Experiment 1

Title: Generate and plot the following signals in time domain and also sketch its amplitude and phase spectrum. Verify the result:

a) Impulse
b) Unit Step
c) Exponential
d) Unit ramp
e) Sinc
f) Rectangular

Learning Objectives

i) To understand basic standard signals
ii) To have hands on simulation using python language

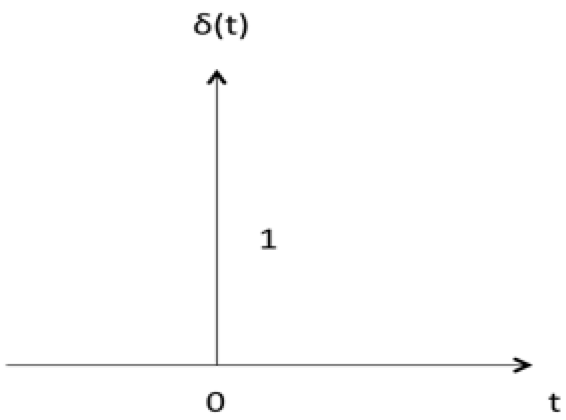
Prerequisites

i) Basic understanding of mathematics
ii) Basic understanding of Python language

Theory

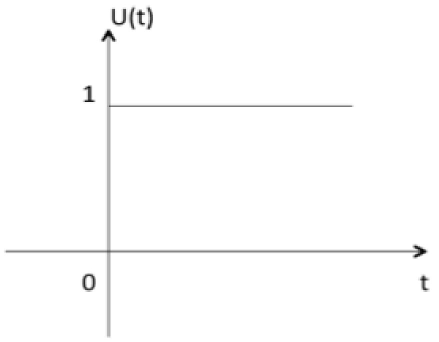
A. Unit Impulse Function

Impulse function is denoted by δ(t). and it is defined as $\delta(t) = \begin{cases} 1 & t = 0 \\ 0 & t \neq 0 \end{cases}$



B. Unit Step Function

Unit step function is denoted by u(t). It is defined as u(t) = $\begin{cases} \mathbf{1} & \boldsymbol{t \geqslant 0} \\ \mathbf{0} & \boldsymbol{t < 0} \end{cases}$

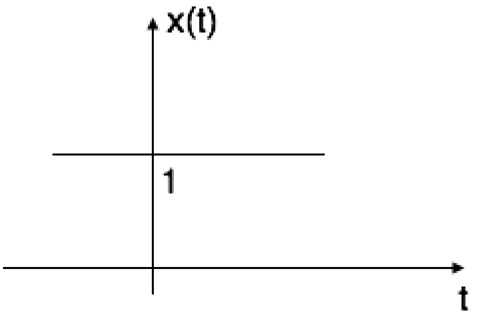


- It is used as best test signal.
- Area under unit step function is unity.

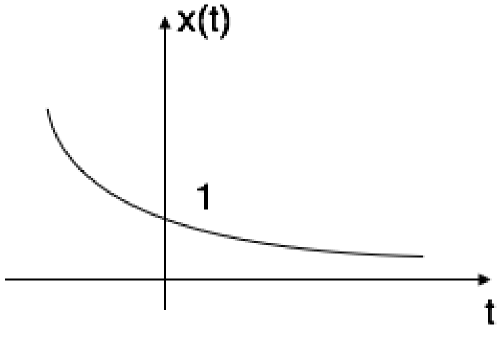
C. Exponential Signal

Exponential signal is in the form of x(t) = $e^{-\alpha t}$
The shape of exponential can be defined by α

