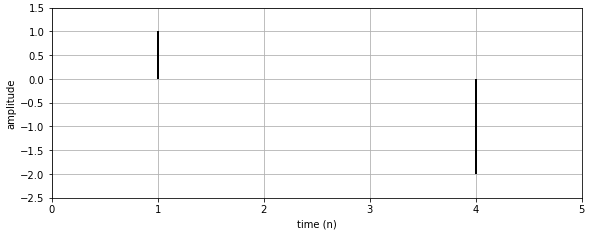
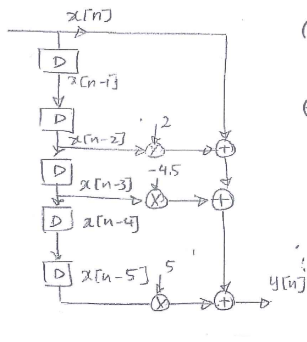
***Seminar 6: FIR Filters  
[solutions]***

1. If the impulse response of an FIR filter is: .
   1. Make a plot (versus n) of

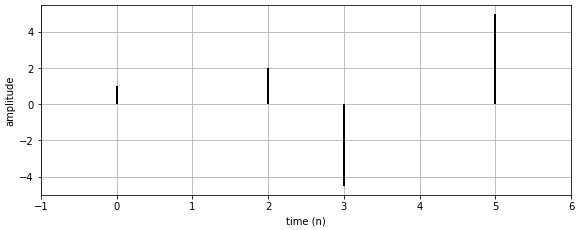
**ANSWER**:  


* 1. Write the difference equation for the FIR filter  
     **ANSWER:**

1. An FIR filter is described by the following difference equation:
   1. Draw the block diagram of the filter

**ANSWER:**  
 

* 1. Compute the impulse response and draw it over *n*

**ANSWER**:   


* 1. Compute for the complex input signal   
     **ANSWER**:

1. Assume that we have a linear system for which we do not know the difference equation but we introduce a signal and the obtained output signal is . Using the property of linearity and time invariance compute the output of the system when the input is   
   **ANSWER**:

Note that

Then using LTI, )

1. Let x[n] be the complex exponential . If we define a new signal , it is possible to express in the form . Determine the numerical values of and .  
   **ANSWER:** , thus

Factor out and

Note: The term , obtained by vector addition of is the frequency response evaluated at

1. For each of the following systems, determine whether or not the system is (1) linear, (2) time-invariant, and (3) causal.
   1. **ANSWER:**Linear. Since scaling x[n] by will give the same scaling of the output: , and the superposition also holds:

Not Time-Invariant. Because we can make the following counter example. Let so that the output is , now change the input to , so we expect the output to shift by 1 time index. However the output is   
  
Causal. Because y[n] only depends on the current value of x[n]

* 1. **ANSWER:** Linear, Time-Invariant, and Causal. Trivial to demonstrate.
  2. **ANSWER**:   
     Not linear: because when we multiply the input by -3, the output does not get multiplied by -3.

Causal: Because y[n] only depends on the current value of x[n]  
Time-Invariant: if input is ,

**ANSWER:**

Not-linear. Since scaling x[n] by will not give the same scaling of the output. Easy demonstration.

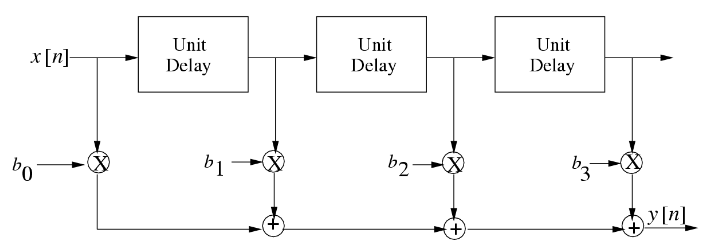
Not Time-Invariant. Since depending on n, the same input value will give different results. Easy demonstration.  
Not Causal. Since the output of a given n will might depend on a higher valued n (given ). Easy demonstration.

* 1. where A and B are constants.  
     **ANSWER:**

Not-linear. Since scaling x[n] by will not give the same scaling of the output. Easy demonstration.

Time-Invariant. Easy demonstration.  
Causal. Because y[n] only depends on the current value of x[n].

1. If an LTI system is described by the block diagram below, where , , , , determine its impulse response .



**ANSWER:**

1. Consider the discrete time system described by .
   1. Describe in words how the value would be computed from the input sequence.  
      **ANSWER**: , which is the average of its previous input sample, x[4], and its next input sample, x[6].
   2. Suppose that the input is the complex exponential signal . Determine an expression for the output .  
      **ANSWER**:
   3. Use your result from part (b) to find the output of the above system due to the input .  
      **ANSWER**:  
      , for all n  
      the system removes a component of the input at frequency (and too).