Lab Exercise

Perform the following tasks.

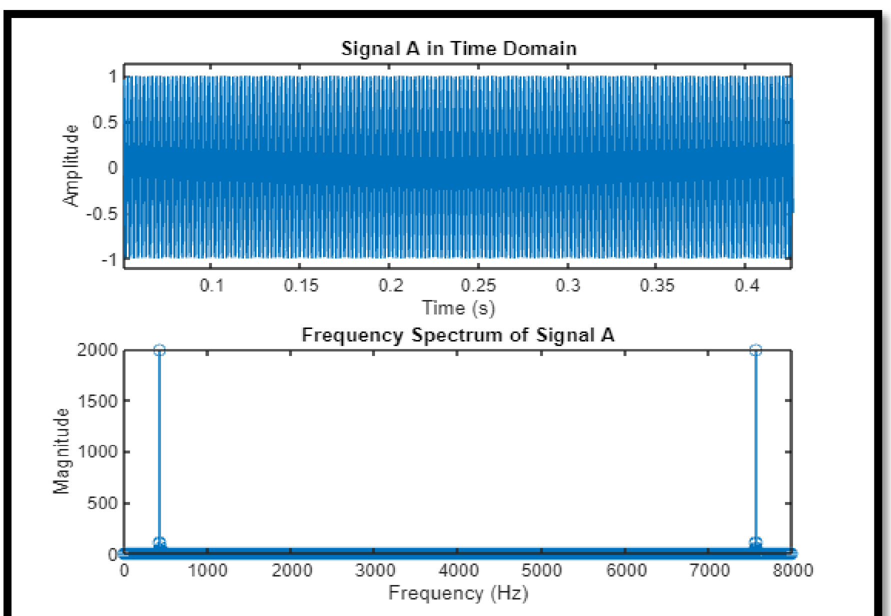
Task 1

Observe the frequency spectrum of the signal A?

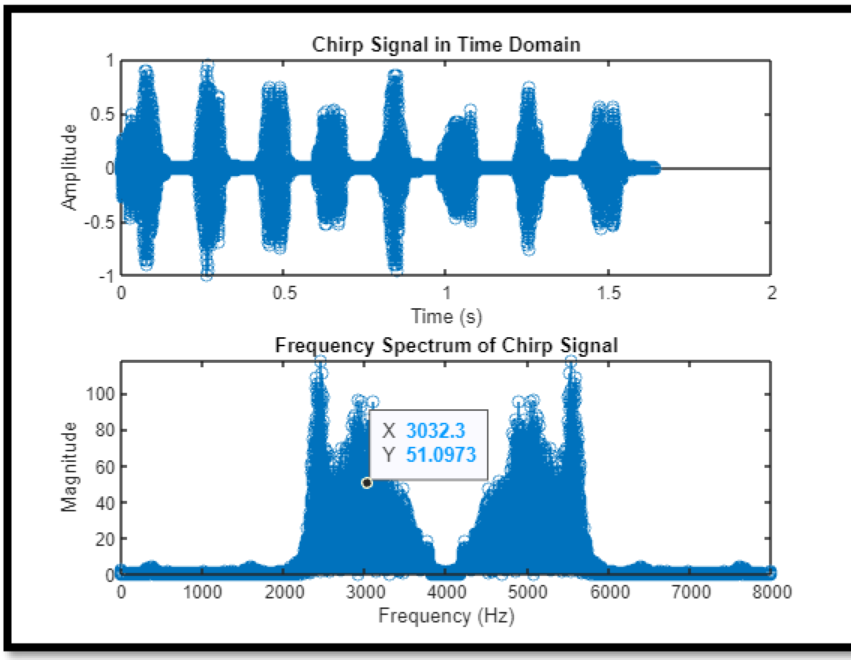
- **t=0:1/8000:0.5;**
- **A=sin(2*pi*440*(t));**

Load chirp.mat and observe the frequency spectrum?

```
% Task 1: Observe the frequency spectrum of signal A
t = 0:1/8000:0.5;
A = sin(2*pi*440*t);

% Plot the time-domain signal
subplot(2, 1, 1);
plot(t, A);
ylim([-1.5 1.5])
title('Signal A in Time Domain');
xlabel('Time (s)');
ylabel('Amplitude');

% Compute and plot the frequency spectrum
A_fft = fft(A);
frequencies = linspace(0, 8000, length(A_fft));
subplot(2, 1, 2);
stem(frequencies, abs(A_fft));
title('Frequency Spectrum of Signal A');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