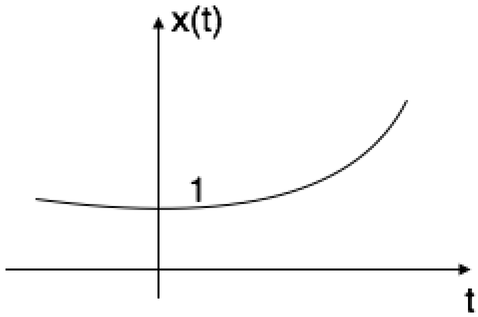
Case i: **if α = 0 → x(t) = e^{0} = 1**



Case ii: **if α < 0 i.e. -ve then x(t) =$e^{-\alpha t}$. The shape is called decaying exponential.**

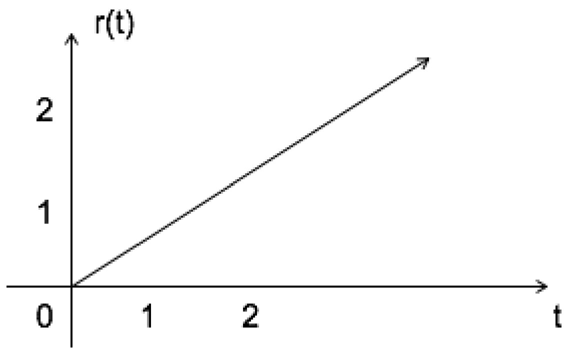


Case iii: **if α > 0 i.e. +ve then x(t) = $e^{-\alpha t}$. The shape is called raising exponential.**



D. Ramp Signal

Ramp signal is denoted by r(t), and it is defined as r(t) = $\begin{cases} t & t \geqslant 0 \\ 0 & t < 0 \end{cases}$

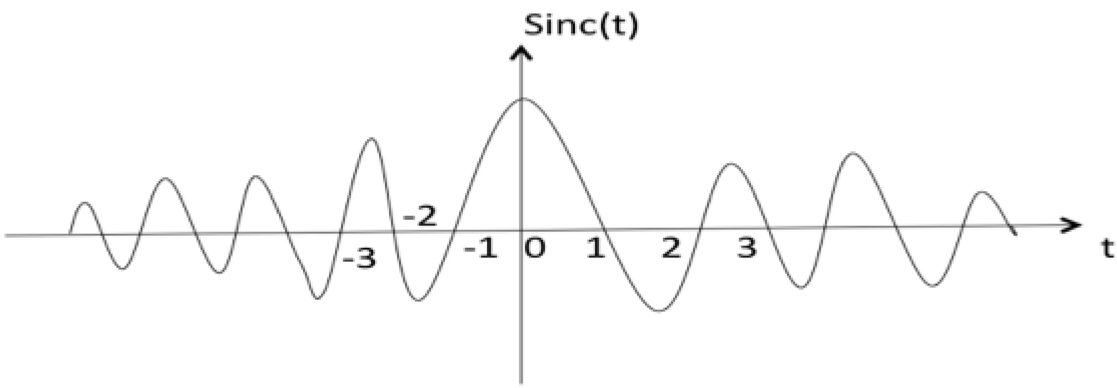


E. Sinc Function

It is denoted as sinc(t) and it is defined as

$$\textbf{sinc(t)} = \frac{\boldsymbol{sin\pi t}}{\boldsymbol{\pi t}}$$

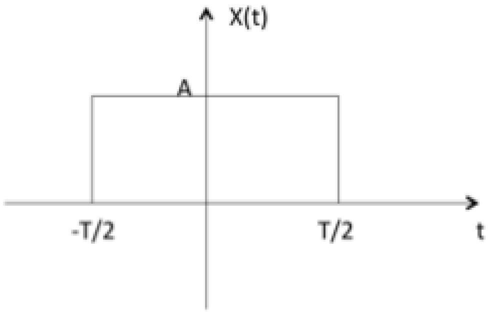
= 0 for t=±1, ±2, ±3...

