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<<< Only Problem 1, 4 and 9 will be graded >>>

In [ ]:
```
import matplotlib.pyplot as plt
%matplotlib inline
plt.style.use('seaborn-v0_8-darkgrid')

import numpy as np
import IPython.display as ipd
import os
from scipy import signal,fftpack
from skimage.io import imread
import cv2
```

Problem 1

Sketch the following signals

1. $x(t) = \sin\left(\frac{\pi}{4}t + 20^\circ\right)$

2. $$x(t) = \begin{cases} t+2, t \leq -2 \\ 0, -2 \leq t \leq 2 \\ t-2, t \geq 2 \end{cases}$$

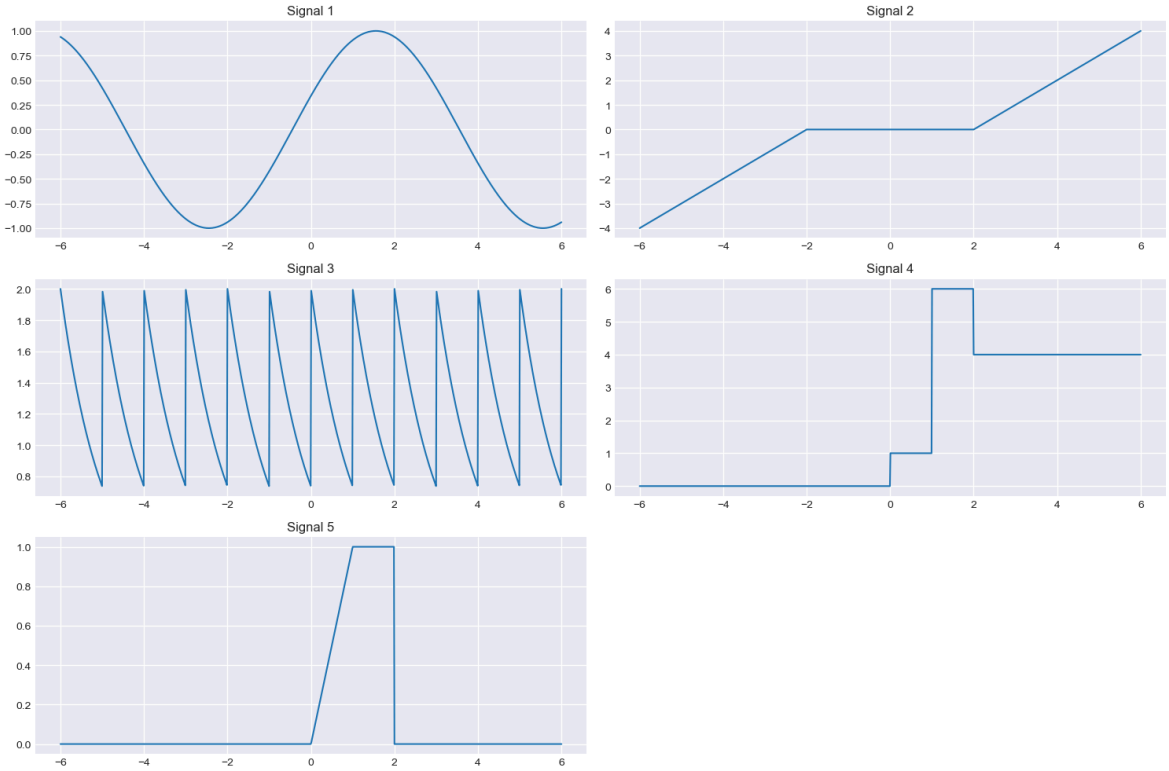
3. $x(t) = 2e^{-t}, 0 \leq t < 1$ and $x(t+1) = x(t)$ for all t

