PRÁCTICA 2

2.4.1 Enunciados

1. Empleando la función desarrollada en el apartado 2.3.1 y dadas las siguientes secuencias:

$$x_1[n] = A_1(\mathrm{u}[n + N_1] - \mathrm{u}[n - N_1])$$

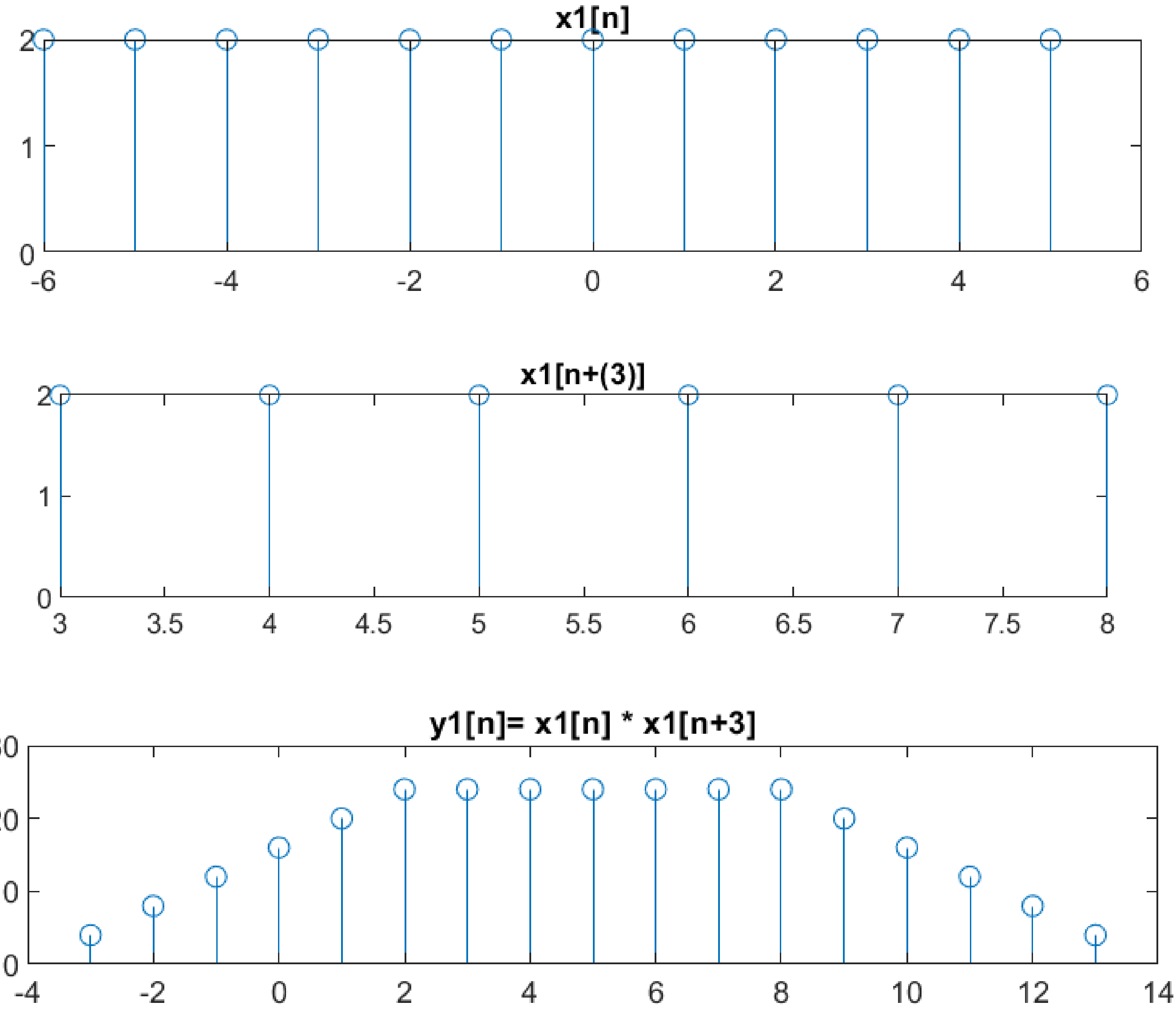
$$x_2[n] = A_2\mathrm{u}[n + N_2] \cdot \mathrm{u}[-n + N_2]$$

$$x_3[n] = A_3(\mathrm{u}[n + N_1] - \mathrm{u}[n - N_2]) \cdot \mathrm{e}^{\mathrm{j}\Omega_1 n}$$

Obtener y representar las siguientes convoluciones (represente también las señales que se convolucionan):

