classmate

Date

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Experiment - 3 : Convolution

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8th August, 2019

3.1 $x(n) = u(n-1) - u(n-6)$

$h(n) = tri\left[\frac{n-6}{4}\right]$

Find the convolution sum,

$y(n) = x(n) * h(n)$

3.2 $x(n) = u(n) - u(n-4)$

$y(n) = nu(n) - 2(n-4)u(n-4) + (n-8)u(n-8)$

Make stem plots of the following convolutions.

i] $x(n) * x(n)$

ii] $x(n) * x(n) * x(n)$

iii] $x(n) * y(n)$

iv] $y(n) * d(n)$

v] $y(n) * y(n)$

vi] Is there any relationship between (i) and $y(n)$? Compare (i),(ii) and (iii), what happens when you repeatedly convolve the signal with itself ?

3.3 Make stem plots of the following signals, decide range of 'n'

$$x(n) = 3\delta(n+2) - \delta(n-1) + 2\delta(n-2)$$

$$h(n) = u(n+4) - u(n-3)$$

i] Stem plot of $x(n) * h(n)$

ii] Plot signals by hand

Experiment – 3: Convolution

3.1.

Unit Step function 'u':

```
% Function #1 for unit step function

function y = u(n);
 y = double(n>=0);
 I = find(round(n)~=n);
 y(I) = NaN;

% NaN is for non-integer arguments
```

Unit Step functions 2 'us':

```
% Unit step function continuous

function y = us(t)
zro = t==0;
pos = t>0;
y = zro/2 + pos;
```

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Triangular function 'tr'

Editor - C:\Users\18BIS0043\Documents\MATLAB\tr.m

T1.m | tr.m | u.m | r.m | us.m

```
% Function #2 for triangular function
% Needs the function r

function y = tr(t);
 y = r(t+1) - 2*r(t) + r(t-1);
```

The 'ramp' function is a part of the triangular function and this function needs the continuous unit step function named 'us'

Editor - C:\Users\18BIS0043\Documents\MATLAB\r.m

T1.m | tr.m | u.m | r.m | us.m

```
% Function r for triangular function
% Needs the function us

function y = r(x)
y = x.*us(x);
```

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Final Program: Using 4 functions – 'tr', 'u', 'r', 'us', for different functionalities as shown in the program

Editor - C:\Users\18BIS0043\Documents\MATLAB\T1.m

T1.m | tr.m | u.m | r.m | us.m | T2.m | +

```
clc
clear all

nx = -2:8;
nh = 0:12;
x = u(nx-1) - u(nx-6); % Function u is defined
h = tr((nh-6)/4); % Function tr is defined
y = conv(x,h);

ny = (nx(1)+nh(1)) + (0:(length(nx)+length(nh)-2));

subplot(3,1,1);
stem(nx,x, 'k--','filled')
xlabel('n');
ylabel('x');
axis([-2,20,0,4]);
grid on;
```

```

subplot(3,1,2);
stem(nh,h,'r','filled');
xlabel('n');
ylabel('h');
axis([-2,20,0,4]);
grid on;

subplot(3,1,3);
stem(ny,y,'o','filled');
xlabel('n');
ylabel('y');
axis([-2,20,0,4]);
grid on;

