DSP Lab Report

Experiment 5

Aim:

1. To plot spectrogram of signals with different windows and window lengths.
2. To identify temporal behaviour of a signal using spectrogram.
3. To understand the meaning of pitch.
4. To identify phonemes using spectrogram.

Code:

Q1)

```
% a = 3

Fs = 100;
dt = 1/Fs;

t = 0:dt:10-dt;

% defining frequency variation
F = inline('1.2*t+8','t');

x = sin(2*pi*F(t).*t);

% plotting chirp signal
figure();
plot(t,x);
title('Chirp signal');
xlabel('time(s)');
ylabel('x(t)');


DFT = fft(x);
N = length(DFT);
k = 0:N-1;
f = Fs/N .* k;

% plotting magnitude spectrum
figure();
plot(f,abs(DFT));
title('abs(DFT) VS frequency');
xlabel('Frequency(Hz)');
ylabel('abs(DFT)');
```

```
% plotting spectrogram
figure();
spectrogram(x,hamming(100),10,[],Fs);
title('Chirp Signal');
```

Q2)

```
% a = 3

Fs = 100;

% defining frequency variation
F = inline('1.2*t+8','t');

x = sin(2*pi*F(t).*t);

% plotting spectrogram
figure();
spectrogram(x,hamming(100),10,[],Fs);
title('Chirp Signal - Hamming(100)');

figure();
spectrogram(x,hanning(100),10,[],Fs);
title('Chirp Signal - Hanning(100)');

figure();
spectrogram(x,blackman(100),10,[],Fs);
title('Chirp Signal - Blackman(100)');

figure();
spectrogram(x,hamming(150),10,[],Fs);
title('Chirp Signal - Hamming(150)');

figure();
spectrogram(x,hamming(200),10,[],Fs);
title('Chirp Signal - Hamming(200)');

figure();
spectrogram(x,hanning(150),10,[],Fs);
title('Chirp Signal - Hanning(150)');

figure();
spectrogram(x,hanning(200),10,[],Fs);
title('Chirp Signal - Hanning(200)');
```

```
figure();
spectrogram(x,blackman(150),10,[],Fs);
title('Chirp Signal - Blackman(150)');

figure();
spectrogram(x,blackman(200),10,[],Fs);
title('Chirp Signal - Blackman(200)');
```

Q3)

```
% a = 3
[y, Fs] = audioread('instru3.wav');

dt = 1/Fs;
N = length(y);
t = 0:dt:N/Fs-dt;

% plotting instru3 spectrogram
figure();
spectrogram(y,hamming(100),10,[],Fs);
title('instru3');

DFT = fft(y);
k = 0:N-1;
f = Fs/N .* k;

% plotting magnitude spectrum
figure();
plot(f,abs(DFT));
title('abs(DFT) VS Frequency');
xlabel('Frequency(Hz)');
ylabel('abs(DFT)');
```

Q4)

```
% a = 3

[y, Fs] = audioread('Opera.wav');

% plotting opera spectrogram
figure();
spectrogram(y,hamming(1000),10,[],Fs);
title('Opera');
```

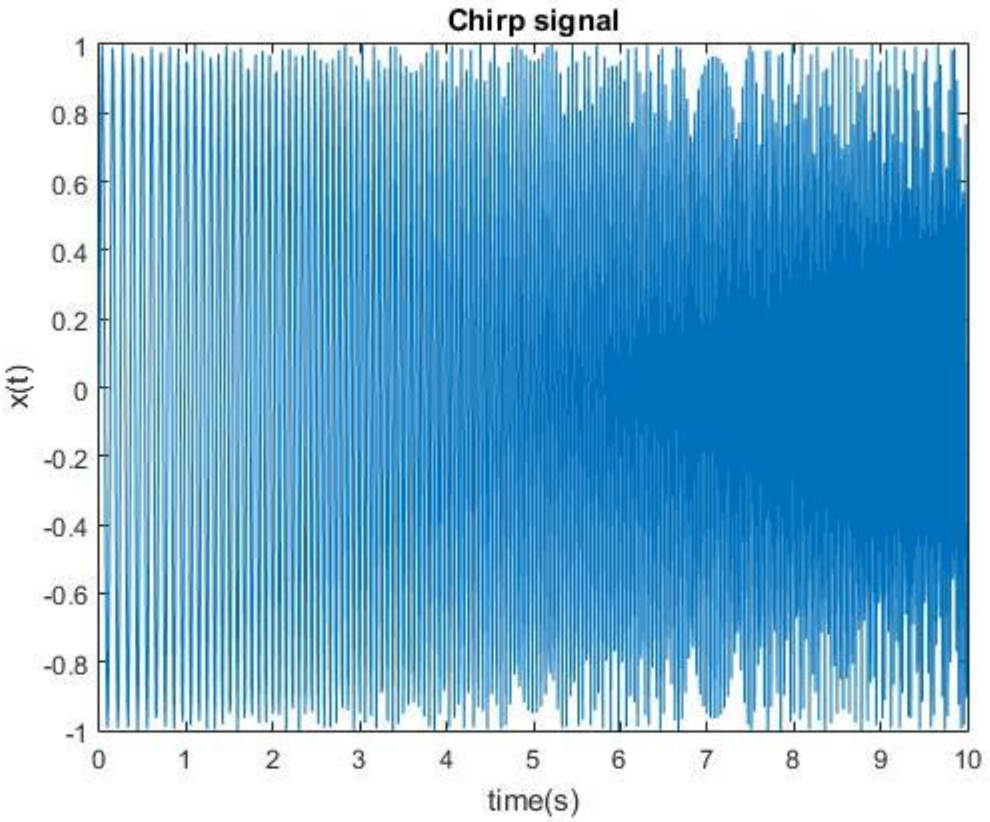
```
N = length(y);
DFT = fft(y);
k = 0:N-1;
f = Fs/N .* k;

% plotting magnitude spectrum
figure();
plot(f,abs(DFT));
title('abs(DFT) VS Frequency');
xlabel('Frequency(Hz)');
ylabel('abs(DFT)');
```