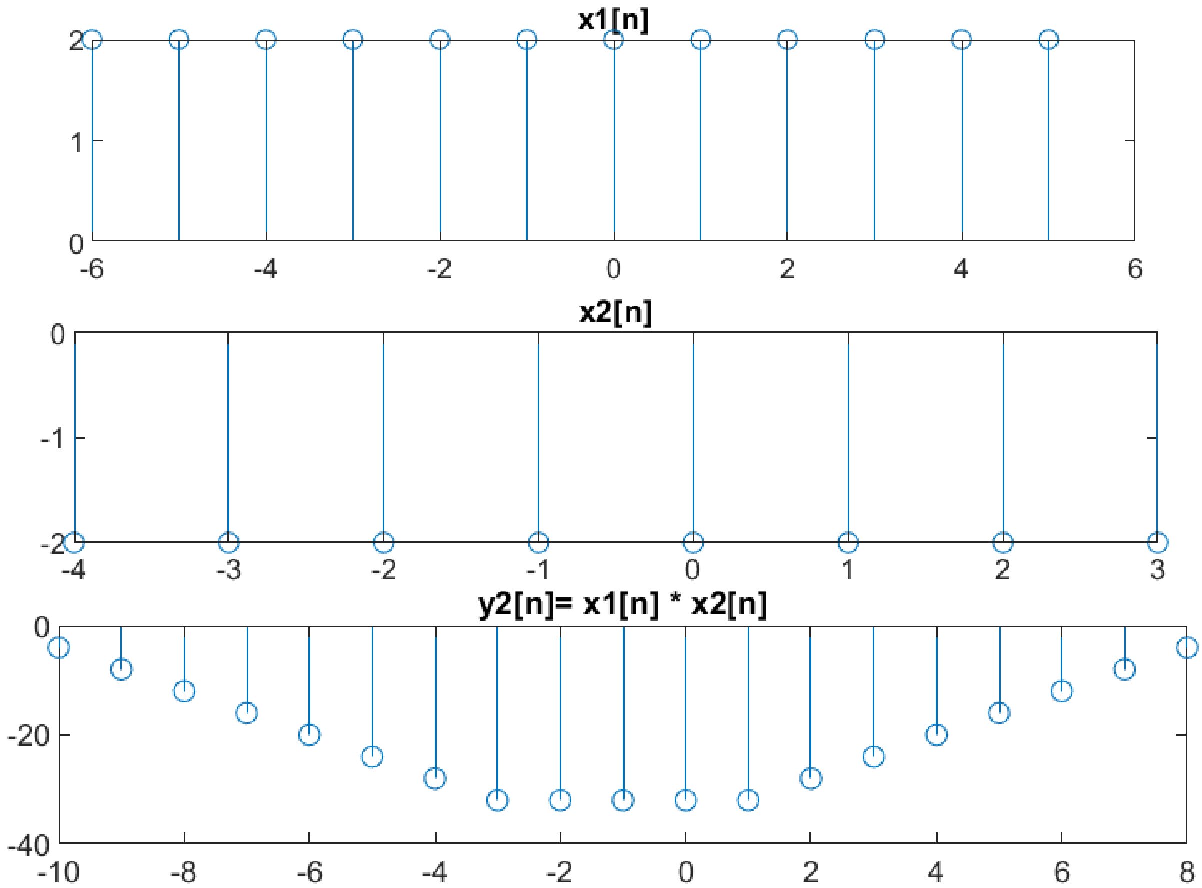
1.1. $y_1[n] = x_1[n] * x_1[n + N_3]$

```
function [y1, ini_y]= convolucion(x1, ini_x, h,
ini_h)
ini_x = -6;
n_x = ini_x : 5;

ini_h = 3;
n_h = ini_h : 8;

x1 =2.*ones(1,length(n_x));
h= 2.*ones(1, length(n_h));


y1 = conv(x1,h);
ini_y = ini_x + ini_h;

subplot(3,1,1)
stem (n_x, x1)
title('x1[n]')

subplot(3,1,2)
stem (n_h, h)
title('x1[n+3]')

subplot(3,1,3)
n_y = ini_y :(ini_y + length(y1)-1);
stem (n_y,y1);
title('y1[n]= x1[n] * x1[n+3]')
end
```


x1[n]
x1[n+(3)]
y1[n]= x1[n] * x1[n+3]