```

****Output screenshots 1&2 are shown in the next page*

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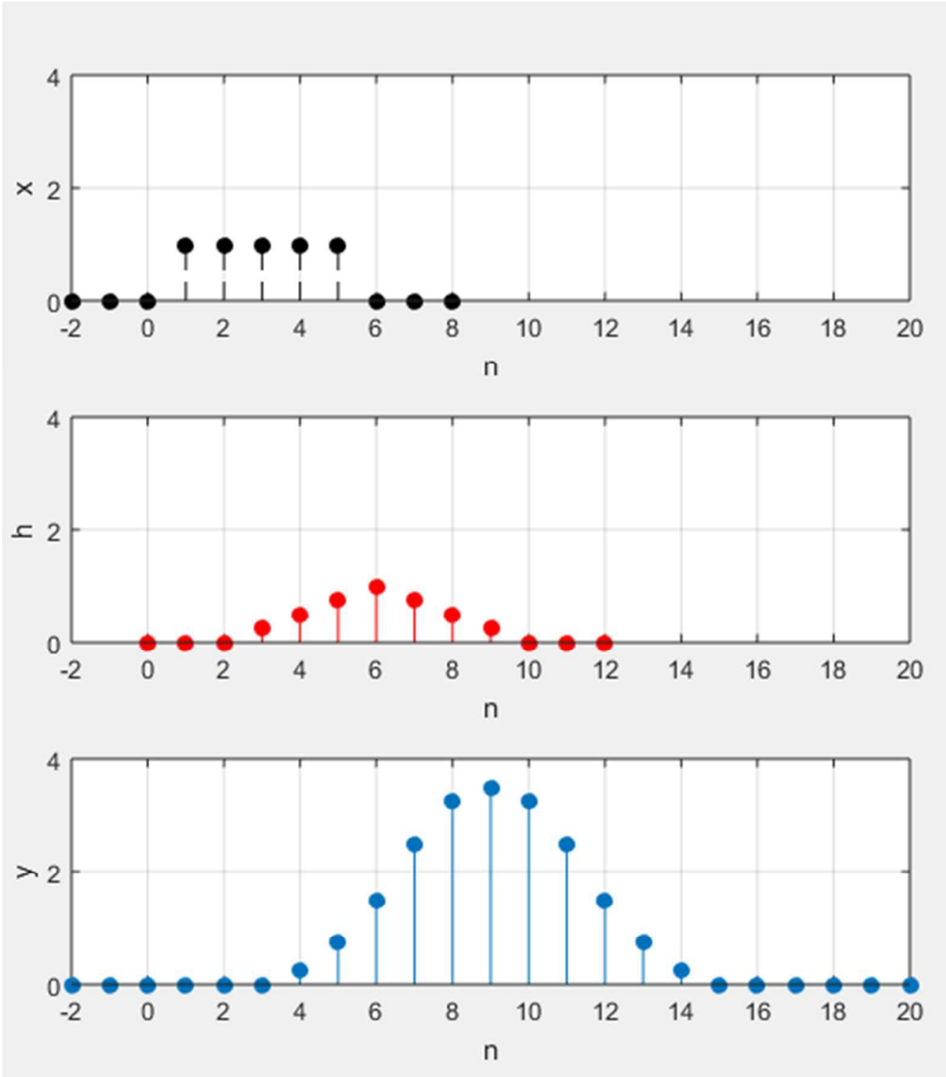

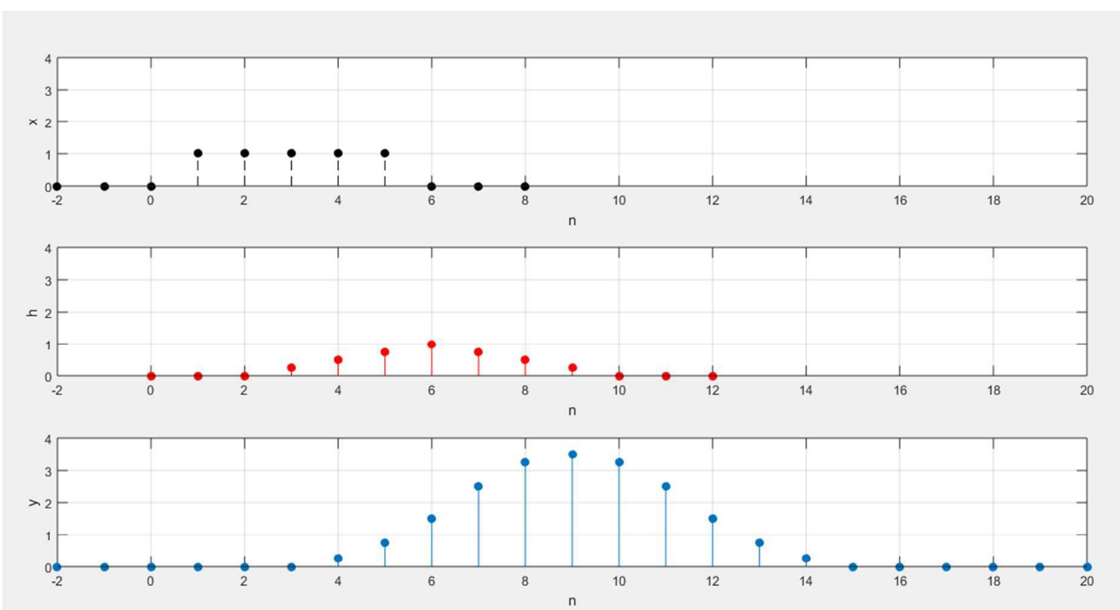

3.2

Program:

Defining functions 'u', unit impulse function 'd', x(n) and y(n).

