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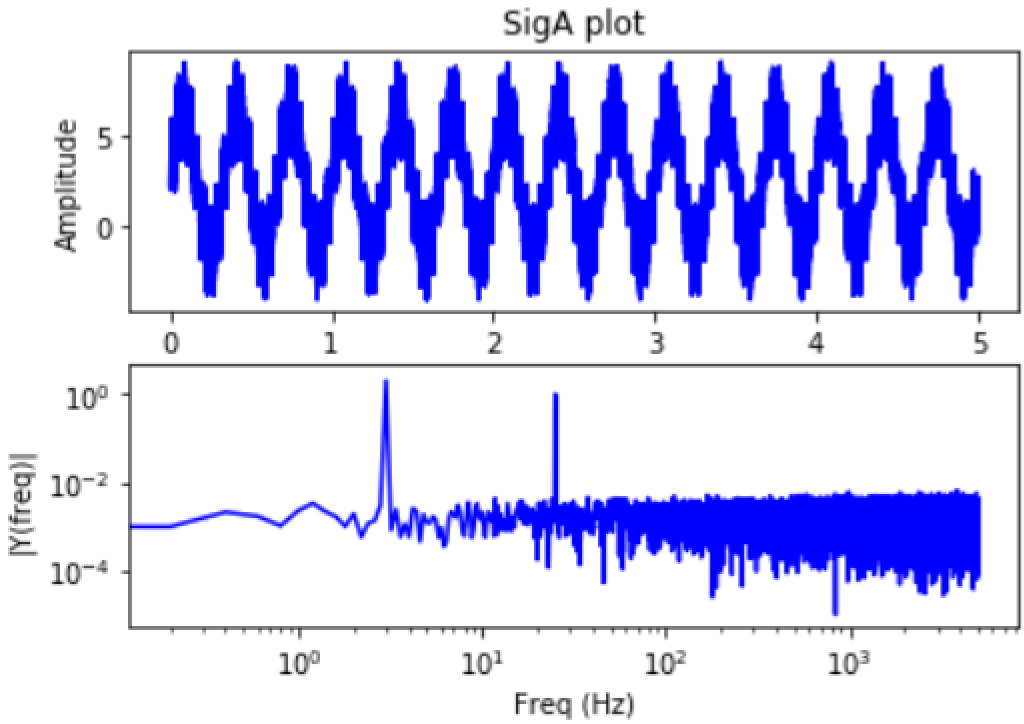
ME 433

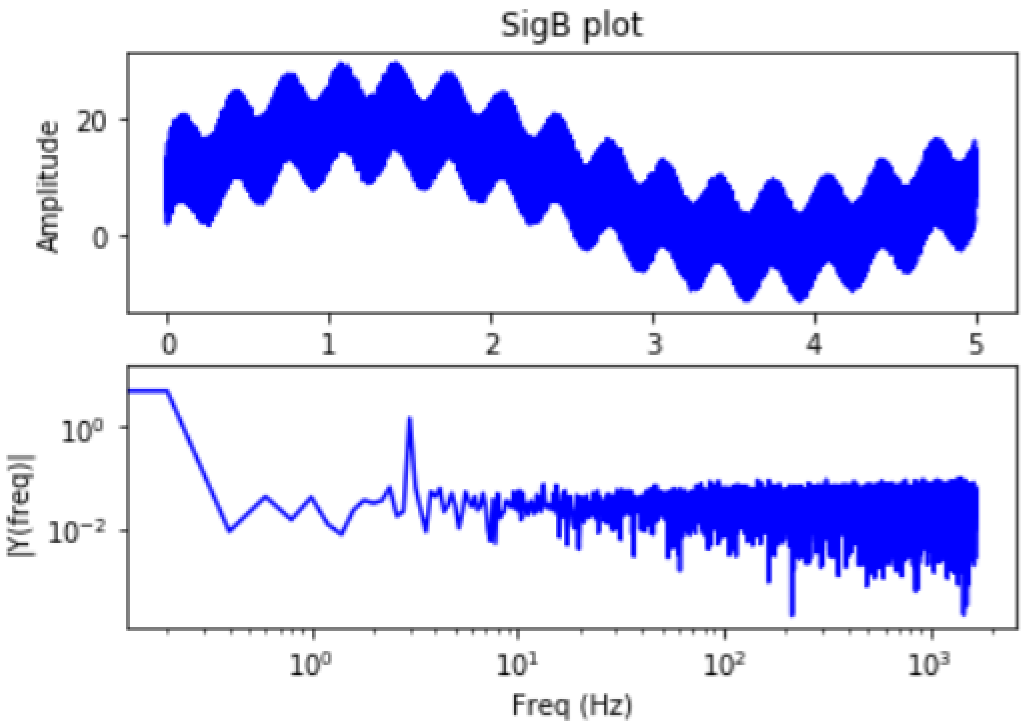
Note: Wasn't sure what signal was wanted for some of these plots. For example for sigB it appears to be the combination of 2 sin waves, the plot was smoothed so that both were visible. For sigD I used values which kept the oscillations and just smoothed them out. Code is also in the separate jupyter notebook.

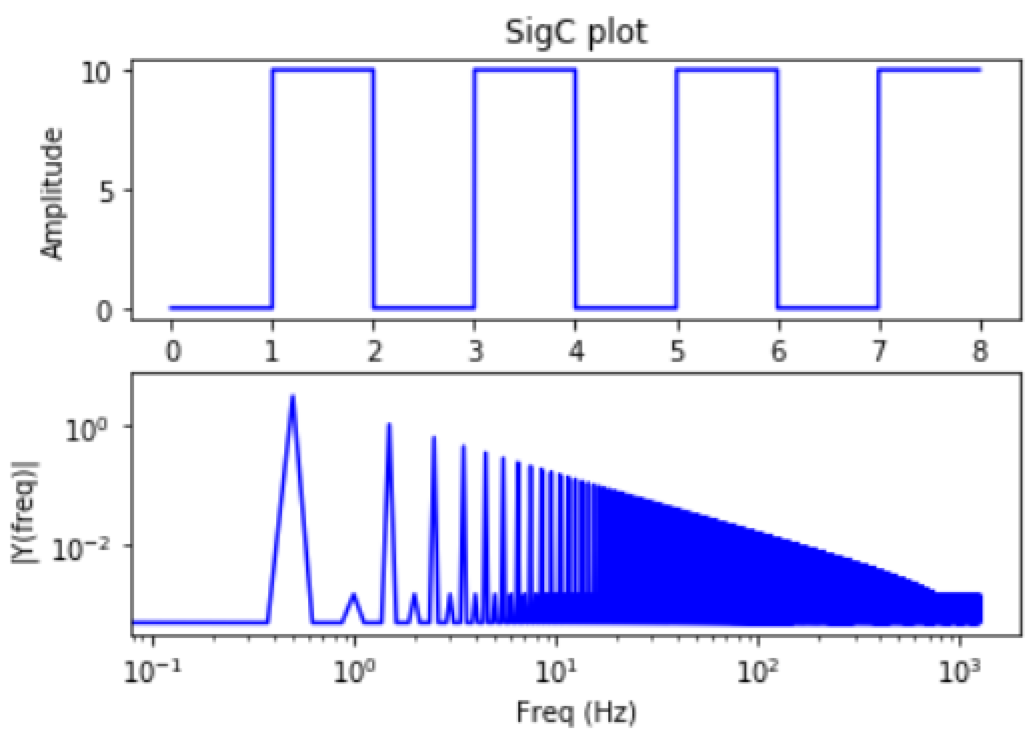
Question 4:

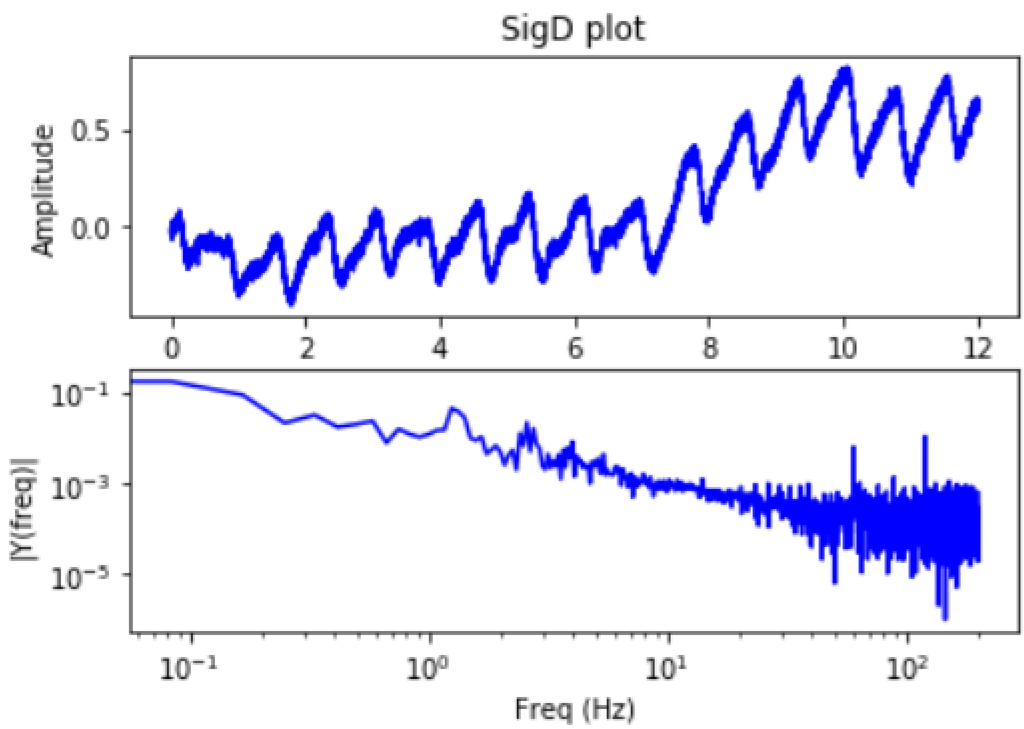
```
#question 4
import matplotlib.pyplot as plt
import numpy as np
import csv

t = [] # column 0
data1 = [] # column 1
data2 = [] # column 2

with open('sigA.csv') as f:
    # open the csv file
    reader = csv.reader(f)
    for row in reader:
        # read the rows 1 one by one
        t.append(float(row[0])) # leftmost column
        data1.append(float(row[1])) # second column
        #data2.append(float(row[2])) # third column
endtime=t[-1]
print(endtime)
nsamples=len(data1)
print(nsamples)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)
print(sam_rate)

Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,t[-1],Ts) # time vector
y = data1 # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs
frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,y,'b')
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax2.loglog(frq,abs(Y),'b') # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
```

```
plt.show()
```




SigB plot
Amplitude
20
0
0
1
2
3
4
5
|Y(freq)|
10^0
10^{-2}
10^0
10^1
10^2
10^3
Freq (Hz)


SigC plot
Amplitude
10
5
0
0
1
2
3
4
5
6
7
8
|Y(freq)|
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Freq (Hz)