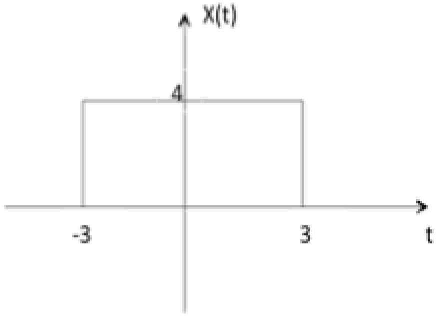


F. Rectangular Signal

Let it be denoted as x(t) and it is defined as

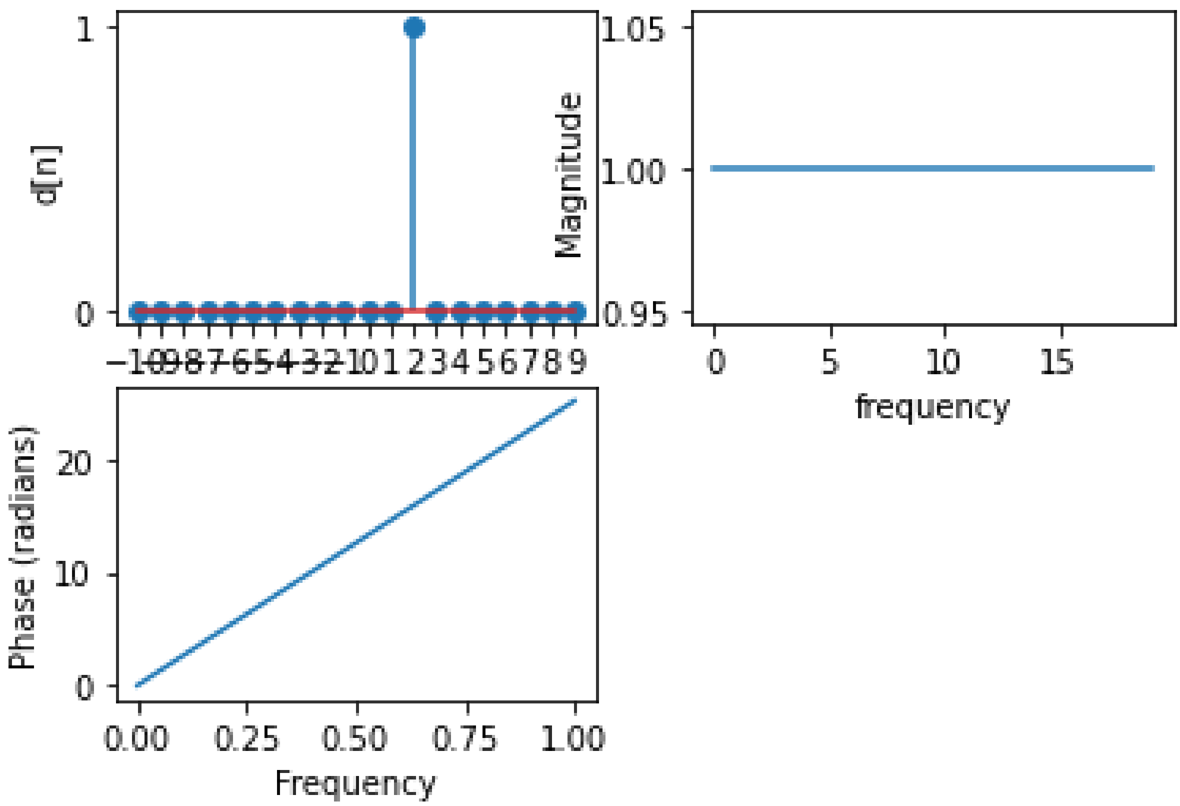
$$x(t) = A\, rect\left[\frac{r}{T}\right] \qquad \text{ex: } 4\, rect\left[\frac{r}{6}\right]$$