Editor - C:\Users\18BIS0043\Documents\MATLAB\T2.m

T2.m

```
clc
clear all

nx = -5:10;
ny = -5:10;
nd = -5:10;

d = 1.*(nd==0);

x = u(nx) - u(nx-4); % Function u is defined
y = ny.*u(ny) - 2.*(ny-4).*u(ny-4) + (ny-8).*u(ny-8);
```

**** h1 – h5 are signals corresponding to the sub-question (a to e).*

Editor - C:\Users\18BIS0043\Documents\MATLAB\T2.m

T2.m

```

h1 = conv(x,x);
nh1 = (nx(1)+nx(1)) + (0:(length(nx)+length(nx)-2));

% Convolution is associative
% x(n)*x(n)*x(n) = (x(n)*x(n))*x(n)
s = conv(x,x);
s2 = (nx(1)+ny(1)) + (0:(length(nx)+length(ny)-2));
h2 = conv(s,x);
nh2 = (nx(1)+s2(1)) + (0:(length(nx)+length(s2)-2));


h3 = conv(x,y);
nh3 = (nx(1)+ny(1)) + (0:(length(nx)+length(ny)-2));

h4 = conv(y,d);
nh4 = (nx(1)+nd(1)) + (0:(length(nx)+length(nd)-2));

h5 = conv(y,y);
nh5 = (ny(1)+ny(1)) + (0:(length(ny)+length(ny)-2));

```

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Plotting the first 3 graphs:

Editor - C:\Users\18BIS0043\Documents\MATLAB\T2.m

T2.m

```
    subplot(3,2,1);
    stem(nh1,h1,'k--','filled')
    xlabel('nh1');
    ylabel('h1');
    title('x(n) * x(n)');
    axis([-5,10,0,15]);
    grid on;

    subplot(3,2,2);
    stem(ny,y,'m','filled');
    xlabel('ny');
    ylabel('y');
    axis([-5,10,0,15]);
    title('y(n)');
    grid on;

    subplot(3,2,3);
    stem(nh3,h3,'o','filled');
    xlabel('n');
    ylabel('h3');
    axis([-5,20,0,15]);
    title('x(n) * y(n)');
    grid on;
```

Plotting the last 3 graphs:

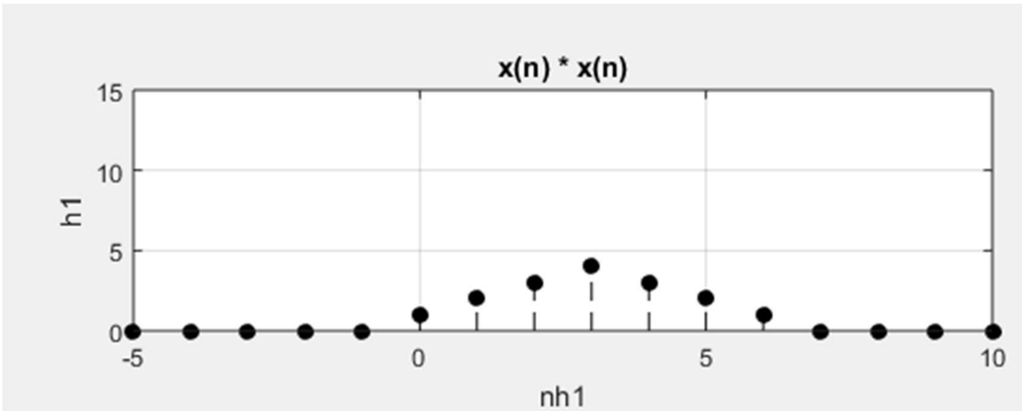
Editor - C:\Users\18BIS0043\Documents\MATLAB\T2.m