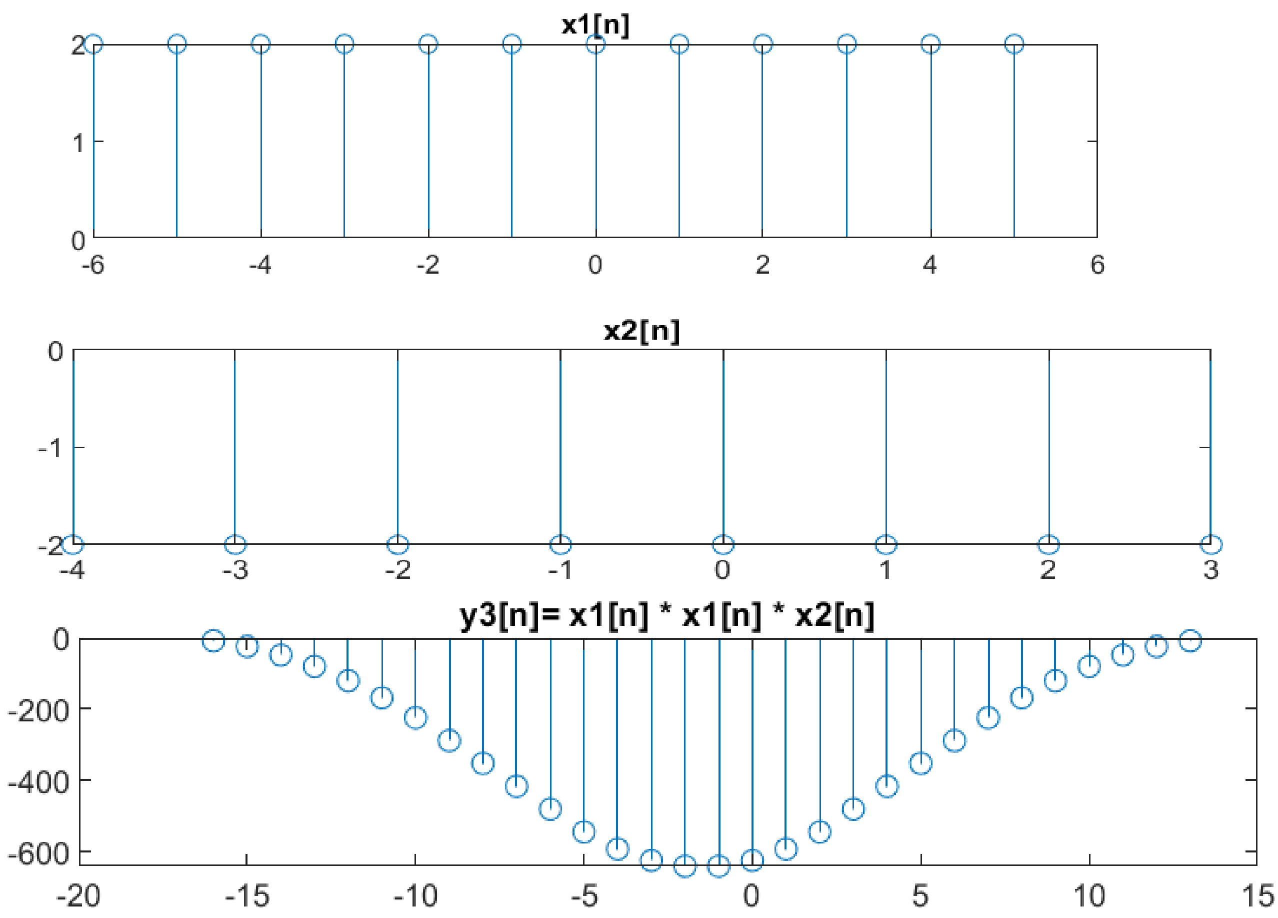
1.2. $y_2[n] = x_1[n] * x_2[n]$

```
function [y2, ini_y]= convolucion2(x1, ini_x, x2, ini_x2)
ini_x = -6;
n_x = ini_x : 5;

ini_x2 = -4;
n_2 = ini_x2 : 3;

x1 =2.*ones(1,length(n_x));
x2 =(-2).*ones(1,length(n_2));


y2 = conv(x1,x2);
ini_y = ini_x + ini_x2;

subplot(3,1,1)
stem (n_x, x1)
title('x1[n]')

subplot(3,1,2)
stem (n_2, x2)
title('x2[n]')

subplot(3,1,3)
n_y = ini_y :(ini_y + length(y2)-1);
stem (n_y,y2);
title('y2[n]= x1[n] * x2[n]')
end
```



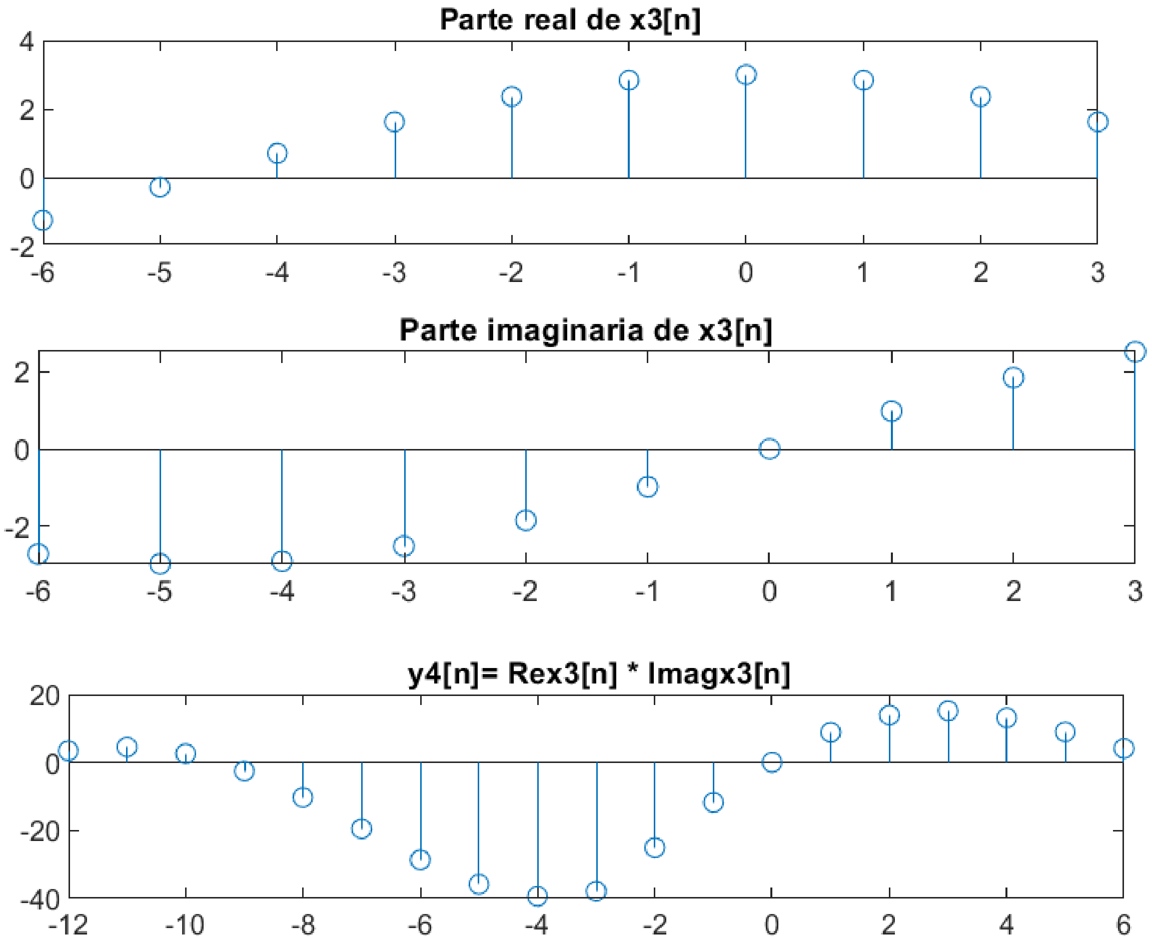
1.3. $y_3[n] = x_1[n] * x_1[n] * x_2[n]$

```
function [y3, ini_y3]= convolucion3(x1, ini_x, y2, ini_y)
ini_x = -6;
n_x = ini_x : 5;

ini_x2 = -4;
n_2 = ini_x2 : 3;

x1 =2.*ones(1,length(n_x));
x2 =(-2).*ones(1,length(n_2));


y2 = conv(x1,x2);
ini_y = ini_x + ini_x2;

y3 = conv(x1,y2);
ini_y3 = ini_x + ini_y;

subplot(3,1,1)
stem (n_x, x1)
title('x1[n]')

subplot(3,1,2)
stem (n_2, x2)
title('x2[n]')

subplot(3,1,3)
n_y = ini_y3 :(ini_y3 + length(y3)-1);
stem (n_y,y3);
title('y3[n]= x1[n] * x1[n] * x2[n]')
end
```



