Signals and Systems 2

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Lab #4: Sampling/reconstruction

High-level objectives:

(a) Use the help system, to learn about Matlab commands and syntax.
(b) Explore and modify examples, to understand third-party code and to write your own.
(c) Get familiar with basic Matlab commands.
(d) Analyze examples of code and relate them with the theory.
(e) Introduce good working habits for creating and presenting reports.

The deliverable for each group consists of a **single .zip file**, including all the materials required at the different exercises, and well as the required manual calculations in paper. The document should be named (please, **be strict** on that, it will be processed automatically):

SiS2_Lab4_NameSurnameMember1_NameSurnameMember2.zip

Submit only **one document per group** to Aula Global.

Sampling and reconstruction

```
%% Sampling and reconstruction lab
clear,clc,close all;

%% Parameters
f_M = 50;     % frequency of original signal [Hz]
f_s = 2*f_M;     % sampling rate [Hz]
omega_M = 2*pi*f_M;     % frequency of original signal [rad/s]
omega_s = 2*pi*f_s;     % sampling rate [rad/s]
T = 1/f_s;     % sampling period [s]
duration = 10/f_M;     % signal duration [s]

%% Generate "continuous-time" signal
t = 0:duration/1000:duration;     % continuous-time axis
x = cos(2*pi*f_M*t);     % continuous-time signal

%% Generate sampled, discrete-time signal
nT = 0:T:duration;     % discrete-time axis
x_s = cos(2*pi*f_M*nT);     % sampled signal
N = length(nT);     % number of samples

%% Signal reconstruction
x_r = zeros(length(t));
sinc_train = zeros(N,length(t));
f_c = f_s/2;     % filter cutoff frequency [Hz]
omega_c = 2*pi*f_c;     % filter cutoff frequency [rad/s]
for idx_t = 1:length(t)
  for n = 0:N-1
    sinc_train(n+1,:)  = omega_c*T/pi * sin(omega_c*(t-n*T)) ./ (omega_c*(t-n*T));
    x_r(idx_t) = x_r(idx_t) + % ...  **missing line of code**
  end
end

%% Plot the sinc train
figure; hold on; grid on;
plot(t,x_s.'.*sinc_train,'LineWidth',2)
stem(nT,x_s,'LineWidth',2)
xlabel('Time [s]')
ylabel('Amplitude')
title('Sinc train used for interpolation')

%% Plot the sampled and reconstructed signals
figure; hold on; grid on;
plot(t,x,'LineWidth',2)
stem(nT,x_s,'LineWidth',2)
plot(t,x_r,'--','LineWidth',2)
xlabel('Time [s]')
ylabel('Amplitude')
legend('Original signal','Sampled signal','Reconstructed signal')
title('Original, sampled, and reconstructed signals')
```

Assignments:

(a) Analyze and explain the above code.

(b) Complete the **missing line of code** to reconstruct the original signal by using the following formula from the theory:

$$x_r(t) = \sum_{n=0}^{N-1} x(nT) \frac{\omega_c T}{\pi} \frac{\sin(\omega_c(t - nT))}{\omega_c(t - nT)}.$$

(c) Set a sampling rate `f_s` that allows to reconstruct the original signal. Produce plots.

(d) Set a sampling rate `f_s` that incurs aliasing. Produce plots.