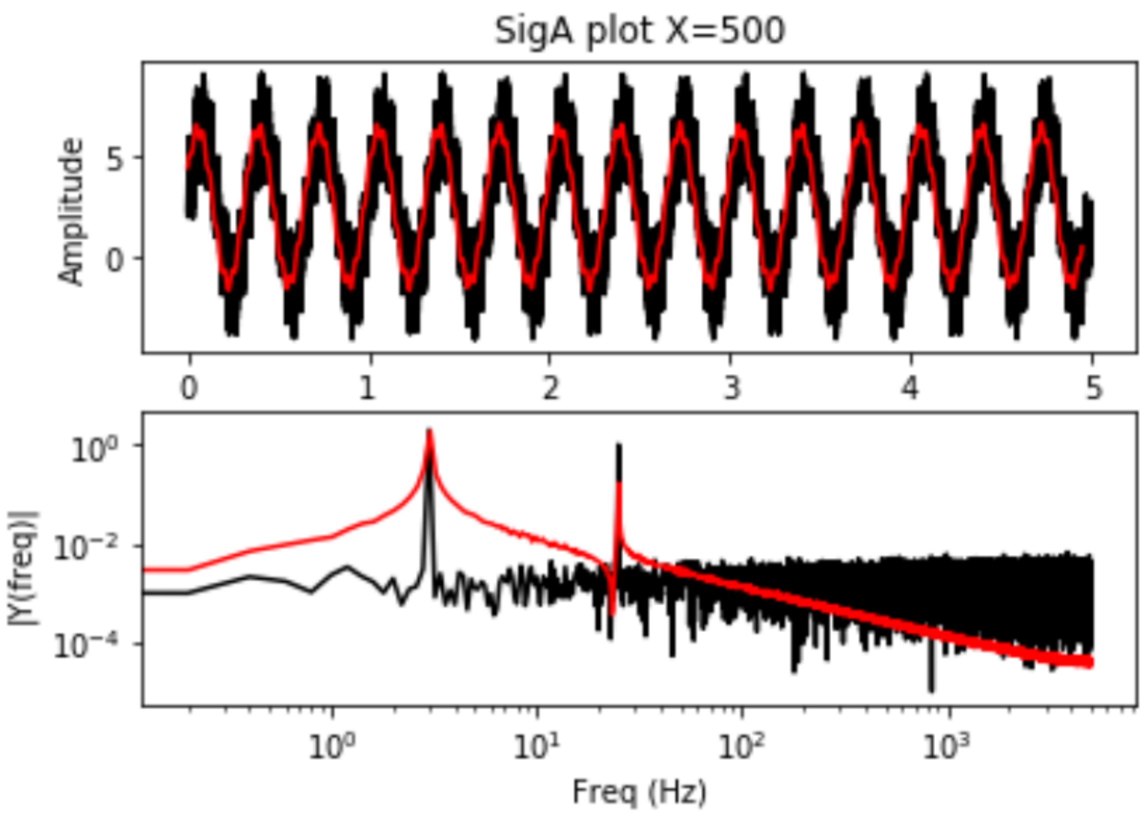


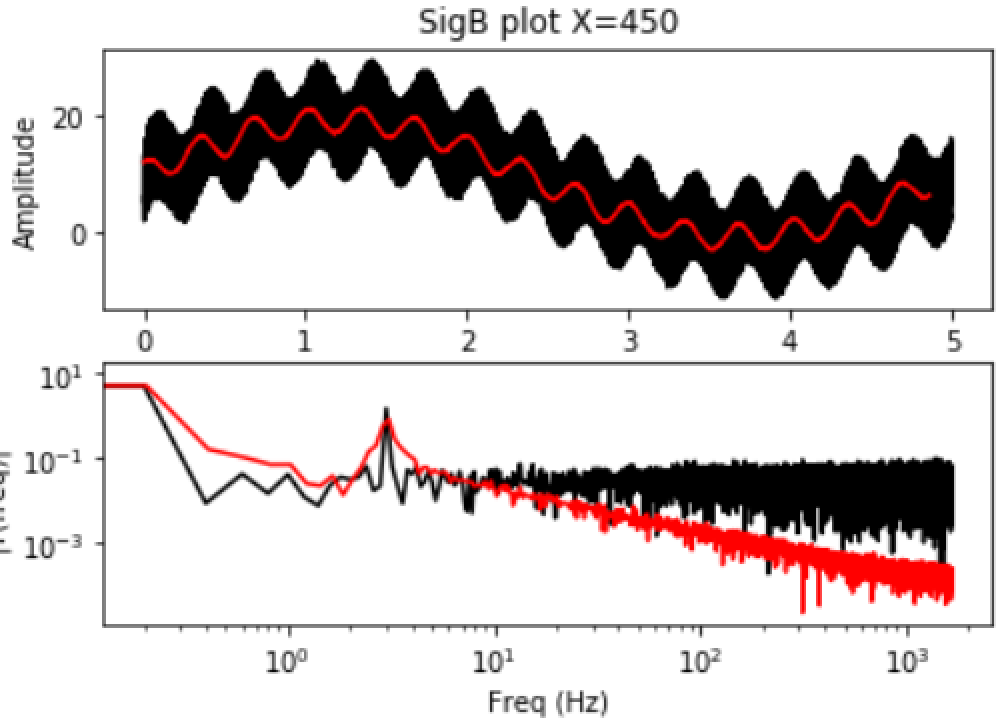
Question 5 MAF Transform:

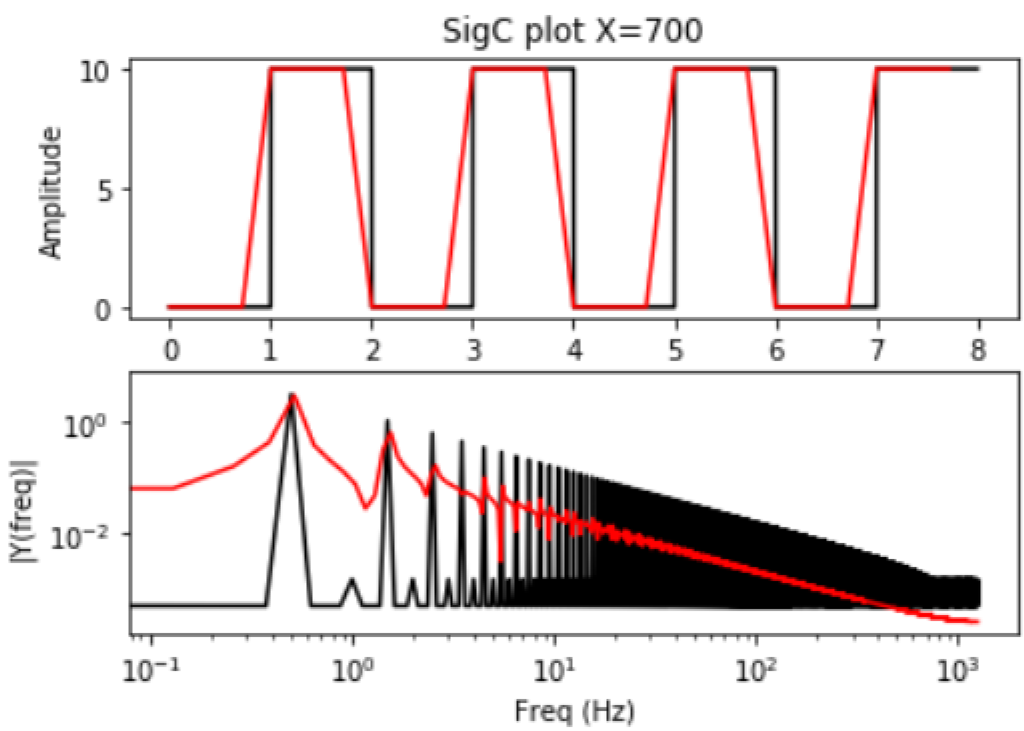
```
#question 5
import matplotlib.pyplot as plt
import numpy as np
import csv

t = [] # column 0
data1 = [] # column 1
data2 = [] # column 2
X=500;
newdata=[]#the averaged vector
newtime=[]#the shortened time vector
tempdata=0;#the temporary averaged value

with open('sigC.csv') as f:
    # open the csv file
    reader = csv.reader(f)
    for row in reader:
        # read the rows 1 one by one
        t.append(float(row[0])) # leftmost column
        data1.append(float(row[1])) # second column
        #data2.append(float(row[2])) # third column

    for i in range(0,(len(data1)-X)):
        tempdata=0
        for ii in range(0,X):
            tempdata=tempdata+data1[i+ii]
        newdata.append(tempdata/X)
        newtime.append(t[i])
```