1.4. $y_4[n] = \mathrm{Re}\,\{x_3[n]\} * \mathrm{Im}\,\{x_3[n - N_4]\}$

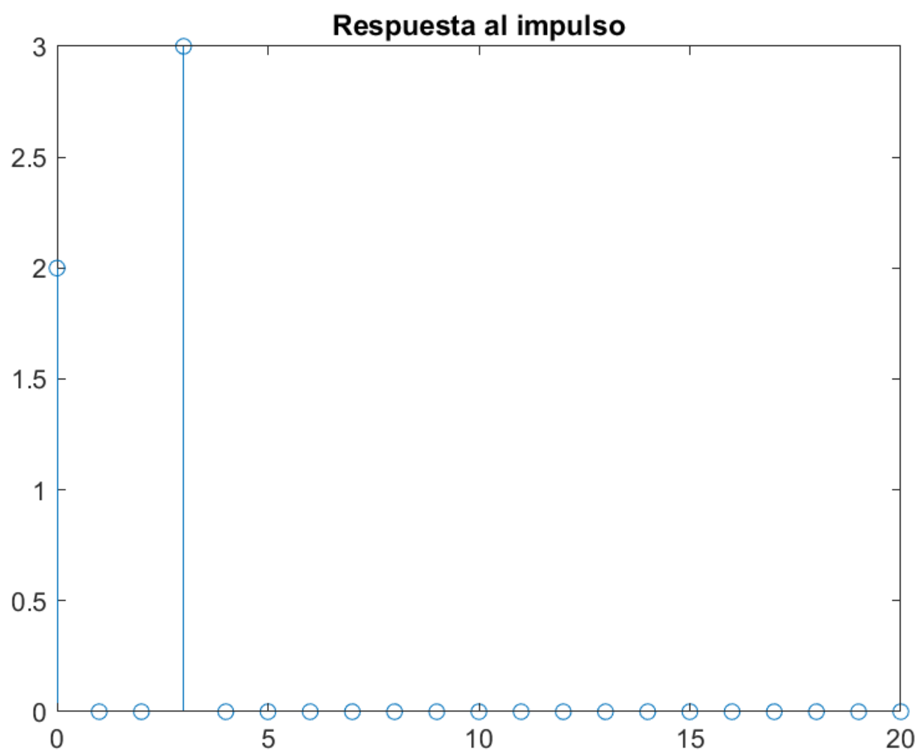
```
function [y4, ini_y4]= convolucion4(x3, ini_x3, imag_x3, ini_imag_x3)

ini_x3= -6;
n_x3 = ini_x3 : 3;

x3 = 3*exp((1/3)*1i.*n_x3).*ones(1, length(n_x3));

subplot(311);
stem(n_x3, real(x3));
title('Parte real de x3[n]');

subplot(312);
stem(n_x3, imag(x3));
title('Parte imaginaria de x3[n]');
ini_imag_x3 = ini_x3;
imag_x3 = imag(x3);

y4 = conv(x3,imag_x3);
ini_y4 = ini_x3 + ini_imag_x3;

n_y = ini_y4 : ini_y4 + length(y4)-1;
subplot(313);
stem(n_y, y4);
title(' y4[n]= Re{x3[n]} * Imag{x3[n]}');
end
```



2. Obtener y representar, para n=0,1…N_5, la respuesta al impulso de los sistemas LTI descritos por las siguientes ecuaciones en diferencias. Observando la respuesta al impulso, determinar si los sistemas son estables.