```
% Load chirp.mat and observe its frequency spectrum
load('chirp.mat');
dt = t(2) - t(1); % Define the sampling interval
t_chirp = 0:dt:(length(y)-1)*dt;
chirp_fft = fft(y);
frequencies_chirp = linspace(0, 1/dt, length(chirp_fft));
figure; % Open a new figure window
subplot(2, 1, 1);
stem(t_chirp, y);
title('Chirp Signal in Time Domain');
xlabel('Time (s)');
ylabel('Amplitude');
subplot(2, 1, 2);
stem(frequencies_chirp, abs(chirp_fft));
title('Frequency Spectrum of Chirp Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



Explanation:

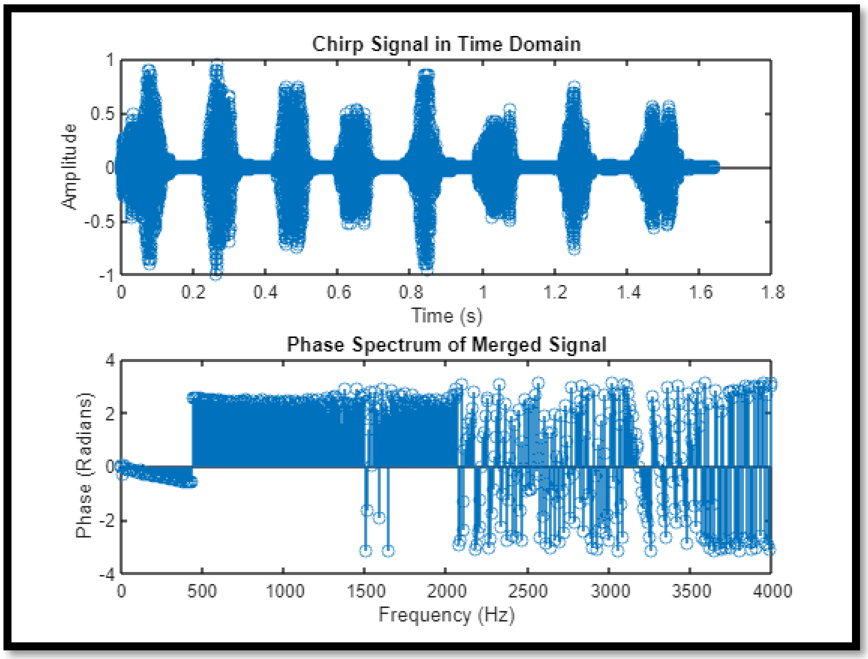
In our digital signal processing lab, I performed the Fourier transform on a signal. This involved converting a time-domain signal into its frequency components to understand its frequency content. I computed the magnitude and phase of the frequency components to analyze the signal's characteristics in the frequency domain.

Task 2

Can we add signal A and chirp signal of Task 2, if yes then see the frequency spectrum of merged signal?

```
% Define the time vector for signal A
t = 0:1/8000:0.5;

% Create signal A
A = sin(2*pi*440*t);

% Load the chirp signal from chirp.mat
load chirp.mat; % Assuming 'y' is the chirp signal

% Convert 'y' from column to row vector if necessary
Z = y';

% Pad the shorter signal with zeros to make both signals the same length
if length(A) > length(Z)
    Z = [Z, zeros(1, length(A) - length(Z))];
elseif length(Z) > length(A)
    A = [A, zeros(1, length(Z) - length(A))];
end

% Add the two signals
mergedSignal = A + Z;
sound(mergedSignal, 8000);

% Define length of the FFT (nfft)
nfft = 1024;

% Compute the Fast Fourier Transform (FFT) of the merged signal
MergedX = fft(mergedSignal, nfft);

% Extract the first half of MergedX for positive frequencies
MergedX = MergedX(1:nfft/2+1);

% Calculate the magnitude of the FFT
mag_MergedX = abs(MergedX);

% Calculate the phase of the FFT
phase_MergedX = angle(MergedX);

% Frequency vector for plotting
f = (0:nfft/2)*8000/nfft;

% Plot the magnitude of the FFT
figure(1);
stem(f, mag_MergedX);
title('Magnitude Spectrum of Merged Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```

