ASSIGNMENT 9

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1 Finding the Spectrum of $\cos^3(0.86t)$

The plot of $\cos^3(0.86t)$ without window.

The peaks are broader in the plot without window compared to the one with window because of the jumps at the ends of the signal,when we didn't multiply a window to it.

1.1 Without window

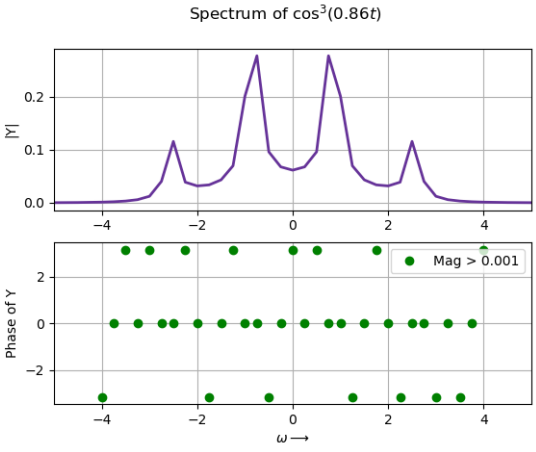


Figure 1: Spectrum of $\cos^3(t)$

The plot of $\cos^3(0.86t)$ with window.

1.2 With window

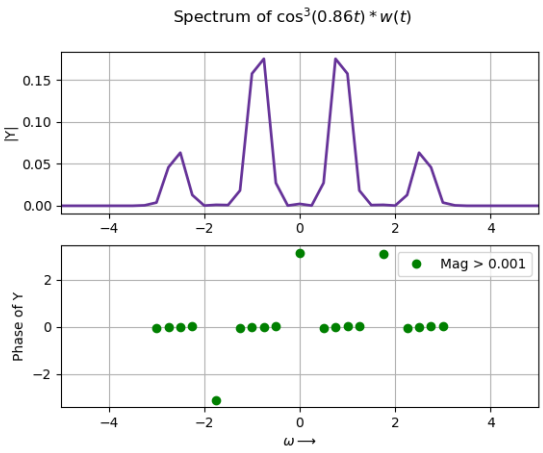


Figure 2: Spectrum of $\cos^3(t)$ with window

2 Estimating w and δ for $\cos(wt + \delta)$

Take weighted mean of w with weight as mag**2 gives an estimate of w.This is equivalent to the least square estimate method. we can do the same thing for delta as well.

$$\omega = \frac{\sum_{(} \omega * |Y|^2)}{\sum_{|} Y|^2} \tag{1}$$

$$\delta = \frac{\sum_{(} \delta * |Y|^2)}{\sum_{|} Y|^2} \tag{2}$$

This approach works well if signal's time is from -4π to 4π rather than from $-\pi$ to π. if t is from $-\pi$ to π we get less error for w $\geq$ 1 and more error for w $\leq$ 1,because of the overlapping of the two peaks, which are widened by the window.

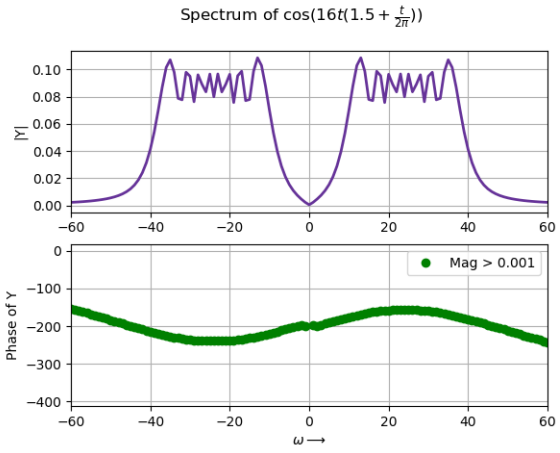
```
def findCos(w,Ymag,Yphi,truevals=[],Sup=1e-2):
'''To find the phase and freq of a given cosine'''
ii = np.where(np.logical_and(Ymag>Sup,w>0))
Mag = np.abs(Ymag[ii])**2
w0 = np.sum(w[ii]*Mag)/np.sum(Mag)
if np.allclose(Yphi[w==1], Yphi[w==2], atol=1e-1):
    delta = np.sum(Yphi[ii]*Mag)/np.sum(Mag)
else:
    delta = Yphi[w==1][0]
return [w0,delta],np.abs(np.array(truevals)-np.array([w0,delta]))
```

for noise added signals The transform for this will be sum of transforms of signal and noise. since the noise is gaussian the transform will be band unlimited. with highest magnitude of 0.08 to nearly remove the effect of noise on the calculation we will consider only points with magnitude ≥ 0.01.

```
True value of w 0.86 and delta 1.5707963267948966
[7.28914114e-04 7.72140423e-05]
without noise
Mean value of w0 0.8607289141139 and delta 1.5708735408372274
Mean error in W0 0.0007289141138919764,delta 7.721404232730045e-05
Max error in W0 0.0007289141138919764,delta 7.721404232730045e-05
[0.03924775 0.0178008 ]
with noise
Mean value of w0 0.8858592807876889 and delta 1.5644014590359094
Mean error in W0 0.026086217396879743,delta 0.014935307712383111
Max error in W0 0.13289014768149865,delta 0.05945355697237198
```

