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.

Code for ramp function

```
function y = ramp(t,m,ad)
% t: length of time
% m: slope of the ramp function
% ad: advance (positive), delay (negative) factor
y=[];
count=1;
p=-(ad/m);
for i=t
    if(m>0)
        if i< p
            y(count)=0;
        else
            y(count)=m*i + ad;
        end


    else
        if i< p
            y(count)=m*i + ad;
        else
            y(count)=0;
        end
    end
    count=count+1;
end
```

Code for unit-step function

```
function y = ustep(t,ad)
% ad: advance (positive), delay (negative) factor
% t: length of time
y=[];
count=1;
for i =t
    if i< (-1*ad)
        y(count)=0;
    else
        y(count)=1;
    end
    count=count+1;
end
```

Execute following programme,

```
clear all;
Ts=0.01;
t= -5:Ts:5;

y1 = ramp(t,1,3);
y2 = ramp(t,1,1);
y3 = ramp(t,1,0);
y4 = ustep(t,-3);
y = y1-2*y2+3*y3-y4;

plot(t,y,'k');
xlabel( 'time' ) ;
ylabel( 'y(t)' ) ;
```

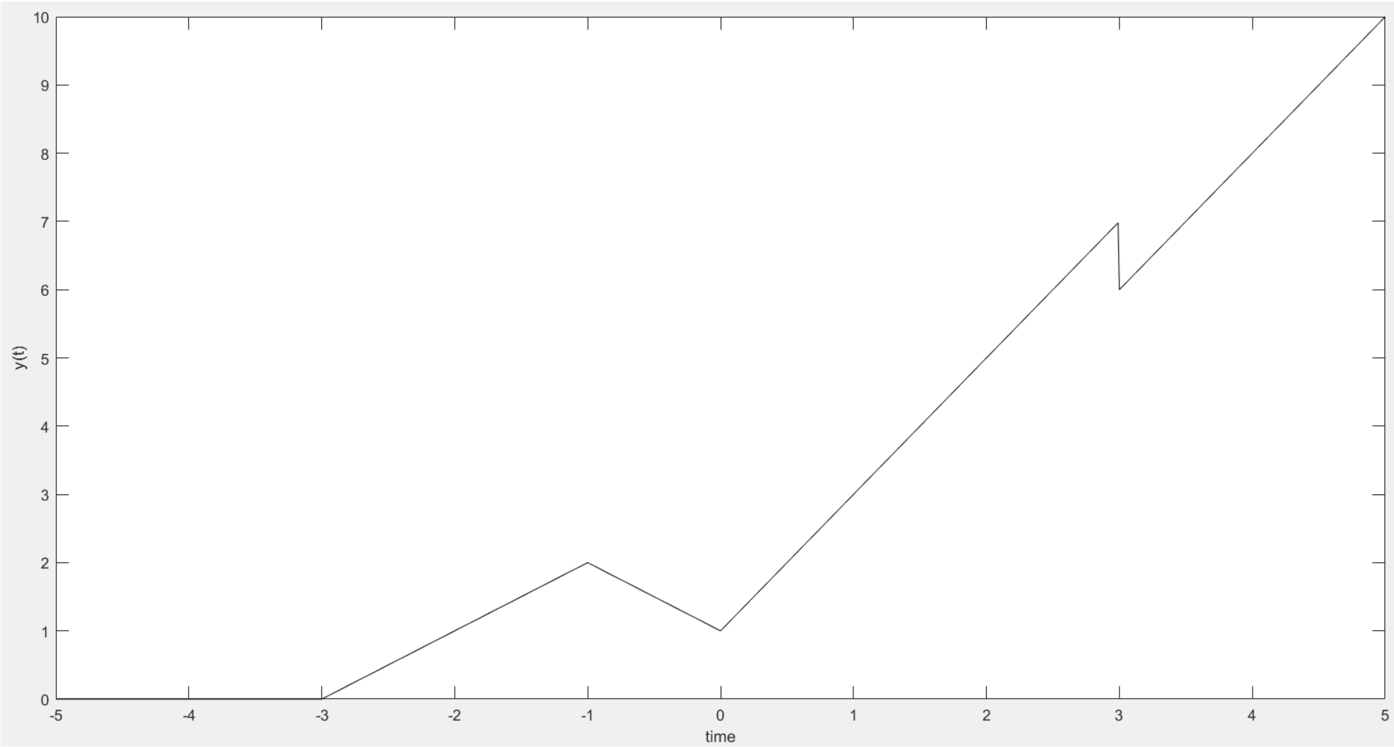


Figure 01: Variation of y(t) with time(t)

Analytical Explanation

The analysis of the graph can be divided into 5 regions in on the time axis.

Region 1 (t < -3),

In this region since there is no function involved, y = 0

Therefore, y(t) = 0

Region 2 (-3 <= t < -1),

