# Problem Set 5

## Research method Problem Set 5 due Wed 5th Dec, 23:59

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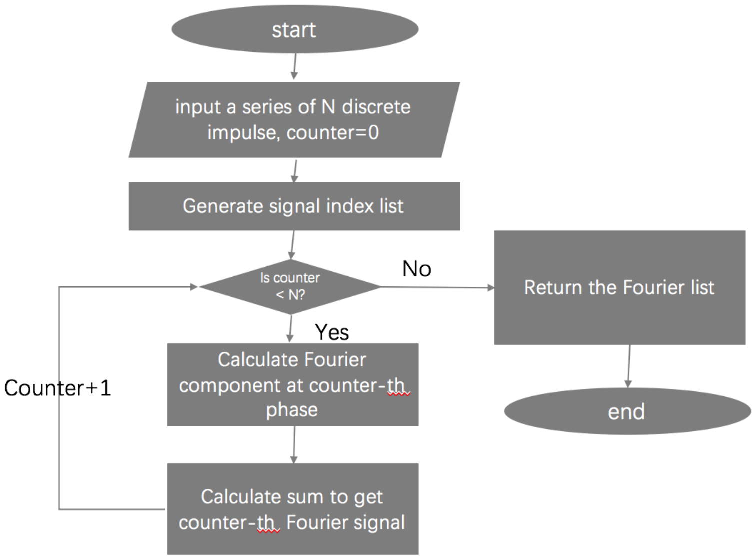
For Problem Set 5, I use the following packages:

```
import matplotlib.pyplot as plt

import numpy as np

import scipy as sp

import scipy.stats as ss

from scipy.fftpack import fft, ifft
```

## Problem 1

Answer:

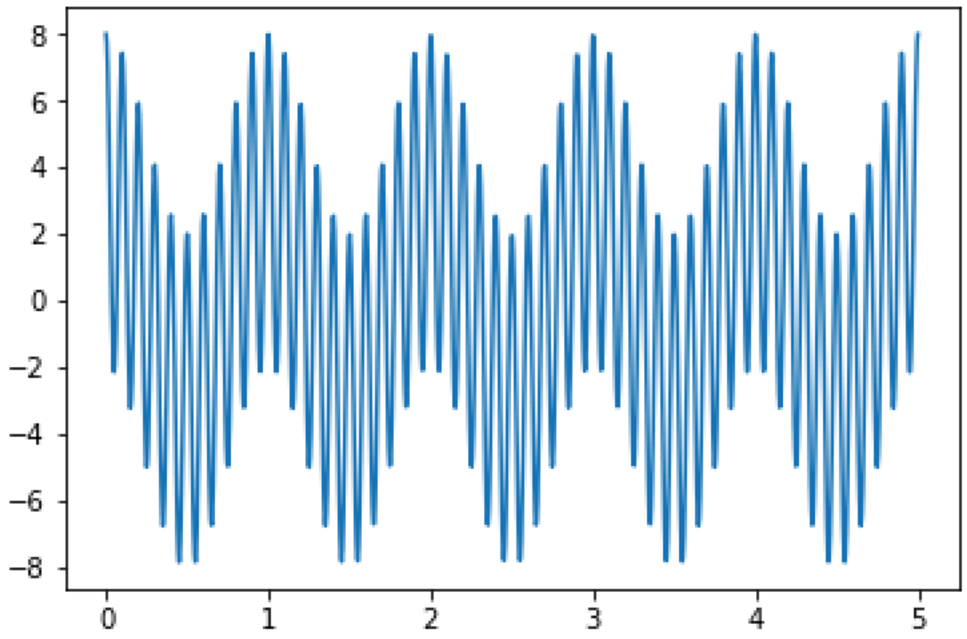
a)


start
input a series of N discrete impulse, counter=0
Generate signal index list
Is counter < N?
No
Yes
Return the Fourier list
Calculate Fourier component at counter-th phase
Counter+1
end
Calculate sum to get counter-th Fourier signal

