EE386 Digital Signal Processing Lab **Jul-Dec 2021**

Experiment : 5

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This lab experiment covers various practicality of Digital Signal Processing such as Spectrogram plotting and analysis for different windowing techniques and sizes, Pitch Extraction, and also Specto-Temporal analysis of Speech. Along with Python, I have used libraries such as numpy, pandas, scipy etc. The code to my entire work in this lab experiment is here. And the input files and my output files can be viewed here.

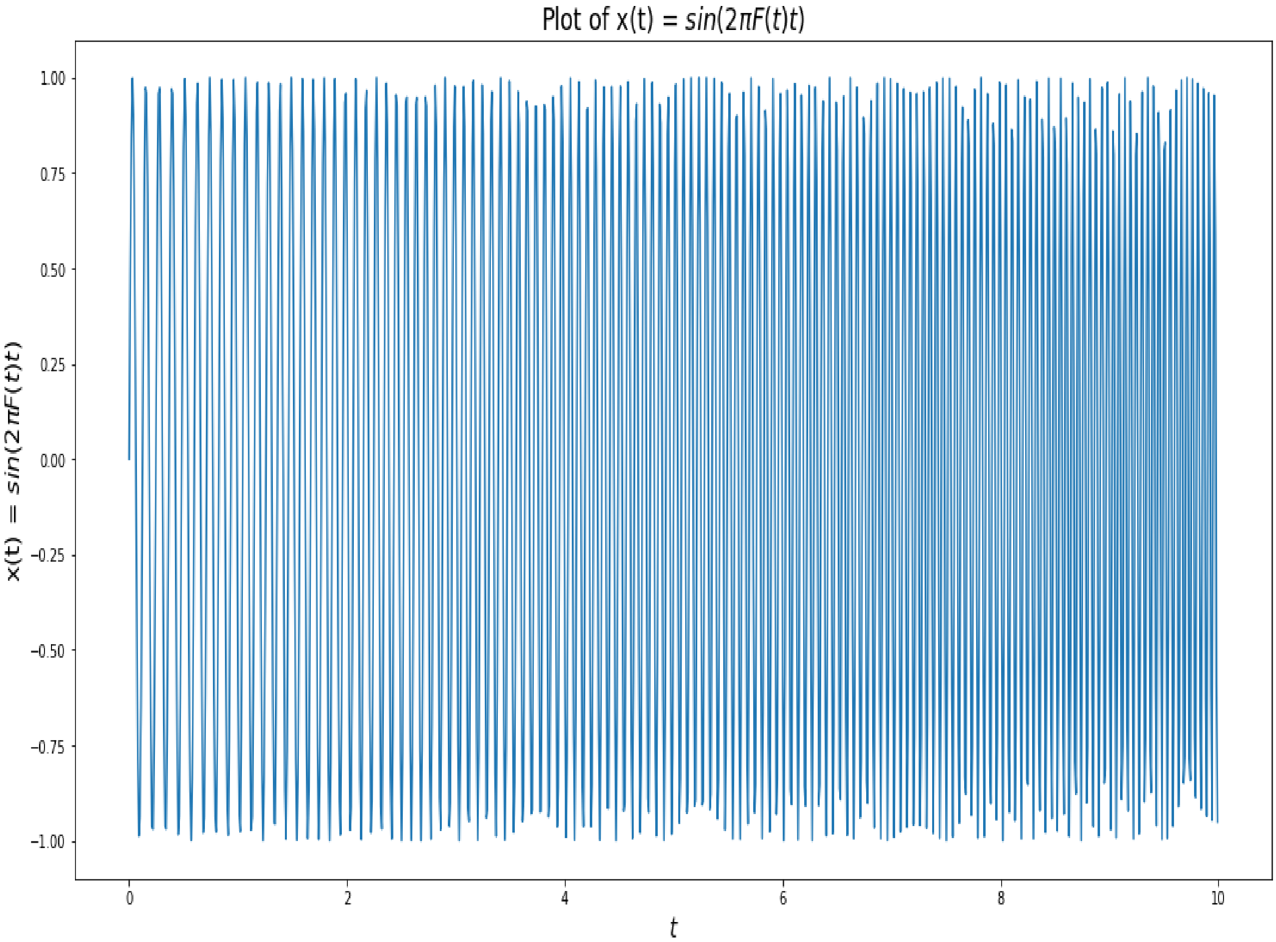
Please Note : I have used $\alpha = 3$ because my registration number is 191910.

Question 1 - Spectrogram of Chirp Signal

(Subproblem - 1)

This subproblem wants us to plot the signal x(t) = $\sin(2\pi F(t)t)$, with F(t) increasing linearly from 2 + 2α Hz = 8Hz to 5 + 5α Hz = 20 Hz at a sampling rate of 100 samples per second for duration of 10 seconds.