The function y = t + 3 , involved in this region.

Therefore, y(t) = t + 3

As displayed on the graph, from -3 to -1 it has behaved according to y(t) = t + 3

Region 3 (-1 <= t < 0),

Two functions are involved in this region. They are y = (t+3) , y = (t+1)

Therefore, y(t) = (t + 3) – 2(t + 1) = (-t + 1)
As displayed on the graph, from -1 to 0 it has behaved according to y(t) = -t + 1 with negative gradient.

Region 3 (0 <= t < 3),

Three functions are involved in this region. They are y = (t+3) , y = (t+1), y = t

Therefore, y(t) = (t + 3) – 2(t + 1) + 3(t) = (2t + 1)
As displayed on the graph, from 0 to 3 it has behaved according to y(t) = 2t + 1 with positive increased gradient than in region 2.

Region 4 (3 <= t),

Four functions are involved in this region. They are y = (t+3) , y = (t+1), y = t , y = -1

(from the unit step)

Therefore, y(t) = (t + 3) – 2(t + 1) + 3(t) - 1 = (2t)
As displayed on the graph, above 3 it has behaved according to y(t) = 2t with the same gradient in region 1. Since the y intercept has decreased to 0, the graph has came down at t = 3.

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

Code

```
clear all;
Ts=0.01;
t= -5:Ts:5;
y=[];
count=1;

for i=t
    y(count)=3*exp(-i)*cos(4*pi*i);
    count=count+1;
end

plot(t,y);
```