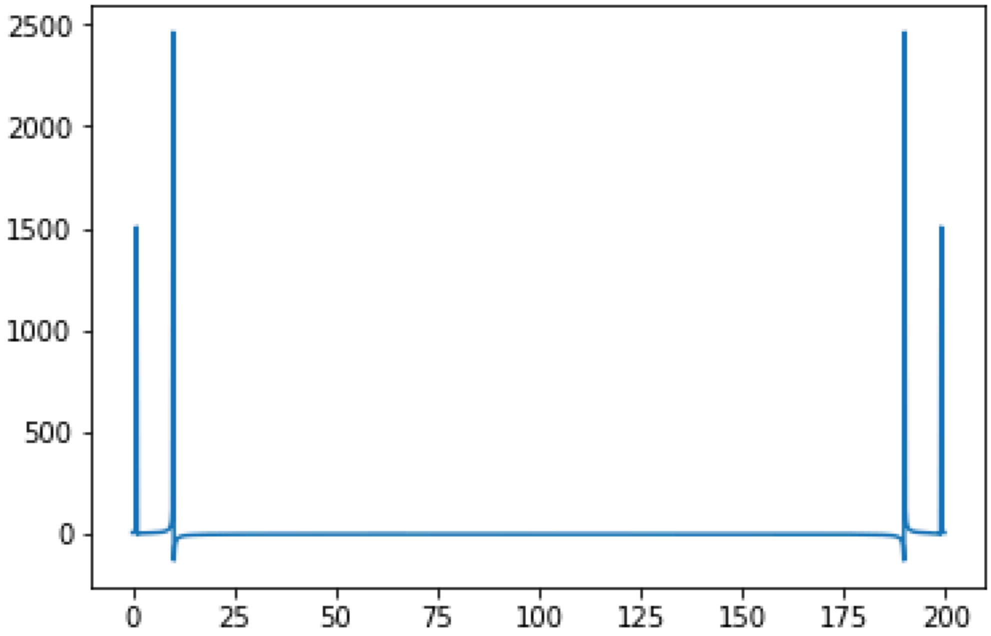
b)

```
sample_num=1000

x=np.linspace(0,5,sample_num)

y=5*np.cos((20*np.pi)*x) + 3*np.cos((2*np.pi)*x)

Maxtime=5.

timestep=Maxtime/sample_num

FreqStep =1./( Maxtime )

w=np.fft.fft(y)

plt.figure()

plt.plot(x,y)
```

I draw 5 seconds plot and the figure is shown in :



c)



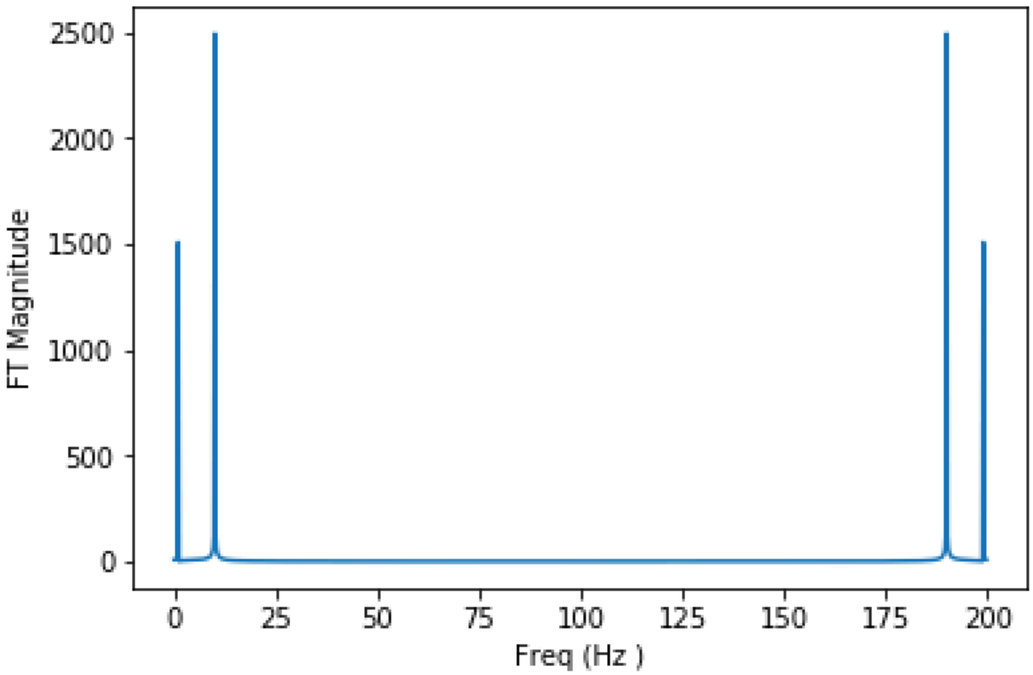
```
sample_num=1000

x=np.linspace(0,5,sample_num)

y=5*np.cos((20*np.pi)*x) + 3*np.cos((2*np.pi)*x)

Maxtime=5.

timestep=Maxtime/sample_num

FreqStep =1./( Maxtime )

freq =[]

for i in range(sample_num):

        freq.append(i*FreqStep)

def nativeFFT(x):

        size = len(x)

        samples = np.arange(0, size)
```

```
    res = []
    for i in samples:
        res.append(sum(np.exp(-samples * i * 2.0 * np.pi * 1j/size) * y))
    return res
ab = (nativeFFT(y))
plt.plot(freq, ab)
```

