Marwadi University Marwadi Chandarana Group NAAC A+	**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: 20/11/2025**	**Enrollment No: 92510133049**

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)
```

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```
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()
```

Output:

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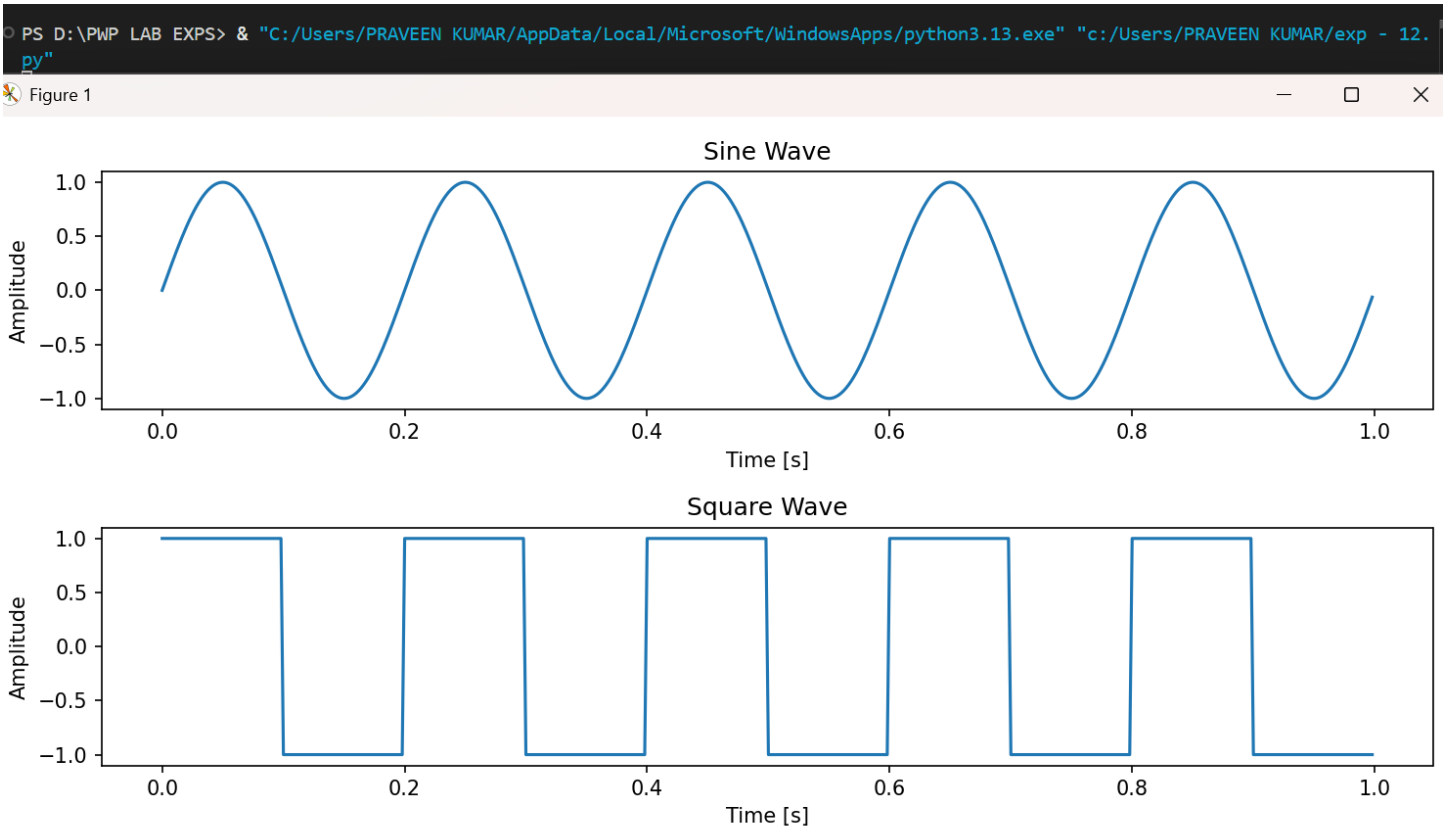

Triangular and Ramp signal

```
import numpy as np

import matplotlib.pyplot as plt

from scipy import signal

# Parameters

fs = 600  # Sampling frequency

f = 6  # Frequency of the signal

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

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```
# 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()
```

Output:

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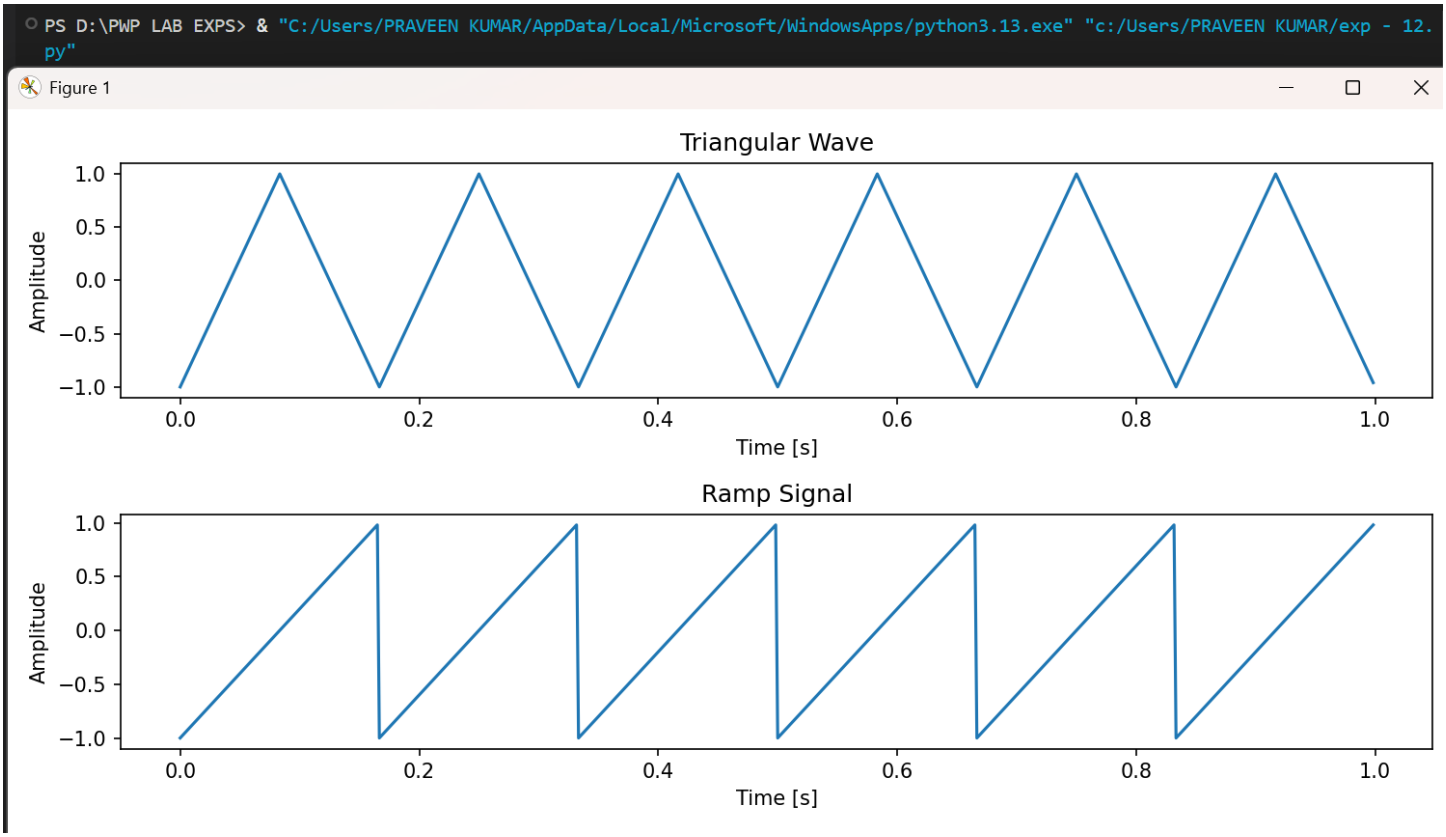

#Elementary signals

```
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)
```

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```
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)
```

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```
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()
```

Output:

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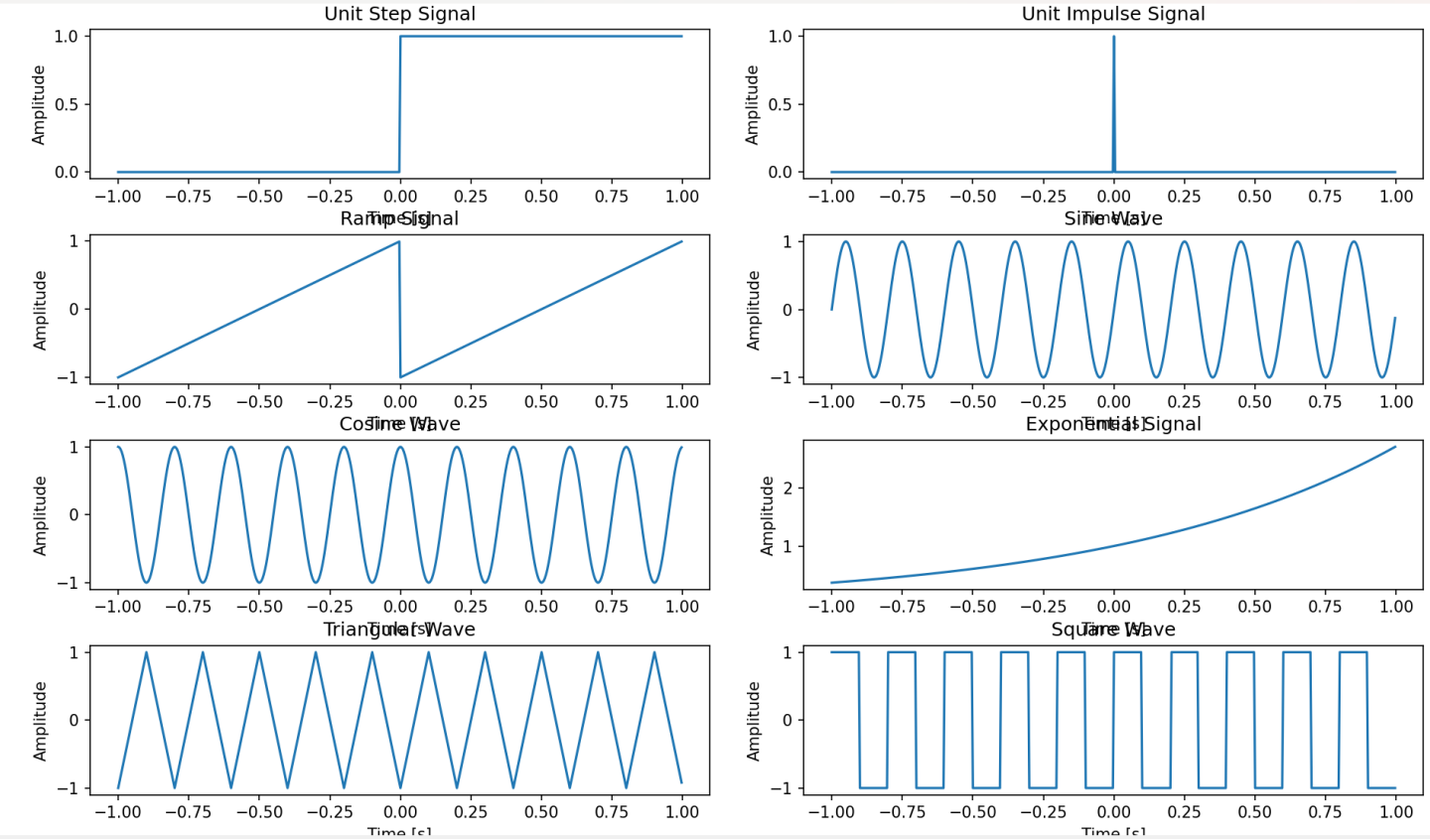

Signal Classification

```
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
```

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```
# 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')
```

 # Discrete signal operation

```
import numpy as np
import matplotlib.pyplot as plt
# Parameters
n = np.arange(0, 20)  # Discrete time array (0 to 19)
```

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```
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)')
```

