EE387 – BASIC SIGNAL REPRESENTATION AND CONVOLUTION

LIYANAGE D.P.
E/15/202
SEMESTER 06

PART 1: Basic Signal Representation in MATLAB

1. Write a Matlab program and necessary functions to generate the following signal:

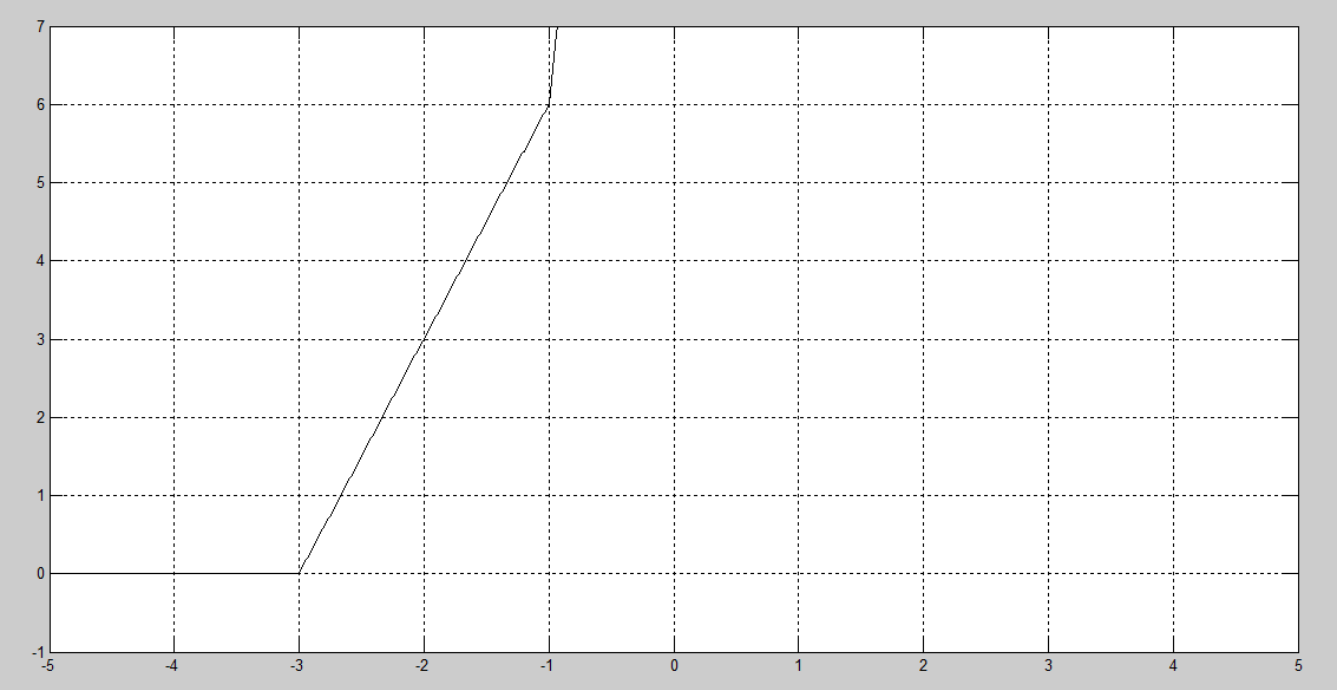
$$y(t) = r(t+3) - 2r(t+1) + 3r(t) - u(t-3)$$

Then plot it and verify analytically that the obtained figure is correct.

```
clear all;
Ts=0.01;
t= -5:Ts:5;
y1 = ramp(t,3,3);
y2 = ramp(t,-6,1);
y3 = ramp(t,3,0);
y4 = ustep(t,-3);
y = y1-2*y2+3*y3-y4;
plot(t,y,'k');
axis([-5 5 -1 7]);
grid
```

```
function y = ramp(t,m,ad)
% t: length of time
% m: slope of the ramp function
% ad: advance (positive), delay (negative) factor

% Write your code

for k = 1: length(t)
    x = t+ad;
    if x(k) >= 0
        y(k) = x(k)*m;
    else
        y(k) = 0;
    end
end
```

