

# Digital Signal Processing (DSP) Lab Problems

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## 1 Introduction

This document contains lab problems on Digital Signal Processing (DSP), including Discrete Fourier Transform (DFT), Discrete-Time Fourier Transform (DTFT), and Filtering. Python implementations are provided for each problem.

## 2 Basic Signal Operations

### 2.1 Signal Generation and Transformations

Generate a discrete-time sine wave and perform the following operations:

- Time Shifting:  $x[n - k]$
- Time Reversal:  $x[-n]$
- Time Scaling:  $x[a \cdot n]$

## 3 Discrete Fourier Transform (DFT)

The DFT is given by:

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

Implement DFT manually and compare it with `numpy.fft.fft()`.

## 4 Discrete-Time Fourier Transform (DTFT)

The DTFT is computed as:

$$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n} \quad (2)$$

## **5 Fast Fourier Transform (FFT) Efficiency**

Compare execution times for manual DFT vs. FFT.

## **6 Filtering in the Frequency Domain**

Apply a low-pass filter in the frequency domain to remove high-frequency components.