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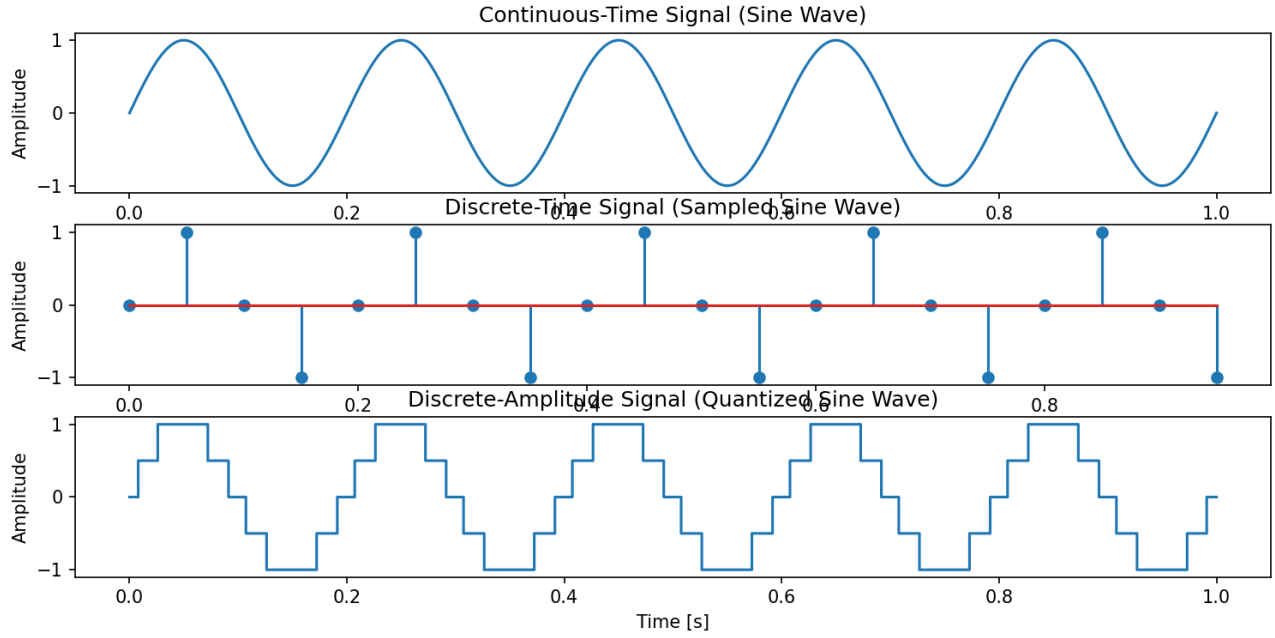
```
plt.ylabel('Amplitude')

# Advanced Signal

plt.subplot(3, 1, 3)

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()
```

Output:



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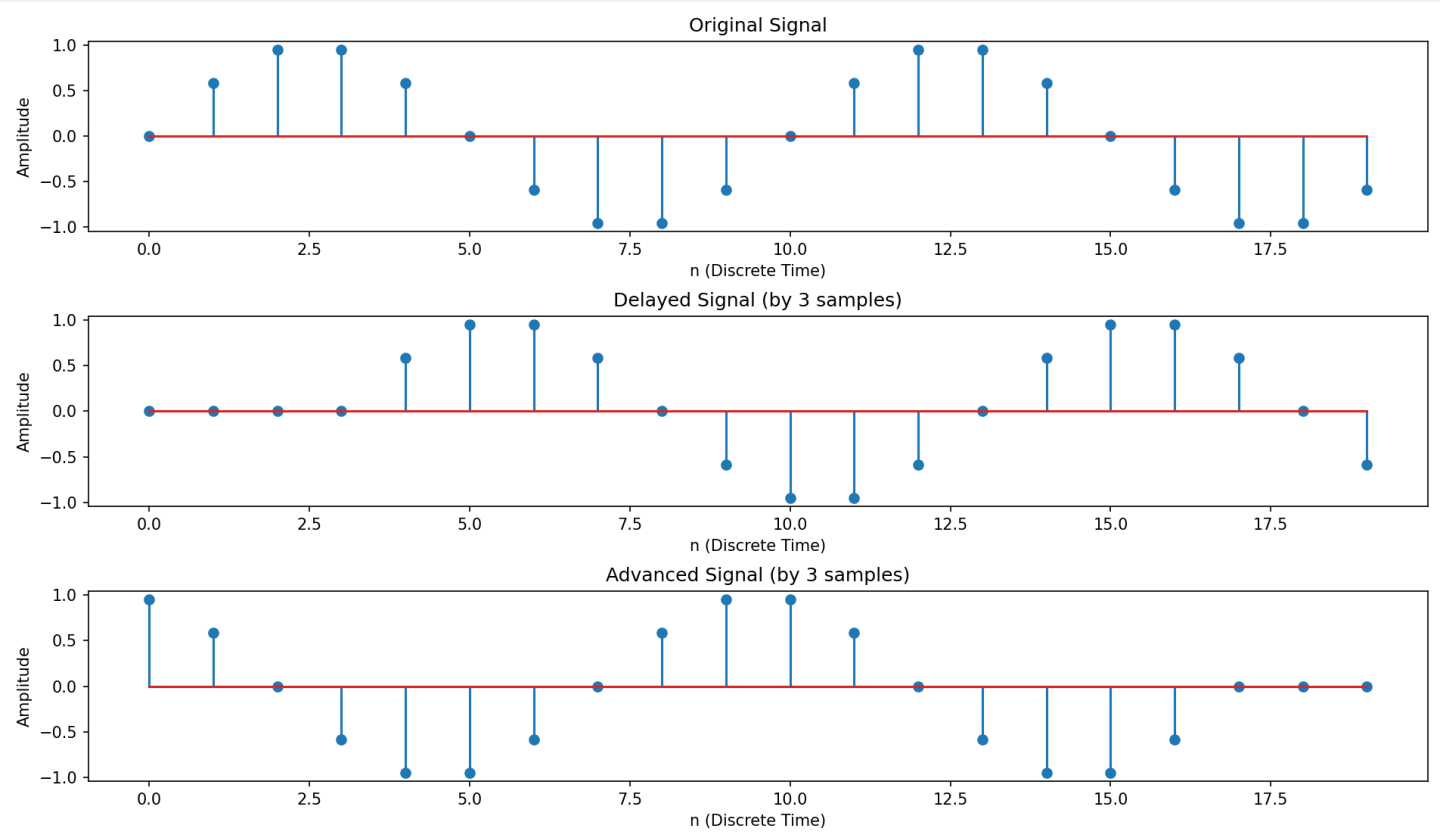