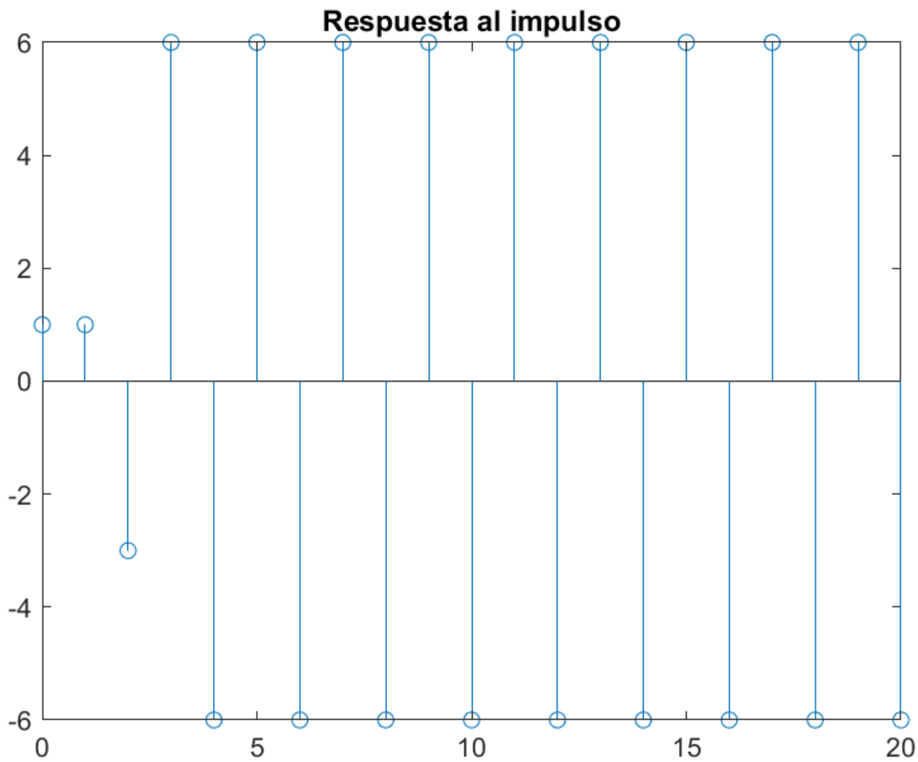
2.1. $y[n] = A_1 x[n] + A_3 x[n - N_3]$, C.I. nulas.

```
a=1;
b=[2 0 0 3];
n=0:20;
imp=[1 zeros(1, 20)];
h=filter(b, a, imp);
stem(n,h); title('Respuesta al impulso');
```



2.2. $y[n] + y[n-1] = x[n] + A_1\, x[n-1] + A_2\, x[n-2] + A_3 x[n-3]$, C.I. nulas.

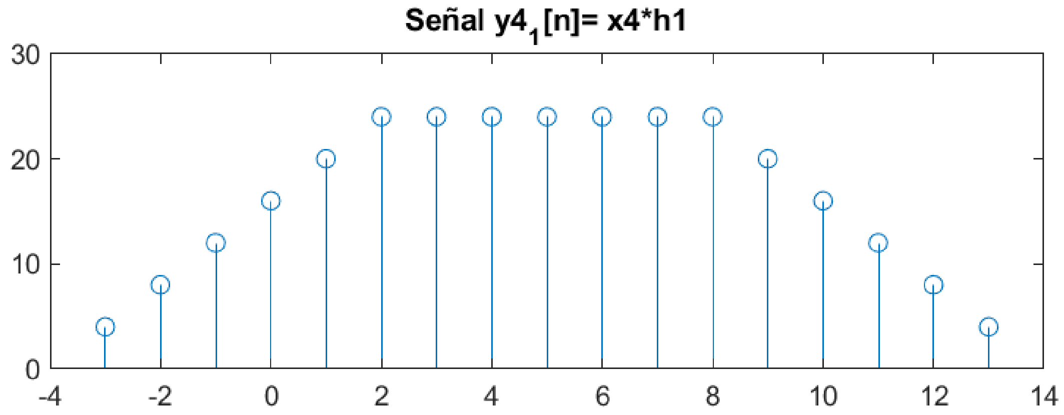
```
a=[1 1];
b=[1 2 -2 3];
n=0:20;
imp=[1 zeros(1, 20)];
h=filter(b, a, imp);
stem(n,h); title('Respuesta al impulso');
```