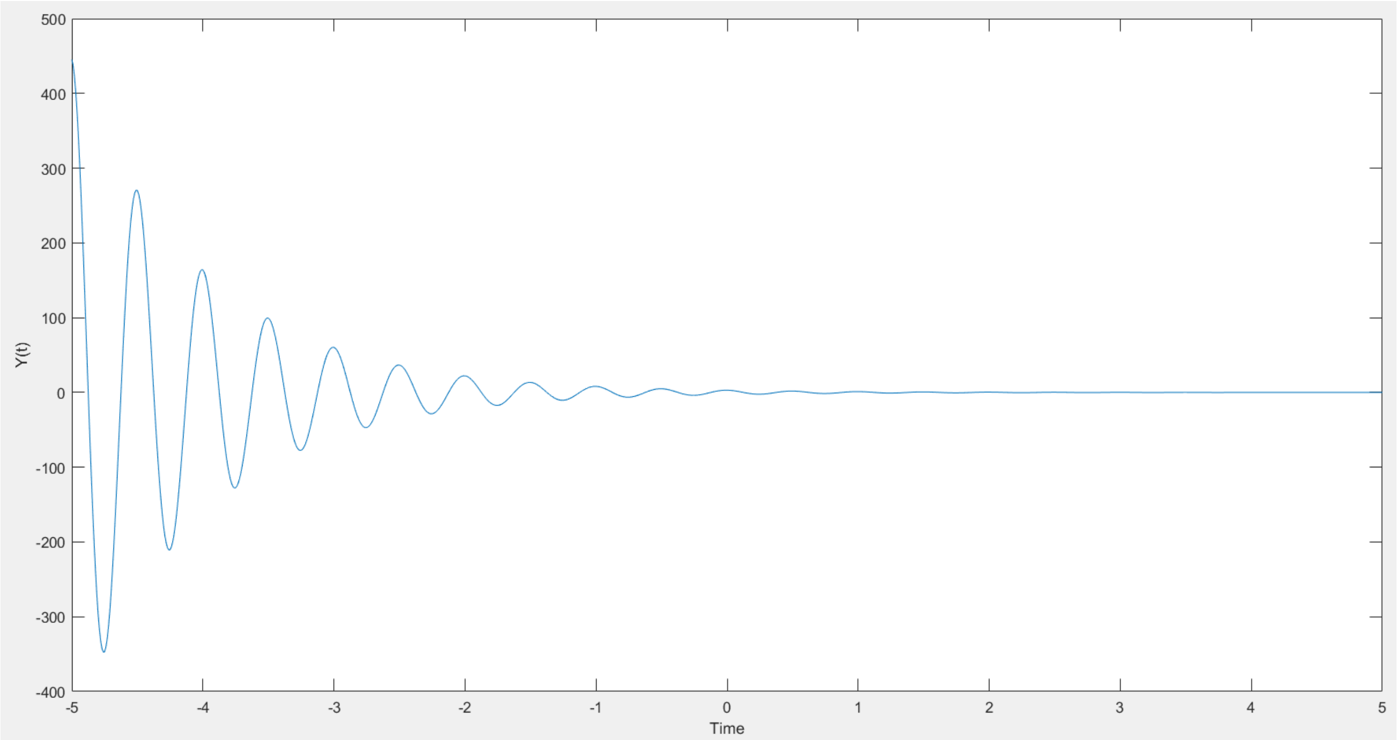


Figure 02: Variation of y(t) with time(t)

