EE2703: Assignment 9

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EE19B130

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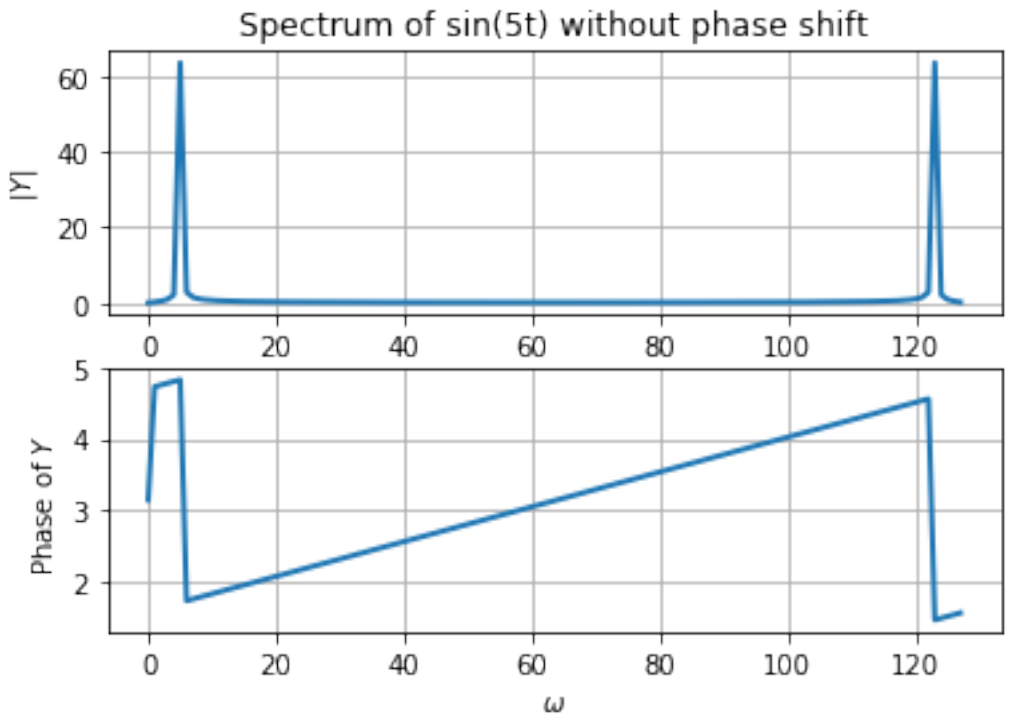
[1]:
```
from pylab import *
```

[2]:
```
x=rand(100)
X=fft(x)
y=ifft(X)
c_[x,y]
print ("Absolute Maximum Error = ",abs(x-y).max())
```

```
Absolute Maximum Error =  4.46552732754851e-16
```

0.0.1 Example-1

[3]:
```
x=linspace(0,2*pi,128)
y=sin(5*x)
Y=fft(y)

# Plotting
figure()
subplot(2,1,1)
title("Spectrum of sin(5t) without phase shift")
plot(abs(Y),lw=2)
grid(True)
ylabel(r"$|Y|$")

subplot(2,1,2)
plot(unwrap(angle(Y)),lw=2)
ylabel(r"Phase of $Y$")
xlabel(r"$\omega$")
grid(True)
show()
```

