190041220-lab-6

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#Moving Average Filter (MAF)

[ ]:
```
import numpy as np
import math
import matplotlib.pyplot as plt
```

1. Write a function y = maf(x,M) which will take an input signal x and filter the signal using a M point moving average filter.

a. Generate a signal, add some random noise (it is better if your signal looks something like the one in Figure 15-1.a) and then test your function maf() to demonstrate the noise reduction capability of the filter for various values of M.

Generate a signal, add some random noise

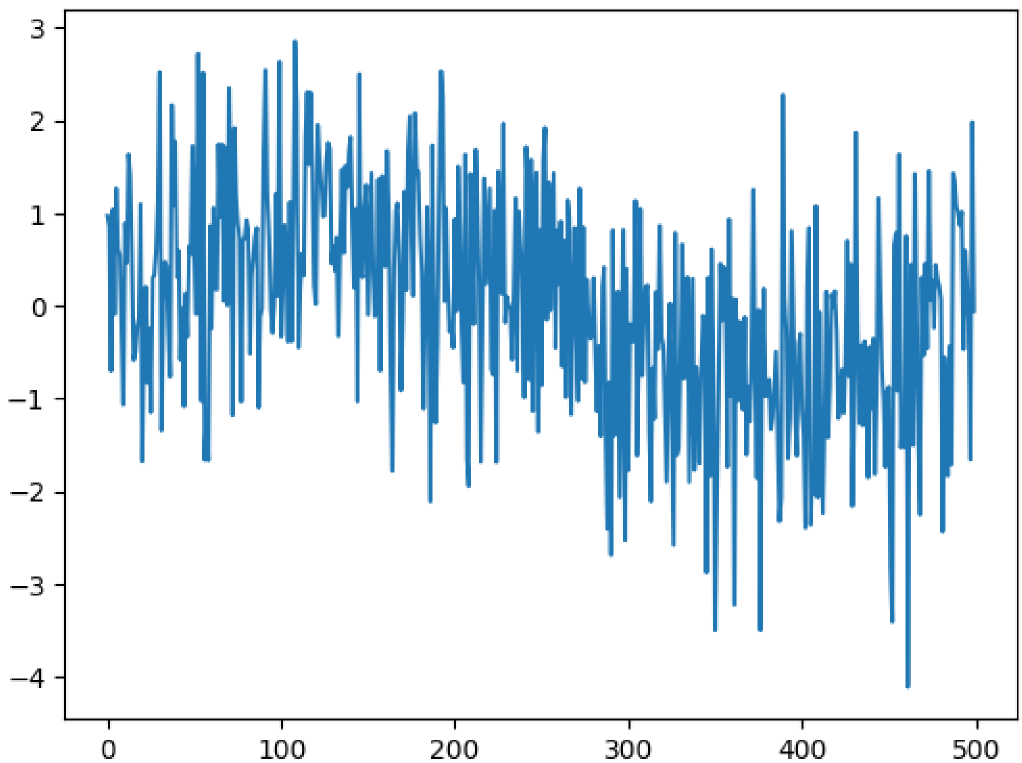
[ ]:
```
noise = np.random.normal(0, 1, 500)
sin_signal = np.sin(np.linspace(0, 2*math.pi, 500))
x = sin_signal + noise
```

[ ]:
```

```

[ ]:
```
plt.plot(x)
```

[ ]:
```
[<matplotlib.lines.Line2D at 0x7fb03820cc40>]
```



[ ]:

```

```

[ ]:

```
def maf(x, M):
    y = np.zeros(x.shape)
    low = math.floor(M/2)
    s = np.sum(x[:M])
    y[low] = s/M

    for i in range(low+1, x.shape[0]-low):
        s = s + x[i + low] - x[i - (low + 1)]
        y[i] = s / M

    return y
```

[ ]:

```
y = maf(x, 5)
```

the noise reduction capability of the filter for various values of M

[ ]:

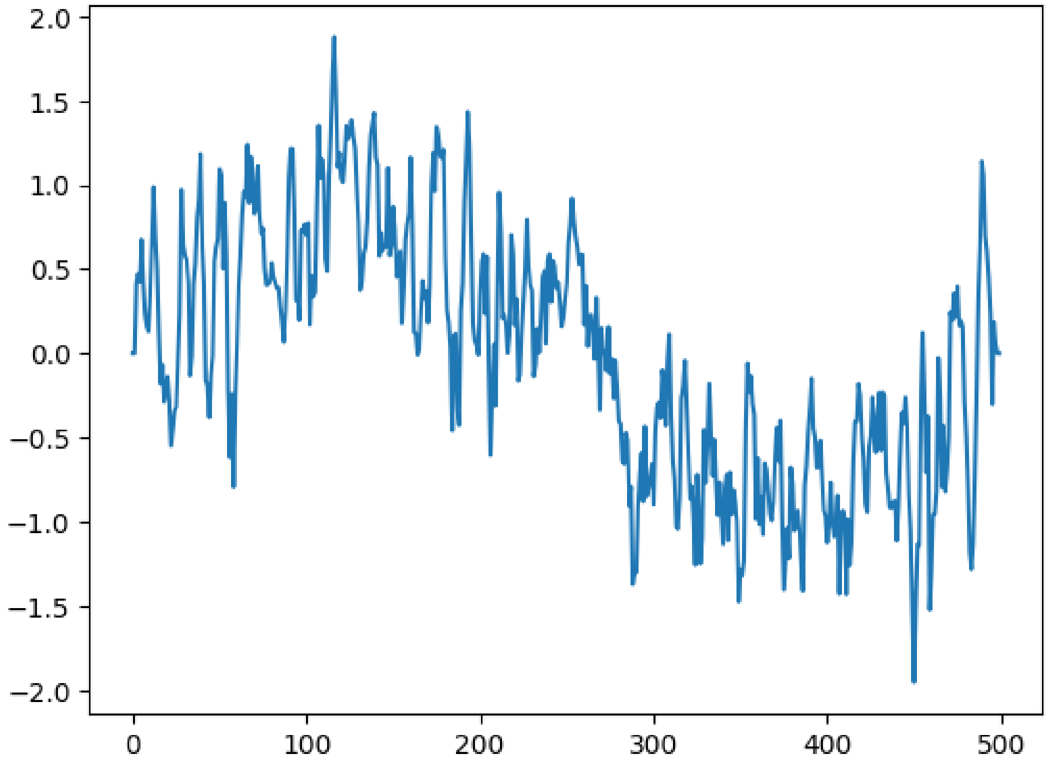
```

```

[ ]:

```
plt.plot(y)
```

[ ]: [<matplotlib.lines.Line2D at 0x7fb0380a0a30>]

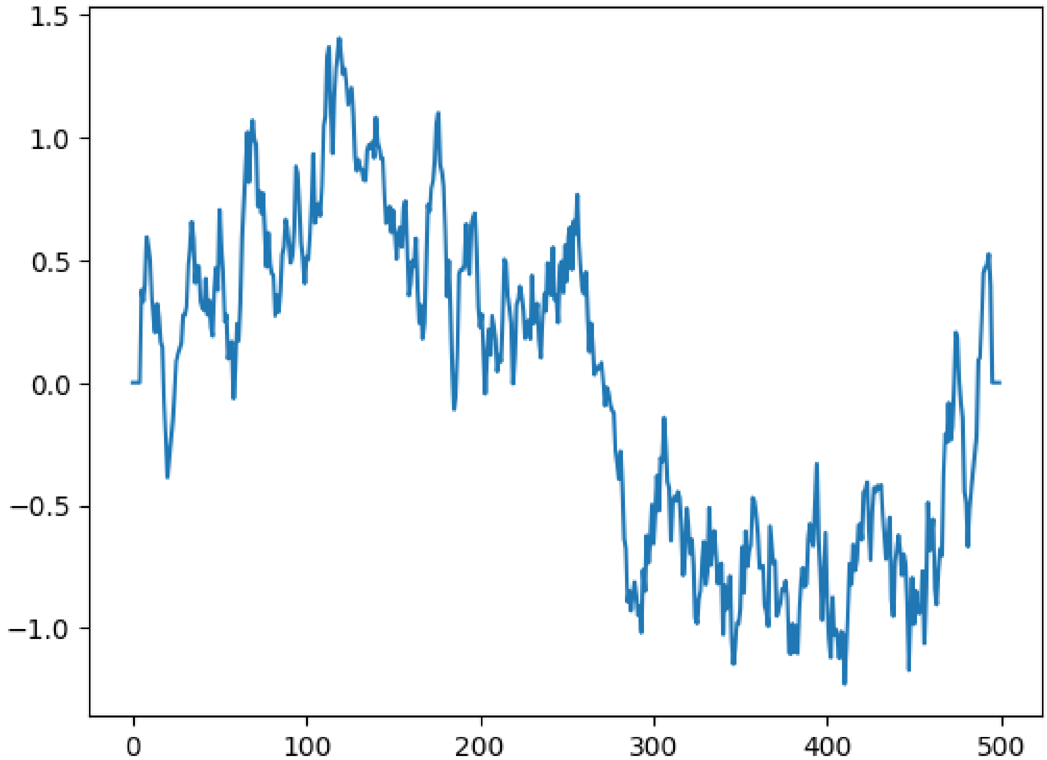


[ ]:

b. Explain the plots as you increase the value of M. In practice, try to verify the characteristics shown in Figure 15-1.b and 15.1.c

[ ]:
```
y1 = maf(x, 11)
plt.plot(y1)
```

[ ]: [<matplotlib.lines.Line2D at 0x7fb038028a60>]



[ ]:

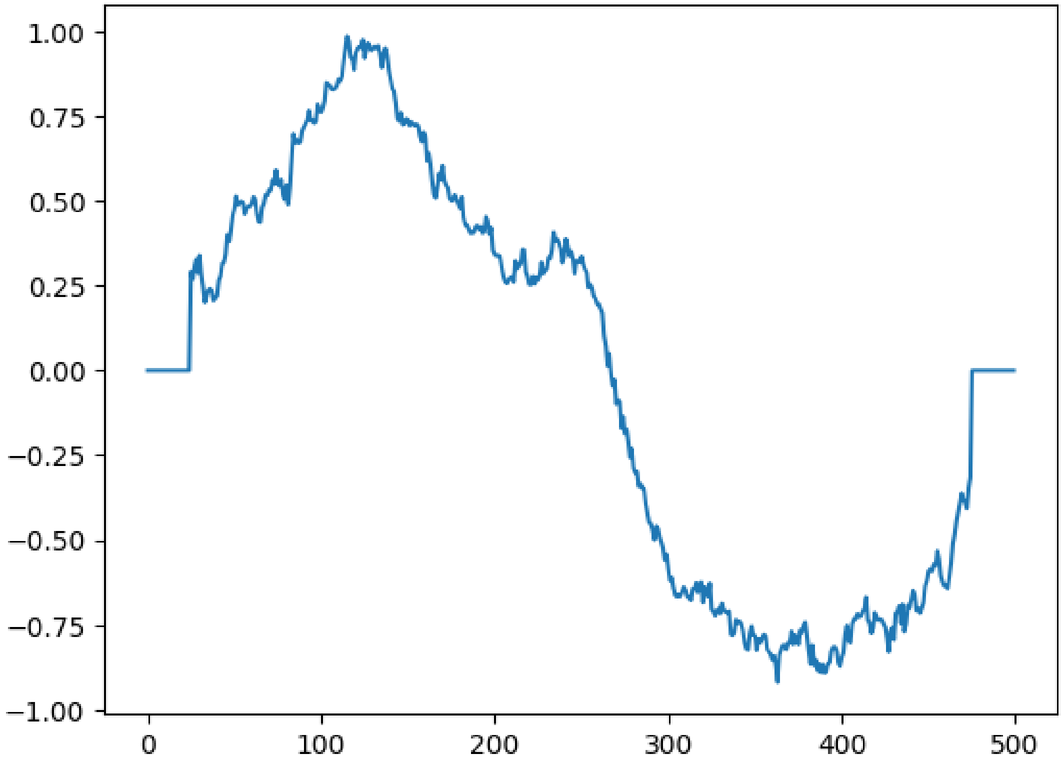
```

```

[ ]:

```
y2 = maf(x, 51)
plt.plot(y2)
```

[ ]: [<matplotlib.lines.Line2D at 0x7fb021f89ee0>]



[ ]:
```
```

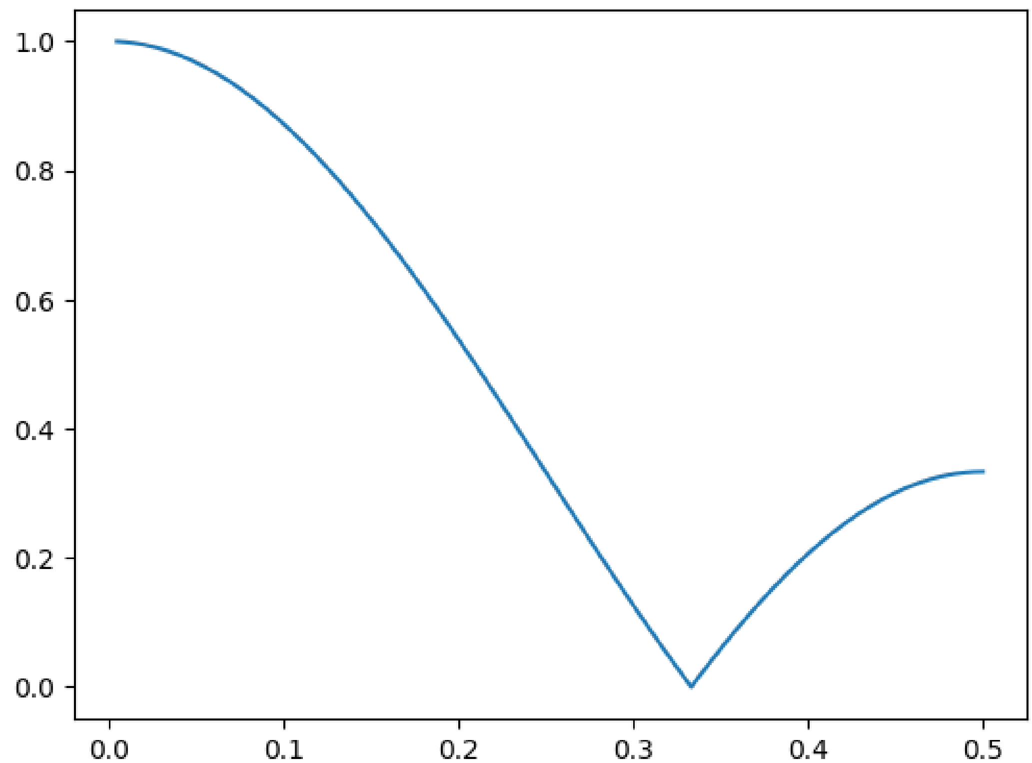
2. Using equation 15-2, generate the frequency response of a moving average filter (for 3-point, 11- point and 31-point) and plot them in a single figure, to verify Figure 15-2.