Post Lab Exercise:

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.
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.
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.
d. Generate a 10 Hz sine wave and scale its amplitude by a factor of 3. Plot the original and scaled signals together.
e. Generate a 5 Hz sine wave and reverse it in time. Plot the original and reversed signals on the same graph.

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ANSWERS

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.

C: > Users > PRAVEEN KUMAR > exp - 12.py > ...

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

# Sampling parameters
fs = 1000
t = np.linspace(0, 1, fs, endpoint=False)

# Generate sine waves
f1 = 5
f2 = 10
signal1 = np.sin(2 * np.pi * f1 * t)
signal2 = np.sin(2 * np.pi * f2 * t)

# Combine the signals
combined_signal = signal1 + signal2

# Plot the result
plt.figure(figsize=(10, 4))
plt.plot(t, combined_signal, label='Combined Signal (5 Hz + 10 Hz)', color='purple')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.title('Combined Sine Wave Signal')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

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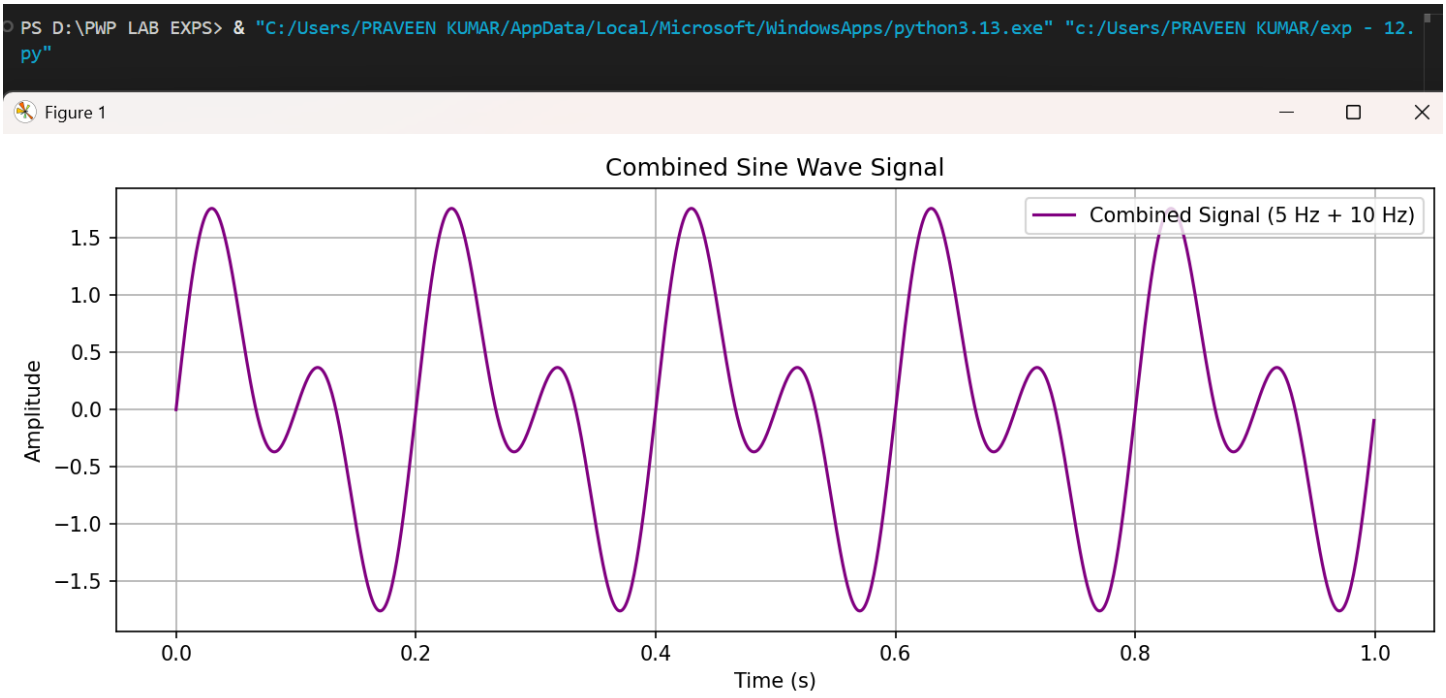
```
PS D:\PWP LAB EXPS> & "C:/Users/PRAVEEN KUMAR/AppData/Local/Microsoft/WindowsApps/python3.13.exe" "c:/Users/PRAVEEN KUMAR/exp - 12.
py"
```



