EE2703 : Applied Programming Lab
Assignment 8

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EE20B041

April 18, 2022

Assignment

Computing how to obtain DFT and recovering analog fourier transform for some known fucntions by sampling of the function.
For computing the DFT :

$$X[k] = \sum_{n=0}^{N-1} x[n]e^{-j2\pi kn/N}$$

The synthesis equation is given as :

$$x[n] = \frac{1}{N}\sum_{n=0}^{N-1} X[k]e^{j2\pi kn/N}$$

Q1

For $f(t) = sin(5t)$ **:**

128 samples from $[0, 2\pi]$ are taken for $f(t) = sin(5t)$:

```
x = np.linspace(0,2*np.pi, 129)
x = x[0:-1]
y = np.sin(5*x)
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/128
w = np.linspace(-64,64,129)
w = w[0:-1]
```

For obtaining the spectrum of $f(t)$:

```
plt.figure()
plt.subplot(2,1,1)
plt.plot(w,abs(Y),lw=2)
plt.ylabel(r"$|Y|\rightarrow$")
plt.xlim([-15,15])
plt.grid(True)

plt.subplot(2,1,2)
plt.plot(w,np.angle(Y),'ro',lw=2)
ii=np.where(abs(Y)>1e-3)
plt.plot(w[ii],np.angle(Y[ii]),'go',lw=2)
plt.xlim([-15,15])
```

```
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlabel(r"$k\rightarrow$")
plt.grid(True)
plt.show()
```

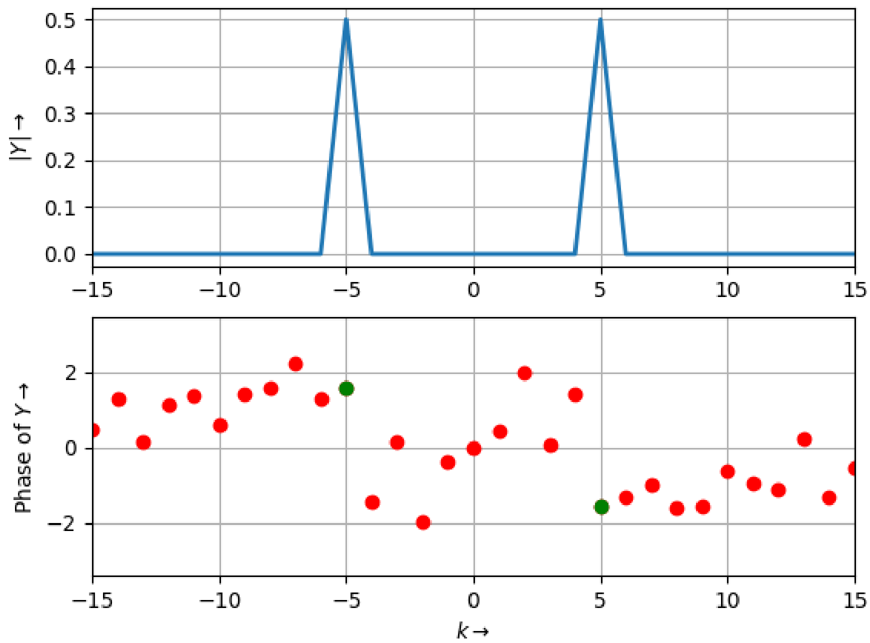

Figure 1: Magnitude and Phase of DFT of $sin(5t)$

For $f(t) = (1 + 0.1cos(t))cos(10t)$ **:**

513 samples from $[-4\pi, 4\pi]$ are taken. This has same sampling rate as the last example but the spacing is tighter.

```
x = np.linspace(-4*np.pi,4*np.pi, 513)
x = x[0:-1]
y = (1 + 0.1*np.cos(x))*np.cos(10*x)
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/512
w = np.linspace(-64,64,513)
w = w[0:-1]
```

For the spectrum :

```
plt.figure()
plt.subplot(2,1,1)
plt.plot(w, abs(Y),lw=2)
plt.ylabel(r"$|Y|\rightarrow$")
plt.xlim([-15,15])
plt.grid(True)

plt.subplot(2,1,2)
plt.plot(w,np.angle(Y),'ro',lw=2)
ii=np.where(abs(Y)>1e-3)
plt.plot(w[ii],np.angle(Y[ii]),'go',lw=2)
plt.xlim([-15,15])
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlabel(r"$k\rightarrow$")
plt.grid(True)
plt.show()
```