4. $x(t) = u(t) + 5u(t-1) - 2u(t-2)$

5. $x(t) = r(t) - r(t-1) - u(t-2)$

In [ ]:
```
# 1.
def x1(t):
    return np.sin(np.pi/4 * t + np.pi/9)

# 2.
def x2(t):
    if t < -2: return t+2
    elif (-2 <= t <= 2): return 0
```

```
    else: return t-2

# 3.
def x3(t):
    return 2 * np.exp(-np.mod(t, 1))

# 4.
def u(t):
    return np.heaviside(t, 1)

# 5.
def r(t):
    return t * np.heaviside(t, 1)


t = np.linspace(-6, 6, 1000)

x_1 = x1(t)
x_2 = np.array([x2(i) for i in t])
x_3 = x3(t)
x_4 = u(t) + 5*u(t-1) - 2*u(t-2)
x_5 = r(t) - r(t-1) - u(t-2)

# Plot
plt.figure(figsize=(15, 10))

plt.subplot(3, 2, 1)
plt.plot(t, x_1)
plt.grid(True)
plt.title('Signal 1')

plt.subplot(3, 2, 2)
plt.plot(t, x_2)
plt.grid(True)
plt.title('Signal 2')

plt.subplot(3, 2, 3)
plt.plot(t, x_3)
plt.grid(True)
plt.title('Signal 3')

plt.subplot(3, 2, 4)
plt.plot(t, x_4)
plt.grid(True)
plt.title('Signal 4')

plt.subplot(3, 2, 5)
plt.plot(t, x_5)
plt.grid(True)
plt.title('Signal 5')

plt.tight_layout()
plt.show()
```



Problem 2

Determine whether each of following signals is periodic, and if so, find its period.

1.

$x(t) = \sin\left(\frac{\pi}{3}t\right) + \cos\left(\frac{8\pi}{3}t\right)$ 2. $x(t) = \exp\left(j\frac{7\pi}{6}t\right) + \exp\left(j\frac{5\pi}{6}t\right)$

3.

$x(t) = \exp\left(j\frac{7\pi}{6}t\right) + \exp\left(\frac{5\pi}{6}t\right)$

Problem 3

Determine whether the following signals are power or energy signals or neither. Justify your answers

1. $x(t) = A\sin(t), -\infty < t < \infty$
2. $x(t) = A(u(t-a) - u(t+a)),\ a > 0$
3. $x(t) = \exp(-at)u(t),\ a > 0$
4. $x(t) = A\exp(bt)u(t),\ b > 0$

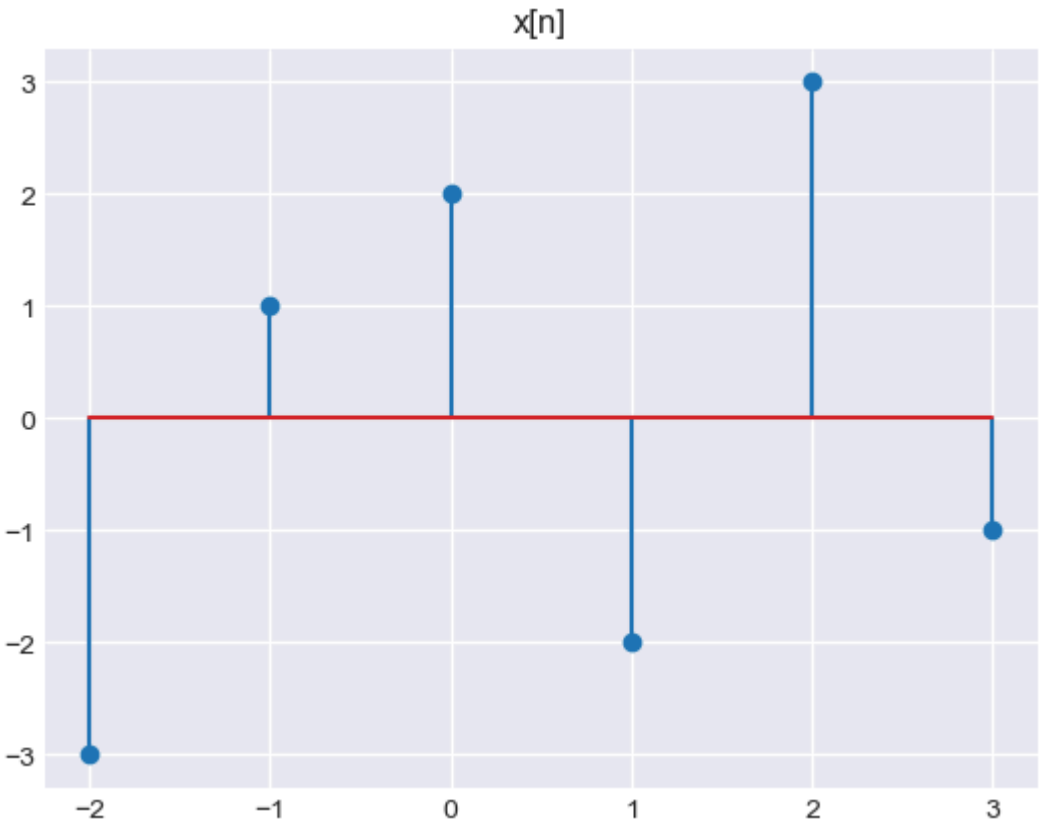
Problem 4

For the discrete time signal x[n] shown in Figure below, sketch each of the following