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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.

C: > Users > PRAVEEN KUMAR > exp - 12.py > ...

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

# Sampling parameters
fs = 500
duration = 2
t = np.linspace(0, duration, int(fs * duration), endpoint=False)

# Generate signals
sine_wave = np.sin(2 * np.pi * 5 * t)
cosine_wave = np.cos(2 * np.pi * 10 * t)

# Element-wise multiplication
product_signal = sine_wave * cosine_wave

# Plot the result
plt.figure(figsize=(10, 4))
plt.plot(t, product_signal, label='Sine(5 Hz) × Cosine(10 Hz)', color='teal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.title('Element-wise Multiplication of Sine and Cosine Waves')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

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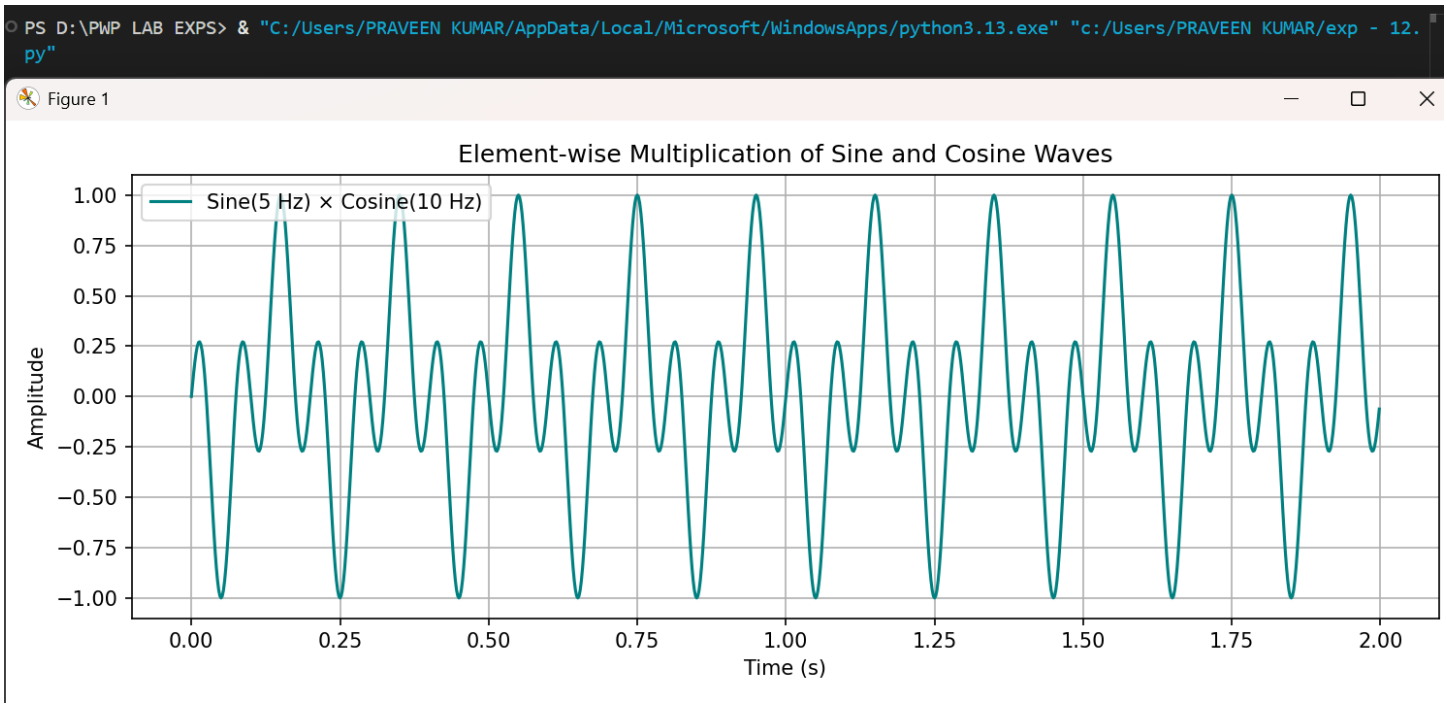
```
PS D:\PWP LAB EXPS> & "C:/Users/PRAVEEN KUMAR/AppData/Local/Microsoft/WindowsApps/python3.13.exe" "c:/Users/PRAVEEN KUMAR/exp - 12.py"
```



