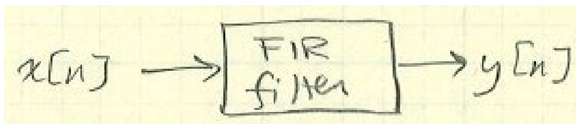
Coverage: FIR Filters and Convolution

Remember to include copies of all MATLAB plots and scripts in your homework submissions.

Problems

(1) Consider the FIR filter and input signal.



$$b[k] = \begin{cases} 1, & k = 0 \\ -1, & k = 2 \\ 0, & \text{otherwise} \end{cases}$$

$$x[n] = u[n+1] + u[n-2] + 3u[n-5] - 5u[n-10]$$

- **(a)** Use the table method to determine $y[n]$ for $-5 \le n \le 15$, i.e. tabulate n, $x[n]$, and $y[n]$.
- **(b)** Create stem plots for $x[n]$ and $y[n]$.
- **(c)** Use MATLAB's `filter` function to computer $y[n]$ for $-5 \le n \le 15$.
- **(d)** Use MATLAB's `stem` function to visualize $x[n]$ and $y[n]$ for $-5 \le n \le 15$.

(2) Repeat problem (1) for

$$b[k] = \begin{cases} \frac{1}{3}, & k = 0, 1, 2 \\ 0, & \text{otherwise} \end{cases}.$$

(3) Consider the DT sinusoidal signal $x[n] = 5\cos(\pi n/4)\, u[n]$.

- **(a)** Design an FIR filter with exactly two non-zero coefficients that will yield $y[n] = 0$ in the steady state after the filter has been running for several time steps after $n = 0$.
- **(b)** Confirm your design with MATLAB, plotting $x[n]$ and $y[n]$ as stem plots for $0 \le n \le 20$.

(4) The impulse response of an LTI system is given by

$$h[n] = \{\underline{3}, -2, 4, -4, 5, -10\}.$$

The underlined value indicates the time $n = 0$ sample. The input to the system is

$$x[n] = \{2, 4, \underline{10}, 0, -10\}.$$

(a) Plot $x[n]$ and $h[n]$.

(b) Determine the difference equation for this system.

(c) Calculate $y[n]$ as the convolution of $x[n]$ and $h[n]$ using synthetic multiplication.

(d) Plot $y[n]$ as a stem plot.

(e) Use the MATLAB `conv` function to confirm your work. Include the MATLAB code and its results from the command line in your submission.

(5) Another LTI system has the impulse response

$$h[n] = \{-10, 5, -4, 4, -2, \underline{3}\}$$

which is the time-reversed equivalent of the response from problem (4). Repeat problem (4) with this impulse response.