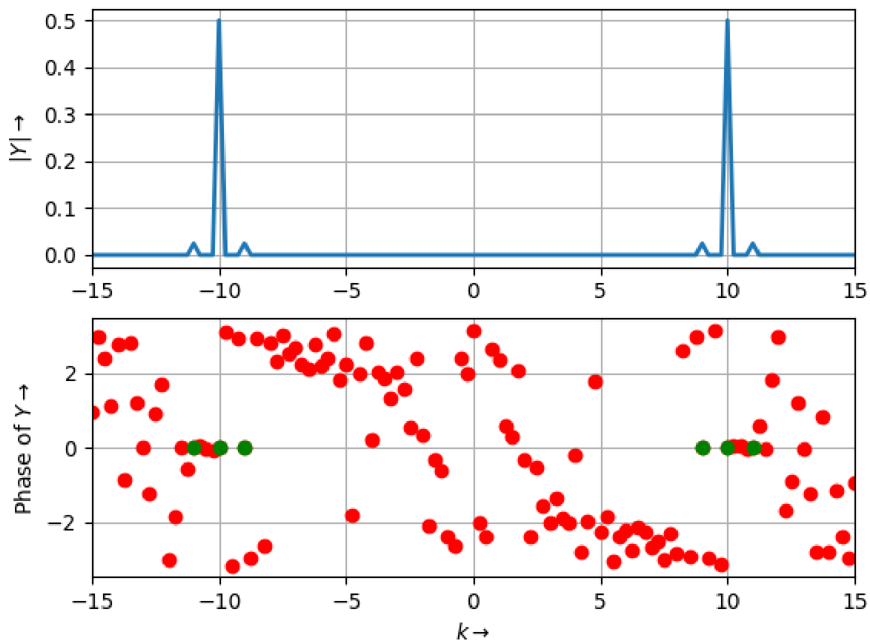

Figure 2: Magnitude and Phase of DFT of $f(t)$

Q2

For $f(t) = sin^3 t$ **:**

512 samples from $[-4\pi, 4\pi]$ are taken :

```
t = np.linspace(-4*np.pi, 4*np.pi, 513)
t = t[0:-1]
y = (np.sin(t))**3
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/512
w = np.linspace(-64, 64, 513)
w = w[0:-1]
```

Magnitude and Phase of DFT :

```
plt.figure()
plt.subplot(2,1,1)
plt.plot(w, abs(Y))
plt.xlim([-5,5])
plt.ylabel(r"$|Y|\rightarrow$")
plt.grid()

plt.subplot(2,1,2)
plt.plot(w, np.angle(Y), ".", markersize = 4)
ii = np.where(abs(Y) > 1e-3)
plt.plot(w[ii], np.angle(Y[ii]), "go", markersize = 5)
plt.xlabel(r"$w\rightarrow$")
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlim([-5,5])
plt.grid()
plt.show()
```

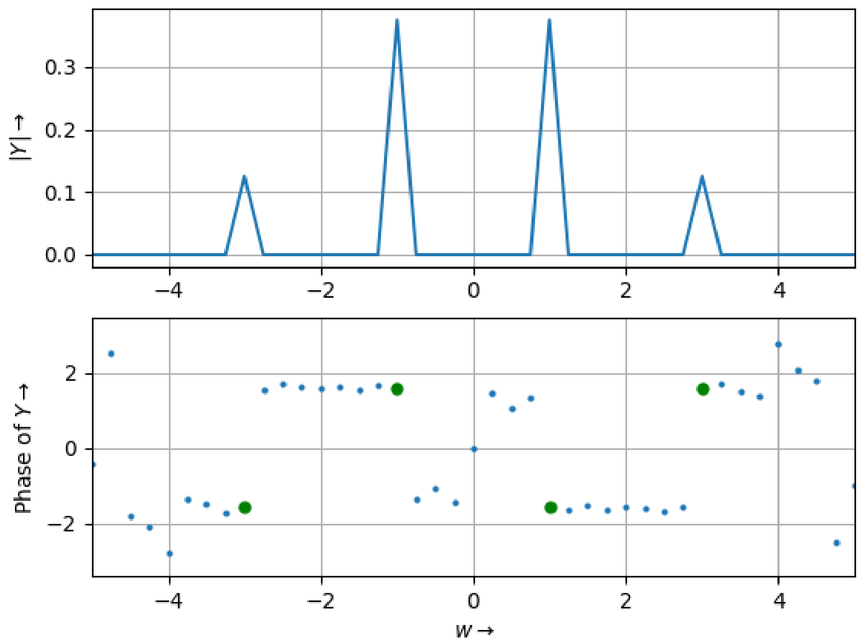

Figure 3: Magnitude and Phase of DFT of sin^3t

For $f(t) = cos^3t$ **:**

512 samples from $[-4\pi, 4\pi]$ are taken :

```
t = np.linspace(-4*np.pi, 4*np.pi, 513)
t = t[0:-1]
y = (np.cos(t))**3
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/512
w = np.linspace(-64, 64, 513)
w = w[0:-1]
```