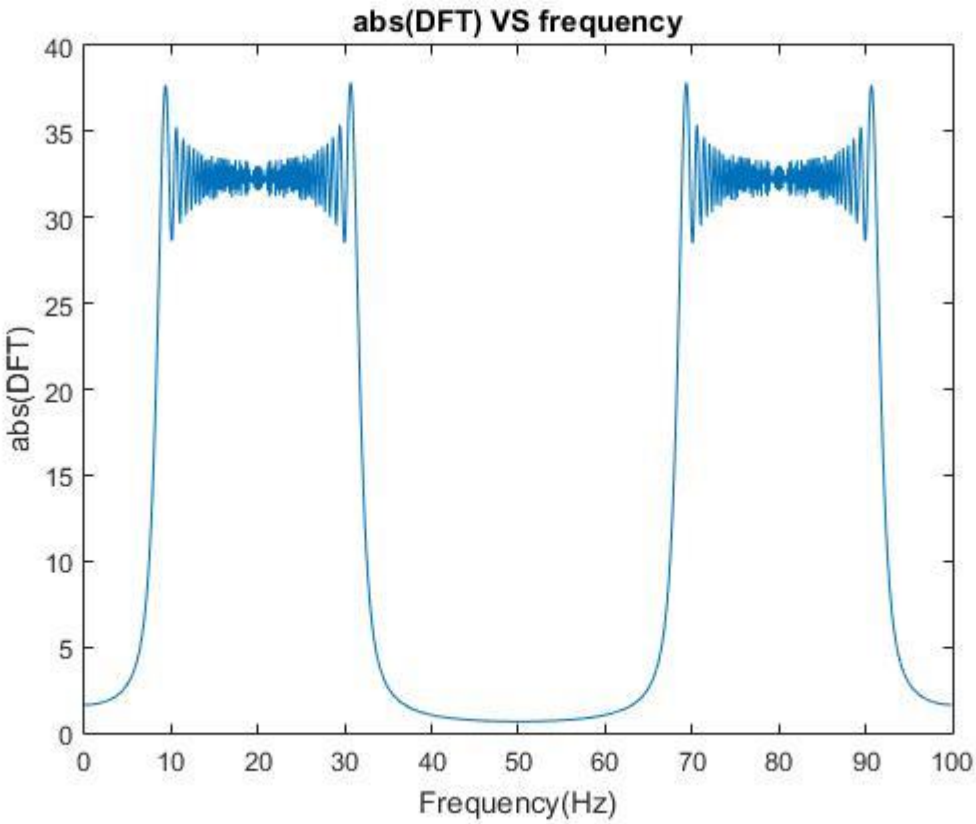
Q5)

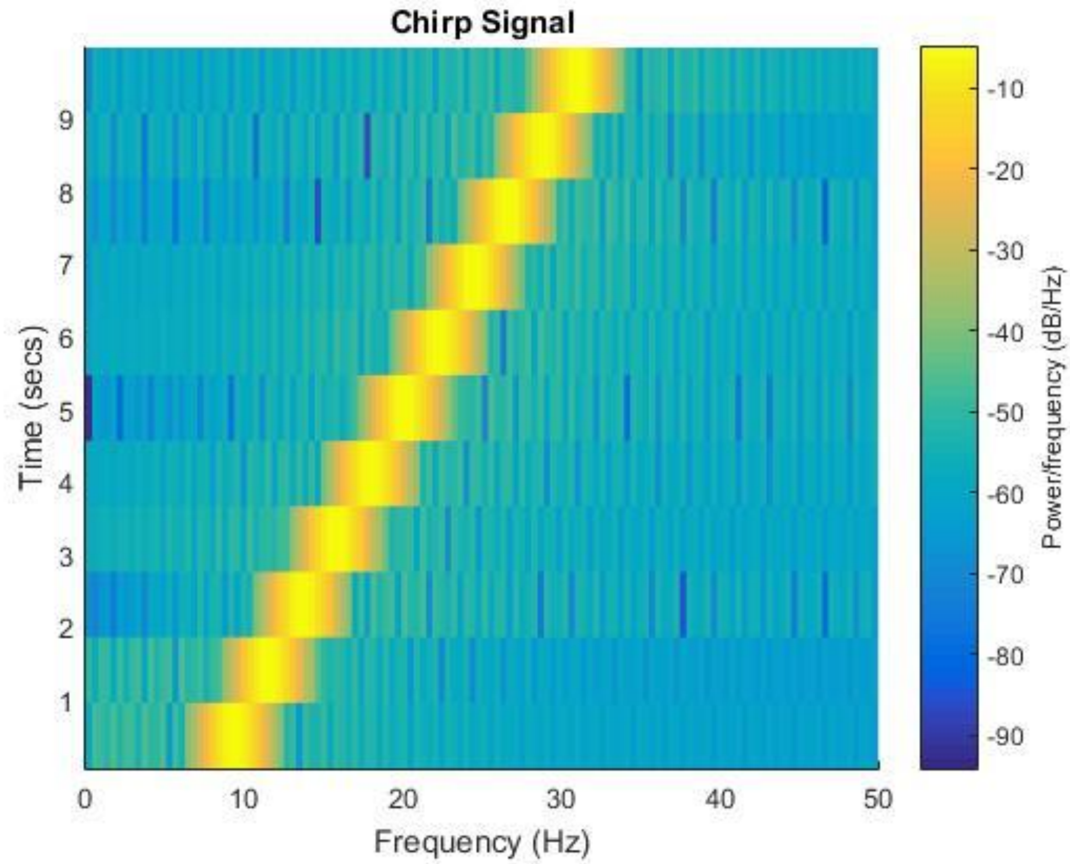
```
% recorded audio
[y, Fs] = audioread('name.wav');

% converting sampling frequency to 4000 Hz
N = length(y);
y = y(1:4:N);
Fs = Fs/4;

% plotting spectrogram
figure();
spectrogram(y,blackman(1250),10,[],Fs);
title('Name');
```

