Experiment 1 : Discrete Convolution

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Experiment No.	1

AIM:	The aim of this experiment is to study mathematical operation such as : • Linear Convolution • Circular Convolution • Linear Convolution using Circular Convolution.
OBJECTIVE:	• To Develop a function to find Linear Convolution and Circular Convolution • To Calculate Linear convolution, Circular convolution, Linear Convolution using Circular Convolution and verify the results using mathematical formulation. • To Conclude on aliasing effect in Circular convolution
INPUT SPECIFICATION:	• Length of first Signal L and signal values. • Length of second Signal M and signal values.
PROBLEM DEFINITION:	• Find Linear Convolution and Circular Convolution of L point sequence x[n] and M point sequence h[n]. • Find Linear Convolution of L point sequence x[n] and M point sequence h[n] using Circular convolution. • Give your conclusion about No of values in Linearly Convolved signal, Aliasing effect in Circular Convolution.

Case 1 : Liner convolution

Question : Perform linear convolution of two signal A={12,13,10,11} and B={9,7,14,2}

Code solution :

```
/tmp/fVvxpSxecg.o

Enter the length of the input signal x[n] (L): 4
Enter the values for x[n]:
12 13 10 11

Enter the length of the impulse response h[n] (M): 4
Enter the values for h[n]:
9 7 14 2


x[n] =   12.00    13.00    10.00    11.00

h[n] =   9.00    7.00    14.00    2.00

y[n] =   108.00    201.00    349.00    375.00    243.00    174.00    22.00
```

Result analysis :
The linear convolution of
A={12,13,10,11} L=4
B={9,7,14,2} M = 4
y[n]={108,201,349,375,243,174,22} LENGTH =7

Question : Perform linear convolution of two signal A={12,13,10,11} and B={9,7,14,2}

Code solution :

```
/tmp/kkjsKrW9yJ.o

Enter the length of the input signal x[n] (L): 4
Enter the values for x[n]:
23 12 13 17

Enter the length of the impulse response h[n] (M): 3
Enter the values for h[n]:
9 8 7


x[n] =   23.00    12.00    13.00    17.00

h[n] =   9.00    8.00    7.00

y[n] =   207.00    292.00    374.00    341.00    227.00    119.00
```

Result analysis :
The linear convolution of
A={23,12,13,17} L=4
B={9,8,7} M=3
y[n]={207,292,374,341,227,119} LENGTH = 6

Case 2 : Circular convolution

Question : To perform circular convolution between two sequences **A = [4, 6, 9, 10]**
B = [3, 2, 1, 11, 7]

Code solution :

```
/tmp/irej4L9aLa.o
Enter the length of the first signal A: 4
Enter the values of signal A:
4 6 9 10


Enter the length of the second signal B: 5
Enter the values of signal B:
3 2 1 11 7

Signal A = 4.00    6.00    9.00    10.00    0.00
Signal B = 3.00    2.00    1.00    11.00    7.00

Circular Convolution Result y[n] = 163.00   199.00   113.00   98.00   123.00
```

Solution :

To perform circular convolution between two sequences, both sequences must be of the same length. Since sequence `A` has 4 elements and sequence `B` has 5 elements, we'll first need to pad the shorter sequence `A` with zeros to match the length of `B`.

Step 1: Pad the shorter sequence

- **A = [4, 6, 9, 10]** L = 4 becomes **A' = [4, 6, 9, 10, 0]**
- **B = [3, 2, 1, 11, 7] M=5**

Now, both sequences are of length 5.

The circular convolution result is: **y = [163, 199, 113, 98, 123] LENGTH = 5**

Question : To perform circular convolution between two sequences **A = [7,8,9,10]**
B = [7,8,9,10]

Code solution :

```
/tmp/W7tDG4qXwr.o
Enter the length of the first signal A: 4
Enter the values of signal A:
7 8 9 10


Enter the length of the second signal B: 4
Enter the values of signal B:
7 8 9 10

Signal A = 7.00    8.00    9.00    10.00
Signal B = 7.00    8.00    9.00    10.00

Circular Convolution Result y[n] = 290.00   292.00   290.00   284.00
```

Solution :

Result analysis :
The CIRCULAR convolution of
A={7,8,9,10} L=4
B={7,8,9,10} M=4

y[n]={290,292,290,284} LENGTH = 4

Case 3 : Linear Convolution using Circular Convolution

Question : A=[6,9,10,13] , B=[12,8,7,14] , solve linear convolution but use the method of circular convolution

code solution :

```
/tmp/nbUY1kwtCR.o
Enter the length of the first signal A: 4
Enter the values of signal A:
6 9 10 13

Enter the length of the second signal B: 4
Enter the values of signal B:
12 8 7 14

Signal A = 6.00    9.00    10.00    13.00
Signal B = 12.00    8.00    7.00    14.00

Linear Convolution Result y[n] =
72.00   156.00   234.00   383.00   300.00   231.00   182.00
```

Result analysis :

Since the circular convolution assumes that the sequences are of the same length, we need to pad the sequences with zeros to make their lengths equal to N+M−1, where N and M are the lengths of the original sequences A and B

Given:

- Signal A: A=[6,9,10,13]
- Signal B: B=[12,8,7,14]

The length of the circular convolution will be N+M−1=4+4−1=7.

Pad both sequences with zeros to make their lengths 7:

- A=[6,9,10,13,0,0,0]
- B=[12,8,7,14,0,0,0]

The linear convolution result using circular convolution method is:

y[n]=[72,156,234,383,300,231,182]

CONCLUSION:	• Function Accuracy: The developed functions for Linear and Circular Convolution produced accurate results, which matched with mathematical formulations. • Linear Convolution Length: The output length $N=L+M-1$ was correctly calculated, matching theoretical expectations. • Causality Preservation: The output of Linear Convolution remains causal if both input signals are causal. • Circular Convolution Calculation: Using N=Maximum(L,M) accurately computed Circular Convolution, reflecting the periodic nature of the signals. • Linear Convolution via Circular Convolution: Selecting $N \geq L+M-1$ for Circular Convolution correctly produced the Linear Convolution results. • Aliasing in Circular Convolution: Aliasing effects were observed in Circular Convolution, highlighting the need to manage signal length and periodicity to minimize these effects.