Magnitude and Phase of DFT :

```
plt.figure()
plt.subplot(2,1,1)
plt.plot(w, abs(Y))
plt.xlim([-5,5])
plt.ylabel(r"$|Y|\rightarrow$")
plt.grid()
```

```
plt.subplot(2,1,2)
plt.plot(w, np.angle(Y), ".", markersize = 4)
ii = np.where(abs(Y) > 1e-3)
plt.plot(w[ii], np.angle(Y[ii]), "go", markersize = 5)
plt.xlabel(r"$w\rightarrow$")
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlim([-5,5])
plt.grid()
plt.show()
```

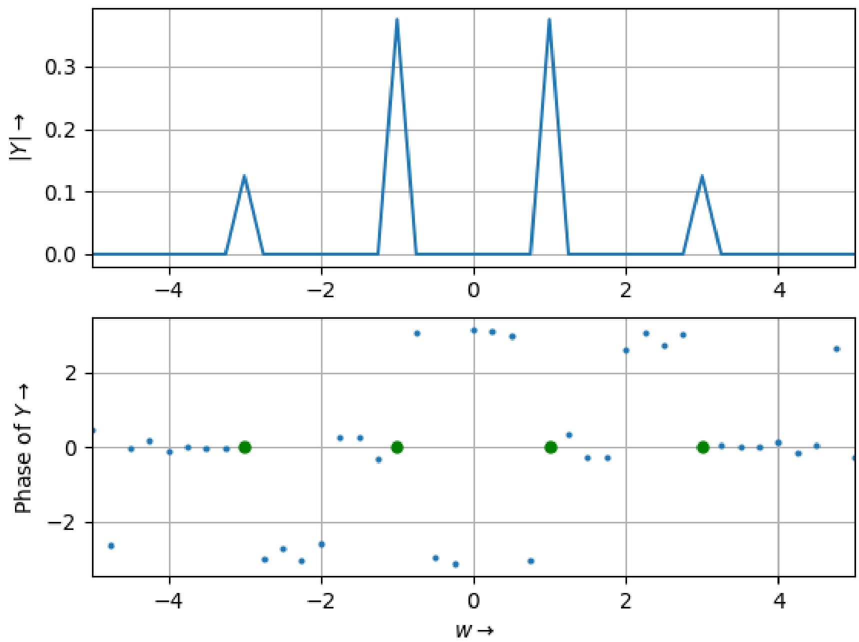

Figure 4: Magnitude and Phase of DFT of cos^3t

Q3

Spectrum for :

$$f(t) = cos(20t + 5cos(t))$$

```
t = np.linspace(-4*np.pi, 4*np.pi, 513)
t = t[0:-1]
```

```
y = np.cos(20*t + 5*np.cos(t))
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/512
w = np.linspace(-64, 64, 513)
w = w[0:-1]
```

Magnitude and phase of DFT :

```
plt.figure()
plt.subplot(2,1,1)
plt.plot(w, abs(Y))
plt.xlim([-30,30])
plt.ylabel(r"$|Y|\rightarrow$")
plt.grid()

plt.subplot(2,1,2)
plt.plot(w, np.angle(Y), ".", markersize = 4)
ii = np.where(abs(Y) > 1e-3)
plt.plot(w[ii], np.angle(Y[ii]), "go", markersize = 5)
plt.xlabel(r"$w\rightarrow$")
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlim([-30,30])
plt.grid()
plt.show()
```

