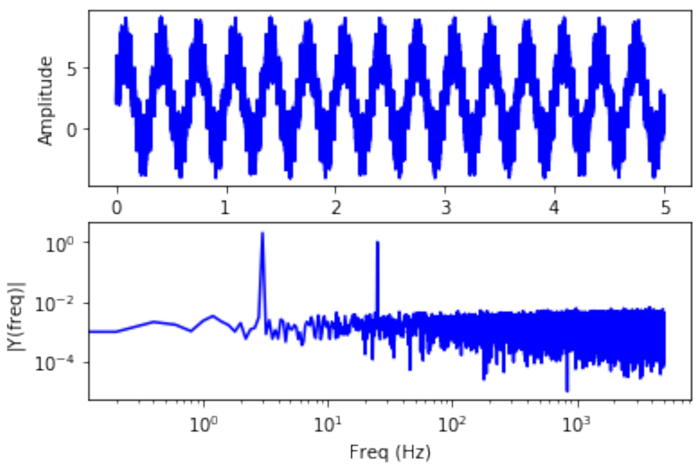
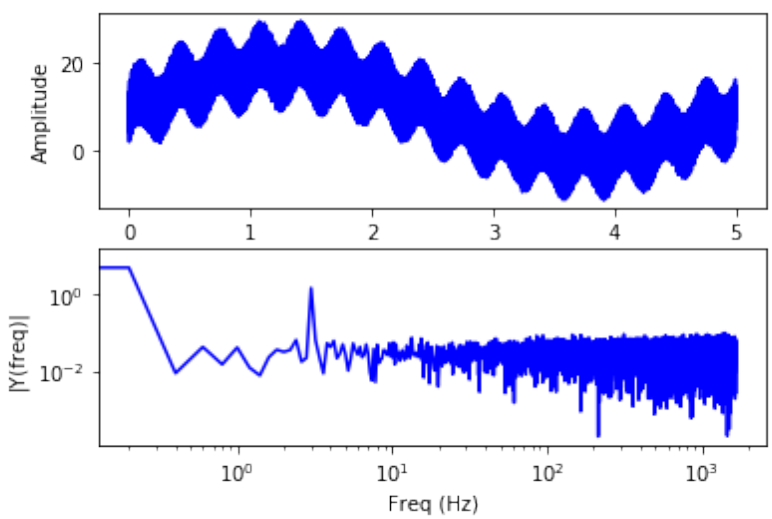
HW 2: Digital Signal Processing

4)

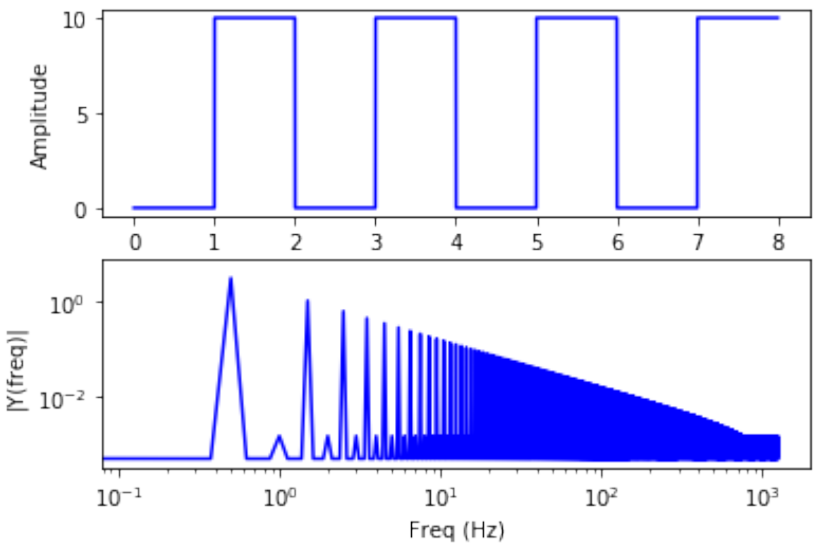
sigA:



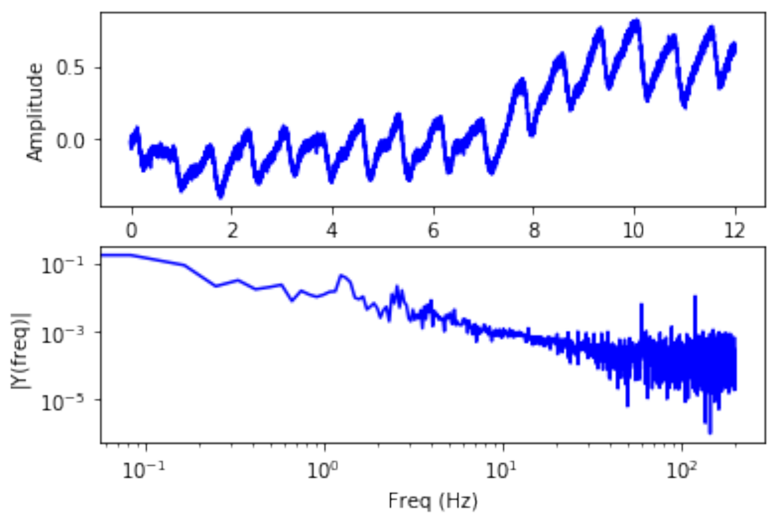

sigB:




sigC:




sigD:

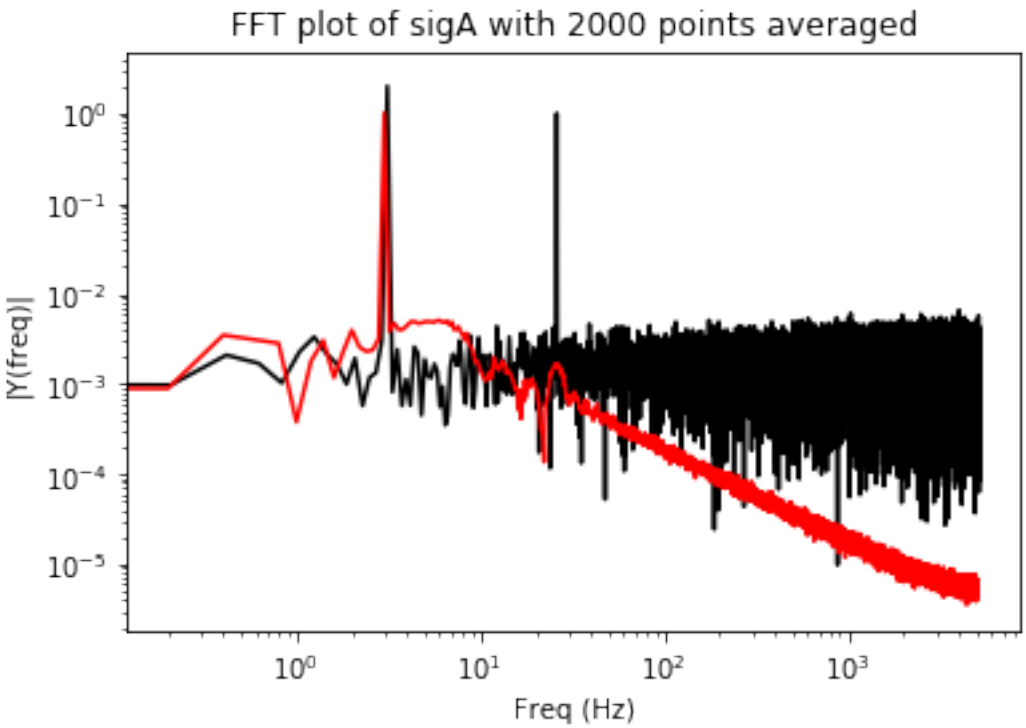


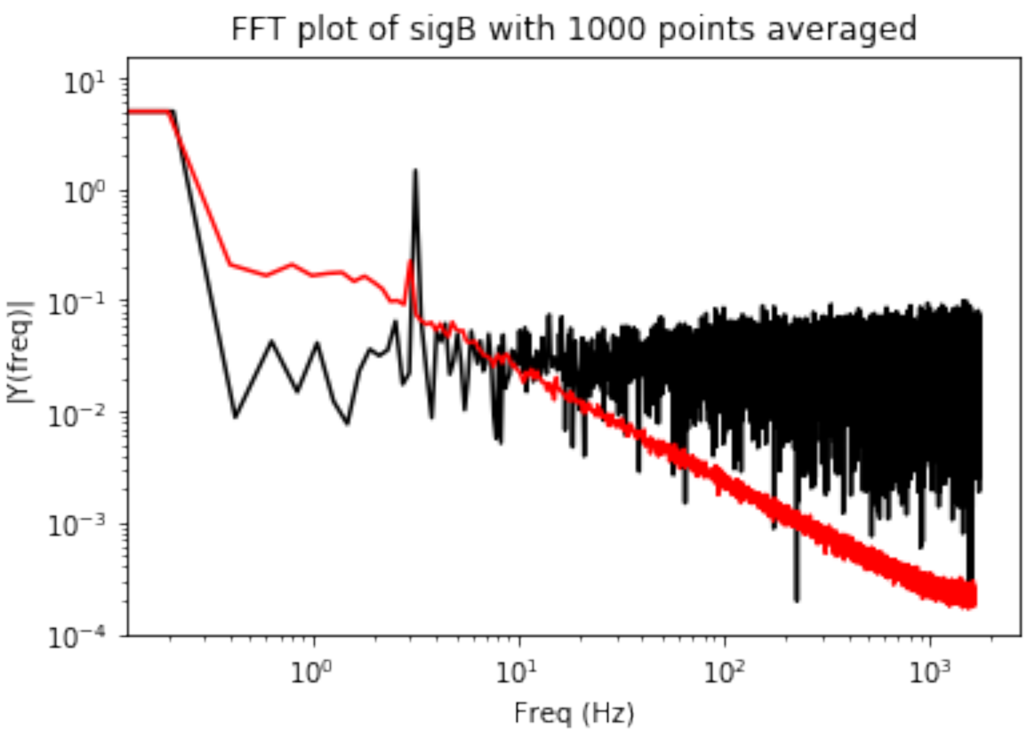

Code (same for all cases other than “sigA” being replaced with “sigB,” “sigC,” “sigD”):

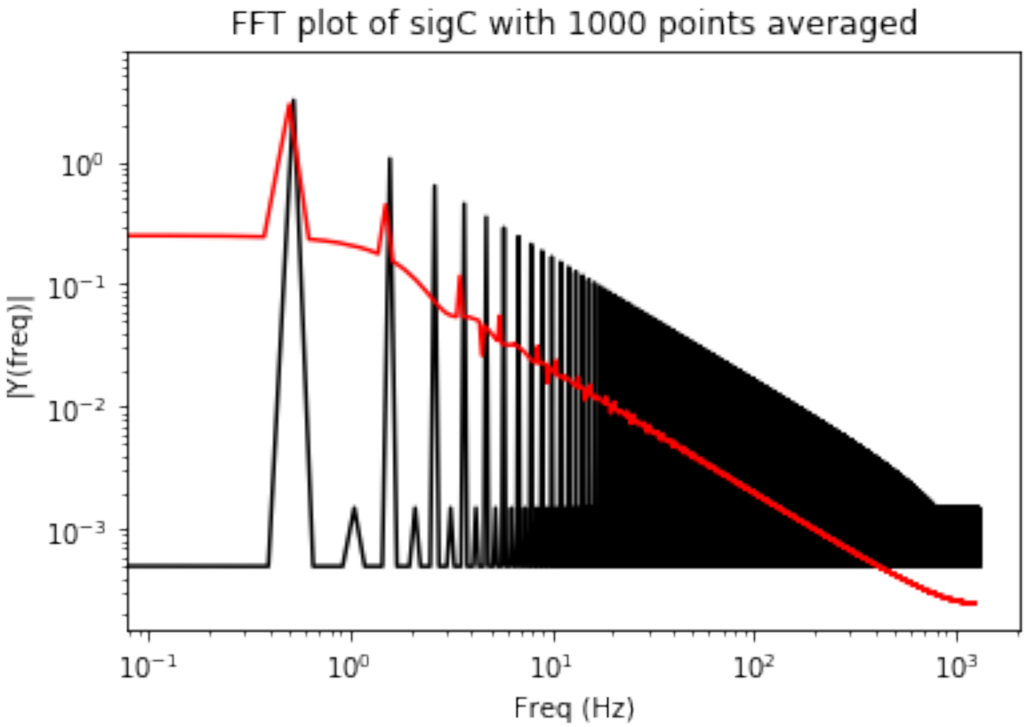
```
# FFT for sigA

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