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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.

C: > Users > PRAVEEN KUMAR > exp - 12.py > ...

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

# Sampling parameters
fs = 1000
duration = 1
t = np.linspace(0, duration, int(fs * duration), endpoint=False)

# Original 5 Hz sine wave
original_signal = np.sin(2 * np.pi * 5 * t)

# Time-shifted signal by 0.1 seconds
shifted_signal = np.sin(2 * np.pi * 5 * (t - 0.1))

# Plot both signals
plt.figure(figsize=(10, 4))
plt.plot(t, original_signal, label='Original Signal', color='blue')
plt.plot(t, shifted_signal, label='Shifted Signal (0.1s)', color='orange', linestyle='--')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.title('Original vs. Time-Shifted 5 Hz Sine Wave')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

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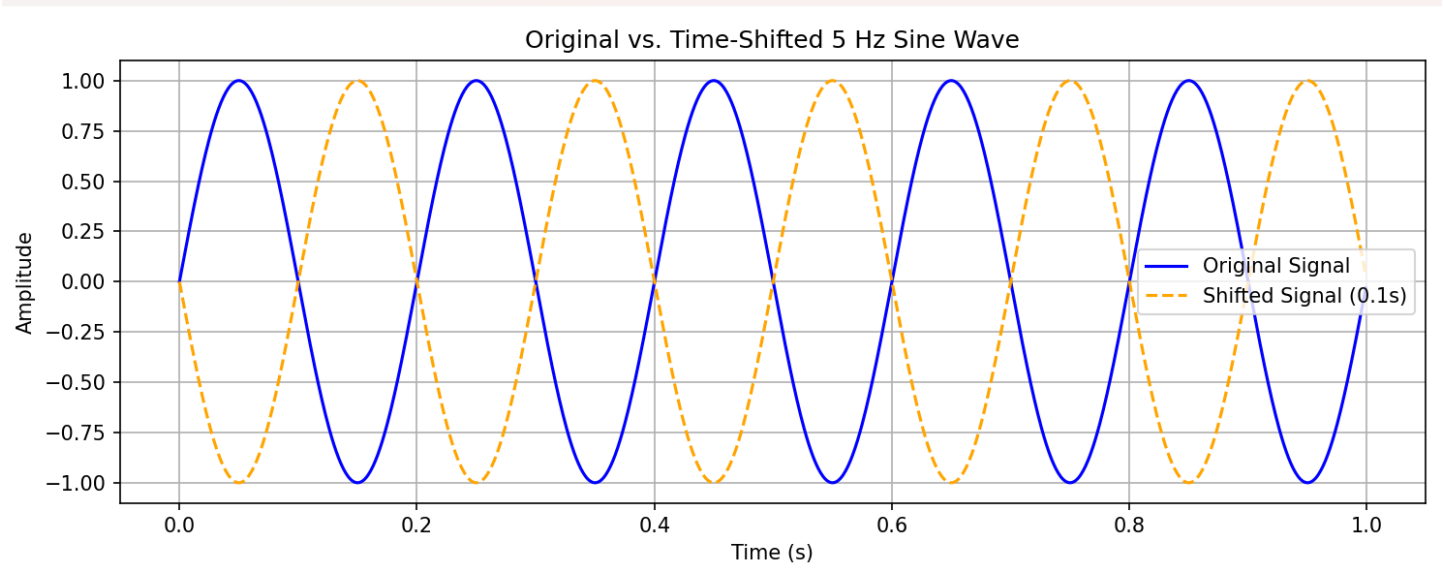
```
PS D:\PWP LAB EXPS> & "C:/Users/PRAVEEN KUMAR/AppData/Local/Microsoft/WindowsApps/python3.13.exe" "c:/Users/PRAVEEN KUMAR/exp - 12.py"
```



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

C: > Users > PRAVEEN KUMAR > exp - 12.py > ...