T2.m

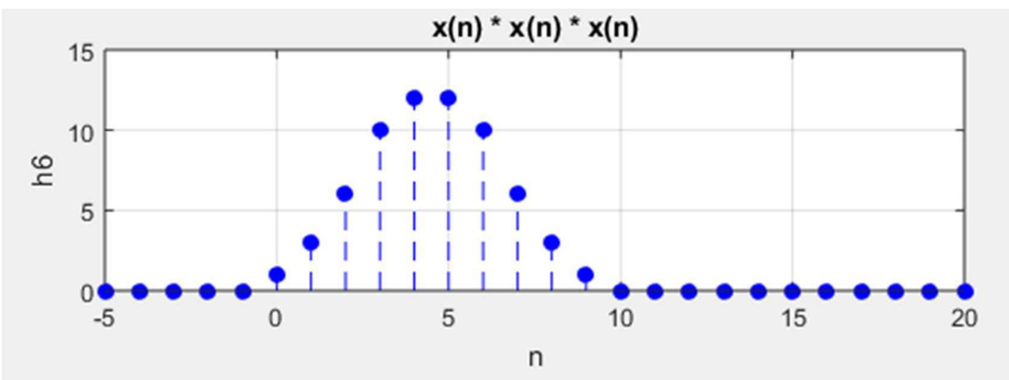
```

    subplot(3,2,4);
    stem(nh4,h4,'g','filled');
    xlabel('n');
    ylabel('h4');
    axis([-5,20,0,15]);
    title('y(n) * d(n)');
    grid on;

    subplot(3,2,5);
    stem(nh5,h5,'r--','filled');
    xlabel('n');
    ylabel('h5');
    axis([-5,20,0,60]);
    title('y(n) * y(n)');
    grid on;

    subplot(3,2,6);
    stem(nh2,h2,'b--','filled');
    xlabel('n');
    ylabel('h6');
    axis([-5,20,0,15]);
    title('x(n) * x(n) * x(n)');
    grid on;
```

Outputs:

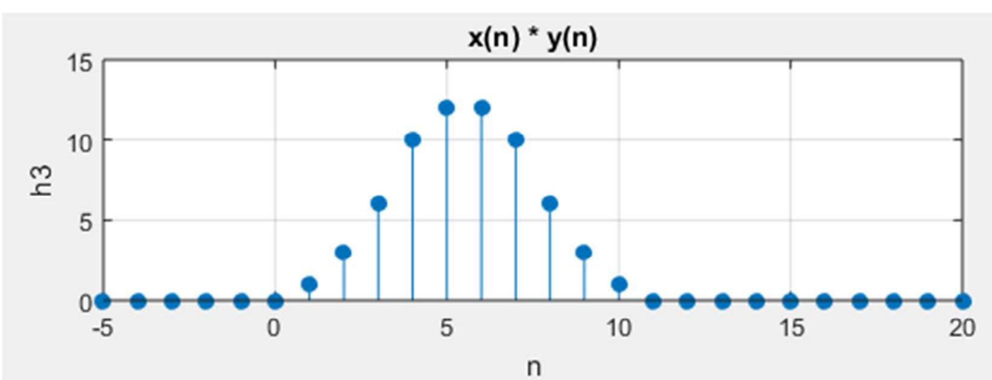
i.



ii.



iii.



