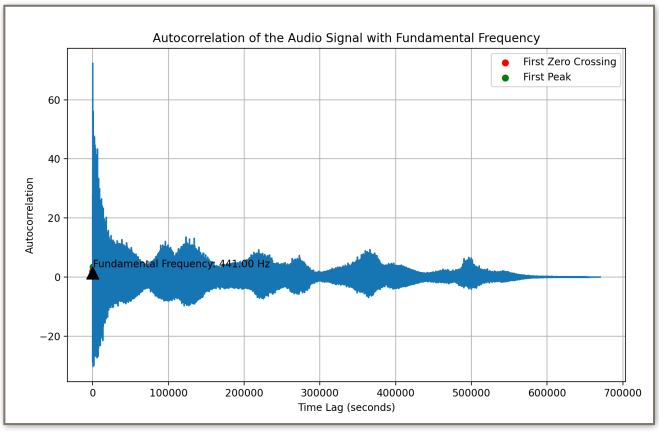
Assignment-1

Question 2. Real-Time pitch estimation of an Audio Signal.

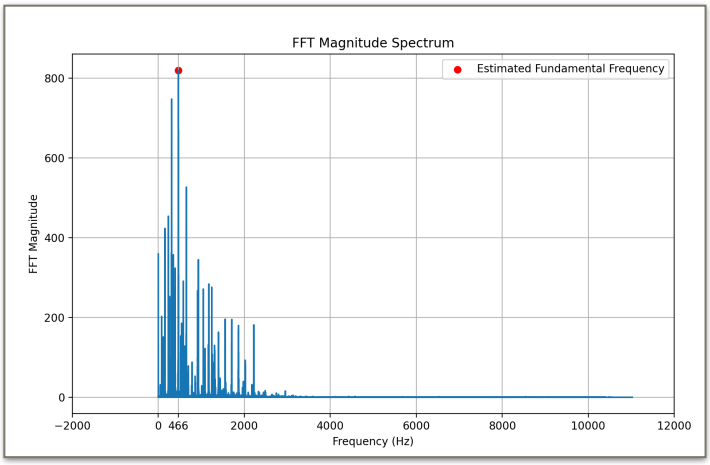


Autocorrelation of a Tanpura (Flat E scale)(estimated-441Hz)

Approach 1 (Autocorrelation):- I am using auto-correlation of the incoming signal to estimate the fundamental frequency of the signal. Given an audio signal **x[n]**, the autocorrelation at a **lag k** is computed by multiplying the signal with a time-shifted version of itself and summing the products. When the lag k corresponds to the period of the fundamental frequency, the autocorrelation will exhibit a peak. This is because the signal correlates well with itself when aligned with its repeating pattern.

For example, if the fundamental frequency is f Hz, and the sampling rate is Fs samples per second, then the lag corresponding to the period of the fundamental frequency is **k = Fs / f**.

To find the **fundamental frequency,** I looked for the first peak after the first zero-crossing in the autocorrelation function. The peak indicates the lag that corresponds to the period of the fundamental frequency. The reciprocal of this lag gives us the estimated fundamental frequency.



FFT Spectrum of a Tanpura (Flat E scale)(estimated-466 Hz)

Approach 2 (FFT):-

First, I applied the **FFT** to the signal to convert it from the time domain to the frequency domain. Then, identified the dominant frequency component in the frequency domain. This could be done by finding the peak in the **FFT magnitude spectrum**.

The fundamental frequency is the frequency corresponding to the peak found. Now using the formula: **fundamental_frequency = peak_frequency * (sample_rate / fft_length)**, where **peak_frequency** is the frequency corresponding to the peak in the spectrum, **sample_rate** is the sampling rate of the signal, and **fft_length** is the length of the FFT, we got the fundamental frequency or the pitch of the signal.