Project1_Solution

September 7, 2024

1 Project 1 - Discrete-Time Periodic Signals

1.0.1 Periodic Trigonometric Discrete-Time Signals

in index/time and frequency domains

$$x(n) = cos(2\pi nk/N)$$

where k/N is a rational fraction

[1]:
```
import numpy as np
from numpy.fft import fft, fftshift, fftfreq
import matplotlib.pyplot as plt
%matplotlib inline
```

Define functions for graphing

[3]:
```
def graphit(x,yaxis_str,title_it):
    '''Display a discrete-time signal'''
    n = np.arange(0,len(x))
    plt.figure()
    plt.stem(n,x)
    plt.xlim(-1,2*N)
    plt.grid()
    plt.xlabel('$n$')
    plt.ylabel(yaxis_str)
    plt.xticks(np.arange(0,2*N,2))
    plt.title(title_it)

def graphfreqmag(y,yaxis_str,title_str):
    '''Display the magnitude of the frequency content of a discrete-time␣
 ↪signal'''
    Y = fftshift(fft(y))/len(y)
    F = fftshift(fftfreq(len(Y)))
    plt.figure()
    plt.stem(F,abs(Y))
    plt.grid()
    plt.xlabel('$F = k/N$')
    plt.ylabel(yaxis_str)
```