[ ]:
```
def freq_response(M):
    t = np.linspace(0, 0.5, 100)
    H = np.sin(math.pi * t * M)/(M * np.sin(math.pi * t))
    H[H<0] = -H[H<0]
    return H, t
```

[ ]:
```
H, t = freq_response(3)
plt.plot(t, H)
```

```
<ipython-input-9-69c311bbda36>:3: RuntimeWarning: invalid value encountered in
true_divide
  H = np.sin(math.pi * t * M)/(M * np.sin(math.pi * t))
```

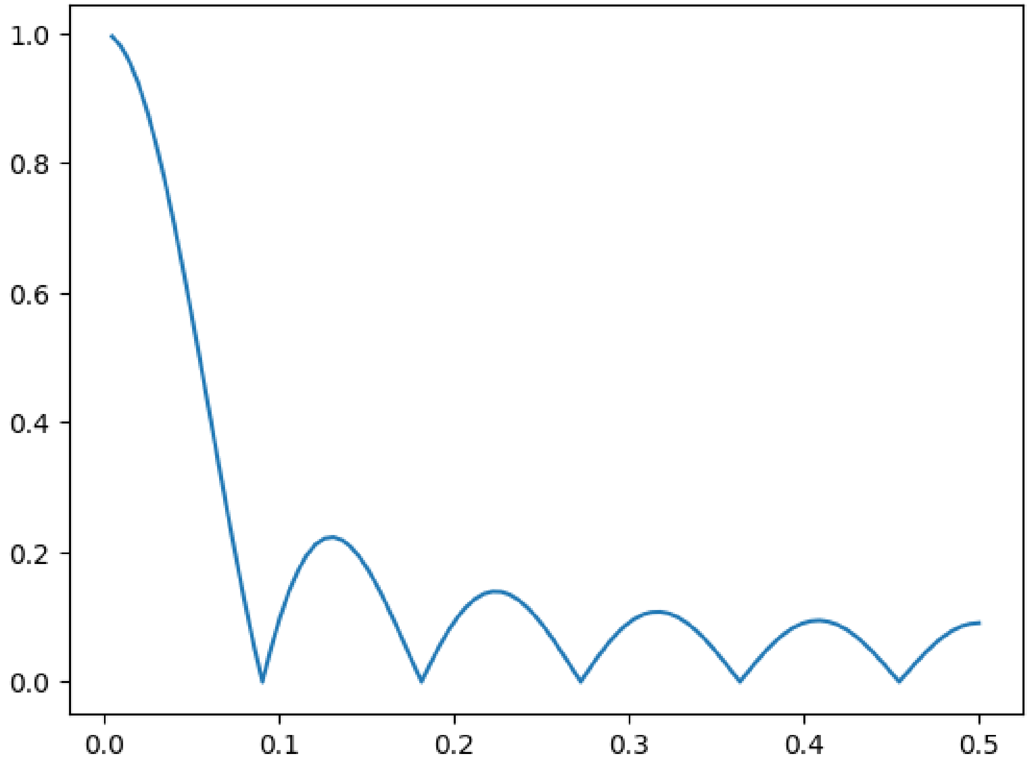
[ ]: [<matplotlib.lines.Line2D at 0x7fb021f1a0d0>]



[ ]:
```
H, t = freq_response(11)
plt.plot(t, H)
```

```
<ipython-input-9-69c311bbda36>:3: RuntimeWarning: invalid value encountered in
true_divide
  H = np.sin(math.pi * t * M)/(M * np.sin(math.pi * t))
```

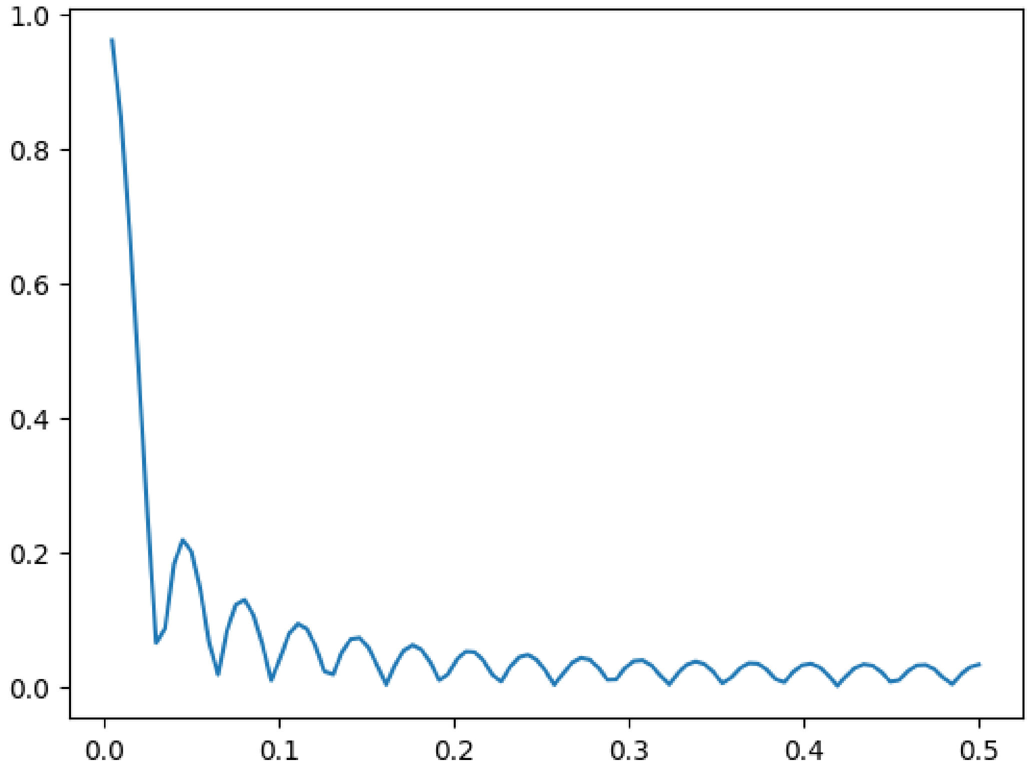
[ ]:
```
[<matplotlib.lines.Line2D at 0x7fb021e8e850>]
```



