# Signals and its properties

Signals and codes (SK)

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Exercise 1

# Exercise content

- Signals
  - using MATLAB
  - plotting signals
    - basic types of signals
    - sinusoids
    - complex exponentials
  - computing characteristic values of signals
    - instantaneous value
    - average value
    - signal energy
    - signal power
    - effective value

# Exercises

## Exercise 01_0: Plotting function, put MATLAB into operation

Consider continuous time signal $x(t) = 3t$

a) Use MATLAB to plot the signal within time interval < 0 , 2 > ms *well enough*. Label your plot carefully, make a title, axes labels, grid.

b) Use `LineSpec` `'-o'` for the plot to see which samples are shown in the plot.

```
%% defining parameters

slope=3;

fs=1e3; % sample frequency of the plot
tmin=0; %time limits
tmax=2e-3;
```

Help for a):

```
title('Linear signal'); % plot title string
xlabel('t (s)'); % x axis label string
grid on; % shows grid in actual plot
```

Help for b) :
for help type `LineSpec` into Command Window and press F1 with a cursor within the word `LineSpec`

# Exercises

## Exercise 01_0: Solution

```
% plot linear function

%% initialize

clear; % clears all variables in workspace
close all; % close all figures

%% defining parameters

slope=3;

fs=1e3; % sample frequency of the plot
tmin=0; %time limits
tmax=2e-3;

%% computation

Ts=1/fs;

t=tmin:1/(1*fs):tmax; %defining vector of time
x=slope*t; % defining signal
plot(t,x);  % for subtask a)
%plot(t,x,'-o');  % for subtask b)
grid on
xlabel('time (sec)');
ylabel('x (t)');

title(sprintf('Linear function x = %.2f * t, sample rate fs = %.3E Hz',slope,fs));  %sprintf prints to the string
```

Attention!

Please, always save all the scripts created to make them available for editing in the future.

There is no time for writing each script for each exercise as a new one from the very beginning.

# Exercises

## Exercise 01_1: Plotting function, instantaneous value

Consider continuous time signal $x(t) = \mathrm{e}^{-50t} \cdot \cos 2\pi 1000t$

a) Use MATLAB to plot the signal within time interval < 0 , 30 > ms *well enough*. Label your plot carefully, make a title, axes labels, grid.

b) Find instantaneous value $x(t_i)$ for time instant $t_i = 20$ ms. Discuss the result value in terms of time constant of exponential function and frequency of cosine function.

c) Is the signal periodic? If so, what is the period?

```
%% defining parameters

% sinus
a=1; % amplitude
f0=1000; % frequency
p=0; % initial phase
% exponential
tau=1/50;

fs=???; % sample frequency
tmin=0; %tlimits
tmax=0.03;
```

Help:
use `exp(x)` for Euler number powered to `x`
use `x.*y` for multiplying each element of `x` by each element of `y` (note: `x` and `y` must have the same dimensions)

# Exercises

## Exercise 01_2: Plotting functions, stem plot

Consider continuous time cosine signal of amplitude $230 \cdot \sqrt{2}$, frequency 50 Hz and initial phase π/6.

a) Use MATLAB to plot 5 periods of the given signal *well enough*. Label your plot carefully, make a title, axes labels, grid.

b) Show a stem plot in the same figure with parameterized sample frequency denoted as `fs_stem`. Substitute values 600, 310, 300, 290, 200, 110, 100, 90, 60, 50, 40, 10 Hz consequently for `fs_stem` and observe the results. Try to make conclusion about the sample frequency.

c) Determine average value, signal energy, signal power and effective value of the original continuous time cosine signal. Use MATLAB for the computation, where it is suitable.

```
%% defining parameters

a=230*sqrt(2); % amplitude
f0=50; % frequency
p=pi/6; % initial phase

fs=5000; % sample frequency of dense plot (fs >> f0)
fs_stem=600; %sample frequency for stem plot
noT=5; %periods to be plotted
```

Help:
use `x.^2` for squaring each element of `x`
use `hold on;` for more plots in one figure
use `length(x)` for counting items in vector `x`
use `fprintf('Signal power is %.4E\n',P);`
for writing line separated text (`\n`) to the command window and controlling format of written variable `P`
(formatSpec i.e. `%.4E` or `%.2f` )

# Exercises

## Exercise 01_3: Plotting functions, complex exponentials

Consider discrete time complex signal $x[n] = 3e^{j2\pi\cdot 10\cdot n\cdot T_s}$ with sample frequency $f_s$ = 40 Hz. Imaginary unit $\sqrt{-1}$ is denoted as *j*.

a) Use MATLAB to plot five periods in two subpllots. The first subplot should show the given signal in a complex plane. The second one should show the real part of $x[n]$, i.e. $\mathrm{Re}\{x[n]\}$ depending on discrete time $n \cdot T_s$. Use `LineSpec '-o'` for both figures.

b) Repeat the same with sample frequency $f_s$ = 39 Hz;

c) Repeat the same with sample frequency $f_s$ = 400 Hz;

d) Repeat the same with sample frequency $f_s$ = 390 Hz;

e) Determine average value, signal energy, signal power and effective value of the signal $x[n]$. Compute for sample frequencies 40, 39 and 400 Hz. Then compare the results with computing these values for signal $x[n] = 3\sqrt{2}\cos(2\pi \cdot 10 \cdot n \cdot T_s)$

```
%% defining parameters

a=3; % amplitude
f0=10; % frequency
p=0; % initial phase

fs=40; % sample frequency of plots
noT=5; %periods to be plotted
```

Help:
1) use symbol `1i` for imaginary unit in MATLAB or simply `j=sqrt(-1);`
2) use `exp(x)` for Euler number powered to `x`
3) note that `n*Ts` is the time `t` (you don't need to declare other variable `n`)
4) `plot(x); %plots imaginary part of x as a function of real part of x`
5) `real(x)` evaluates real part of `x`
6) Use/edit the following syntax

```
figure('Position', [100, 100, 1300, 500]); %defining position of corners
of the figure
subplot(1,2,1)
plot(x,'-o');
...
subplot(1,2,2)
plot(t,real(x),'-o');
```