Assignment 9

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Introduction

In this assignment we learn the use of different libraries provided by *pylab* to obtain Fourier transforms of various time varying sequences.

Fourier Transform of a Random Function

I start by simulating the various Fourier transforms which sir has demonstrated in the document. We start by finding the Fourier transform of a random function and finding the error between its inverse Fourier transform and the actual function value. The error obtained is $2.5523721645747573e-16$ in one of the simulations.

Fourier Transform of $sin(5t)$

I use the functions as follows:

```
x=linspace(0,2*pi,128)
y=sin(5*x)
Y=fft(y)
```

Here is the result obtained on plotting the same

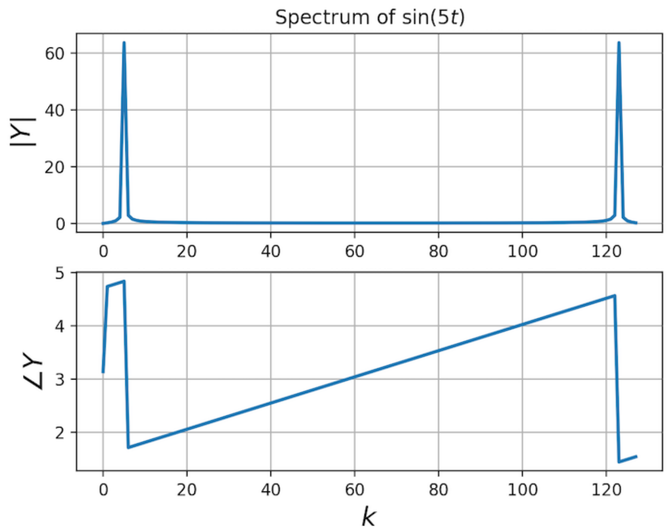

Figure 1: Magnitude and phase plots

Shifted Fourier Transform of $sin(5t)$

Since the above transform is not about 0, we use $fftshift$ to achieve the same. This is how it is obtained. Since we want 128 points using *linspace* we sample 129 and ignore the last point.

```
x=linspace(0,2*pi,129)
x=x[:-1]
y=sin(5*x)
Y=fftshift(fft(y))/128.0
```

Here is the result obtained on plotting the same

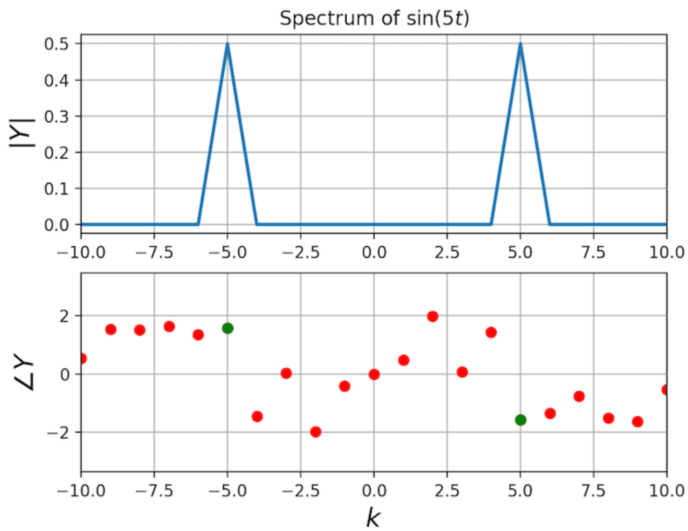

Figure 2: Magnitude and phase plots

AM Modulation

Now we try to obtain the spectrum of the AM modulated signal $(1 + 0.1\cos(t))\cos(10t)$. Here is the code I used to achieve the same.

```
t=linspace(0,2*pi,129)
t=t[:-1]
y=(1+0.1*cos(t))*cos(10*t)
Y=fftshift(fft(y))/128.0
w=linspace(-64,63,128)
```

Here is the result obtained on plotting the same

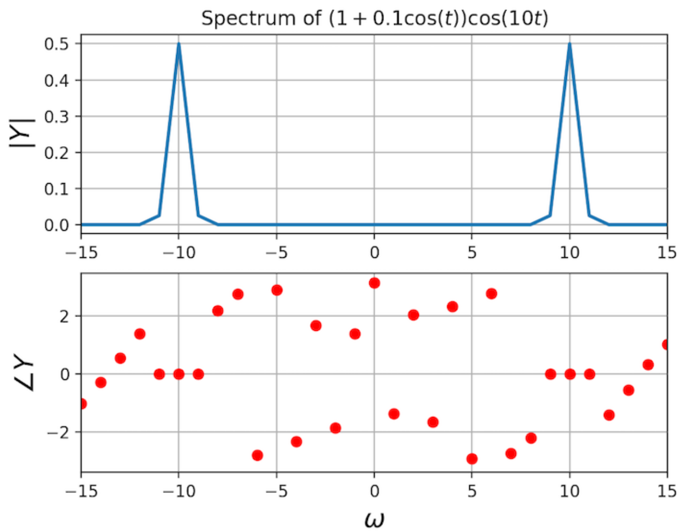

Figure 3: Magnitude and phase plots

AM Modulation with more samples

Now we attempt the same problem as above but with double the points sampled to obtain a higher precision.

```
t=linspace(-4*pi,4*pi,513)
t=t[:-1]
y=(1+0.1*cos(t))*cos(10*t)
Y=fftshift(fft(y))/512.0
w=linspace(-64,64,513)
```

