Untitled

March 9, 2022

1 Obligatorisk oppgave

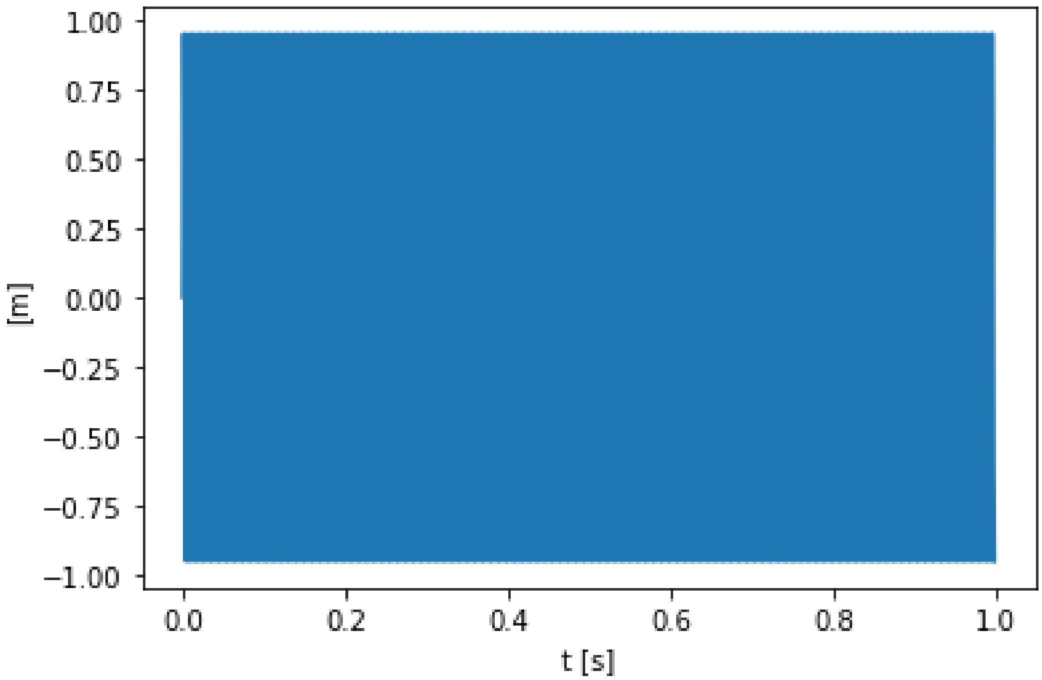
1.1 oppgave 1

1.1.1 1a)

Vi har at $g(t) = A\sin(2\pi ft)$, der $A = 1$m, $f = 200$Hz. vi har at samplingsfrekvens $f_s = 1$kHz, og at samplingstiden $T = 1$s. vi kjenner til relasjonen $f_s = 1/\Delta t$ og har dermed også at $\Delta t = f_s^{-1} = 1$ms.

[1]:
```
"""Dette terminalvinduet er felles for all kode uanvhengig av oppgave"""
"""Modules"""
import numpy as np
import matplotlib.pyplot as plt
import scipy.fft as fft
```

[2]:
```
"""Parametere felles for oppgave 1"""
#below are given specifically in assignment
f_s = 1e3 #Hz, sample frequency
A = 1 #m, ????
T = 1 #s, sample period.
dt = 1/f_s #timestep, s
N = int(T/dt)
t = np.arange(0,T,dt) #time array from 0 to T, with increment dt.

def g(t,f):
    return A*np.sin(2*np.pi*f*t)

x = g(t,f=200) #

plt.plot(t,x)
plt.xlabel('t [s]')
plt.ylabel('[m]')
plt.show()
```

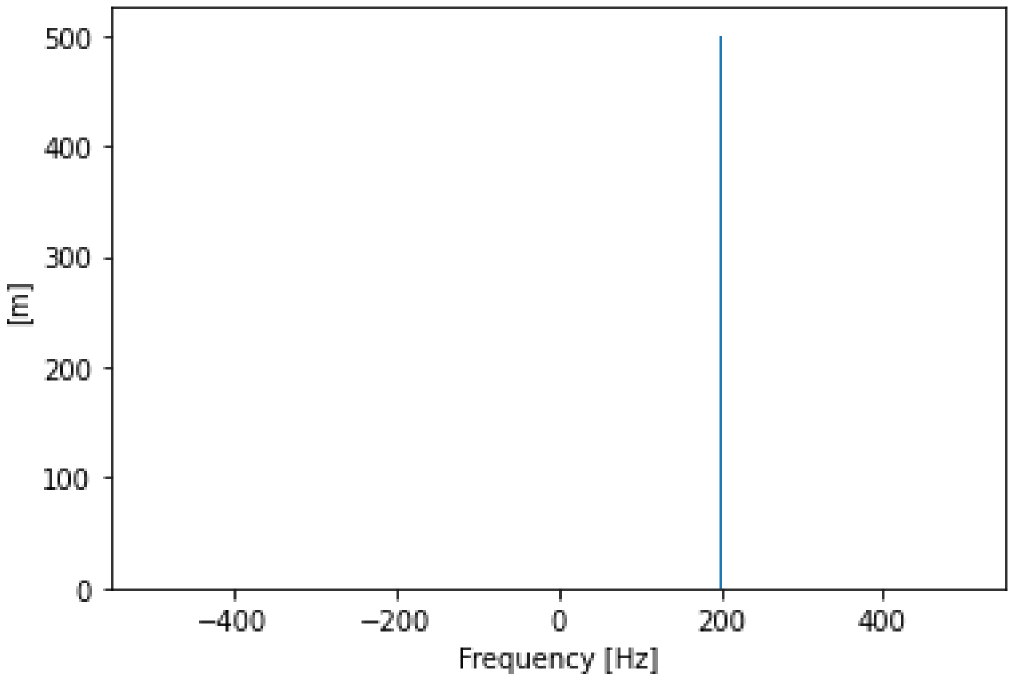


utfører en diskret fourier transformasjon. Dette gjør jeg med scipy sin "fft" funksjon. Scipy funksjonen implementerer denne formelen:

$$X_k = \frac{1}{N}\sum_{n=0}^{N-1} x_n e^{-i\frac{2\pi}{N}kn}.$$

[3]:
```
"""lager arrays for DFT, og plotter de"""
x_fourier = fft.fft(x)
f_array = fft.fftfreq(N,dt)
plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('[m]')
```

