	Marwadi University Faculty of Engineering & Technology Department of Information and Communication Technology	
Subject: Programming With Python (01CT1309)	Aim: Practical based on Signal Processing using Scipy	
Experiment No: 12	Date:	Enrollment No:92510133025

]**Aim:** Practical based on Signal Processing using Scipy

IDE:

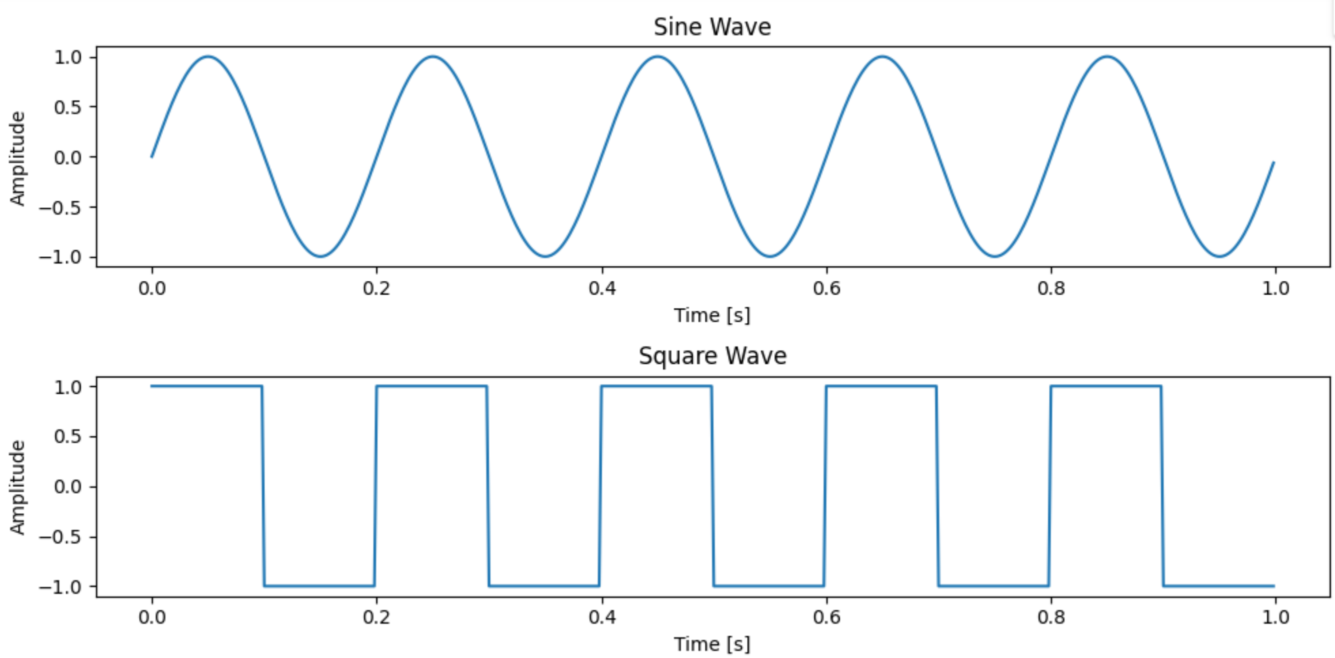
What is SciPy?

SciPy is a free and open-source Python library used for scientific computing and technical computing. It is a collection of mathematical algorithms and convenience functions built on the NumPy extension of Python. It adds significant power to the interactive Python session by providing the user with high-level commands and classes for manipulating and visualizing data. As mentioned earlier, SciPy builds on NumPy and therefore if you import SciPy, there is no need to import NumPy.

Generates a sine wave and a square wave with a frequency of 5 Hz and a sampling frequency of 500 Hz.

```
import numpy as np

import matplotlib.pyplot as plt

from scipy import signal

# Parameters

fs = 500  # Sampling frequency

f = 5  # Frequency of the signal

t = np.linspace(0, 1, fs, endpoint=False)  # Time array

# Create a sine wave signal

sine_wave = np.sin(2 * np.pi * f * t)

# Create a square wave signal using scipy

square_wave = signal.square(2 * np.pi * f * t)

# Plot the signals

plt.figure(figsize=(10, 5))

plt.subplot(2, 1, 1)
```

```
plt.plot(t, sine_wave)
plt.title('Sine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(2, 1, 2)
plt.plot(t, square_wave)
plt.title('Square Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.tight_layout()
plt.show()
```