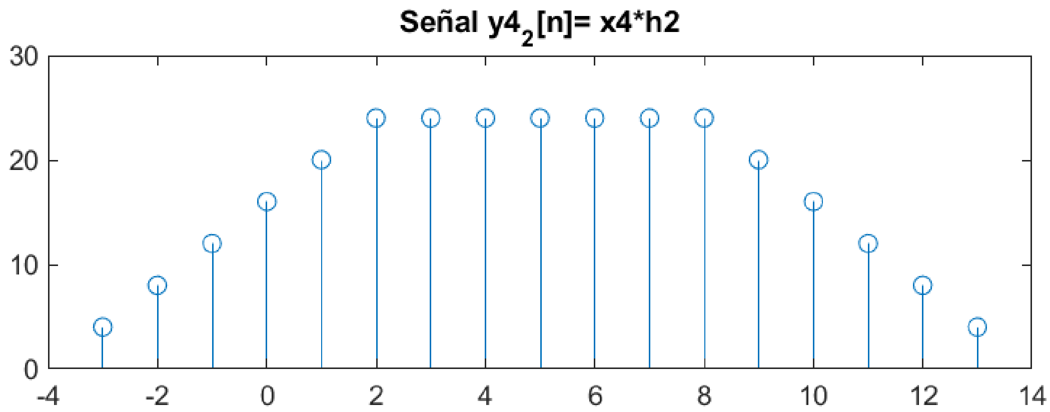


3. Obtener y representar, para n=0,1…N_5, la salida de los anteriores sistemas cuando la entrada es:

3.1. $x_4[n] = A_1(\mathrm{u}[n] - \mathrm{u}[n - N_1])$

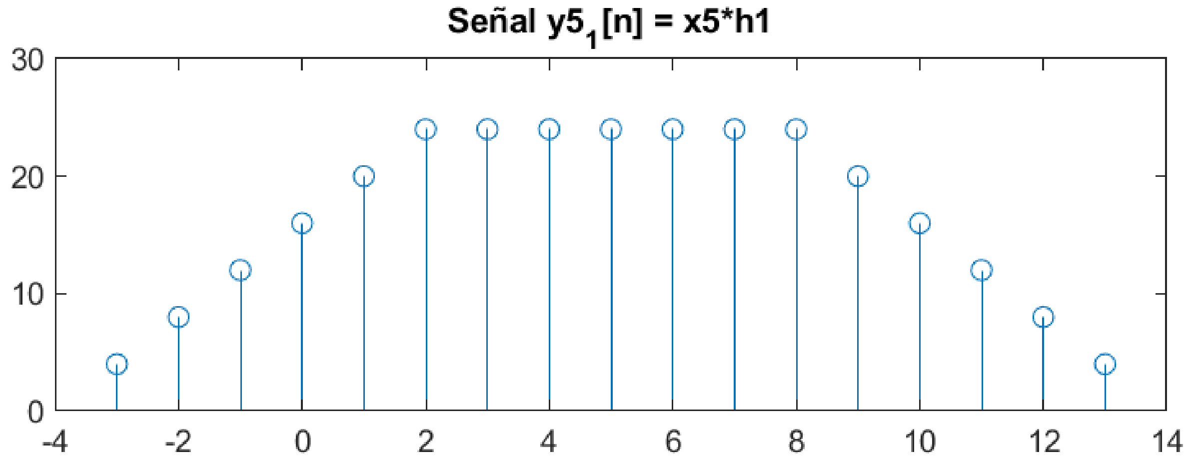
```
n = 0:20;
impulso = [1 zeros(1,20)];

%%y[n] = 2 x[n] + 3 x[n - 3]
a= 1;
b = [2 0 0 3];
h1 = filter(b,a,impulso);


%% y[n] + y[n - 1] = x[n] + 2 x[n - 1] + 2 x[n - 2] -2 x[n - 3]
a1 = [1 1];
b1 = [1 2 -2 3];
h2 = filter(b1,a1,impulso);


%% x4[n]= 2*(u[n]-u[n-6])
u = zeros(size(n)); u(n>=0) = 1;
u2 = zeros(size(n)); u(n>=6) = 1;
x4 = 2.*(u-u2);


%% y4_1[n]= x4*h1
[y4,ini_4y] = convolucion(x4,0,h1,3);
n4y = ini_4y:length(y4)+ini_4y-1;


%% y4_2[n]= x4*h2
[y5,ini_5y] = convolucion(x4,0,h2,0);
n5y = ini_5y:length(y5)+ini_5y-1;

figure
subplot(211)
stem(n4y,y4), title('Señal y4_1[n]= x4*h1')
subplot(212)
stem(n5y,y5),title('Señal y4_2[n]= x4*h2')
```

