# DSAA COMPUTER

# ASSIGNMENT-4

**NAME** :- **ANIRUDH KANNAN V P**

**ROLL NO** : - **201601004**

## QUESTION 1:-

**Write matlab codes for the convolution algorithm for causal signals using the following methods**

- **Definition**

**y[n] = x[n] ∗ h[n] = sigma(k=0,k=n) h(k)x(n — k)**

- **The tabular method**

### II. APPLICATION

**Demonstrate and compare the application of the above codes for the following examples and verify the results theoretically.**

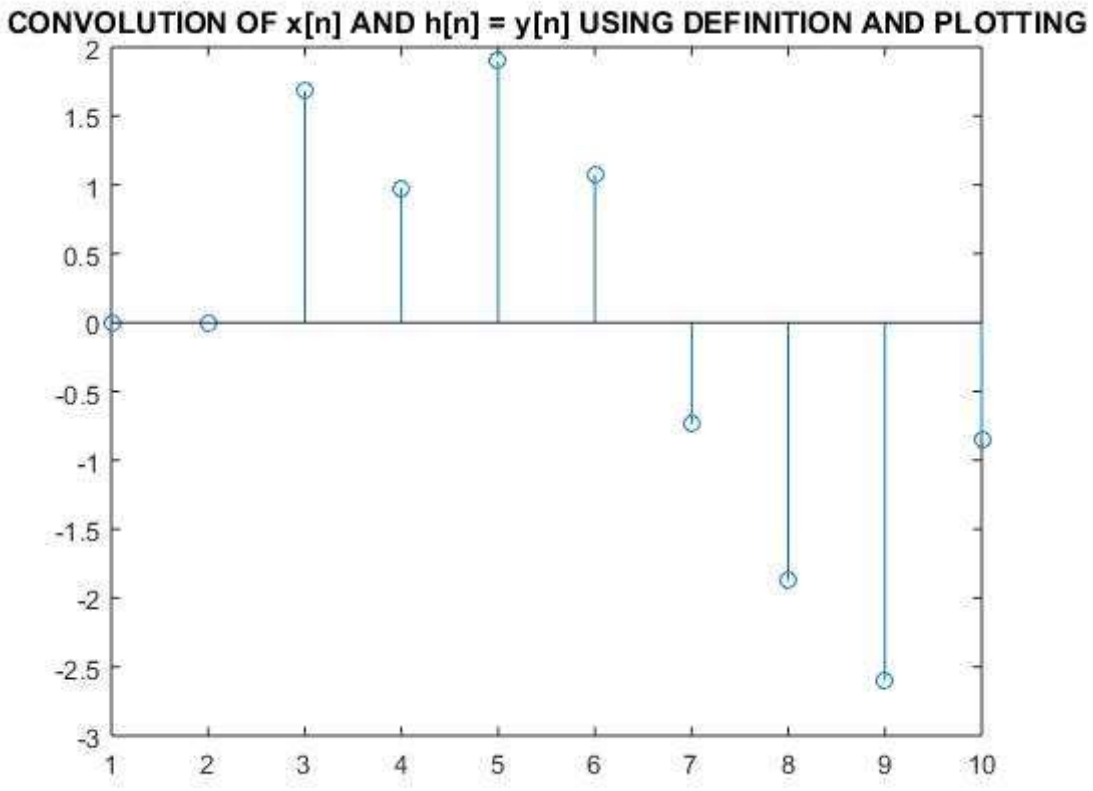
- **x[n] = sin (7/22*πn) where n = 0, · · · , 6**

**h[n] = [0, 2, —1, 3]**

# MATLAB CODE:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
close all;
clear all;

%n from 0..6 given in question
n = 0:1:6;

%h given in question
h = [0,2,-1,3];

%x given in question
x = sin((pi*7*n)/22);

%l= length of convoluted vector
l = length(x)+length(h)-1;

%Creating a zero vector
X = zeros(1,l);
H = zeros(1,l);
Yn = zeros(1,l);

X(1:length(x)) = x;
H(1:length(h)) = h;

i = 1;
j = 1;

while j<=l
    while i<=j
        Yn(j) = Yn(j) + X(j-i+1)*H(i);
        i = i+1;
    end
    j = j+1;
    i = 1;
end

stem(Yn);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING DEFINITION AND
PLOTTING');
```

# OUTPUT AND DISCUSSION:-




**The main motive is to find the convolution between x[n] and h[n] and find y[n] using Matlab code and by manual calculations by using definition and tabular method both. The matlab code for finding convolution by definition is declared above.**

**First zero vectors of X and H of length are created of length l = length(x)+length(h) - 1 by definition of convolution.**

**using the code:**

```
%Creating a zero vector
X = zeros(1,l);
H = zeros(1,l);
Yn = zeros(1,l);