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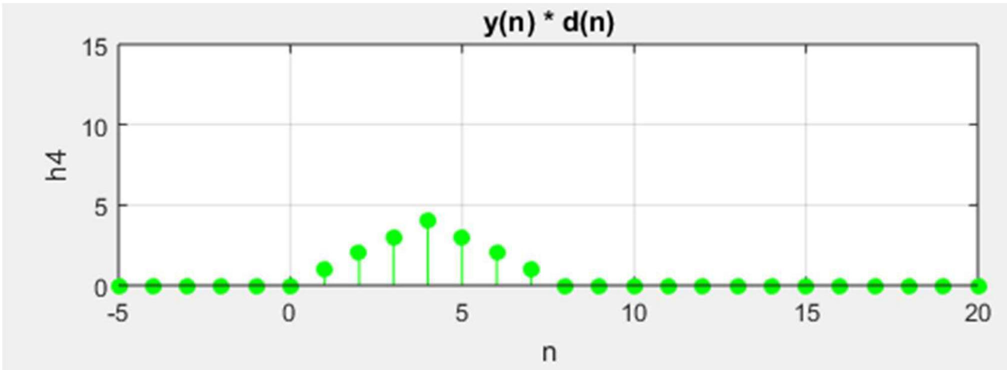
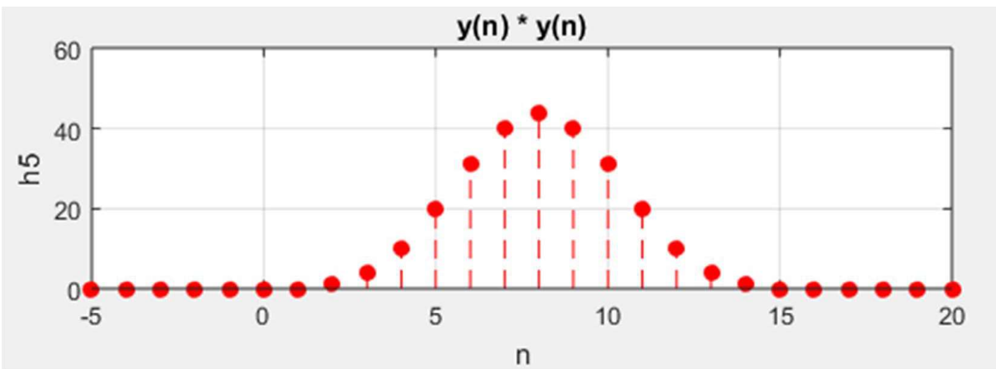
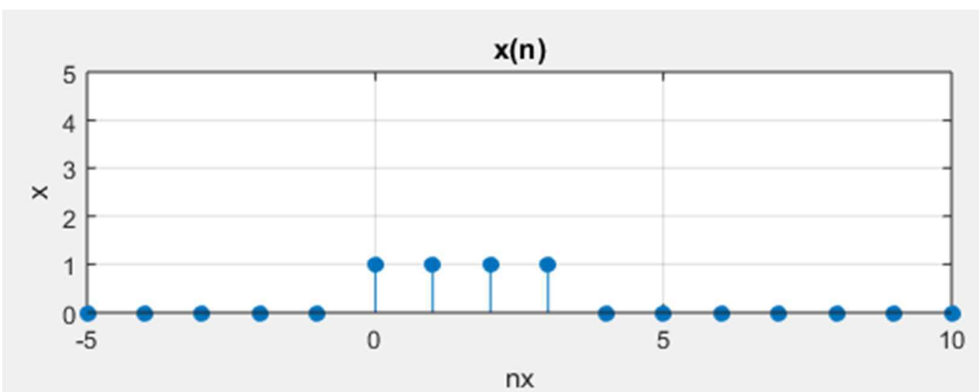
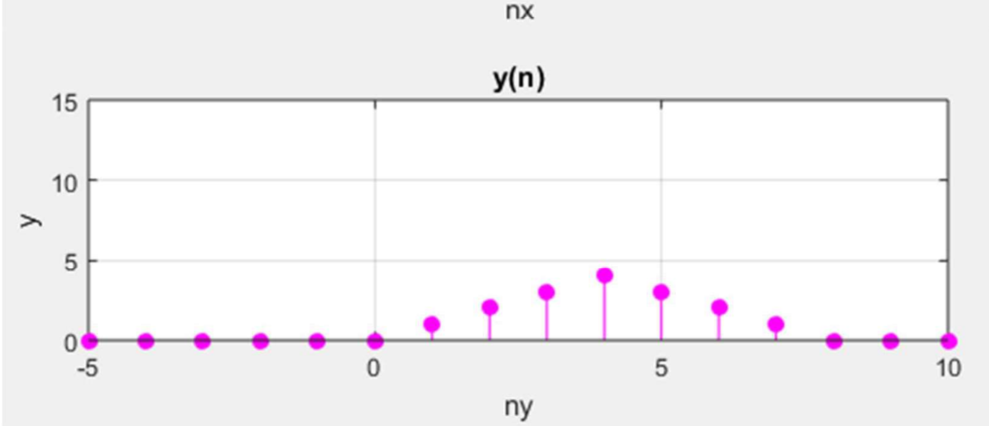
iv.



v.