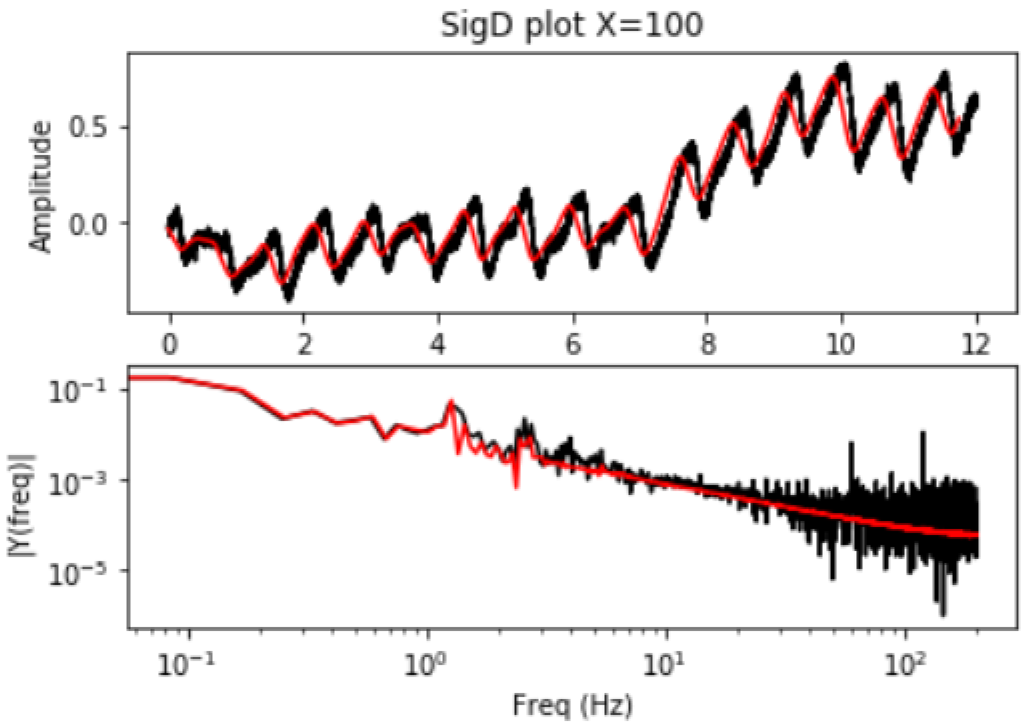
```
#unfiltered data
endtime=t[-1]
nsamples=len(data1)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)


Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,t[-1],Ts) # time vector
y = data1 # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs

frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,y,color="black")
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax1.set_title('Unfiltered sample')
ax2.loglog(frq,abs(Y),color="black") # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
plt.show()
y2=y
Y2=Y
frq2=frq
endtime=newtime[-1]
nsamples=len(newdata)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)

Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,newtime[-1],Ts) # time vector
y = newdata # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs
frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,y2,color="black")
ax1.plot(newtime,y,'r-')
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax1.set_title('Filtered sample X='+str(X))
ax2.loglog(frq2,abs(Y2),color="black") # plotting the fft
```

```
ax2.loglog(frq,abs(Y),'r-') # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
plt.show()
```




SigB plot X=450
Amplitude
20
0
0
1
2
3
4
5
|Y(freq)|
10^1
10^{-1}
10^{-3}
10^0
10^1
10^2
10^3
Freq (Hz)


SigC plot X=700
Amplitude
10
5
0
0
1
2
3
4
5
6
7
8
|Y(freq)|
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Freq (Hz)