[3]: `Text(0, 0.5, '[m]')`

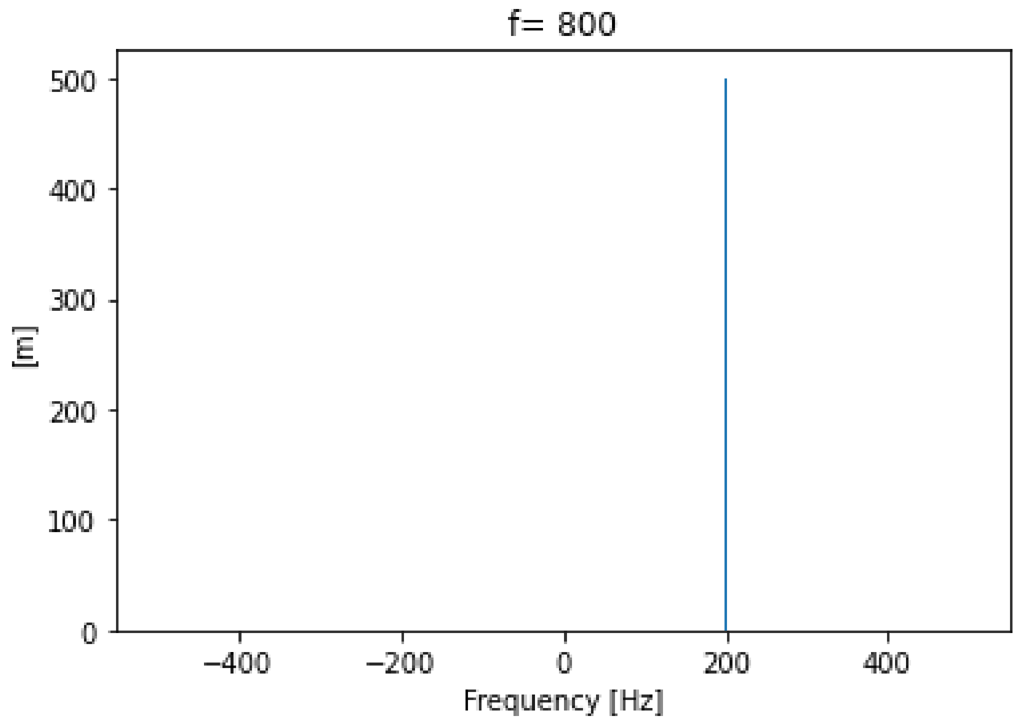


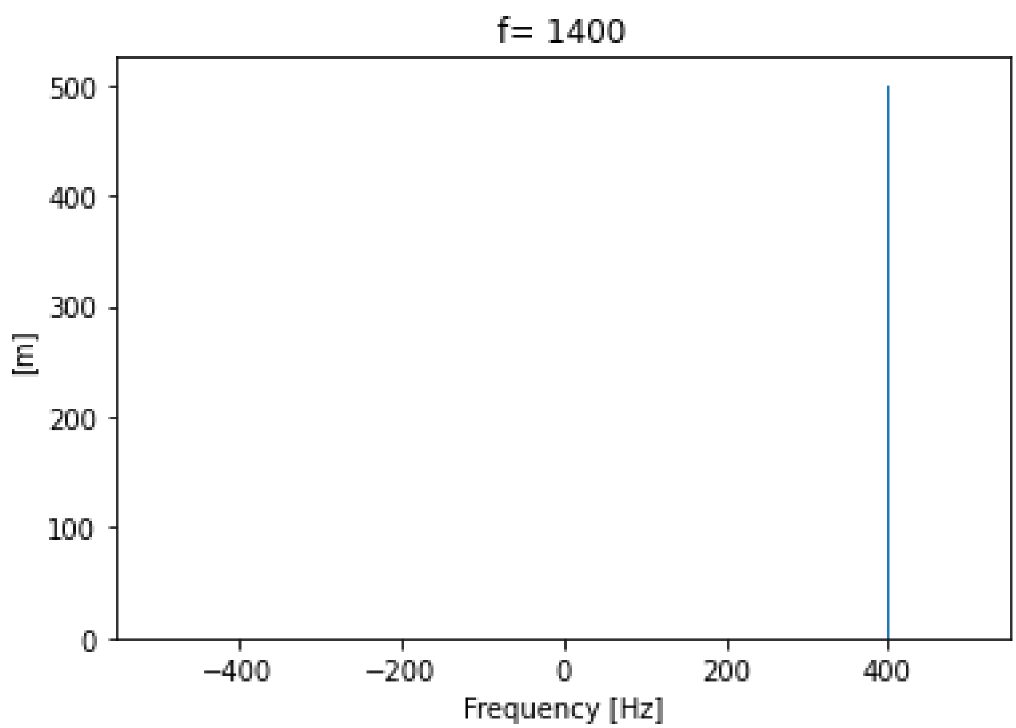
Vi ser i plottet at vi har en topp på $f = 200$Hz, som er hva vi forventer å se, da dette er fourier transformasjon av en funksjon med frekvens $f = 200$. Vi ser også at amplituden er ganske svær, som også er omtrent er som forventet, da denne toppen skal være en δ funksjon, der toppen strengt talt går mot uendelig, men dette skjer jo ikke fordi vi gjør ting på numerisk vis.