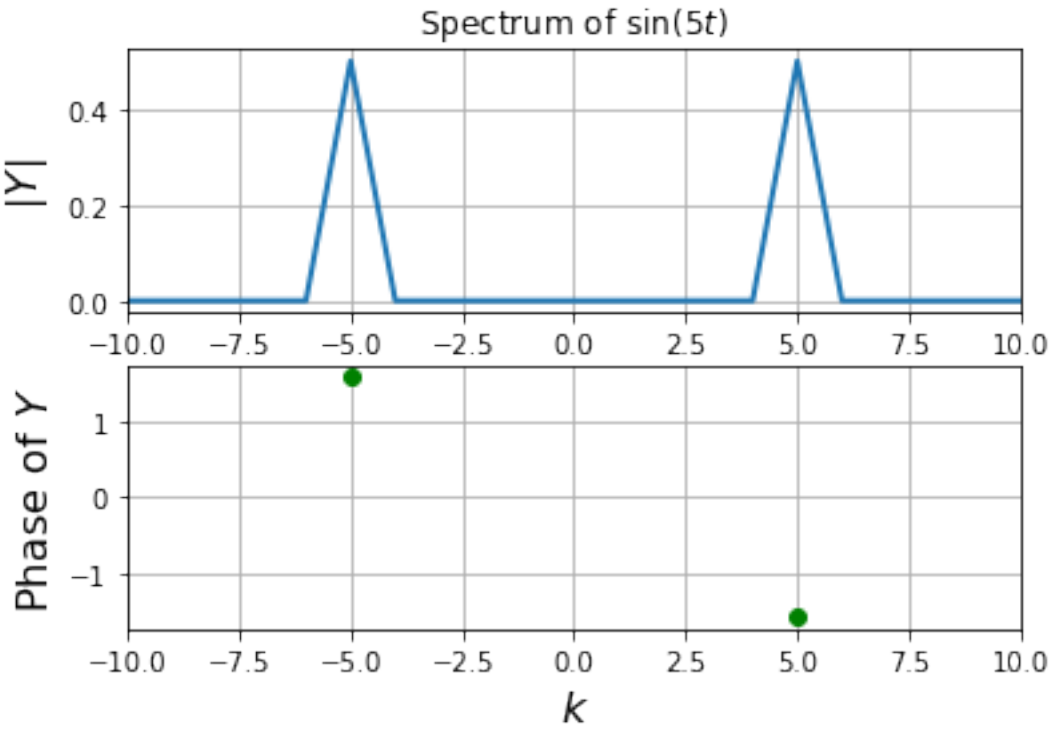


[4]:
```
def dft(x_start,x_end,steps,f,xlim1,titl,ylabel1,ylabel2,xlabel1,savename,go=False):

    #finding FFT
    sampling_rate = steps/(x_end-x_start)
    x=linspace(x_start,x_end,steps+1)[:-1]
    y = f(x)
    Y=fftshift(fft(y))/float(steps)
    w=sampling_rate*(linspace(-pi,pi,steps+1)[:-1])

    #plotting
    figure()
    subplot(2,1,1)
    plot(w,abs(Y),lw=2)
    xlim([-xlim1,xlim1])
    ylabel(ylabel1,size=16)
    title(titl)
    grid(True)
    subplot(2,1,2)
    ro = False

    if (ro):
        plot(w,angle(Y),'ro',lw=2)
```

```
    if(go):
        ii=where(abs(Y)>1e-3)
        plot(w[ii],angle(Y[ii]),'go',lw=2)

    xlim([-xlim1,xlim1])
    ylabel(ylabel2,size=16)
    xlabel(xlabel1,size=16)
    grid(True)
    savefig(savename)
    show()
    return
```