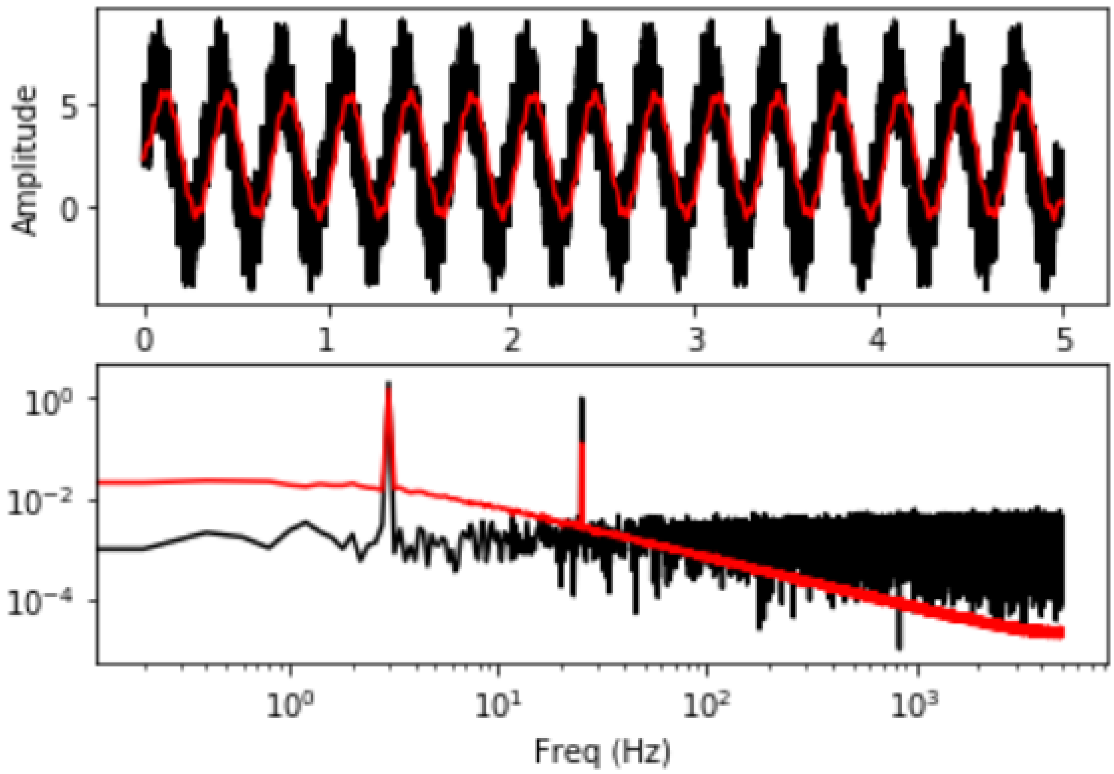


Question 6: IIR filter

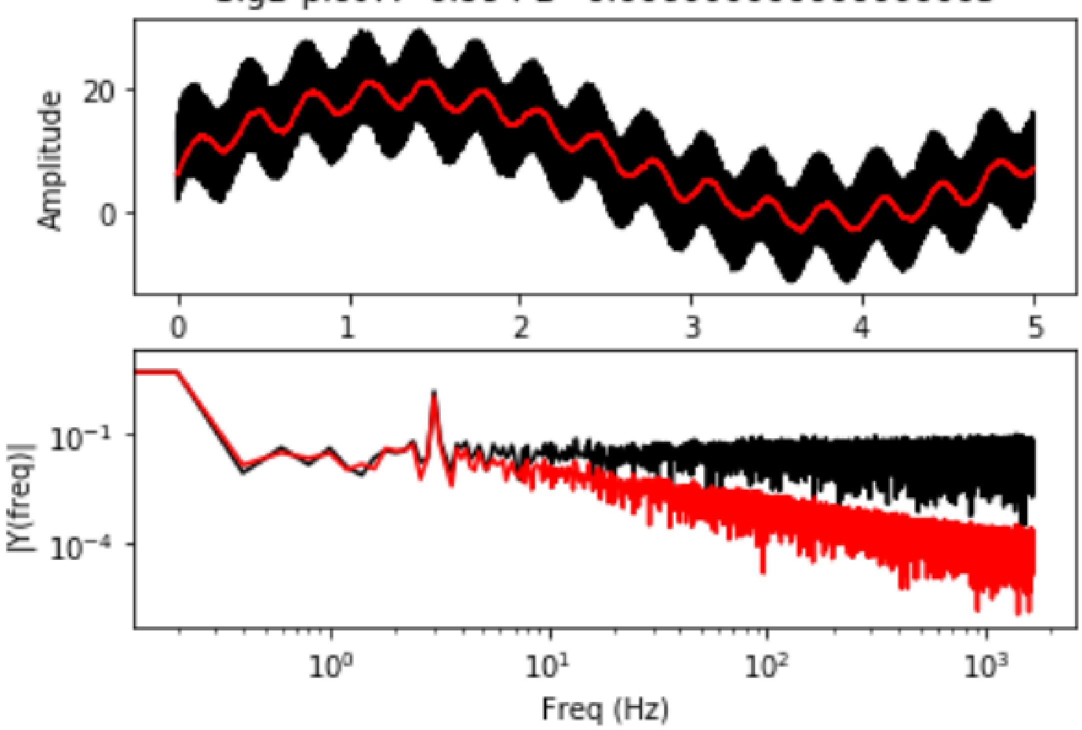
```
#question 6
import matplotlib.pyplot as plt
import numpy as np
import csv

t = [] # column 0
data1 = [] # column 1
data2 = [] # column 2
A=.95
B=1-A
with open('sigD.csv') as f:
    # open the csv file
    reader = csv.reader(f)
    for row in reader:
        # read the rows 1 one by one
        t.append(float(row[0])) # leftmost column
        data1.append(float(row[1])) # second column
        #data2.append(float(row[2])) # third column
endtime=t[-1]
nsamples=len(data1)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)



newdata=[]#the new vector
new_avg=data1[0]
for i in range(0,len(data1)):
    new_avg=A*new_avg+B*data1[i]
```

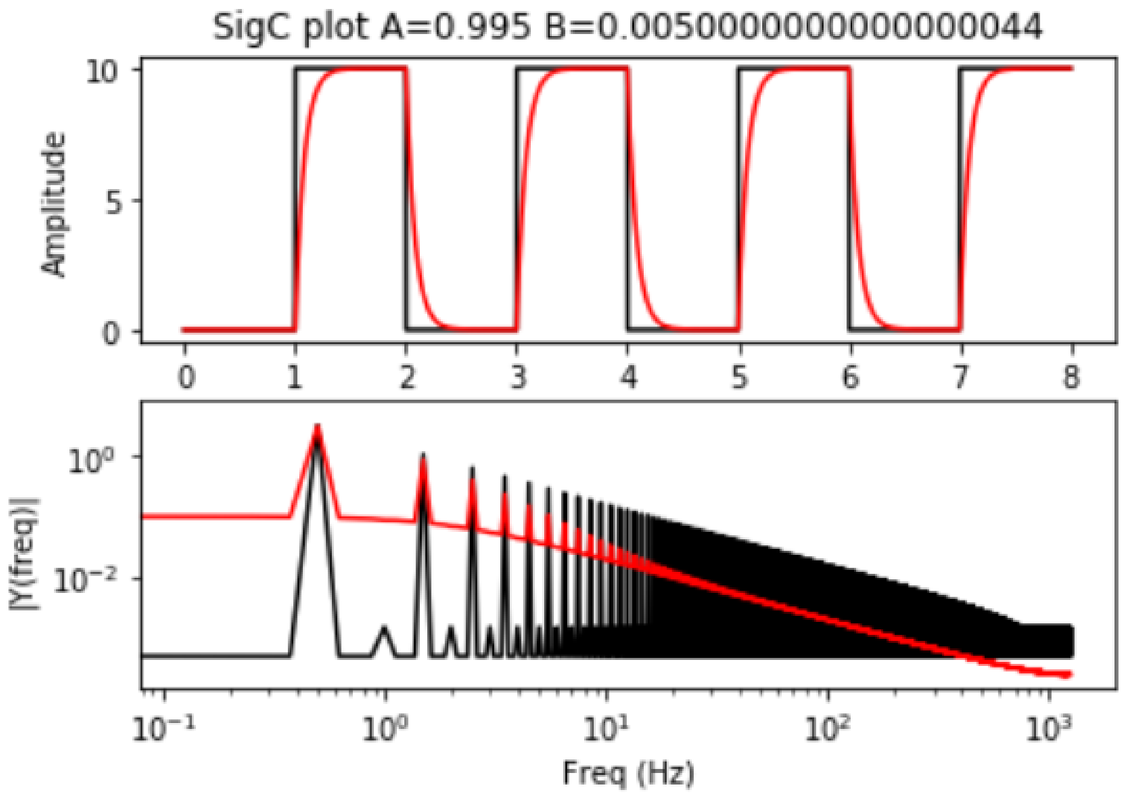
```
    newdata.append(new_avg)


Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,t[-1],Ts) # time vector
y = data1 # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs
frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,t[-1],Ts) # time vector
y = newdata # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs
frq2 = k/T # two sides frequency range
frq2= frq[range(int(n/2))] # one side frequency range
Y2 = np.fft.fft(y)/n # fft computing and normalization
Y2 = Y2[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,data1,color="black")
ax1.plot(t,newdata,color="red")
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax1.set_title('SigD plot A='+str(A)+" B="+str(B))
ax2.loglog(frq,abs(Y),color="black") # plotting the fft
ax2.loglog(frq2,abs(Y2),color="red") # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
plt.show()
```