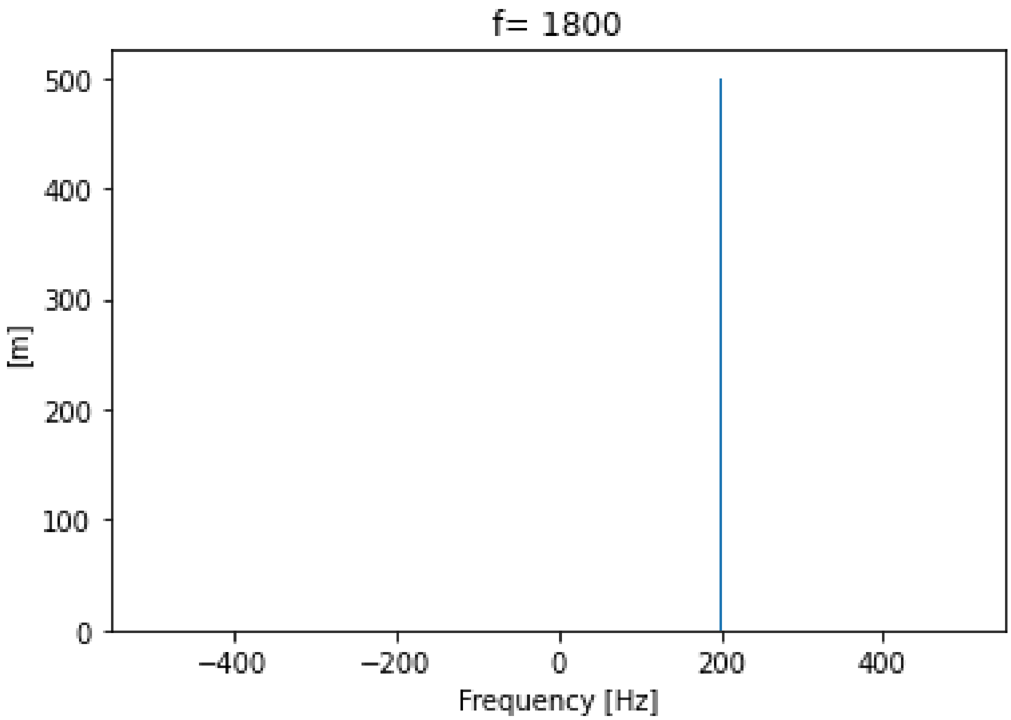
1.2 1b)

kjører nå DFT på g(t) der frekvensen f er 800,1400, og 1800Hz.

[4]:
```
freqs = [800,1400,1800]
for i in freqs:
    x = g(t,f=i) #
    x_fourier = fft.fft(x)
    plt.bar(f_array,np.abs(x_fourier))
    plt.xlabel('Frequency [Hz]')
    plt.ylabel('[m]')
    plt.title(f'f= {i}')
    plt.show()
```


f= 800
500
400
300
200
100
0
[m]
−400
−200
0
200
400
Frequency [Hz]


f= 1400
500
400
300
200
100
0
[m]
−400
−200
0
200
400
Frequency [Hz]



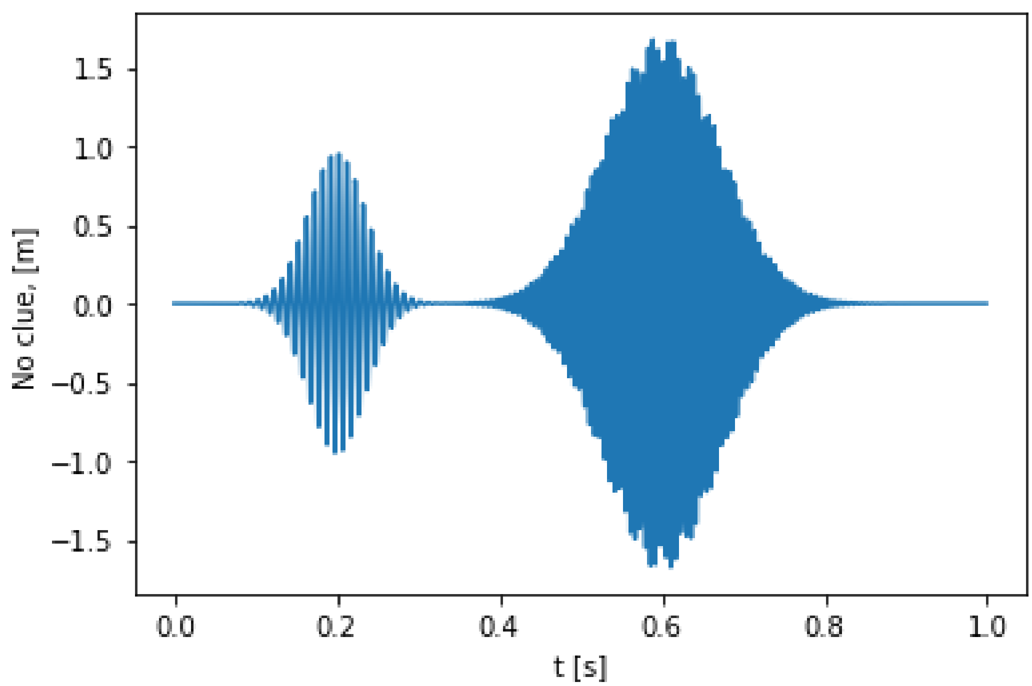
Vi ser for $g(f = 800, t)$ at vi har en topp i $f = 200$Hz, som ikke tilsvarer hva vi så i oppgave 1a, der vi så at DFT for $g(f = 200, t)$ hadde en topp i $f = 200$Hz. Dette kan forklares ved Nyquist-Shannon samplingsteoremet som sier: "The sampling frequency must be at least twice as high as the highest frequency component in a signal for the sampled signal to provide an unambiguous picture of the signal.". Altså for F=800Hz, så skulle samplingsfrekvensen f_s vært minst 1600Hz. Det som skjer når kriteriet ikke er møtt, er at vi får en "falsk" frekvens som følge av folding, og da får vi en alias frekvens. somsom