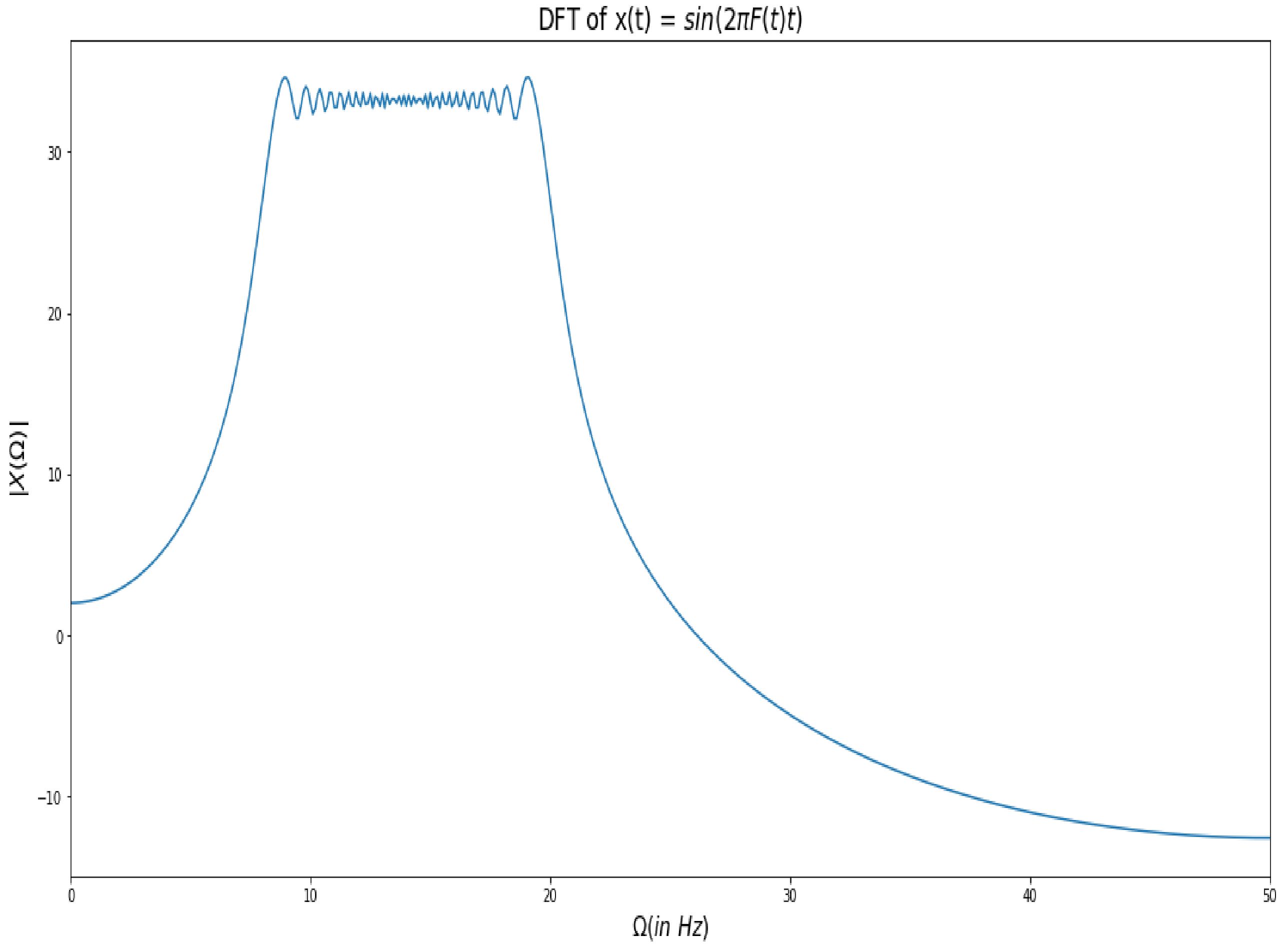
The code to this question can be found here



(Subproblem - 2)

This problem asks us to plot the frequency spectrum of the signal (x(t) = $\sin(2\pi F(t)t)$) using FFT.

The code to this question can be found here



- The problem with DFT plots is that we tend to lose a lot of information about the signal as the spectral content varies with time.
- Hence we must prefer to use spectrogram over the DFT plots as shown below, they provide more valuable information for signals' whose spectral content varies over time.

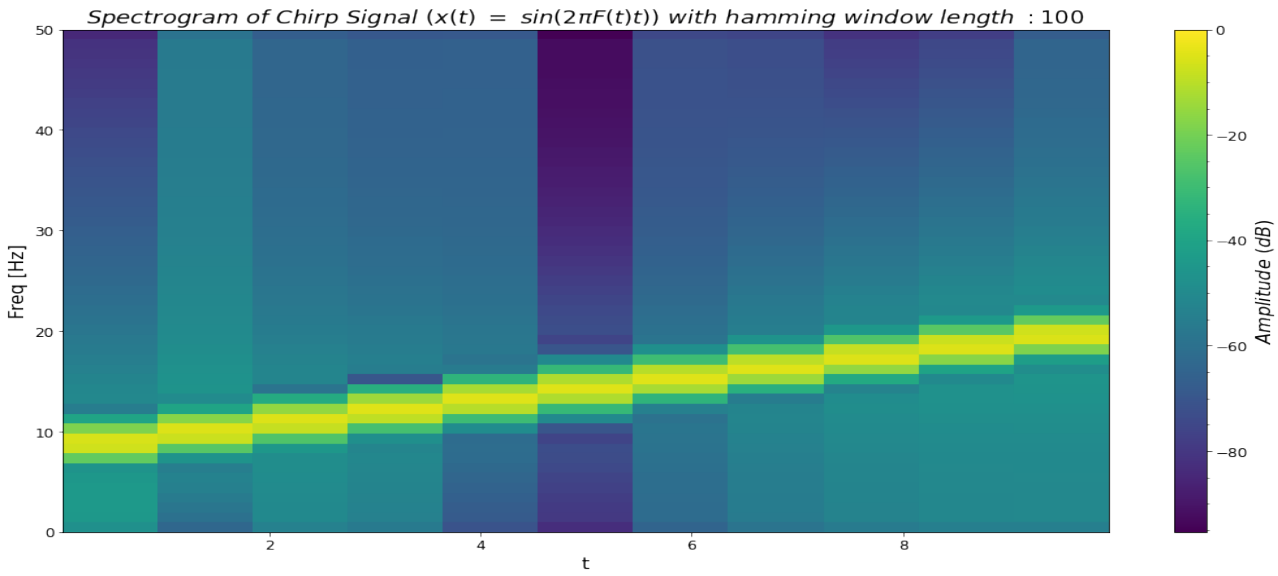
(Subproblem - 3)