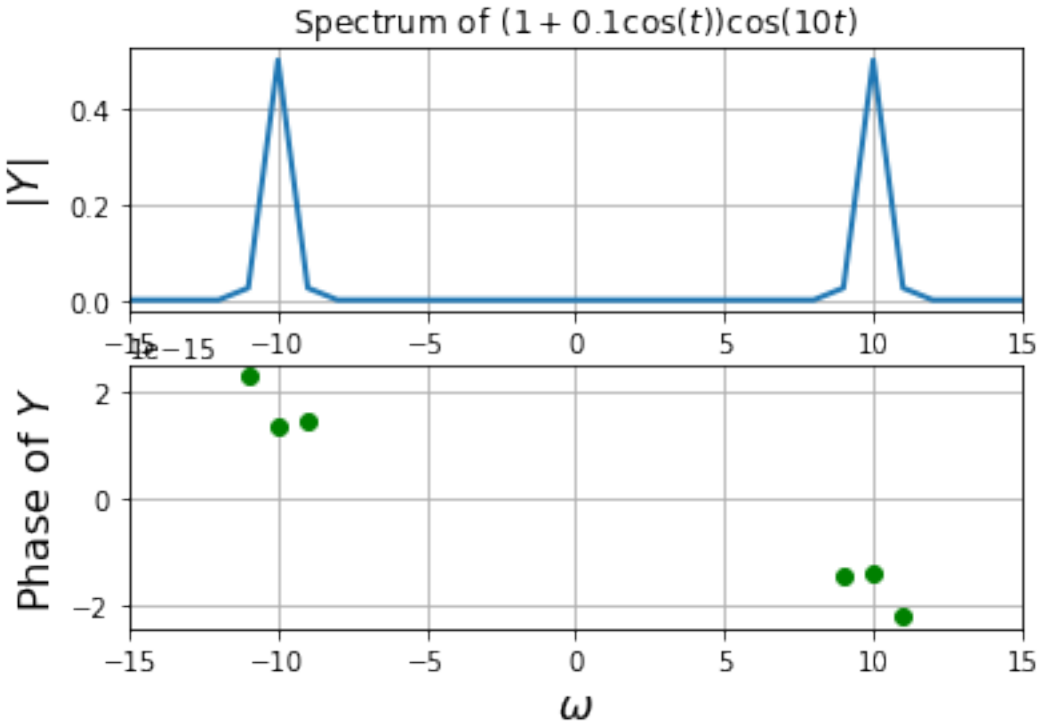
0.0.2 Example-2

[5]:
```
def f3(x):
    return sin(5*x)

dft(0,2*pi,128,f3,10,r"Spectrum of $\sin(5t)$",r"$|Y|$",r"Phase of␣
 ↪$Y$",r"$k$","fig9-2.png",go = True)
```



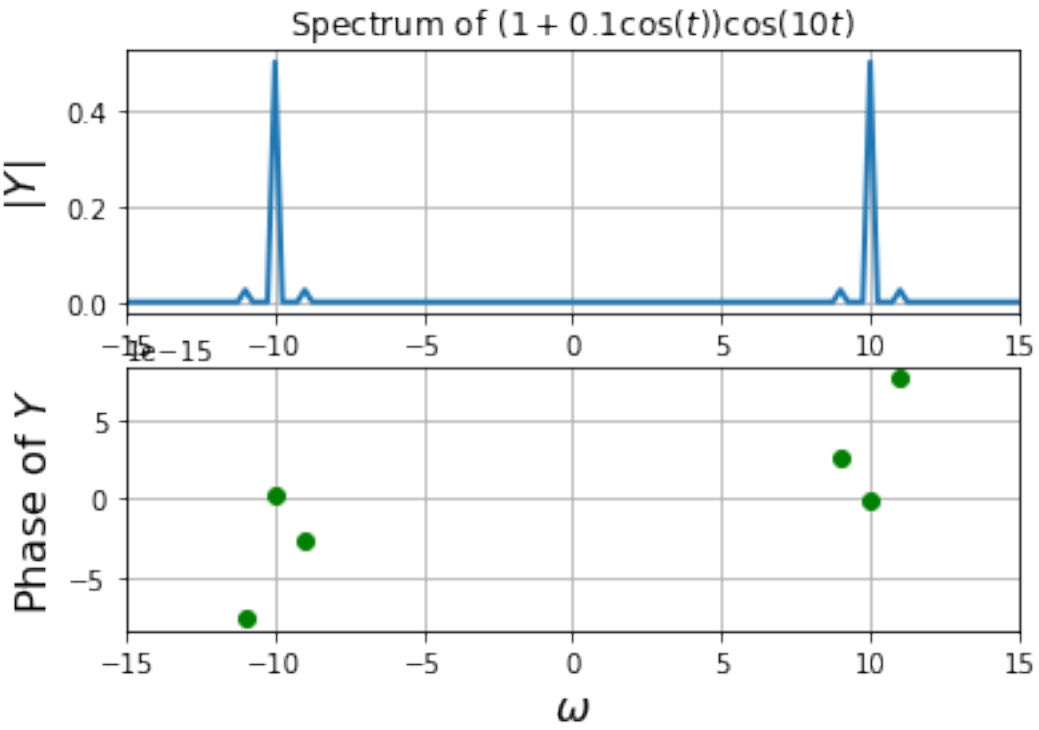
0.0.3 Example-3

[6]:
```
def f4(t):
    return (1+0.1*cos(t))*cos(10*t)

dft(0,2*pi,128,f4,15,r"Spectrum of $\left(1+0.
↪1\cos\left(t\right)\right)\cos\left(10t\right)$",r"$|Y|$",r"Phase of␣
↪$Y$",r"$\omega$","fig9-3.png",go =True)
```