X(1:length(x)) = x;
H(1:length(h)) = h;
```

**Then by the definition y[n] = x[n] ∗ h[n] = sigma(k=0,k=n) h(k)x(n − k) , Y[n] is filled by using two while loops.**

```
while j<=l
    while i<=j
        Yn(j) = Yn(j) + X(j-i+1)*H(i);
        i = i+1;
    end
    j = j+1;
    i = 1;
end
```

**Then by the definition y[n] = x[n] ∗ h[n] = sigma(k=0,k=n) h(k)x(n − k) , Y[n] is filled by using two while loops.**

**and then y[n] is plotted using stem function.**

**y[n] is also calculated manually and the calculations are shown below:-**

# DSAA COMPUTER ASSIGNMENT-3

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- 20160004
- CSE BATCH-A

(1)

$x[n] = \sin\left[\frac{7}{22} \times pi \times n\right]$ $n = 0, 1, 2, 3 \ldots 6$

↳ substituting $pi = 3.14$ & $n = 0, 1 \ldots 6$

$x[n] = [0, 0.8413, 0.9096, 0.1423, -0.7557, -0.9595, -0.2817]$

$h[n] = [0, 2, -1, 3]$

By definition $y[n] = x[n] * h[n] = \sum_{k=0}^{4} h(k)\, x(n-k)$

$y[n]$ will have $7+4-1 = 10$ values

$y[0] = x[0]\, h[0] = 0.$

$y[1] = x[0]\, h[1] + x[1]\, h[0] = 0 + 0 = 0$

$y[2] = x[0]\, h[2] + x[1]\, h[1] + x[2]\, h[0]$

$= 0 + 1.6825 + 0 = 1.6825.$

$y[3] = x[0]\, h[3] + x[1]\, h[2] + x[2]\, h[1] + x[3]\, h[0]$

$= 0 + (-0.8413) + (1.8192) + 0 = 0.9780$

$$y[4] = x[0]h[4] + x[1]h[3] + x[2]h[2] + x[3]h[1] + x[4]h[0] = 1.8988.$$

$$y[5] = x[0]h[5] + x[1]h[4] + x[2]h[3] + x[3]h[2] + x[4]h[1] + x[5]h[0] = 1.0751$$

$$y[6] = x[0]h[6] + x[1]h[5] + x[2]h[4] + x[3]h[3] + x[4]h[2] + x[5]h[1] + x[6]h[0] = -0.7362$$

$$y[7] = x[0]h[7] + x[1]h[6] + x[2]h[5] + x[3]h[4] + x[4]h[3] + x[5]h[2] + x[6]h[1] + x[7]h[0] = -1.8712$$

$$y[8] = x[0]h[8] + x[1]h[7] + x[2]h[6] + x[3]h[5] + x[4]h[4] + x[5]h[3] + x[6]h[2] + x[7]h[1] + x[8]h[0] = -2.5967$$

$$y[9] = x[0]h[9] + x[1]h[8] + x[2]h[7] + x[3]h[6] + x[4]h[5] + x[5]h[4] + x[6]h[3] + x[7]h[2] + x[8]h[1] + x[9]h[0] = -0.8452$$

∴ By definition of convolution

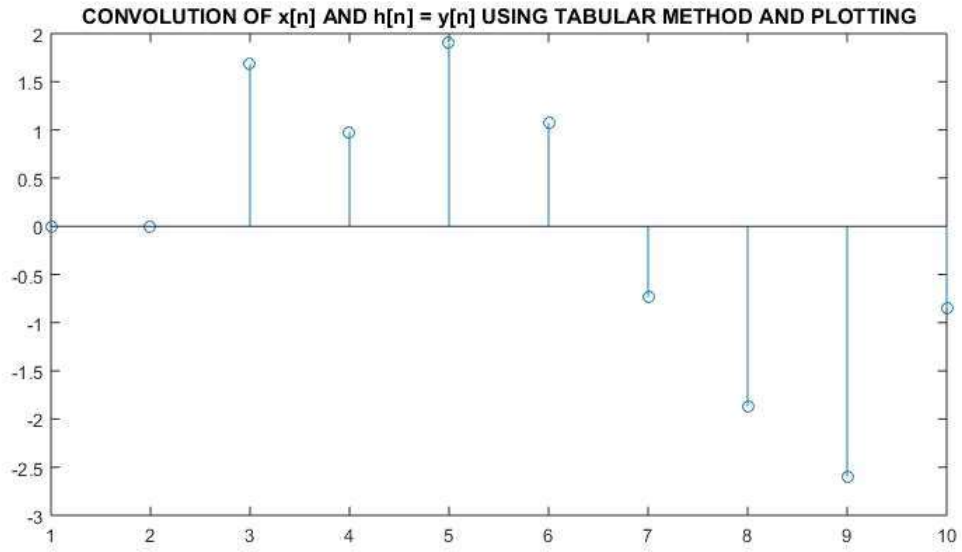
$$y[n] = [0, 0, 1.6825, 0.9780, 1.8988, 1.0751, -0.7362, -1.8712, -2.5967, -0.8452]$$

**Thus it can be seen that the convoluted value from both the manual values and matlab codes match exactly and thus the code for matlab is right.**

# MATLAB CODE:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
close all;
clear all;

%n from 0..6 given in question
n = 0:1:6;

%h given in question
h = [0,2,-1,3];

%x given in question
x = sin((pi*7*n)/22);

%l= length of convoluted vector
l = length(x)+length(h)-1;

%Creating zero vectors
X = zeros(1,l);
H = zeros(1,l);
%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H(1:length(h)) = h;


table = zeros(l);

i = 1;
j = 1;

while j<=l
        while i<=j
            table(j,i) = X(j-i+1);
            i = i+1;
        end
        j = j+1;
        i = 1;
```

```
end
H = zeros(1,l);
H(1:length(h)) = h;

result = table*H'

stem(result);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING TABULAR METHOD AND
PLOTTING');
```