PART 2: Time-Domain Convolution

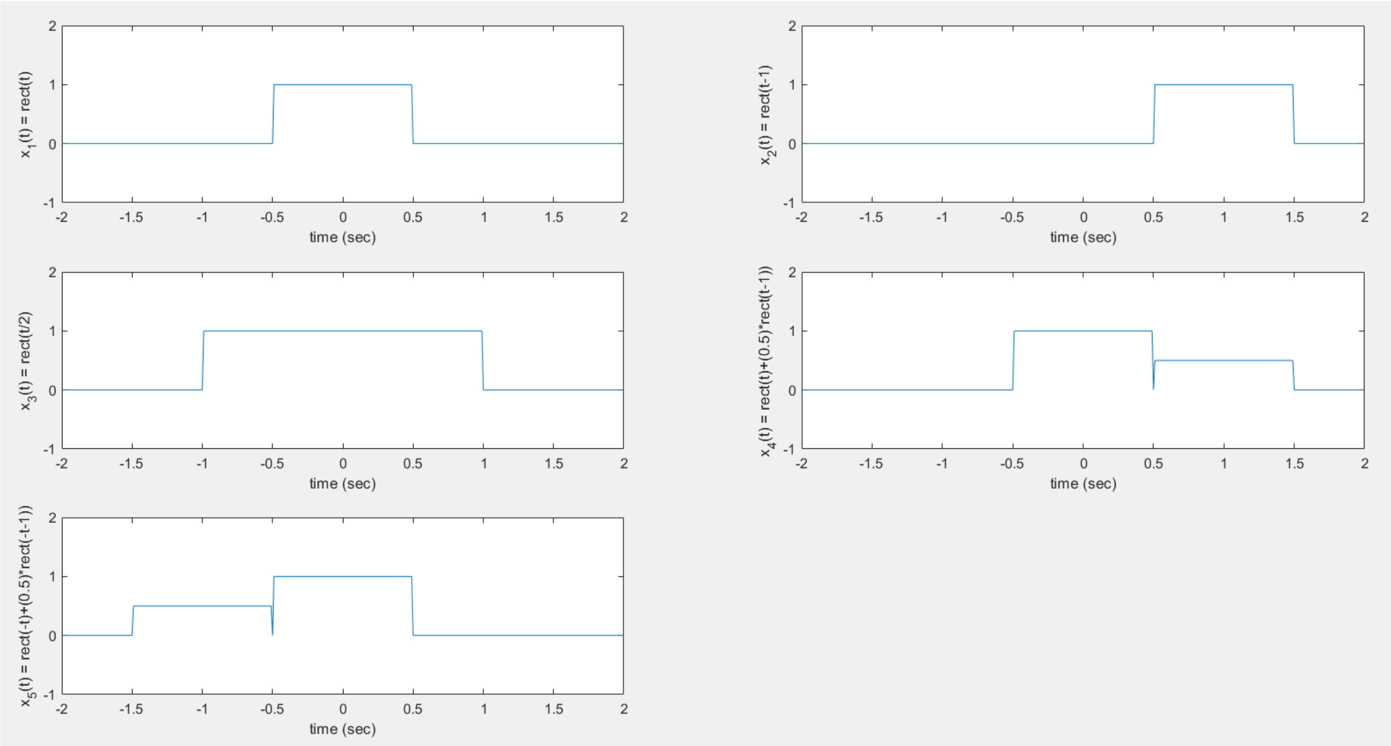
Elementary signal operations

Code for rectangular pulse

```
function x = rect(t)
x=[];
count=1;
for i = t
    if (i> -0.5 & i<0.5)
        x(count)=1;
    else
        x(count)=0;
    end
    count=count+1;
end
```

Execute following programme,

```
clear all;
f_s=100; % sampling frequency
T_s=1/f_s;
t =[-5:T_s:5];

x1 = rect(t);
x2 = rect(t-1);
x3 = rect(t/2);
x4 = rect(t)+(0.5)*rect(t-1);
x5 = rect(-t)+(0.5)*rect(-t-1);

subplot(3,2,1);
plot(t,x1);
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_1(t) = rect(t)')

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

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

subplot(3,2,4);
plot(t,x4);
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_4(t) = rect(t)+(0.5)*rect(t-1))')

subplot(3,2,5);
plot(t,x5);
axis( [-2 2 -1 2]);
xlabel( 'time (sec)' )
ylabel('x_5(t) = rect(-t)+(0.5)*rect(-t-1))')
```



<u>Figure 3: Variations of the function with time</u>

Convolution

Code for convolution

```
clear all;
f_s=100; % sampling frequency
T_s=1/f_s;
t =[-5:T_s:5];

x1 = rect(t);
x2 = rect(t-1);

y = conv(x1,x1); %convolution of x1 and x2
t_y = -10:T_s:10; % seperate time axis for signal 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_2(t)');
```