```

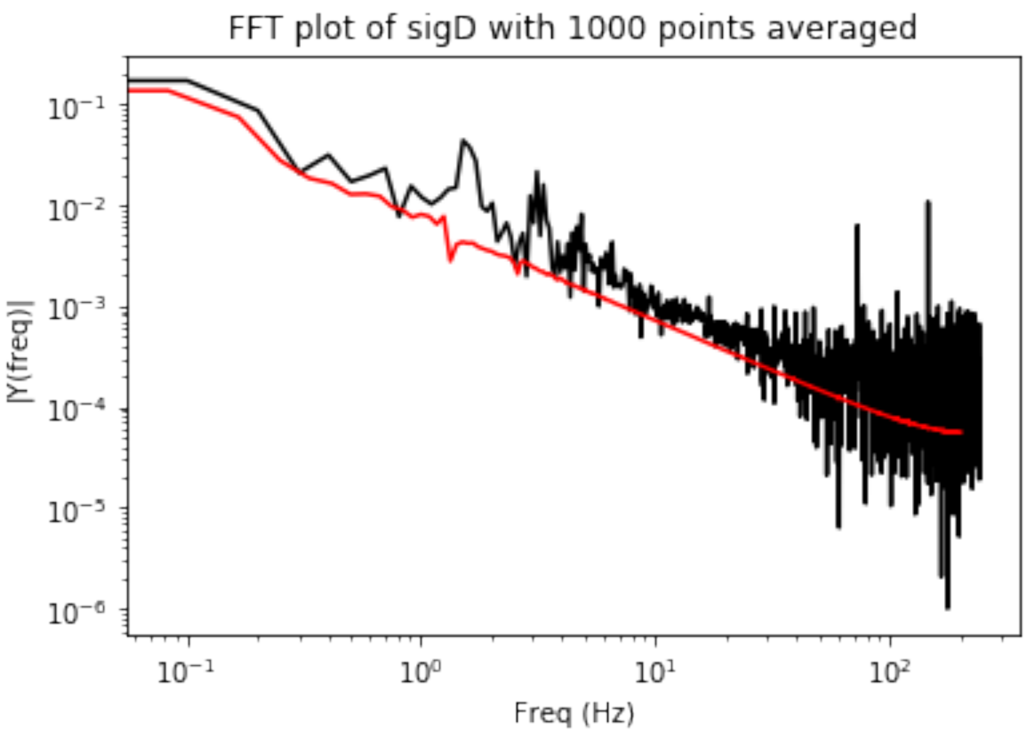
```
    data1.append(float(row[1])) # second column

plt.plot(t, data1)

samplerate = len(data1)/t[-1]
print(samplerate)
print(len(data1))

# FFT for sigA

Fs = samplerate # 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()
```

