SIGNALS AND SYSTEMS (LAB 10)

TASK : 01

(a)

$$x[n] = \cos[10\omega_0 n] + 0.5\cos[14\omega_0 n] \quad \text{——} \ (1)$$

We know, $\cos(x) = \dfrac{e^{jx} + e^{-jx}}{2}$

Expanding eq (1)

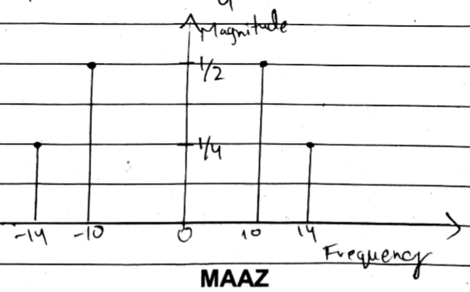
$$x[n] = \frac{e^{j10\omega_0 n} + e^{-j10\omega_0 n}}{2} + 0.5\left[\frac{e^{j14\omega_0 n} + e^{-j14\omega_0 n}}{2}\right]$$

$$= \frac{1}{2}e^{j10\omega_0 n} + \frac{1}{2}e^{-j10\omega_0 n} + \frac{1}{4}e^{j14\omega_0 n} + e^{-j14\omega_0 n}$$

By Euler's method the magnitudes will be

$C_{10} = \frac{1}{2}$ $\quad C_{-10} = \frac{1}{2}$

$C_{14} = \frac{1}{4}$ $\quad C_{-14} = \frac{1}{4}$



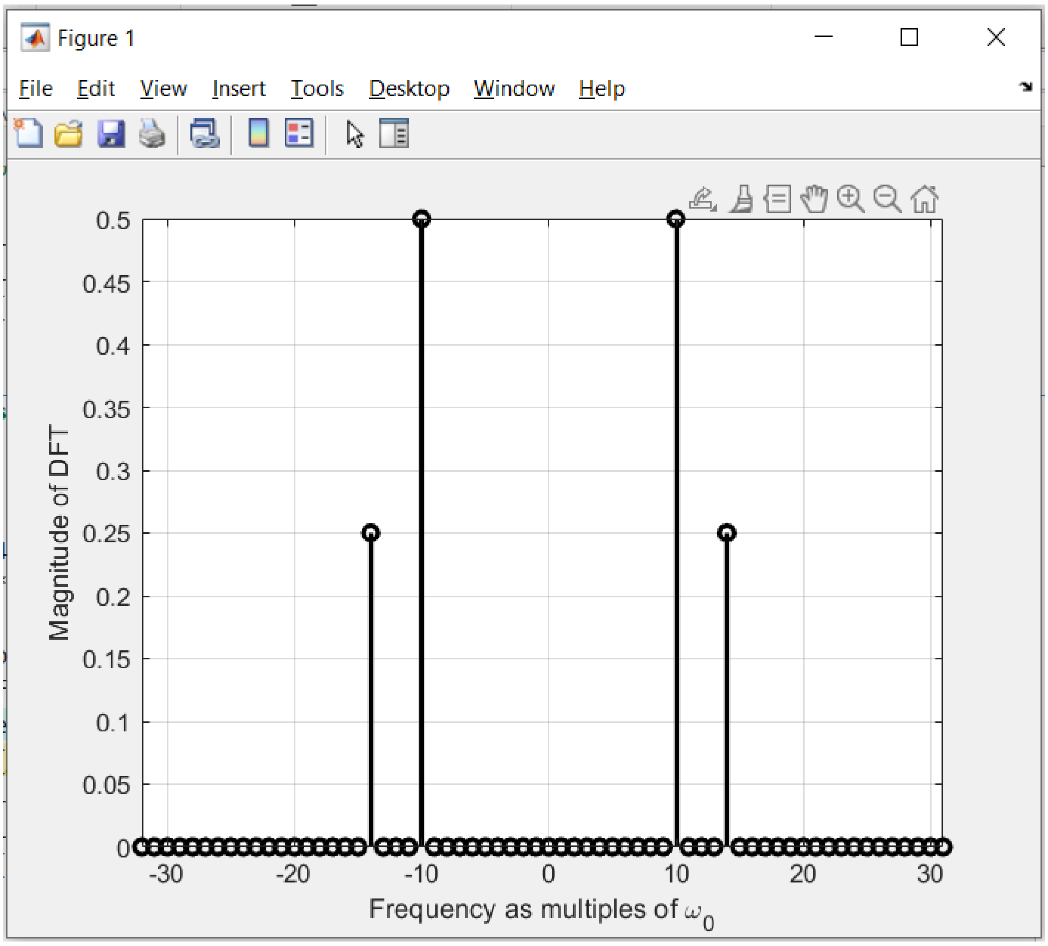
MAAZ

(b)