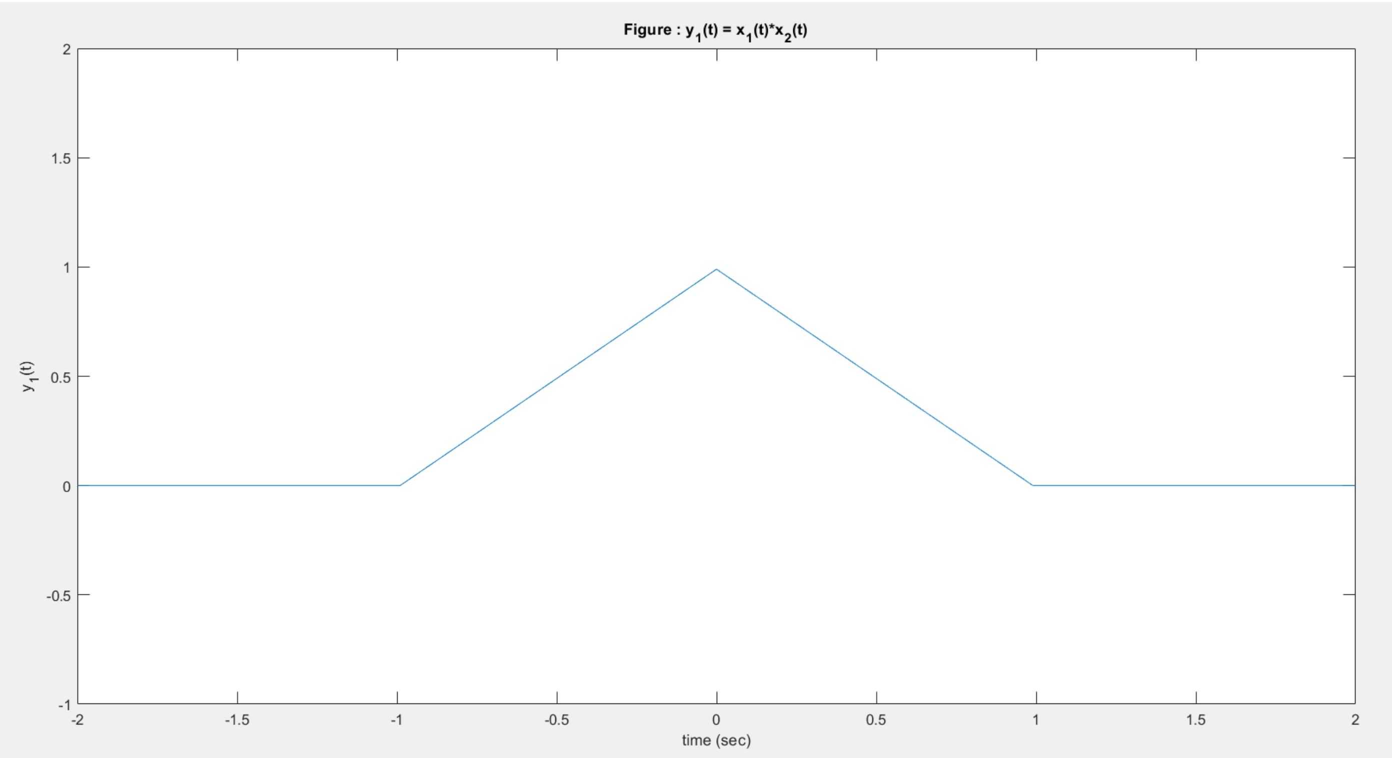


Figure 04: Variation of y_1(t) with time(t)

EXERCISE

1. 1) x(n) = { 1,2,4 }, h(n) = {1,1,1,1,1}

Code

```
clear all;
x=[1,2,3];
h=[1,1,1,1];
y=conv(x,h);

n1=1:length(x)
n2=1:length(h)
n3=1:length(y)

subplot(2,2,1);
stem(n1,x)
axis( [0 length(x)+1 0 max(x)+1]);
xlabel( 'n');
ylabel('x(n)');

subplot(2,2,2);
stem(n2,h)
axis( [0 length(h)+1 0 max(h)+1])
xlabel( 'n');
ylabel('h(n)');


subplot(2,2,3);
stem(n3,y)
axis( [0 length(y)+1 0 max(y)+1])
xlabel( 'n');
ylabel('y(n)');
```

