

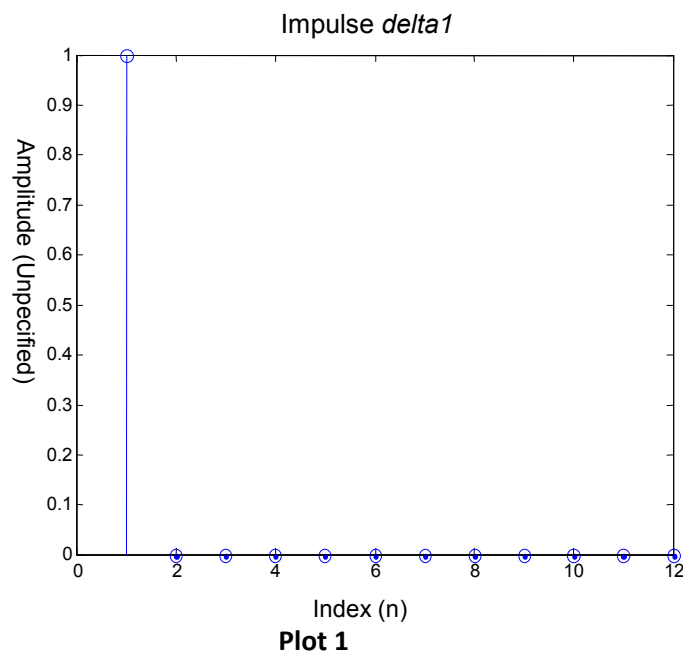
Project #1: Convolution

1. Write a MATLAB function to generate a periodic waveform of total length L . Each period must be a truncated, decaying exponential $A \exp(-bn)$ with decay rate b that begins with amplitude A and lasts a total of M samples. The result should look something like a series of waves. By learning from the triangular waveform function example in MATLAB for DSP, it is possible to write this function without loops. (This is not necessary for full credit.) Include a listing of your function.

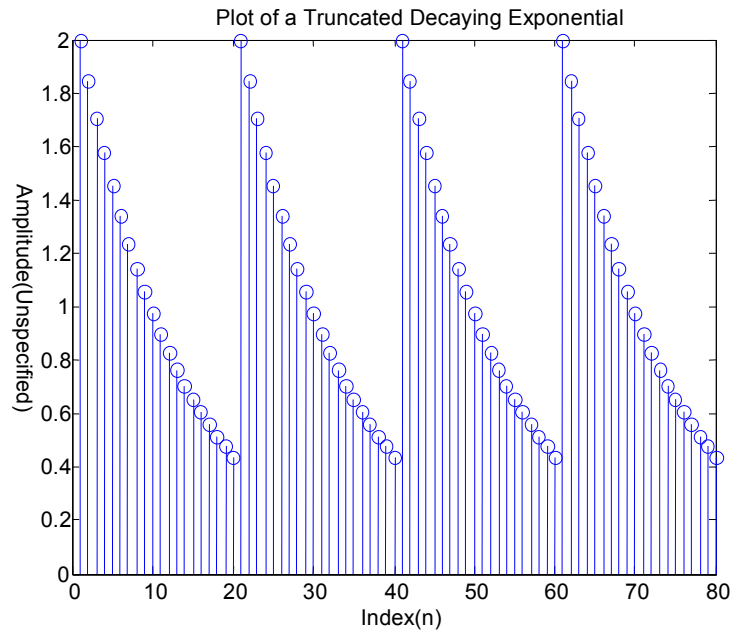
```
-----  
function pw = decay(L, A, b, n)  
% Usage Ex. decay(80,2,0.08,20)  
z = A.*exp(-b.*(0:n-1));  
period = L/n; % Number of periods = Total length of waveform/samples per  
period  
for i = 1:round(period/2)  
    z = horzcat(z,z);  
end  
stem(z)  
title('Plot of a Truncated Decaying Exponential')  
xlabel('Index (n)')  
ylabel('Amplitude (Unspecified)')  
-----
```

2. Create two signals:

- (a) Create a length-12 vector representing an impulse ($\delta_1 = [1, \text{zeros}(1,11)]$). Note that this is an impulse with some of the zeros shown, not a pulse.