SigA plot A=0.998 B=0.0020000000000000018

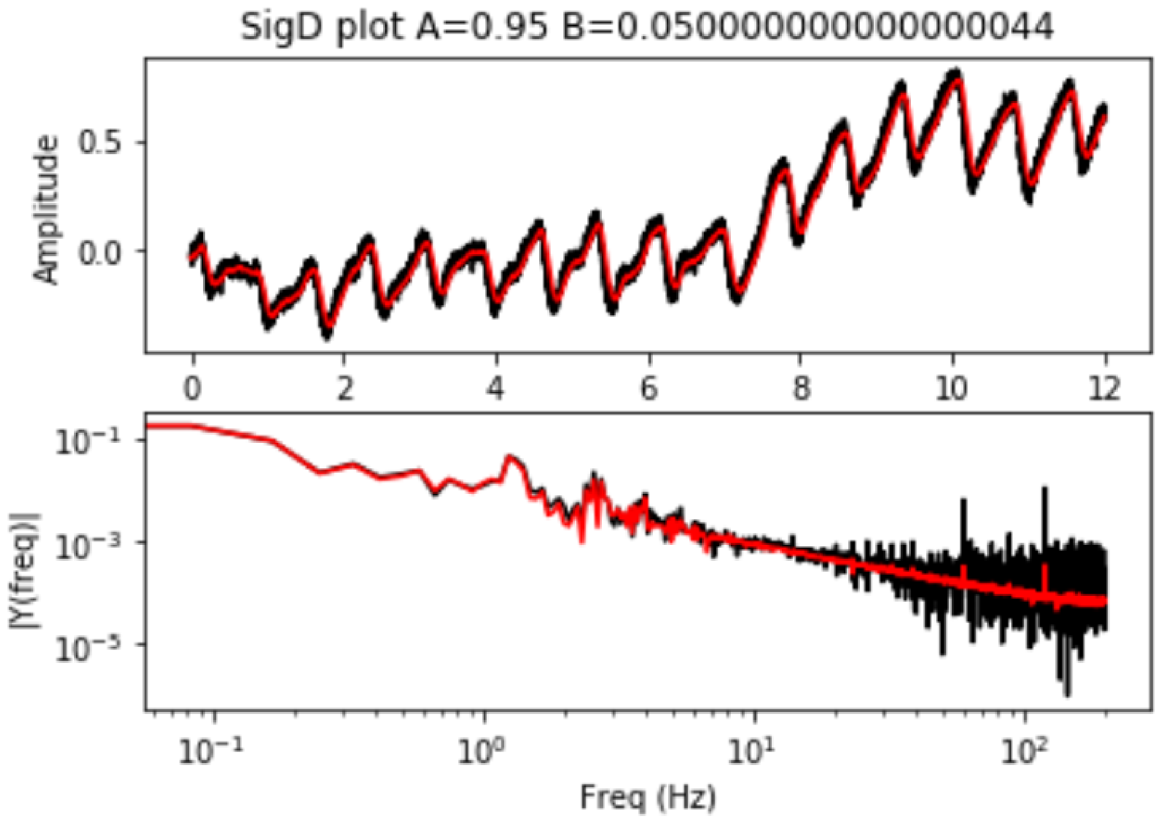


SigB plot A=0.994 B=0.0060000000000000005





SigC plot A=0.995 B=0.005000000000000044
Amplitude
10
5
0
0
1
2
3
4
5
6
7
8
|Y(freq)|
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Freq (Hz)



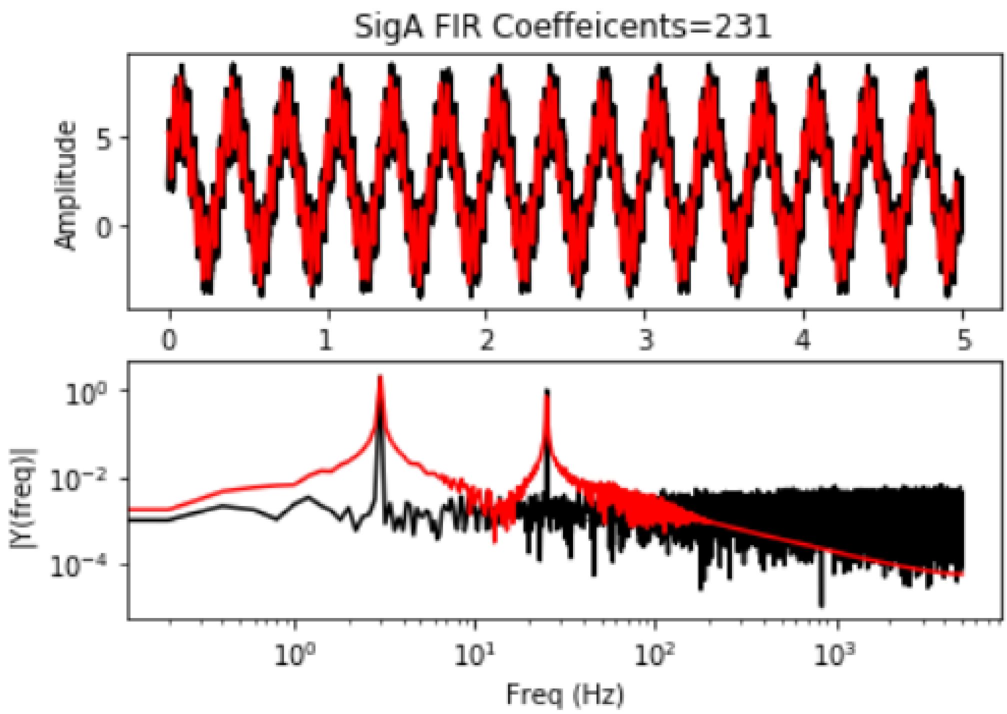

```
#question 7 FIR Response (SIG A data loaded
import matplotlib.pyplot as plt
import numpy as np
import csv

t = [] # column 0
data1 = [] # column 1
data2 = [] # column 2

newdata=[]#the averaged vector
newtime=[]#the shortened time vector
tempdata=0;#the temporary averaged value
Constants=[] #The FIR contstants
h = [
    0.000000000000000000,
    0.000009291614166548,
    0.000050548523936133,
    0.000082648554461720,
    0.000000000000000000,
    -0.000263718332932162,
    -0.000598895948257723,
    -0.000683824606726953,
    -0.000158386273069903,
    0.001027219811730566,
    0.002318936748160005,
    0.002640811218668270,
    0.001013754286002316,
    -0.002523719254668862,
```