[ ]:
```
H, t = freq_response(31)
plt.plot(t, H)
```

```
<ipython-input-9-69c311bbda36>:3: RuntimeWarning: invalid value encountered in
true_divide
  H = np.sin(math.pi * t * M)/(M * np.sin(math.pi * t))
```

[ ]:
```
[<matplotlib.lines.Line2D at 0x7fb021e00bb0>]
```



3. Verify Figure 15-3 using a 4x4 subplot. Choose a suitable MAF kernel, use convolution to generate 2 pass and 4 pass kernels. Generate the step response and the Frequency response in dB.

[ ]:
```
onep = maf(x, 51)
twop = maf(onep, 51)
threep = maf(twop, 51)
fourp = maf(threep, 51)
```

[ ]:
```
onep_fr = np.sqrt(np.fft.rfft(onep).real ** 2 + np.fft.rfft(onep).imag ** 2)
twop_fr = np.sqrt(np.fft.rfft(twop).real ** 2 + np.fft.rfft(twop).imag ** 2)
fourp_fr = np.sqrt(np.fft.rfft(fourp).real ** 2 + np.fft.rfft(fourp).imag ** 2)
```

[ ]:
```
onep_sr = np.cumsum(onep)
twop_sr = np.cumsum(twop)
fourp_sr = np.cumsum(fourp)
```

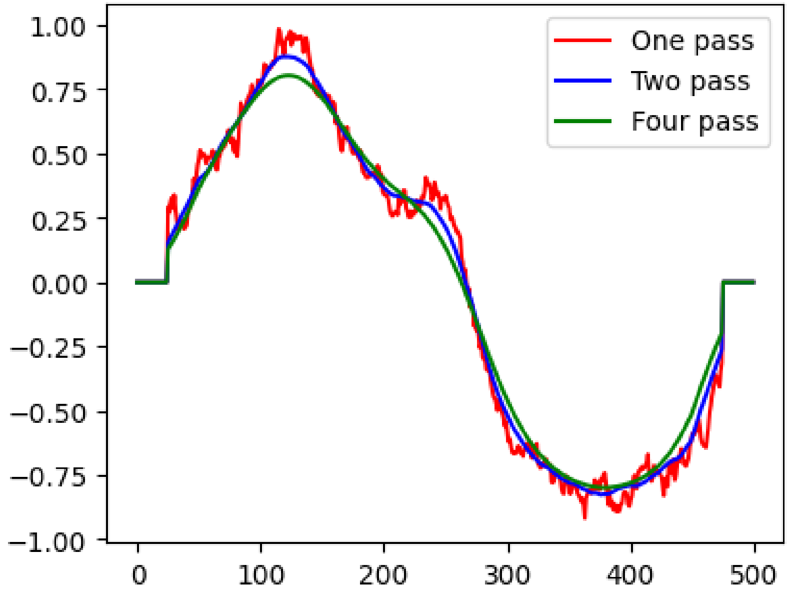
[ ]:
```
onep_frdb = 20 * np.log(onep_fr)
twop_frdb = 20 * np.log(twop_fr)
fourp_frdb = 20 * np.log(fourp_fr)
```

[ ]:
```
```

[ ]:
```
plt.figure(figsize=(10, 8))

plt.subplot(2, 2, 1)
plt.plot(onep, 'r', label="One pass")
plt.plot(twop, 'b', label="Two pass")
plt.plot(fourp, 'g', label="Four pass")
plt.legend()
```

[ ]: <matplotlib.legend.Legend at 0x7fb021dbc550>

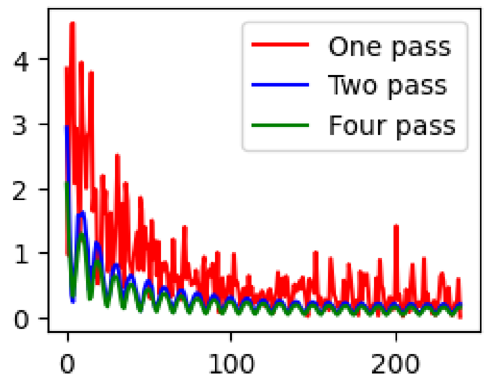


[ ]:
```

```

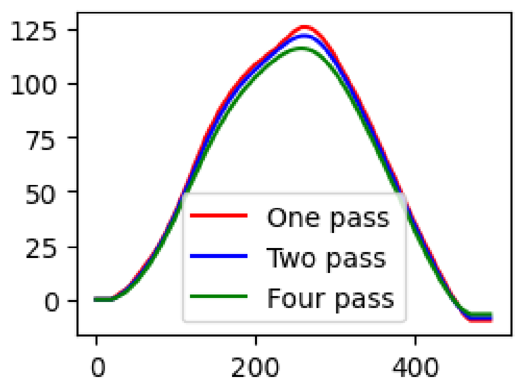
[ ]:
```
plt.subplot(2, 2, 2)
plt.plot(onep_fr[10:], 'r', label="One pass")
plt.plot(twop_fr[10:], 'b', label="Two pass")
plt.plot(fourp_fr[10:], 'g', label="Four pass")
plt.legend()
```