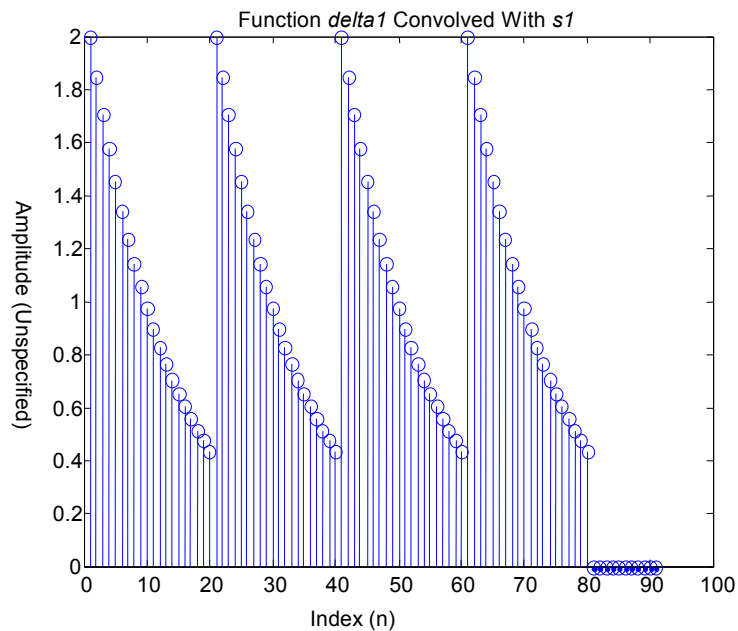


(b) Create a wave s_1 with $L=80$, $A=2$, $b=0:08$, and $M=20$.



Plot 2

3. Use *conv* to convolve s_1 and δ_{10} , and plot the result using *stem*.



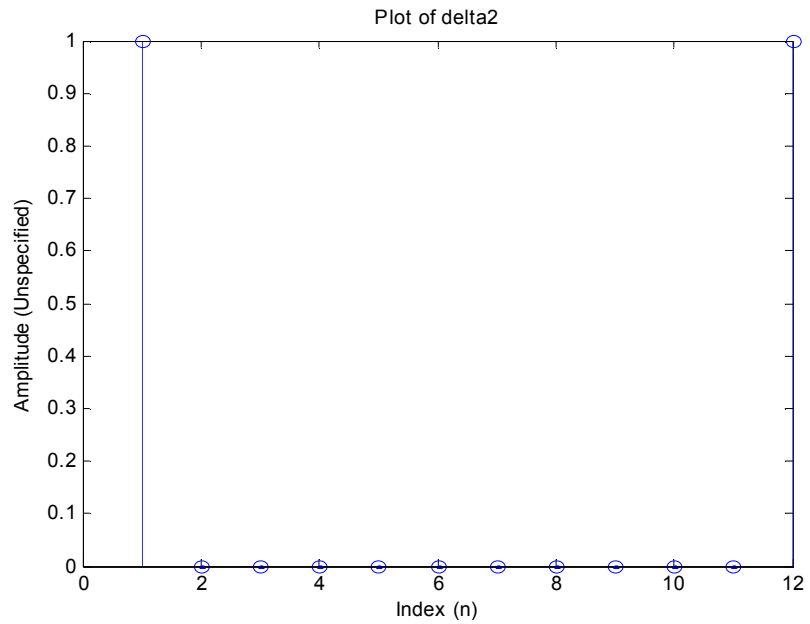
Plot 3

From the plot, one can see that the convolution of an impulse at $x=1$ followed by 10 zeros and a truncated, decaying exponential is the set of truncated exponentials followed by the 10 zeros.

Note: It should be noted that, although mathematically these functions start at 0, in MATLAB the index begins at 1. So all of the data should be shifted as described by $x[n+1]$ (It seemed an unnecessary chore to shift the function considering the scope and purpose of this project).