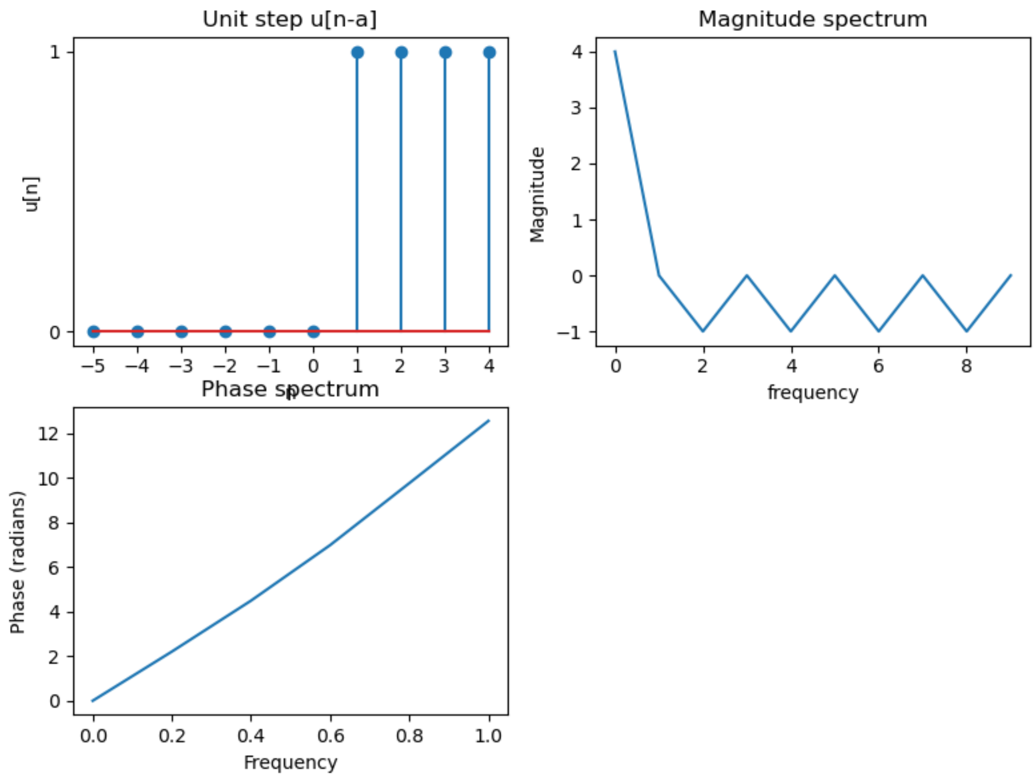
Simulation Code

A. Impulse Function



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

# Function to plot Impulse signal d(a)
def unit_impulse(a, n):
    delta = []
    for sample in n:
        if sample == a:
            delta.append(1)
        else:
            delta.append(0)

    return delta

a = 2 # Enter delay or advance
UL = 10
LL = -10
n = np.arange(LL, UL, 1)
d = unit_impulse(a, n)

#calculating amplitude spectrum usinf fft
y = np.fft.fft(d)

Y_mag = abs(y)   #this gives magnitude of spectrum

plt.subplot(2,2,1)
plt.stem(n, d)
plt.xlabel('n')
plt.xticks(np.arange(LL, UL, 1))
plt.yticks([0, 1])
plt.ylabel('d[n]')

plt.subplot(2,2,2)
plt.xlabel('frequency')
plt.ylabel('Magnitude')
plt.plot(Y_mag)