d)

```
sample_num=1000
x=np.linspace(0,5,sample_num)
y=5*np.cos((20*np.pi)*x) + 3*np.cos((2*np.pi)*x)
Maxtime=5.
timestep=Maxtime/sample_num
FreqStep =1./( Maxtime )
freq =[]
for i in range(sample_num):
    freq.append(i*FreqStep)
w= np.fft.fft(y)
mag=[]
for line in w:
    mag.append(np.linalg.norm(line))
plt.figure()
plt.plot(freq , mag)

plt.xlabel('Freq (Hz )')

plt.ylabel('FT Magnitude')
```

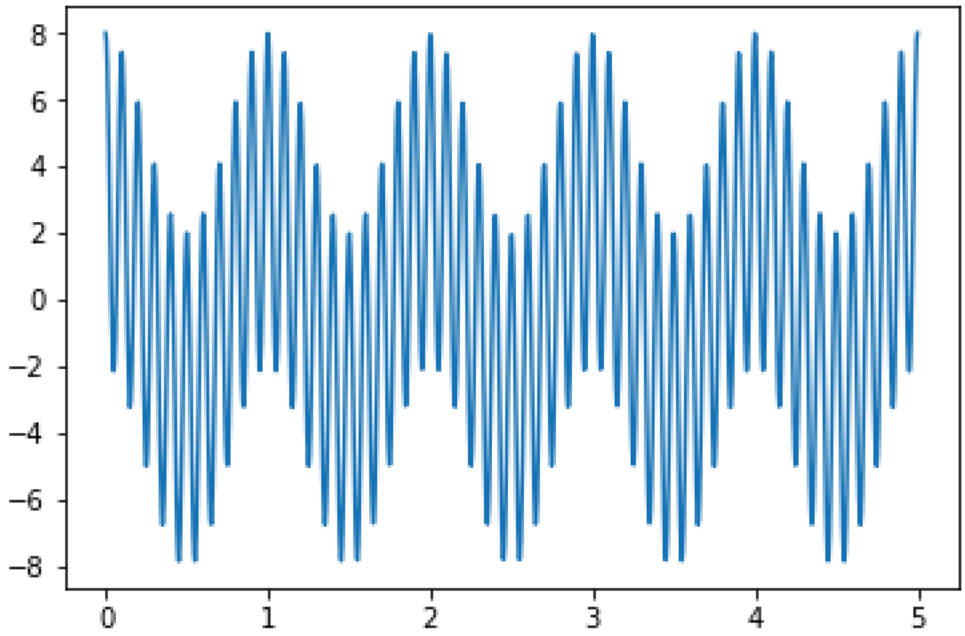
The result is :



e)

```
from scipy.fftpack import fft, ifft

plt.figure()

plt.plot(x, ifft(w))
```

The result is:



## Problem 2

Answer:

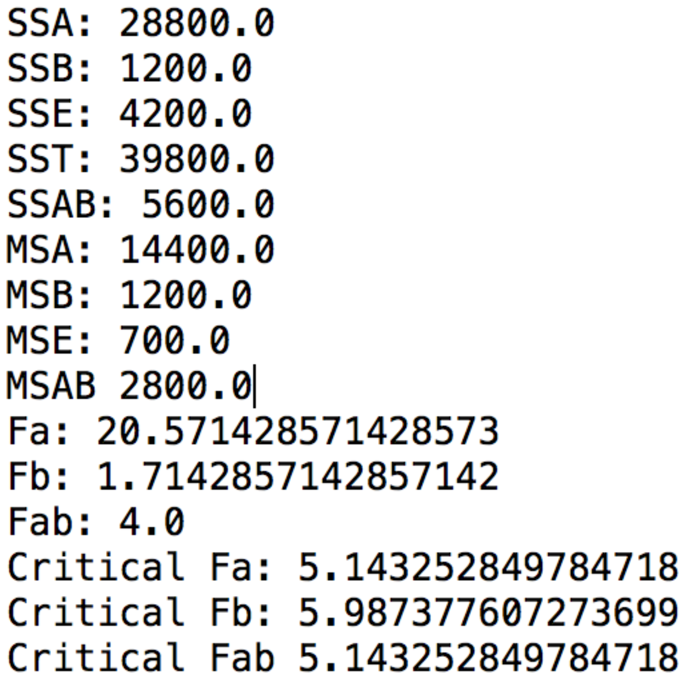
```
def twoFactor():

        data =
[[[100,140],[180,140]],[[230,210],[160,200]],[[310,270],[210,250]]]

        size_data = len(data)

        size_data_row = len(data[0])

        size_data_unit = len(data[0][0])

        DoF1 = size_data-1

        DoF2 = size_data_row-1

        DoF3 = (size_data-1)*(size_data_row-1)

        DoF4 = size_data * size_data_row * (size_data_unit-1)
```

```
    mean1 = []
    for i in range(size_data):
        mean1.append(np.mean(data[i]))

    mean2 = []
    for i in range(size_data_row):
        tmp = []
        for j in range(size_data):
            tmp.append(data[j][i])
        mean2.append(np.mean(tmp))

    SSA = size_data_row * size_data_unit * np.var(mean1) * len(mean1)
    SSB = size_data * size_data_unit * np.var(mean2) * len(mean2)
    sse_list = []
    for j in range(size_data_row):
        for i in range(size_data):
            sse_list.append(len(data[i][j])*np.var(data[i][j]))
    SSE = sum(sse_list)
    SST = np.var(data) * size_data * size_data_row * size_data_unit
    SSAB = SST – SSA – SSB - SSE
```

```
print 'SSA:',SSA
print 'SSB:',SSB
print 'SSE:',SSE
print 'SST:',SST
print 'SSAB:',SSAB

MSA = SSA/(size_data-1.0)
MSB = SSB/(size_data_row-1.0)
MSAB = SSAB/((size_data-1.0) * (size_data_row-1.0))
MSE = SSE/(size_data * size_data_row * (size_data_unit-1))
print 'MSA:',MSA
print 'MSB:',MSB
print 'MSE:',MSE
print 'MSAB',MSAB

Fa = MSA/MSE
Fb = MSB/MSE
Fab = MSAB/MSE
Fac = ss.f.ppf(0.95, DoF1, DoF4)
Fbc = ss.f.ppf(0.95, DoF2, DoF4)
Fabc = ss.f.ppf(0.95, DoF3, DoF4)
print 'Fa:', Fa
```

```
    print 'Fb:', Fb

    print 'Fab:', Fab

    print 'Critical Fa:', Fac

    print 'Critical Fb:', Fbc

    print 'Critical Fab', Fabc

twoFactor()
```

The result is :



```
SSA: 28800.0
SSB: 1200.0
SSE: 4200.0
SST: 39800.0
SSAB: 5600.0
MSA: 14400.0
MSB: 1200.0
MSE: 700.0
MSAB 2800.0
Fa: 20.571428571428573
Fb: 1.7142857142857142
Fab: 4.0
Critical Fa: 5.143252849784718
Critical Fb: 5.987377607273699
Critical Fab 5.143252849784718
```

From the results, only Fa > critical Fa so factor A would be significant.

**Problem 3**

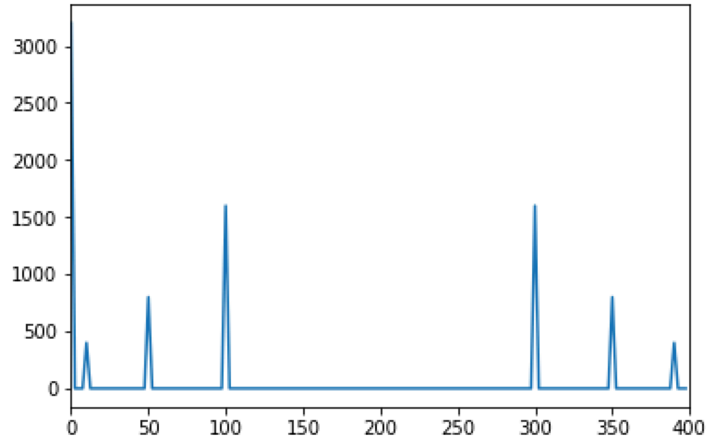
Answer:

The max frequency is 100 and the question need to plot 0.4s so the twice minimum sample point is 100*0.4*2*2 = 160

a)

```
Ns= 160 #number of samples

time = np.linspace(0, 0.4, Ns, endpoint = False)

y=20 + 10*np.cos((2*np.pi)*50*time) + 5*np.cos((2*np.pi)*10*time) + 20*np.cos((2*np.pi)*100*time)

Maxtime = 0.4

timestep = Maxtime/Ns

FreqStep =1./( Maxtime )

freq =[]

for i in range(Ns):

        freq.append (i*FreqStep)

w = np.fft.fft(y)

plt.figure()

plt.plot(freq ,w)

plt.xlim (0, 400)
```

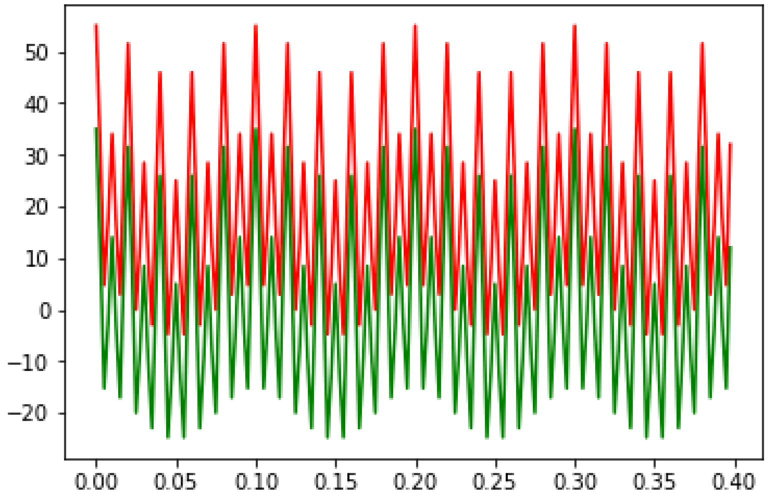
The result is below and there are 7 Fourier components (including 4 components presented at lower Hz and other higher 3 components are symmetry components).



b)

```
def window(freq, spec, f):

        F_spec=spec

        F_spec[f]=0

        return F_spec

filtered0 = window(freq, w, 0)

plt.figure()

plt.plot(freq, filtered0)

plt.xlim (0 ,400)

plt.figure()

plt.plot(time,y, 'r')

F_spec= np.fft.ifft(filtered0)

plt.plot(time, F_spec, 'g')
```

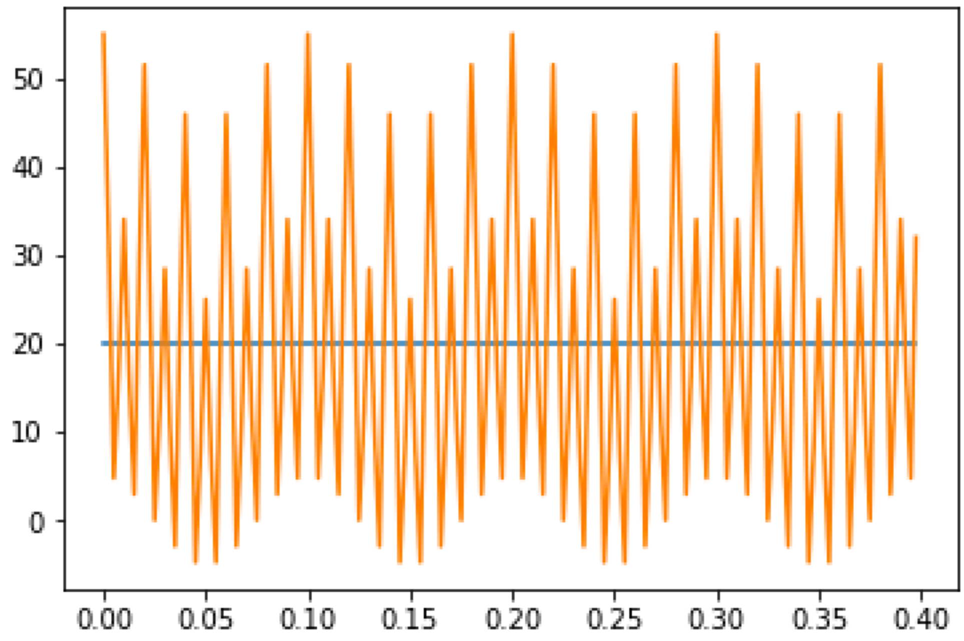
window() function can remove the 0 hz from the frequency spectrum. Then, I use ifft to replot against f() and the red one is before and green one is after.