CODE:

```
clc
clear
P = 64;
w = 2*pi/P;
n = 0:P-1;
x = cos(10*w*n) + 0.5*cos(14*w*n); %Finite-time signal
hx = fft(x); %Compute the DFT of x
shiftedx = fftshift(hx); %shift on x-axis
stem([-P/2:P/2-1],abs(shiftedx)/P,'k','LineWidth',2);
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
axis([-P/2 P/2-1 0 inf]);
grid;
```

SNAPSHOT:



TASK : 02

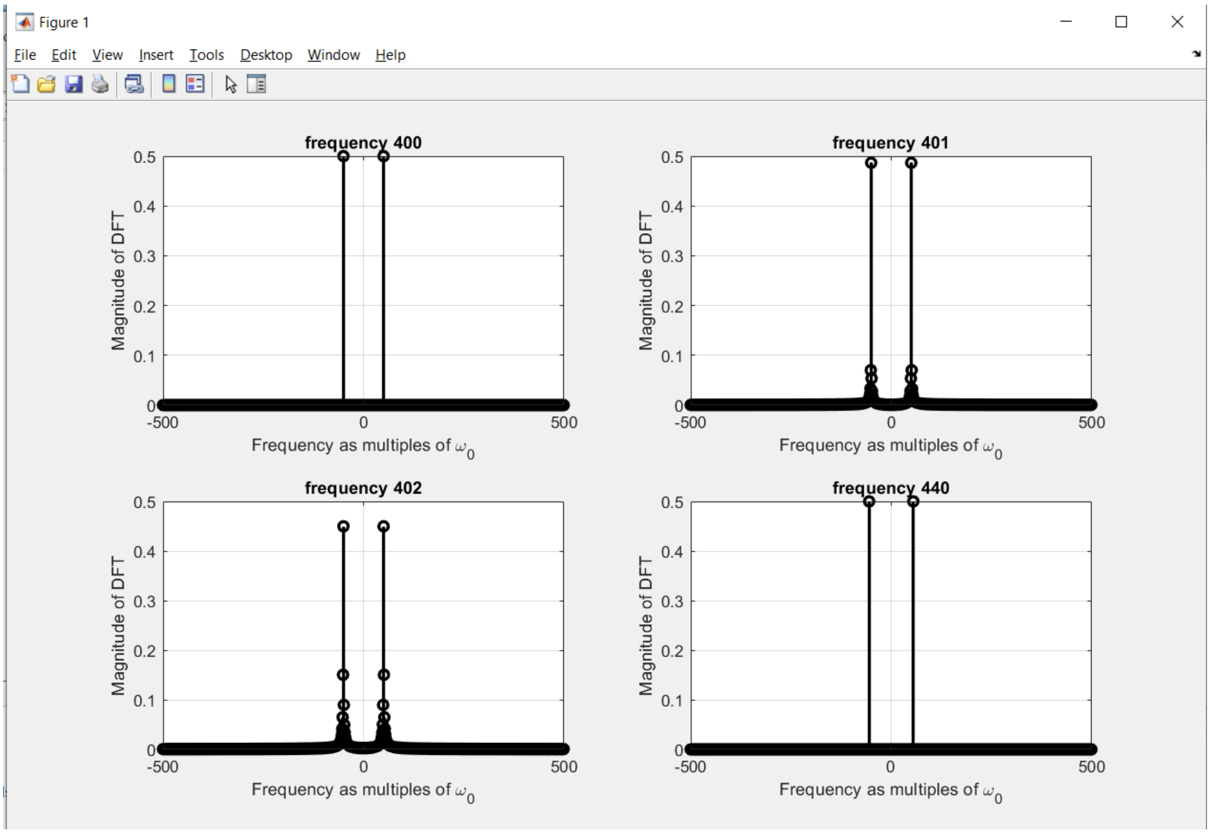
PART (a-e)

