- Ramp: A signal that linearly increases or decreases over time.
- Exponential: A signal that grows or decays exponentially over time.

The sine function is periodic, meaning it repeats its values over a certain interval, Sinc: A mathematical function often used in signal processing, with properties important in filtering and interpolation.

- Folding: Reversing the direction of a signal by multiplying it with a flipped version of itself.
- Shifting: Moving a signal horizontally along the time axis.
- Scaling: Adjusting the amplitude or duration of a signal.
- Addition: Combining two or more signals by adding their corresponding values at each point in time.

Convolution of a signal is an operation that combines two signals to produce a third signal,

$$y(t) = x_1(t) * x_2(t)$$

$$= \int_{-\infty}^{\infty} x_1(\tau)\, x_2(t-\tau)\, d\tau$$

$$= \int_{-\infty}^{\infty} x_2(\tau)\, x_1(t-\tau)\, d\tau$$

Teacher's Signature:....

Convolution has applications that include **probability, statistics, acoustics, spectroscopy, signal processing and image processing, geophysics, engineering, physics, computer vision and differential equations**. The convolution can be

- Probability and Statistics: Used in probability distributions and statistical analysis.
- Acoustics: Modeling sound propagation and reverberation.
- Spectroscopy: Analyzing spectra of electromagnetic radiation.
- Signal Processing: Filtering, noise reduction, and feature extraction.
- Image Processing: Image enhancement, feature detection, and segmentation.
- Geophysics: Seismic data analysis and imaging subsurface structures.
- Engineering: System modeling, control theory, and dynamic system analysis.
- Physics: Solving wave equations and modeling physical phenomena.
- Computer Vision: Object recognition, image classification, and scene understanding.
- Differential Equations: Solving differential equations and modeling dynamic systems.

Expt. No. Page No. 08 Date

I> Properties of Convolution —

1> Commutative Property of Convolution

The commutative property of convolution states that the order in which we convolve two signals does not change the result i.e.

$$x_1(t) * x_2(t) = x_2(t) * x_1(t)$$

2> Distributive Property of Convolution

The distributive property of convolution states that if there are three signals $x_1(t)$, $x_2(t)$ and $x_3(t)$. Then the convolution of $x_1(t)$ is distributive over the addition i.e.

$$x_1(t) * [x_2(t) + x_3(t)] = [x_1(t) * x_2(t)] + [x_1(t) * x_3(t)]$$

3> Associative Property of Convolution

The associative property of convolution states that the way in which the signals are grouped in a convolution does not change the result i.e.

$$x_1(t) * [x_2(t) * x_3(t)] = [x_1(t) * x_2(t)] * x_3(t)$$

Teacher's Signature:

47 Convolution of signal with Impulse

This property of convolution states that the convolution states that the convolution of an arbitary signal $x(t)$ with a unit impulse signal is the signal itself ie.

$$x(t) * \delta(t) = x(t).$$

Result

We succesfully implemented the convolution of signal and it properties

Conclusion

Convolution is an important tool for analysing the signal and system functionality ie. how system react over signal.

Circular convolution is a mathematical operation that combines two cyclic signals by "wrapping around" their ends, often used in scenarios where signals repeat periodically.

DFT (Discrete Fourier Transform) transforms a discrete signal from time domain to frequency domain, while IDFT (Inverse Discrete Fourier Transform) performs the reverse, from frequency domain to time domain, enabling analysis and manipulation of signals in both domains.

for the corrected signals.

The general expressions for DFT an
IDFT are as follows :-

Equation for DFT -

$$X(k) = \sum_{n=0}^{N-1} x[n] \, e^{-j\frac{2\pi kn}{N}}$$

Equation for IDFT -

$$x(n) = \sum_{k=0}^{N-1} X[k] \, e^{j\frac{2\pi kn}{N}}$$

Result

We successfully implement the c
of DFT and IDFT in MATLAB a
verified it

Software → MATLAB

Theory →

<u>Circular shift Property</u> :- The multiplication of the sequence $X(k)$ with the complex exponential sequence $e^{-j2\pi km/N}$ is equivalent to the circular shift of the $x(n)$ by m units.

Mathematically,

$$DFT\{x(n-m)_N\} = e^{-j2\pi km/N} \cdot X(k)$$

Result

We successfully implemented the code of circular shift

Software Used :-

MATLAB

Theory :-

Auto Correlation :- It measures the similarity of a signal with itself at different time instants. Mathematically, the auto correlation function $R_{xx}(k)$ of a discrete signal $x(n)$ is defined as-

$$R_{xx}(k) = \sum_{n=-\infty}^{\infty} x(n) \cdot x^*(n-k)$$

where k represents the time delay or lag. Auto correlation is used to identify periodicity, cyclic pattern and the presence of repeating structures within a signal

Cross Correlation :- Cross correlation measures the similarity between two different signals as a function of time shift between them. Mathematically, the cross-correlation function $R_{xy}(k)$ between the two discrete signals $x(n)$ and $y(n)$ is given by -

$$R_{xy}(k) = \sum_{n=-\infty}^{\infty} x(n)\, y^*(n-k)$$

In MATLAB, auto correlation and cross correlation can be efficiently computed using built in functions ~~such~~ as

Fast Fourier transform

A **Fast Fourier Transform** (**FFT**) is an algorithm that computes the Discrete Fourier Transform (DFT) of a sequence, or its inverse (IDFT).

1. **Decimation in Time (DIT) FFT**:
   - In DIT FFT, the input sequence is recursively divided in the time domain.
   - The algorithm starts with the entire sequence and recursively divides it into smaller subsequences.
   - At each stage, the FFT is computed for the smaller subsequences and combined to obtain the final FFT result.
   - It typically uses a radix-2 Cooley-Tukey algorithm, where the input sequence is decomposed into smaller even and odd subsequences.
2. **Decimation in Frequency (DIF) FFT**:
   - In DIF FFT, the input sequence is recursively divided in the frequency domain.
   - The algorithm starts with the entire frequency domain and recursively divides it into smaller frequency bands.
   - At each stage, the FFT is computed for the smaller frequency bands and combined to obtain the final FFT result.
   - It also uses a radix-2 Cooley-Tukey algorithm but starts with the frequency domain decomposition instead of the time domain.