plt.subplot(2,2,3)
plt.phase_spectrum(d) # this shows phase of signal

plt.show()
```

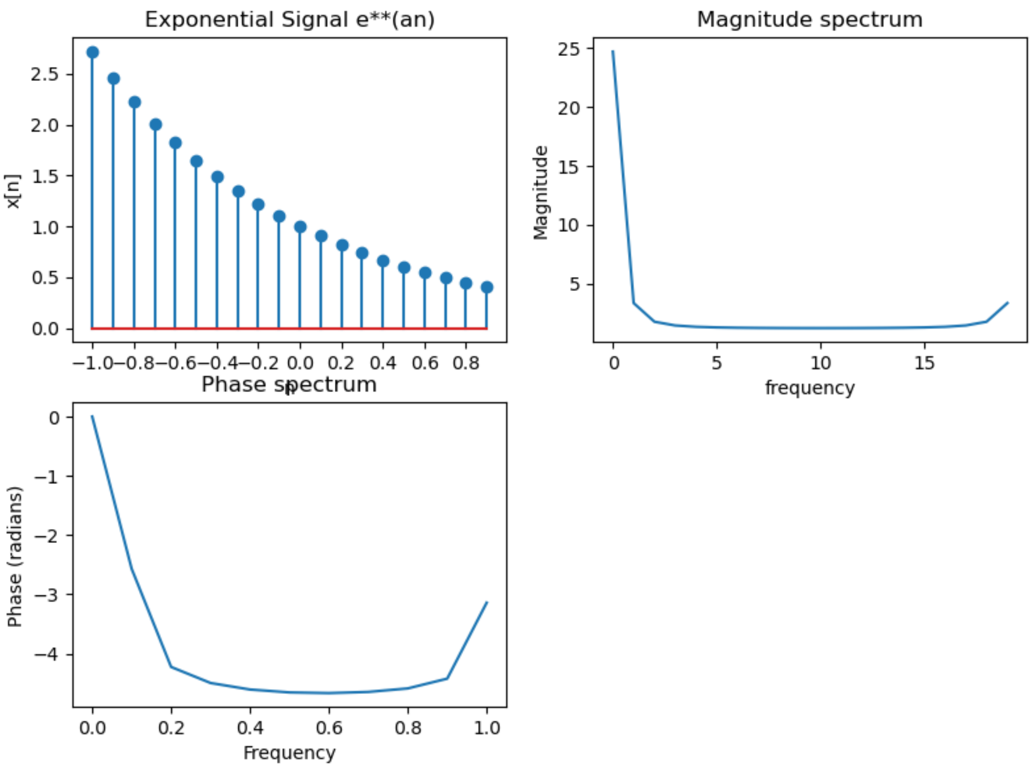
B. Unit Step




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

# function to generate unit step u[n-a]
# LL and UL are lower and upper limits of discrete time line
def unit_step(a, n):
    unit =[]
    for sample in n:
        if sample<a:
            unit.append(0)

        else:
            unit.append(1)
    return(unit)

# plot unit step function u[n-a]
a = 1 # Enter delay or advance
UL = 5
LL = -5
n = np.arange(LL, UL, 1)
unit = unit_step(a, n)

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

```
plt.stem(n, unit)
plt.xlabel('n')
plt.xticks(np.arange(LL, UL, 1))
plt.yticks([0, 1])
plt.ylabel('u[n]')
plt.title('Unit step u[n-a]')

y = np.fft.fft(unit)
plt.subplot(2,2,2)
plt.xlabel('frequency')
plt.ylabel('Magnitude')
plt.plot(y)
plt.title('Magnitude spectrum')

plt.subplot(2,2,3)
plt.phase_spectrum(unit)
plt.title('Phase spectrum')