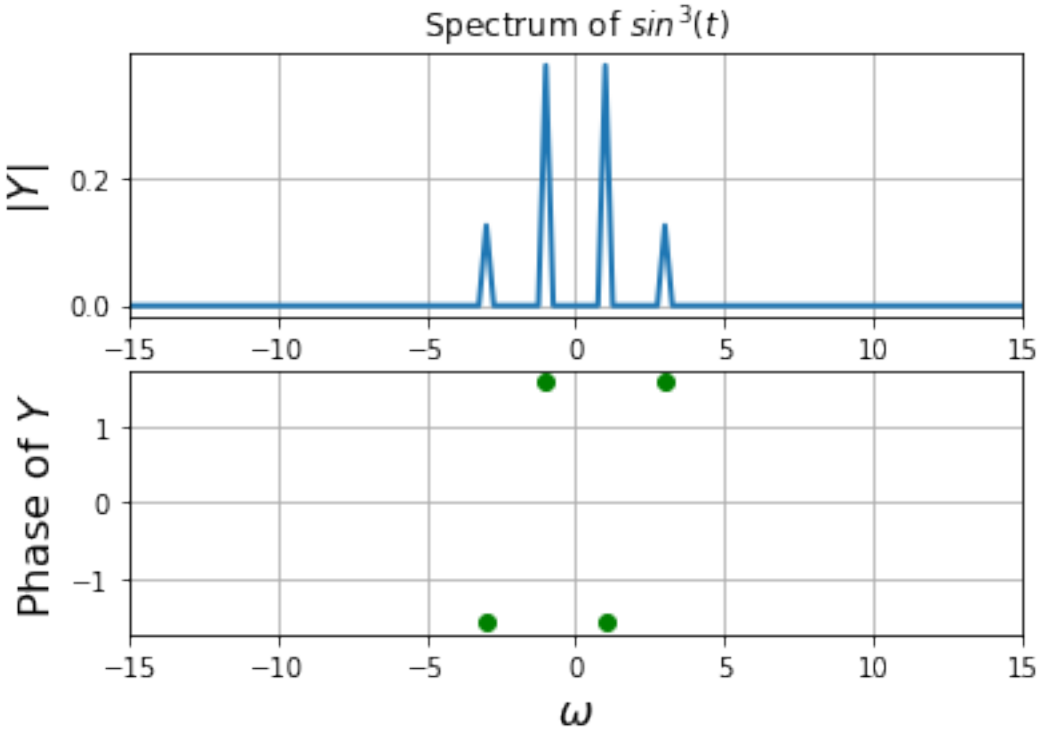
0.0.4 Example-4

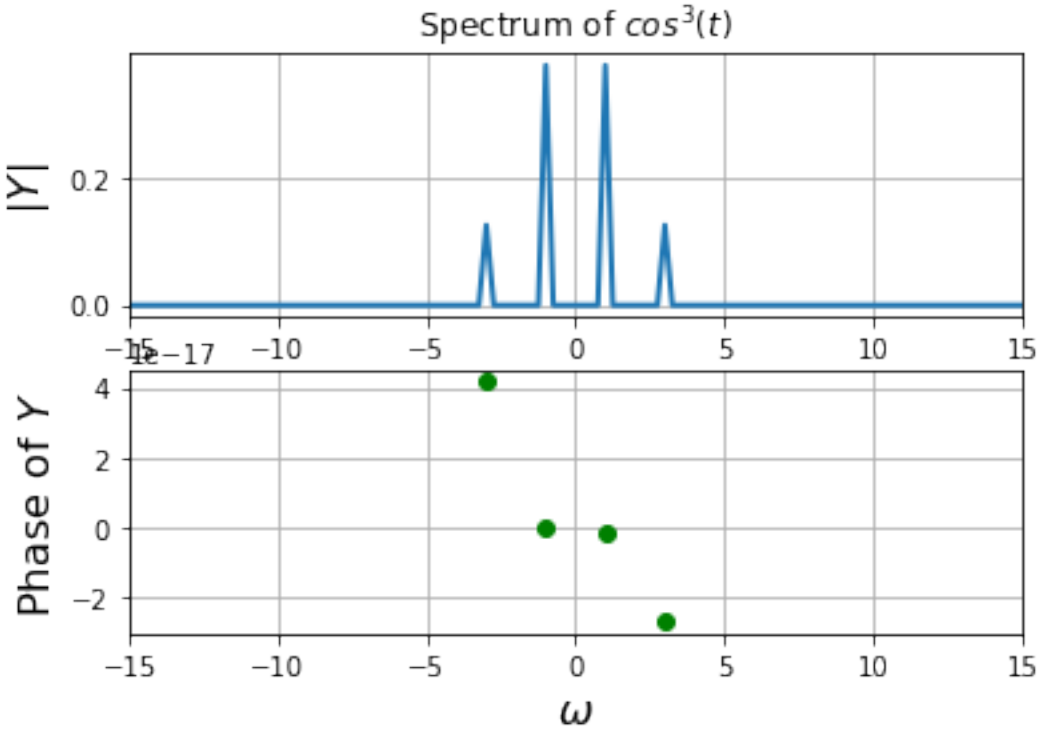
[7]:
```
dft(-4*pi,4*pi,512,f4,15,r"Spectrum of $\left(1+0.
↪1\cos\left(t\right)\right)\cos\left(10t\right)$",r"$|Y|$",r"Phase of␣
↪$Y$",r"$\omega$","fig9-4.png",go =True)
```