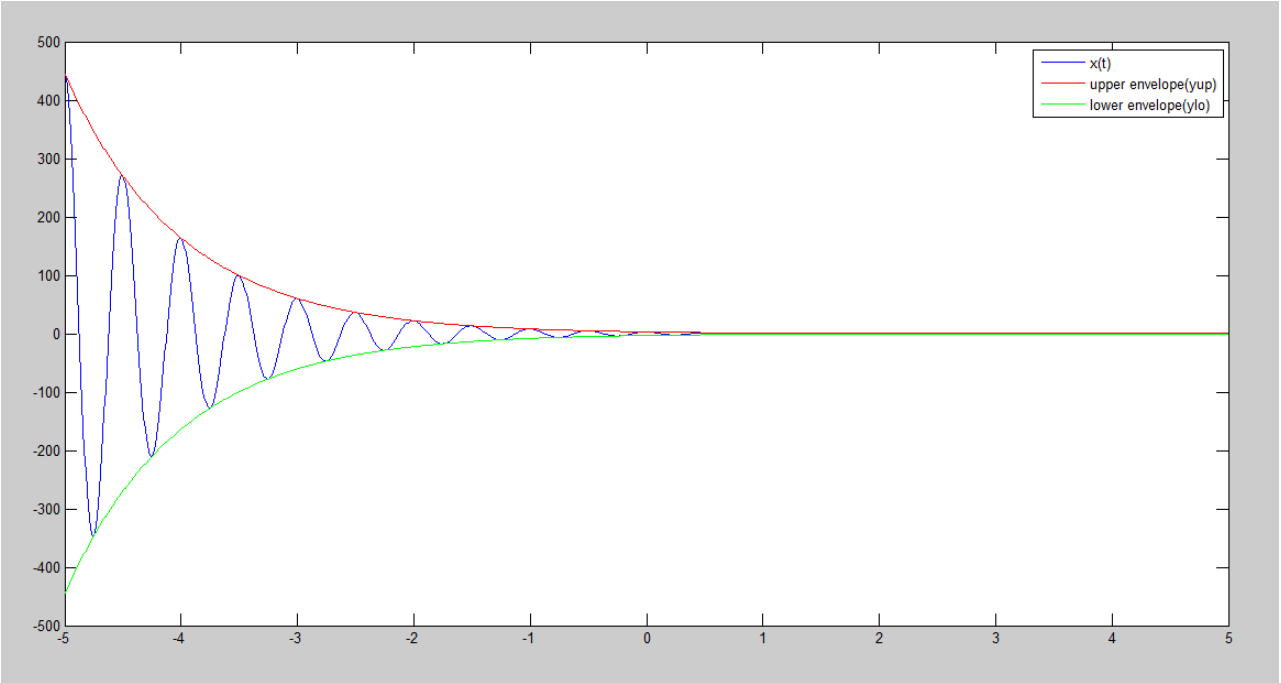
```
function y = ustep(t,ad)
% Write your code
for k = 1:length(t)
    x = t+ad;
    if x(k) >= 0
        y(k) = 1;
    else
        y(k) = 0;
    end
end
```



2. For the damped sinusoidal signal $x(t) = 3e^{-t}\cos(4\pi t)$ write a MATLAB program to generate x(t) and its envelope, then plot.

```
function [y,yup,ylo] = dampsig(t)

y = 3.*exp(-t).*cos(4.*pi.*t);
yup = 3*exp(-t);
ylo = -3*exp(-t);
end
```

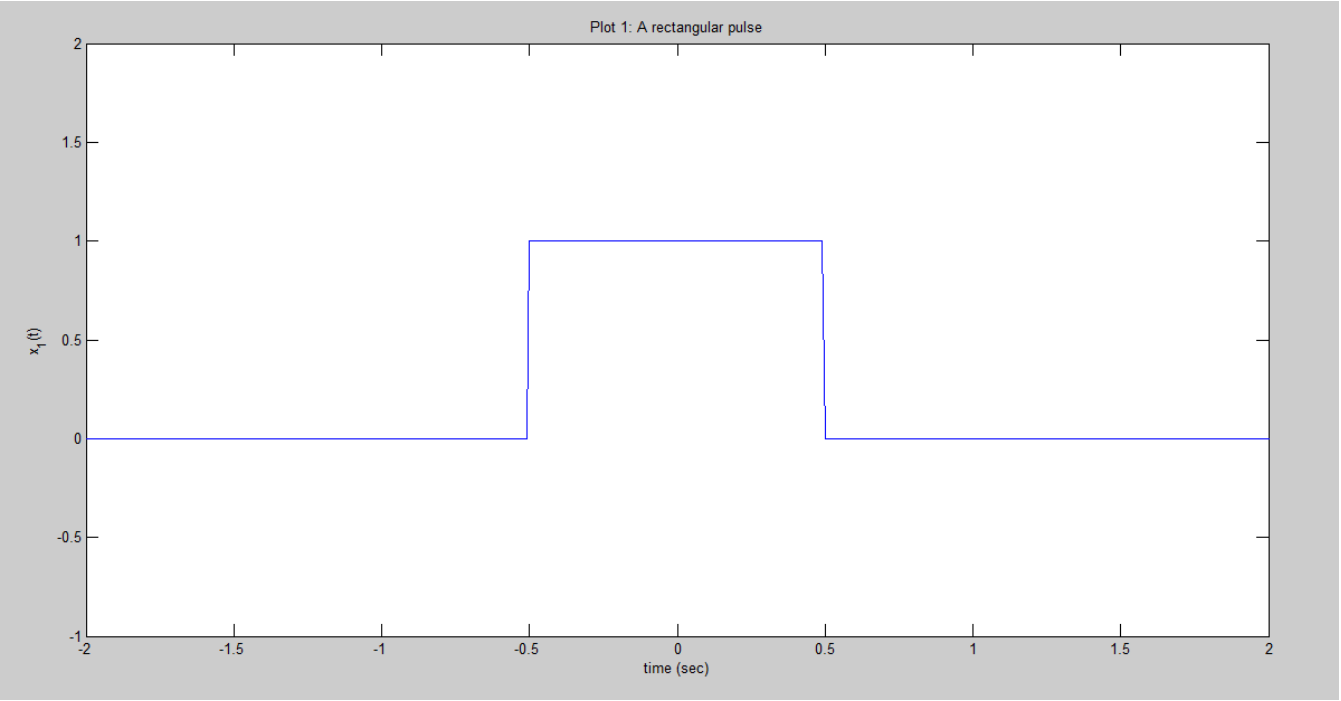
```
Ts=0.01; t= -5:Ts:5;
[y,yup,ylo] = dampsig(t)
plot(t,y)
hold on
plot(t,yup,'r')
plot(t,ylo,'g')
```