Triangular and Ramp signal

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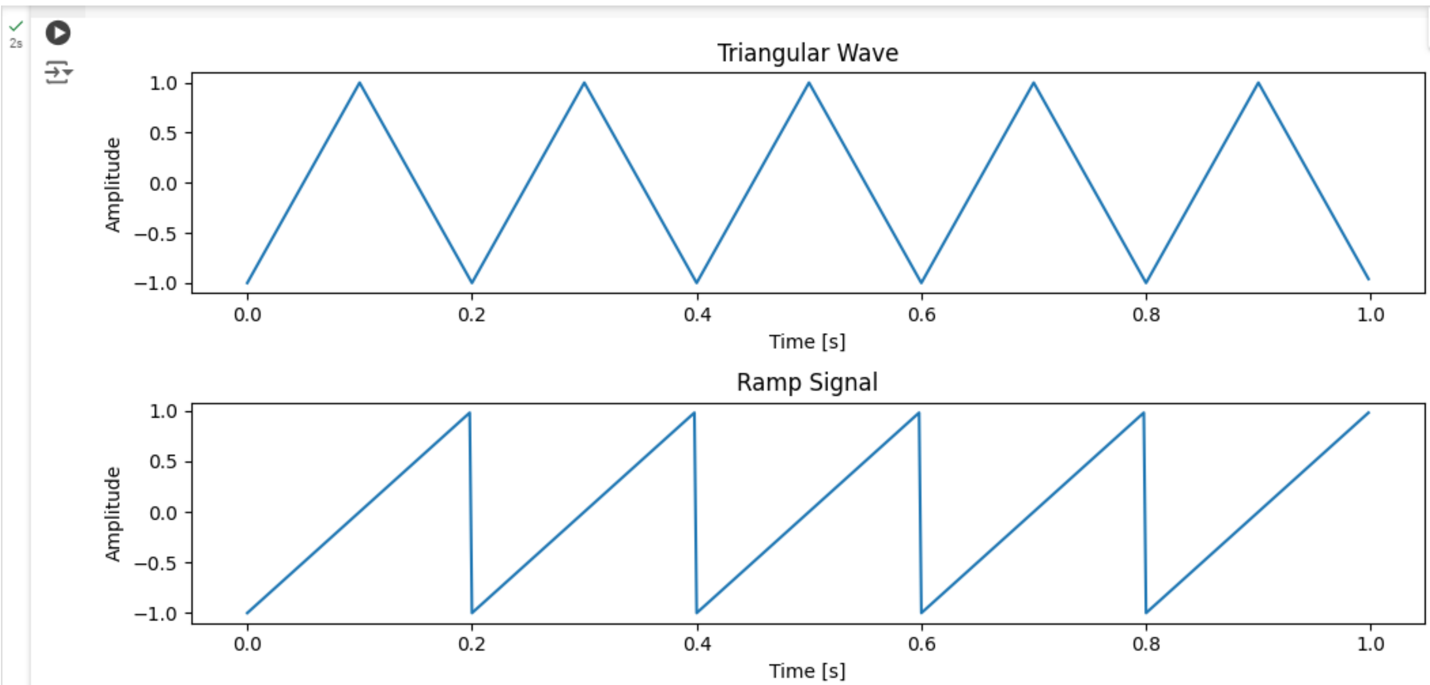
```
import numpy as np

import matplotlib.pyplot as plt

from scipy import signal

# Parameters

fs = 500  # Sampling frequency

f = 5  # Frequency of the signal

t = np.linspace(0, 1, fs, endpoint=False)  # Time array

# Create a triangular wave signal using scipy

triangular_wave = signal.sawtooth(2 * np.pi * f * t, 0.5)

# Create a ramp (sawtooth) signal using scipy

ramp_signal = signal.sawtooth(2 * np.pi * f * t)

# Plot the signals

plt.figure(figsize=(10, 5))

plt.subplot(2, 1, 1)

plt.plot(t, triangular_wave)

plt.title('Triangular Wave')

plt.xlabel('Time [s]')

plt.ylabel('Amplitude')

plt.subplot(2, 1, 2)

plt.plot(t, ramp_signal)

plt.title('Ramp Signal')

plt.xlabel('Time [s]')
```

```
plt.ylabel('Amplitude')
plt.tight_layout()
plt.show()
```



#Elementary signals

```
import numpy as np
import matplotlib.pyplot as plt
from scipy import signal
```

```
# Parameters

fs = 500  # Sampling frequency

t = np.linspace(-1, 1, fs, endpoint=False)  # Time array

# 1. Unit Step Signal

unit_step = np.heaviside(t, 1)

# 2. Unit Impulse Signal (Dirac Delta)

unit_impulse = np.zeros_like(t)

unit_impulse[fs//2] = 1  # Impulse at t=0

# 3. Ramp Signal

ramp_signal = signal.sawtooth(2 * np.pi * t, 1)

# 4. Sine Wave

f_sine = 5  # Frequency of the sine wave

sine_wave = np.sin(2 * np.pi * f_sine * t)

# 5. Cosine Wave

f_cosine = 5  # Frequency of the cosine wave

cosine_wave = np.cos(2 * np.pi * f_cosine * t)

# 6. Exponential Signal

exponential_signal = np.exp(t)

# 7. Triangular Wave

triangular_wave = signal.sawtooth(2 * np.pi * 5 * t, 0.5)

# 8. Square Wave

square_wave = signal.square(2 * np.pi * 5 * t)
```

```
# Plot the signals
plt.figure(figsize=(12, 12))
plt.subplot(4, 2, 1)
plt.plot(t, unit_step)
plt.title('Unit Step Signal')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 2)
plt.plot(t, unit_impulse)
plt.title('Unit Impulse Signal')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 3)
plt.plot(t, ramp_signal)
plt.title('Ramp Signal')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 4)
plt.plot(t, sine_wave)
plt.title('Sine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
```

```
plt.subplot(4, 2, 5)
plt.plot(t, cosine_wave)
plt.title('Cosine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 6)
plt.plot(t, exponential_signal)
plt.title('Exponential Signal')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 7)
plt.plot(t, triangular_wave)
plt.title('Triangular Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.subplot(4, 2, 8)
plt.plot(t, square_wave)
plt.title('Square Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.tight_layout()
plt.show()
```