0.1 2. Spectrum of sin^3t and cos^3t

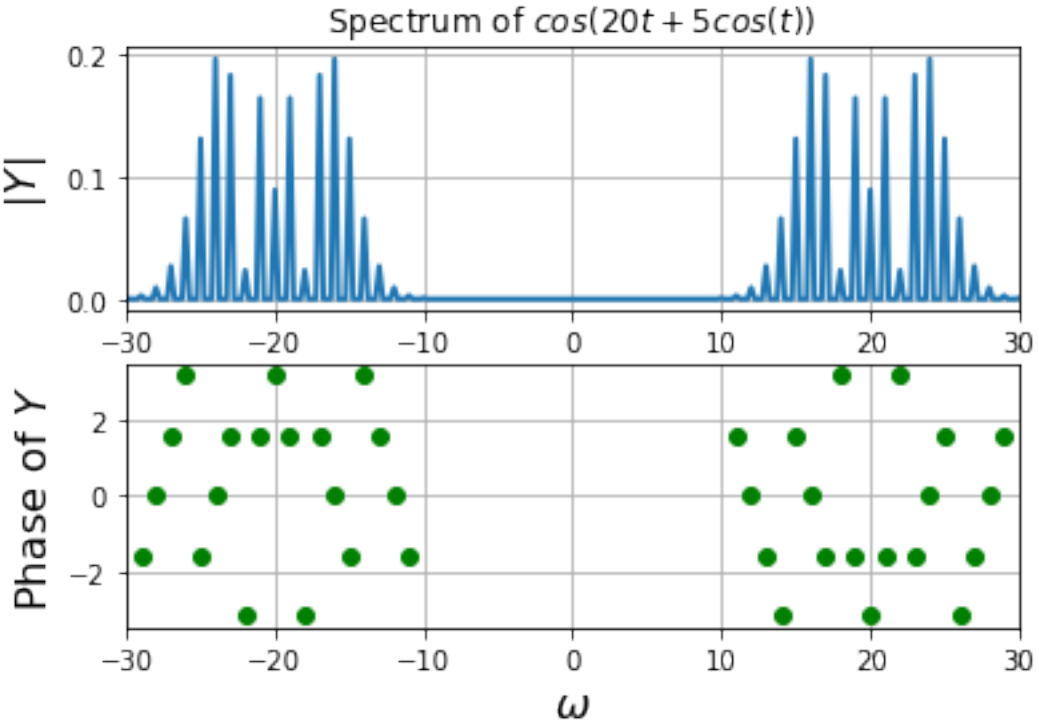
[8]:
```
def f6(x):
    return (sin(x))**3

def f7(x):
    return (cos(x))**3

dft(-4*pi,4*pi,512,f6,15,r"Spectrum of $sin^3(t)$",r"$|Y|$",r"Phase of␣
 ↪$Y$",r"$\omega$","fig9-5.png",go =True)
dft(-4*pi,4*pi,512,f7,15,r"Spectrum of $cos^3(t)$",r"$|Y|$",r"Phase of␣
 ↪$Y$",r"$\omega$","fig9-6.png",go =True)
```