PART 2: Time-Domain Convolution

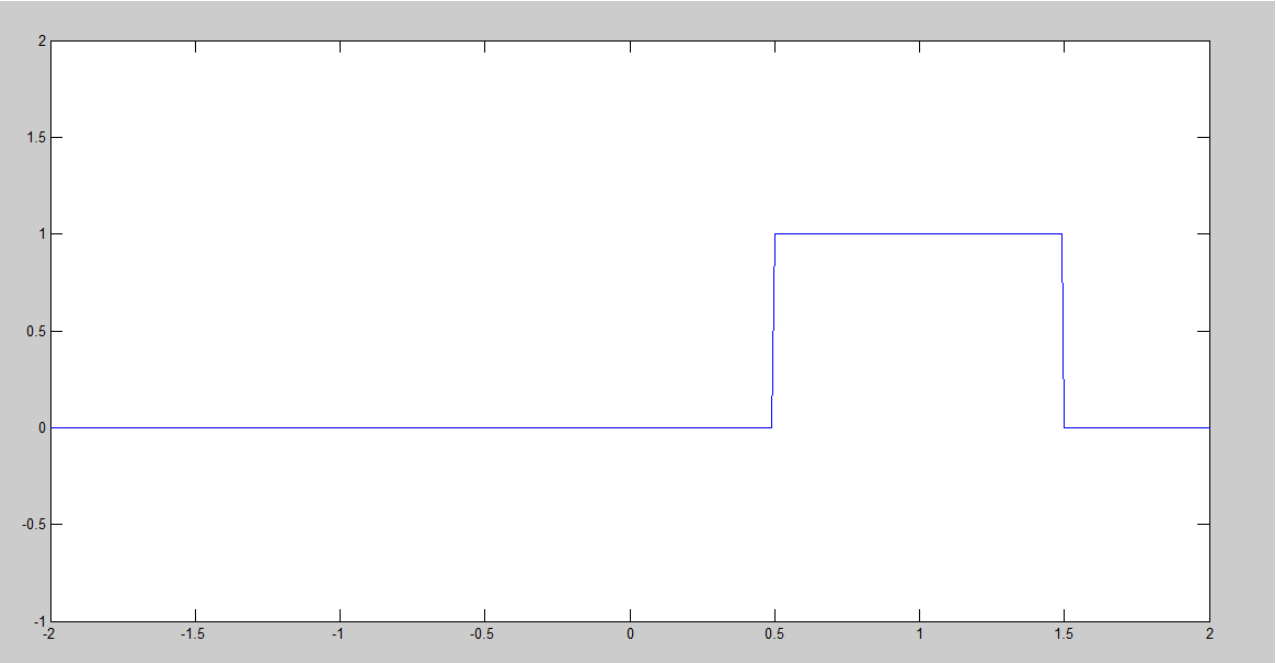
Creating a rectangular pulse in MATLAB

```
function x = rect(t)
    for k = 1:length(t)
        if t(k) >= -0.5 && t(k) < 0.5
            x(k) = 1;
        else
            x(k) = 0;
        end
    end
end


f_s = 100
T_s = 1/f_s
t = [-5:T_s:5]
x1 = rect(t)
plot(t,x1)
hold
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' ) ;
ylabel( 'x_1(t)' ) ;
title ('Plot 1: A rectangular pulse');
```

