**Sanuj Shakya**
**IoE, Pulchowk Campus**

# Lab Module 3

**Initial report must include MATLAB programs for each of the problems given below along with necessary derivations of Fourier Transforms. The properly labeled graphical representation of each signal must be included in the final report along with necessary discussions.**

## Section A

## Continuous Time and Discrete Time Fourier Transforms

If *x(t)* and *X(jω)* are continuous time Fourier transform pairs i.e. $x(t) \xleftrightarrow{F.T.} X(j\omega)$, then the Fourier transform equation and inverse Fourier transform equation are given by,

$$X(j\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$$

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(j\omega)e^{j\omega t}d\omega$$

Similarly, for discrete time Fourier transform pair $x[n] \xleftrightarrow{F.T.} X(e^{j\omega})$, the Fourier transform equation and inverse Fourier transform equation are given by,

$$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n}$$

$$x[n] = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(e^{j\omega})e^{j\omega n}d\omega$$

**Problems**

1. Use FT analysis equation to find the FT of $x(t) = \begin{cases} 2 & ; \quad |t| \leq 5 \\ 0 & ; otherwise \end{cases}$. Use a MATLAB program to plot the time domain signal as well as its frequency spectrum and comment.

2. Find the discrete time Fourier transform of $x[n] = 0.5^n u[n]$ using the FT equation. Then use suitable MATLAB program to observe the time domain plot and frequency spectrum of the given signal and comment on it.

## Section B

## Discrete Fourier Transform

The N-point DFT of a finite duration sequence *x[n]* is given by:

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

Similarly, the inverse DFT (IDFT) equation is given by:

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

Following is a MATLAB function that is used to generate an N-point DFT of an input sequence *x[n]*:

```
%function to generate N-point DFT

function [X,k] = NDFT (x,N)
n = 0:N-1;
if (length(x) < N)
      %zero padding
      x = [x zeros(1,N-length(x))];
elseif (length(x) > N)
      %truncating
      x = x(1:N);
end
X=zeros(1,N);
for i = 1:N
      X(i) = sum(x(n+1).*exp(-j*k*2*pi*n/N));
end
k = 0:N-1;
```

**Problems**

1. Using above function, find the 4-point DFT of a sequence *x[n] = {1, 2, 2, 1}*. Also observe the magnitude and phase plots for *x[n]* and *X(k)*.

2. For a sequence $x[n] = 0.5^n u[n]$, generate and observe magnitude and phase spectrums using
   a. 8-point DFT
   b. 64-point DFT
   c. 512-point DFT

   Compare the results with the result from **Sec. A Prob. 2** and comment.