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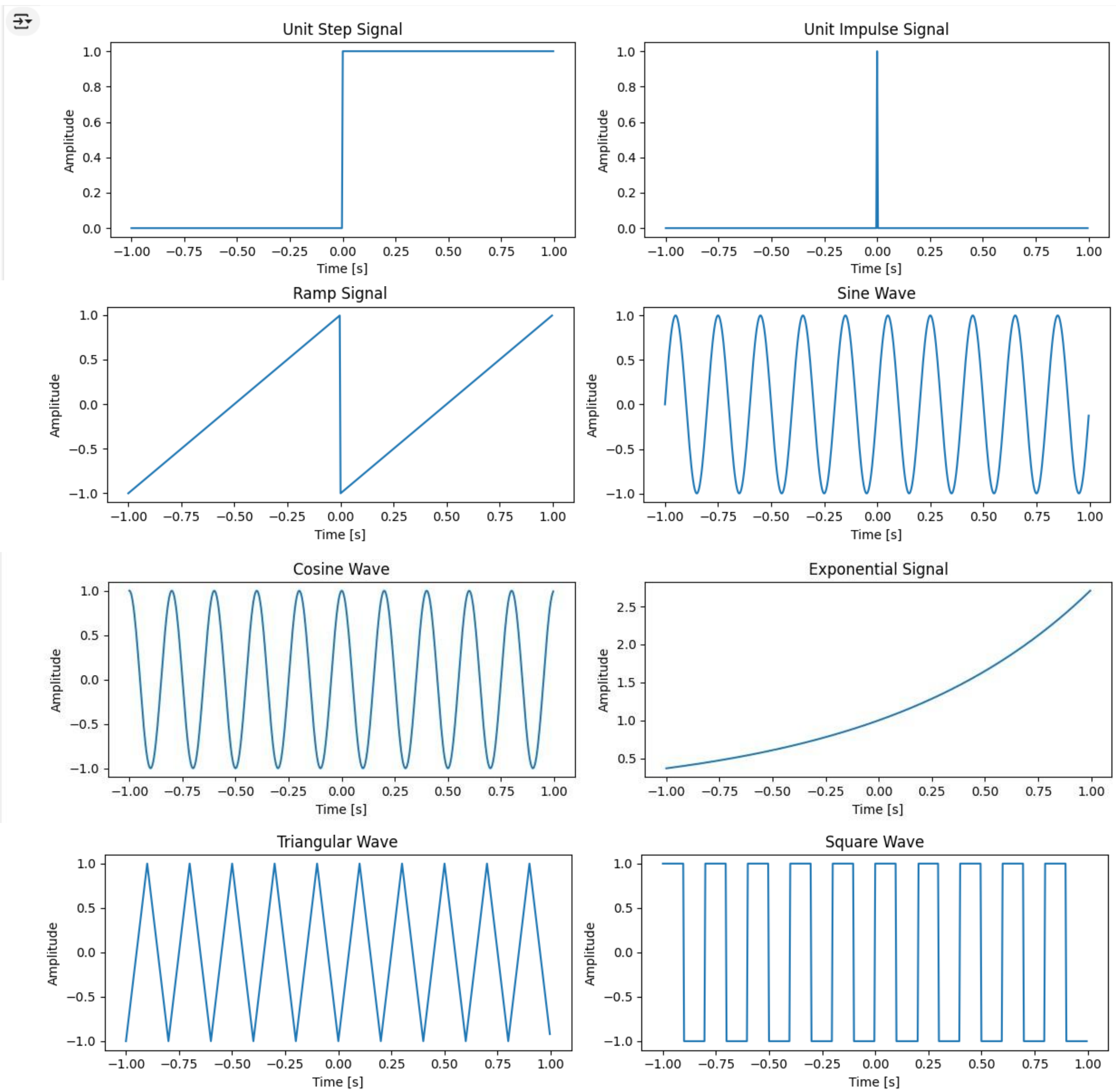


