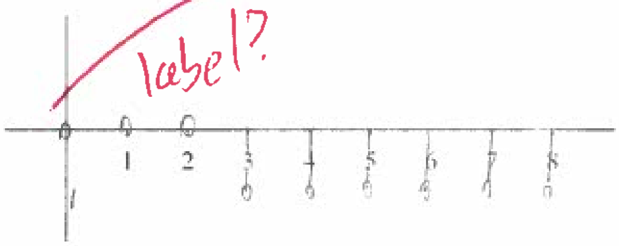
Let the filters and input be defined by the impulse responses

$$h_0[n] = g_0[-n] = \delta[n-2] \quad , \quad h_1[n] = g_1[-n] = \delta[n-5] \quad , \quad x[n] = (-1)^n u[n]$$

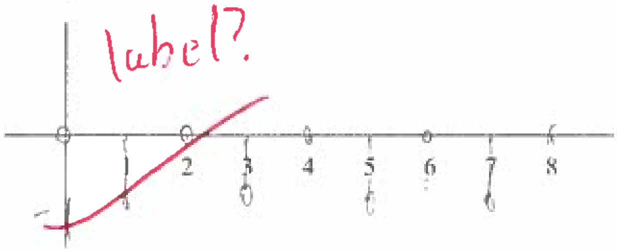
(a) *(12 pts)* Sketch $y_1[n]$ and $v_1[n]$ (inverse z-transforms of $Y_1(z)$ and $V_1(z)$) for $0 \le n \le 8$.

-1

label?



label?



$X(z) = \frac{1}{1+z^{-1}}$ $H_1(z) = z^{-5}$

$X_1(z) = H_1(z)X(z) = \frac{z^{-5}}{1+z^{-1}}$

$x_1[n] = (-1)^{n-5} \cdot u(n-5)$

$g_1[n] = \delta[n+5]$

$G_1(z) = z^5$

(b) *(8 pts)* **(True or False)** If the frequency responses $H_0(\omega)$ and $H_1(\omega)$ are periodic with a period of π (i.e., $H_0(\omega) = H_0(\omega - \pi)$ and $H_1(\omega) = H_1(\omega - \pi)$), then the filter bank always satisfies the alias canceling conditions. **Justify why.**

-3

False ~~True~~. ~~Because it satisfies Orthogonal Filter Bank.~~

$\cancel{G_0(z)G_0(z^{-1}) + G_0(-z)G_0(-z^{-1}) = 2}$.

$\cancel{G_1(z)G_1(z^{-1}) + G_1(-z)G_1(-z^{-1}) = 2}$.

$\cancel{G_0(z)G_1(z^{-1}) + G_0(-z)G_1(-z^{-1}) = 0}$.

Because

$H_0(w)$ ~~H~~ $G_0(w) + G_1(w)G_1 \ldots =$

~~when $w \to w - \pi$~~

~~$z \to z^{-1}$~~

$G_0(w)G_0(-w) + G_0(w)G_1(-w) \neq$

Be more specific.

Not satisfies alias canceling ← why?

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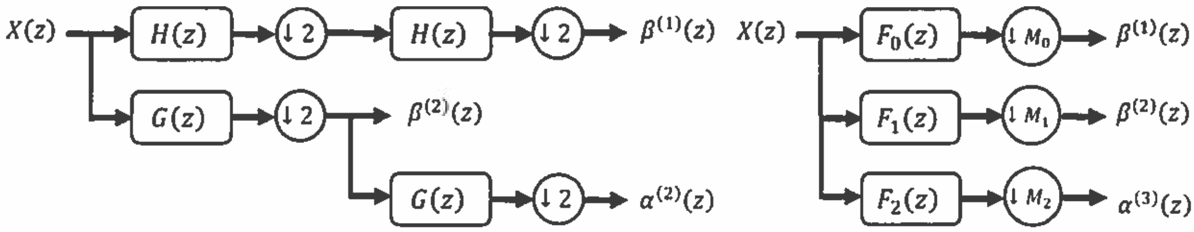
Question #4: Consider the following **non-standard** wavelet bank and filter bank.