**Here in the tabular method, a table is created of length l and full of zeroes. The matrix should not be looped and multiplied directly as if each value is multiplied directly the order will be in the order of O(n^4).**

**.So to solve the question in asymtotically lesser time complexity it is multiplied by using matrix multiplication. First a table is created with zeroes of length 1..l where l=(length(x)+length(h)-1) and then the matrix is multiplied.**

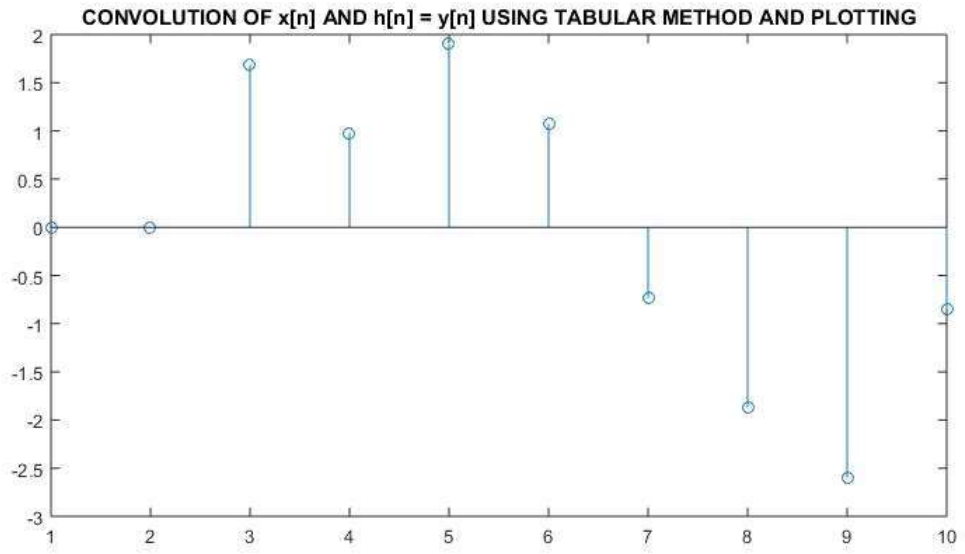
**The code is given below:**

```
i = 1;
j = 1;

while j<=l
        while i<=j
            table(j,i) = X(j-i+1);
            i = i+1;
        end
```

```
        j = j+1;
        i = 1;
end
```

**Then the matrix is plotted using stem by multiplying with h transpose.**

```
H = zeros(1,l);
H(1:length(h)) = h;

result = table*H'

stem(result);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING TABULAR METHOD AND
PLOTTING');
```




**The output from manual calculations is given below and it matches the given output.**

$x[n] = \sin\left[\frac{7}{22} \times pi \times n\right]$ $n = 0,1,2,3 \ldots 6$

↳ substitute $pi = 3.14$ & $n = 0,1 \ldots 6$

$h[n] = [0, 2, -1, 3]$

| $x[n]$ ↓ \ $h[n]$ → | 0 | 2 | −1 | 3 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0.8413 | 0 | 1.6826 | −0.8413 | 2.5239 |
| 0.9096 | 0 | 1.8192 | −0.9096 | 2.7288 |
| 0.1423 | 0 | 0.2846 | −0.1423 | 0.4269 |
| −0.7557 | 0 | −1.5114 | +0.7557 | −2.2671 |
| −0.9595 | 0 | −1.919 | +0.9595 | −2.8785 |
| −0.2817 | 0 | −0.5634 | +0.2817 | −0.8451 |

Summing values across diagonals

$y[n] = [0, 0, 1.6825, 0.9780, 1.8986, 1.0751, -0.7863, -1.8712, -2.5967, -0.8452]$

↳ same values match.