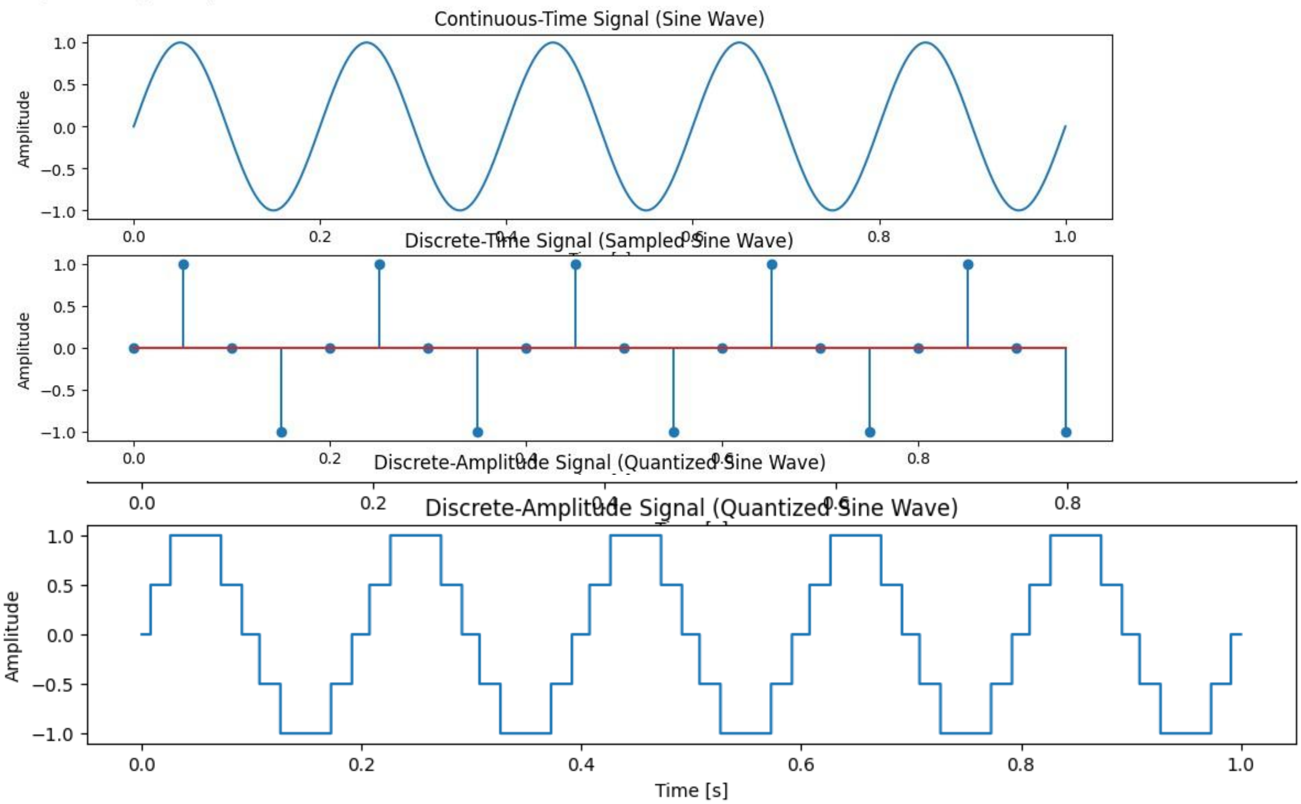
Signal Classification

```
import numpy as np

import matplotlib.pyplot as plt


# Parameters

fs = 20  # Sampling frequency for discrete-time signal

t_continuous = np.linspace(0, 1, 1000)  # Time array for continuous signals

t_discrete = np.arange(0, 1, 1/fs)  # Discrete time array


# Generate a continuous-time sine wave

f = 5  # Frequency of the signal

continuous_signal = np.sin(2 * np.pi * f * t_continuous)


# Generate a discrete-time sine wave (sampled)

discrete_time_signal = np.sin(2 * np.pi * f * t_discrete)


# Discretize the amplitude (quantization) for the continuous-time signal

num_levels = 4  # Number of quantization levels

discrete_amplitude_signal = np.round(continuous_signal * (num_levels / 2)) / (num_levels / 2)


# Discretize both time and amplitude

discrete_time_amplitude_signal = np.round(discrete_time_signal * (num_levels / 2)) / (num_levels / 2)
```

```
# Plot the signals

plt.figure(figsize=(12, 10))


# Continuous-Time Signal

plt.subplot(4, 1, 1)

plt.plot(t_continuous, continuous_signal)

plt.title('Continuous-Time Signal (Sine Wave)')

plt.xlabel('Time [s]')

plt.ylabel('Amplitude')


# Discrete-Time Signal

plt.subplot(4, 1, 2)

plt.stem(t_discrete, discrete_time_signal, use_line_collection=True)

plt.title('Discrete-Time Signal (Sampled Sine Wave)')

plt.xlabel('Time [s]')

plt.ylabel('Amplitude')


# Discrete-Amplitude Signal

plt.subplot(4, 1, 3)

plt.plot(t_continuous, discrete_amplitude_signal, drawstyle='steps-pre')

plt.title('Discrete-Amplitude Signal (Quantized Sine Wave)')

plt.xlabel('Time [s]')
```

plt.ylabel('Amplitude')

```
<ipython-input-7-d2dd2b22ace7>:35: MatplotlibDeprecationWarning: The 'use_line_collection' parameter of stem() was deprecated in Matplotlib 3.6 and will be remov
  plt.stem(t_discrete, discrete_time_signal, use_line_collection=True)
Text(0, 0.5, 'Amplitude')
```



 # Discrete signal operation

import numpy as np

import matplotlib.pyplot as plt

Parameters

n = np.arange(0, 20) # Discrete time array (0 to 19)

signal = np.sin(0.2 * np.pi * n) # Example discrete-time signal (sine wave)

Delay the signal by 3 samples

delay = 3

```
delayed_signal = np.zeros_like(signal)

delayed_signal[delay:] = signal[:-delay]

# Advance the signal by 3 samples

advance = 3

advanced_signal = np.zeros_like(signal)

advanced_signal[:-advance] = signal[advance:]

# Plot the original and shifted signals

plt.figure(figsize=(12, 8))

# Original Signal

plt.subplot(3, 1, 1)

plt.stem(n, signal, use_line_collection=True)

plt.title('Original Signal')

plt.xlabel('n (Discrete Time)')

plt.ylabel('Amplitude')

# Delayed Signal

plt.subplot(3, 1, 2)

plt.stem(n, delayed_signal, use_line_collection=True)

plt.title(f'Delayed Signal (by {delay} samples)')

plt.xlabel('n (Discrete Time)')

plt.ylabel('Amplitude')

# Advanced Signal

plt.subplot(3, 1, 3)
```