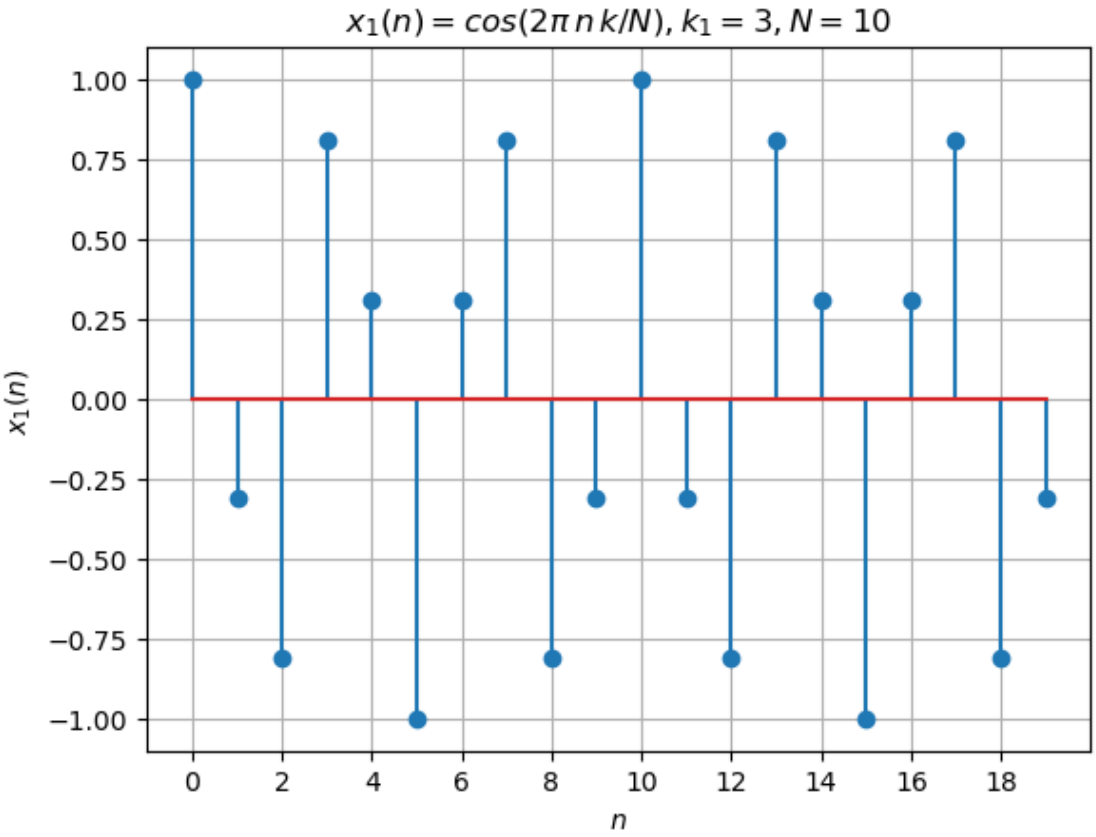
```
    plt.title(title_str)
```

1.0.2 Single frequency periodic sequence

$$x(n) = cos(2\pi nk/N)$$

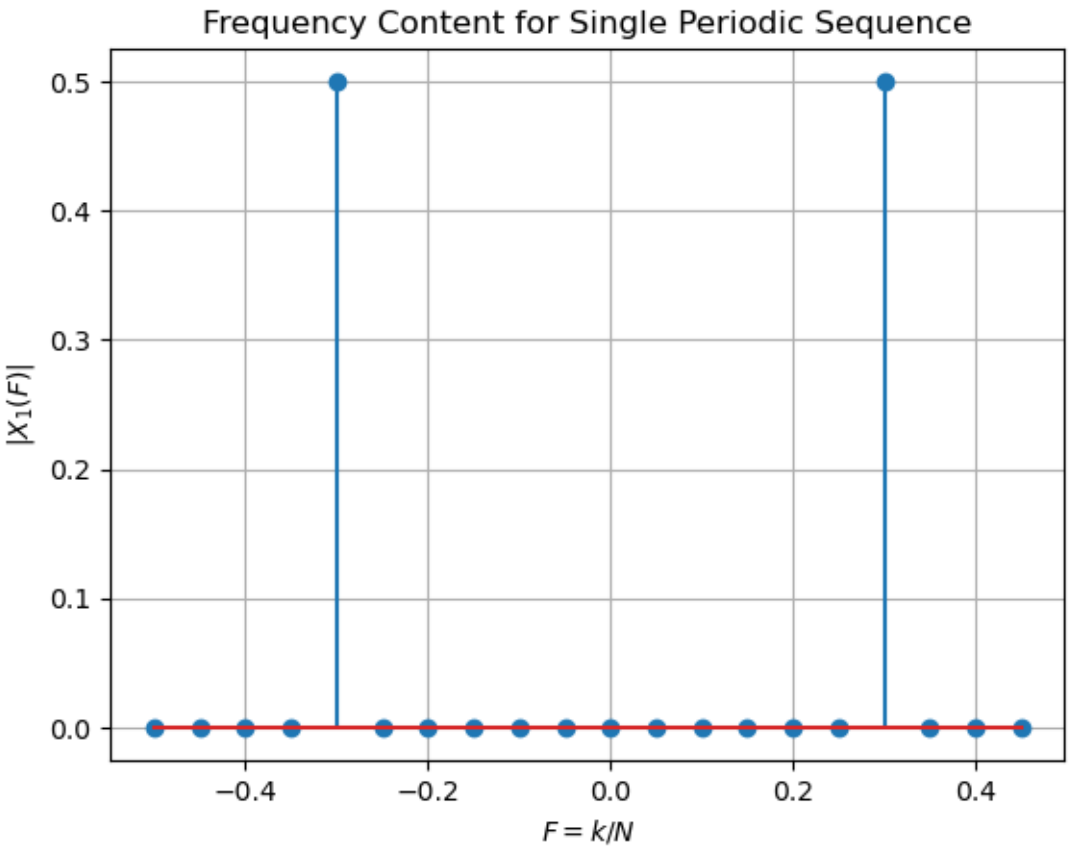
where k/N is a rational fraction

[4]:
```
k1, N = 3, 10
Fn = k1/N             # |Fn| <= 1/2 required
n = np.arange(0,2*N)
w = 2*np.pi*Fn
x1 = np.cos(w*n)
title_str = rf"$x_1(n) = cos(2 \pi \,n\,k/N), k_1 = {k1}, N = {N}$"
graphit(x1,'$x_1(n)$',title_str)
```