plt.show()
```

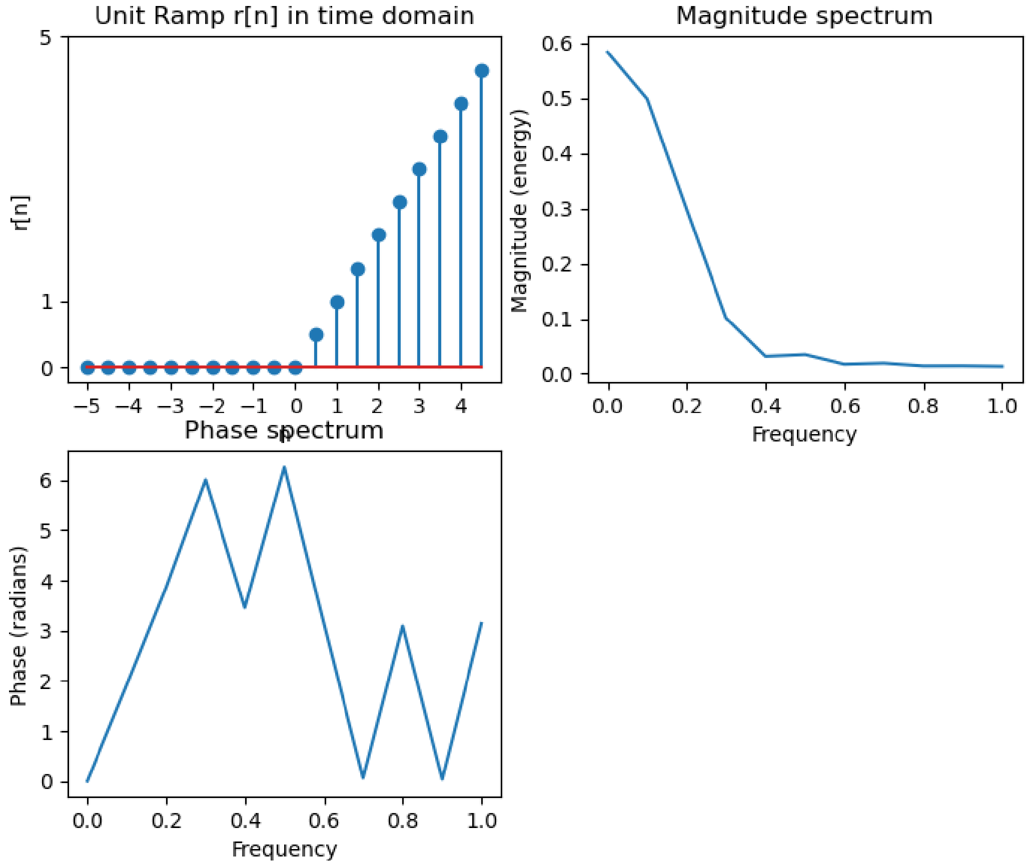
C. Exponential




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

sample=[]
a = -1
UL = 1
```

```
LL = -1
n = np.arange(LL, UL, 0.1)
N=-n
# Function to generate exponential signals e**(at)
def exponential(a, N):
    expo =[]
    for sample in n:
        expo.append(np.exp( a*sample))
    return (expo)

x = exponential(a, n)

plt.subplot(2,2,1)
plt.stem(n, x)
plt.xlabel('n')
plt.xticks(np.arange(LL, UL, 0.2))
plt.ylabel('x[n]')
plt.title('Exponential Signal e**(an)')

y = np.fft.fft(x)
plt.subplot(2,2,2)
plt.xlabel('frequency')
plt.ylabel('Magnitude')
plt.plot(y)
plt.title('Magnitude spectrum')

plt.subplot(2,2,3)
plt.phase_spectrum(x)
plt.title('Phase spectrum')

plt.show()
```