1.3 oppgave 2

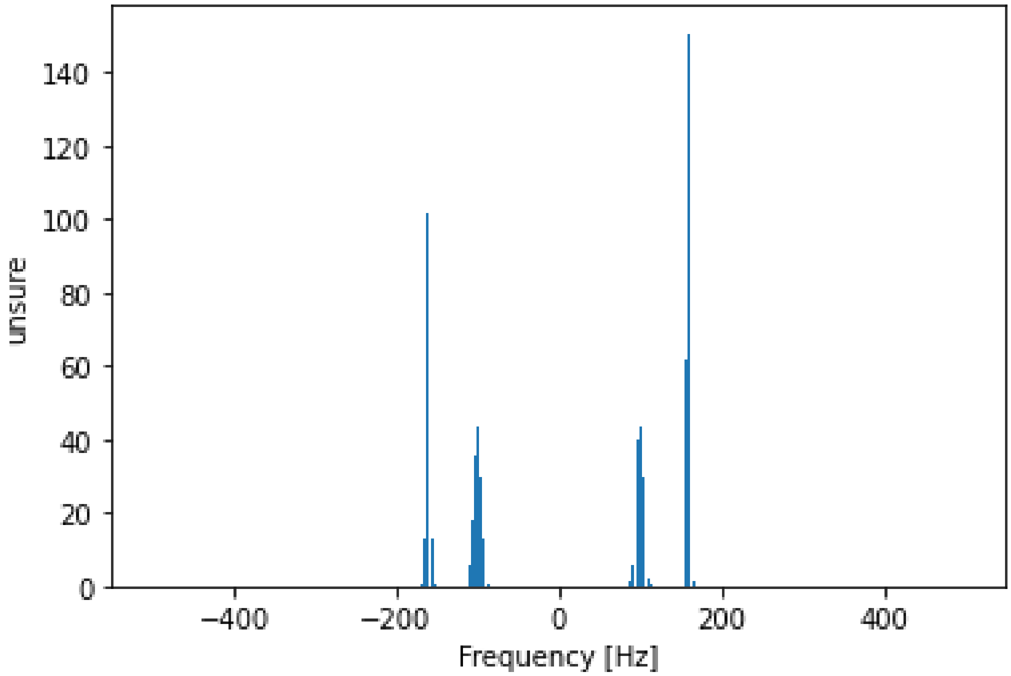
1.3.1 a)

[5]:
```
"""Modules"""
import numpy as np
import matplotlib.pyplot as plt
import scipy.fft as fft
"""Constants"""
A1 = 1      #m
A2 = 1.7    #m
f1 = 100    #Hz, frequency 1
f2 = 160    #Hz, frequency 2
t1 = 0.2    #s
t2 = 0.6    #s
sigma1 = 0.05   #s
```

```
sigma2 = 0.10   #s

f_s = 1e3       #Hz
T = 1           #s
dt = 1/f_s #timestep, s
N = int(np.ceil(T/dt))



def f(t):
    A = A1*np.sin(2*np.pi*f1*t)*np.exp(-((t-t1)/sigma1)**2)
    B = A2*np.sin(2*np.pi*f2*t)*np.exp(-((t-t2)/sigma2)**2)
    return A+B

t = np.arange(0,T,dt) #time array from 0 to T, with increment dt.
x = f(t)



plt.plot(t,x)
plt.xlabel('t [s]')
plt.ylabel('No clue, [m]')
plt.show()
x_fourier = fft.fft(x)
f_array = fft.fftfreq(N,dt)

plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('Amplitude')
```



[5]: Text(0, 0.5, 'unsure')

