***Seminar 7: Frequency Response of FIR Filters***

1. Suppose the input signal to an FIR system is: . If we define a new signal to be the first difference , it is possible to express in the form . Determine the numerical values of A, , and .
2. A linear time-invariant system is described by the difference equation
   1. Find the frequency response ; then express it as a mathematical formula, in polar form (magnitude and phase).
   2. is a periodic function of ; determine the period.
   3. Plot the magnitude and phase of as a function of for . Do it by hand and then check the Python (package scipy.signal) function freqz.
   4. Find all the frequencies , for which the output response to the input is zero.
   5. When the input to the system is , determine the output signal and express it in the form .
3. For each of the following frequency responses determine the corresponding impulse response
   1. = 1+
   2. = 2
   3. =1+ + 3
4. The frequency response of a linear time-invariant filter is given by the formula
   1. Write the difference equation that gives the relation between the input x[n] and the output y[n].
   2. What is the output if the input is ?
   3. If the input is of the form =, for what values of will y[n]=0 for all n?
5. Suppose that three systems are connected in cascade; i.e., the output of is the input to and the output of is the input to. The three systems as specified as follows:

where the output of is and its input is .

* 1. Determine the equivalent system that is a single operation from the input x[n] (into ) to the output y[n], which is the output of . Thus, x[n] is and y[n] is .
  2. Use the frequency response to write one difference equation that defines the overall system in terms of x[n] and y[n] only.

1. The complex-values frequency response of an L-point moving average filter is  
   1. Derive a formula for the phase of and make a plot.
   2. Derive a formula for the magnitude of and make a plot.
2. An LTI filter is described by the difference equation
   1. What is the impulse response of this system?
   2. Obtain an expression for the frequency response of this system.
   3. Sketch the frequency response (magnitude and phase) as a function of frequency.
   4. Suppose that the input is for . Obtain an expression for the output in the form .
   5. Suppose that the input is , where u[n] is the unit-step sequence. For what values of n will the output be equal to the output y[n] in (d)?
3. The general frequency response of an FIR filter of order 2 is . If we have a representation of an FIR filter of order 2 of the form: :
   1. Compute the coefficients
   2. What is its magnitude, ?
   3. What is its phase, ?