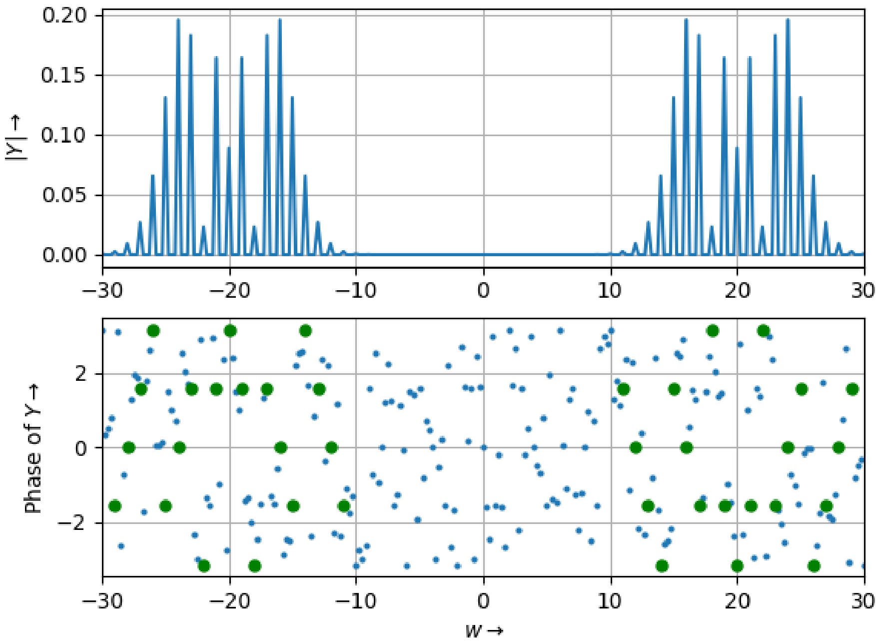

Figure 5: Magnitude and Phase of DFT of $cos^3 t$

The signal has a main frequency of 20rad/s, therefore we observe a spike at 20 in the spectrum and the other spikes in the spectrum is due to the cos(5t) part of the signal.

Q4

Spectrum for :

$$f(t) = e^{-t^2/2}$$

```
t = np.linspace(-32,32,513)
t = t[0:-1]
y = np.exp(-(t**2)/2.0)
Y = np.fft.fft(y)
Y = np.fft.fftshift(Y)/512.0
w = np.linspace(-64,64, 513)
w = w[0:-1]

plt.figure()
```

```
plt.subplot(2,1,1)
plt.plot(w, abs(Y))
plt.xlim([-5,5])
plt.ylabel(r"$|Y|\rightarrow$")
plt.grid()

plt.subplot(2,1,2)
plt.plot(w, np.angle(Y), ".", markersize = 4)
ii = np.where(abs(Y) > 1e-3)
plt.plot(w[ii], np.angle(Y[ii]), "go", markersize = 5)
plt.xlabel(r"$w\rightarrow$")
plt.ylabel(r"Phase of $Y\rightarrow$")
plt.xlim([-15,15])
plt.grid()
plt.show()
```

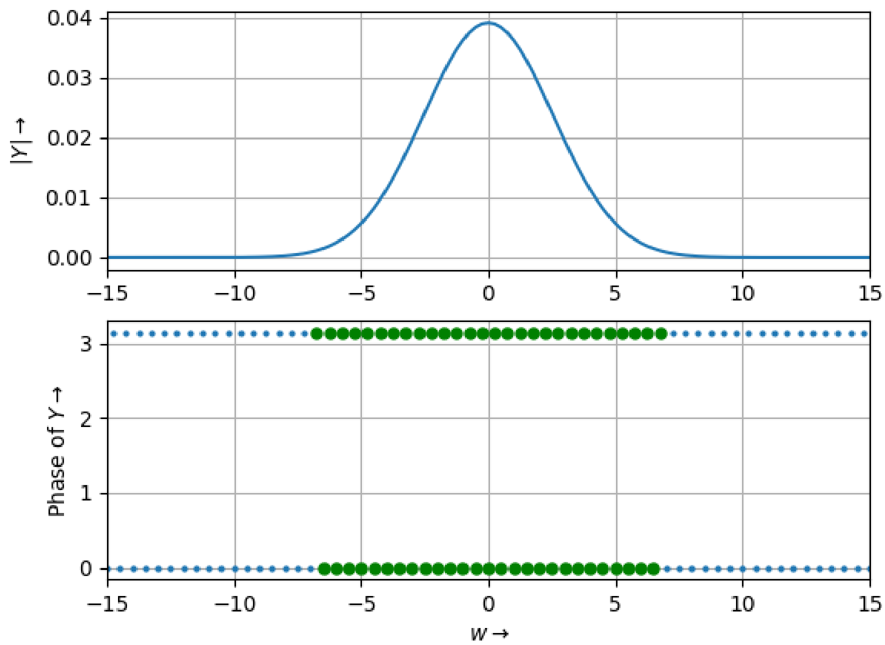

Figure 6: Magnitude and Phase of DFT of $cos^3 t$

We get a peak of approx 0.039 for the time range of $[-32, 32]$. The peak value changes with the time range we chose to sample.

Conclusion

In this assignment we evaluated DFT for various signal. DFT which is widely used or a major operation in image processing, mobile communications etc. DFT is aslo used to solve partial DE. It is basically used to perform Fourier analysis in many practical applications.