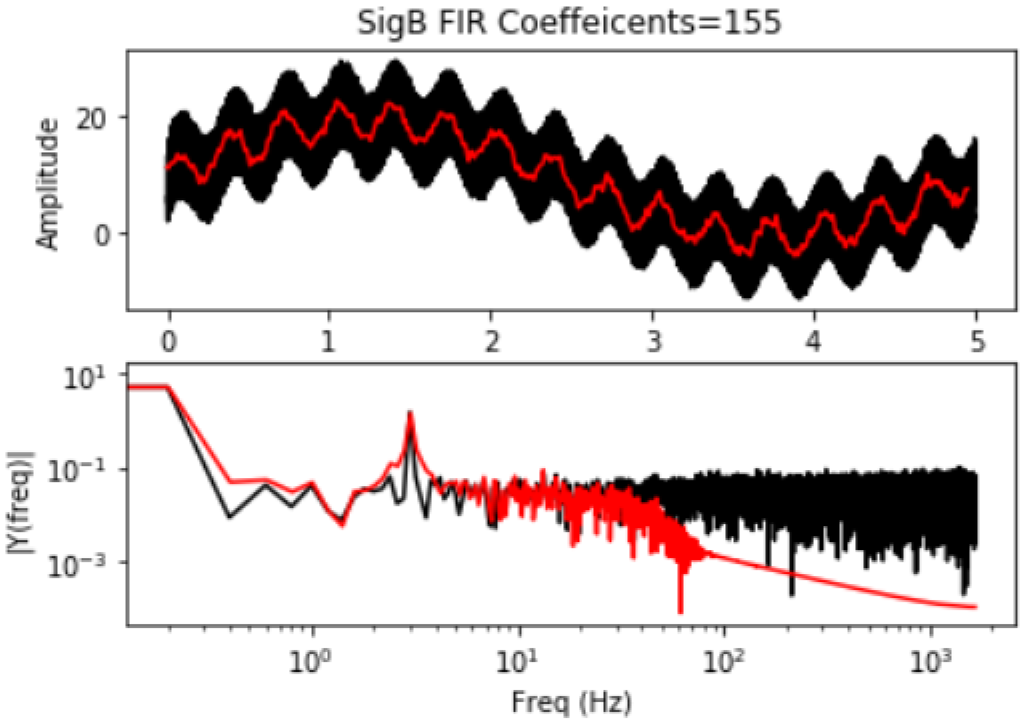
```
    -0.006325631253687232,
    -0.007561897310826583,
    -0.003831874832884219,
    0.004738477060165078,
    0.014323274838318484,
    0.018447375737723894,
    0.011433631732265579,
    -0.007231490196232454,
    -0.030231505621782617,
    -0.043749386035555130,
    -0.033153126834597833,
    0.009232303164279268,
    0.078287872718538265,
    0.155824099666343502,
    0.216872056812350694,
    0.240022308028222775,
    0.216872056812350694,
    0.155824099666343502,
    0.078287872718538265,
    0.009232303164279266,
    -0.033153126834597826,
    -0.043749386035555143,
    -0.030231505621782628,
    -0.007231490196232453,
    0.011433631732265581,
    0.018447375737723908,
    0.014323274838318490,
    0.004738477060165081,
    -0.003831874832884219,
    -0.007561897310826589,
    -0.006325631253687240,
    -0.002523719254668863,
    0.001013754286002317,
    0.002640811218668273,
    0.002318936748160003,
    0.001027219811730566,
    -0.000158386273069903,
    -0.000683824606726953,
    -0.000598895948257722,
    -0.000263718332932162,
    0.000000000000000000,
    0.000082648554461720,
    0.000050548523936133,
    0.000009291614166548,
    0.000000000000000000,
]

X=len(h)

with open('sigD.csv') as f:
    # open the csv file
    reader = csv.reader(f)
    for row in reader:
        # read the rows 1 one by one
        t.append(float(row[0])) # leftmost column
        data1.append(float(row[1])) # second column
```