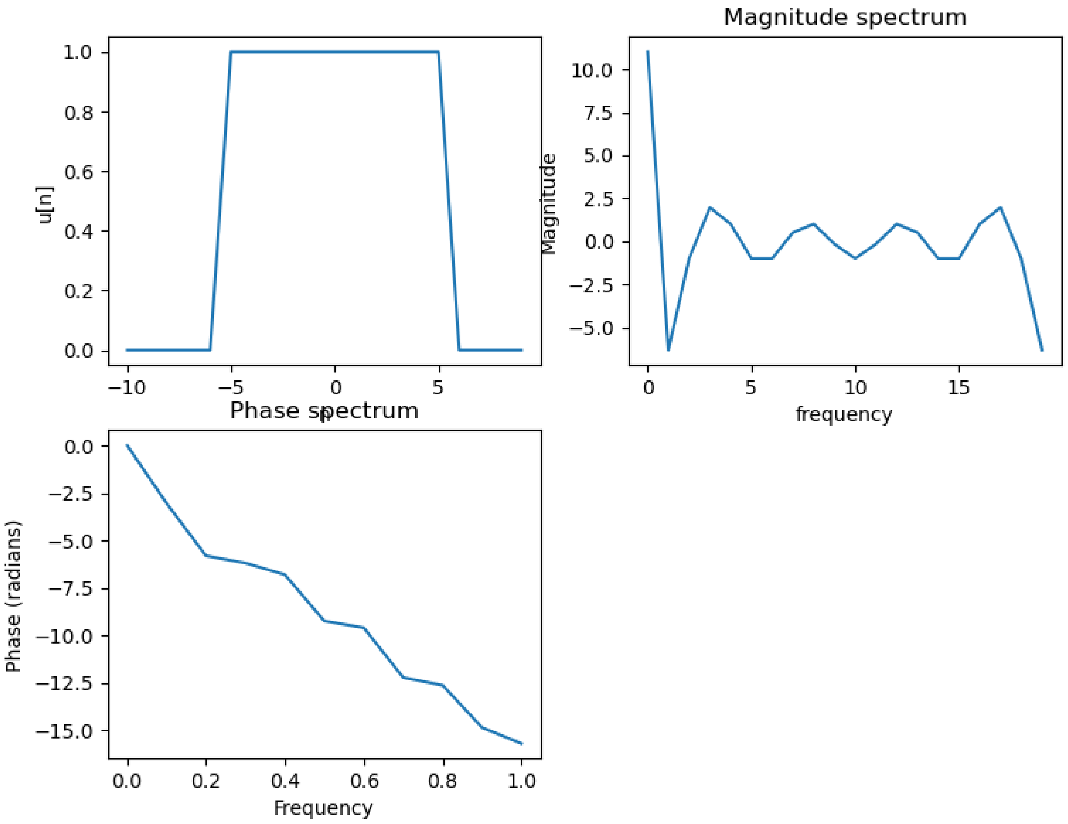
D. Unit Ramp




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

# Function to generate unit ramp signal r(n)
# r(n)= n for n>= 0, r(n)= 0 otherwise
def unit_ramp(n):
    ramp =[]
    for sample in n:
        if sample<0:
            ramp.append(0)
        else:
            ramp.append(sample)
    return ramp

UL = 5
LL = -5
n = np.arange(LL, UL, 0.5)
r = unit_ramp(n)

plt.subplot(2,2,1)
plt.stem(n, r)
plt.xlabel('n')
```

```
plt.xticks(np.arange(LL, UL, 1))
plt.yticks([0, UL, 1])
plt.ylabel('r[n]')
plt.title('Unit Ramp r[n] in time domain')

plt.subplot(2,2,2)
plt.xlabel('frequency')
plt.ylabel('Magnitude')
plt.magnitude_spectrum(r)
plt.title('Magnitude spectrum')

plt.subplot(2,2,3)
plt.phase_spectrum(r)
plt.title('Phase spectrum')