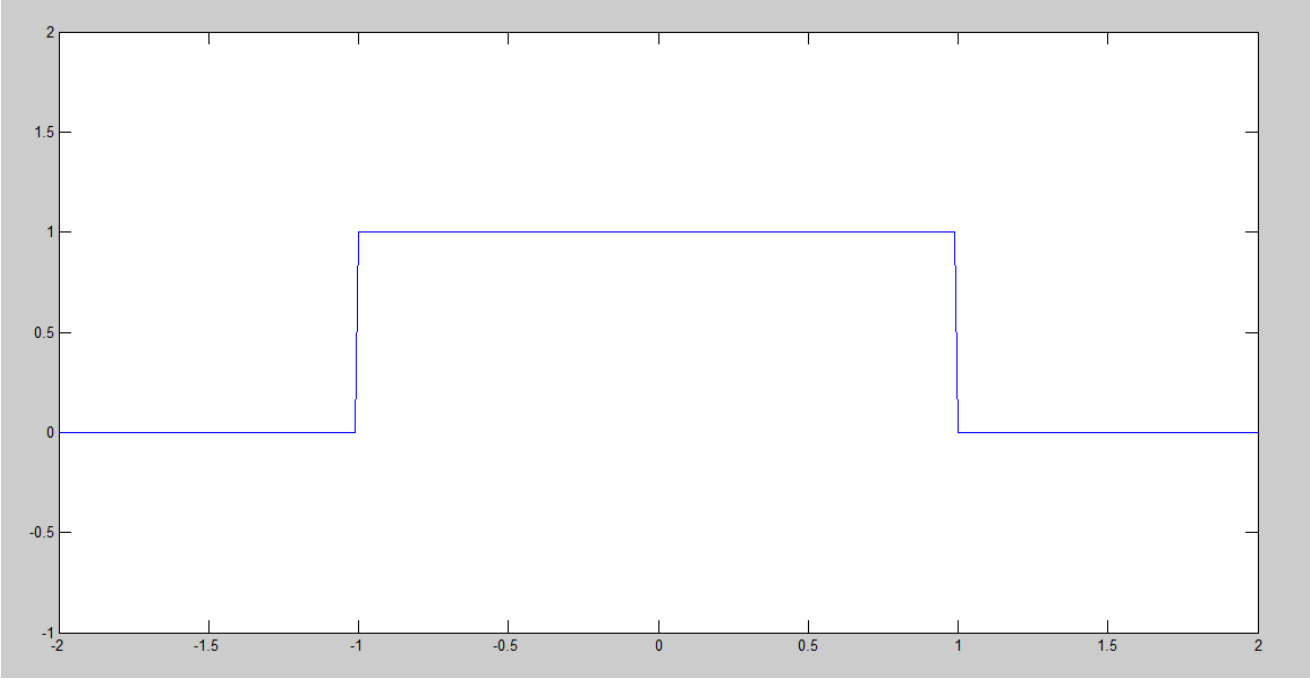


Elementary signal operations

```
x2 = rect(t-1);
plot(t,x2);
axis( [-2 2 -1 2]);
```

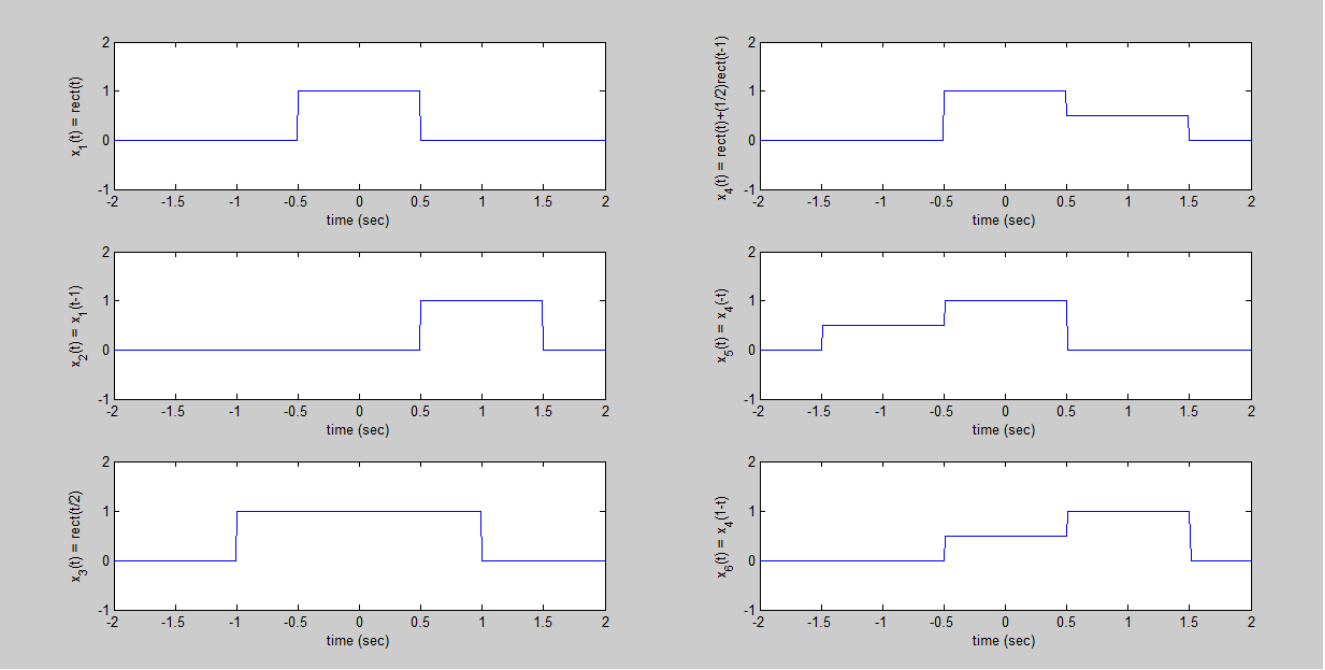



```
x3 = rect(t/2);
plot(t,x3);
axis( [-2 2 -1 2]);
```