# QUESTION 2:-

**h[n] = exp[−j2π*nk/N]**

**where n = 0, · · · , 7**

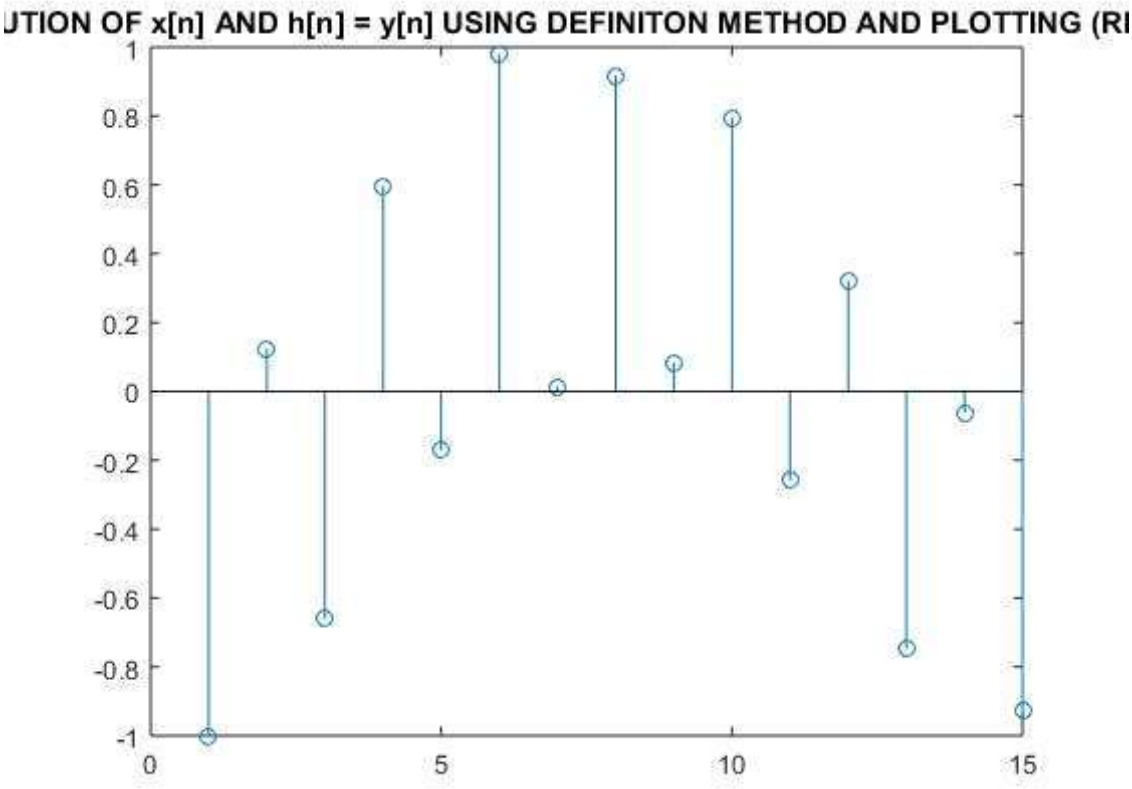
**x[n] = [−1, 1, −1, 1, −1, 1, −1, 1]**

# MATLAB CODE:-

# REAL PART:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
close all;
clear all;

%DECLARING k=23 and N=25 in question
k = 23;
N = 25;

%n from 0..6 given in question
n = 0:1:7;

%h given in question
h1 = real(exp(-j*2*pi*n*k/N));
h2 = imag(exp(-j*2*pi*n*k/N));
h3 = (exp(-j*2*pi*n*k/N));

%x given in question
x = [-1,1,-1,1,-1,1,-1,1];


%l= length of convoluted vector
l = length(x)+length(h1)-1;