CODE:

```
clc
clear all
close all
n = 1000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*400*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
fHz = find(shx);
figure
subplot 221
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 400')
grid;
```

```
%frequency = 401
n = 1000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*401*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
subplot 222
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 401')
grid;
%frequency = 402
n = 1000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*402*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
subplot 223
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 402')
grid;
%frequency = 440
n = 1000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*440*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
subplot 224
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 440')
grid;
```

SNAPSHOT:



OBSERVATIONS:

- There are extra samples in 401 and 402 frequency but not in 400 and 440. This is because 8000/400 which is the sampling freq divided by signal freq is a whole number and 440 is a frequently used value. Because of this reason there are no extra samples on frequencies 400 and 440. For all other values of the frequency that do not result in a whole number when divided by sampling frequency, there will be extra values other than the frequency we are plotting.

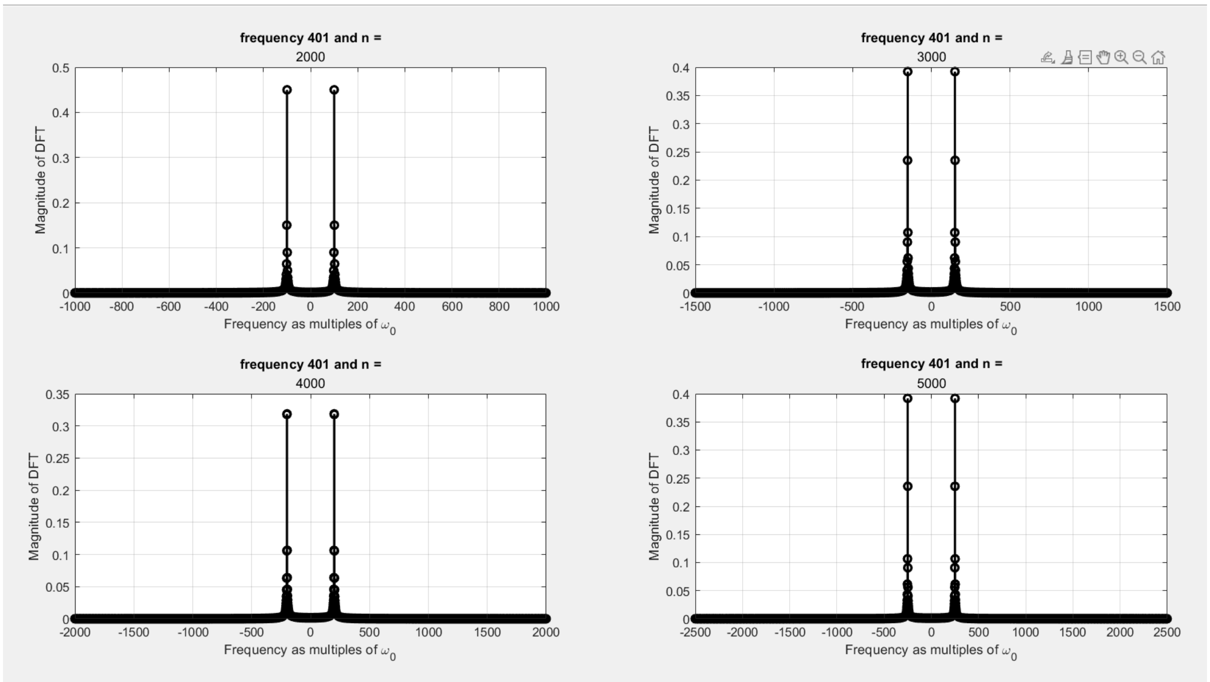
PART (f)

CODE:

```
close all
clc
clear all
%frequency = 401
figure
for i=1:i+1:4
   n = 1000 + i*1000;
   fs = 8000;
   t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
   xn = sin(2*pi*401*t);
   hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not
8000
   shx = fftshift(hx); %shift on x-axis
   subplot(2,2,i)
   stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
   ylabel('Magnitude of DFT');
   xlabel('Frequency as multiples of \omega_0');
   title('frequency 401 and n =',n)
   grid;
```

```
end
```

SNAPSHOT:



OBSERVATIONS:

- The extra samples come in closer together if we increase the value of n.