5)


FFT plot of sigA with 2000 points averaged
|Y(freq)|
Freq (Hz)


FFT plot of sigB with 1000 points averaged
|Y(freq)|
Freq (Hz)




Code (same for all cases other than “sigA” being replaced with “sigB,” “sigC,” “sigD”):

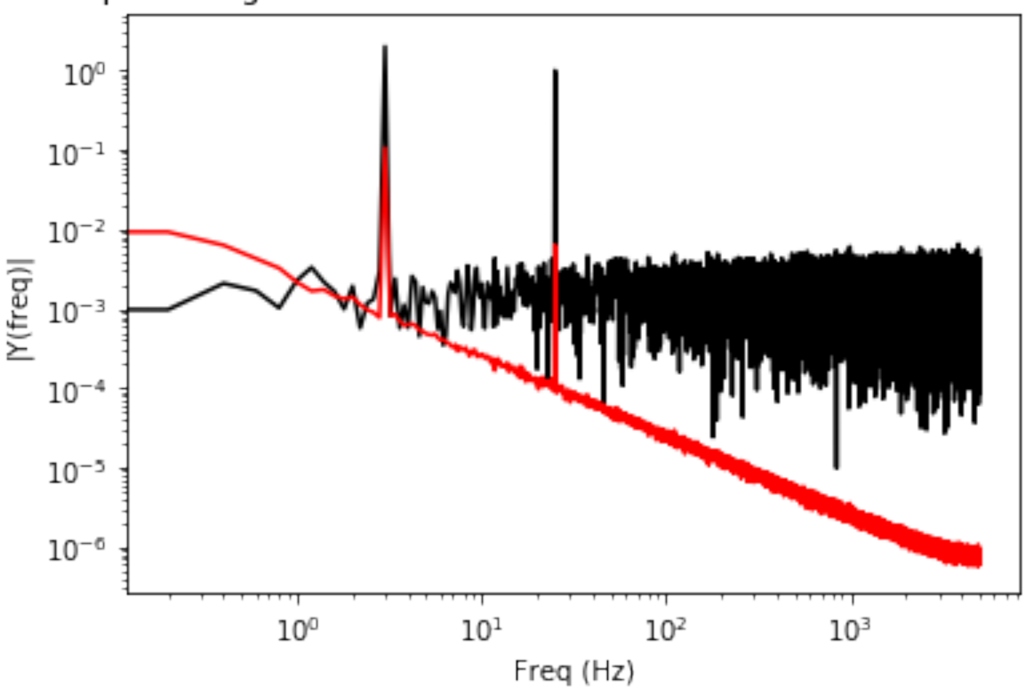
```
# Low pass filter sigA
```

```
t = [] # column 0
data1 = [] # column 1

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

data = data1.copy()
x = 2000
newdata = []

for i in range(x):
    data.insert(i, 0)
for j in range(len(data)-x):
    sum = 0
    for i in range(x):
        sum = sum + data[j + x - i]
    avg = sum/x
    newdata.append(avg)

samplerate = len(data)/t[-1]
newsamplerate = len(newdata)/t[-1]


# FFT for sigA

Fs = samplerate # 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))]
```

