Signals and Systems Laboratory
Indian Institute of Technology Jammu
Experiment No.-6

Objective- (a) Frequency domain analysis of delayed signal, x(n) → y(n)= x(n-k) and scaled signal, x(n) → y(n) = x($\frac{n}{4}$).
(b) Compare with original signal x(n).
Apparatus- Python+matplotlib.
Theory-
Time Delay of Discrete-Time Sequence:
The time-shifting property of discrete-time Fourier transform states that if a signal x(n) is shifted by k in time domain, then its DTFT is multiplied by $e^{-j\omega k}$. Therefore, if

$$x(n) \underset{\longleftrightarrow}{FT} X(\omega)$$

Then,

$$x(n-k) \underset{\longleftrightarrow}{FT} e^{-j\omega k} X(\omega)(Timedelay)$$

where, k is an integer.
Proof:

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

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

Substituting (n-k) =m, then n = (m+k), we get,

$$F[x(n-k)] = \sum_{m=-\infty}^{\infty} x(m)e^{-j\omega(m+k)} = \sum_{m=-\infty}^{\infty} x(m)e^{-j\omega m}e^{-j\omega k}$$

$$\Rightarrow F[x(n-k)] = e^{-j\omega k} \sum_{m=-\infty}^{\infty} x(m)e^{-j\omega m}$$

$$\therefore F[x(n-k)] = e^{-j\omega k} X(\omega);$$

This property is called the time delay property of x(n).
Time Scaling of Discrete-Time Sequence:
The time scaling for the discrete sequence can be defined as,

$$x(n) \rightarrow y(n) = x(kn)$$

Here, k>1, then the signal is compressed in time.

$$x(n) \rightarrow y(n) = x(\frac{n}{k})$$

Since k < 1, hence the signal is expanded by a factor k.
Algorithm-

a. Start the process.

b. Frequency domain analysis of time delay and time scaling property of signal x(n).

c. Execute the program.

d. Plot the output for each function.

e. Stop the process.

Observations-
Result- Performed frequency domain analysis of time delay and time scaling property of signal x(n).
Precautions:-

- Program must be written carefully to avoid errors.
- Programs can never be saved as standard function name.
- Commands must be written in proper format.