This question asks us to use the same signal and plot a spectrogram of the signal in a separate plot. And also to try different windowing techniques and different windowing lengths.

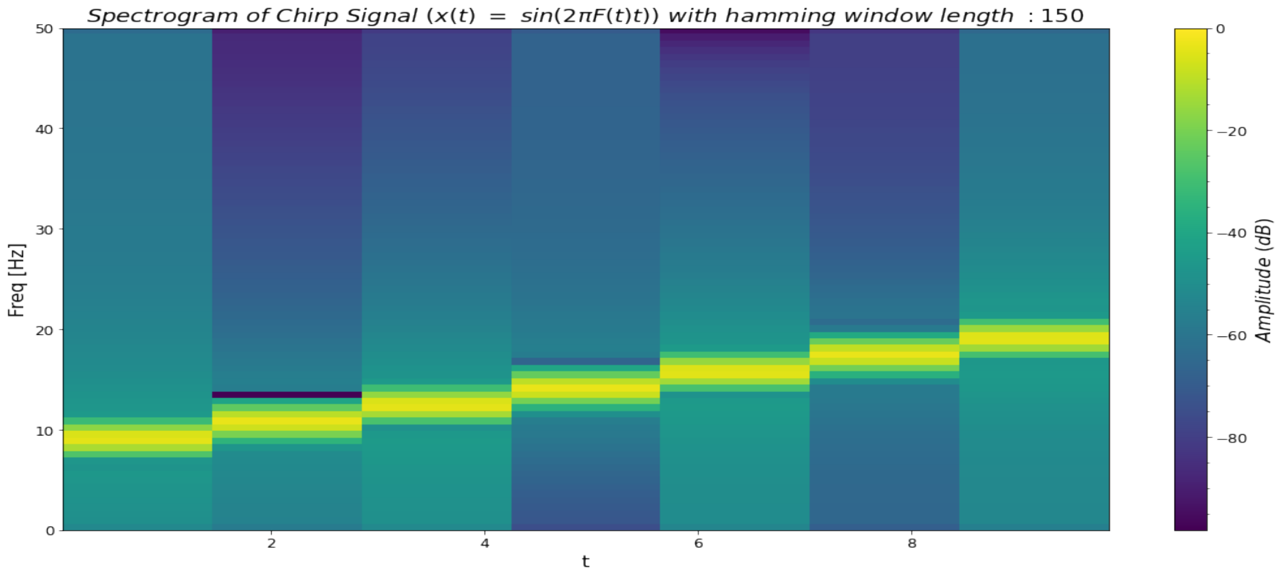
The code to this question can be found here

Plots for different windowing techniques and different windowing lengths :

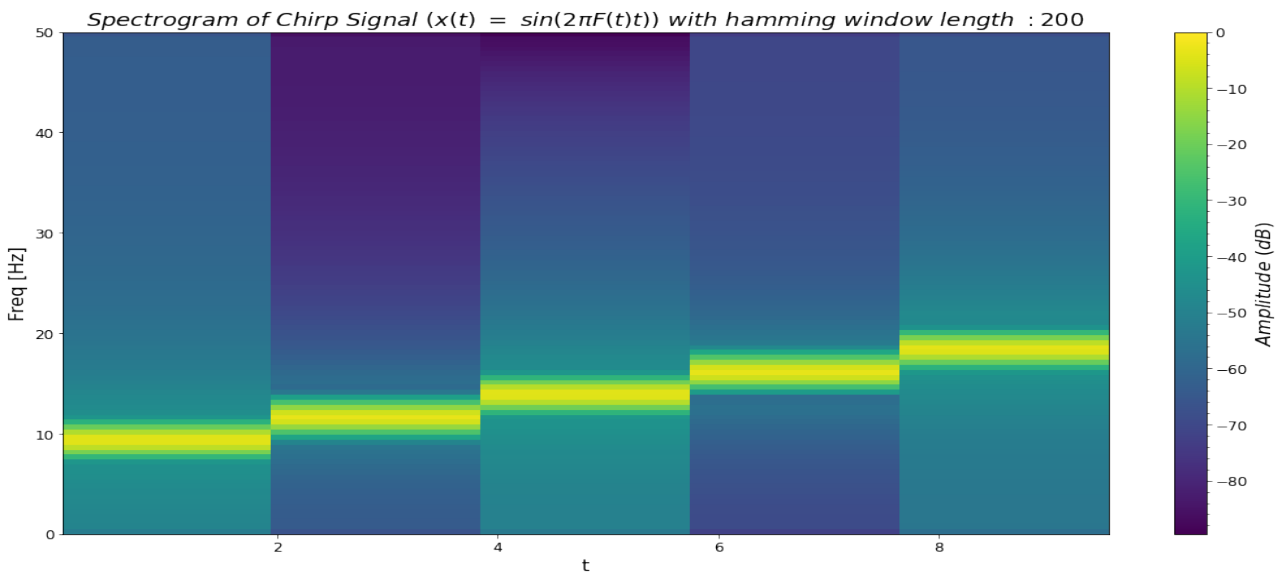
Spectrogram of x(t) with Hamming Window length of 100 samples :