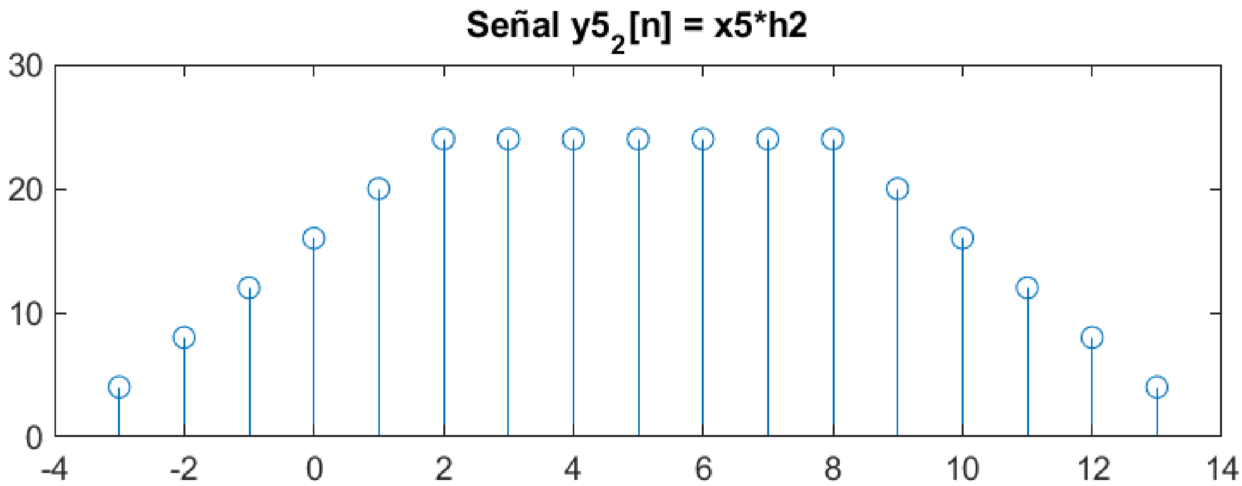

Señal $y4_1$[n]= x4*h1
30
20
10
0
-4
-2
0
2
4
6
8
10
12
14


Señal $y4_2$[n]= x4*h2
30
20
10
0
-4
-2
0
2
4
6
8
10
12
14

3.2. $x_5[n] = A_3 \cdot e^{j\Omega_1 n} u[n]$

```
n = 0:20;
impulso = [1 zeros(1,20)];

%%y[n] = 2 x[n] + 3 x[n - 3]
a= 1;
b = [2 0 0 3];
h1 = filter(b,a,impulso);


%% y[n] + y[n - 1] = x[n] + 2 x[n - 1] + 2 x[n - 2] -2 x[n - 3]
a1 = [1 1];
b1 = [1 2 -2 3];
h2 = filter(b1,a1,impulso);


%% x4[n]= 2*(u[n]-u[n-6])
u = zeros(size(n)); u(n>=0) = 1;
u2 = zeros(size(n)); u(n>=6) = 1;
x4 = 2.*(u-u2);

%% x5[n] = 3*exp(1j*1/3*n)*u[n]
x5 = 3*exp(1j*(1/3).*n).*u;

%% y5_1[n]= x5*h1
[y6,ini_6y] = convolucion(x5,0,h1,3);
n6y = ini_6y : length(y6)+ini_6y - 1;


%% y5_2[n]= x5*h2
[y7,ini_7y] = convolucion(x5,0,h2,0);
n7y = ini_7y : length(y7)+ini_7y - 1;


figure
subplot(211)
stem(n6y,y6),title('Señal y5_1[n] = x5*h1')
subplot(212)
stem(n7y,y7), title('Señal y5_2[n] = x5*h2')
```


Señal y5$_1$[n] = x5*h1
30
20
10
0
-4
-2
0
2
4
6
8
10
12
14


Señal y5$_2$[n] = x5*h2
30
20
10
0
-4
-2
0
2
4
6
8
10
12
14

4. Para la conexión de sistemas representada en la figura 2-7, y sabiendo que:

   - *S1* es un sistema LTI tal que $y[n] + A_4 y[n-2] = A_1 x[n-N_4]$ y que parte con C.I. nulas.
   - *S2* es un sistema LTI cuya respuesta al impulso es

   $$h[n] = \delta[n] + A_1\delta[n-N_4] + A_2\delta[n-N_2] + A_3\delta[n-N_1]$$

   - $x[n] = A_1 \cos(\Omega_2 n)(\mathrm{u}[n] - \mathrm{u}[n-N_6])$

   Represente gráficamente las señales de $s[n]$, $v[n]$ e $y[n]$ en el intervalo n=0:15.