Here is the result obtained on plotting the same

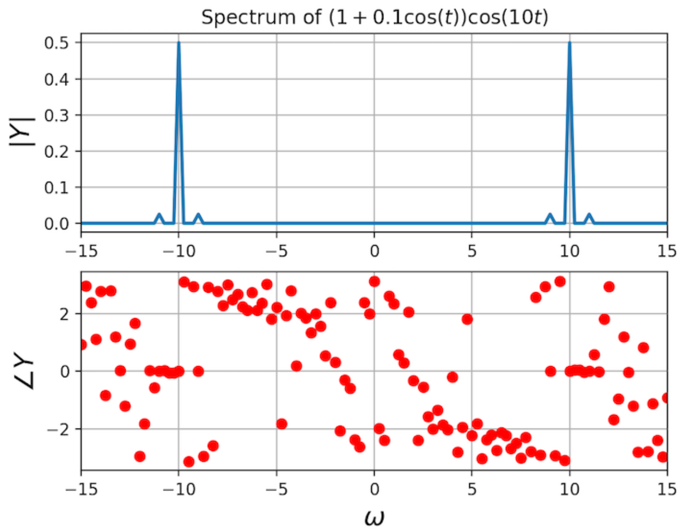

Figure 4: Magnitude and phase plots

Spectrum of $\sin^3(t)$

Here I attempt to find the spectrum of $\sin^3(t)$. The code I use to achieve the same is as shown.

```
x=linspace(0,2*pi,129)
x=x[:-1]
y=(sin(x))**3
Y=fftshift(fft(y))/128.0
w=linspace(-64,63,128)
```

Here is the result obtained on plotting the same.
It can be seen that peaks are noticed near the frequencies of 1 and 3 which are the constituents of the cube of a sine.

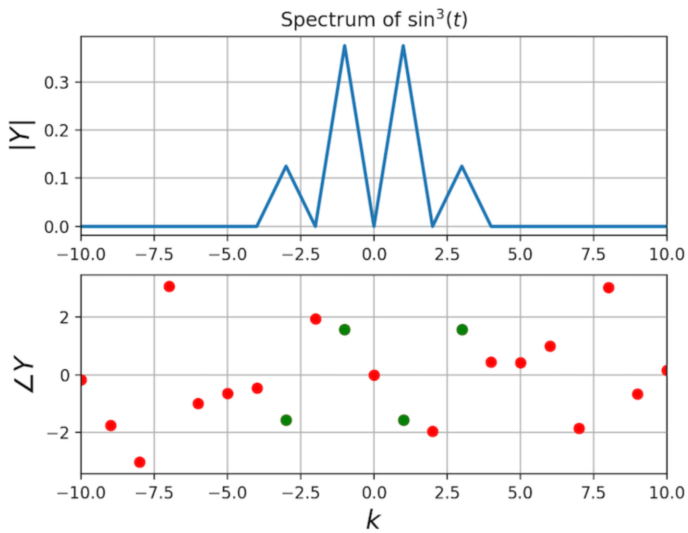

Figure 5: Magnitude and phase plots

Spectrum of $\cos^3(t)$

Here I attempt to find the spectrum of $\cos^3(t)$. The code I use to achieve the same is as shown.

```
x=linspace(0,2*pi,129)
x=x[:-1]
y=(cos(x))**3
Y=fftshift(fft(y))/128.0
w=linspace(-64,63,128))
```

Here is the result obtained on plotting the same.
The entire process as can be seen is the same for sine and cosine.

