Full Name: _____ **Lab Section:** _____

ECE 6534 (Spring 2015) – Exam Practice **Date: March 10, 2015**

Question	# of Points Possible	# of Points Obtained	Grader
# 1	16		
# 2	16		
# 3	18		
# 4	18		
# 5	16		
# 6	16		
Total	100		

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 Utah and ECE 3500 and without additional external help. The guidelines include, but are not limited to,

- 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

_____ _____

Student Date

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Question #1: Consider the subspace of $\mathbb{R}^{N\times N}$ spanned by $\mathcal{S} = \left\{xx^H, yy^H\right\}$ such that $x, y \in \mathbb{R}^N$.

(a) *(6 pts)* Determine $\dim(\mathcal{S})$. **Justify why**.

(b) *(5 pts)* Does $\mathcal{S}$ define a subspace of finite, linear, time-invariant filters? **Justify why**.

(c) *(5 pts)* Consider $\mathcal{S}_2 = \left\{xy^H\right\}$, where $x \in \mathbb{R}^N$. Is $\mathcal{S}_2$ a subspace of $\mathcal{S}$? **Justify why**.

Question #2: Let $x \in \mathbb{R}^{50}$ and $x \neq 0$.

(a) *(6 pts)* Is $z(x) = |x_1| + (|x_2 + x_3|^4)^{1/4} + |x_4|$ a norm? **Justify why?**

(b) *(6 pts)* Is $|\sum_{n=0}^{N} |x[n]|^{1/2}|^2$ a norm? **Justify why?**

(c) *(5 pts)* Is $x^H A x$ for $A \in \mathbb{R}^{50 \times 50}$ a norm? **Justify why?**

Question #3: Let A be a linear, causal, time-invariant, and BIBO stable system in which that absolute value of all eigenvalues is less than 1. Let $B = (I - A)^{-2}$

(a) *(5 pts)* Is B time-invariant? **Justify why.**

(b) *(4 pts)* Is B causal? **Justify why.**

(c) *(4 pts)* Is B memoryless? **Justify why.**

(d) *(5 pts)* Is B BIBO stable? **Justify why.**

Question #4:

(a) *(6 pts)* (True / False) A projection operator is always invertible. **Justify why.**

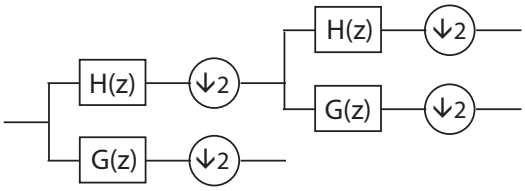
(b) *(6 pts)* (True / False) A filter is orthogonal (or unitary) if the absolute square of its frequency response is equal at all frequencies. **Justify why.**

(c) *(6 pts)* (True /False) For filters of length N, we can always use biorthogonality to achieve perfect reconstruction in an N-channel filter bank. **Justify why.**

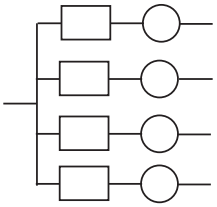
Question #5:

(a) *(8 pts)* Draw the block diagram for the system $H^* D_2 U_2 H + G^* D_2 U_2 G$.

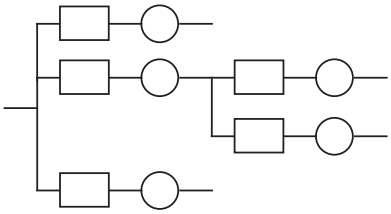
(b) *(8 pts)* Simplify the following wavelet tree into a standard filter bank representation.



Question #6: *(16 pts)* Sketch the time-frequency tiling for the following filter banks.



(a)



(b)