Spring/Summer 2018

Computer Lab Assignment 1

ECE 580 - Introduction to Discrete-Time Signals

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Objective:
The basic objective of this exercise is to familiarize you with Matlab and the basic discrete-time signals. Matlab is used as a tool to achieve this purpose.

1. Consider the curve
$$y = 20\sqrt{\frac{20 - (x+5)/5 - (x+5)^2/5^2}{4 + (-x+15)^2/5^2}}.$$
   (a) What is the range of the variable x, which makes y real?
   (b) Sketch the curve and estimate the global maximum (only real values of y).
   (c) Find the value of this maximum and the corresponding value of x at the maximum.

2. Plot the following functions on the same graph with black, red and brown colors respectively. Take the interval $0 \leq t \leq 20$ and choose a suitable $\triangle t$ (e.g., $0.01s$).
   (a) $y_1(t) = 6e^{-t/2}$
   (b) $y_2(t) = 12e^{-0.25t}$
   (c) $y_3(t) = 12e^{-t/4}\cos(12t + \frac{\pi}{3}) + 6e^{-t/2}$

   Limit the Y-axis from - 7 to 16 and the X-axis from 0 to 15. Also determine the values of $y_3(t)$ at $t = 3$ and $t = 5$, the minimum and maximum values of $y_3(t)$, and the time where $y_2(t) = 8$. Also, use the legend command to identify the different curves.

3. Consider the continuous-time signal given by $x(t) = 128t^2\ e^{-0.3466t}\cos(0.6\pi t + \frac{\pi}{3})u_a(t)$.
   (a) Plot $x(t)$. Hence, find the its max. value and the time where the max. occurs.
   (b) Determine the integral $A = \int\limits_0^\infty x(t)dt$.
   (c) In case the integral $\int\limits_0^{t_0} x(t)dt = 0.4A$, determine the value of t_0.
   (d) Determine the energy of the signal $x(t)$.

4. Write an expression for the Taylor series expansion for the signal $log_e(1-x)$, where $|x| < 1$.
   (a) Find the exact value of $log_e(0.5)$.
   (b) In case we are calculating $log_e(0.5)$ using its Taylor series expansion, how many terms do we need to obtain an accuracy of $\leq 0.1\%$?

5. Generate and plot the following discrete-time signals (sequences):

(a) $x_1(n) = \delta(n-3) * \delta(n+2)$,	$-6 \le n \le 10$
(b) $x_2(n) = 2\delta(n-320)$,	$300 \le n \le 350$
(c) $x_3(n) = 3.6\delta(n+6) + 2.4\delta(n-5)$,	$-12 \le n \le 8$
(d) $x_4(n) = u(-n+2)u(2n+9)$,	$-10 \le n \le 20$
(e) $x_5(n) = p_4(n) * p_2(n)$,	$-12 \le n \le 12$.

Note: The * is the convolution sign and $p_N(n)$ is a pulse of length N.

6. Determine which sequences are periodic. Hence, for the periodic ones, find their period, average power and plot 5 periods. For part (c), show that it is possible to express the sequence using a simple formula. As for the aperiodic signals, just plot 40 samples.

   (a) $x_1(n) = 2\cos(\frac{\pi}{6}n + \frac{\pi}{4})$
   (b) $x_2(n) = \sin(\frac{\pi}{15}n + \frac{\pi}{5})$
   (c) $x_3(n) = 4\sin(3\pi n - \frac{\pi}{2})$
   (d) $x_4(n) = \cos(\frac{\pi}{\sqrt{15}}n)$
   (e) $x_5(n) = \sin(\frac{\pi}{4}n) + 3\cos(\frac{\pi}{3}n - \frac{\pi}{3})$
   (f) $x_6(n) = 4\sin(\frac{\pi}{5}n + \frac{\pi}{4})\cos(\frac{\pi}{3}n)$
   (g) $x_7(n) = 2sinc(\frac{\pi}{15}n)$. Hint: Choose $-100 \le n \le 100$. Hence, find the energy.

7. Generate a sampled sinusoid with the following data:

   - Signal frequency = 0.25 kHz,
   - Sampling frequency = 16 kHz,
   - Inial phase = 45 degrees,
   - Starting time = 0 sec.,
   - Amplitude = 10,
   - Ending time = 10 msec.

   Make two plots of the resulting signal: one as a function of time (in msec.), and the other as a function of the sample index n used in $t_n = nt$. Calculate the digital frequency of the sequence and its period in samples (if periodic).

8. Consider a signal $x(n)$, given that $a = 0.81$, and is described by:

$$x(n) = \begin{cases} a^{(|n|/2)}, & \text{n is an even integer;} \\ 0, & \text{otherwise.} \end{cases}$$

   (a) Sketch $x(n)$. Hint: Choose the range $|n| \le 40$.
   (b) Find the energy of the signal. Verify using the equation and Matlab.
   (c) Consider $y(n) = nx(n)$. Plot $y(n)$ and hence, determine the maximum, minimum, their corresponding values of n at the max. and min.
   (d) Find the energy of $y(n)$.

9. Consider the following discrete-time exponential signal $x(n) = 75(-0.95)^n u(n-3)$.

   (a) Plot $x(n)$ over the range $n = 0, 1, 2, \ldots, 20$.

   (b) Find the sum of the sequence for the above range. Hence, verify the result using the closed form.

   (c) Determine the sum of the sequence $x(n)$ over the entire range of integers, i.e., $n = 0, 1, 2, \ldots, \infty$.

   (d) Find the energy of the sequence $x(n)$.