Let $H(z)$ and $G(z)$ be defined by the transfer functions:

$$H(z) = 1 - z^{-1} \quad , \quad G(z) = 1 + z^{-1}$$

(a) *(10 pts)* Use the Noble identities to simplify the reconstruction bank (left) and represent it as a filter bank (right). Determine M_0, M_1, M_2, $F_0(z)$, $F_1(z)$, $F_2(z)$. **Fully simplify.**

$\downarrow 2 \rightarrow H(z) = H(z^2) \rightarrow \downarrow 2.$

$\downarrow 2 \rightarrow G(z) = G(z^2) \rightarrow \downarrow 2.$

$M_0 = 4. \quad M_1 = 2. \quad M_2 = 4.$

$F_0(z) = H(z)H(z^2) \quad F_1(z) = G(z). \quad F_2(z) = G(z)G(z^2)$

$= 1 - z^{-1} - z^{-2} + z^{-3} \quad = 1 + z^{-1} \quad = 1 + z^{-1} + z^{-2} + z^{-3}$

(b) *(12 pts)* Let the input signal be defined by

$$X(z) = -2z^{-2}.$$

Compute $\beta^{(1)}(z)$, $\beta^{(2)}(z)$, and $\alpha^{(2)}(z)$.

-4

$F_0(z)X(z) = -2z^{-2}(1 - z^{-1} - z^{-2} + z^{-3})$

$= -2z^{-2} + 2z^{-3} + 2z^{-4} - 2z^{-5}$

$\beta^{(1)}(z) = 2(-z^{-1} + z^{-2})$ ✗

$F_1(z)X(z) = -2z^{-2}(1 + z^{-1}) = 2(-z^{2} - z^{3}).$

$\beta^{(2)}(z) = -2z^{-1}$

$F_2(z)X(z) = -2z^{-2}(1 + z^{-1} + z^{-2} + z^{-3}) = 2(-z^{2} - z^{3} - z^{4} - z^{5})$

$\alpha^{(2)}(z) = -2(z^{-1} + z^{-2})$ ✗

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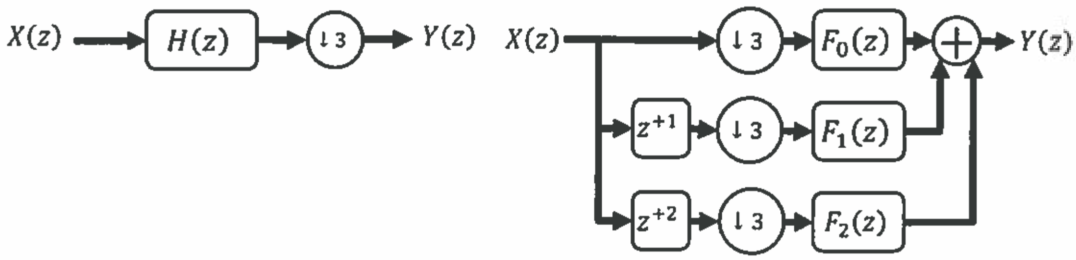
Question #5: Consider a filter and its polyphase implementation, as shown below.



Let $h[n]$, $f_0[n]$, $f_1[n]$, and $f_2[n]$ be the inverse z-transforms of $H(z)$, $F_0(z)$, $F_1(z)$, and $F_2(z)$.

(a) *(12 pts)* Let $h[n] = \delta[n] + \sum_{k=-\infty}^{\infty} 4\delta[n-3k-2]$. Mathematically express $f_0[n]$, $f_1[n]$, and $f_2[n]$.

$$f_0[n] = h[-3n] = \delta[n] + \sum_{k=-\infty}^{\infty} 4\delta[-3n-3k-2].$$

-8

$$f_1[n] = h[-3n+1] = \delta[-3n+1] + \sum_{k=-\infty}^{\infty} 4\delta[-3n-3k-1].$$

Simplify

$$f_2[n] = h[-3n+2] = \delta[-3n+2] + \sum_{k=-\infty}^{\infty} 4\delta[-3n-3k]$$

(b) ~~*(8 pts)*~~ **(True or False)** If $H(z)$ represents an FIR filter, then the filters represented by $F_0(z)$, $F_1(z)$, and $F_2(z)$ will be 1/6 the length of $H(z)$ in time. **Justify why.**

False. Because
$$\begin{cases} f_0[n] = h[-3n] \\ f_1[n] = h[-3n+1] \\ f_2[n] = h[-3n+2]. \end{cases}$$

So. they ~~will~~ will be $\frac{1}{3}$ the length of H(z) in time