Problem Set 1

Due: 5:00pm PST, Thursday, January 20th — EE 483, Spring 2022

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1. (*Practice with sketching*) Sketch (by hand) the following discrete signals, where $u[n]$ is the unit step function, $\delta[n]$ is the unit impulse function, and n is the discrete time variable:
   (a) $a[n] = (n-2)^2(u[n+3] - u[n-1])$
   (b) $b[n] = u[-n+3]u[3n-2]$
   (c) $c[n] = 3u[n+1] - 2u[n-2] - u[n-3]$
   (d) $d[n] = c[-n+2]$
   (e) $e[n] = c[-n^2]$

2. (*Practice with MATLAB*) The MATLAB software package has nice tools for plotting discrete signals. For each of the signals from problem 1, write MATLAB code that uses MATLAB's `stem` command to plot the signal over an appropriate range of n. (I encourage you to consult the MATLAB help whenever you are asked to use a command that you're not familiar with – for example, if you type the command `help stem` at the MATLAB command prompt, MATLAB will provide you with a detailed explanation of the inputs and outputs that the `stem` command expects.) **Alternatively, you can solve this problem in Python, e.g., using functions from the `matplotlib` library.**

3. (*Alternate Representations*) For each of the signals from problem 1, represent the signal as an ordered list of numbers. For example, the unit impulse sequence $\delta[n]$ would have the representation:
$$\{\ldots, 0, 0, \underset{\uparrow}{1}, 0, 0, \ldots\}.$$

4. (*Your Interests*) In lecture, we gave (highly incomplete) lists of many kinds of digital signals and many applications of digital signal processing. Is there a class of signals (audio, images, videos, electronic brain signals, etc.) that is especially appealing/interesting to you? Are there applications of signal processing that seem especially interesting to you? There are no correct answers to these questions – the only way to lose points would be to fail to write an answer.

5. (*Refreshing your memory of important systems concepts*) Consider an LTI continuous-time system that has input $x(t)$ and output $y(t)$, with $y(t) = \int_0^T x(t-\tau)d\tau$. (Note: The purpose of Problem 5 is to help students remember prerequisite material related to continuous-time linear systems. This problem **will not be graded and does not need to be submitted with your solutions**, although if you find yourself struggling with any of these questions, you are strongly encouraged to go back and review these topics..)

   (a) Calculate the impulse response of this system, i.e., the output when $x(t) = \delta(t)$.

(b) Now calculate the output when $x(t) = \delta(t - t_0)$. Is your answer consistent with the previous claim that the system is LTI?

(c) Calculate the frequency response $X(j\Omega)$ for this system, using the Fourier transform definition given in lecture. Make sure your answer is fully simplified (it will be helpful to recall the Euler identity: $e^{i\theta} = \cos(\theta) + i\sin(\theta)$).

(d) Calculate the output of this system when the input is

$$x(t) = \begin{cases} 1, & 0 \leq t \leq S \\ 0, & \text{else.} \end{cases}$$

You are asked to do this calculation in two different ways:

i. Calculate the integral directly in the time domain.

ii. Calculate the output using a Fourier-based approach.