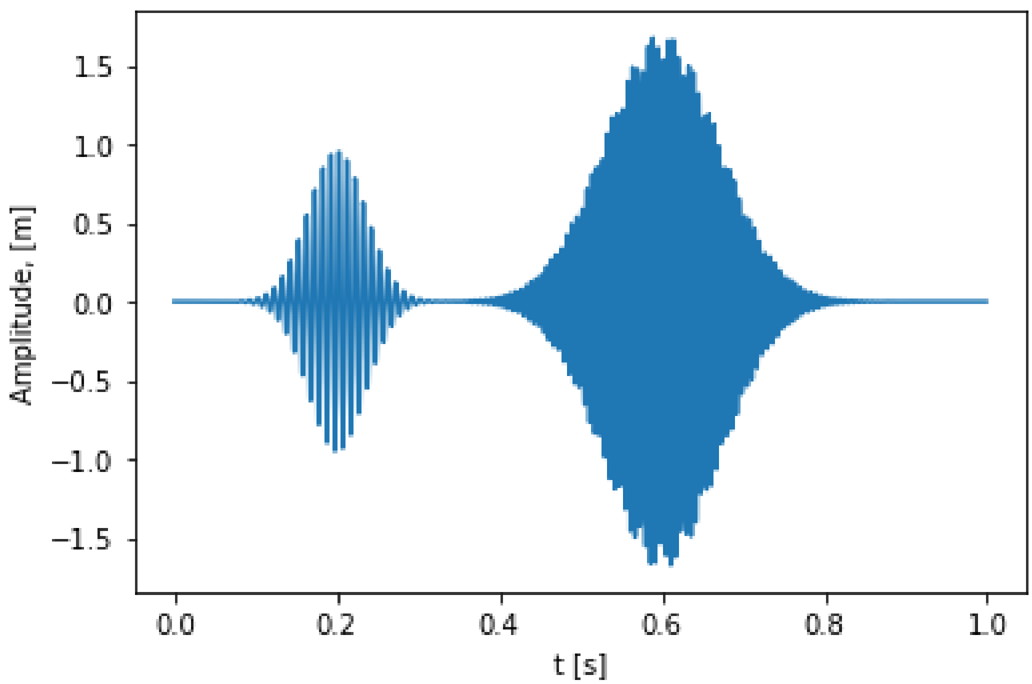


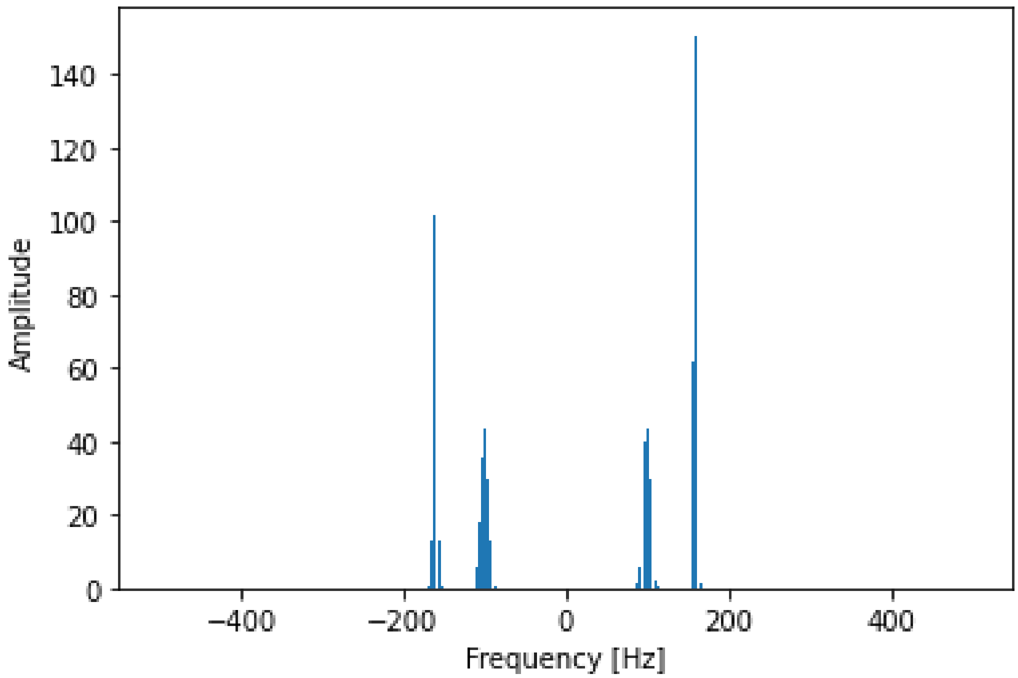
1.3.2 2b)

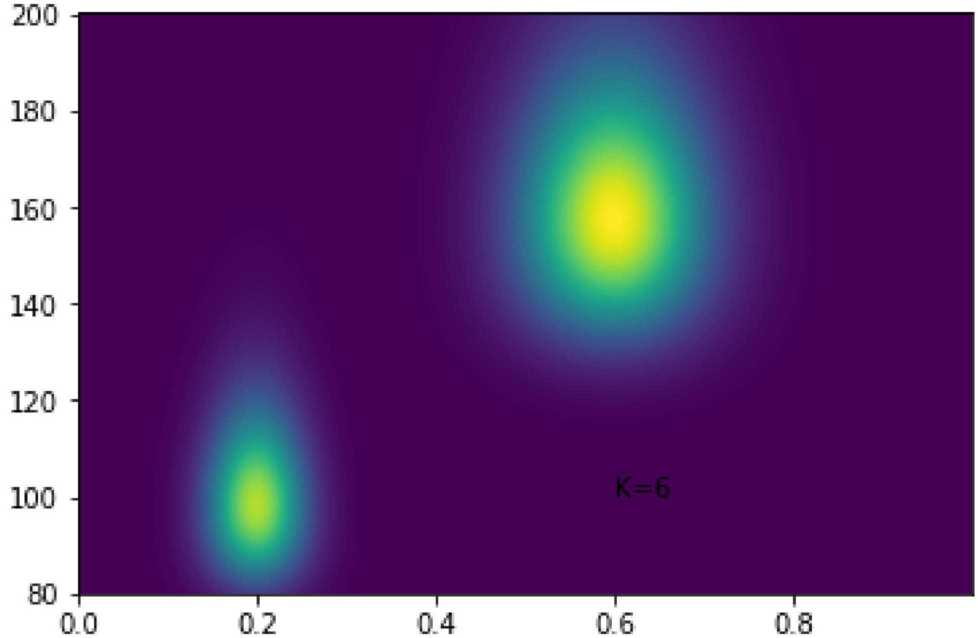
[6]:
```
%reset -f
import numpy as np
import matplotlib.pyplot as plt
import scipy.fft as fft

"""Constants"""
A1 = 1      #m
A2 = 1.7    #m
f1 = 100    #Hz, frequency 1
f2 = 160    #Hz, frequency 2
t1 = 0.2    #s
t2 = 0.6    #s
sigma1 = 0.05   #s
sigma2 = 0.10   #s

f_s = 1e3       #Hz, sampling frequency
T = 1           #s
dt = 1/f_s #timestep, s
```