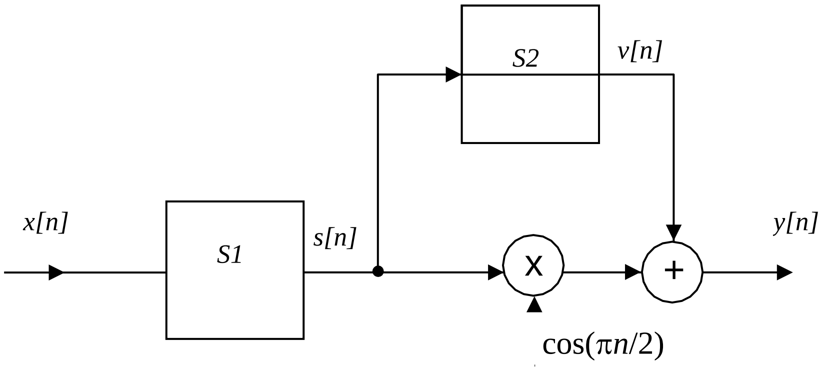
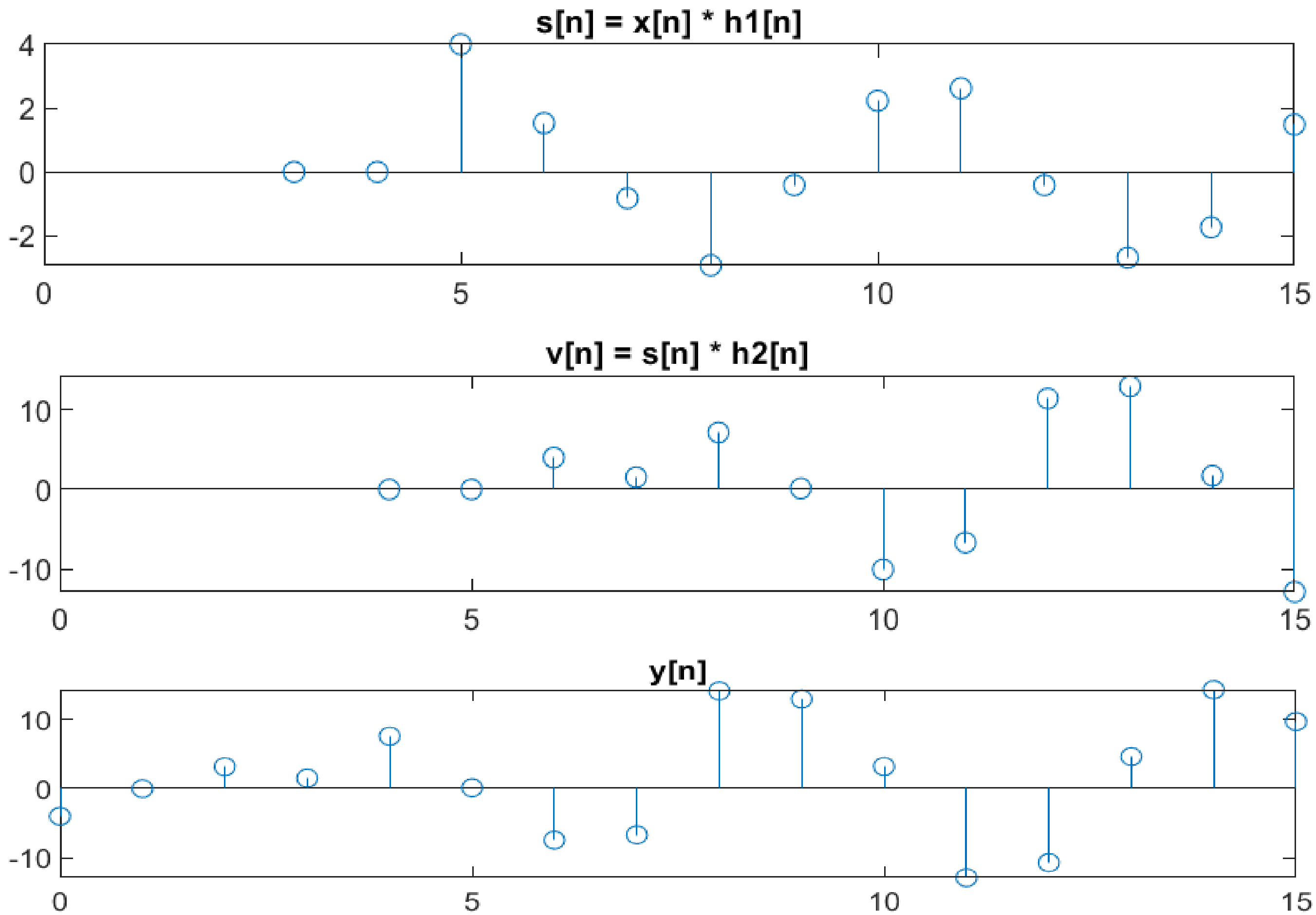


Figura 2-7. Interconexión de sistemas LTI.

```
function [v, ini_v]= convolucion5(s, ini_s, h2, ini_h2)
n=0:15;

ini_x=0;

x= 2*cos((3*pi)/8.*n).*(n>=0 & n<=(11));

a=[1 0 -0.5];
b=[0 0 2];
imp=[1 zeros(size(n))];
h=filter(b, a, imp);
vector = find(h ~= 0);
ini_h = vector(1);

s = conv(x,h);
ini_s = ini_x + ini_h;
n_s = ini_s : length(s)+ ini_s-1;
subplot(311)
stem(n_s, s)
title('s[n] = x[n] * h1[n]')
axis([0 15 min(s) max(s)]);

ini_h2 = 1;
imp1 = [1 zeros(1, 15)];
imp2 = 2.*[zeros(1, 2) 1 zeros(1, 13)];
imp3 = (-2).*[zeros(1, 4) 1 zeros(1, 11)];
imp4 = 2.* [zeros(1, 6) 1 zeros(1, 9)];
h2 = imp1 + imp2 + imp3 + imp4;
```

```
v = conv(s,h2);
ini_v = ini_s + ini_h2;
n_v = ini_v: ini_v + length(v)-1;
subplot(312)
stem(n_v, v)
title('v[n] = s[n] * h2[n]');
axis([0 15 min(v) max(v)]);

coseno = zeros(1, length(s));
coseno(n>=0 & n<=15)= cos(pi*n/2);
s1 = s.*coseno;

N = zeros(size(v));
ini_y = 0:(length(v)-1);
vector_s1 = find(s1~=0);
r = s1(vector_s1(1):vector_s1(end));
N(ini_y >=0 & ini_y < length(r))= r;

y = v + N;

subplot(313);
stem(ini_y, y);
title('y[n]')

axis([0 15 min(y) max(y)]);
end
```



2.4.2 Valores de las constantes

$A_1 = 2$; $A_2 = -2$; $A_3 = 3$; $A_4 = -1/2$

$N_1 = 6$; $N_2 = 4$; $N_3 = 3$; $N_4 = 2$

$N_5 = 20$; $N_6 = 12$;

$\Omega_1 = 1/3$; $\Omega_2 = 3\pi/8$