Observations and graphs:

Q1)





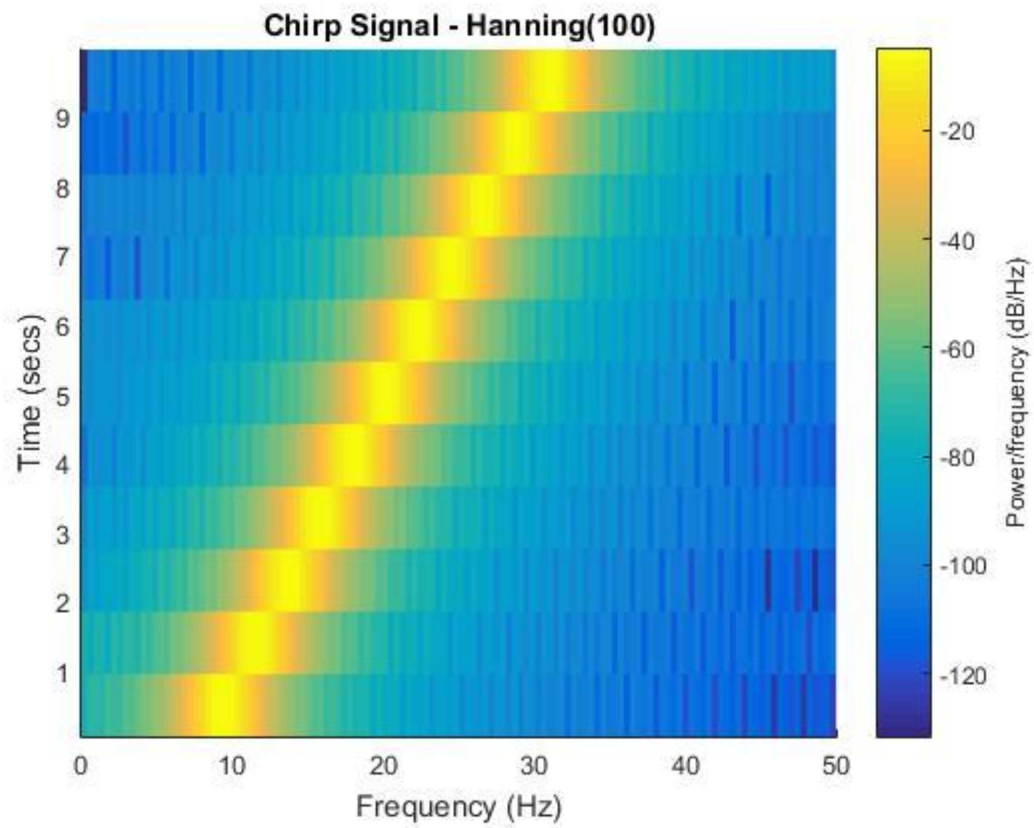


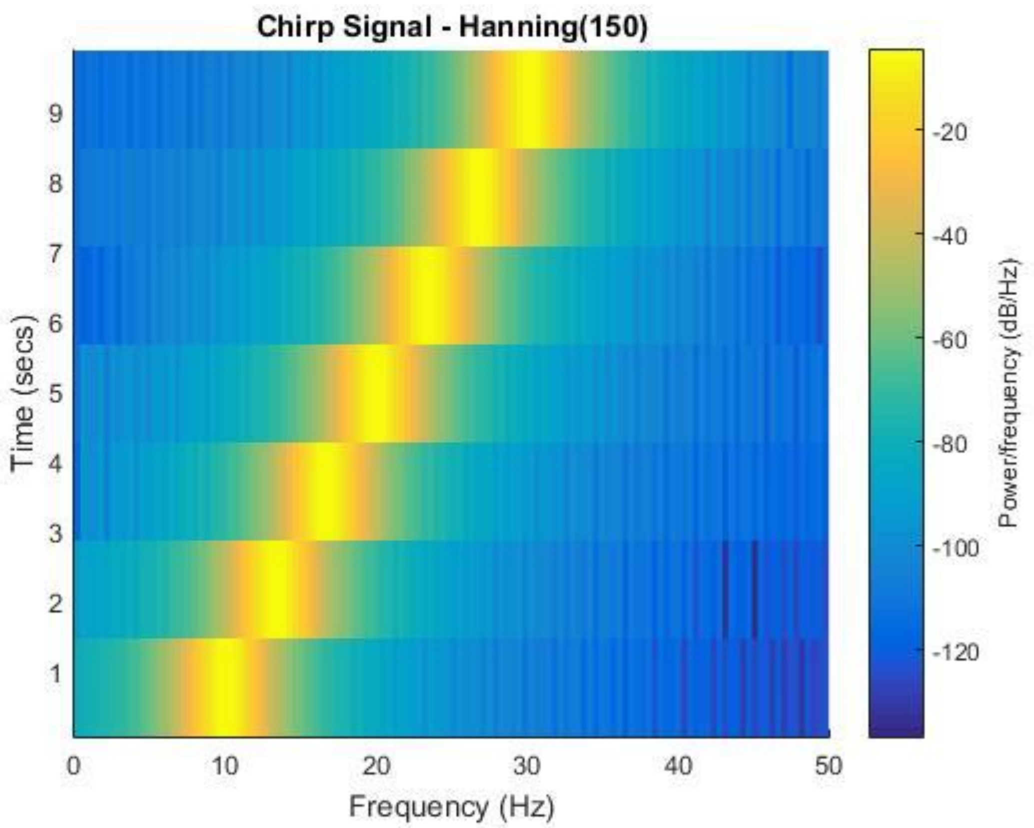
- From the magnitude spectrum plot, we can identify the frequency components but we do not know the timing for which that frequency component exists.