plt.show()
```

E. Rectangular



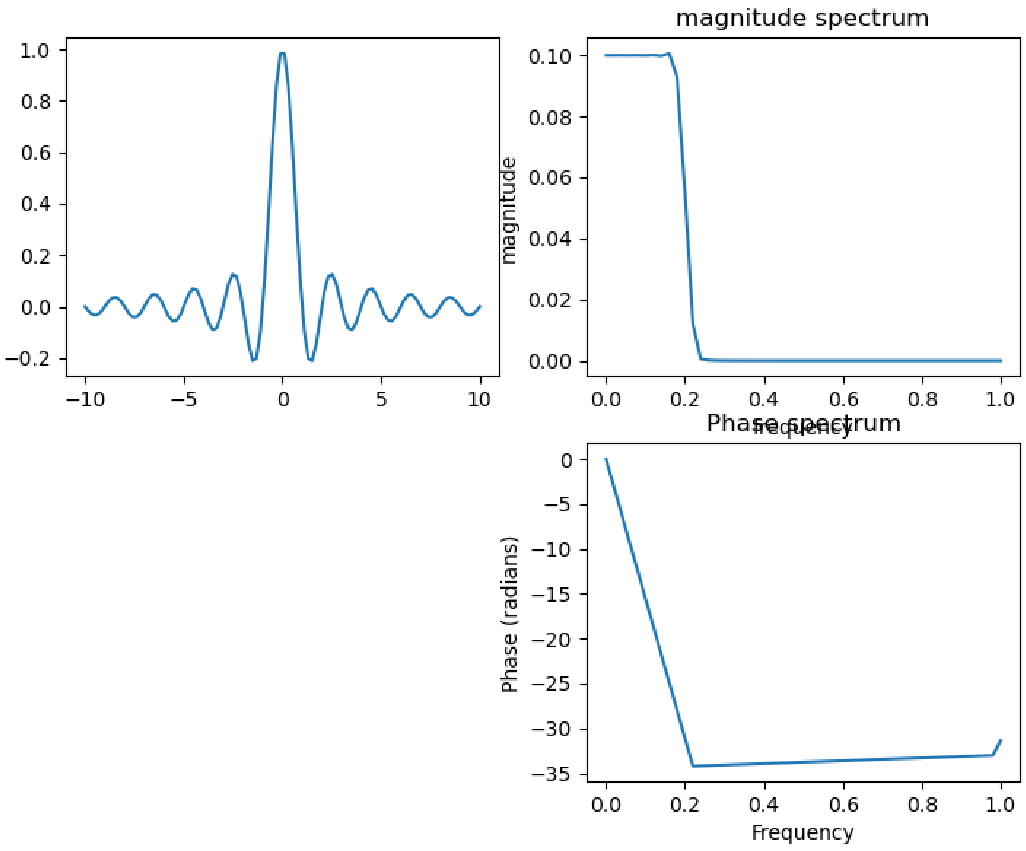

```
import numpy as np
import matplotlib.pyplot as plt

# LL and UL are lower and upper limits of discrete time line
```

```
def rect_angular(a, T):
    mag =[]
    UL = T + 5
    LL = (-T) - 5
    n = np.arange(LL, UL, 1)
    for sample in n:
        if (sample >= (-T)) and (sample <= T):
            mag.append(a)

        else:
            mag.append(0)
    return(mag, n)

a = 1 # Amplitude
T = 5 # Time period

rect, n = rect_angular(a, T)   # calling rect angular fun

plt.subplot(2,2,1)
plt.plot(n, rect)
plt.xlabel('n')
plt.ylabel('u[n]')
plt.title('')

y = np.fft.fft(rect)
plt.subplot(2,2,2)
plt.xlabel('frequency')
plt.ylabel('Magnitude')
plt.plot(y)
plt.title('Magnitude spectrum')

plt.subplot(2,2,3)
plt.phase_spectrum(rect)
plt.title('Phase spectrum')

plt.show()
```

F. Sinc

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

Fs = 10
x = np.linspace(-Fs, Fs, 100)

y = np.sinc(x)

plt.subplot(2,2,1)
plt.plot(x, y)

plt.subplot(2,2,2)
plt.magnitude_spectrum(y)
plt.xlabel('frequency')
plt.ylabel('magnitude')
```

```
plt.title('magnitude spectrum')

plt.subplot(2,2,4)
plt.phase_spectrum(y)
plt.title('Phase spectrum')

plt.show()
```



Assignment

Task1: Write description for codes of 2 signals
Task2: Vary the parameters of the signals and observe the magnitude and phase spectrum