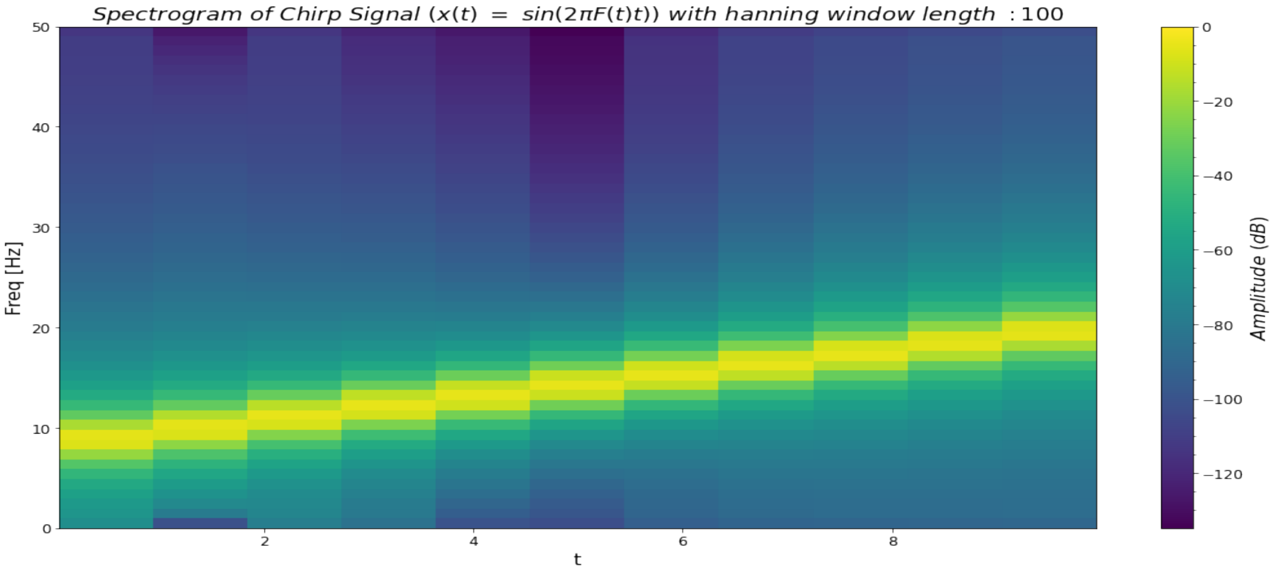
Spectrogram of x(t) with Hamming Window length of 150 samples :



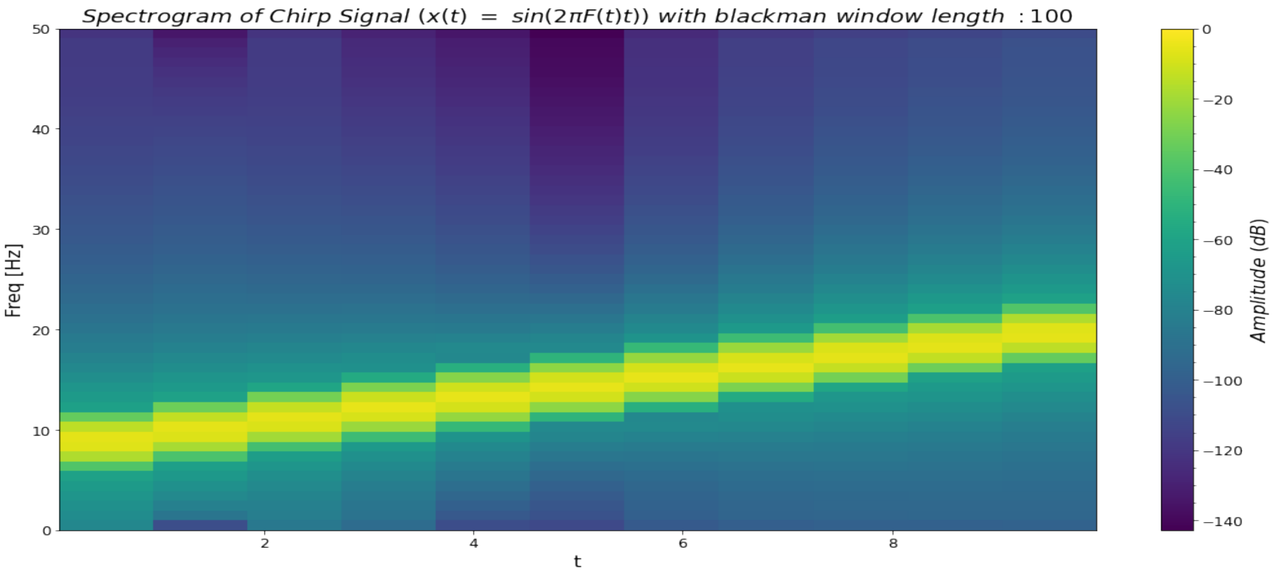
Spectrogram of x(t) with Hamming Window length of 200 samples :