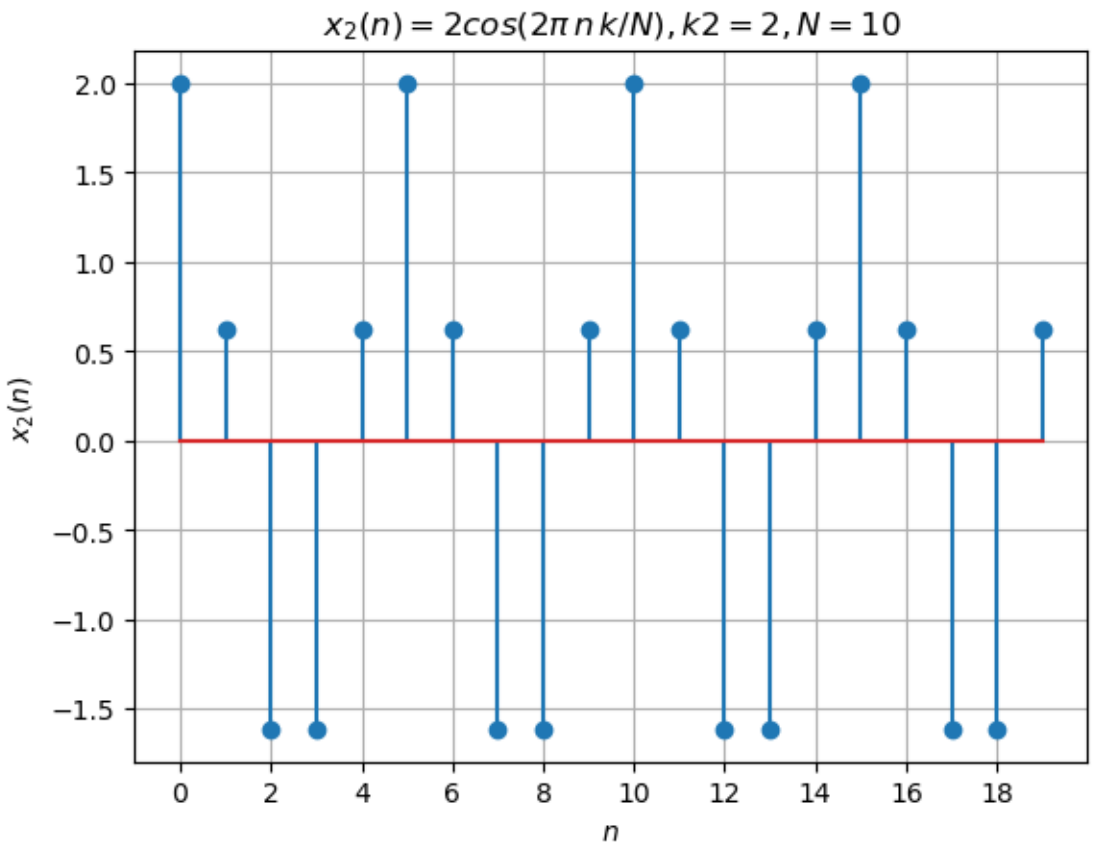
1.0.3 Frequency Distribution for single frequency periodic sequence

[5]:
```
yaxis_str = '$|X_1(F)|$'
title_str = 'Frequency Content for Single Periodic Sequence'
graphfreqmag(x1,yaxis_str,title_str)
```