c)

```
Ns= 160 #number of samples

time = np.linspace(0, 0.4, 160, endpoint = False)

y=20 + 10*np.cos((2*np.pi)*50*time) + 5*np.cos((2*np.pi)*10*time) + 20*np.cos((2*np.pi)*100*time)

FreqStep = 1./0.4

freq = np.arange(0,len(time)*FreqStep,FreqStep)

f = [sum(np.exp(-time*i*2*np.pi*1j)*y) for i in freq]

y_removeTime = np.fft.ifft(f * (freq==0))

plt.figure()

plt.plot(time, y_removeTime)

plt.plot(time, y)
```

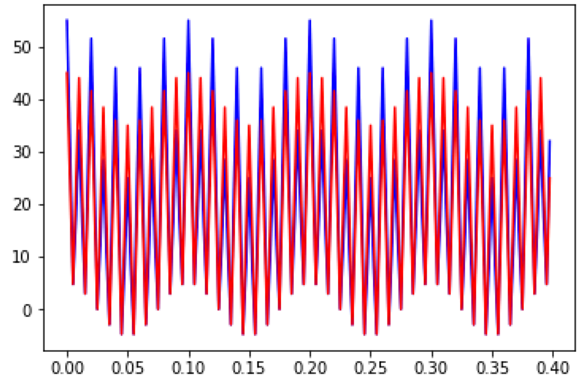
The result is shown below, the orange one is for previous f(t) and the blue straight line is for removing time varying signal.



d)

```
def window(freq, spec, f0):
    indx0 = freq.index(f0)
    F_spec=spec
    F_spec[indx0]=0
    indx0 = freq.index(f0)
    indx02 = len(freq) - indx0
    F_spec[indx02] = 0
    return F_spec
filtered50 = window (freq, w, 50)
plt.figure()
plt.plot(time, y, 'b')
F_spec=np.fft.ifft(filtered50)
plt.plot(time, F_spec, 'r')
```

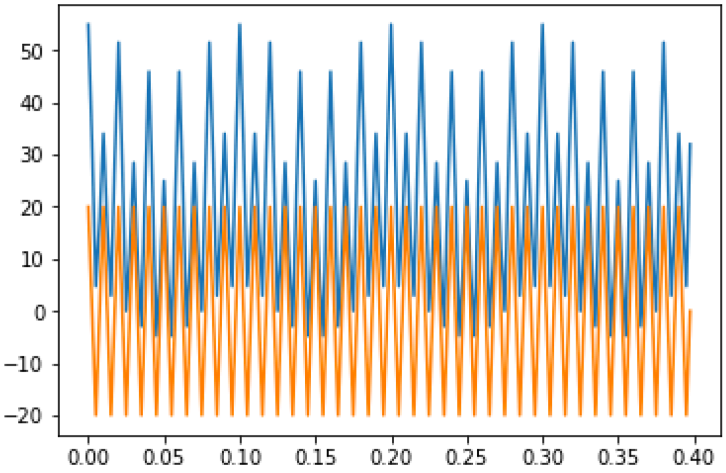
The result is shown below, the blue one is for previous figure and the read one is after removing 50 Hz, and if I need to remove 50 Hz and 350 Hz also needs to be removed.



e) If removing the below 100 Hz, the range above 300 Hz also needs to be removed.

```
def window(freq, spec, f0):
    indx0 = freq.index(f0)
    indx02 = len(freq) - indx0
    F_spec=spec
    F_spec[0: int( indx0 )]=0
    F_spec[indx02+1: len(freq)]=0
    return F_spec


filtered50 = window (freq, w, 100)
plt.figure()
plt.plot(time,y)
F_spec=np.fft.ifft(filtered50)
plt.plot(time, (F_spec))
```

The result is below and the blue one is before and orange one is after.


50
40
30
20
10
0
−10
−20
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40