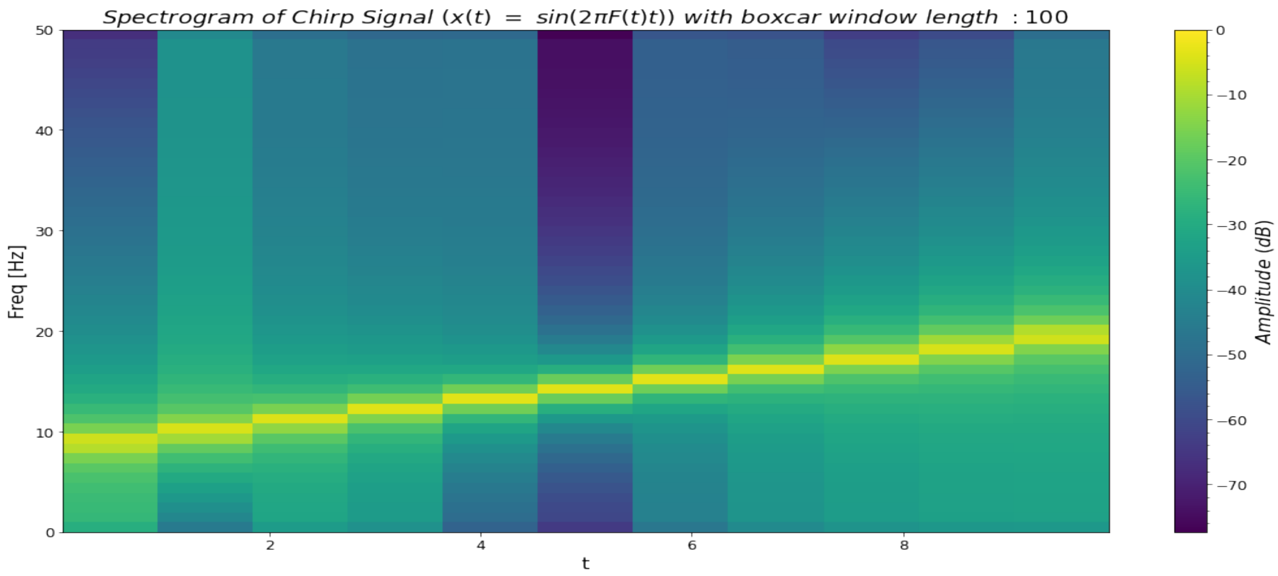
Spectrogram of x(t) with Hanning Window length of 100 samples :



Spectrogram of x(t) with Blackman Window length of 100 samples :



Spectrogram of x(t) with Rectangular Window length of 100 samples :



Some conclusions that can be drawn from all these plots :

- Time resolution and overlapping share a directly proportional relationship i.e for better time resolution, we need better overlapping.
- Temporal resolution and windowing length have a directly proportional relationship i.e longer windows have better temporal resolution.

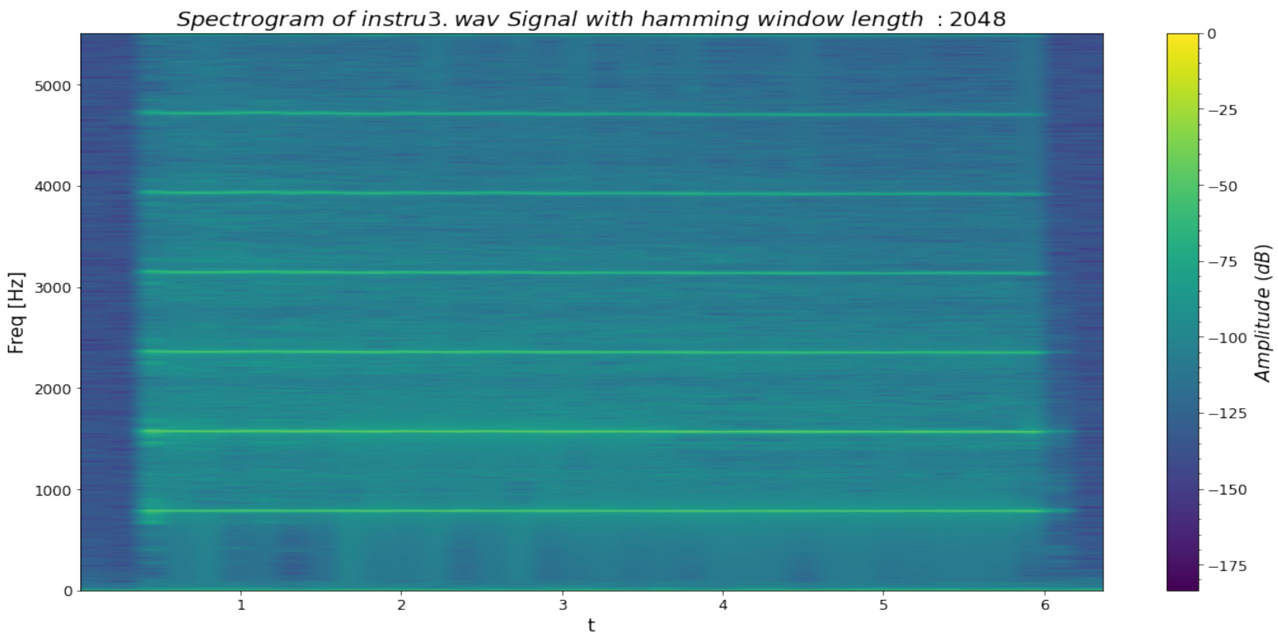
Question 2 - Pitch Extraction

(Subproblem - 1)