%Creating zero vectors
X = zeros(1,l);
```

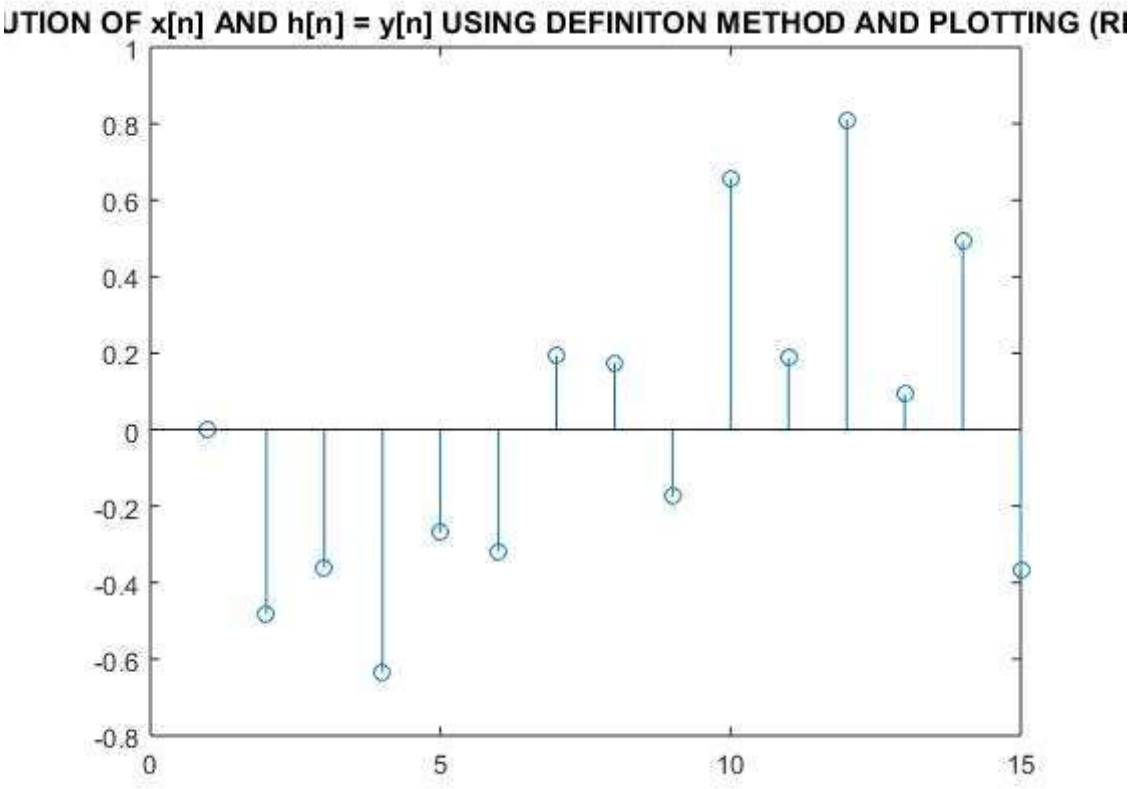
```
H1 = zeros(1,l);
H2 = zeros(1,l);
H3 = zeros(1,l);

Yn1 = zeros(1,l);
Yn2 = zeros(1,l);
Yn3 = zeros(1,l);


%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H1(1:length(h1)) = h1;
H2(1:length(h2)) = h2;
H3(1:length(h3)) = h3;

table = zeros(l);

i = 1;
j = 1;

while j<=l
    while i<=j
        Yn1(j) = Yn1(j) + X(j-i+1)*H1(i);
        Yn2(j) = Yn2(j) + X(j-i+1)*H2(i);
        Yn3(j) = Yn3(j) + X(j-i+1)*H3(i);
        i = i+1;
    end
    j = j+1;
    i=1;
end

stem(Yn1);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING DEFINITON METHOD AND
PLOTTING (REAL PARTS)');
```




# IMAGINARY PART:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
close all;
clear all;

%DECLARING k=23 and N=25 in question
k = 23;
N = 25;

%n from 0..6 given in question
n = 0:1:7;

%h given in question
h1 = real(exp(-j*2*pi*n*k/N));
h2 = imag(exp(-j*2*pi*n*k/N));
```

```
h3 = (exp(-j*2*pi*n*k/N));

%x given in question
x = [-1,1,-1,1,-1,1,-1,1];


%l= length of convoluted vector
l = length(x)+length(h1)-1;

%Creating zero vectors
X = zeros(1,l);
H1 = zeros(1,l);
H2 = zeros(1,l);
H3 = zeros(1,l);

Yn1 = zeros(1,l);
Yn2 = zeros(1,l);
Yn3 = zeros(1,l);


%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H1(1:length(h1)) = h1;
H2(1:length(h2)) = h2;
H3(1:length(h3)) = h3;

table = zeros(l);

i = 1;
j = 1;

while j<=l
    while i<=j
        Yn1(j) = Yn1(j) + X(j-i+1)*H1(i);
        Yn2(j) = Yn2(j) + X(j-i+1)*H2(i);
        Yn3(j) = Yn3(j) + X(j-i+1)*H3(i);
        i = i+1;
    end
    j = j+1;
    i=1;
end

stem(Yn2);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING DEFINITON METHOD AND
PLOTTING (IMAGINARY PARTS)');
```




## OUTPUT AND DISCUSSION:-

**The main motive is to find the convolution between x[n] and h[n] and find y[n] using Matlab code and by manual calculations by using definition and tabular method both. The matlab code for finding convolution by definition is declared above.**

**First zero vectors of X and H of length are created of length l = length(x)+length(h) - 1 by definition of convolution.**

**using the code:**

```
%Creating zero vectors
X = zeros(1,l);
H1 = zeros(1,l);
H2 = zeros(1,l);
H3 = zeros(1,l);

Yn1 = zeros(1,l);
Yn2 = zeros(1,l);
Yn3 = zeros(1,l);
```

```
%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H1(1:length(h1)) = h1;
H2(1:length(h2)) = h2;
H3(1:length(h3)) = h3;
```

