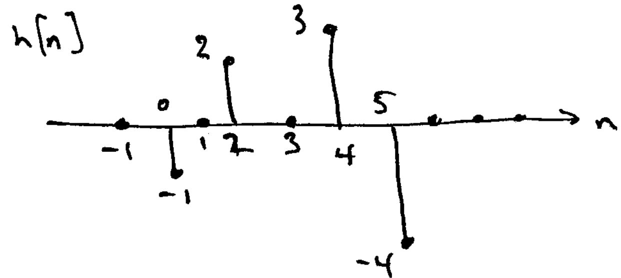
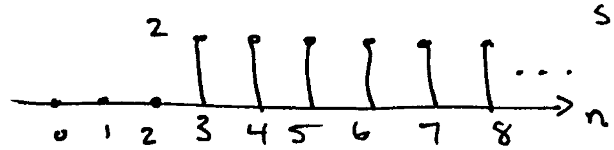
7.1 (a) $h[n] = -\delta[n] + 2\delta[n-2] + 3\delta[n-4] - 4\delta[n-5]$



(b) $b_k = \begin{cases} -1, & k=0 \\ 2, & k=2 \\ 3, & k=4 \\ -4, & k=5 \\ 0, & \text{otherwise} \end{cases}$

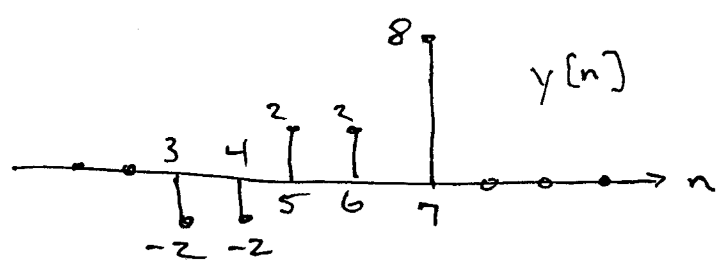
(c) $M=5, \; L=6$

(d) $s[n] = 2u[n-3]$

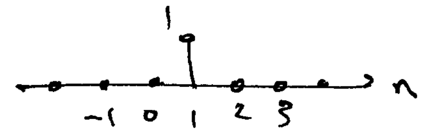


(e)

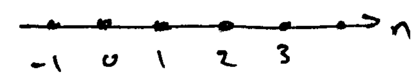
n	0	1	2	3	4	5	6	7	8	9	10	11	12
$x[n]$	0	0	0	2	2	2	2	2	2	2	2	2	2
$h[n]$	-1	0	2	0	3	-4	0	0	0	0	0	0	0
$h[0]x[n]$	0	0	0	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
$h[1]x[n-1]$	0	0	0	0	0	0	0	0	0	0	0	0	0
$h[2]x[n-2]$	0	0	0	0	0	4	4	4	4	4	4	4	4
$h[3]x[n-3]$	0	0	0	0	0	0	0	0	0	0	0	0	0
$h[4]x[n-4]$	0	0	0	0	0	0	0	6	6	6	6	6	6
$h[5]x[n-5]$	0	0	0	0	0	0	0	0	-8	-8	-8	-8	-8
$y[n]$	0	0	0	-2	-2	2	2	8	0	0	0	0	0



7.2 (a) 1. $h[n] = n\,\delta[n-1] = \delta[n-1]$



2. $h[n] = \delta[\underbrace{2^{|n-1|}}_{\text{never zero}}] \Rightarrow h[n] = 0$



(b) 1.
$$x_1[n] \longmapsto y_1[n] = n\,x_1[n-1]$$
$$x_2[n] \longmapsto y_2[n] = n\,x_2[n-1]$$
$$a x_1[n] + b x_2[n] \longmapsto n\{a x_1[n-1] + b x_2[n-1]\}$$
$$a y_1[n] + b y_2[n] = a n x_1[n-1] + b n x_2[n-1]$$
equal

$\Rightarrow$ <u>LINEAR</u>

2.
$$x_1[n] \longmapsto y_1[n] = x_1[2^{|n-1|}]$$
$$x_2[n] \longmapsto y_2[n] = x_2[2^{|n-1|}]$$
$$a x_1[n] + b x_2[n] \longmapsto a x_1[2^{|n-1|}] + b x_2[2^{|n-1|}]$$
$$a y_1[n] + b y_2[n] = a x_1[2^{|n-1|}] + b x_2[2^{|n-1|}]$$
equal

$\Rightarrow$ LINEAR

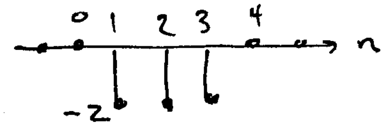
(c) 1.
$$x[n-2] \longmapsto n\,x[n-3]$$
$$y[n-2] = (n-2)\,x[n-3]$$
not equal $\Rightarrow$ NOT TIME INVARIANT

2.
$$x[n-2] \longmapsto x[2^{|n-1|} - 2]$$
$$y[n-2] = x[2^{|n-2-1|}]$$
not equal $\Rightarrow$ NOT TIME INVARIANT

(d) 1. Causal. Only needs input for one sample in the past.

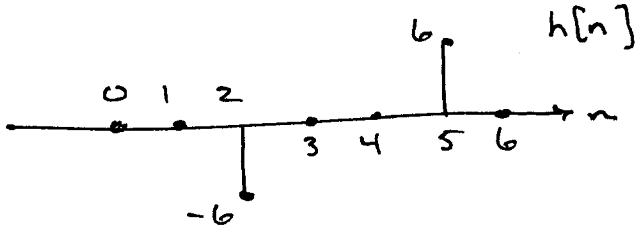
2. Not causal: $y[4] = x[2^{|4-1|}] = x[8]$ which is in the future.