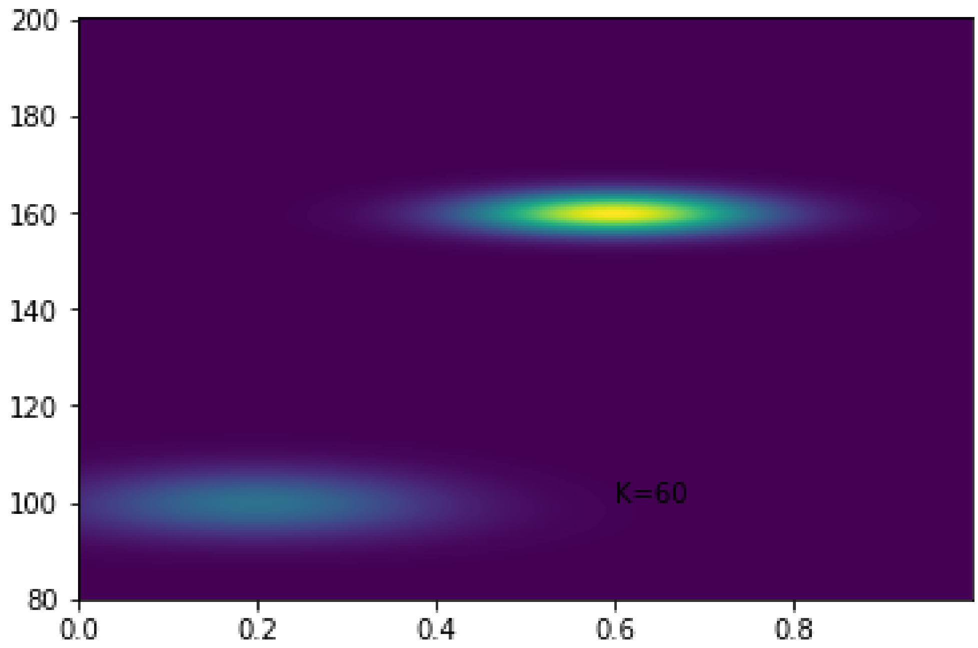
```
N = int(np.ceil(T/dt))

def f(t):
    A = A1*np.sin(2*np.pi*f1*t)*np.exp(-((t-t1)/sigma1)**2)
    B = A2*np.sin(2*np.pi*f2*t)*np.exp(-((t-t2)/sigma2)**2)
    return A+B

t = np.arange(0,T,dt) #time array from 0 to T, with increment dt.
x = f(t)

plt.plot(t,x)
plt.xlabel('t [s]')
plt.ylabel('Amplitude, [m]')
plt.show()
# regn ut og plot DFT via FFT her
x_fourier = fft.fft(x)
f_array = fft.fftfreq(N,dt)
plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('Amplitude')
plt.show()
# forslag til funksjoner



# implementer morlet wavelet i tidsdomenetet
def wavelet_td(omegaa, K, tk, tn):
    psi = C*( np.exp(-1j*omegaa*(tn-tk)) - np.exp(-K**2))*np.
↪exp(-omegaa**2*(tn-tk)**2/(2*K)**2)
    return psi # returner wavelet¨en, for gitte parametre

# wavelet transformen (i tidsdomenet)
def wavelet_transform_td(t, tk, xn, omegaa, K, N):
    A =  wavelet_td(omegaa,K,tk,t)
    gamma = np.zeros(N, dtype=np.complex )
    gamma = np.sum(np.conjugate(A)*xn)
    return gamma # returnerer gamma, for en gitt omegaa
# diagramfunksjon (felles for tids- og Fourierdomenet)

def wavelet_diagram(t, xn, omega_range, K, N):
    M = len(omega_range)
    diagram = np.zeros((M,N),dtype=np.complex)
    tk = t.copy()
    for i in range(N):
        for j in range(M):
            diagram[j,i] = wavelet_transform_td(t,tk[i], xn,omega_range[j],K,N)
    return diagram # returnerer et 2D diagram for en gitt K
```

```
# generere og plotte wavelets
K_vals = [6, 60]
tk = 0
C = 1
for K in K_vals:
    omegas = np.logspace(np.log10(80), np.log10(200), N) * 2 * np.pi # definere␣
↪hvike analysefrekvenser du vil bruke her
    waveletDiagram6 = wavelet_diagram(t, x, omegas, K, N) # dette kallet gir ut␣
↪en 2D diagram, og en gitt tidserie, valgt K-verdi og set av ønskete omegas
    plt.pcolormesh(t, omegas / 2.0 / np.pi, np.absolute(waveletDiagram6),␣
↪shading='auto')
    plt.text(0.6,100,f'K={K}')
    plt.xlabel('time [s]')
    plt.ylabel('frequency [Hz
    plt.show()
```




Amplitude
Frequency [Hz]
0
20
40
60
80
100
120
140
−400
−200
0
200
400


K=6
80
100
120
140
160
180
200
0.0
0.2
0.4
0.6
0.8



1.4 Oppgave 3

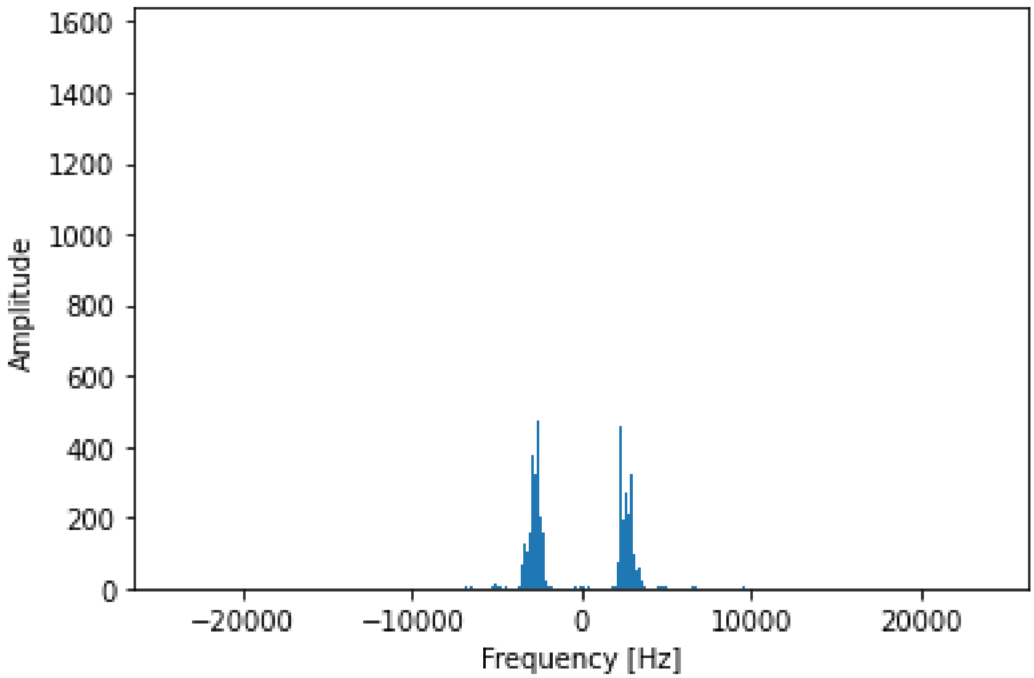
1.4.1 a)