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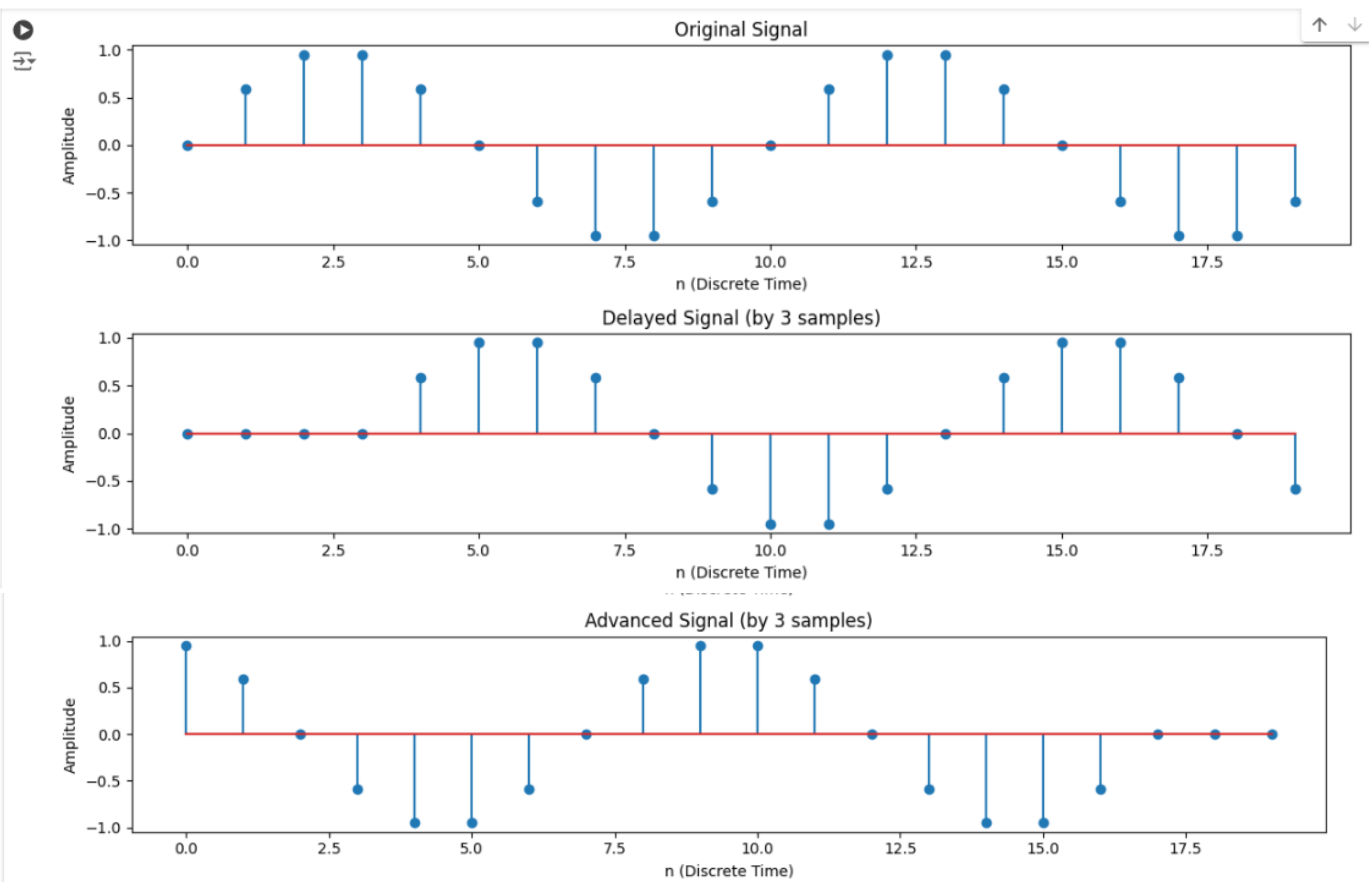
```
plt.stem(n, advanced_signal, use_line_collection=True)

plt.title(f'Advanced Signal (by {advance} samples)')

plt.xlabel('n (Discrete Time)')

plt.ylabel('Amplitude')

plt.tight_layout()

plt.show()
```



Post Lab Exercise:

a. Generate two sine wave signals with frequencies of 5 Hz and 10 Hz, both sampled at 1000 Hz for 1 second. Add the two signals together and plot the result.