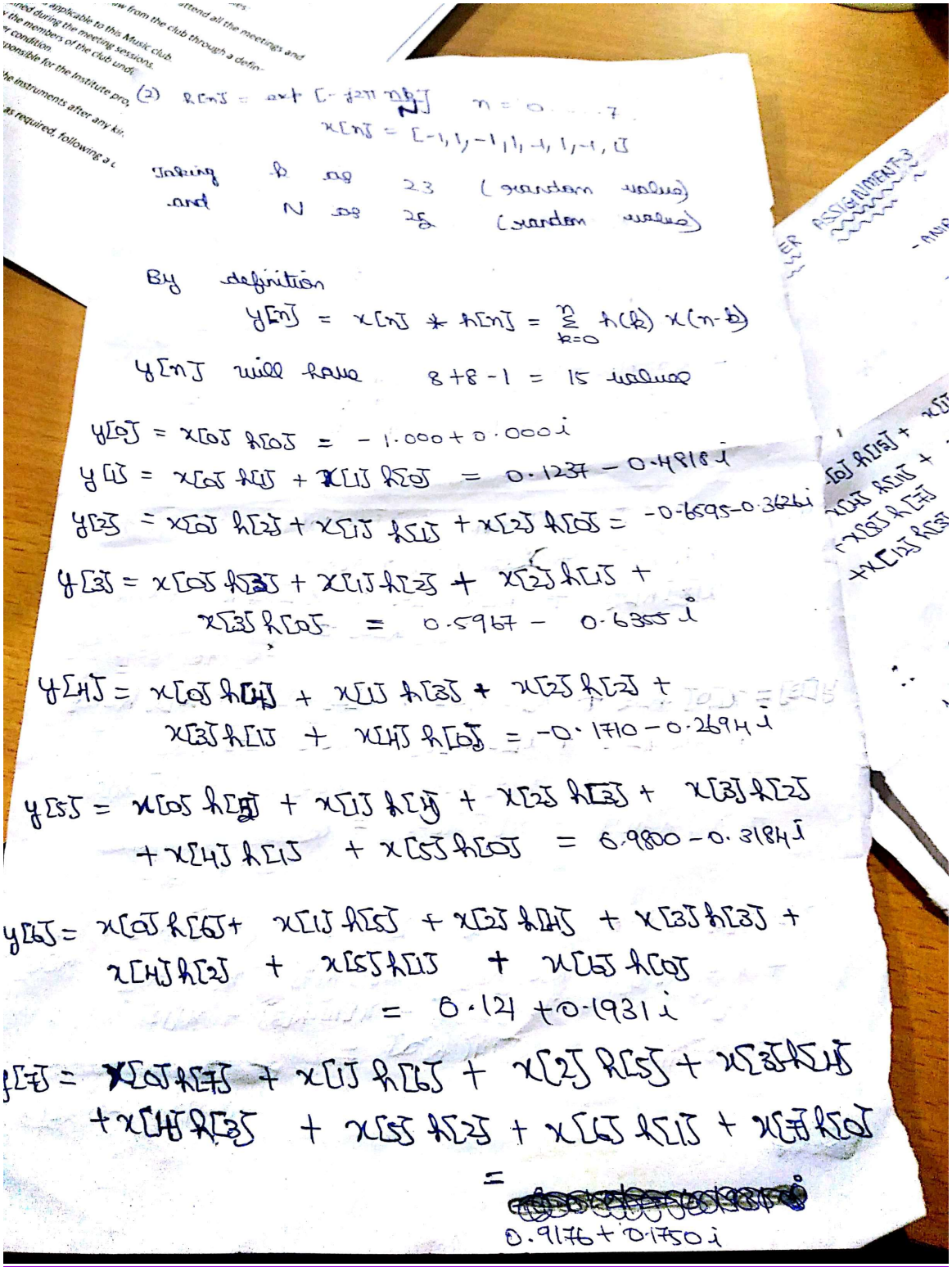
**Then by the definition y[n] = x[n] ∗ h[n] .Y[n] is filled by using two while loops.**

```
i = 1;
j = 1;

while j<=l
    while i<=j
        Yn1(j) = Yn1(j) + X(j-i+1)*H1(i);
        Yn2(j) = Yn2(j) + X(j-i+1)*H2(i);
        Yn3(j) = Yn3(j) + X(j-i+1)*H3(i);
        i = i+1;
    end
    j = j+1;
    i=1;
end

stem(Yn2);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING DEFINITON METHOD AND
PLOTTING (IMAGINARY PARTS)');
```