- From the spectrogram, we get the additional information of variation of fundamental frequency with time. So, for signals with varying frequency, spectrogram is better.

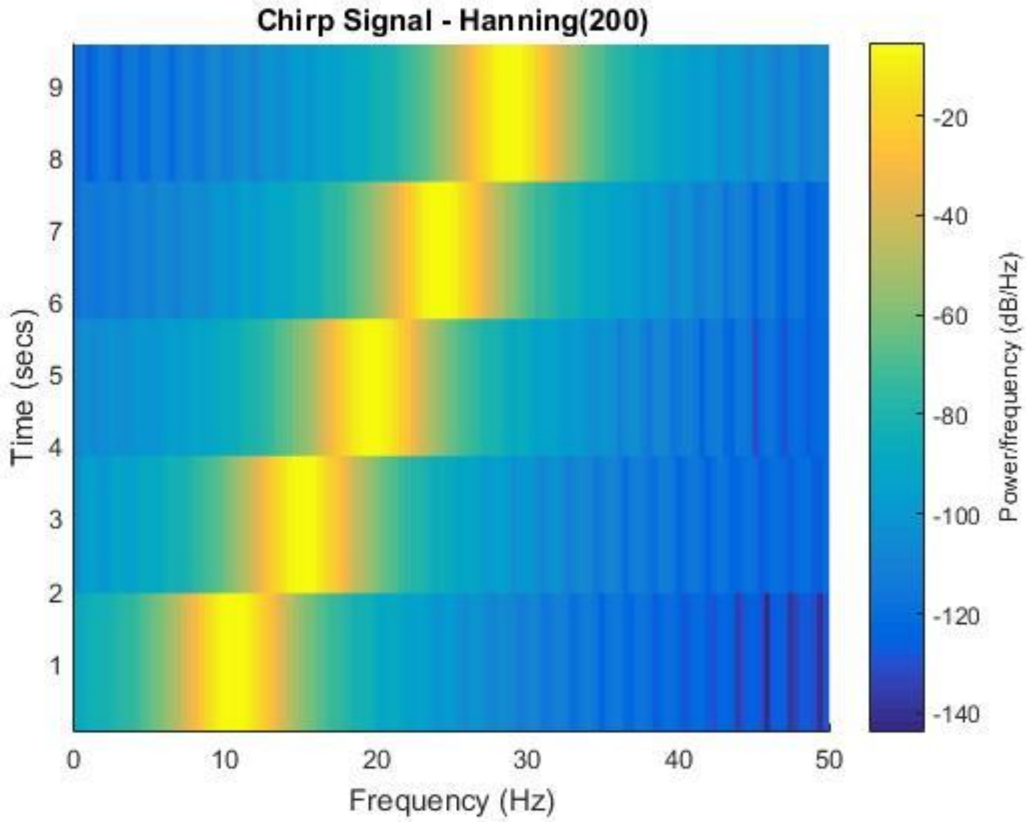
Q2)

a)