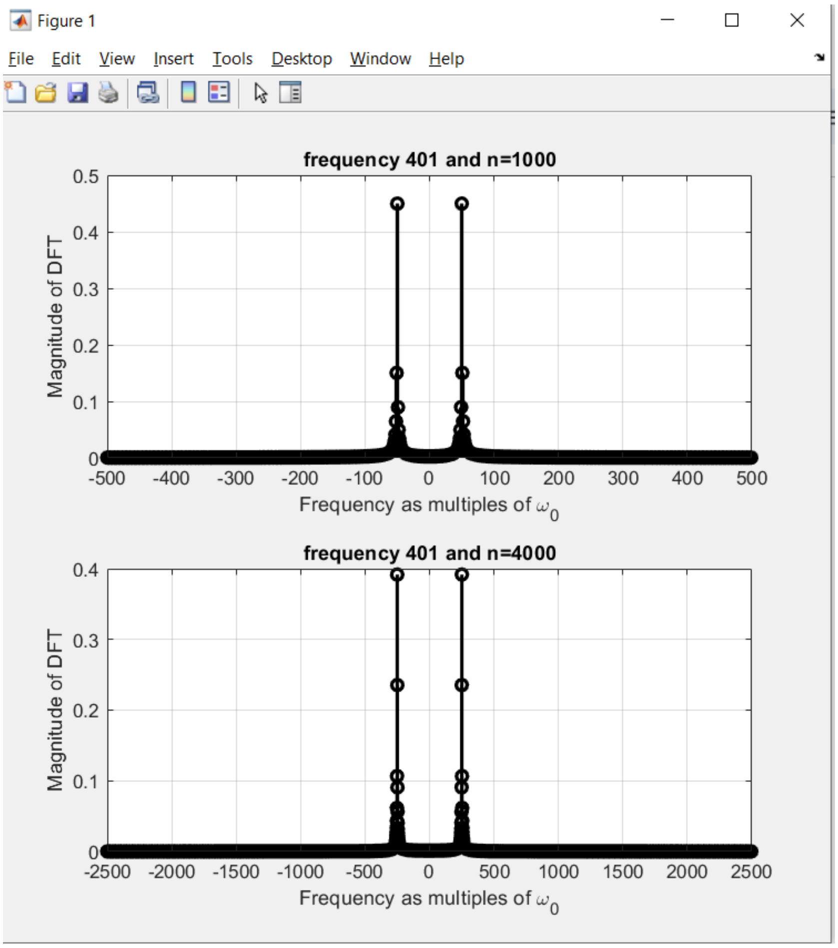
PART (g)

CODE:

```
close all
clc
%frequency = 402 and n=1000
n = 1000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*402*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
figure
subplot 211
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 401 and n=1000')
grid;
%frequency = 402 and n=4000
n = 5000;
fs = 8000;
t = 0:1/fs:n/fs; %t is from 0 to 1/8 since T = n/fs
xn = sin(2*pi*401*t);
hx = fft(xn,n); %Compute the DFT of x but the samples are n=1000 and not 8000
shx = fftshift(hx); %shift on x-axis
subplot 212
```

```
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
title('frequency 401 and n=4000')
grid;
```

SNAPSHOT:



TASK : 03

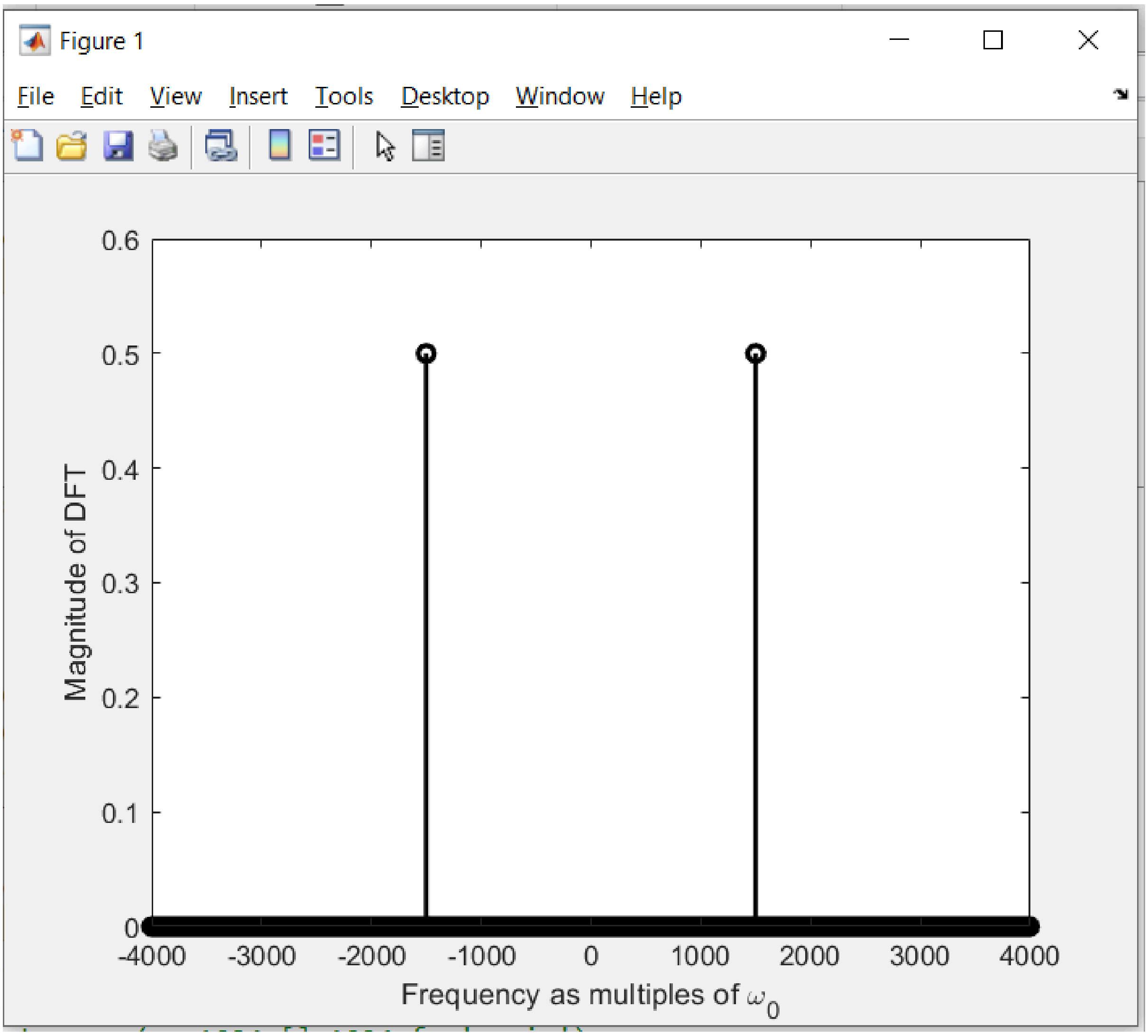
PART(A)

CODE:

```
clc
clear all
close all
n=8000;
fs=8000;
xn = cos(3000*pi*(0:1/fs:n/fs)) %calculating time period by n/fs = 8k/8k
hx = fft(xn,n); %Compute the DFT of x
shx = fftshift(hx); %shift on x-axis
figure
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
```

```
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
```

SNAPSHOT:

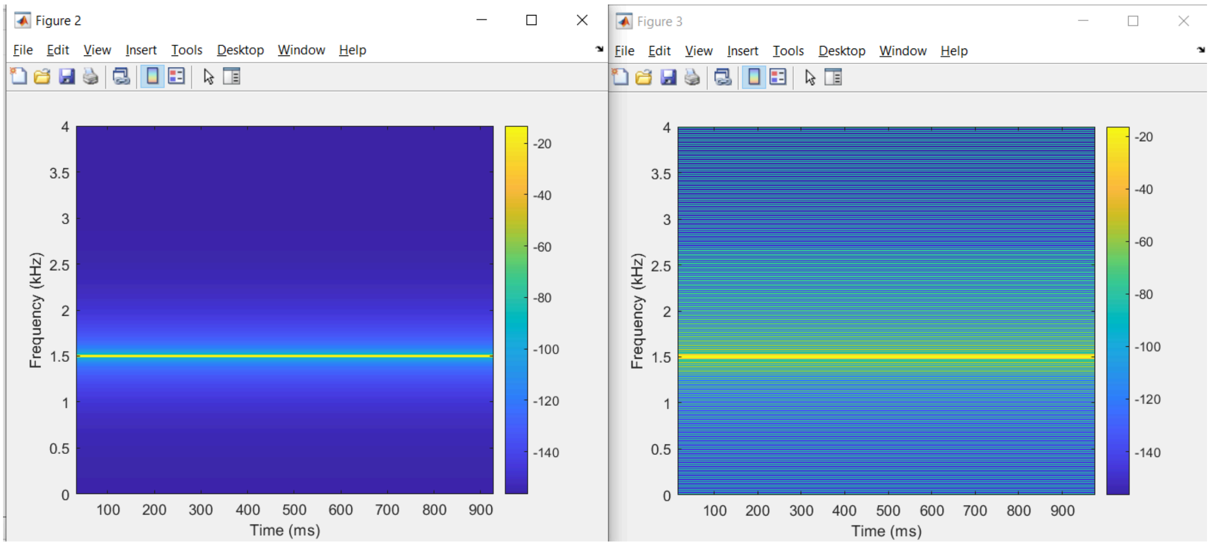


PART(B):