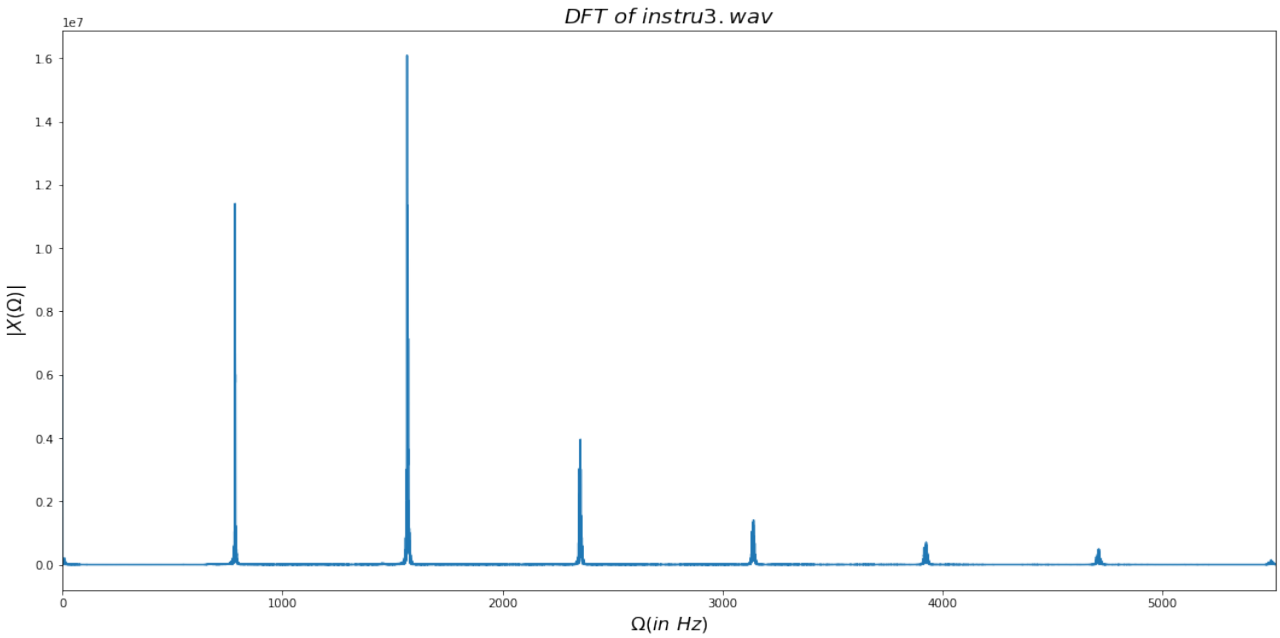
This question asks us to plot the spectrogram of the instru3.wav, using any windowing technique and windowing length of our choice. So I used Hamming window with a window length of 2048 samples.

The code to this question can be found here

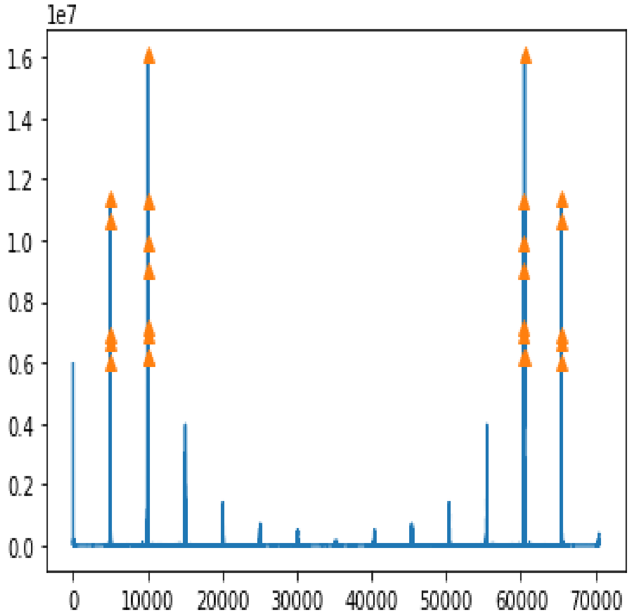
The spectrogram of instru3.wav signal with Hamming window of window length = 2048 :



Conventional spectral plot of the same signal :



By peak picking we can find the fundamental frequency :