3.3

Program:

Editor - C:\Users\18BIS0043\Documents\MATLAB\T3.m

T2.m | u.m | us.m | T3.m

```
clc
clear all

nx = -10:10;
nh = -10:10;
nd = -10:10;
d1 = 3.*(nd==-2);       % 3d[n+2]
d2 = 1.*(nd==1);        % d[n-1]
d3 = 2.*(nd==2);        % 2d[n-2]

h = u(nh+4) - u(nh-3); % Function u is defined
x = d1-d2+d3;

y = conv(x,h);
ny = (nx(1)+nh(1)) + (0:(length(nx)+length(nh)-2));

```

Editor - C:\Users\18BIS0043\Documents\MATLAB\T3.m

T2.m | u.m | us.m | T3.m

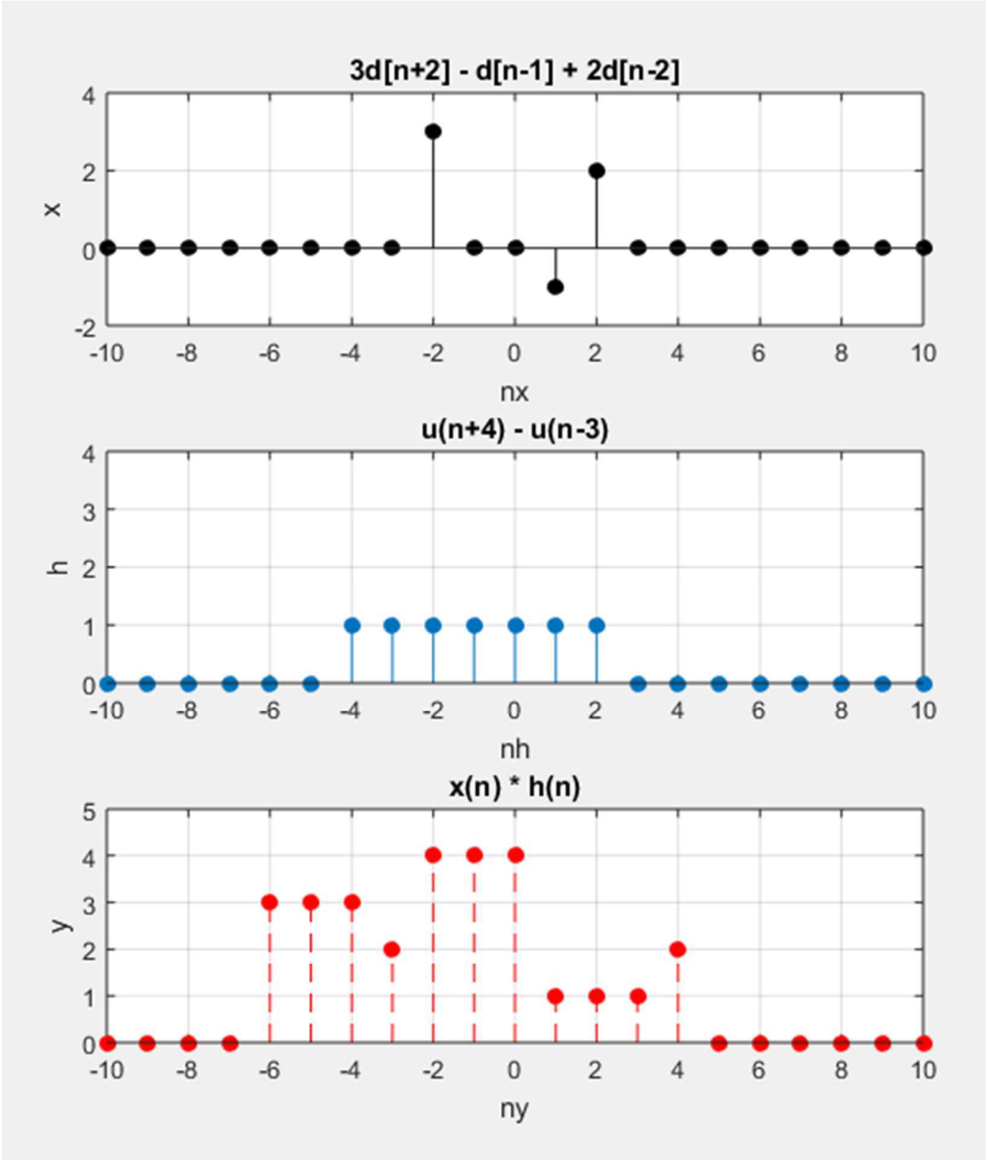
```
stem(nx,x,'k','filled')
xlabel('nx');
ylabel('x');
title('3d[n+2] - d[n-1] + 2d[n-2]')
axis([-10,10,-2,4]);
grid on;

subplot(3,1,2)
stem(nh,h,'o','filled')
xlabel('nh');
ylabel('h');
title('u(n+4) - u(n-3)');
axis([-10,10,0,4]);
grid on;

subplot(3,1,3)
stem(ny,y,'r--','filled')
xlabel('ny');
ylabel('y');
title('x(n) * h(n)');
axis([-10,10,0,5]);
grid on;