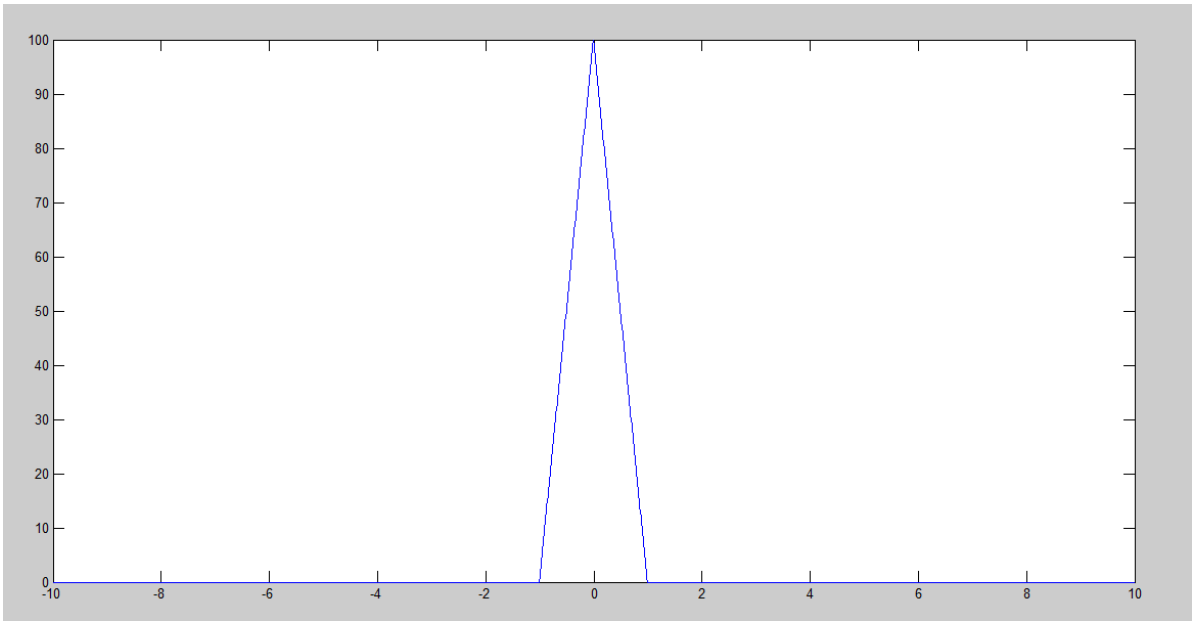

```
x4 = rect(t)+0.5*rect(t-1);

x5 = rect(-t)+0.5*rect(-t-1);

x6 = rect(1-t)+0.5*rect(-t);

subplot(3,2,1)
plot(t,x1)
axis( [-2 2 -1 2]);
```

```
xlabel( 'time (sec)' )
ylabel('x_1(t) = rect(t)')

subplot(3,2,3)
plot(t,x2)
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_2(t) = x_1(t-1)')

subplot(3,2,5)
plot(t,x3)
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_3(t) = rect(t/2)')

subplot(3,2,2)
plot(t,x4)
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_4(t) = rect(t)+(1/2)rect(t-1)')

subplot(3,2,4)
plot(t,x5)
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_5(t) = x_4(-t)')

subplot(3,2,6)
plot(t,x6)
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_2(t) = x_4(1-t)')
```