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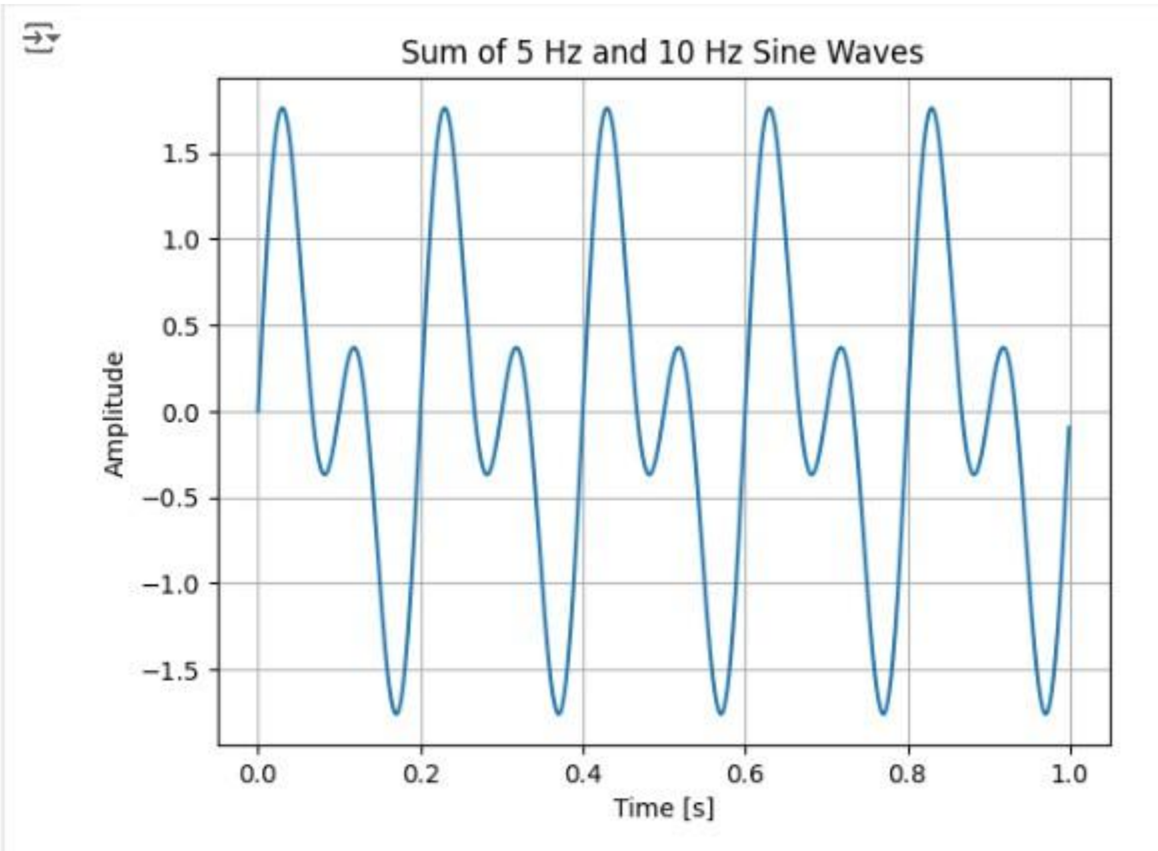
CODE:

```
import numpy as np
import matplotlib.pyplot as plt

# Parameters
fs = 1000  # Sampling frequency
t = np.arange(0, 1, 1/fs)  # Time vector for 1 second

# Sine waves
sine_5hz = np.sin(2 * np.pi * 5 * t)
sine_10hz = np.sin(2 * np.pi * 10 * t)

# Sum of sine waves
sum_sine = sine_5hz + sine_10hz

# Plotting
plt.figure()
plt.plot(t, sum_sine)
plt.title('Sum of 5 Hz and 10 Hz Sine Waves')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.grid(True)
plt.show()
```

OUTPUT:



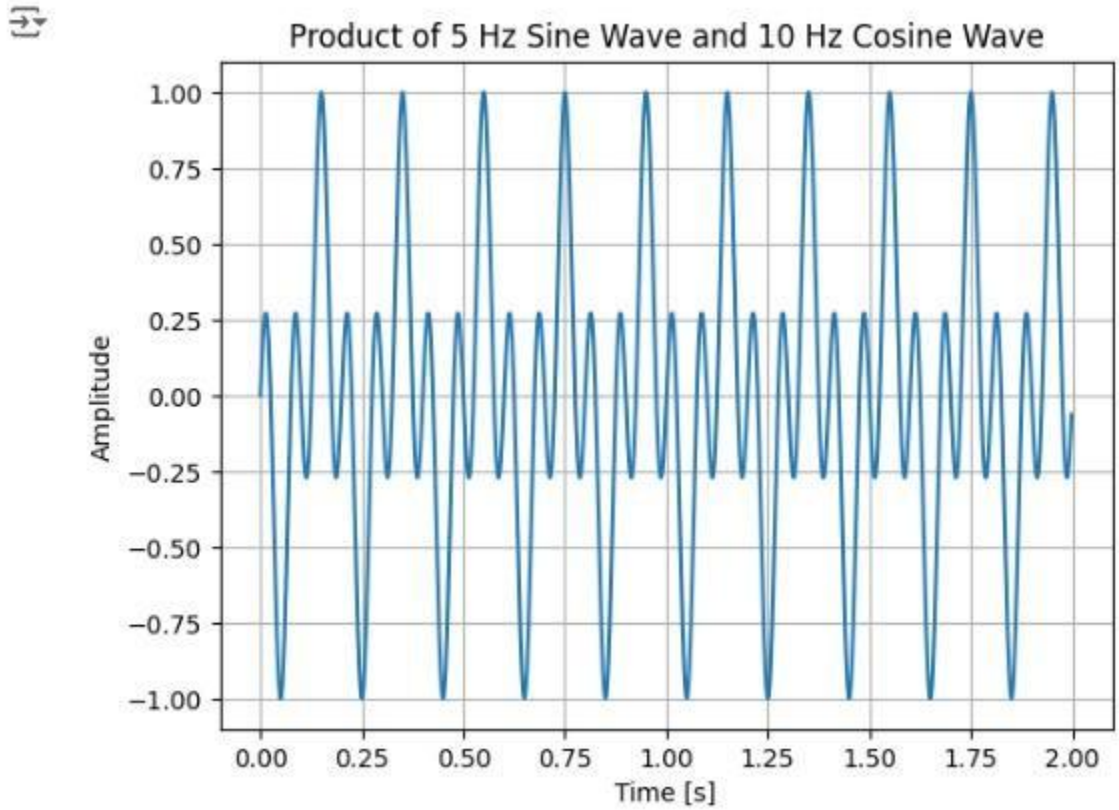
b. Generate a 5 Hz sine wave and a 10 Hz cosine wave, both sampled at 500 Hz for 2 seconds. Multiply the two signals element-wise and plot the resulting signal.

