Name:

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COM-303 - Signal Processing for Communications
Midterm Exam

Monday, March 31 2014, 14:15 to 16:00

- **Room assignment**: if your last name begins with a letter from 'A' to 'G' inclusive, you should be in room INM200, otherwise you should be in room AAC231.
- **Write your name** on the top left corner of **ALL sheets you turn in**, including this one. When you are done, **staple** all your sheets together **with this sheet on top**!
- You can have two A4 sheet of *handwritten* notes (front and back). Please **no photocopies, no books and no electronic devices**. Turn off your phone if you have it with you.
- There are 5 problems for a total of 100 points; the number of points for each problem is indicated next to it.
- Please write your derivations clearly, as there is partial credit.

Exercise 1. (20 points)

Consider the LTI filter described by the following CCDE:

$$y[n] = \frac{1}{4M}x[n+M] + \frac{1}{2M}\sum_{k=-M+1}^{M-1} x[n-k] + \frac{1}{4M}x[n-M]$$

(a) find the impulse response of the system

(b) sketch the impulse response for $M = 3$

(c) find the frequency response of the filter, separating magnitude and phase

(d) is the filter linear phase? what is its delay?

Exercise 2. (10 points)

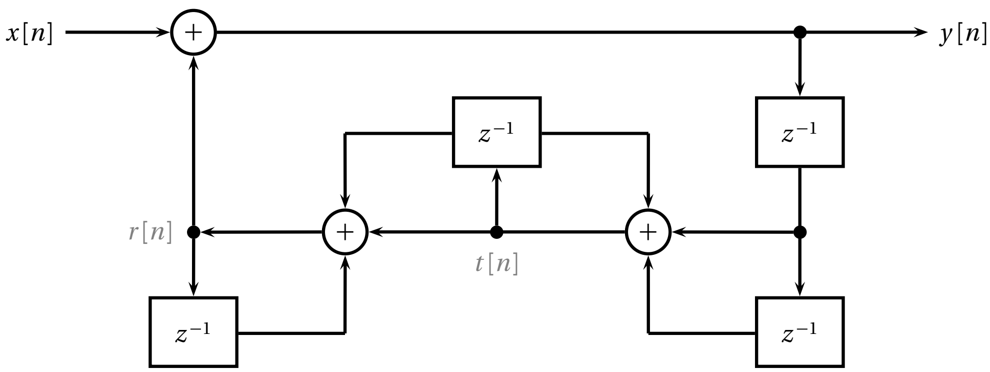
Give an example of a linear time-VARIANT transformation and show why it is time-variant.

Exercise 3. (30 points)
You have been asked to implement a five-point DFT on a microprocessor that can only perform real-valued additions, subtractions and multiplications (in other words, there is no mathematical library with which to compute trigonometric functions, nor native support for complex numbers). In your code, you can store the values of just the two following numerical constants:

$$C = \cos(2\pi/5) \approx 0.309$$
$$S = \sin(2\pi/5) \approx 0.951$$

Write an algorithm that, for a real-valued input data vector $[x_0, x_1, x_2, x_3, x_4]$, computes the real and imaginary parts of its 5-point DFT using only additions, multiplications and the constants C, S. You can use any notation you prefer but try to be as clear as possible in your derivation.

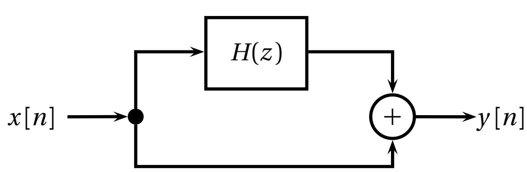
Exercise 4. (30 points)
Consider the LTI system described by the following block diagram:



(a) determine the transfer function of the system *(Hint: start by considering the CCDEs which describe the relations between the internal signals $r[n]$ and $t[n]$, the input and the output)*

(b) sketch the pole-zero plot for the system. Assuming the system is causal, is it stable?

Exercise 5. (10 points)
Assume $x[n] = \sin \omega_c n$ and consider the following system where $H(z)$ is the ideal Hilbert filter:



Write the expression for $y[n]$.