Fundamental Frequency : 783.277899

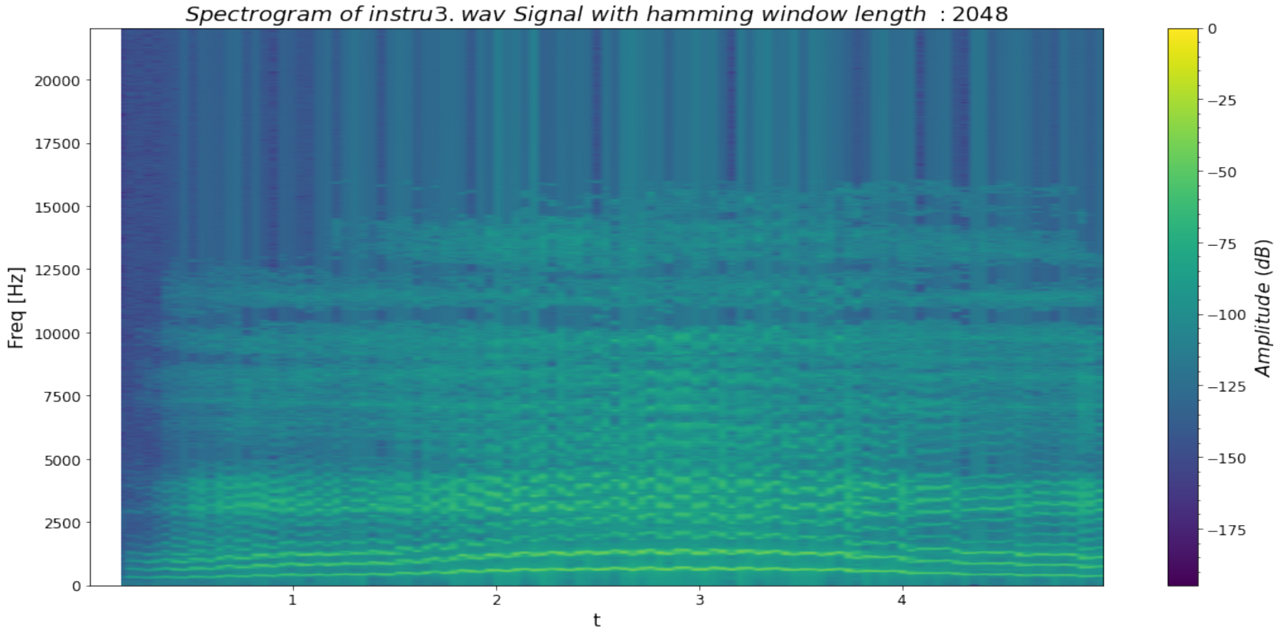
- I found out that **Fundamental Frequency = 783.277899**.
- Obviously, the maximum spectral energy can be found near the fundamental frequency.
- Normally the degree of highness or lowness of a tone is termed as pitch and this is dependent on the rate of vibrations. This same pitch is helpful in telling apart various humans, instruments, animals etc.

(Subproblem - 2)

This question asks us to plot the spectrogram of the Opera.wav, using any windowing technique and windowing length of our choice. So I used Hamming window with a window length of 2048 samples.

The code to this question can be found here

The spectrogram of Opera.wav signal with Hamming window of window length = 2048 :