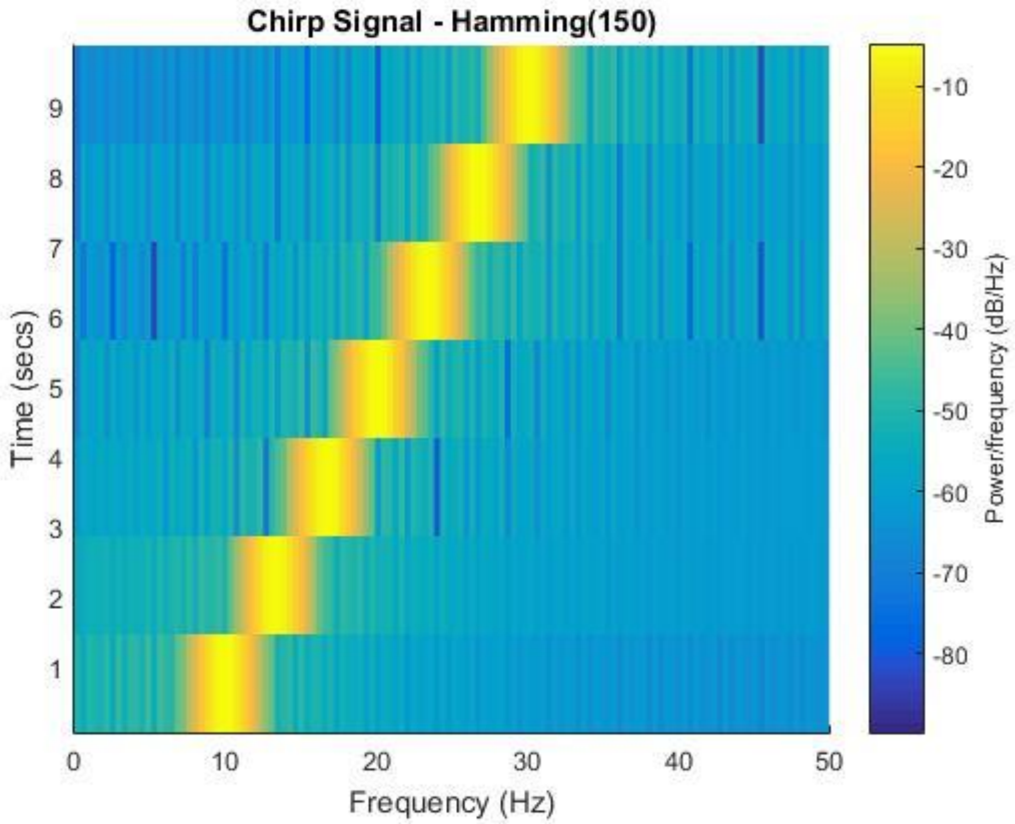
- From the spectrograms with different window lengths, we see that larger window lengths gives better frequency resolution but decreases time resolution and vice versa.
- Hence it is a trade-off between frequency resolution and time resolution.

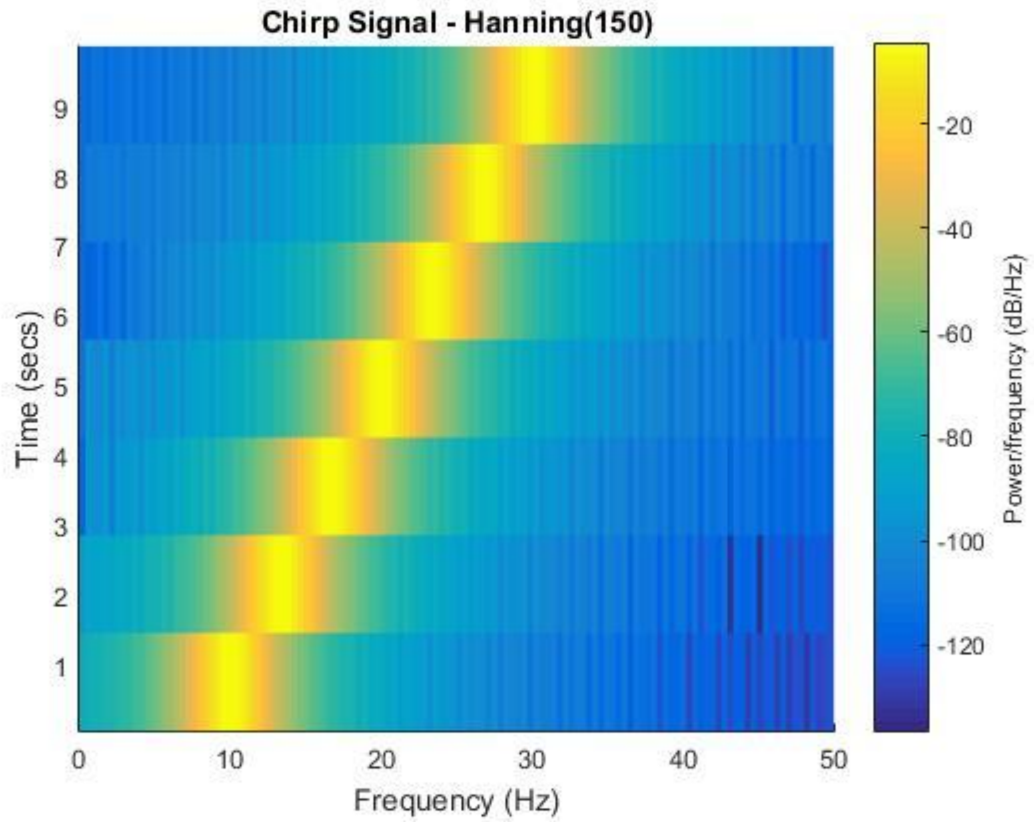

Chirp Signal - Hanning(100)
Time (secs)
Frequency (Hz)
Power/frequency (dB/Hz)
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
-20
-40
-60
-80
-100
-120