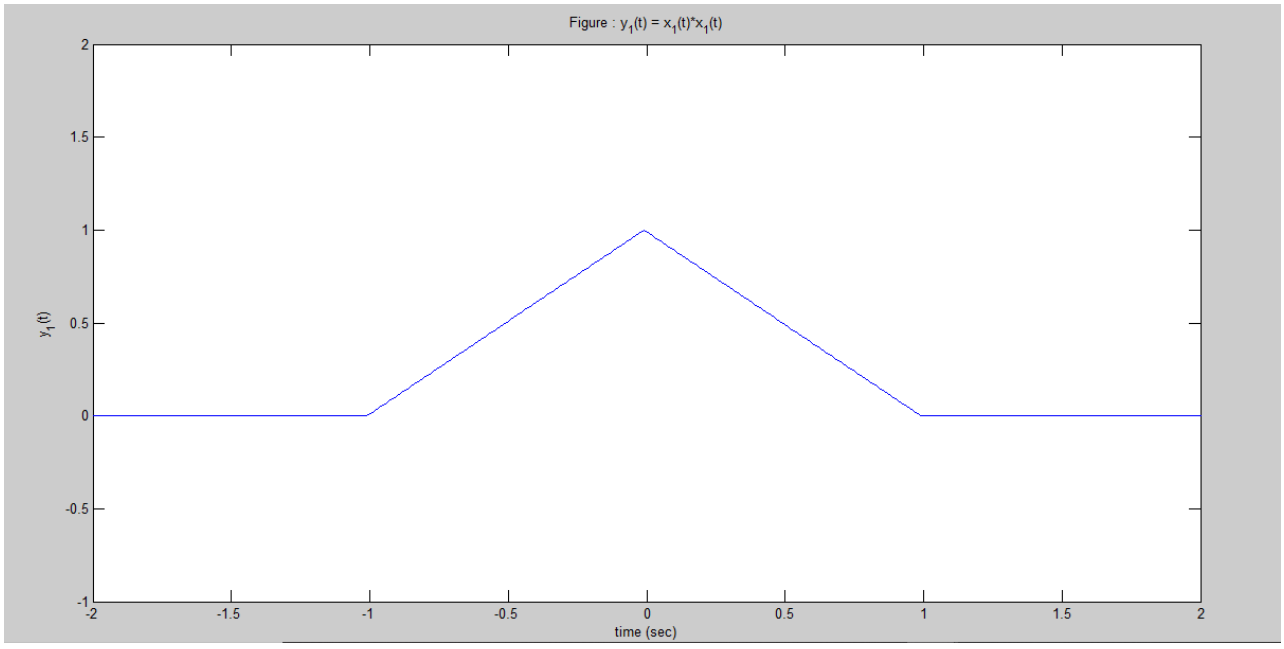


Convolution

```
t_y = -10:T_s:10;
plot( t_y, y)
```



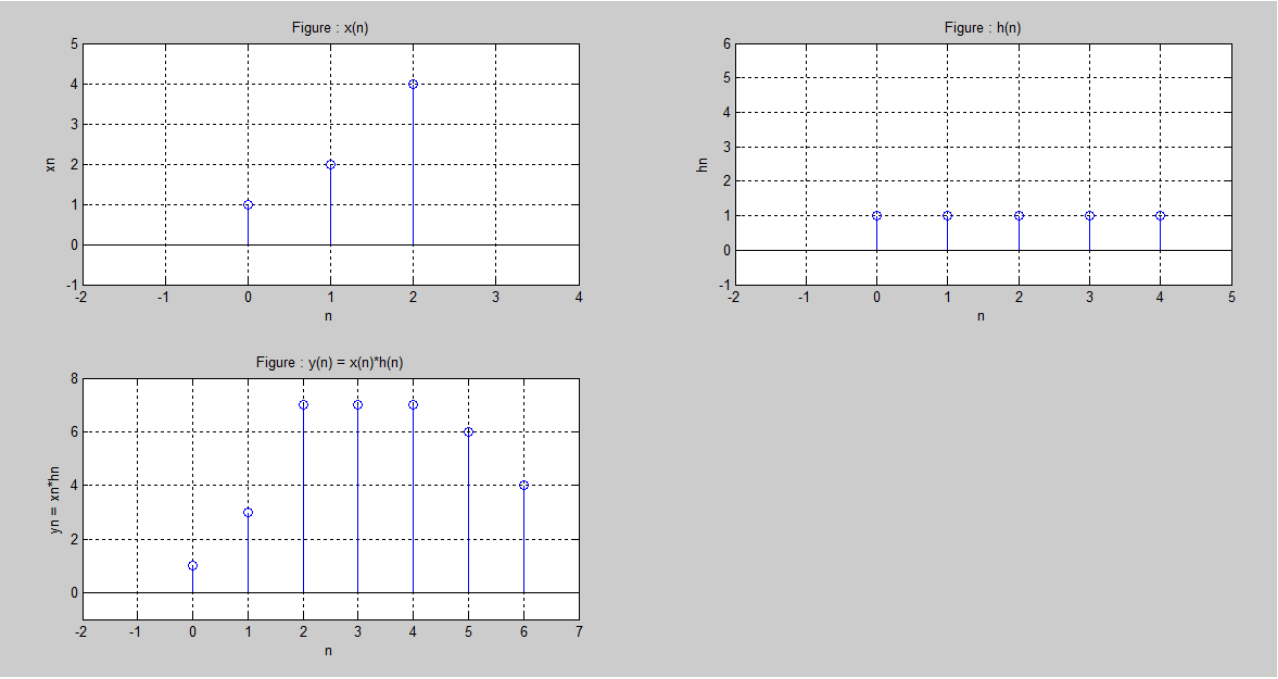

```
y1 = T_s*conv(x1,x1);
plot(t_y, y1);
axis( [-2 2 -1 2] ) ;
xlabel( 'time (sec)');
ylabel('y_1(t)');
title('Figure : y_1(t) = x_1(t)*x_1(t)');
```



Exercises

1) a)