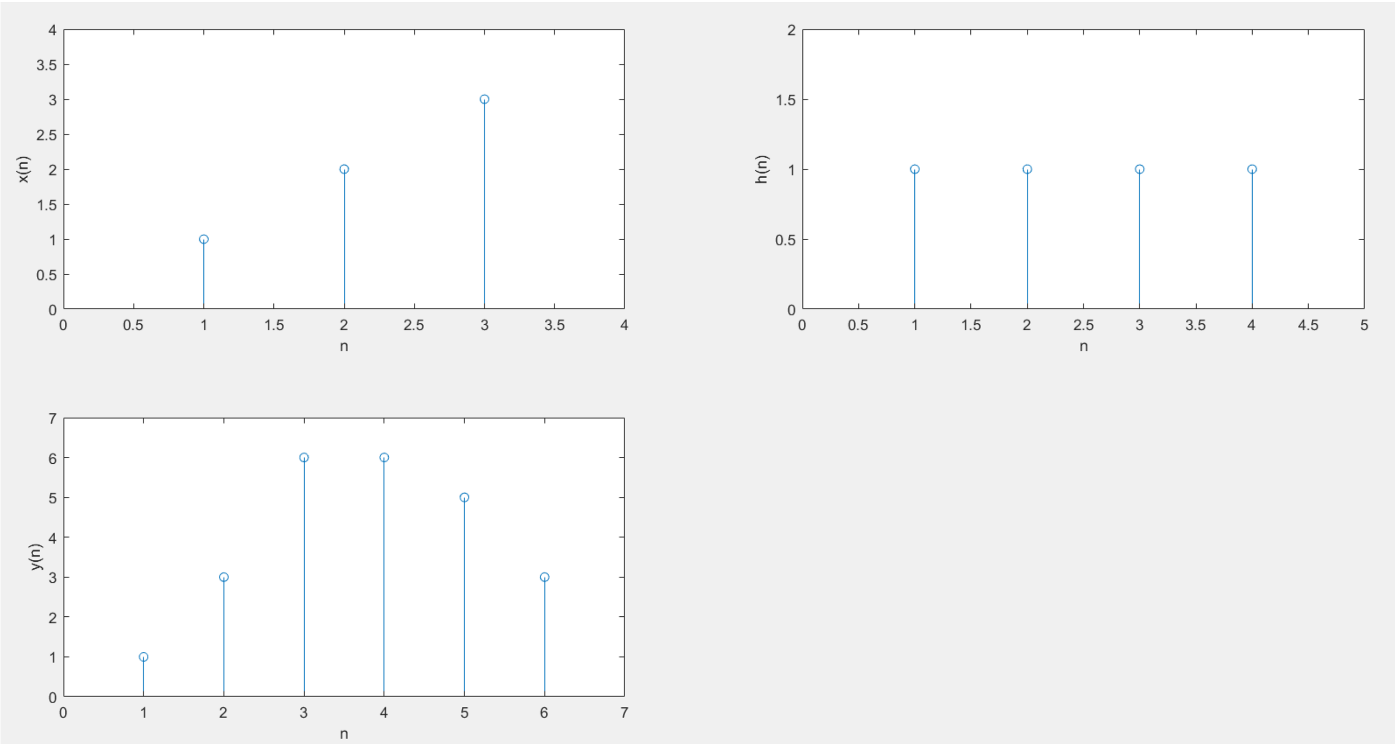


Figure 05: Variation of x(n), h(n) and y(n) with n

2) x(n) = { 1,2,3,4,5 }, h(n) = {1}

Code

```
clear all;
x=[1,2,3,4,5];
h=[1];
y=conv(x,h);

n1=1:length(x)
n2=1:length(h)
n3=1:length(y)

subplot(2,2,1);
stem(n1,x)
axis( [0 length(x)+1 0 max(x)+1]);
xlabel( 'n');
ylabel('x(n)');

subplot(2,2,2);
stem(n2,h)
axis( [0 length(h)+1 0 max(h)+1])
xlabel( 'n');
ylabel('h(n)');


subplot(2,2,3);
stem(n3,y)
axis( [0 length(y)+1 0 max(y)+1])
xlabel( 'n');
ylabel('y(n)');
```