**Then by the definition y[n] = x[n] ∗ h[n] is filled by using two while loops.**

**and then y[n] is plotted using stem function.**

**y[n] is also calculated manually and the calculations are shown below:-**

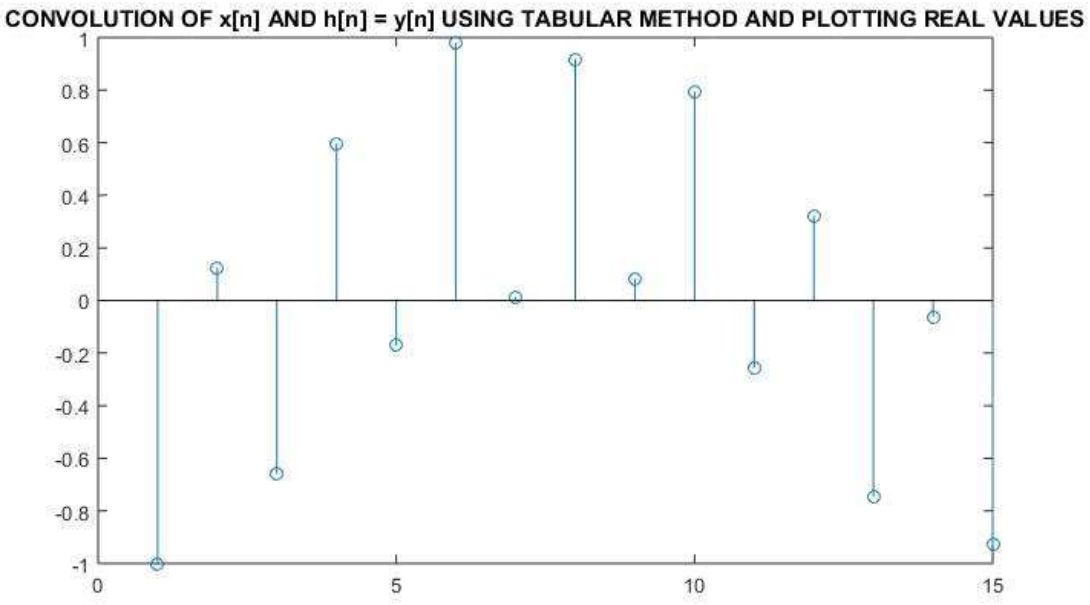

(2) h[n] = ax + [-j2π nb/N]  n = 0 ... 7
x[n] = [-1, 1, -1, 1, -1, 1, -1, 1]
Taking b as 23 (random value)
and N as 25 (random value)
By definition
y[n] = x[n] * h[n] = Σ h(k) x(n-k)
y[n] will have 8+8-1 = 15 values
y[0] = x[0] h[0] = -1.000 + 0.000 i
y[1] = x[0] h[1] + x[1] h[0] = 0.1237 - 0.4818 i
y[2] = x[0] h[2] + x[1] h[1] + x[2] h[0] = -0.6695 - 0.3626 i
y[3] = x[0] h[3] + x[1] h[2] + x[2] h[1] +
x[3] h[0] = 0.5967 - 0.6355 i
y[4] = x[0] h[4] + x[1] h[3] + x[2] h[2] +
x[3] h[1] + x[4] h[0] = -0.1710 - 0.2694 i
y[5] = x[0] h[5] + x[1] h[4] + x[2] h[3] + x[3] h[2]
+ x[4] h[1] + x[5] h[0] = 0.9800 - 0.3184 i
y[6] = x[0] h[6] + x[1] h[5] + x[2] h[4] + x[3] h[3] +
x[4] h[2] + x[5] h[1] + x[6] h[0]
= 0.124 + 0.1931 i
y[7] = x[0] h[7] + x[1] h[6] + x[2] h[5] + x[3] h[4] +
x[4] h[3] + x[5] h[2] + x[6] h[1] + x[7] h[0]
=
0.9176 + 0.1750 i

# MATLAB CODE:-

# REAL PART:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
close all;
clear all;

%DECLARING k=23 and N=25 in question
k = 23;
N = 25;

%n from 0..6 given in question
n = 0:1:7;

%h given in question
h1 = real(exp(-j*2*pi*n*k/N));
h2 = imag(exp(-j*2*pi*n*k/N));
h3 = (exp(-j*2*pi*n*k/N));

%x given in question
x = [-1,1,-1,1,-1,1,-1,1];


%l= length of convoluted vector
l = length(x)+length(h1)-1;

%Creating zero vectors
X = zeros(1,l);
H1 = zeros(1,l);
H2 = zeros(1,l);
H3 = zeros(1,l);

Yn1 = zeros(1,l);
Yn2 = zeros(1,l);
Yn3 = zeros(1,l);


%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H1(1:length(h1)) = h1;
H2(1:length(h2)) = h2;
H3(1:length(h3)) = h3;

table = zeros(l);
```

```
i = 1;
j = 1;

while j<=l
    while i<=j
        %Yn1(j) = Yn1(j) + X(j-i+1)*H1(i);
        %Yn2(j) = Yn2(j) + X(j-i+1)*H2(i);
        %Yn3(j) = Yn3(j) + X(j-i+1)*H3(i);
        table(j,i) = X(j-i+1);
        i = i+1;
    end
    j = j+1;
    i=1;
end