1. $x[2-n]$
2. $x[3n-4]$

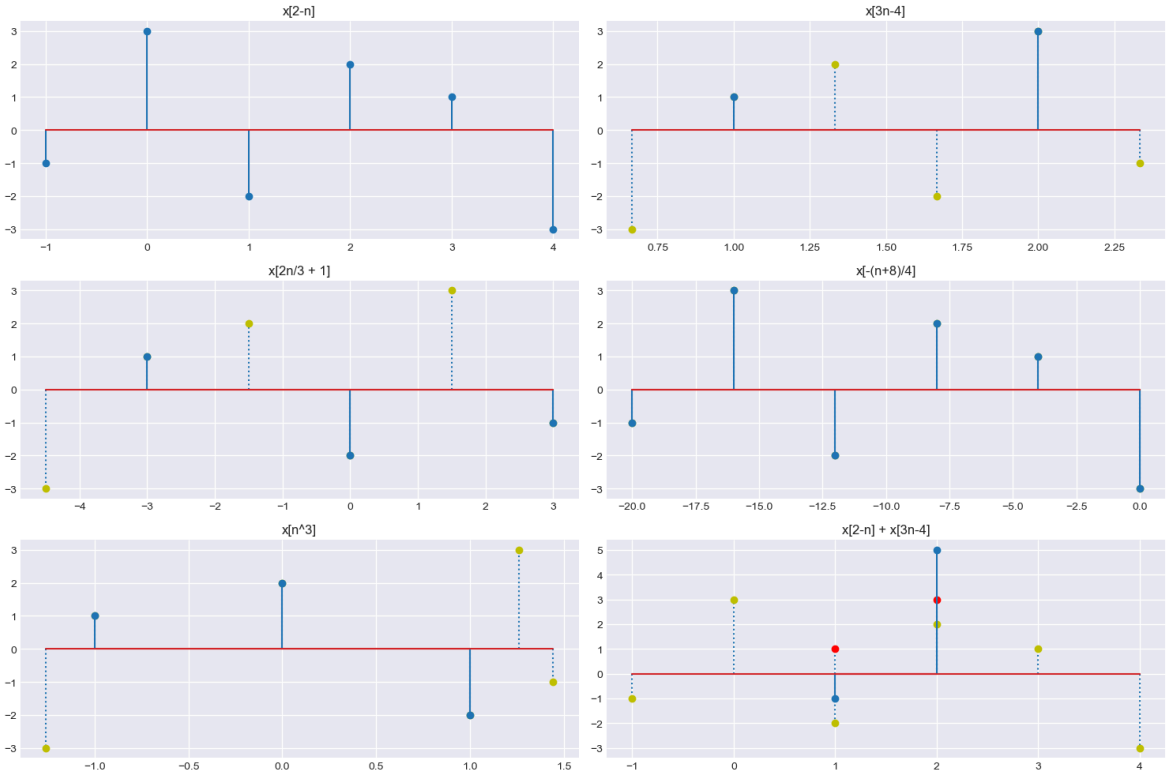
3. $x\left[\frac{2}{3}n+1\right]$
4. $x\left[-\frac{n+8}{4}\right]$
5. $x[n^3]$
6. $x[2-n]+x[3n-4]$

In [ ]:
```
# x[n]
t = np.arange(-2,4)
x_n = np.array([-3,1,2,-2,3,-1])
plt.stem(t, x_n)
plt.title('x[n]')
plt.show()
```