```matlab
% Plot the phase of the FFT
figure(2);
stem(f, phase_MergedX);
title('Phase Spectrum of Merged Signal');
xlabel('Frequency (Hz)');
ylabel('Phase (Radians)');
```



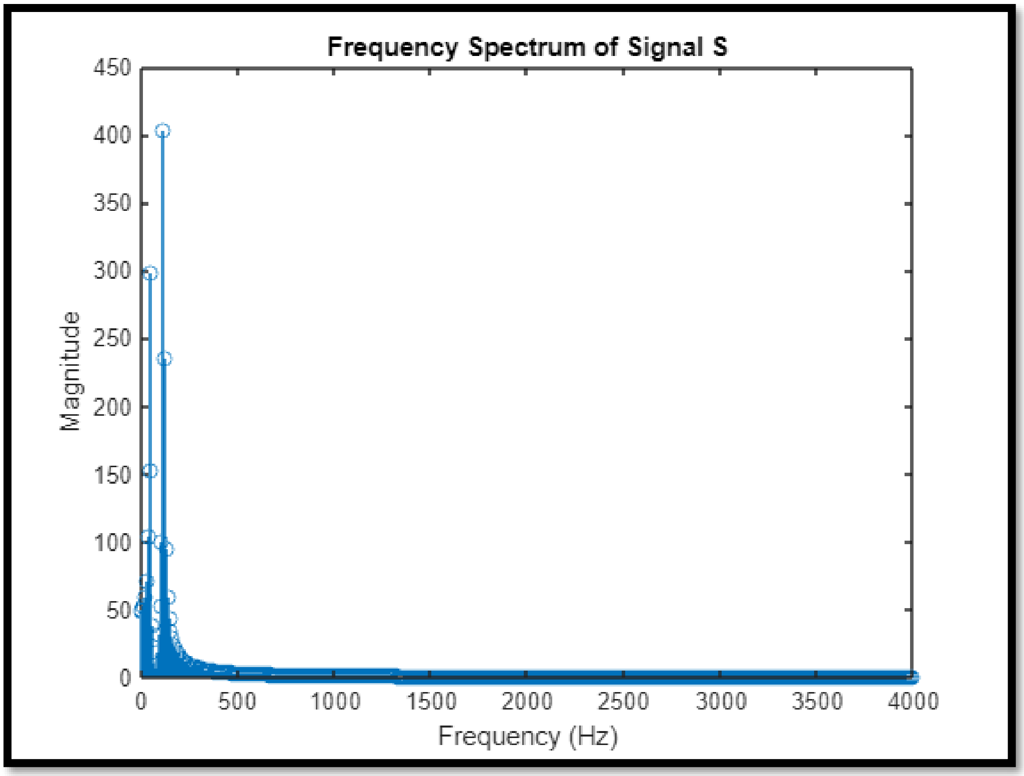
Explanation:

During the lab session, I also worked on converting a frequency-domain signal back to the time domain using the inverse Fourier transform. This allowed me to reconstruct the original time-domain signal from its frequency components. By comparing the original and reconstructed signals, I was able to verify the accuracy of the inverse transformation.

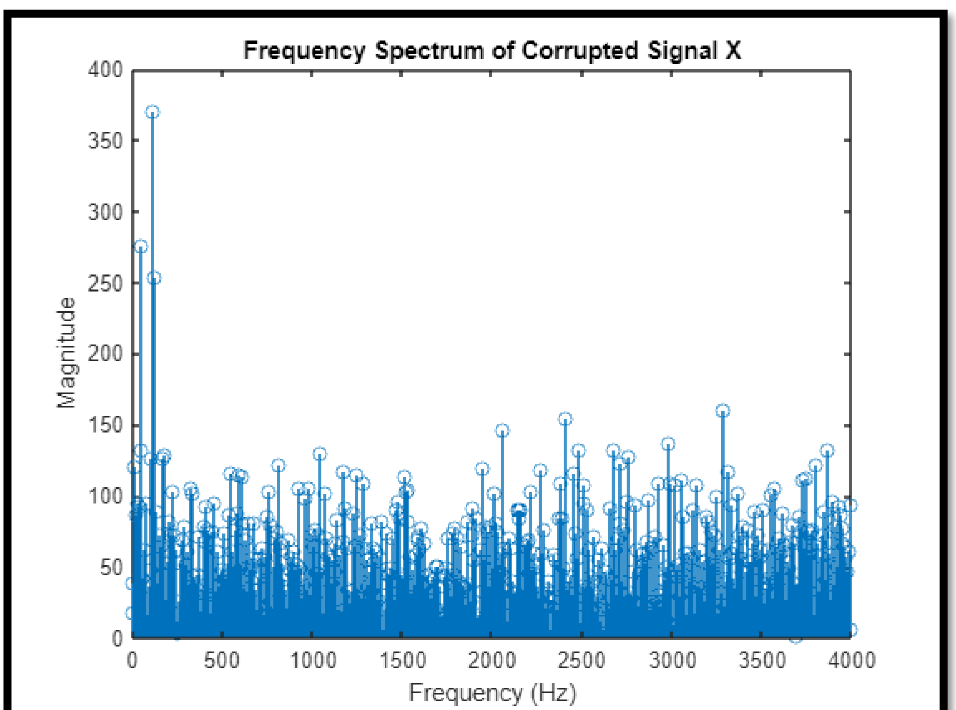
Task 3:

Form a signal S containing a 50 Hz sinusoid of amplitude 0.7 and a 120 Hz sinusoid of amplitude 1. Corrupt the signal by adding noise. X = S + 2*randn(size(t)); Listen both signals and observe the frequency spectrum of both?