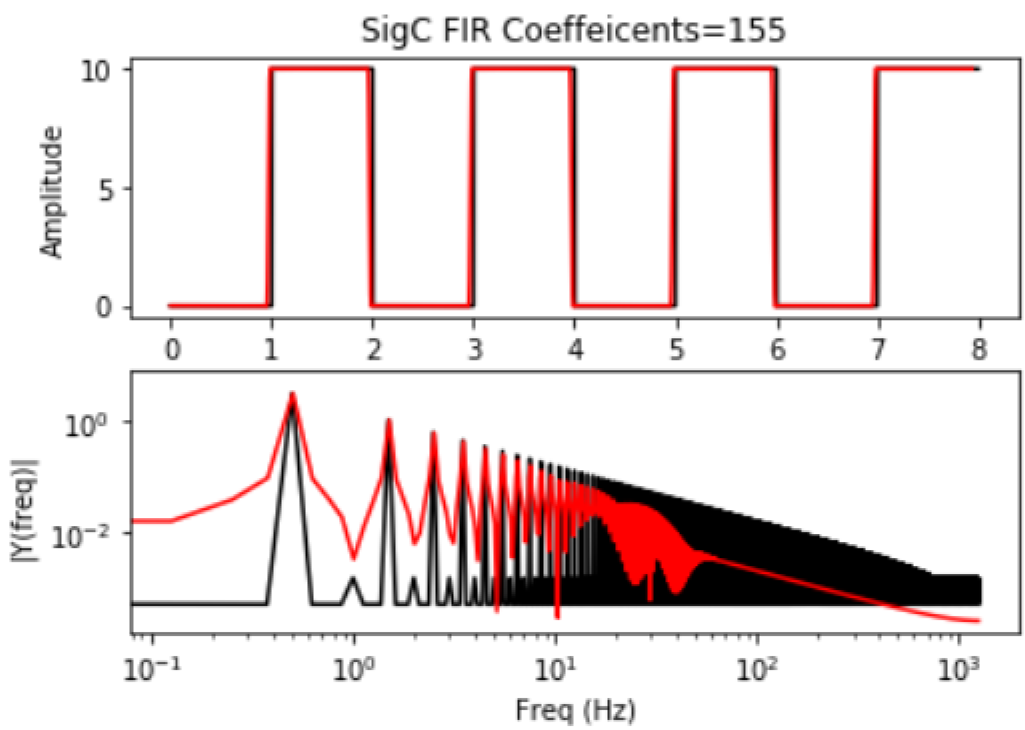
```
        #data2.append(float(row[2])) # third column

    for i in range(0,(len(data1)-X)):
        tempdata=0
        for ii in range(0,X):
            tempdata=tempdata+ data1[i+ii]*h[ii]
        newdata.append(tempdata)
        newtime.append(t[i])

#unfiltered data
endtime=t[-1]
nsamples=len(data1)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)
print(sam_rate)


Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,t[-1],Ts) # time vector
y = data1 # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs

frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,y,color="black")
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax1.set_title('Unfiltered sample')
ax2.loglog(frq,abs(Y),color="black") # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
plt.show()
y2=y
Y2=Y
frq2=frq
endtime=newtime[-1]
nsamples=len(newdata)
sam_rate=nsamples/endtime
sam_rate=round(sam_rate)

Fs = sam_rate # sample rate
Ts = 1.0/Fs; # sampling interval
ts = np.arange(0,newtime[-1],Ts) # time vector
y = newdata # the data to make the fft from
n = len(y) # length of the signal
k = np.arange(n)
T = n/Fs
frq = k/T # two sides frequency range
frq = frq[range(int(n/2))] # one side frequency range
```

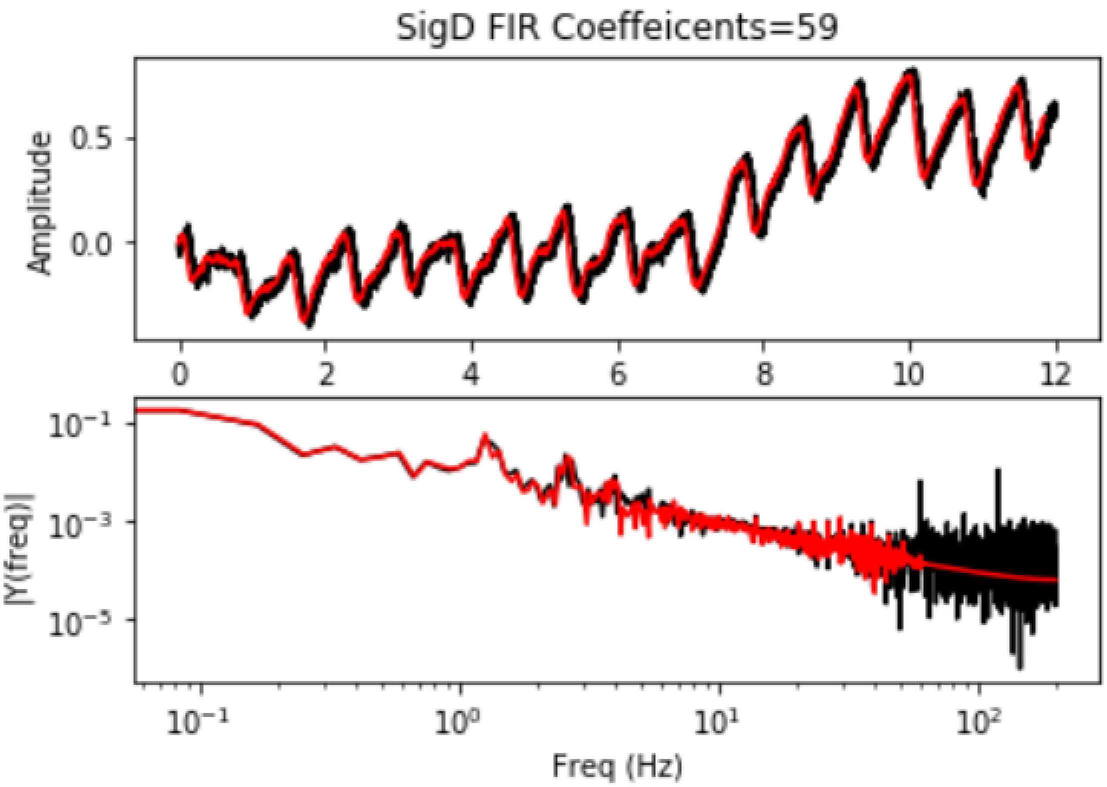
```
Y = np.fft.fft(y)/n # fft computing and normalization
Y = Y[range(int(n/2))]

fig, (ax1, ax2) = plt.subplots(2, 1)
ax1.plot(t,y2,color="black")
ax1.plot(newtime,y,'r-')
ax1.set_xlabel('Time')
ax1.set_ylabel('Amplitude')
ax1.set_title('FIR Coeffeicents='+str(X))
ax2.loglog(frq2,abs(Y2),color="black") # plotting the fft
ax2.loglog(frq,abs(Y),'r-') # plotting the fft
ax2.set_xlabel('Freq (Hz)')
ax2.set_ylabel('|Y(freq)|')
plt.show()
```

NOTE: For SigA the website does not let me go below a 100Hz cutoff frequency. This is about the best I can get under these conditions.




SigB FIR Coeffeicents=155
Amplitude
|Y(freq)|
Freq (Hz)


SigC FIR Coeffeicents=155
Amplitude
|Y(freq)|
Freq (Hz)


SigD FIR Coeffeicents=59
Amplitude
0.5
0.0
0
2
4
6
8
10
12
|Y(freq)|
10^{-1}
10^{-3}
10^{-5}
10^{-1}
10^{0}
10^{1}
10^{2}
Freq (Hz)