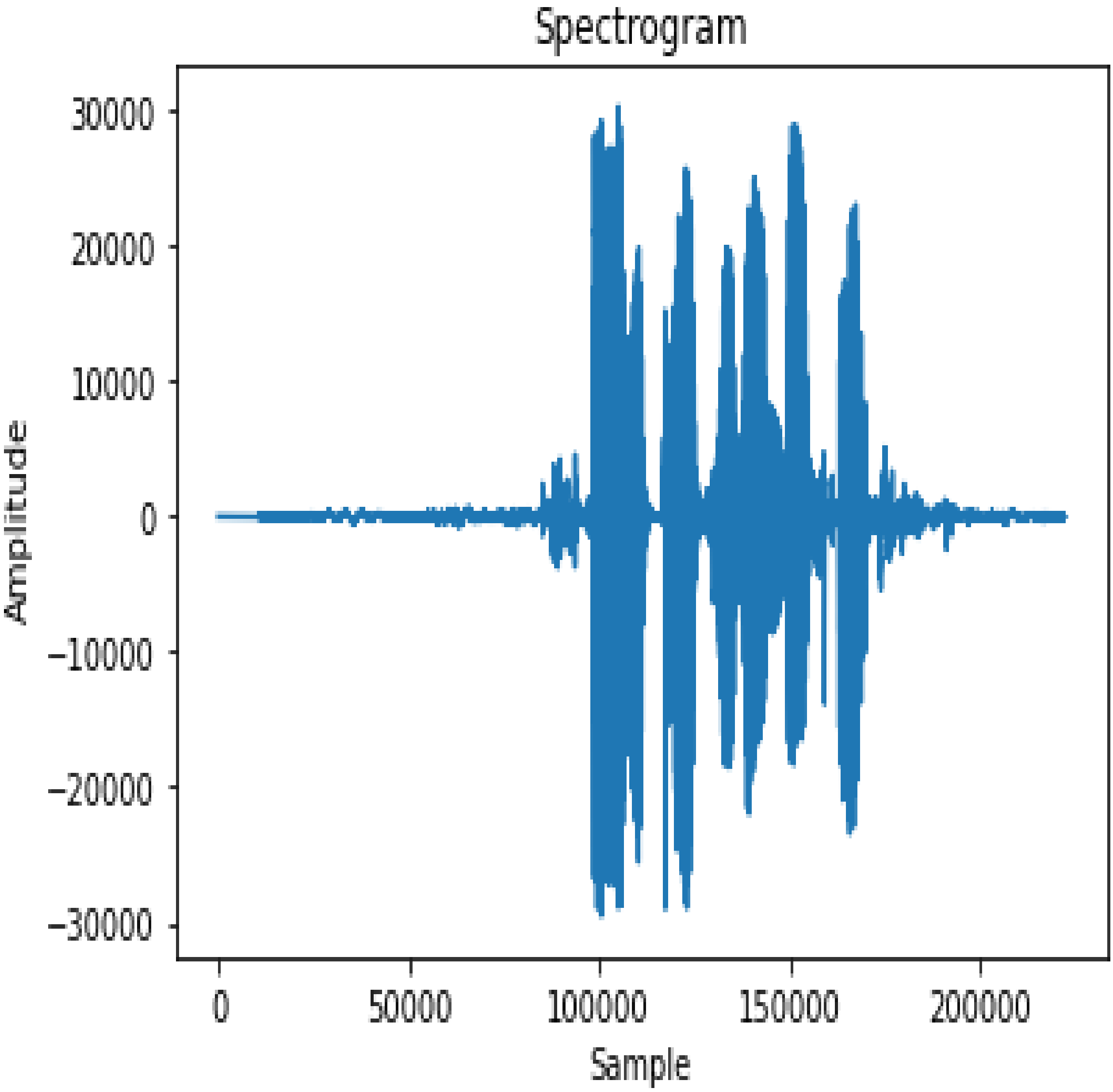


Question 3 - Spectro-Temporal Analysis of Speech

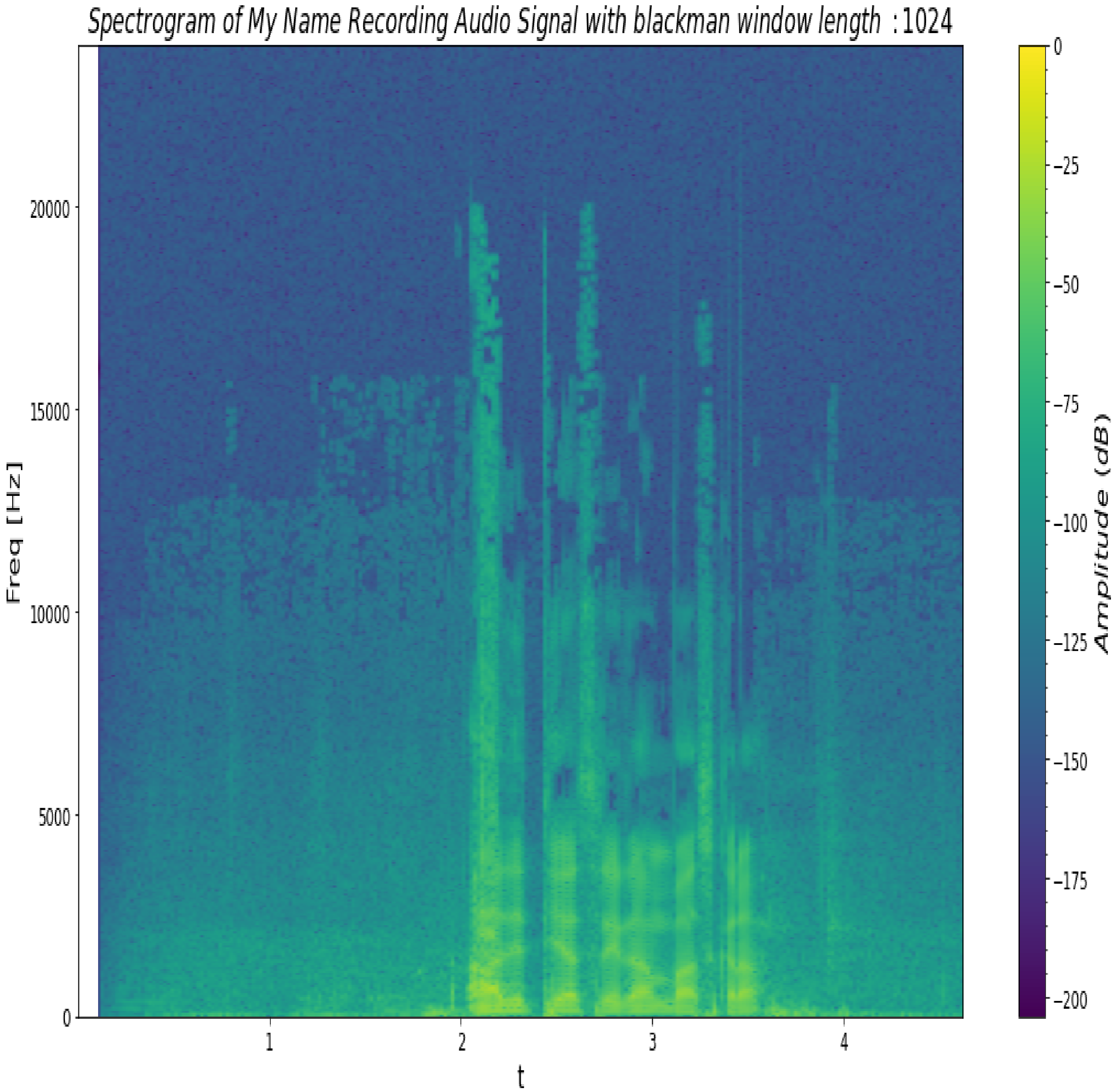
The question asks us to record saying our name (Aditya Sriram Bhaskara) and then plot the spectrogram and analyse the plot.

The code to this question can be found <u>here</u>

The conventional plot of the signal looks like :



Now I used Blackman windowing technique and have used a window of length 1024 samples, so the plot is as follows :



1 Appendix

- Note : I have used $\alpha = 2$ because my registration number is 191910. Since $\alpha = 1 +$ mod(910,4) = 3
- The link to all the code is here. And the input files and my output files can be viewed
- The link to all input and output files are here.
- The Github repo to all code and previous experiments can be found here