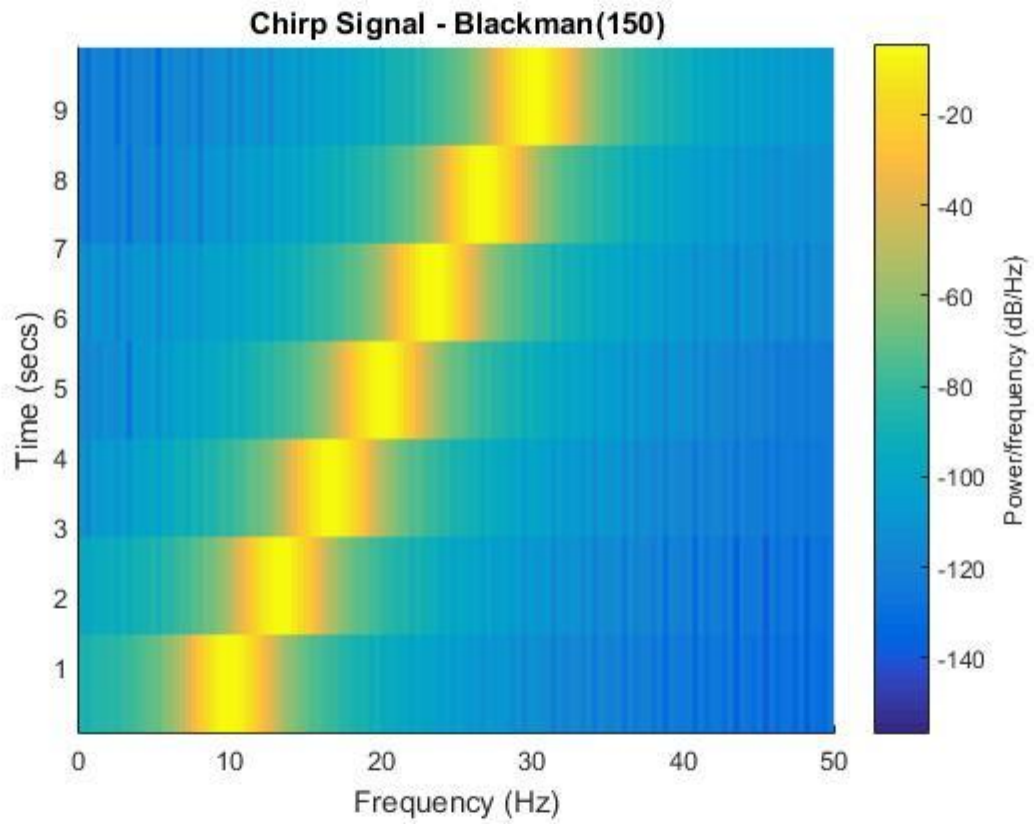

Chirp Signal - Hanning(150)
Time (secs)
Frequency (Hz)
Power/frequency (dB/Hz)
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
-20
-40
-60
-80
-100
-120


Chirp Signal - Hanning(200)
Time (secs)
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
Frequency (Hz)
-20
-40
-60
-80
-100
-120
-140
Power/frequency (dB/Hz)

b)