```
% Define the time vector for the signals
t = 0:1/8000:1;  % Assuming a duration of 1 second

% Form the signal S containing a 50 Hz sinusoid of amplitude 0.7 and a 120 Hz sinusoid
of amplitude 1
S = 0.7 * sin(2*pi*50*t) + sin(2*pi*120*t);

% Corrupt the signal by adding noise
X = S + 2*randn(size(t));

% Listen to the original signal S
sound(S, 8000);

% Listen to the corrupted signal X
sound(X, 8000);

% Compute the Fast Fourier Transform (FFT) of the original signal S
nfft = 1024;
SX = fft(S, nfft);
mag_SX = abs(SX);
f_SX = (0:nfft/2)*8000/nfft;

% Compute the Fast Fourier Transform (FFT) of the corrupted signal X
X = X(:);  % Ensure X is a column vector
nfft = 1024;
X_fft = fft(X, nfft);
mag_X = abs(X_fft);
f_X = (0:nfft/2)*8000/nfft;

% Plot the frequency spectrum of the original signal S
figure;
stem(f_SX, mag_SX(1:nfft/2+1));
title('Frequency Spectrum of Signal S');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```




```
% Plot the frequency spectrum of the corrupted signal X
figure;
stem(f_X, mag_X(1:nfft/2+1));
title('Frequency Spectrum of Corrupted Signal X');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```