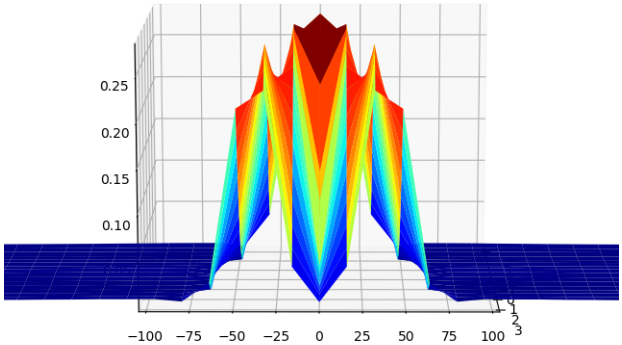
3 Spectrum of Chirped signal $\cos(16t(1.5 + \frac{t}{2\pi}))$

The frequency(ω) of the chirped signal is continuously increasing from 16 to 32 in the interval -π to π

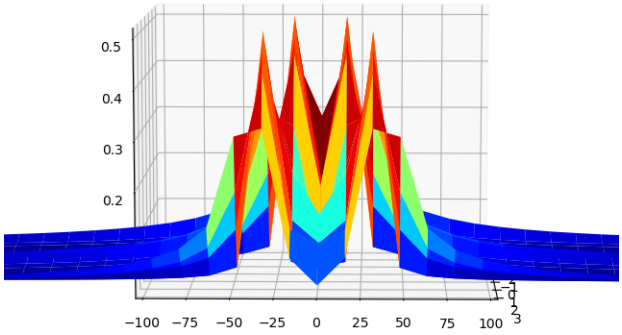


from these 3d plots we can see that the frequency of the signal increases when we go from -π to π(from the positions of peaks at a given time instant) The distances of the peaks from the mid point represent the frequency of the signal.The phase of the signal is also changing from -ve to +ve as we go from -π to π.

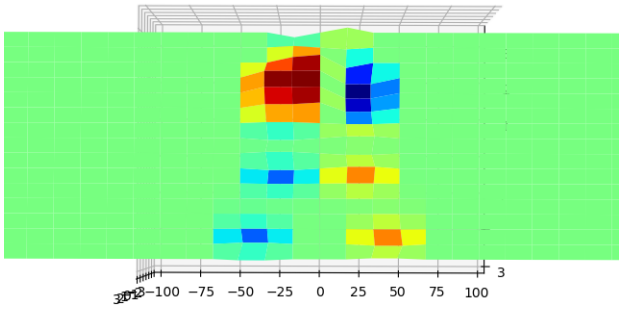
Mag with window



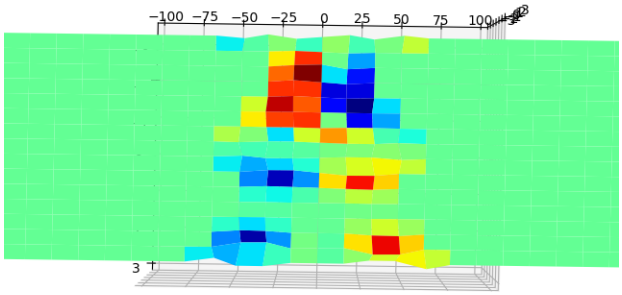
Mag with out window



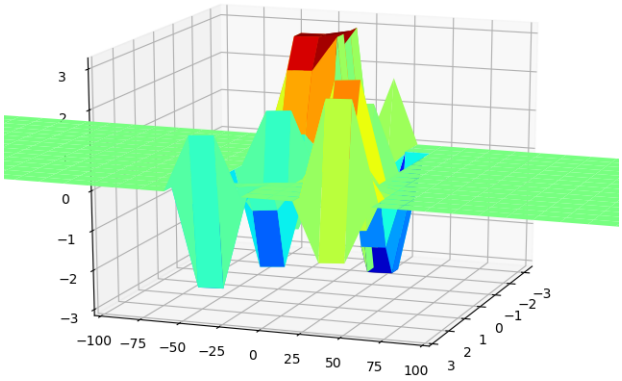
Phi with window



Phi with out window



Phi with window



Phi with out window