Spectrum of $sin^3(t)$
|Y|
0.2
0.0
−15
−10
−5
0
5
10
15
Phase of Y
1
0
−1
ω


Spectrum of $cos^3(t)$
|Y|
0.2
0.0
−15
−10
−5
0
5
10
15
1e−17
4
2
0
−2
Phase of Y
ω

0.2 3. Spectrum of cos(20t + 5cos(t))

[9]:
```
def f8(x):
    return cos(20*x + 5*cos(x))

dft(-4*pi,4*pi,512,f8,30,r"Spectrum of $cos(20t + 5cos(t))$",r"$|Y|$",r"Phase of␣
↪$Y$",r"$\omega$","fig9-7.png",go =True)
```



0.3 4. Gaussian

[10]:
```
#defining gaussian and its expected CTFT
def gauss(x):
    return exp(-0.5*x**2)

def expectedgauss(w):
    return 1/sqrt(2*pi) * exp(-w**2/2)
```

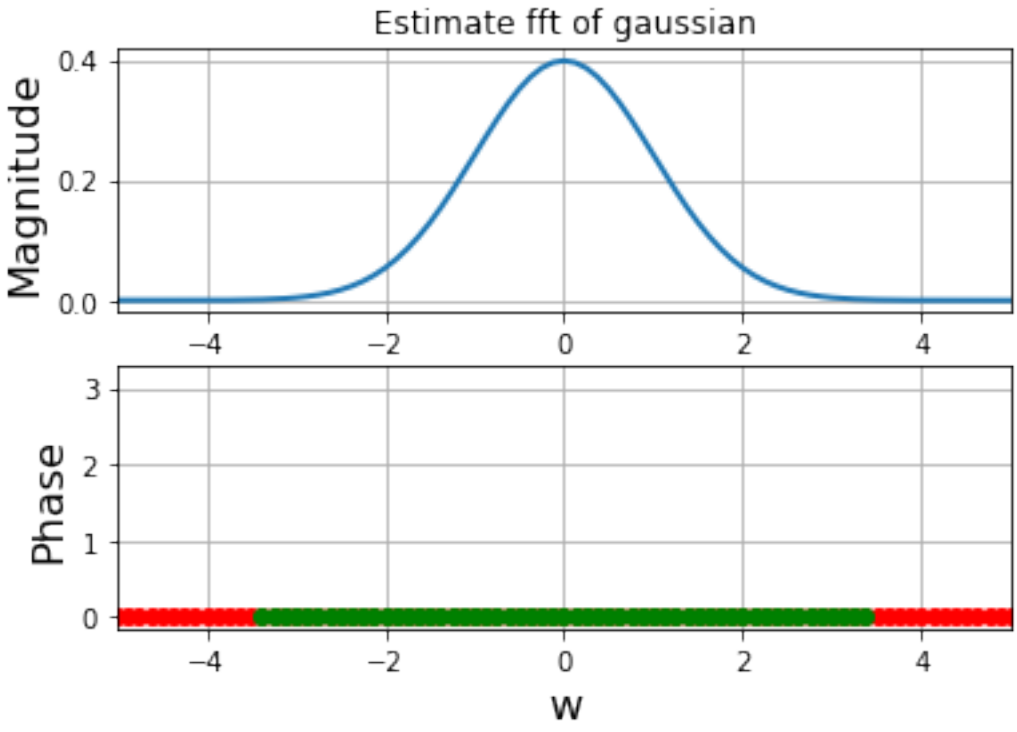
[11]:
```
def estdft(tolerance=1e-6,samples=128,func = gauss,expectedfn =␣
↪expectedgauss,wlim = 5):
    T = 8*pi
    N = samples
```

