COMP.SGN.100 Introduction to Signal Processing,
Exercise 3, 13.-14.9.2021

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*) The analog signal consists of a single sine wave having frequency 1000 Hz. The signal is sampled at intervals of 0.0006 seconds.

(a) Does aliasing occur?

(b) If your answer is positive, what is the frequency that the signal is interpreted to have after the sampling?

(c) What would be a sufficient sampling frequency to prevent aliasing?

Task 2. (*Pen & paper*) Strictly speaking, the Nyquist frequency is not always enough to avoid aliasing. Let's consider such a situation in this task.

(a) Sample the signal $x(t) = \sin(20\pi t)$ at intervals of 0.05 seconds starting from the time $t = 0$ s. Determine the values of the first five samples. Can the original signal be reconstructed from these sample values?

(b) What happens if the sampling starts at $t = 0.025$ s? What are the first five samples in that case? Can the original signal be reconstructed from these sample values, or could these samples present some other signal having the same frequency.

Task 3. (*Matlab*) Plot these signals so that the figures are similar to those shown in Section 3.1 of the lecture handout:

(a) Plot the unit sample $\delta(n)$. Use the Matlab command given on p. 38 to create vector `delta`. Since the horizontal axis of the image has points $-7, -6, -5, \ldots, 7$, create a vector `n` that contains these points: `n = -7:7;`. Finally draw the plot of the unit sample with the command `stem(n', delta);`.

(b) Plot the unit step $u(n)$ (p. 39).

(c) Plot the ramp signal $r(n)$ (p. 40).

Task 4. *(Matlab)*

(a) Create a 10×10 matrix:

$$A = \begin{pmatrix} 1 & 2 & \cdots & 10 \\ 11 & 12 & \cdots & 20 \\ \vdots & \vdots & \ddots & \vdots \\ 91 & 92 & \cdots & 100 \end{pmatrix}.$$

(*Hint:* `help reshape, help transpose`)

(b) Raise each element of the matrix A to the third power. (*Hint:* `help power`)

(c) Calculate the third power A^3 of the matrix A. (*Hint:* `help mpower`)

(d) Create a 10×10 matrix of random numbers and assign it to the variable B. (*Hint:* `help rand`)

(e) Calculate the inverse matrix of the matrix B and assign it to the variable C. Calculate the matrix product of the matrices B and C. (*Hint:* `help inv`)

Task 5. *(Matlab)* Download the test signal `seiska.wav` from the course Moodle (`Ex_3.zip`). Read it into Matlab using the command `[x,Fs]=audioread('seiska.wav');`, plot the spectrogram of the signal with the command `spectrogram` (parameters e.g. `x, 256, [], [], Fs, 'yaxis'`) and listen to the signal using the command `soundsc`.

Next, design a high pass filter that removes low frequencies from the signal. This is done with the command [1]

```
h = fir1(30, 0.3, 'high');
```

Filter the test signal with the filter you just designed. The command is

```
y = filter(h, 1, x);
```

where `x` is the variable that you stored the test signal with `audioread`.

Listen to the signal `y` and plot its spectrogram. Were the low frequencies removed?

[1] It will be explained later in the course what the command actually does.