H = zeros(1,l);
H(1:length(h1)) = h1;

result = table*H'

stem(result);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING TABULAR METHOD AND
PLOTTING REAL VALUES');
```

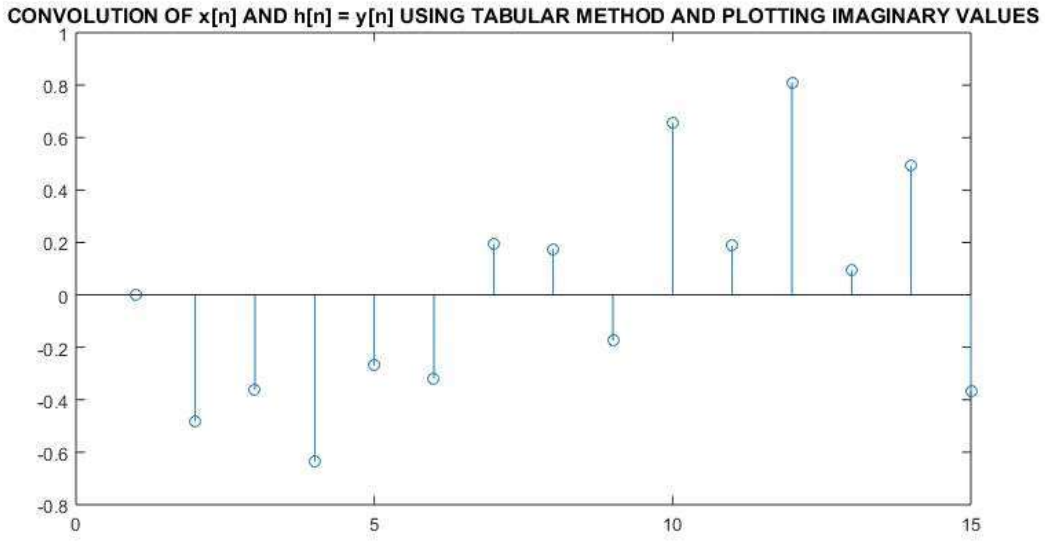



# IMAGINARY PART:-

```
%%COMP ASSIGN-2
%%ANIRUDH KANNAN V P
%%201601004
%%UG2 CSE

clc;
```

```
close all;
clear all;

%DECLARING k=23 and N=25 in question
k = 23;
N = 25;

%n from 0..6 given in question
n = 0:1:7;

%h given in question
h1 = real(exp(-j*2*pi*n*k/N));
h2 = imag(exp(-j*2*pi*n*k/N));
h3 = (exp(-j*2*pi*n*k/N));

%x given in question
x = [-1,1,-1,1,-1,1,-1,1];


%l= length of convoluted vector
l = length(x)+length(h1)-1;

%Creating zero vectors
X = zeros(1,l);
H1 = zeros(1,l);
H2 = zeros(1,l);
H3 = zeros(1,l);

Yn1 = zeros(1,l);
Yn2 = zeros(1,l);
Yn3 = zeros(1,l);


%initialising the X,H vectors with values from x,h
X(1:length(x)) = x;
H1(1:length(h1)) = h1;
H2(1:length(h2)) = h2;
H3(1:length(h3)) = h3;

table = zeros(l);

i = 1;
j = 1;

while j<=l
    while i<=j
        %Yn1(j) = Yn1(j) + X(j-i+1)*H1(i);
        %Yn2(j) = Yn2(j) + X(j-i+1)*H2(i);
        %Yn3(j) = Yn3(j) + X(j-i+1)*H3(i);
        table(j,i) = X(j-i+1);
        i = i+1;
    end
    j = j+1;
    i=1;
end
```

```
H = zeros(1,l);
H(1:length(h2)) = h2;

result = table*H'

stem(result);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING TABULAR METHOD AND
PLOTTING IMAGINARY VALUES');
```




**Here in the tabular method, a table is created of length l and full of zeroes. The matrix should not be looped and multiplied directly as if each value is multiplied directly the order will be in the order of O(n^4).**

**.So to solve the question in asymtotically lesser time complexity it is multiplied by using matrix multiplication. First a table is created with zeroes of length 1..l where l=(length(x)+length(h)-1) and then the matrix is multiplied.**

**The code is given below:**

```
i = 1;
j = 1;

while j<=l
        while i<=j
            table(j,i) = X(j-i+1);
            i = i+1;
        end
        j = j+1;
        i = 1;
end
```

**Then the matrix is plotted using stem by multiplying with h transpose.**

```
H = zeros(1,l);
H(1:length(h1)) = h1;

result = table*H'

stem(result);
title('CONVOLUTION OF x[n] AND h[n] = y[n] USING TABULAR METHOD AND
PLOTTING REAL PART');
```

**Similarily the same is done for imaginary part.**

**xxxxxxxxxxxxxxxxxxxxxxxxxxxxEND OF DOCUMENTxxxxxxxxxxxxxxxxxxxx**