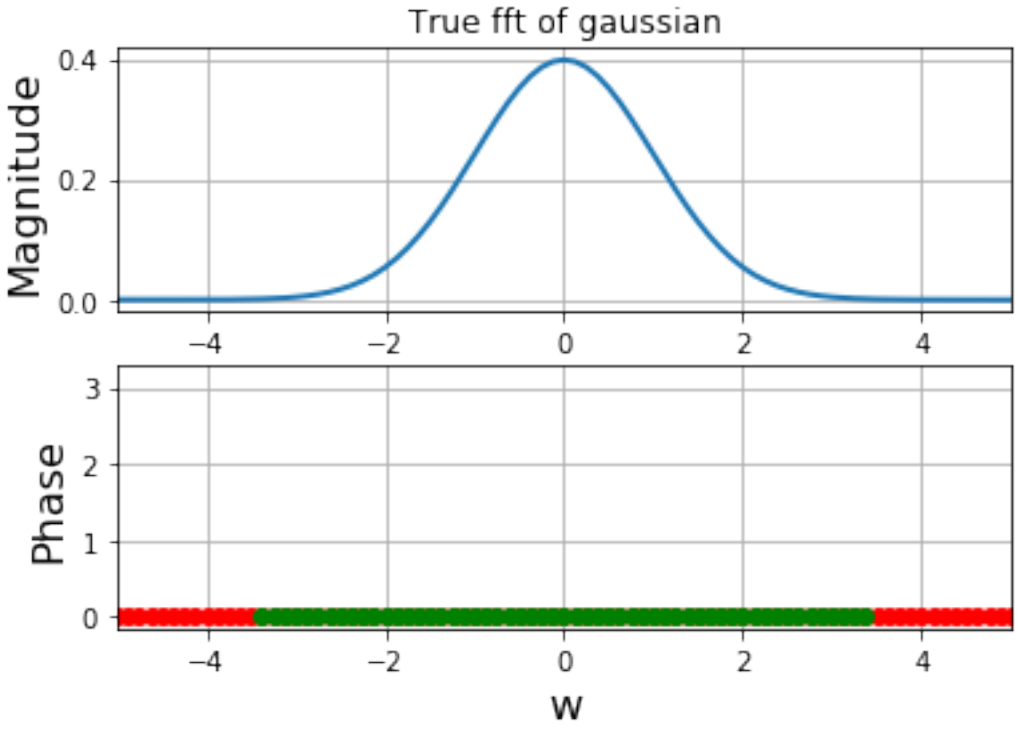
```
Yold=0
err=tolerance+1
iters = 0
#iterative loop to find window size
while err>tolerance:
    x=linspace(-T/2,T/2,N+1)[:-1]
    w = linspace(-N*pi/T,N*pi/T,N+1)[:-1]
    y = gauss(x)
    Y=fftshift(fft(ifftshift(y)))*T/(2*pi*N)
    err = sum(abs(Y[::2]-Yold))
    Yold = Y
    iters+=1
    T*=2
    N*=2

#calculating error
true_error = sum(abs(Y-expectedfn(w)))
print("True error: ",true_error)
print("samples = "+str(N)+" time period = pi*"+str(T/pi))

mag = abs(Y)
phi = angle(Y)
phi[where(mag<tolerance)]=0

# plot estimate
figure()
subplot(2,1,1)
plot(w,abs(Y),lw=2)
xlim([-wlim,wlim])
ylabel('Magnitude',size=16)
title("Estimate fft of gaussian")
grid(True)
subplot(2,1,2)
plot(w,angle(Y),'ro',lw=2)
ii=where(abs(Y)>1e-3)
plot(w[ii],angle(Y[ii]),'go',lw=2)
xlim([-wlim,wlim])
ylabel("Phase",size=16)
xlabel("w",size=16)
grid(True)
show()

#plotting expected output
Y_ = expectedfn(w)
mag = abs(Y_)
phi = angle(Y_)
phi[where(mag<tolerance)]=0
```

```
    figure()
    subplot(2,1,1)
    plot(w,abs(Y),lw=2)
    xlim([-wlim,wlim])
    ylabel('Magnitude',size=16)
    title("True fft of gaussian")
    grid(True)
    subplot(2,1,2)
    plot(w,angle(Y),'ro',lw=2)
    ii=where(abs(Y)>1e-3)
    plot(w[ii],angle(Y[ii]),'go',lw=2)
    xlim([-wlim,wlim])
    ylabel("Phase",size=16)
    xlabel("w",size=16)
    grid(True)
    show()

    return
```

[12]:
```
estdft()
```

```
True error:  1.4532298948786486e-14
samples = 512 time period = pi*32.0
```




True fft of gaussian
Magnitude
0.4
0.2
0.0
−4
−2
0
2
4
Phase
3
2
1
0
−4
−2
0
2
4
w