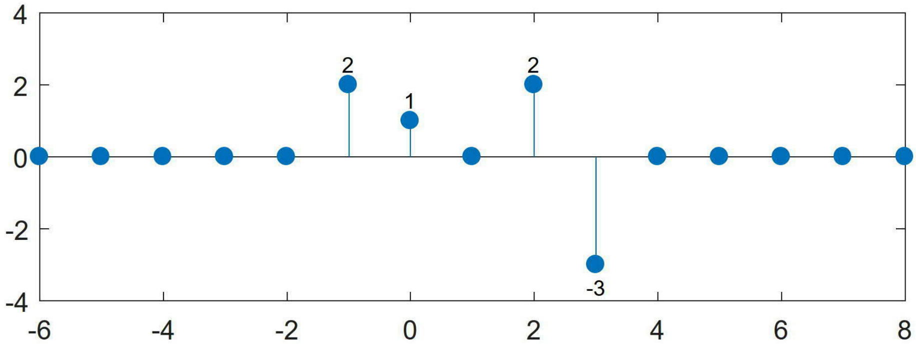
COMP.SGN.100 Introduction to Signal Processing,
Exercise 7, 27.-28.9.2021

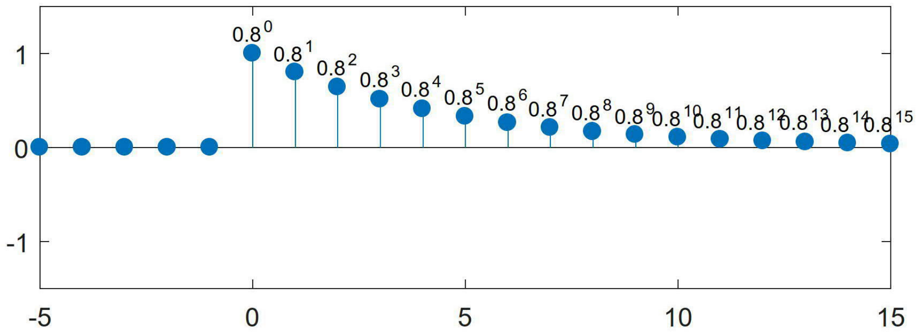
Pen & paper task solutions should be submitted to Moodle at least one hour before your exercise session. Matlab tasks are done during the exercise session.

Task 1. *(Pen & paper)*

(a) Calculate the z-transform expression of the signal in the figure below.



(b) Calculate the z-transform expression of the signal in the figure below.



(c) Calculate the DTFT expressions of the signals in (a) and (b).

Task 2. *(Pen & paper)* The z-transform of the impulse response of a filter is

$$H(z) = \frac{1 + 2z^{-1} + z^{-2}}{1 + z^{-1} + z^{-2}}.$$

Draw the pole-zero plot of the system. Is the filter stable?

Task 3. *(Pen & paper)* The filter

$$y(n) = \frac{1}{4}x(n) - \frac{1}{2}x(n-1) + \frac{1}{4}x(n-2)$$

is implemented in hardware with the sampling rate 16000 Hz. What is the amplitude response (i.e. amplification/attenuation) of the filter at the frequency 4000 Hz? *Hint:* Calculate $H(z)$ and $H(e^{i\omega})$, substitute normalized angular frequency ω into the formula you obtained and take the absolute value. The normalized angular frequency corresponding to the frequency f is $\omega = 2\pi f/F_s$, where F_s is the sampling rate.

Task 4. *(Matlab)* In the course Moodle `Ex7_Task4.mat` (`Ex_7.zip`) is a corrupted version of Matlab's test signal `handel`. Your task is to find the impulse response of the distortion process. Read the file into Matlab. It contains the variables `x` (original) and `y` (distorted). The distorted signal is obtained by convolving impulse response $h(n)$ with the original signal

$$y(n) = h(n) * x(n).$$

Now you have the vectors $x(n)$ and $y(n)$ in Matlab. Solve $h(n)$ with FFT and plot the first 10 terms.

Task 5. *(Matlab)* Consider points $n = 0 : 70$. Filter the signal $x(n) = u(n)\sin(0.05 \cdot 2\pi n)$ with the system in the example on pp. 72-73 in the lecture handout:

$$y(n) = 0.0349x(n) + 0.4302x(n-1) - 0.5698x(n-2) + 0.4302x(n-3) + 0.0349x(n-4).$$

Compare the result with the estimated response $y(n) = 0.3050u(n)\sin(0.05 \cdot 2\pi n - 0.6283)$. Plot the original signal, the estimated response and the true response in the same figure. (Note that if you used `conv` for the filtering, then plot only the first 71 values of the output so that the length is equal to the input length.)