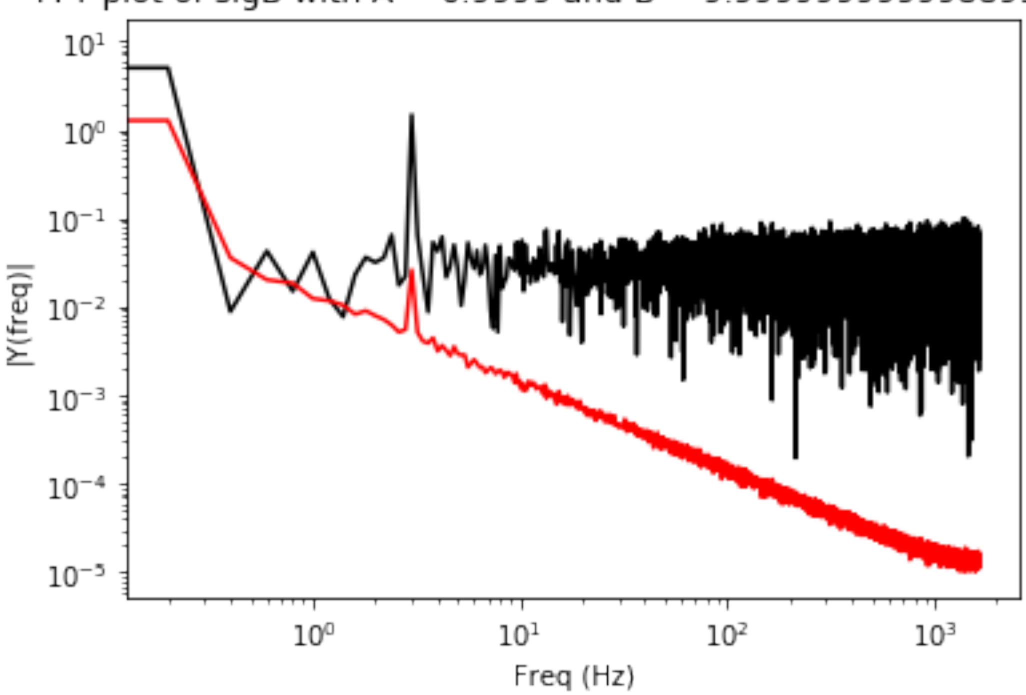
```
plt.loglog(frq,abs(Y),'black') # plotting the fft
plt.xlabel('Freq (Hz)')
plt.ylabel('|Y(freq)|')

# plt.plot(t, data1)
# plt.plot(t, newdata)


# plotting the new sample FFT
samplerate = len(newdata)/t[-1]

# FFT for sigA

Fs = samplerate # 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
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))]


plt.loglog(frq,abs(Y),'red') # plotting the fft
plt.title('FFT plot of sigA with ' + str(x) + ' points averaged')
plt.show()
```

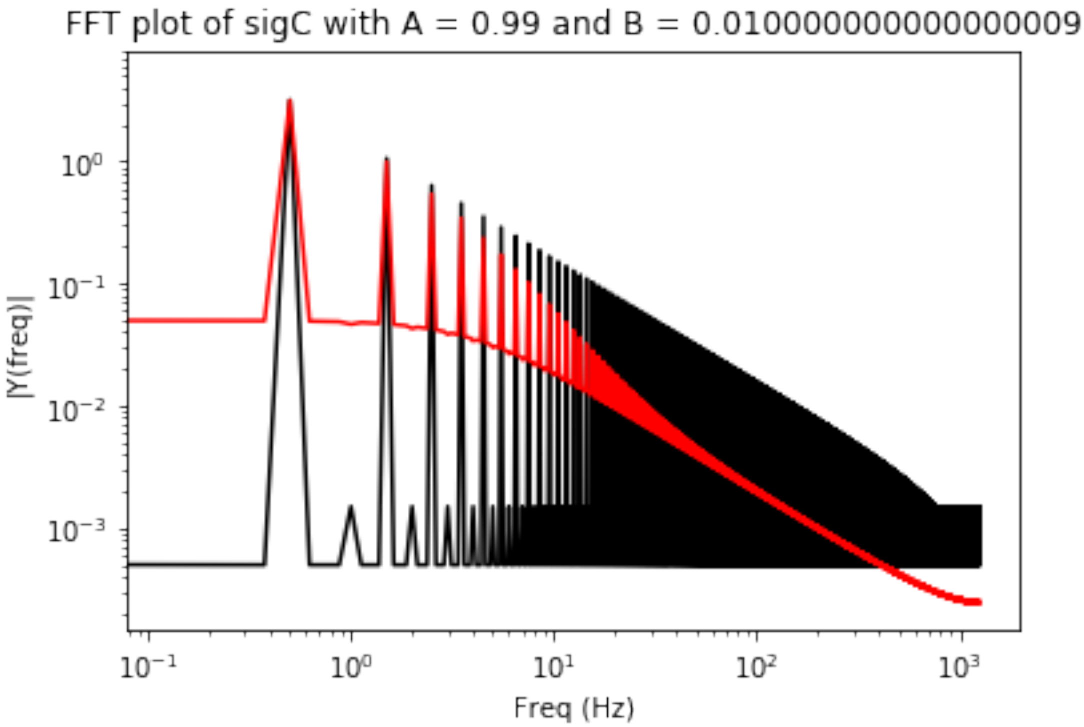
6)

