DIGITAL SIGNAL PROCESSING LABORATORY
Assignment 1

1. Shifting and Reversing Sequences

Discrete time signals are often expressed in terms of time shifted and time reversed combinations of other signals. Consider the finite length sequence, $x[n]$, where

$$x[n] = \{0, 1, 2, 3, 2, 1, 0, -1, -2, -3, -2, -1\} \text{ for } 0 \leq n \leq 11$$

a) Let $s[n] = x[n\text{-}N]$. The signal $s[n]$ is said to be a delayed or shifted version of the sequence $x[n]$. $s[n]$ will represent the signal $x[n]$ shifted N samples to the right if $N > 0$ or shifted $|N|$ samples to the left if $N < 0$. Without using the computer,

i) Sketch $s1[n] = x[n]$
ii) Sketch $s2[n] = x[n\text{-}3]$
iii) Sketch $s3[n] = x[n+5]$

Then write a MATLAB function called **shift** which has the form,
[s,n] = shift(x,N,nx),
where **x** is the sequence to be shifted, **N** is the amount of the shift, **nx** (optional) is the time index for **x**, **s** is the shifted sequence, $x[n\text{-}N]$, and **n** contains the corresponding time index for **s**. Use the **shift** function that you have written to perform the time shifting. Plot your results using the built-in function, **plot(n1,s1,'*',n2,s2,'x',n3,s3,'o')**. Note that specifying positive integers shifts to the right; specifying negative integers shifts to the left.

b) The signal, $x[-n]$, is said to be time reversed. This means that the signal is flipped about the point $n = 0$. Without using the computer

i) Sketch $x[-n]$
ii) Let $v[n] = x[n\text{-}4]$. Sketch $v[-n]$
iii) Let $r[n] = x[n+3]$. Sketch $r[-n]$

Then write a MATLAB function called **reverse** which has the form,
[r,k] = reverse(x,n),
where **x** is the sequence to be reversed, **n** is the time index which corresponds to the sequence contained in **x**, **r** is the reversed sequence, $x[-n]$ and **k** contains the corresponding time index for the **r**. Check your sketches using the **reverse** function that you have written. Plot your results using the **stem** function.

2. Finite Length Sequences

The sequence

$$h[n] = u[n]\text{-}u[n\text{-}N]$$

is a finite length sequence consisting of ones for n in the range $0 \leq n < N$ and zeros everywhere else. It begins at $n = 0$ and ends at $n = N\text{-}1$. Thus, the sequence has a length equal to 10. The sequence

$$h[n] = a^n u[n]$$

is an example of an infinite length sequence, because it contains an infinite number of nonzero samples.

Several finite length sequences are listed below. Find the sequence lengths for each of these sequences and determine their starting and ending points. This exercise should be performed initially without the aid of the computer.

a) $x[n] = u[n-2] - u[n-12]$
b) $v[n] = u[n+16] - u[n-7]$
c) $y[n] = x[n]\, v[n]$
d) $r[n] = x[n] + v[n]$
e) $s[n] = x[n+2]\, v[n-2]$
f) $t[n] = y[n-1] + y[n+1]$

Using the computer, verify your answers and plot your results using the **stem** function.

A true unit step sequence is infinite in duration. To program a true step sequence is an ominous task even for today's computers. You can approximate a step sequence with a long sequence. However, when this finite length sequence is shifted, the length or the starting point of the shifted sequence can change depending on how you wrote your **shift** function. If the two sequences have different lengths or starting points, you will be unable to add, subtract or multiply them. To make these signals compatible for performing arithmetic operations using MATLAB, write a MATLAB function called **compsig** which has the form,

[s1,s2,n] = **compsig(x1,n1,x2,n2)**,

where **x1** and **x2** are sequence with different lengths and starting times, **n1** and **n2** contain the time indices for **x1** and **x2**, respectively, and **s1** and **s2** are the equal length sequences corresponding to **x1** and **x2**, respectively with **n** as a common time index. Because you will approximate infinite length sequences with finite length sequences, arithmetic operations may produce erroneous values at the end of the sequence. Avoid plotting these values by using sequences of length 100 for the calculations and then display your final result using the first 40 or so samples at the beginning of the sequence.

3. Elementary Signals

Generate the following signals for $0 \le n \le 30$

i) $\delta[n]$, the unit impulse sequence.
ii) $r[n]$, the ramp function, defined as $nu[n]$.
iii) $e[n]$, a one-sided exponential, $(5/6)^n u[n]$.

Using the elementary signals just created, generate and plot the following new signals:

a) $v[n] = r[n-6]\, u[n]$
b) $x[n] = \delta[n-15]\, v[n]$
c) $y[n] = e[n+10]\, u[n]$
d) $z[n] = e[n]\,(u[n] - u[n-10])$
e) $c[n] = e[2n - 5]$