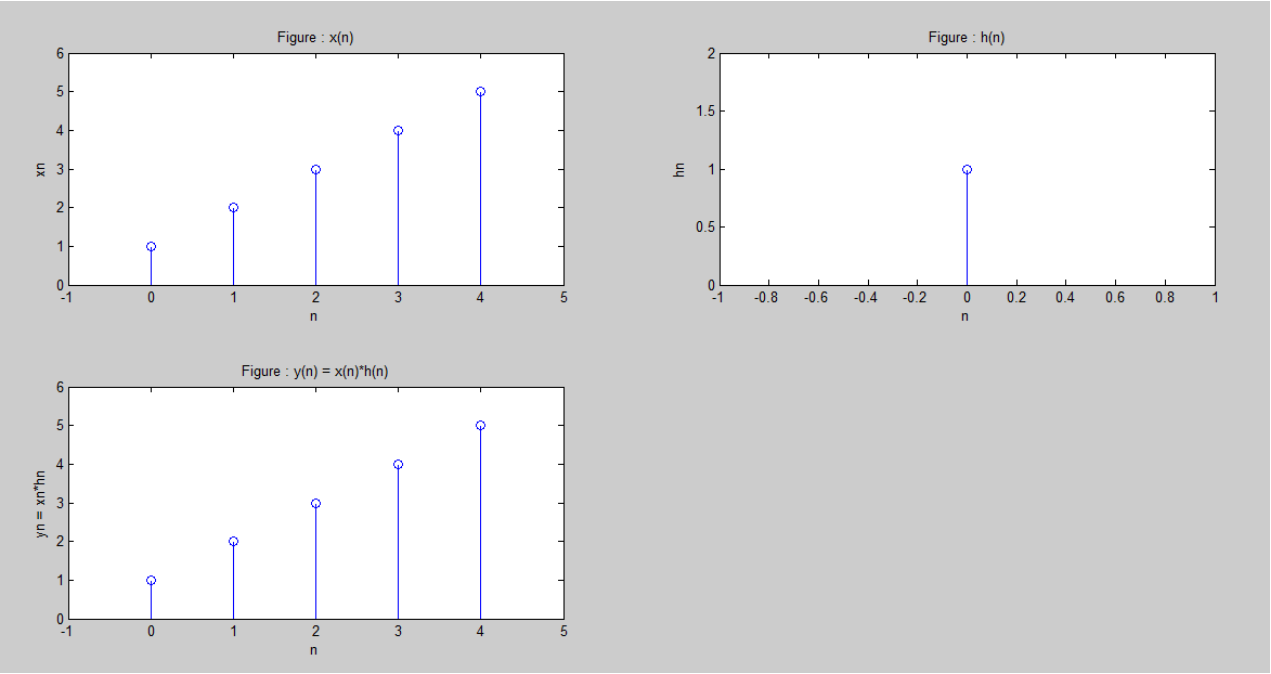
```
subplot(2,2,1)
xn = [1,2,4]
n = 0:2
stem(n,xn)
axis( [-2 4 -1 5]);
xlabel( 'n');
ylabel('Figure : x(n)');grid


subplot(2,2,2)
hn = [1,1,1,1,1]
n = 0:4
stem(n,hn)
axis( [-2 5 -1 6]);
xlabel( 'n');
ylabel('Figure : h(n)');grid


subplot(2,2,3)
yn = conv(xn,hn);
length(yn) = 7
n = 0:6
stem(n,yn)
axis( [-2 7 -1 8]);
xlabel( 'n');
ylabel('Figure : y(n) = x(n)*h(n)');grid
```



b)

```
subplot(2,2,1)
xn = [1,2,3,4,5]
n = 0:4
stem(n,xn)
axis( [-1 5 0 6]);
xlabel( 'n');
```

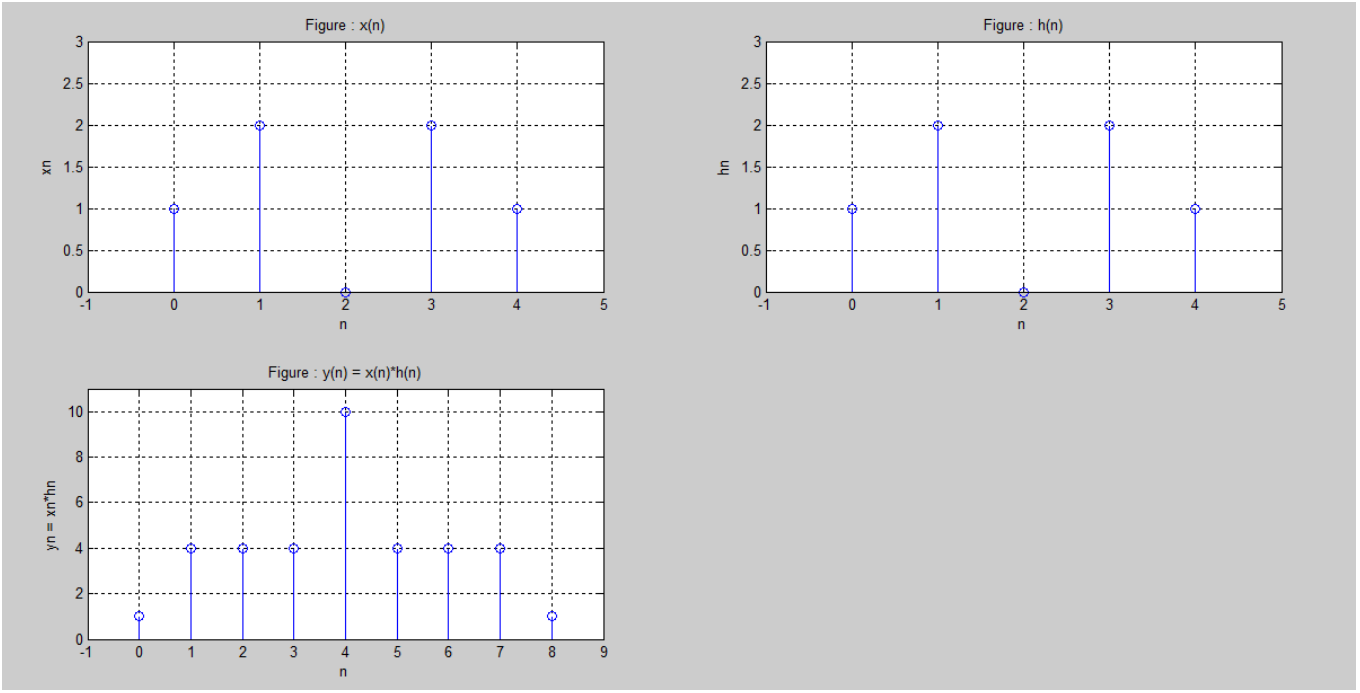
```
ylabel('Figure : x(n)');


subplot(2,2,2)
hn = [1]
n = 0
stem(n,hn)
axis( [-1 1 0 2]);
xlabel( 'n');
ylabel('Figure : h(n)');



subplot(2,2,3)
yn = conv(xn,hn);
length(yn) = 5
n = 0:4
stem(n,yn)
axis( [-1 5 0 6]);
xlabel( 'n');
ylabel('Figure : y(n) = x(n)*h(n)');
```