[ ]: <matplotlib.legend.Legend at 0x7fb021a6c160>



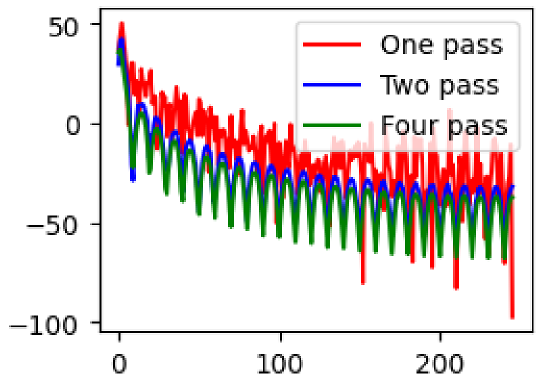
[ ]:
```
plt.subplot(2, 2, 3)
plt.plot(onep_sr[5:], 'r', label="One pass")
plt.plot(twop_sr[5:], 'b', label="Two pass")
plt.plot(fourp_sr[5:], 'g', label="Four pass")
plt.legend()
```

[ ]: <matplotlib.legend.Legend at 0x7fb021d70940>



[ ]:
```
plt.subplot(2, 2, 4)
plt.plot(onep_frdb[5:], 'r', label="One pass")
plt.plot(twop_frdb[5:], 'b', label="Two pass")
plt.plot(fourp_frdb[5:], 'g', label="Four pass")
plt.legend()
```

[ ]: <matplotlib.legend.Legend at 0x7fb021ce0430>



4. Now, write an algorithm that can execute a moving average filter in linear time or O(n). See chapter 15 for hints.

[29]:
```
def maf2(x, M):
  l=x.shape
  y = np.zeros(l)
  low = M//2
  s = 0
  for i in range(M):
    s += x[i]
  y[low] = s/M

  for i in range(low+1, x.shape[0]-low):
      s = s + x[i + low] - x[i - (low + 1)]
      y[i] = s / M

  return y
```

#Windowed-Sinc Filter

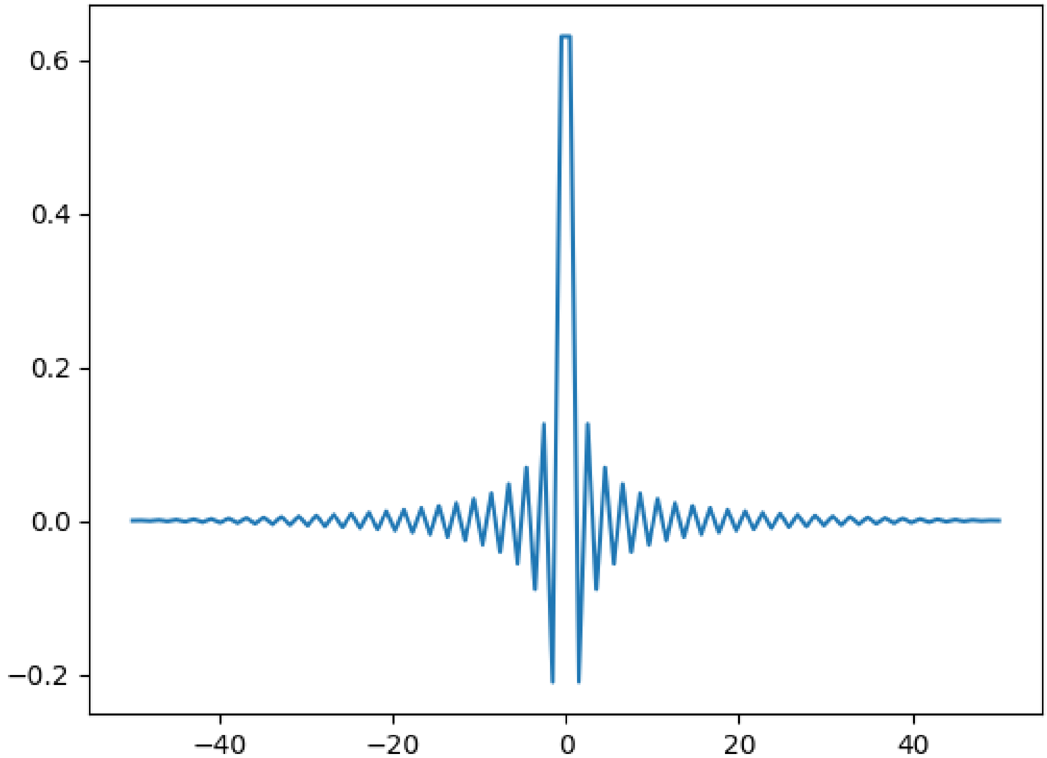
5. Take hundred points from -50 to 50 using the linspace() [or any equivalent function]. Plot the sinc function for these values.