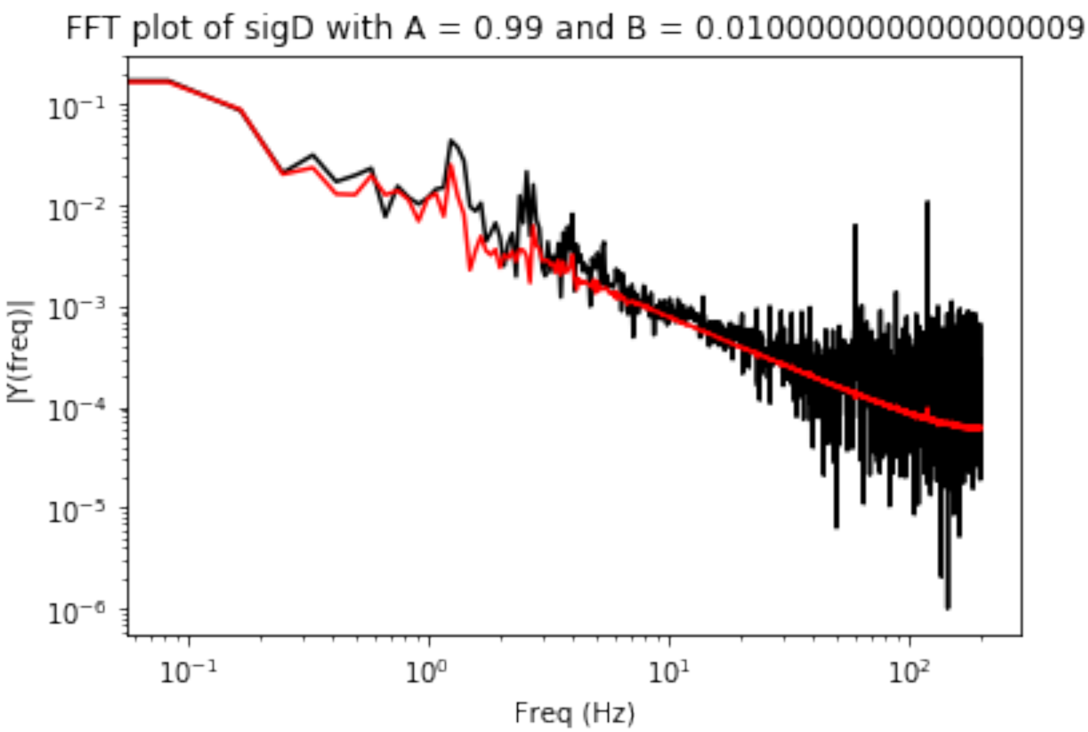
FFT plot of sigA with A = 0.9999 and B = 9.999999999998899e-05




FFT plot of sigB with A = 0.9999 and B = 9.999999999998899e-05






Code (same for all cases other than “sigA” being replaced with “sigB,” “sigC,” “sigD”):

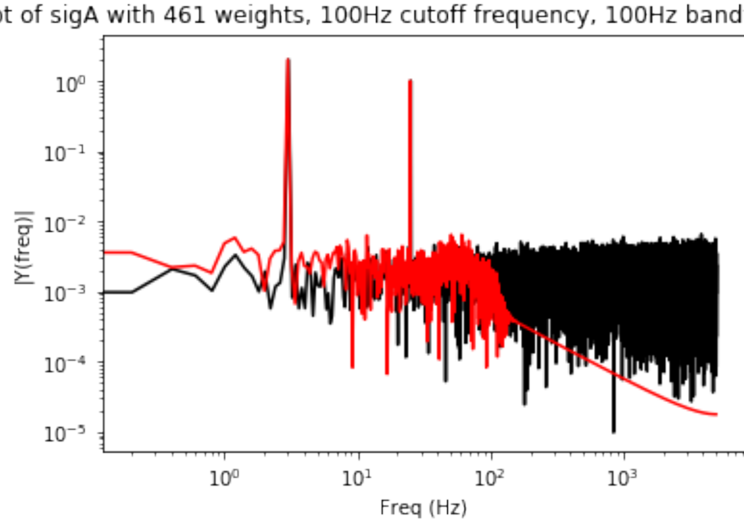
```
# Low pass filtering with an IIR for sigA

t = [] # column 0
```

```
data1 = [] # column 1

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

data = data1.copy()
A = 0.9999
B = 1-A
newdata = []
newdata.append(data[0])

for i in range(1, len(data)):
    newdata.append(A*newdata[i-1] + B*data[i])

samplerate = len(data)/t[-1]
newsamplerate = len(newdata)/t[-1]


# FFT for sigA

Fs = samplerate # 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))]


plt.loglog(frq,abs(Y),'black') # plotting the fft
plt.xlabel('Freq (Hz)')
plt.ylabel('|Y(freq)|')


# plotting the new sample FFT
```