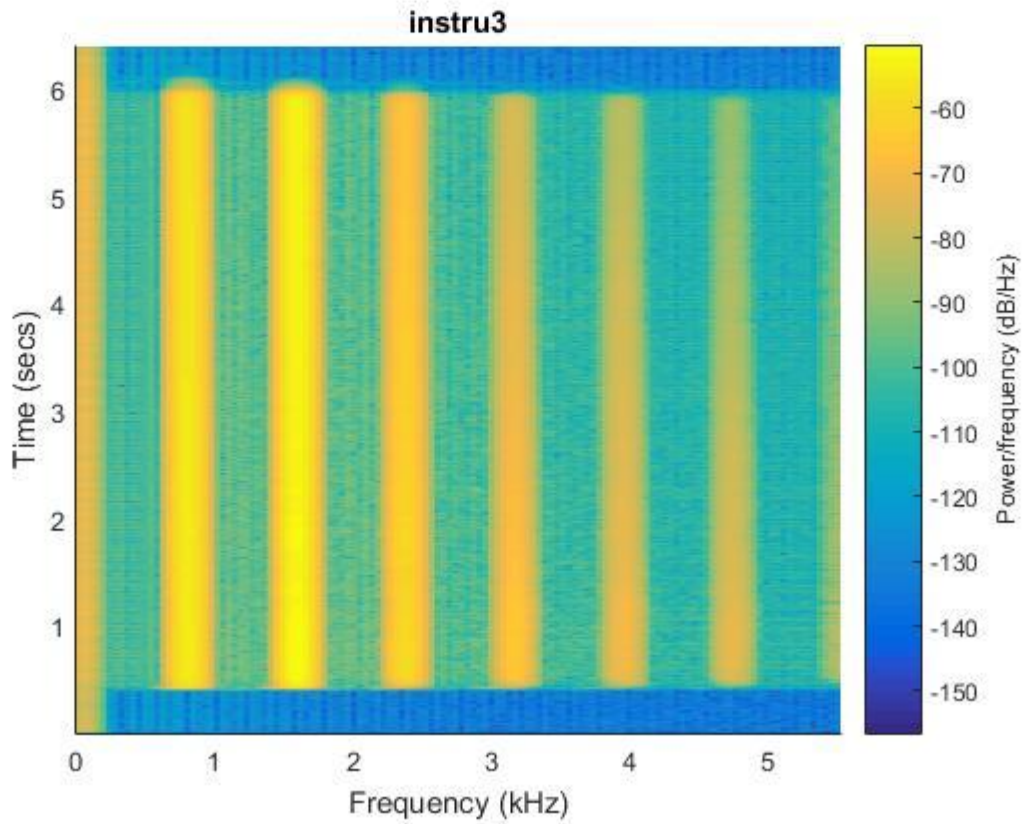

Chirp Signal - Hamming(150)
Time (secs)
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
Frequency (Hz)
-10
-20
-30
-40
-50
-60
-70
-80
Power/frequency (dB/Hz)

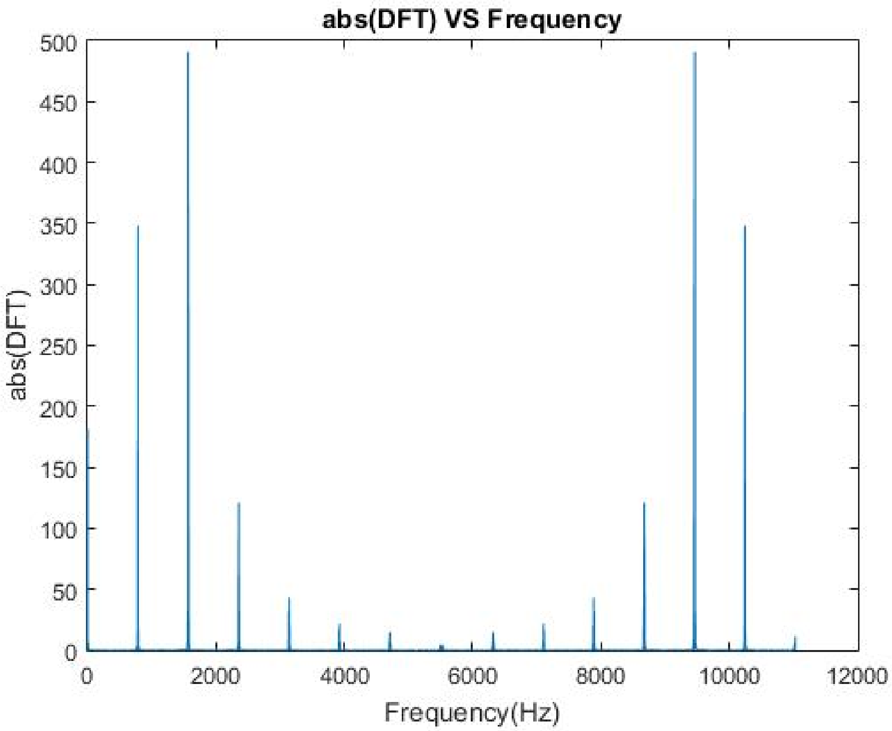

Chirp Signal - Hanning(150)
9
8
7
6
5
4
3
2
1
Time (secs)
0
10
20
30
40
50
Frequency (Hz)
-20
-40
-60
-80
-100
-120
Power/frequency (dB/Hz)


Chirp Signal - Blackman(150)
9
8
7
6
5
4
3
2
1
Time (secs)
0
10
20
30
40
50
Frequency (Hz)
-20
-40
-60
-80
-100
-120
-140
Power/frequency (dB/Hz)

- From the spectrograms with different windows, we can see that Blackman window gives better frequency resolution as there is a more gradual change in frequency components than other windows.

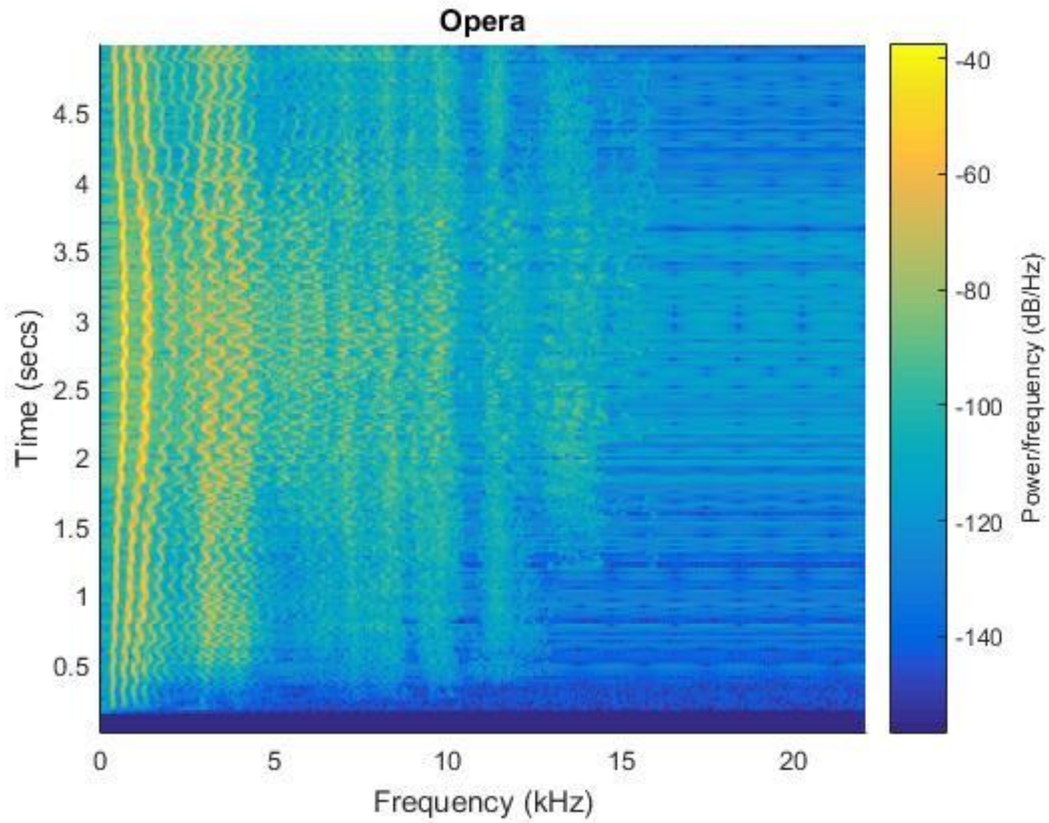
Q3)





