1130-EMARO-MSA-1004# Signal Processing

T4: Fourier transform

Stationary signal

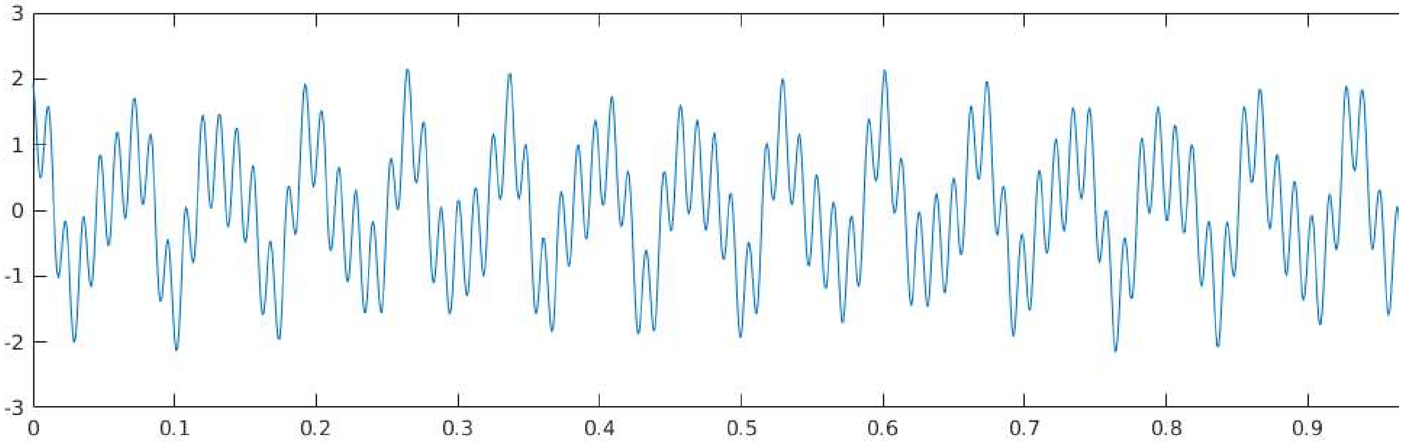
Generate a mixture of three sine waves (use *cos* function) with different amplitudes, phases, and frequencies. The generated signal should have 2 seconds duration and 1kHz sampling rate. Refer to the code below for an example.

```
% System parameters
Fs = 1000;       % Sampling frequency [Hz]
T = 1/Fs;        % Sampling time step [s]
s = 2;           % Signal length [s]
L = s*Fs;        % Signal length (number of samples)
t = (0:L-1)*T;   % Time base
f = 0:1/s:Fs/2;  % Frequency base


% Signal creation
N = 3;               % Number of signals
A = [1.0   0.4  0.8] % Amplitude
B = [ 15    27   83] % Frequency [Hz]
C = [  0 -pi/3 pi/7] % Phase shift

% simple way
x = zeros(size(t));
for i = 1:N
  x = x + A(i) * cos(2 * pi * B(i) * t + C(i));
end

% MATLAB way
x = sum(A' .* cos(2 * pi * B' * t + C'));
```



Fast Fourier Transform

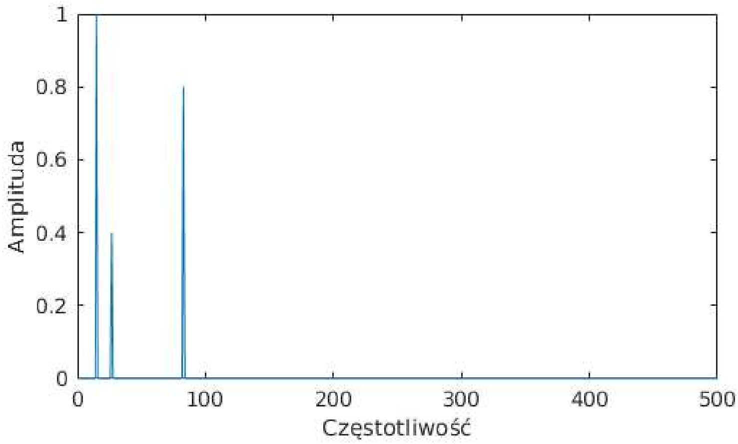
Calculate the Fourier transform of the generated signal (use fft). Present the result as amplitude and phase shift plots. Read the dominant frequencies, their amplitudes, and phase shift. Compare the results with the initial values (used to generate the signal).

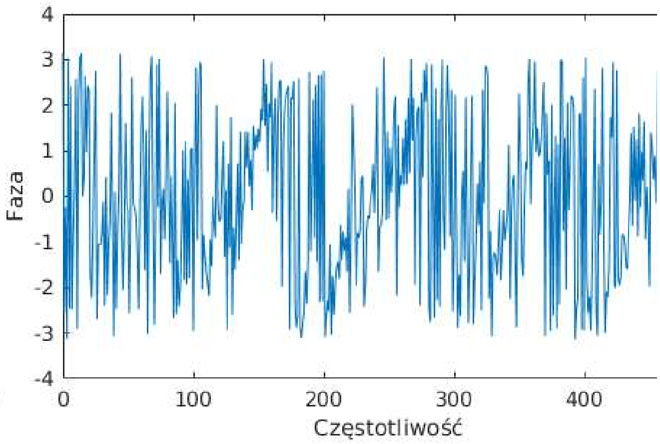
```
Y = fft(x);     % Fast Fourier Transform
A = abs(Y);     % Amplitude
```



```
P = angle(Y);   % Phase
P = P(1:L/2+1); % Cut important part

% Plots
figure;
plot(f, A);
xlabel("Frequency [Hz]");
ylabel("Amplitude");
figure;
plot(f, P);
xlabel("Frequency [Hz]");
ylabel("Phase");
```





Noisy signals

Create a new signal by adding random noise to a signal from the previous task (using randn for example). Analyze the noisy signal in the same way as the clean one. Find three dominant amplitudes and corresponding phase shifts and frequencies (using maxk or sort) and reconstruct the initial signal.

Show both signals (noisy and reconstructed) on the same plot. Compare the retrieved values (frequency, amplitude, and phase) with the original ones. Experiment with the noise strength - how big it must be to make the original signal unrecoverable?