Explanation:

In another part of the lab, I experimented with creating a signal containing multiple frequency components and then visualizing its frequency spectrum. This involved plotting the magnitude and phase spectra of the signal to observe the amplitudes and phase shifts of its frequency components.

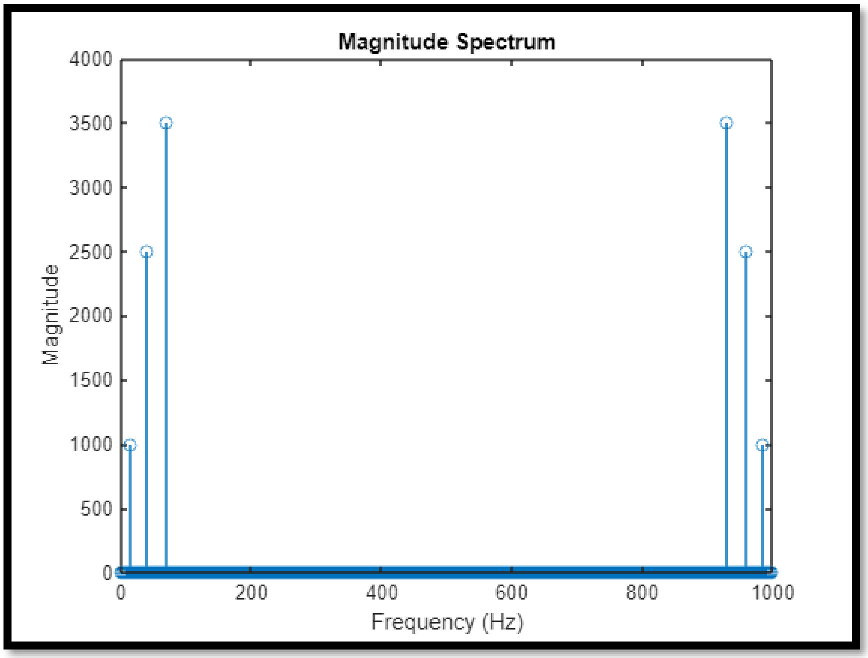
Task 4:

Find the discrete Fourier transform of the following signal (both phase and magnitude plot)?

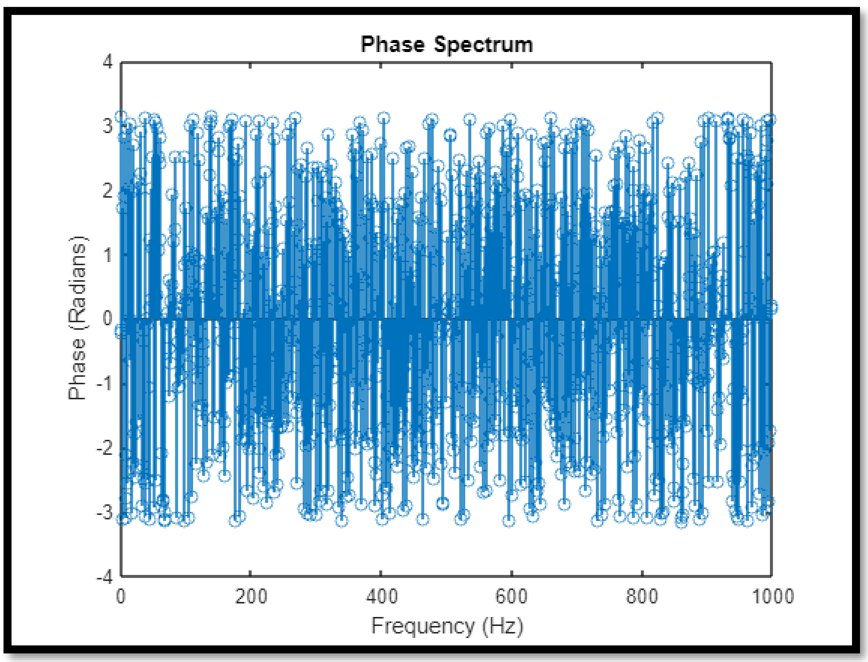
F=2cos(2*pi*15*(t)) + 5cos(2*pi*40*(t)) + 7cos(2*pi*70*(t));

Then convert Frequency domain signal into time domain signal using inverse fourier transform.

```
% Define the sampling frequency and time vector
Fs = 1000; % Sampling frequency in Hz
t = 0:1/Fs:1-1/Fs; % Time vector for 1 second

% Define the signal F
F = 2*cos(2*pi*15*t) + 5*cos(2*pi*40*t) + 7*cos(2*pi*70*t);

% Compute the DFT of the signal F
nfft = length(F); % Number of points in FFT
F_fft = fft(F, nfft); % DFT of signal F

% Compute the magnitude and phase of the DFT
mag_F_fft = abs(F_fft); % Magnitude
phase_F_fft = angle(F_fft); % Phase

% Frequency vector for plotting
f = (0:nfft-1)*Fs/nfft;