[7]:
```
%reset -f
import numpy as np
import matplotlib.pyplot as plt
import scipy.fft as fft
from scipy.io import wavfile
from scipy import signal


samplerate, data = wavfile.read('mistle_thrush.wav')
x_n  = data[:,0] # time series, N samples
N = data.shape[0] # number of samples
f_s = samplerate
dt = 1/f_s
T = N / f_s
print('T = ',T)

x_fourier = fft.fft(x_n)
f_array = fft.fftfreq(N,dt)
plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('Amplitude')
```

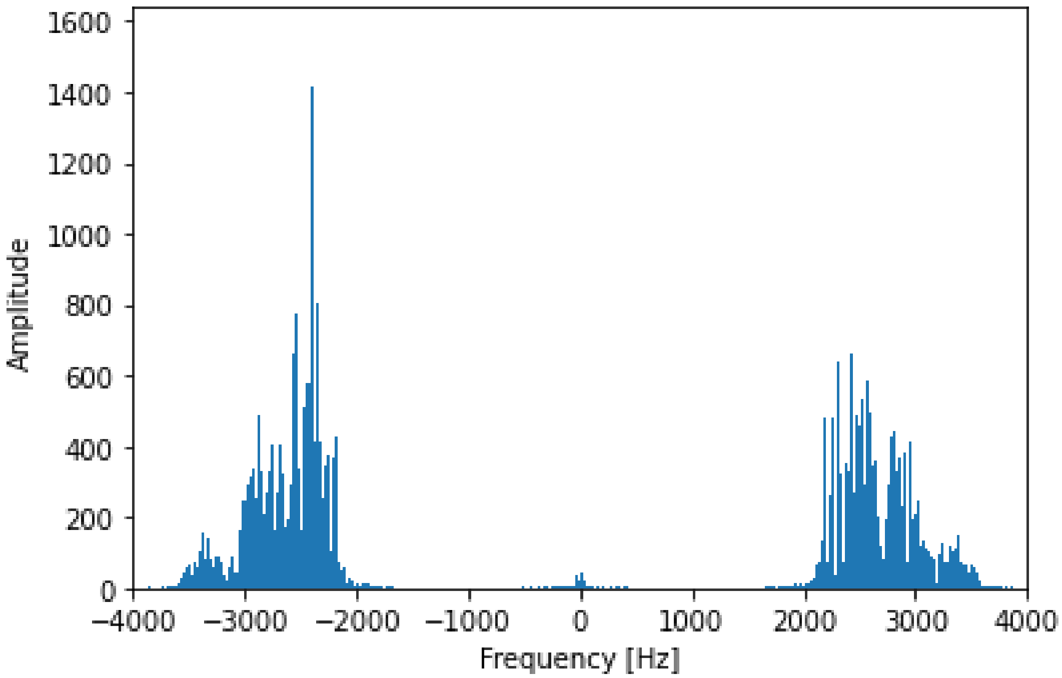
```
plt.show()
```

```
/tmp/ipykernel_2181/3934395783.py:9: WavFileWarning: Chunk (non-data) not
understood, skipping it.
  samplerate, data = wavfile.read('mistle_thrush.wav')
```

```
T =  2.1609166666666666
```



[8]:
```
plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('Amplitude')
plt.xlim(-4000,4000)
plt.show()
```



Vi kan se fra plottene at interesseområdet blir på en frekvens fra 2kHz til litt i underkant av 4kHz.

[9]:
```
print('sampling frequency = ',f_s)
```

```
sampling frequency =  48000
```

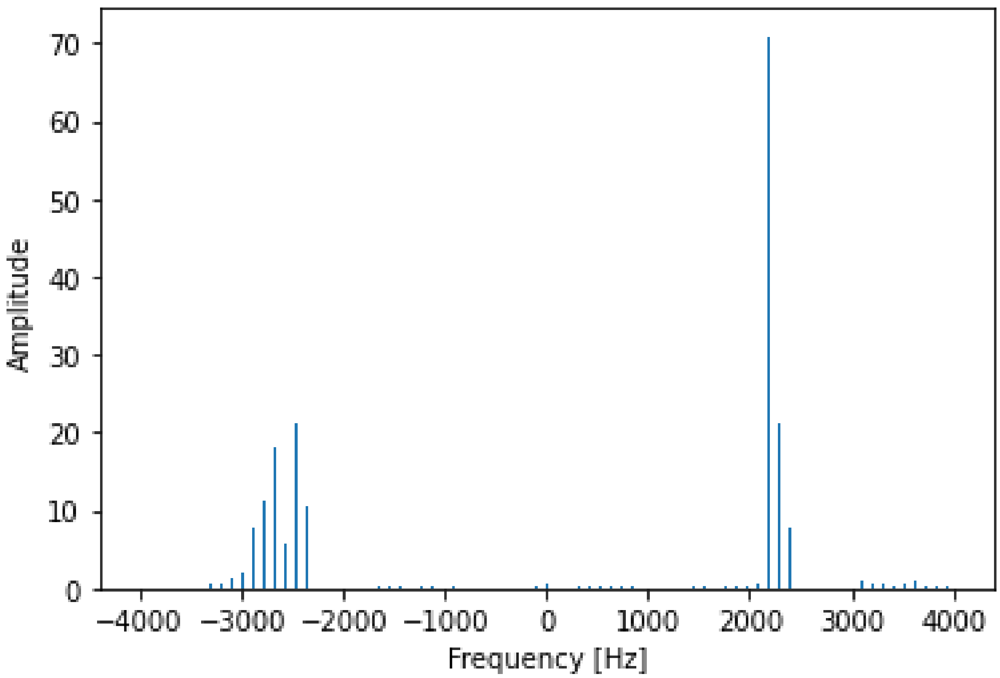
1.4.2 b)

Vi ser at samplingsfrekvensen $f_s = 48\text{kHz}$.