CODE:

```
# Parameters
fs = 500  # Sampling frequency
t = np.arange(0, 2, 1/fs)  # Time vector for 2 seconds

# Sine and Cosine waves
sine_5hz = np.sin(2 * np.pi * 5 * t)
cosine_10hz = np.cos(2 * np.pi * 10 * t)

# Element-wise multiplication
product = sine_5hz * cosine_10hz

# Plotting
```

```
plt.figure()
plt.plot(t, product)
plt.title('Product of 5 Hz Sine Wave and 10 Hz Cosine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.grid(True)
plt.show()
```

OUTPUT:



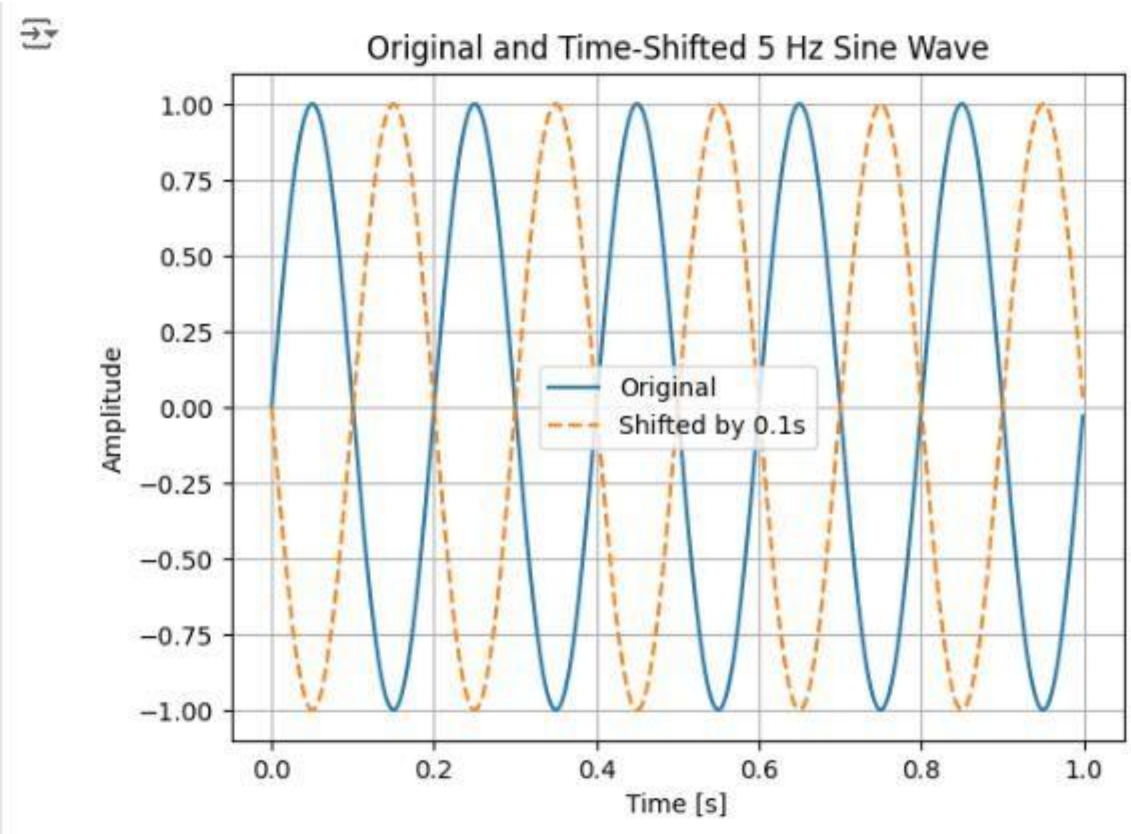
c. Generate a 5 Hz sine wave signal and shift it in time by 0.1 seconds. Plot the original and shifted signals on the same graph for comparison.

CODE:

```
# Parameters
fs = 1000  # Sampling frequency
t = np.arange(0, 1, 1/fs)  # Time vector for 1 second
```

```
# Sine wave
sine_5hz = np.sin(2 * np.pi * 5 * t)

# Time shift
shift = 0.1  # Shift by 0.1 seconds
sine_shifted = np.sin(2 * np.pi * 5 * (t - shift))

# Plotting
plt.figure()
plt.plot(t, sine_5hz, label='Original')
plt.plot(t, sine_shifted, label='Shifted by 0.1s', linestyle='--')
plt.title('Original and Time-Shifted 5 Hz Sine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)
plt.show()
```

OUTPUT:



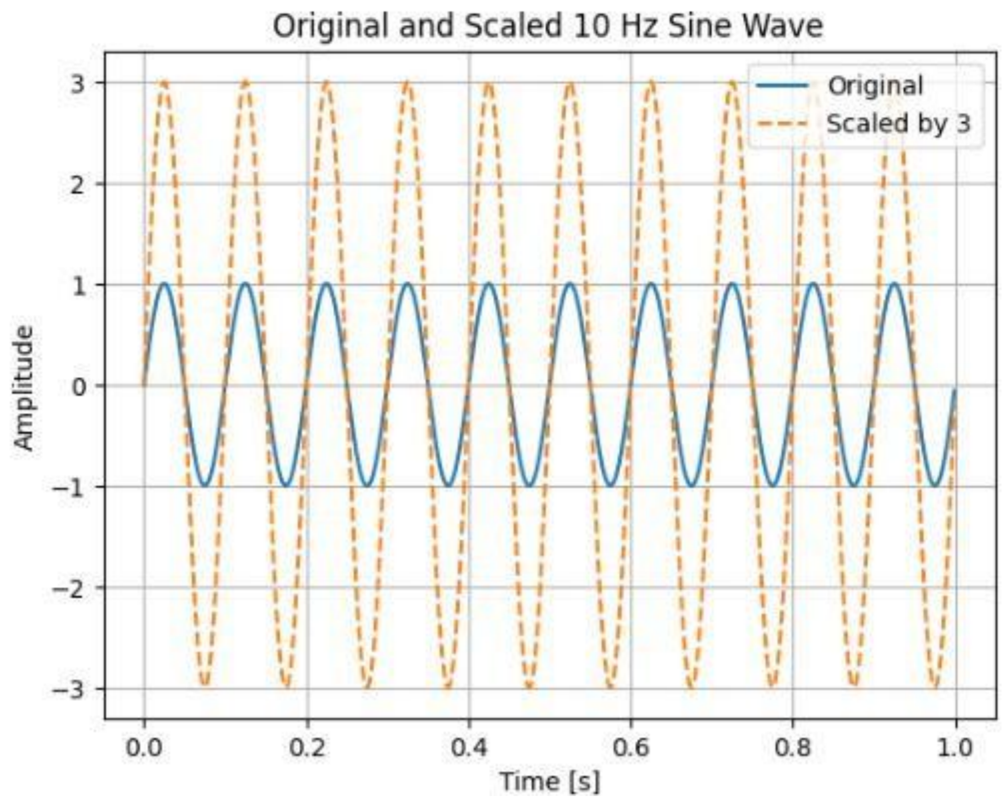
d. Generate a 10 Hz sine wave and scale its amplitude by a factor of 3. Plot the original and scaled signals together.

