PROBLEM:

The diagram in Fig. 1 depicts a *cascade connection* of two linear time-invariant systems; i.e., the output of the first system is the input to the second system, and the overall output is the output of the second system.

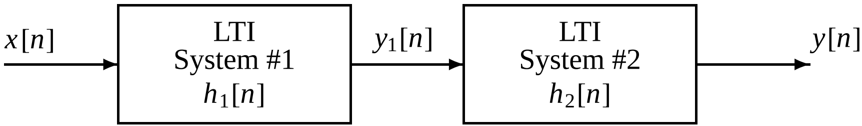

Figure 1: Cascade connection of two LTI systems.

(a) Suppose that System #1 is a "first-difference" filter described by the difference equation

$$y_1[n] = x[n] - x[n-1],$$

and System #2 is described by the impulse response

$$h_2[n] = u[n] - u[n-10]$$

Determine the impulse response sequence, $h[n] = h_1[n] * h_2[n]$, of the overall cascade system.

(b) Obtain a single difference equation that relates $y[n]$ to $x[n]$ in Fig. 1.

McClellan, Schafer and Yoder, *Signal Processing First*, ISBN 0-13-065562-7.
Prentice Hall, Upper Saddle River, NJ 07458.

SOLUTION

a) The impluse response for $y_1[n]$ is $h_1[n] = \delta[n] - \delta[n-1]$ with coefficients $b_k = \{1, -1\}$. The coefficients for $h_2[n]$ are $b_k = \{1, 1, 1, 1, 1, 1, 1, 1, 1, 1\}$. The impulse response for the overall cascade system can be tabulated as follows.

n	0	1	2	3	4	5	6	7	8	9	10	11
$h_2[n]$	1	1	1	1	1	1	1	1	1	1		
$h_1[n]$	1	-1										
	1	1	1	1	1	1	1	1	1	1		
		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	
$h[n]$	1	0	0	0	0	0	0	0	0	0	-1	

Therefore, $h[n] = \delta[n] - \delta[n-10]$.

b) Given the impulse response $h[n]$ from a), then $y[n] = x[n] - x[n-10]$.

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