In [ ]:
```
# x[n]
base_x = np.array([-2,-1,0,1,2,3])
base_y = np.array([-3,1,2,-2,3,-1])

def filterInt(arr_x, arr_y):
    mask = np.where(arr_x % 1 == 0, True, False)
    return arr_x[mask], arr_y[mask]

# Plot
plt.figure(figsize=(15, 10)) # 3 rows, 2 columns

plt.subplot(3, 2, 1)
new_x, new_y = filterInt(-(base_x-2), base_y)
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[2-n]')

plt.subplot(3, 2, 2)
plt.stem((base_x+4)/3, base_y, linefmt=':', markerfmt='yo')
```

```
new_x, new_y = filterInt((base_x+4)/3, base_y)
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[3n-4]')

plt.subplot(3, 2, 3)
plt.stem((base_x-1)*3/2, base_y, linefmt=':', markerfmt='yo')
new_x, new_y = filterInt((base_x-1)*3/2, base_y)
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[2n/3 + 1]')

plt.subplot(3, 2, 4)
plt.stem((-4*base_x)-8, base_y, linefmt=':', markerfmt='yo')
new_x, new_y = filterInt((-4*base_x)-8, base_y)
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[-(n+8)/4]')

plt.subplot(3, 2, 5)
plt.stem(np.cbrt(base_x), base_y, linefmt=':', markerfmt='yo')
new_x, new_y = filterInt(np.cbrt(base_x), base_y)
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[n^3]')

plt.subplot(3, 2, 6)
x1, y1 = filterInt(-(base_x - 2), base_y)
x2, y2 = filterInt((base_x + 4) / 3, base_y)
plt.stem(x1, y1, linefmt=':', markerfmt='yo')
plt.stem(x2, y2, linefmt=':', markerfmt='ro')
new_x = np.intersect1d(x1, x2)
new_y = [y1[np.where(x1 == i)[0][0]] + y2[np.where(x2 == i)[0][0]] for i
plt.stem(new_x, new_y)
plt.grid(True)
plt.title('x[2-n] + x[3n-4]')

plt.tight_layout()
plt.show()
```



Problem 5

Determine whether each of following signals is periodic, and if so, find its period.

1. $x[n] = \sin\left(\frac{\pi n}{4} + \frac{\pi}{8}\right)$
2. $x[n] = \sin\left(\frac{3\pi n}{4}\right) + \sin\left(\frac{\pi}{3}n\right)$
3. $x[n] = \sin\left(\frac{3\pi n}{4}\right)\sin\left(\frac{\pi}{3}n\right)$
4. $x[n] = \exp\left(\frac{6\pi}{5}n\right)$
5. $x[n] = \exp\left(j\frac{5\pi}{6}n\right)$
6. $x[n] = \sum_{m=-\infty}^{\infty}\left[\delta[n-2m] + 2\delta[n-3m]\right]$

Problem 6

[python] Signal transformations : Study the sawtooth function in the figure below. Apply reflection, scaling, shifting operations to the signal and plot the transformed signals compared with the original sawtooth signal.

In [ ]:
```
import numpy as np
from scipy import signal
import matplotlib.pyplot as plt
%matplotlib inline
```

In [ ]:
```
# t = np.linspace(-1, 1, 500)
# plt.plot(t, signal.sawtooth(2 * np.pi * 5 * t))
# plt.show()
```

In [ ]:
```
# t = np.linspace(-1, 1, 500)
# plt.plot(t, signal.sawtooth(2 * np.pi * 5 * t))

# scaling factor = 3 and 1/3
## TODO : writing code for time scaling
```

In [ ]:
```
# t = np.linspace(-1, 1, 500)
# plt.plot(t, signal.sawtooth(2 * np.pi * 5 * t))

# shifting t to the left and right 0.05 units

## TODO : writing code for time shifting
```

In [ ]:
```
# plt.plot(t, signal.sawtooth(2 * np.pi * 5 * t))

## TODO : writing code for time Reflection
```

Problem 7

[python] Elementary signals: study the ramp signal plotted in the example below. \
TODO : plot these signals