[ ]:
```
def sinc(fc):
    t = np.linspace(-50, 50, 100)
    H = np.sin(2 * math.pi * fc * t)/(t * math.pi)
    return H, t
```

[ ]:
```
H, t = sinc(0.5)
```

[ ]:
```
plt.plot(t,H)
```

[ ]:
```
[<matplotlib.lines.Line2D at 0x7fb021c1a580>]
```

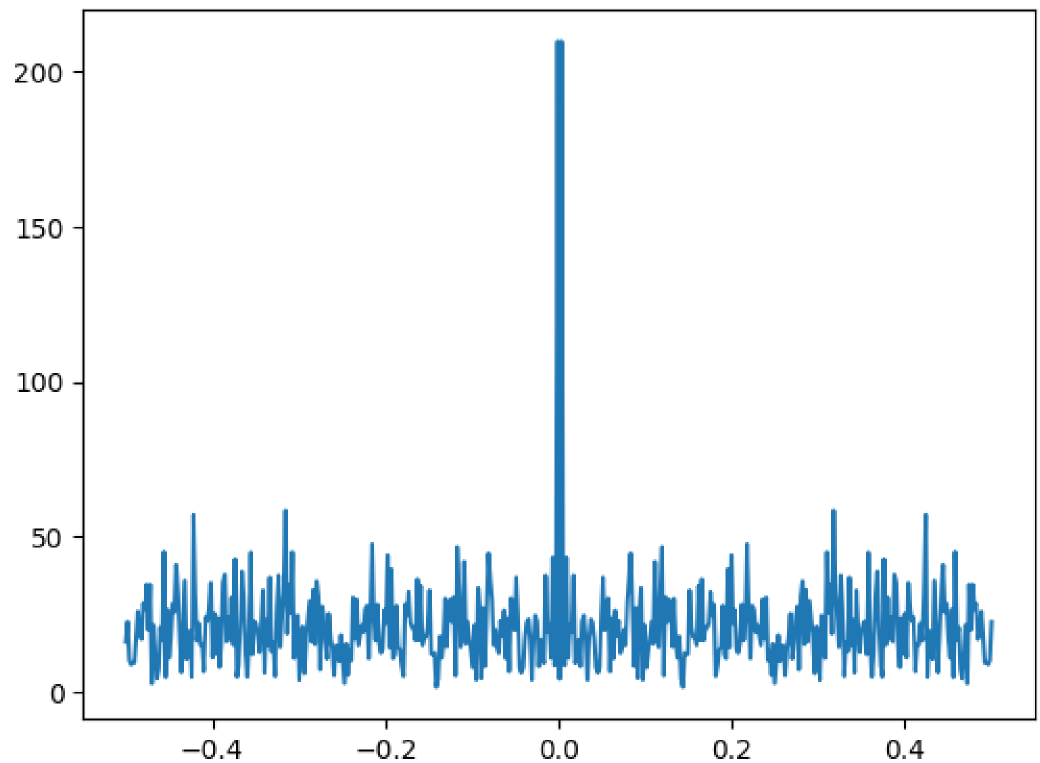


[ ]:

6. Take the sinc function described above. Generate and plot the corresponding frequency response. Now truncate the sinc function to a suitable length (M) and watch the change in frequency response. Smooth the truncated sinc function with Blackman/Hamming window and investigate the frequency response.

[34]:
```
fft = np.fft.fft(x)
magX = abs(np.fft.fftshift(fft))

plt.plot(np.linspace(-.5, 0.5, len(magX)), magX)
plt.show()
```



[ ]:

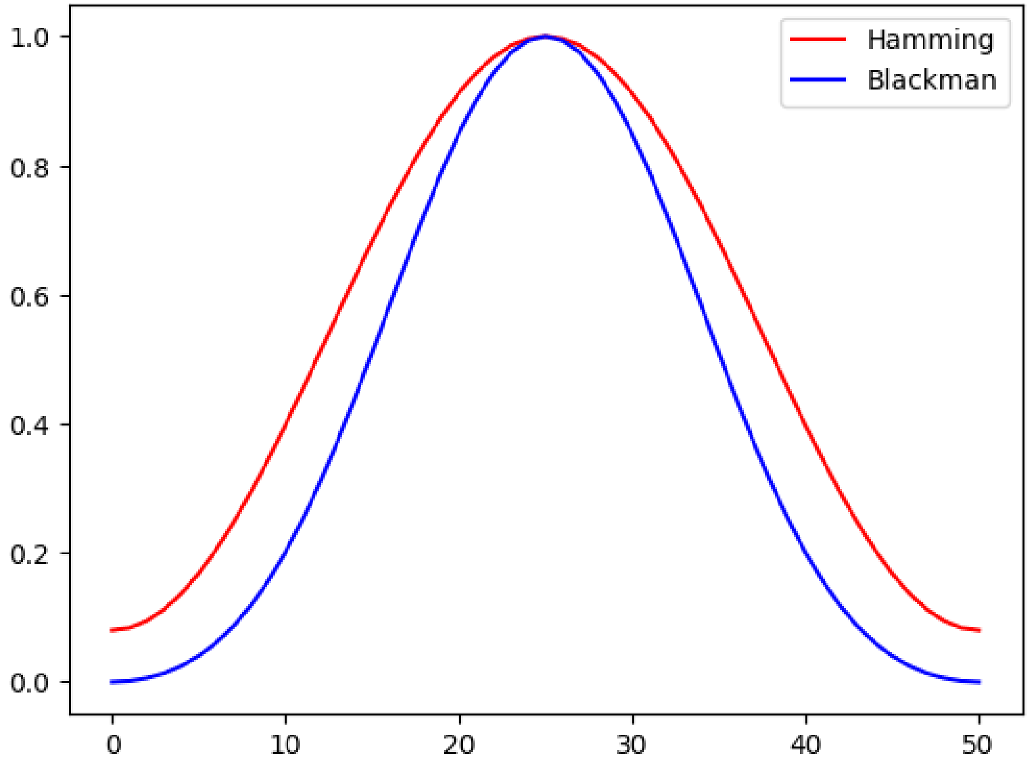
```

```

7. Verify the characteristics of Blackman and Hamming window as stated in the textbook. Use numpy.blackman and numpy.hamming.

[ ]:

```
plt.plot(np.hamming(51), 'r', label="Hamming")
plt.plot(np.blackman(51), 'b', label="Blackman")
plt.legend()
plt.show()
```



[ ]:

[ ]:

8. Verify the characteristics of Blackman and Hamming window as stated in the textbook without using numpy.blackman and numpy.hamming. Use the equations of hamming and blackman window as shown in chapter 16.

[ ]:
```
def blackman_window(n):

    a0 = 0.42
    a1 = 0.5
    a2 = 0.08
    pi = np.pi
    n_values = np.arange(n)
    w = a0 - a1*np.cos(2*pi*n_values/(n-1)) + a2*np.cos(4*pi*n_values/(n-1))
    return w
```

[ ]:
```
def hamming_window(n):
    """
    Compute the Hamming window of length n.
    """
```

```
    alpha = 0.54
    beta = 1 - alpha
    pi = np.pi
    n_values = np.arange(n)
    w = alpha - beta * np.cos(2 * pi * n_values / (n - 1))
    return w
```

[ ]:

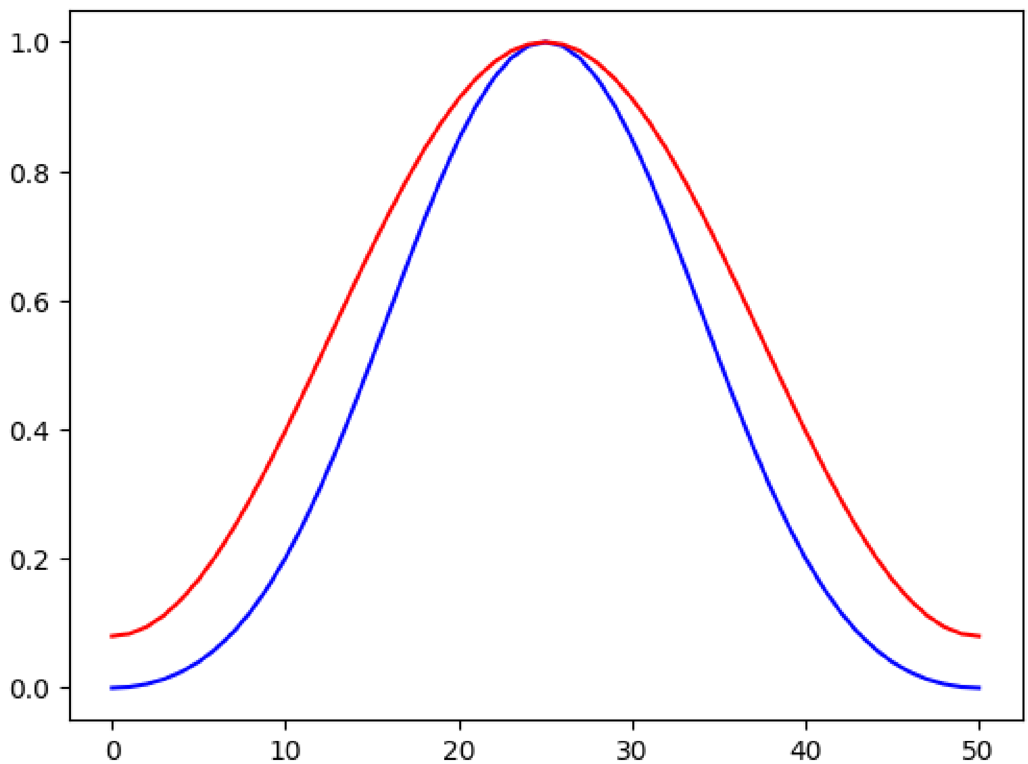
```

```

[ ]:

```
plt.plot(blackman_window(51), 'b', label="Blackman_Window")
plt.plot(hamming_window(51), 'r', label="Hamming_Window")
```

[ ]: [<matplotlib.lines.Line2D at 0x7fb021fb4bb0>]



[ ]:

```

```