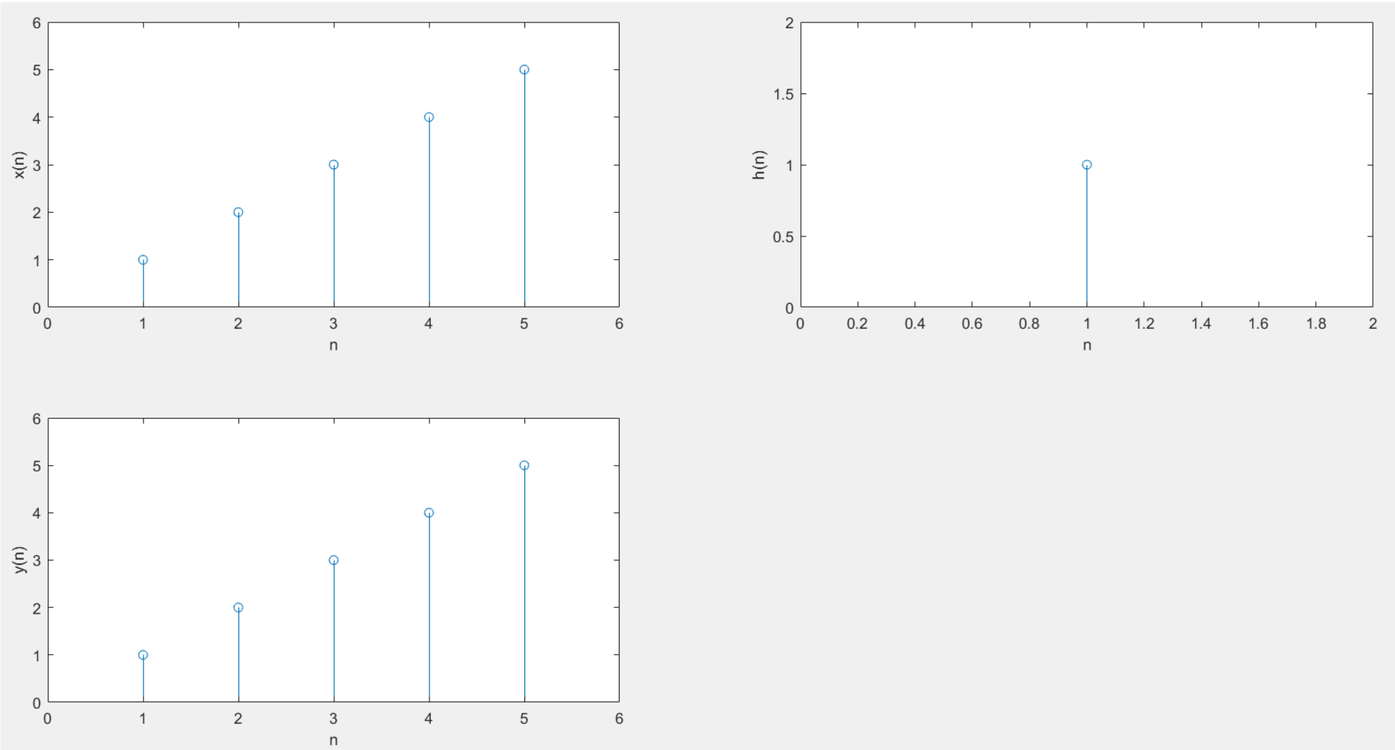


Figure 06: Variation of x(n), h(n) and y(n) with n

3) x(n) = h(n) ={ 1,2,0,2,1}

Code

```
clear all;
x=[1,2,0,2,1];
h=[1,2,0,2,1];
y=conv(x,h);

n1=1:length(x)
n2=1:length(h)
n3=1:length(y)

subplot(2,2,1);
stem(n1,x)
axis( [0 length(x)+1 0 max(x)+1]);
xlabel( 'n');
ylabel('x(n)');

subplot(2,2,2);
stem(n2,h)
axis( [0 length(h)+1 0 max(h)+1])
xlabel( 'n');
ylabel('h(n)');


subplot(2,2,3);
stem(n3,y)
axis( [0 length(y)+1 0 max(y)+1])
xlabel( 'n');
ylabel('y(n)');
```