1. Unit step function
2. Unit impulse function

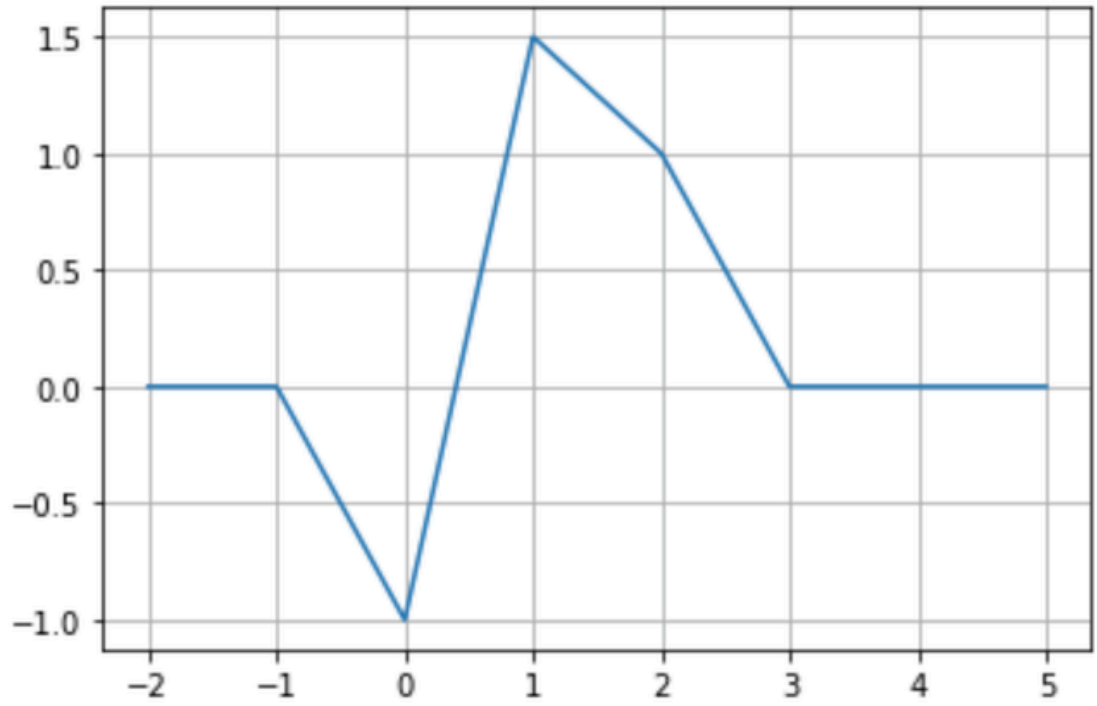
In [ ]:
```
# t = np.linspace(-1, 1, 500)
# ramp_t = t.copy()
# ramp_t[ramp_t < 0 ] = 0
# plt.plot(t, ramp_t)
# plt.show()
```