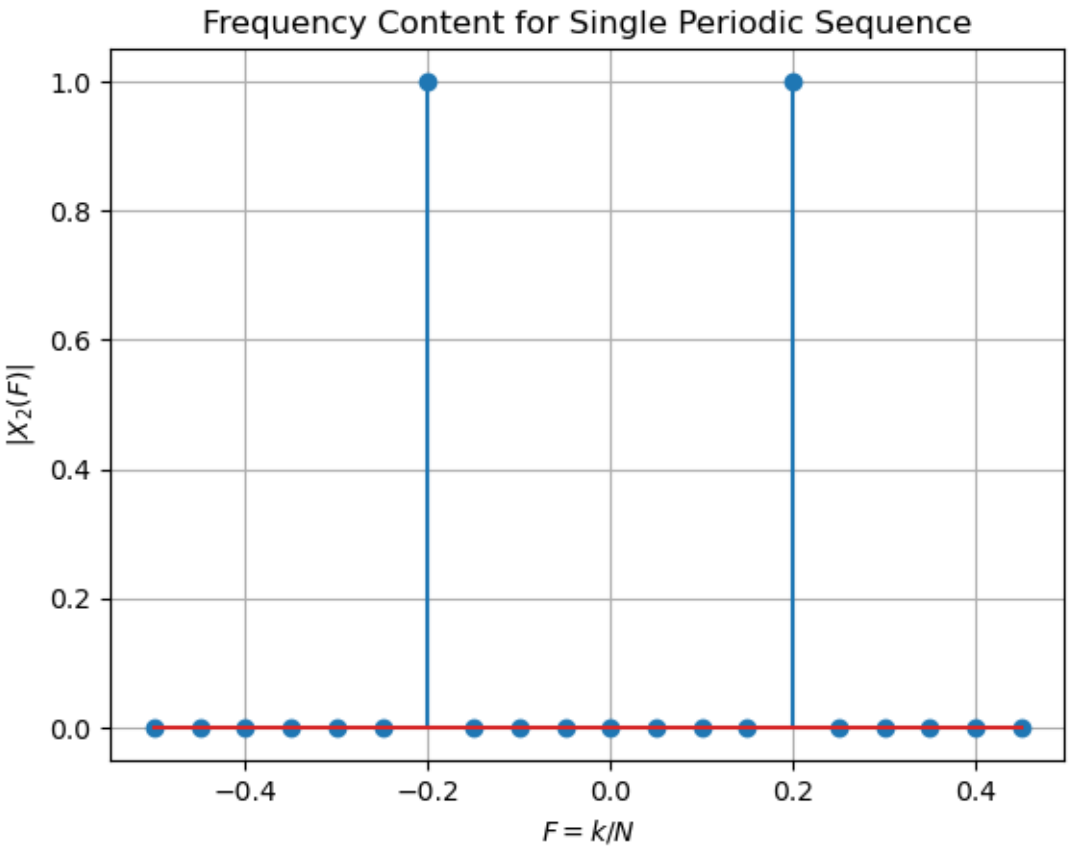
1.0.4 Create a second periodic sequence

[6]:
```
k2 = 2
Fn = k2/N              # |Fn| <= 1/2 required
n = np.arange(0,2*N)
w = 2*np.pi*Fn
x2 = 2*np.cos(w*n)
title_str = rf"$x_2(n) = 2 cos(2\pi\,n\,k/N), k2 = {k2}, N = {N}$"
graphit(x2,'$x_2(n)$',title_str)
```



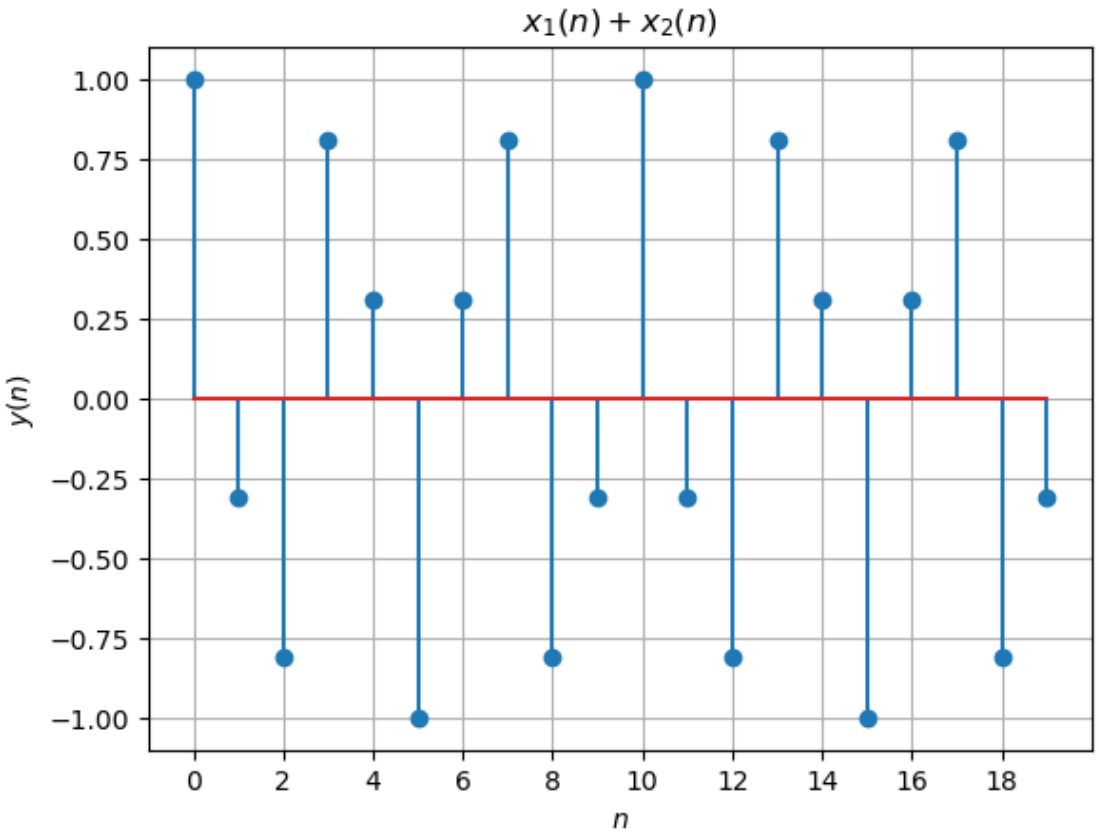
1.0.5 Frequency Distribution for a second single frequency periodic sequence