c)

```
subplot(2,2,1)
xn = [1,2,0,2,1]
n = 0:4
stem(n,xn)
axis( [-1 5 0 3]);
grid
xlabel( 'n');
ylabel('Figure : x(n)');


subplot(2,2,2)
hn = [1,2,0,2,1]
n = 0:4
stem(n,hn)
```

```
axis( [-1 5 0 3]);
grid
xlabel( 'n');
ylabel('Figure : h(n)');


subplot(2,2,3)
yn = conv(xn,hn);
length(yn) = 9
n = 0:8
stem(n,yn)
axis( [-1 9 0 11]);
grid
xlabel( 'n');
ylabel('Figure : y(n) = x(n)*h(n)');
```



2)

-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12
								1	0.5	0.25	0.125									
x9	x8	x7	x6	x5	x4	x3	x2	x1												
	x9	x8	x7	x6	x5	x4	x3	x2	x1											
		x9	x8	x7	x6	x5	x4	x3	x2	x1										
			x9	x8	x7	x6	x5	x4	x3	x2	x1									
				x9	x8	x7	x6	x5	x4	x3	x2	x1								
					x9	x8	x7	x6	x5	x4	x3	x2	x1							
						x9	x8	x7	x6	x5	x4	x3	x2	x1						
							x9	x8	x7	x6	x5	x4	x3	x2	x1					
								x9	x8	x7	x6	x5	x4	x3	x2	x1				
									x9	x8	x7	x6	x5	x4	x3	x2	x1			
										x9	x8	x7	x6	x5	x4	x3	x2	x1		
											x9	x8	x7	x6	x5	x4	x3	x2	x1	
												x9	x8	x7	x6	x5	x4	x3	x2	x1

```
y[0] = 1 = 1 * x1
x1 = 1
```

```
y[1] = 2 = 1*x2 + 0.5*x1
x2 = 1.5

y[2] = 2.5 = 1*x3 + 0.5*x2 + 0.25*x1
x3 = 1.5

y[3] = 3 = 1*x4 + 0.5*x3 + 0.25*x2 + 0.125*x1
x4 = 1.75

y[4] = 3 = 1*x5 + 0.5*x4 + 0.25*x3  + 0.125*x2
x5 = 1.5625

y[5] = 3 = 1*x6 + 0.5*x5 + 0.25*x4 + 0.125*x3
x6 = 1.59375

y[6] = 2 = 1*x7 + 0.5*x6 + 0.25*x5 + 0.125*x4
x7 = 0.59375

y[7] = 1 = 1*x8 + 0.5*x7 + 0.25*x6 + 0.125*x5
x8 = 0.109375

y[8] = 0 = 1*x9 + 0.5*x8 + 0.25*x7 + 0.125*x6
x9 = -0.40234375

function [x] = hyt(n)

    for k = 1:length(n)
        if n(k)>=0 && n(k)<4
            x(k) = (0.5).^n(k);
        else
            x(k) = 0;
        end
    end
end

subplot(2,2,1)
xn = [1,1.5,1.5,1.75,1.5625,1.59375,0.59375,0.109375,-0.40234375]
n = 0:8
stem(n,xn)
xlabel( 'n');
ylabel('Figure : x(n)');
axis( [-1 9 -1 2]);

subplot(2,2,2)
n = 0:3;
hn = hyt(n)
stem(n,hn)
xlabel( 'n');
ylabel('Figure : h(n)');
axis( [-1 4 -1 2]);

subplot(2,2,3)
yn = [1,2,2.5,3,3,3,2,1,0]
n = 0:8
stem(n,yn)
xlabel( 'n');
ylabel('Figure : y(n) = x(n)*h(n)');
```

```
axis( [-1 9 0 4]);
```