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

# Sampling parameters
fs = 1000
duration = 1
t = np.linspace(0, duration, int(fs * duration), endpoint=False)

# Original 10 Hz sine wave
original_signal = np.sin(2 * np.pi * 10 * t)

# Scaled signal (amplitude × 3)
scaled_signal = 3 * original_signal

# Plot both signals
plt.figure(figsize=(10, 4))
plt.plot(t, original_signal, label='Original Signal (10 Hz)', color='blue')
plt.plot(t, scaled_signal, label='Scaled Signal (×3)', color='red', linestyle='--')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.title('Original vs. Scaled 10 Hz Sine Wave')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

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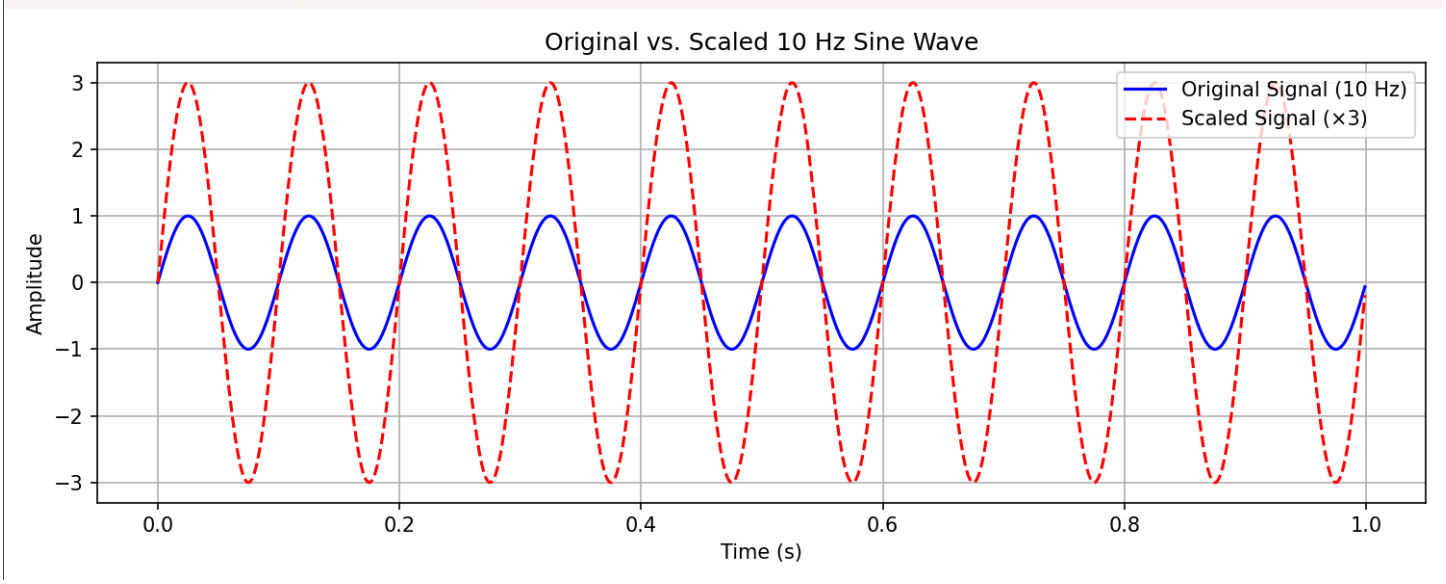
```
PS D:\PWP LAB EXPS> & "C:/Users/PRAVEEN KUMAR/AppData/Local/Microsoft/WindowsApps/python3.13.exe" "c:/Users/PRAVEEN KUMAR/exp - 12.py"
```



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

C: > Users > PRAVEEN KUMAR > exp - 12.py > ...

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

# Sampling parameters
fs = 1000
duration = 1
t = np.linspace(0, duration, int(fs * duration), endpoint=False)

# Original 5 Hz sine wave
original_signal = np.sin(2 * np.pi * 5 * t)

# Time-reversed signal
reversed_signal = original_signal[::-1]
t_reversed = t

# Plot both signals
plt.figure(figsize=(10, 4))
plt.plot(t, original_signal, label='Original Signal', color='blue')
plt.plot(t_reversed, reversed_signal, label='Reversed Signal', color='green', linestyle='--')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.title('Original vs. Time-Reversed 5 Hz Sine Wave')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

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```
PS D:\PWP LAB EXPS> & "C:/Users/PRAVEEN KUMAR/AppData/Local/Microsoft/WindowsApps/python3.13.exe" "c:/Users/PRAVEEN KUMAR/exp - 12.py"
```