% Plot the magnitude spectrum
figure(1);
stem(f, mag_F_fft);
title('Magnitude Spectrum');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
```

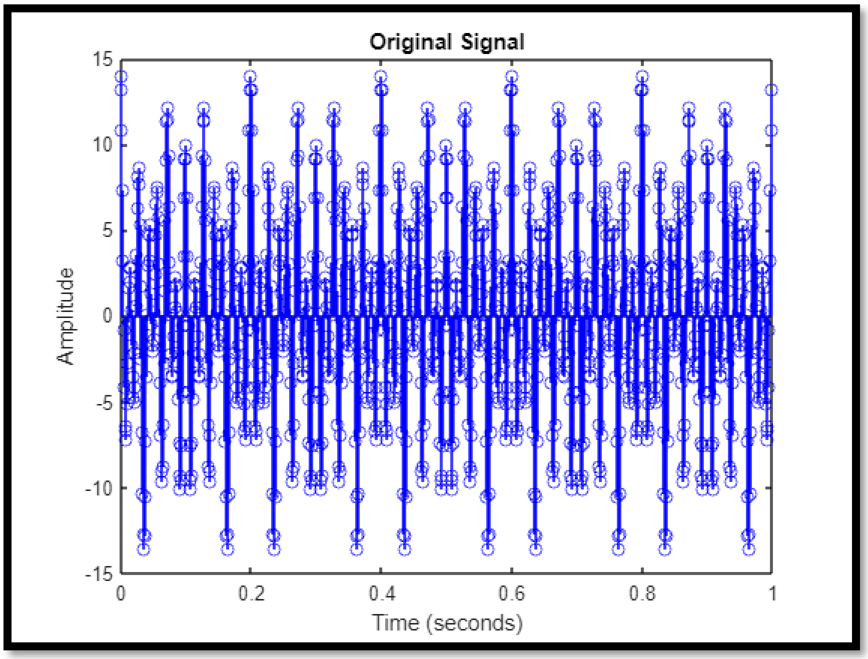



```
% Plot the phase spectrum
figure(2);
stem(f, phase_F_fft);
title('Phase Spectrum');
xlabel('Frequency (Hz)');
ylabel('Phase (Radians)');
```

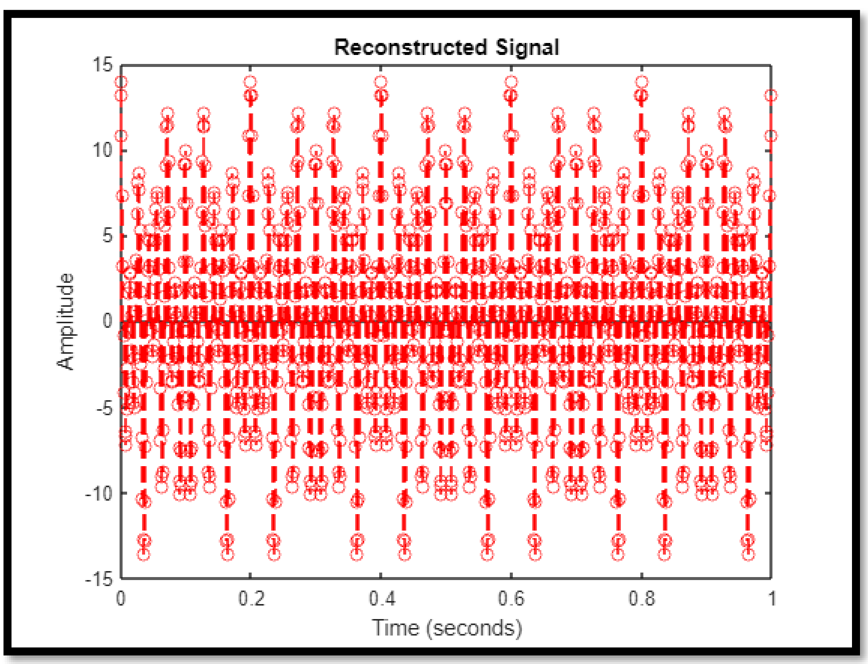



```
% Convert the frequency domain signal back to time domain using IFT
F_ift = ifft(F_fft, nfft);

% Plot the original and reconstructed signals to compare
figure(3);
```

```
stem(t, F, 'b');
title('Original Signal');
xlabel('Time (seconds)');
ylabel('Amplitude');
```




```
figure(4);
stem(t, F_ift, 'r--');
title('Reconstructed Signal');
xlabel('Time (seconds)');
ylabel('Amplitude');
```



Explanation:

In the lab, I dived into the world of Fourier transforms. These magical mathematical tools allowed me to dissect signals, revealing their hidden frequency components. First, I transformed time-domain signals into their frequency-domain counterparts, analyzing magnitudes and phases. Then, I explored the inverse Fourier transform, reconstructing original signals from their frequency components. Visualizing frequency spectra was my next feat-plotting amplitudes and phase shifts.

Conclusion:

Conclusion: Overall, the lab session provided valuable hands-on experience with Fourier transforms and their applications in digital signal processing. I gained a deeper understanding of how signals can be analyzed and manipulated in both the time and frequency domains. By performing these tasks, I developed practical skills in signal processing and gained insight into the importance of understanding the frequency content of signals for various engineering applications.