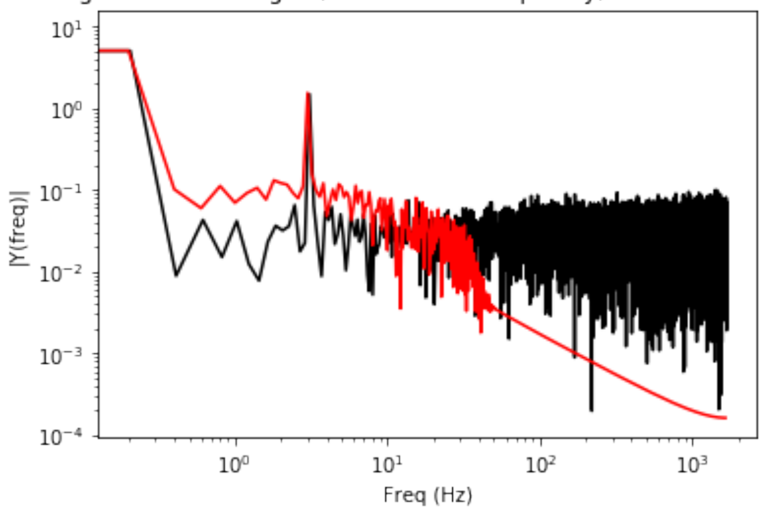
```
samplerate = len(newdata)/t[-1]

# FFT for sigA

Fs = samplerate # 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
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))]


plt.loglog(frq,abs(Y),'red') # plotting the fft
plt.title('FFT plot of sigA with A = ' + str(A) + ' and B = '+ str(B)+ '')
plt.show()
```

7)

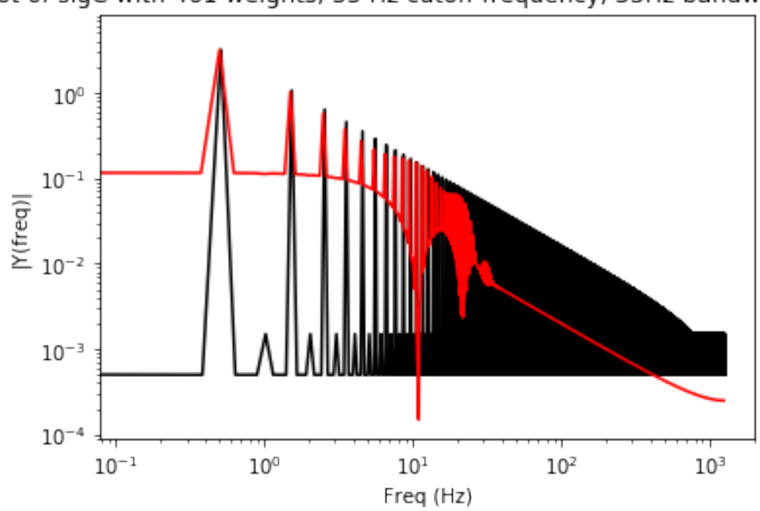
Low Pass FIR plot of sigA with 461 weights, 100Hz cutoff frequency, 100Hz bandwidth, Blackman Window



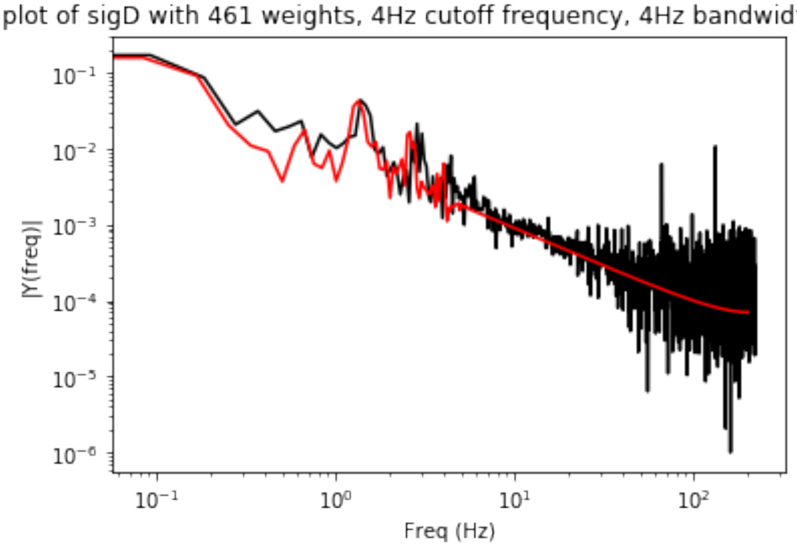
Low Pass FIR plot of sigB with 461 weights, 33Hz cutoff frequency, 33Hz bandwidth, Blackman Window