```

Output:



****Unit Step function 'u' (from page 1) is also used in this program.*

Experiment - 3 : Answers

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3.2 vi] $x[n] * x[n]$ and $y[n]$ are similar graphs with time shifting by 1 unit

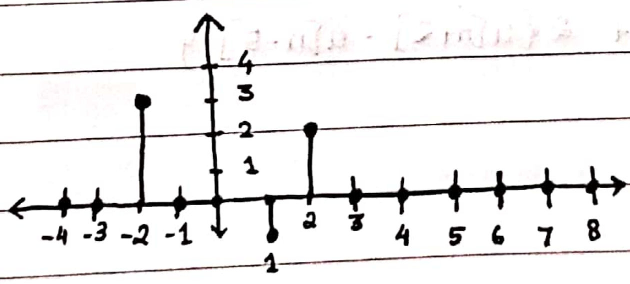
$\therefore$ if $a[n] = x[n] * x[n]$

$\Rightarrow a[n] = y[n+1]$

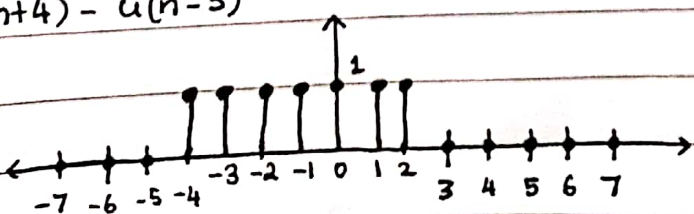
After the first convolution, there will be a triangular distribution, whose base will become broader and peak becomes smoother and asymptotically gaussian. increasing each convolution

Broader base represents a wider range

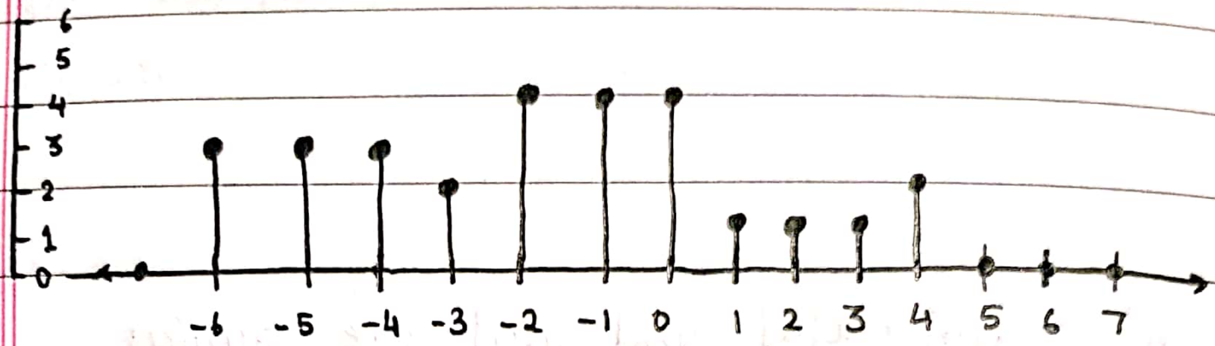
3.3 ii] a. $3\delta(n+2) - \delta(n-1) + 2\delta(n-2)$



ii] b. $u(n+4) - u(n-3)$



ii] c. $x[n] * h[n]$



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$$z[n] = \sum_{-\infty}^{\infty} x[k]\, h[n-k]$$

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

$$= 3h[n+2] - h[n\ 1] + 2h[n-2]$$

$$= 3\{u[n+6] - u[n-1]\}$$

$$- u[n+3] - u[n-k]$$

$$+ 2\{u[n+2] - u[n-5]\}$$