(7.3) (a) $h_1[n] = -2\delta[n-3] - 2\delta[n-2] - 2\delta[n-1]$



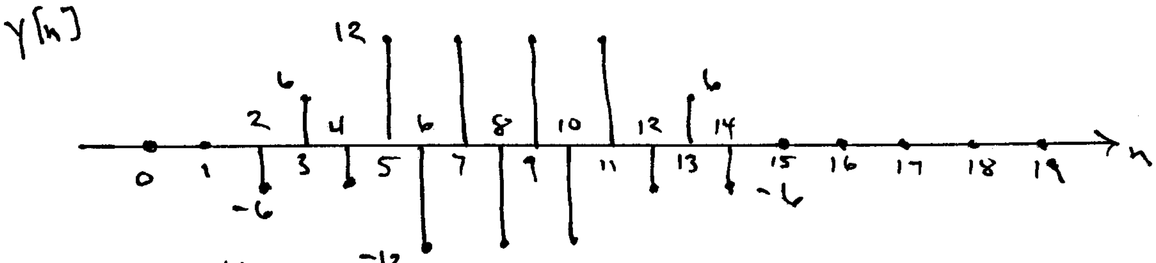
(b) $h[n] = h_1[n] * h_2[n] = \sum_{k=0}^{2} h_2[k]\, h_1[n-k]$

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



(c)

n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$h[n]$	0	0	-6	0	0	6	0	0	0	0	0	0	0	0	0	0
$x[n]$	1	-1	1	-1	1	-1	1	-1	1	-1	0	0	0	0	0	0
$h[2]x[n-2]$	0	0	-6	6	-6	6	-6	6	-6	6	-6	6	0	0	0	0
$h[5]x[n-5]$	0	0	0	0	0	6	-6	6	-6	6	-6	6	-6	6	-6	0
$y[n]$	0	0	-6	6	-6	12	-12	12	-12	12	-12	12	-6	6	-6	0



$y[n]=0$, $n \le 1$ | $y[n] \ne 0$, $2 \le n \le 14$ | $y[n]=0$, $n \ge 15$

7.4 (a) $M=13$ and the filter length $L=14$.

[Note: this system can also be implemented as a length-12 filter with a delay of 2 because $b_0 = b_1 = 0$.]

$$b_k = \begin{cases} 1, & k = 2,4,6,8,10,12 \\ -1, & k = 3,5,7,9,11,13 \\ 0, & \text{otherwise} \end{cases}$$

(b) $$y[n] = \sum_{k=2}^{13} (-1)^k x[n-k] = x[n-2] - x[n-3] + x[n-4] - x[n-5] + \cdots - x[n-13].$$

First non zero for $n=2$, because of $x[n-2]$ term.

Last non zero for $n = 141 = 128+13$, because of $x[n-13]$ term.

(c) $N_3 = 100 + 300 = 400$

$N_4 = 222 + 444 = 666$

$$y[n] = \sum_{k=300}^{444} h[k]\, x[n-k]$$

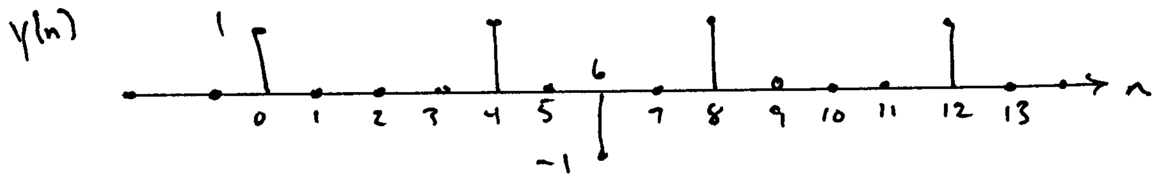
So, to calculate $y[n]$, the system weights and sums terms from $x[n]$ for $n-444$ to $n-300$.

First non zero term in $y[n]$ when $n - 300 = 100$ (the first non zero term in $x[n]$). $\Rightarrow$ $N_3 = 100 + 300 = 400$.

Last non zero term in $y[n]$ when $n - 444 = 222$ (the last non zero term in $x[n]$). $\Rightarrow$ $N_4 = 222 + 444 = 666$.

7.5 (a)

n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$h[n]=[1\,0\,1\,0\,1]$	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
$x[n]=\cos(\frac{\pi}{2}(0{:}8))$	1	0	-1	0	1	0	-1	0	1	0	0	0	0	0	0
$h[0]x[n]$	1	0	-1	0	1	0	-1	0	1	0	0	0	0	0	0
$h[2]x[n-2]$	0	0	1	0	-1	0	1	0	-1	0	1	0	0	0	0
$h[4]x[n-4]$	0	0	0	0	1	0	-1	0	1	0	-1	0	1	0	0
$y[n]$	1	0	0	0	1	0	-1	0	1	0	0	0	1	0	0



(b)

n	0	1	2	3	4	5	6	7	8	9	10	11	12	13
$p[n]$	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	0	0
$p[0]p[n]$	1	1	1	1	1	1	1	0	0	0	0	0	0	0
$p[1]p[n-1]$	0	1	1	1	1	1	1	1	0	0	0	0	0	0
$p[2]p[n-2]$	0	0	1	1	1	1	1	1	1	0	0	0	0	0
$p[3]p[n-3]$	0	0	0	1	1	1	1	1	1	1	0	0	0	0
$p[4]p[n-4]$	0	0	0	0	1	1	1	1	1	1	1	0	0	0
$p[5]p[n-5]$	0	0	0	0	0	1	1	1	1	1	1	1	0	0
$p[6]p[n-6]$	0	0	0	0	0	0	1	1	1	1	1	1	1	0
$y[n]$	1	2	3	4	5	6	7	6	5	4	3	2	1	0