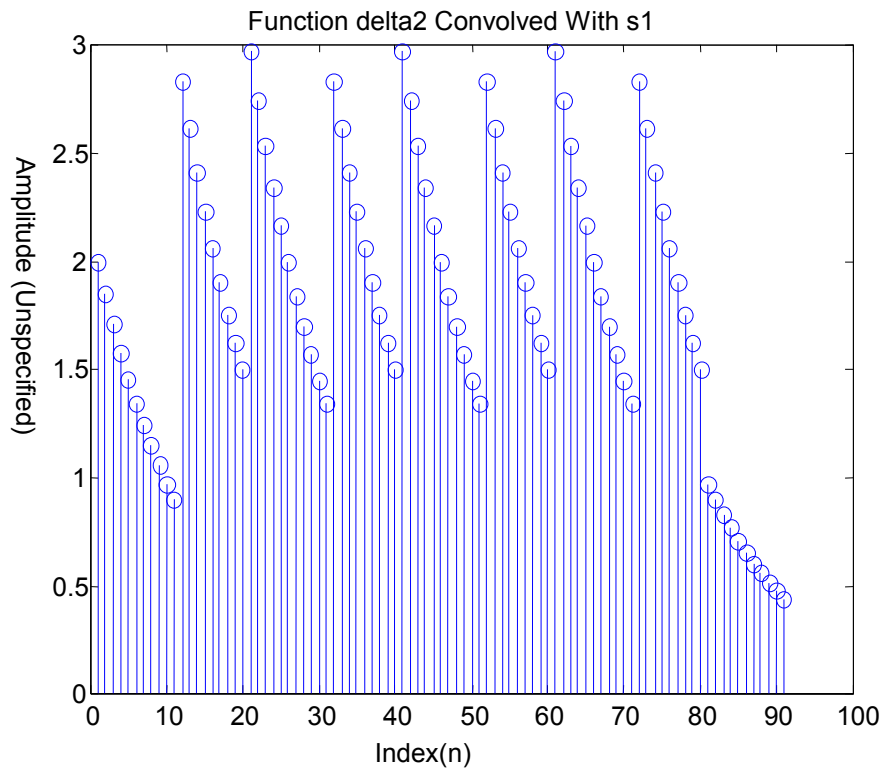
4. Examine another convolution:

(a) Create another vector of length 12 representing an impulse at 0 and 11 ($\delta_2 = [1 \text{ zeros}(1,10) 1]$);



Plot 4

(b) Convolve delta2 with s1 and plot the result.



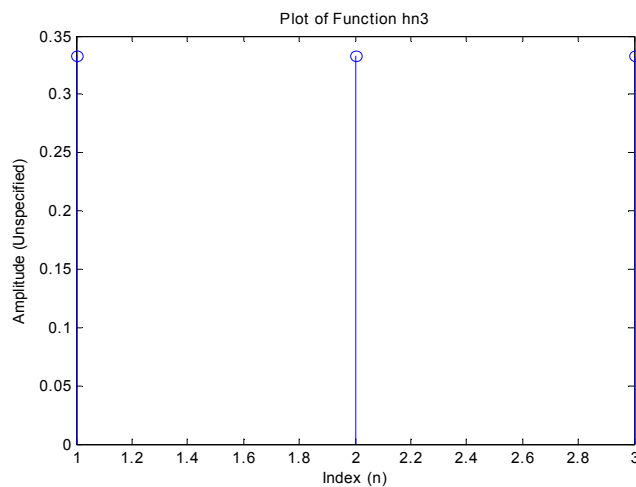
Plot 5

(c) Explain the relationship between this plot and the previous one.

Noting that the function $s1$ is a series of 4 decaying exponentials, each 20 points on the x-axis and also noting that the function $delta2$ is two impulses at 1 and 12 on the x-axis. From the plot, one can see that the convolution of the two discrete functions can be thought of as the repetition of $s1$ at each of the two impulses of $delta2$. The amplitude of the convolved function at each point is the sum of the individual amplitudes.

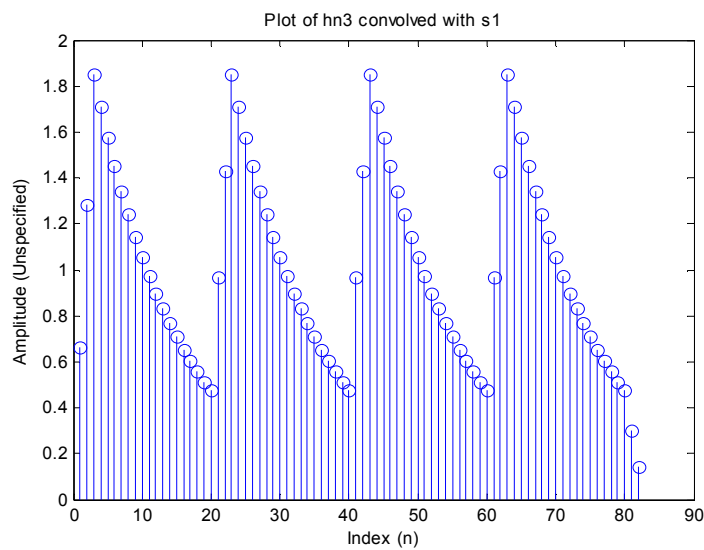
5. Examine another type of impulse response:

(a) Create a flat impulse response $hn3$ that is three points long and normalized by the length ($hn3 = 1/3 * [ones(1,3)]$);).



