Lab 2

Discrete-Time Signals and Systems

Exercise 1 (3 points)

Matlab filename must be `exer01.m`.
Let $x_1[n]$ and $x_2[n]$ be the following signals: $x_1[n] = \cos(0.11\pi n)$ and $x_2[n] = \cos(781n/2260)$.

1. Discuss the periodicity/non-periodicity of both signals. Which one is periodic? And non-periodic? Determine the period.
2. Plot the signals for the duration of one period calculated above.
3. Plot $x_1[n] - x_2[n]$ for large values of n.
4. Discuss the above results. Are both signals the same? If not, what is going on? Explain

Exercise 2 (3 points)

Matlab filename must be `exer02.m`.
Let $x(t)$ be the following continuous-time type signal: $x(t) = 5\sin(2\pi f_c t)$. We have two signals: one with $f_{c1} = 126Hz$ and another with $f_{c2} = 722Hz$.

1. If we sample both signals at different sampling rates (f_{m1} and f_{m2}), determine the relation between f_{m1} and f_{m2} so that the samples are exactly the same.
2. Using the above result, select appropriate values for:
   - f_{m1} and f_{m2}
   - The sample duration T (for example, three times the maximum period of both signals)

   Generate the continuous-time signals ($x_1(t)$ and $x_2(t)$) and the sampled signals $x_1[n]$ and $x_2[n]$. Plot the sampled signals along with the continuous-time signals in the same figure using a time axis.
3. Plot vectors $x_1[n]$ and $x_2[n]$ along a sample number axis.
4. Discuss the results

Exercise 3 (4 points)

Matlab filename must be `exer03.m`.
A LTI system is given by the following difference equation:

$$y[n] = 0.4 \cdot y[n-1] - 0.2 \cdot y[n-2] + x[n] - x[n-1] \tag{2.1}$$

1. Determine the roots of the characteristic polynomial. You can use Matlab's `roots()` function

2. Obtain the mathematical expression of the impulse response.

3. Use Matlab's `filter()` function (see below) to obtain the impulse response of the system.

4. Compare results by plotting them in the same figure.

Note : In order to calculate the response of a system to a given input use the Matlab function `filter`. Let us use an example to show it. A system given by

$$y[n] = -a_1 \cdot y[n-1] - a_2 \cdot y[n-2] + b_0 \cdot x[n] + b_1 \cdot x[n-1] \tag{2.2}$$

The response of the system to a signal $x[n]$ can be computed in Matlab using the following code:

```
% A difference equation given by:
% y[n] + a1 y[n-1] + a2 y[n-2] = b0 x[n] + b1 x[n-1]
% We define the following vectors:
B = [b0 b1];    % Coeffs that multiply x[n], x[n-1],... in the above diff. eq.
A = [1 a1 a2]; % Coeffs that multiply y[n], y[n-1],... in the above diff. eq.
% Just to show how it works, we generate a 100 element random vector
x = randn(1,100); % (Normal distribution, zero mean, variance 1)
y = filter(B,A,x); % I've assumed here that Initial Conditions are zero
% If Initial Conditions are are not zero, let's say y[-1]=ym1,  y[-2]=ym2
ym1 = 1; ym2 = 1;
yic = [ym1 ym2];  % Vector with the initial conditions (order is important!!)
Z = filtic(B,A,yic); % Converts IC into vector Z that filter() recognizes
y = filter(B,A,x,Z); % This is the result of the output with initial ...
    condition ym1 and ym2
```