[12]:
```
f_nyquist = 8000
N_subsample = int(f_s/f_nyquist)
print('N_subsample:',N_subsample)

index_0 = int(0.8/dt) #lowest required index
index_max = int(1/dt) #highest required index
print('index0:',index_0,'index_max:',index_max)

x_new_range = x_n[index_0:index_max:N_subsample]
print('len x_new_range:',np.shape(x_new_range))

T = 0.2 #duration of signal

N = len(x_new_range)
dt = T/N
print('T:',T,'dt:',dt,'N:',N)
```

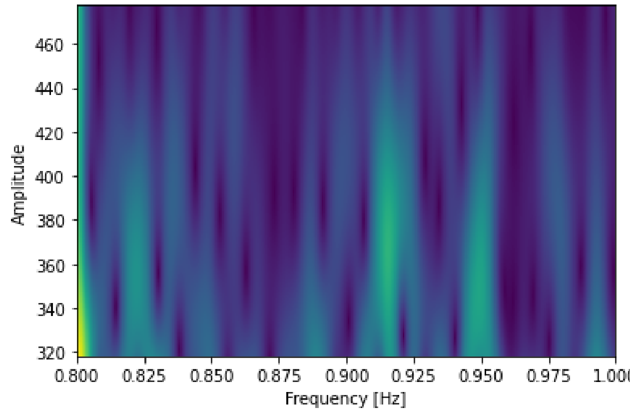
```
x_fourier = fft.fft(x_new_range)
print('len x_fourier:',len(x_fourier))
f_array = fft.fftfreq(N,dt)
print('len f_array:',len(f_array))
plt.bar(f_array,np.abs(x_fourier))
plt.xlabel('Frequency [Hz]')
plt.ylabel('Amplitude')
plt.show()
```

```
N_subsample: 6
index0: 38400 index_max: 48000
len x_new_range: (1600,)
T: 0.2 dt: 0.000125 N: 1600
len x_fourier: 1600
len f_array: 1600
```

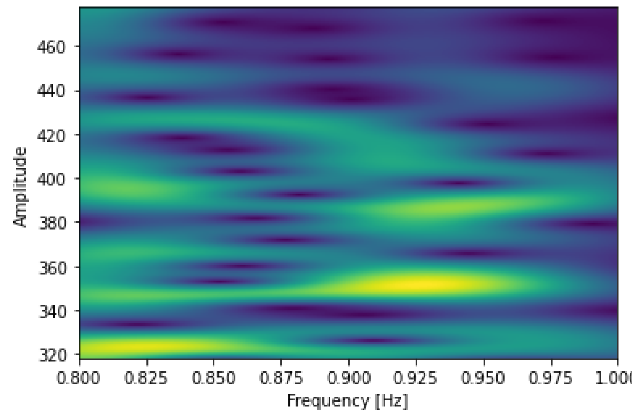


[17]:
```
# implementer morlet wavelet i tidsdomenetet
def wavelet_td(omegaa, K, tk, tn):
    psi = C*( np.exp(-1j*omegaa*(tn-tk)) - np.exp(-K**2))*np.
 ↪exp(-omegaa**2*(tn-tk)**2/(2*K)**2)
    return psi # returner wavelet¨en, for gitte parametre

# wavelet transformen (i tidsdomenet)
def wavelet_transform_td(t, tk, xn, omegaa, K, N):
```

```python
    A =  wavelet_td(omegaa,K,tk,t)
    gamma = np.zeros(N, dtype=np.complex )
    gamma = np.sum(np.conjugate(A)*xn)
    return gamma # returnerer gamma, for en gitt omegaa
# diagramfunksjon (felles for tids- og Fourierdomenet)

def wavelet_diagram(t, xn, omega_range, K, N):
    M = len(omega_range)
    diagram = np.zeros((M,N),dtype=np.complex)
    tk = t.copy()
    for i in range(N):
        for j in range(M):
            diagram[j,i] = wavelet_transform_td(t,tk[i], xn,omega_range[j],K,N)
    return diagram # returnerer et 2D diagram for en gitt K
# generere og plotte wavelets
K_vals = [6, 60]
tk = 0
C = 1
t = np.linspace(0.8,1,N)
for K in K_vals:
    omegas = np.linspace(2000,3000, N)# definere hvike analysefrekvenser du vil␣
 ↪bruke her
    waveletDiagram6 = wavelet_diagram(t, x_new_range, omegas, K, N) # dette␣
 ↪kallet gir ut en 2D diagram, og en gitt tidserie, valgt K-verdi og set av␣
 ↪ønskete omegas
    plt.pcolormesh(t, omegas / 2.0 / np.pi, np.absolute(waveletDiagram6),␣
 ↪shading='auto')
    plt.text(0.6,100,f'K={K}')
    plt.xlabel('Frequency [Hz]')
    plt.ylabel('Amplitude')
    plt.show()
```


460
440
420
400
380
360
340
320
Amplitude
0.800
0.825
0.850
0.875
0.900
0.925
0.950
0.975
1.000
Frequency [Hz]

K=6



K=60

Jeg synes det er vanskelig å forstå hva disse plottene mine betyr. Det virker som at fuglesangen er litt komplisert generelt sett.