CODE:

```
# Parameters
fs = 1000  # Sampling frequency
t = np.arange(0, 1, 1/fs)  # Time vector for 1 second

# Sine wave
sine_10hz = np.sin(2 * np.pi * 10 * t)

# Scaled sine wave
sine_scaled = 3 * sine_10hz

# Plotting
plt.figure()
```

```
plt.plot(t, sine_10hz, label='Original')
plt.plot(t, sine_scaled, label='Scaled by 3', linestyle='--')
plt.title('Original and Scaled 10 Hz Sine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)
plt.show()
```

OUTPUT:



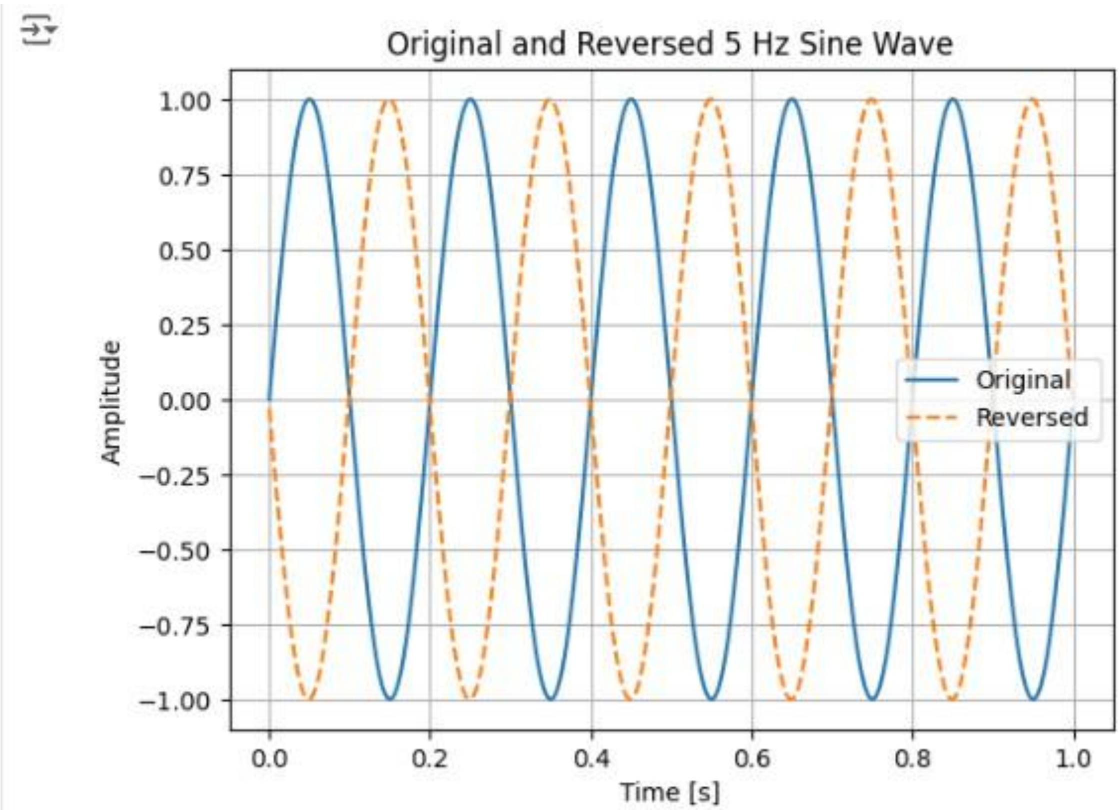
e. Generate a 5 Hz sine wave and reverse it in time. Plot the original and reversed signals on the same graph.

CODE:

```
# Parameters
fs = 1000  # Sampling frequency
t = np.arange(0, 1, 1/fs)  # Time vector for 1 second
```

```
# Sine wave
sine_5hz = np.sin(2 * np.pi * 5 * t)

# Reversed sine wave
sine_reversed = sine_5hz[::-1]

# Plotting
plt.figure()
plt.plot(t, sine_5hz, label='Original')
plt.plot(t, sine_reversed, label='Reversed', linestyle='--')
plt.title('Original and Reversed 5 Hz Sine Wave')
plt.xlabel('Time [s]')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)
plt.show()
```

OUTPUT:



Github link: https://github.com/JenishDesai5115/PWP_postlabs