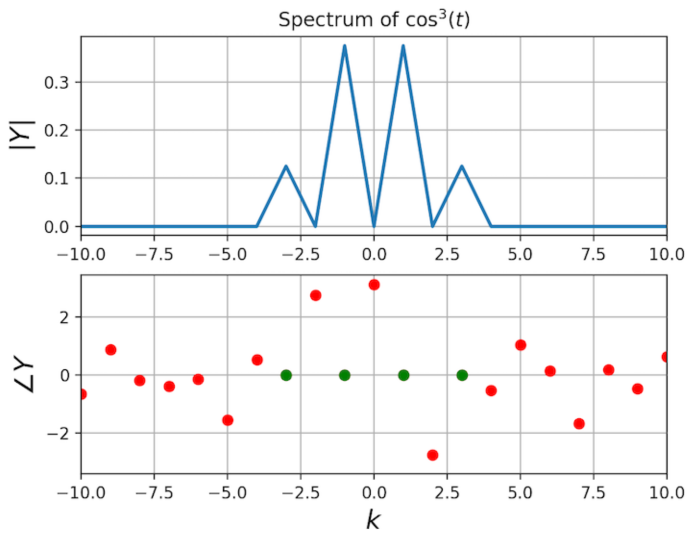

Figure 6: Magnitude and phase plots

Spectrum of $\cos(20t + 5\cos(t))$

Here I attempt to find the spectrum of $\cos(20t + 5\cos(t))$. The code I use to achieve the same is as shown.

```
t=linspace(-4*pi,4*pi,513)
t=t[:-1]
y=cos(20*t+5*cos(t))
Y=fftshift(fft(y))/512.0
w=linspace(-64,64,513)
w=w[:-1]
```

Here is the result obtained on plotting the same.
On plotting the phase at the points only which is greater than 10^-3 it can be noticed that such points lie right where the points where the magnitude of the response is significant. This tells us that the time varying signal contains sinusoids of these frequencies. Observing the phases it can be said it is odd symmetric, since there is reflection about the origin.

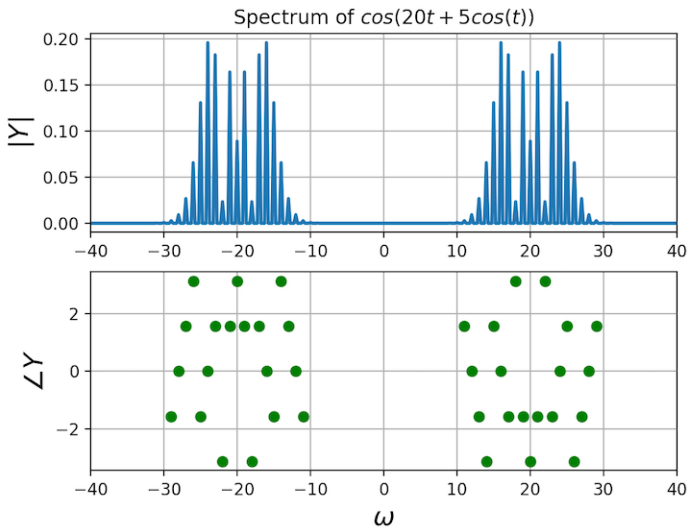

Figure 7: Magnitude and phase plots

Spectrum of Gaussian exponent

Here I attempt to find the spectrum of a Gaussian exponent. I take the range from -8π to 8π to get a reasonable graph and output.

```
t=linspace(-8*pi,8*pi,513)
t=t[:-1]
y=exp(-(t**2)/2)
Y=fftshift(fft(y))/512.0
w=linspace(-64,64,513)
w=w[:-1]
```

Here is the result obtained on plotting the same.
I found a maximum error of 0.0026478044244092613 though the graphs overlap almost completely. On trying different ranges, the error was pretty much the same

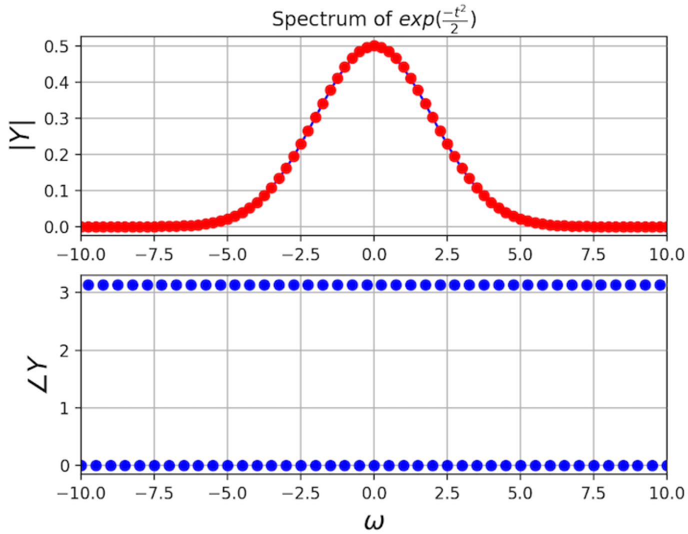

Figure 8: Magnitude and phase plots

Conclusion

Through this assignment I learnt the usage of various libraries available on Python which can be used to visualize the Fourier transform. Shifting the plot of the spectrum is a very good idea as it would lead to easier analysis.