Low Pass FIR plot of sigC with 461 weights, 35 Hz cutoff frequency, 33Hz bandwidth, Blackman Window




Low Pass FIR plot of sigD with 461 weights, 4Hz cutoff frequency, 4Hz bandwidth, Blackman Window



Code (same for all cases other than “sigA” being replaced with “sigB,” “sigC,” “sigD”):

NOTE: FOR CLARITY, WEIGHTS HAVE BEEN REMOVED AND REPLACED WITH “**……”** ACTUAL WEIGHTS ARE LISTED BELOW FOR EACH DATA SAMPLE

```
# Low pass filter sigA

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

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

weights = ……
data = data1.copy()
x = len(weights)
newdata = []

for i in range(x):
    data.insert(i, 0)
for j in range(len(data)-x):
    sum = 0
    for i in range(x):
        sum = sum + weights[i]*data[j + x - i]
    newdata.append(sum)

samplerate = len(data)/t[-1]
newsamplerate = len(newdata)/t[-1]

# plt.plot(t,data1)
# plt.plot(t,newdata)

# FFT for sigD

Fs = samplerate # 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))]


plt.loglog(frq,abs(Y),'black') # plotting the fft
plt.xlabel('Freq (Hz)')
plt.ylabel('|Y(freq)|')


# plotting the new sample FFT
samplerate = len(newdata)/t[-1]

# FFT for sigD

Fs = samplerate # 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
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))]


plt.loglog(frq,abs(Y),'red') # plotting the fft
plt.title('FIR plot of sigA')
plt.show()
```

Weights for sigA:

```
weights = [
    0.000000000000000000,
    0.000000022609304456,
    0.000000092137658127,
    0.000000210376981500,
    0.000000378074907886,
    0.000000594900325696,
```

0.000000859416815111,
0.000001169064300580,
0.000001520149215920,
0.000001907843452345,
0.000002326192331196,
0.000002768131812358,
0.000003225515116128,
0.000003689148900478,
0.000004148839097111,
0.000004593446468231,
0.000005010951901591,
0.000005388531413869,
0.000005712640781930,
0.000005969109667889,
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0.000006183813380806,
0.000006019302503680,
0.000005710837540961,
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-0.000011194650419114,
-0.000014238780007746,
-0.000017558423373286,
-0.000021152263307200,
-0.000025016513915877,
-0.000029144774962341,
-0.000033527896366957,
-0.000038153854386003,
-0.000043007640996822,
-0.000048071168018069,
-0.000053323187482591,
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-0.000064291560877524,
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0.000445730974435899,
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0.000509311477285098,
0.000540238966114795,
0.000570312616856111,
0.000599313955772492,
0.000627017929501001,
0.000653193833411438,
0.000677606318380946,
0.000700016473693936,
0.000720182983235291,
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0.000752815196199786,
0.000764797600901996,
0.000773572526213876,
0.000778906270490711,
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0.000701880702793345,
0.000672303751986135,
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0.000318504121267832,
0.000246611859321968,
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0.000000000000000000,
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-0.000188708962926191,
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-0.000394868909070879,
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-0.000731627901163730,

-0.000849759466277988,
-0.000970124362994252,
-0.001092249969091942,
-0.001215632022708469,
-0.001339735618754229,
-0.001463996385336302,
-0.001587821839857698,
-0.001710592923510197,
-0.001831665711913682,
-0.001950373298678269,
-0.002066027847682981,
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-0.002655275909486315,
-0.002729045047518393,
-0.002793801935577453,
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0.016049583533223350,
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0.018834754706865513,
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0.019476787014068648,
0.019635938885141990,

0.019766805537339234,
0.019868997514539938,
0.019942210313729766,
0.019986225576755702,
0.020000911945533145,
0.019986225576755702,
0.019942210313729766,
0.019868997514539938,
0.019766805537339234,
0.019635938885141990,
0.019476787014068648,
0.019289822810542985,
0.019075600744464561,
0.018834754706865513,
0.018567995542002971,
0.018276108285228892,
0.017959949119311456,
0.017620442063148851,
0.017258575408011220,
0.016875397917563817,
0.016472014808958144,
0.016049583533223350,
0.015609309374042002,
0.015152440884749678,
0.014680265184051732,
0.014194103131501134,
0.013695304404225379,
0.013185242496726660,
0.012665309665806286,
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0.011601463535168468,
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