[7]:
```
# Frequency Distribution
yaxis_str = '$|X_2(F)|$'
title_str = 'Frequency Content for Single Periodic Sequence'
graphfreqmag(x2,yaxis_str,title_str)
```



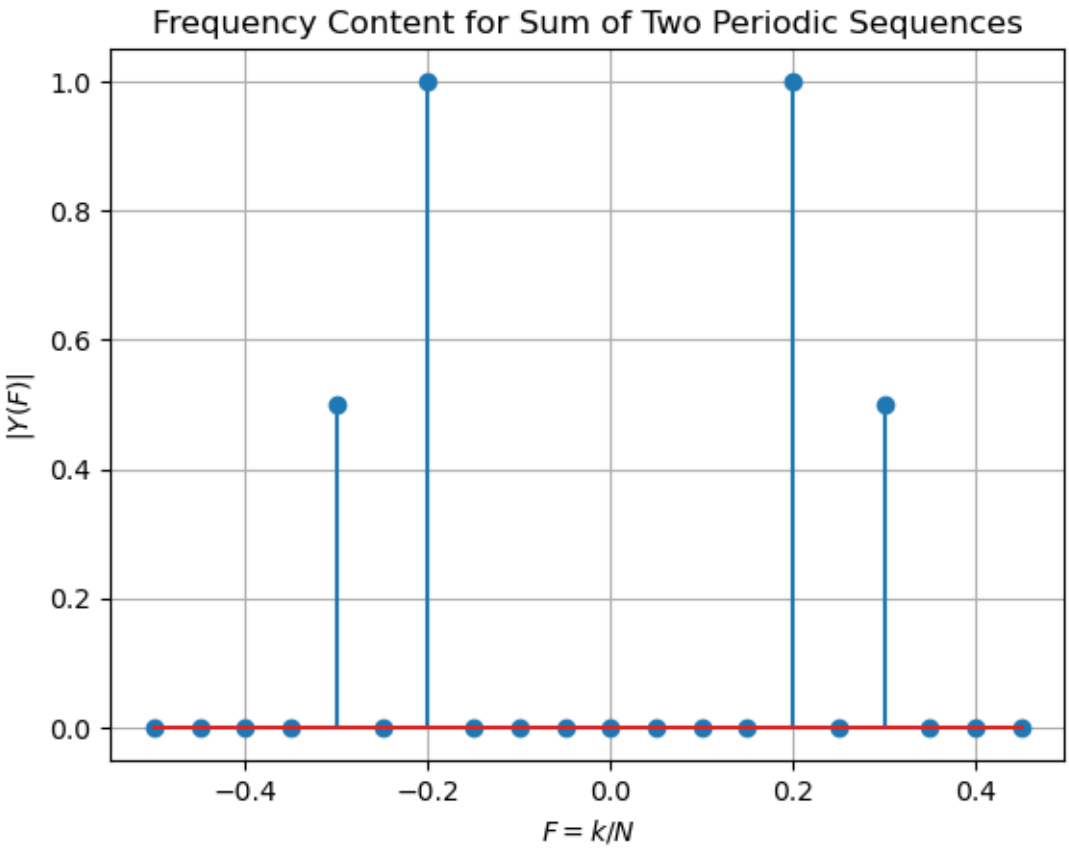
1.0.6 Sum of Two Periodic Sequences

[8]:
```
y = x1 + x2
title_str = '$x_1(n) + x_2(n)$'
graphit(x1,'$y(n)$',title_str)
```



1.0.7 Frequency Distribution for the pair of periodic sequences

[9]:
```
yaxis_str = '$|Y(F)|$'
title_str = 'Frequency Content for Sum of Two Periodic Sequences'
graphfreqmag(y,yaxis_str,title_str)
```


Frequency Content for Sum of Two Periodic Sequences
1.0
0.8
0.6
0.4
0.2
0.0
|Y(F)|
−0.4
−0.2
0.0
0.2
0.4
F = k/N