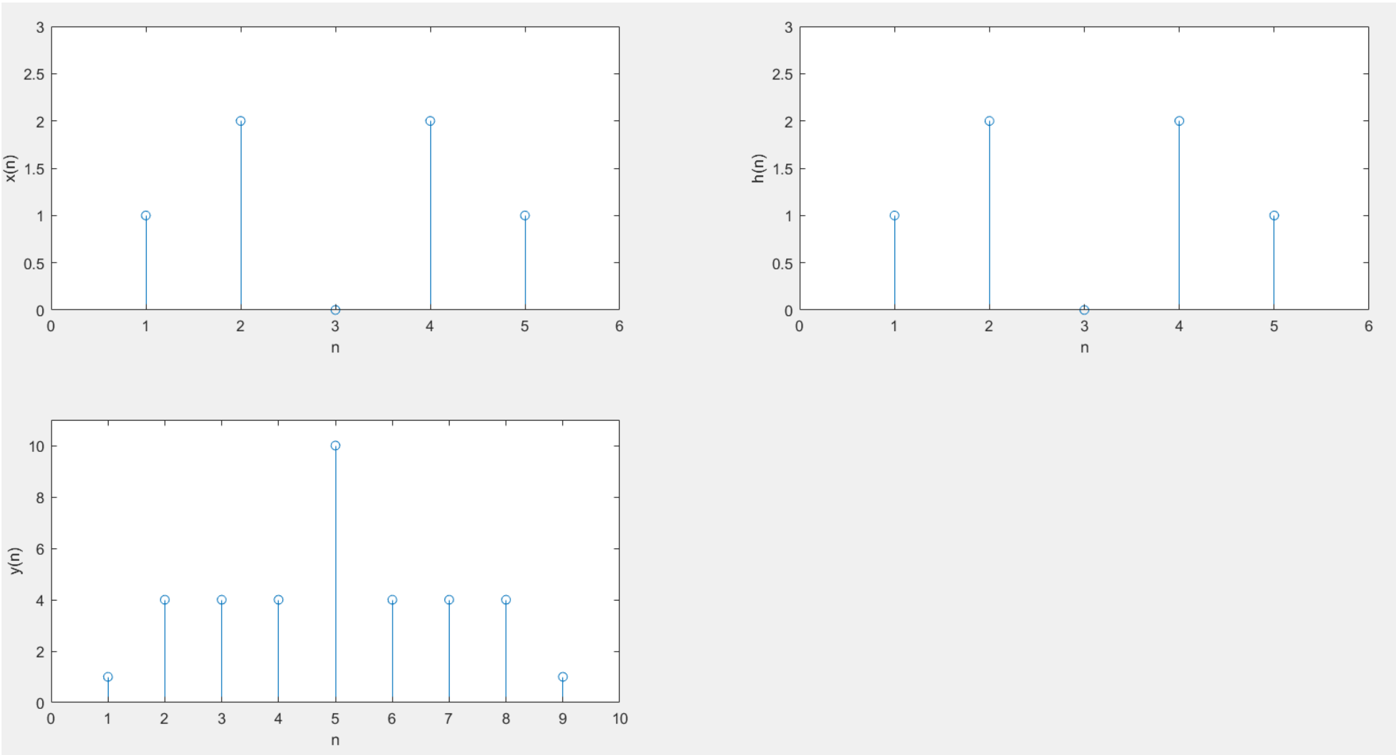


Figure 06: Variation of x(n), h(n) and y(n) with n