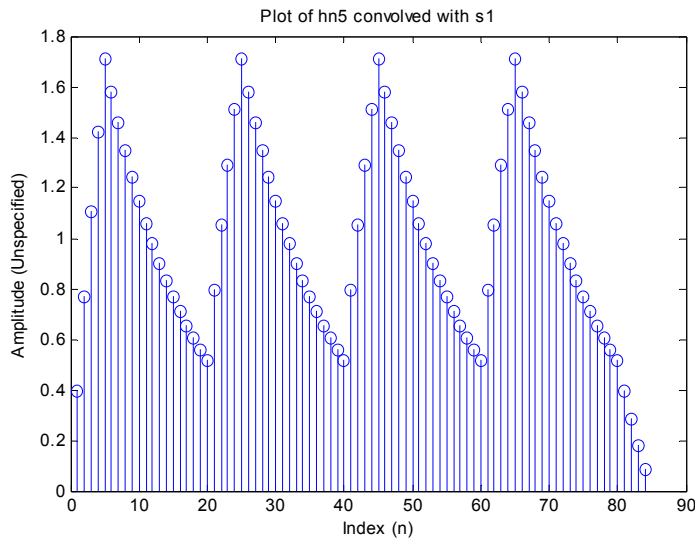
Plot 6

(b) Convolve $hn3$ with $s1$.

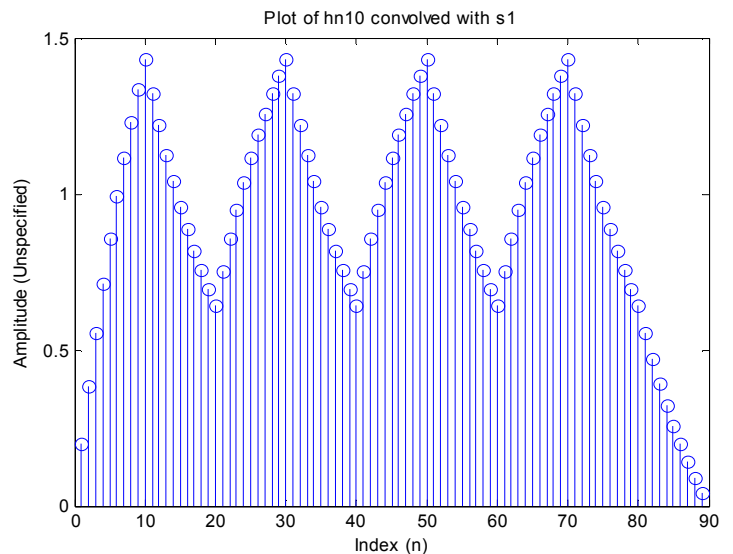


Plot 7

(c) Increase the length of the impulse response to 5 and 10 and redo the convolution.



Plot 8



Plot 9

(d) What happens to the result as the length of the impulse response is increased? Explain.

As before, each of the $s1$ functions starts at each consecutive x -value which corresponds to the positions of the impulses of $hn5$ or $hn10$ which causes the ramping up behavior at the beginning of each decaying exponential. Also, again the amplitude of the convolved set is equal to the sum of the amplitudes of the individual functions.

6. Let $x[n] = \mu[n] - \mu[n - 5]$. Let $h[n] = \delta[n] + 2\delta[n - 3]$. Determine $x[n] * h[n]$ analytically, Explaining each step (Keep $x[n]$ in the form of a difference of two step functions and not a list of numbers. Your answer should be a functional expression, not an explicitly written sequence of numbers.). Check your result using MATLAB. Explain how you checked the result.

*See attached sheet for analytical solution.

To verify in MATLAB:

```
-----
x=[1,1,1,1,1];
h=[1,0,0,2];
stem(conv(x,h))
-----
```

The stem plot matches the calculations on page 6 (although, as noted on page 2, MATLAB begins its index at 1 instead of 0 as it would begin mathematically), therefore, the result is accurate.