- The fundamental pitch of the instrument is close to 784.5 Hz. The fundamental frequency of the instrument is 2*784.5 = 1566 Hz.
- Pitch is a quantity that is not only defined by the frequency but also has a subjective component that takes into account the relative placement of the frequency within the context of an established tuning system.
- The fundamental pitch is the frequency to which the instrument is tuned. Once the instrument is tuned, a musical note can be played in any of the octaves above or below the fundamental pitch, but they are perceived to be similar sounds.

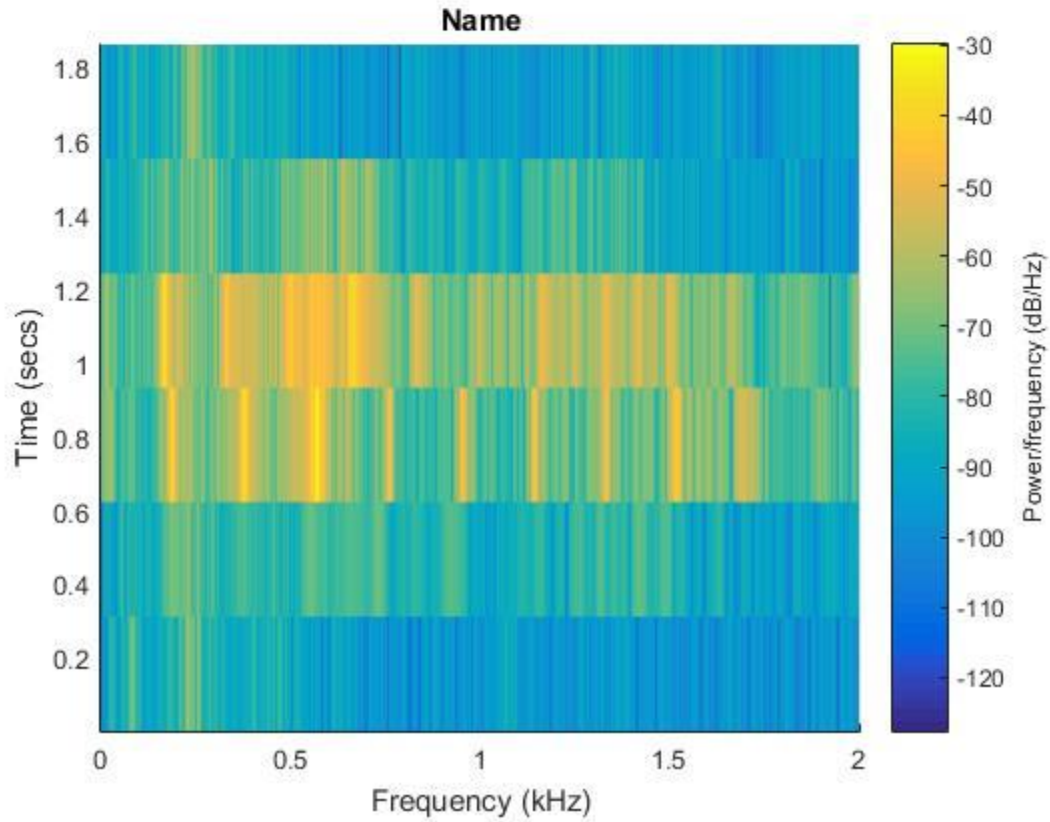
Q4)



- From spectrogram, the variation of the fundamental frequency as opera progresses can be identified easily.
- The first thin bright yellow line gives the variation of frequency with time.

Q5)

- S – 0.191 kHz, 0.6212 s
- K – 0.377 kHz, 0.7763 s
- N – 0.578 kHz, 0.9313 s
- D – 0.173 kHz, 1.0861 s



Conclusions:

- Spectrogram of a chirp signal with different windows like hamming, hanning and blackman window was plotted. Also effect of variation of window size on the spectrogram was observed.
- The fundamental pitch was identified using spectrogram of the instrument.
- The temporal variation of an opera was captured using spectrogram.
- The phonemes in the name were located on the spectrogram.