CODE:

```
clc
clear all
close all
n=8000;
fs=8000;
xn = cos(3000*pi*(0:1/fs:n/fs)) %calculating time period by n/fs = 8k/8k
hx = fft(xn,n); %Compute the DFT of x
shx = fftshift(hx); %shift on x-axis
figure
stem([-n/2:n/2-1],abs(shx)/n,'k','LineWidth',2)
ylabel('Magnitude of DFT');
xlabel('Frequency as multiples of \omega_0');
```

```
figure
spectrogram(xn,512,[],1024,fs,'yaxis');
colorbar
```



OBSERVATION:

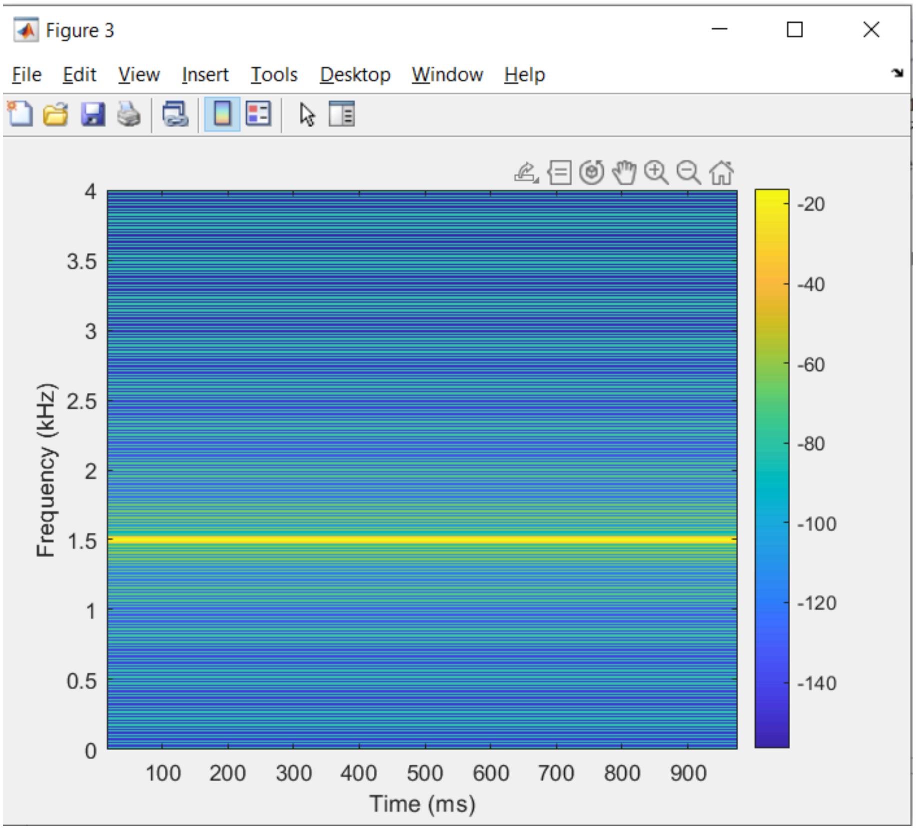
- This makes sense because according to out DFT plot, the signal exists at frequencies -1.5KHz and 1.5KHz and the spectogram validates this. There is a yellow line at 1.5Khz which indicates that the highest amplitude is present at that frequency.
- It can also be observed that the first figure is thinner. This is because the window length is 1024 in the first figure and 512 in the second.
- The greater window length we give, more compressed will be the spectogram so it is better to choose a shorter window length

PART (4):

CODE:

```
p = xn(end:-1:1);
hx = fft(pn,n); %Compute the DFT of x
shx = fftshift(hx); %shift on x-axis
figure
spectrogram(xn,512,[],1024,fs,'yaxis');
colorbar
```

SNAPSHOT:



OBSERVATION:

The spectrum is same since the DFT was an even function of frequency which is mirrored about the y axis.