In [ ]:
```
## TODO : writing code for plotting unit step function
```

In [ ]:
```
## TODO : writing code for plotting unit impulse function
```

Problem 8

Express the signal that shown in Figure below using Unit-ramp functions

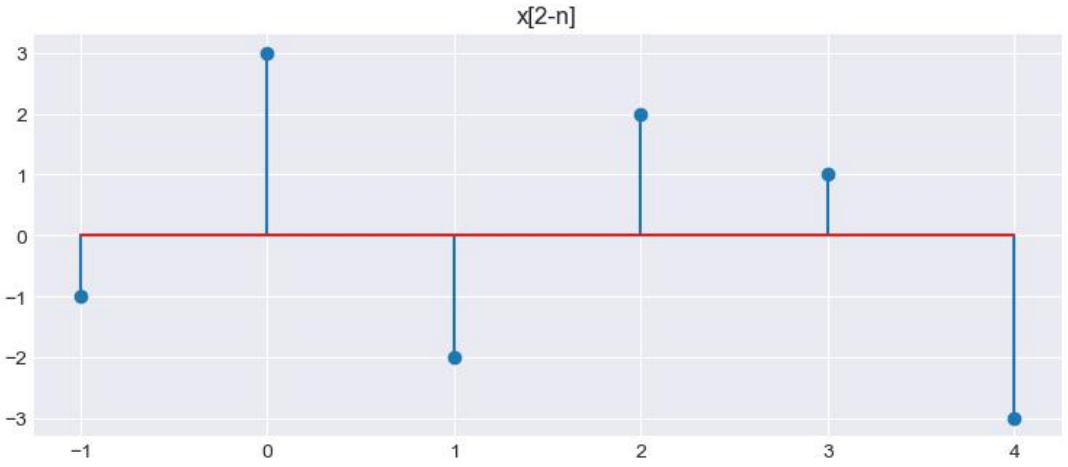


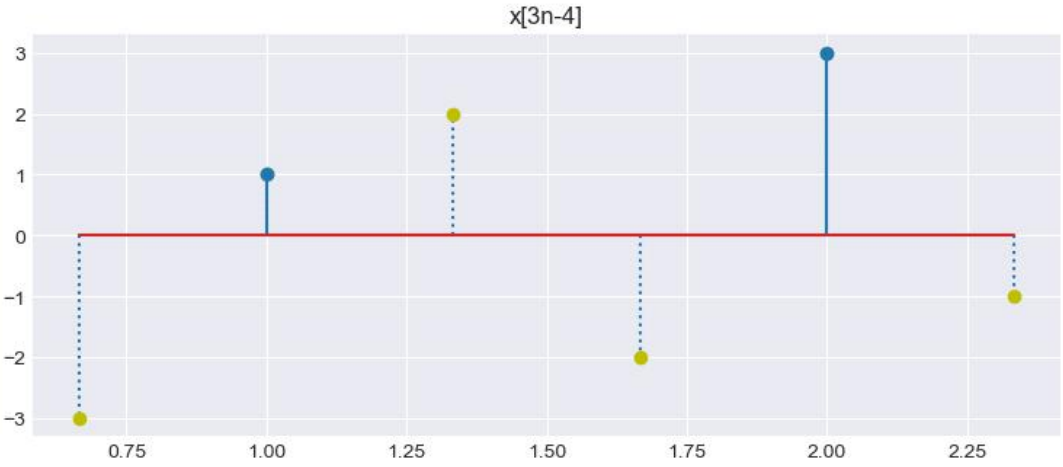
Problem 9

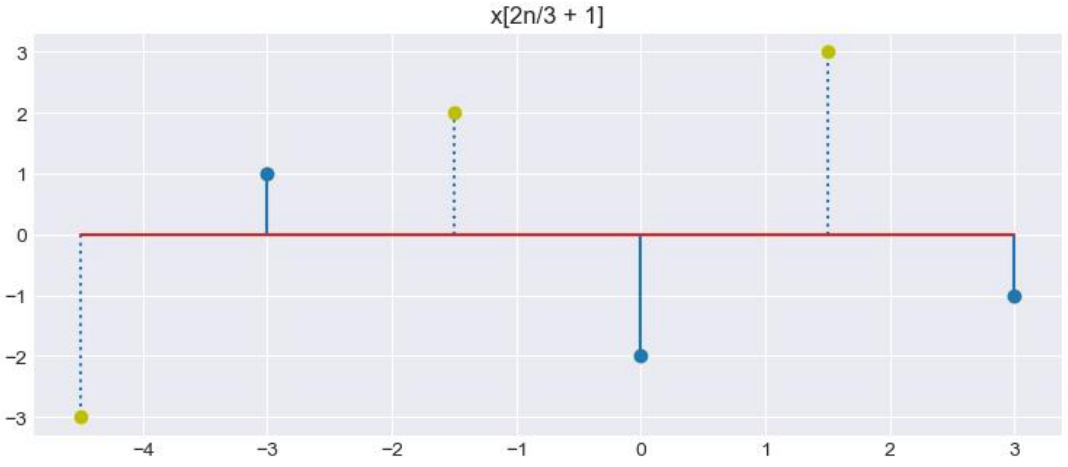
Evaluate the following integrals

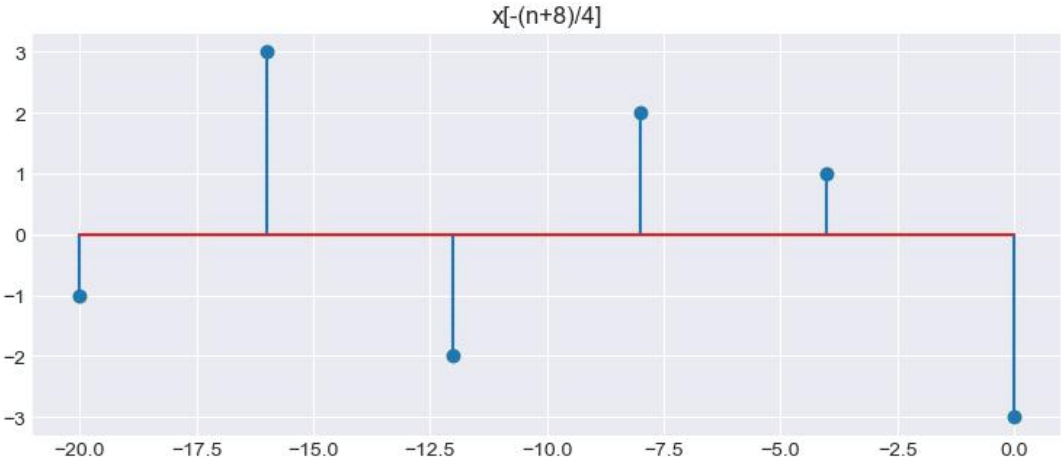
Answer:

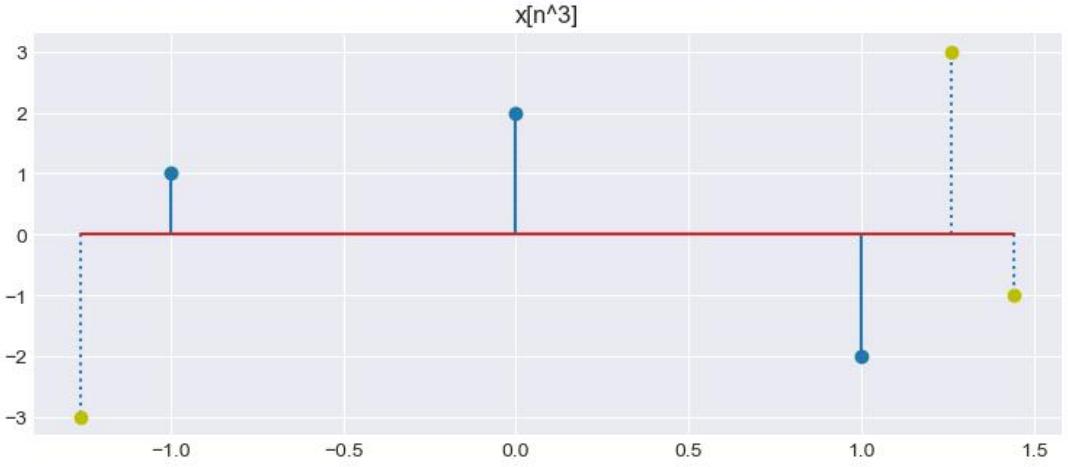
1. $\int_{-\infty}^{\infty} \left(\frac{2}{3}t - \frac{3}{2}\right) \delta(t-1)\, dt = -5/6$
2. $\int_{-\infty}^{\infty} (t-1)\delta\left(\frac{2}{3}t - \frac{3}{2}\right)\, dt = 15/8$
3. $\int_{-3}^{-2} \left[e^{(-t+1)} + \sin\left(\frac{2\pi t}{3}\right)\right] \delta\left(t - \frac{3}{2}\right)\, dt = 0$
4. $\int_{-3}^{2} \left[e^{(-t+1)} + \sin\left(\frac{2\pi t}{3}\right)\right] \delta\left(t - \frac{3}{2}\right)\, dt = e^{-1/2} + \sin(\pi) = \frac{1}{\sqrt{e}}$

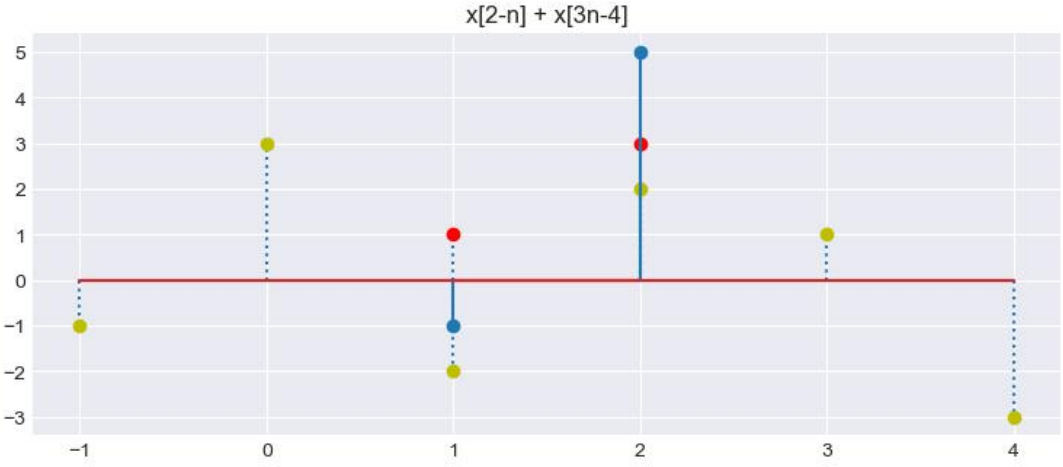

x[2-n]


x[3n-4]


x[2n/3 + 1]


x[-(n+8)/4]


x[n^3]


x[2-n] + x[3n-4]