Experiment 3

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1 Aim of the experiment

Frequency analysis of signals using DFT.

2 Results/Graphs

2.1 Question 1

Table below gives the notation based on the standard concert pitch for different frequency tones. The track files Guitar1.wavto Guitar5.wav contain single notes of electric guitar instrument. Our task is to map them with the corresponding frequencies and find notes of the sounds.

	Frequency in hertz (semitones above or below middle C)							
Octave → Note ↓	0	1	2	3	4	5	6	7
C	16.352 (−48)	32.703 (−36)	65.406 (−24)	130.81 (−12)	261.63 (±0)	523.25 (+12)	1046.5 (+24)	2093.0 (+36)
C♯/D♭	17.324 (−47)	34.648 (−35)	69.296 (−23)	138.59 (−11)	277.18 (+1)	554.37 (+13)	1108.7 (+25)	2217.5 (+37)
D	18.354 (−46)	36.708 (−34)	73.416 (−22)	146.83 (−10)	293.66 (+2)	587.33 (+14)	1174.7 (+26)	2349.3 (+38)
E♭/D♯	19.445 (−45)	38.891 (−33)	77.782 (−21)	155.56 (−9)	311.13 (+3)	622.25 (+15)	1244.5 (+27)	2489.0 (+39)
E	20.602 (−44)	41.203 (−32)	82.407 (−20)	164.81 (−8)	329.63 (+4)	659.26 (+16)	1318.5 (+28)	2637.0 (+40)
F	21.827 (−43)	43.654 (−31)	87.307 (−19)	174.61 (−7)	349.23 (+5)	698.46 (+17)	1396.9 (+29)	2793.8 (+41)
F♯/G♭	23.125 (−42)	46.249 (−30)	92.499 (−18)	185.00 (−6)	369.99 (+6)	739.99 (+18)	1480.0 (+30)	2960.0 (+42)
G	24.500 (−41)	48.999 (−29)	97.999 (−17)	196.00 (−5)	392.00 (+7)	783.99 (+19)	1568.0 (+31)	3136.0 (+43)
A♭/G♯	25.957 (−40)	51.913 (−28)	103.83 (−16)	207.65 (−4)	415.30 (+8)	830.61 (+20)	1661.2 (+32)	3322.4 (+44)
A	27.500 (−39)	55.000 (−27)	110.00 (−15)	220.00 (−3)	440.00 (+9)	880.00 (+21)	1760.0 (+33)	3520.0 (+45)
B♭/A♯	29.135 (−38)	58.270 (−26)	116.54 (−14)	233.08 (−2)	466.16 (+10)	932.33 (+22)	1864.7 (+34)	3729.3 (+46)
B	30.868 (−37)	61.735 (−25)	123.47 (−13)	246.94 (−1)	493.88 (+11)	987.77 (+23)	1975.5 (+35)	3951.1 (+47)

Code : task1.m

a) Graph

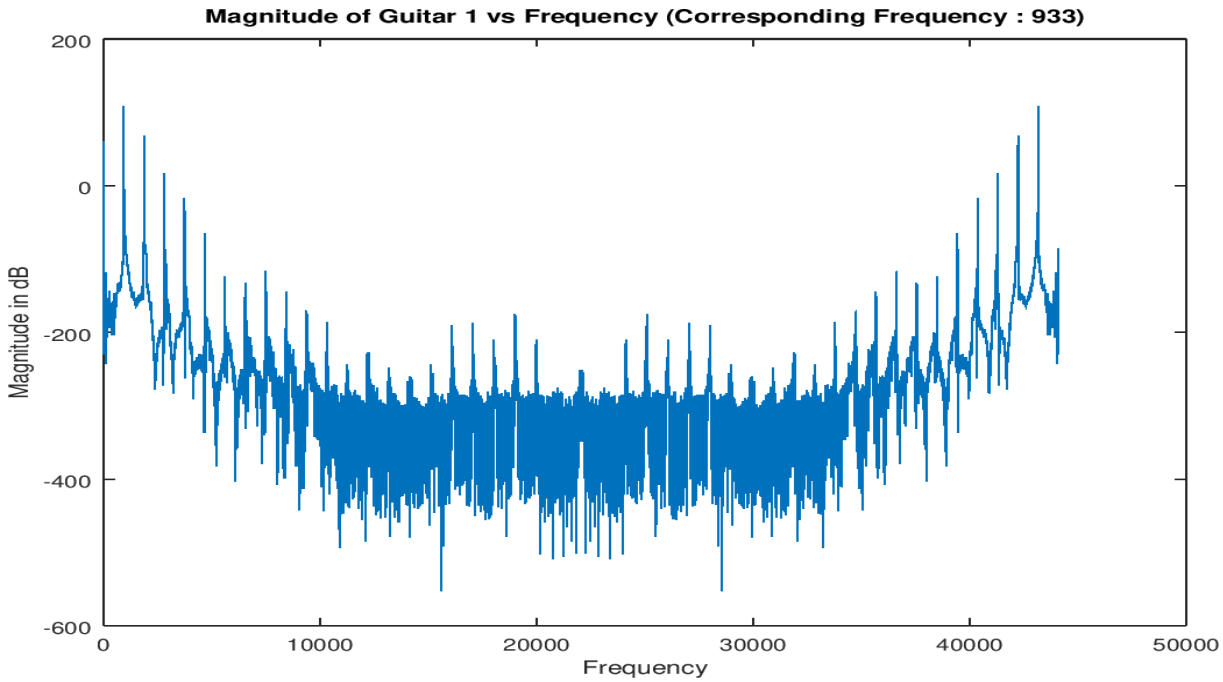

Figure 1: Guitar 1

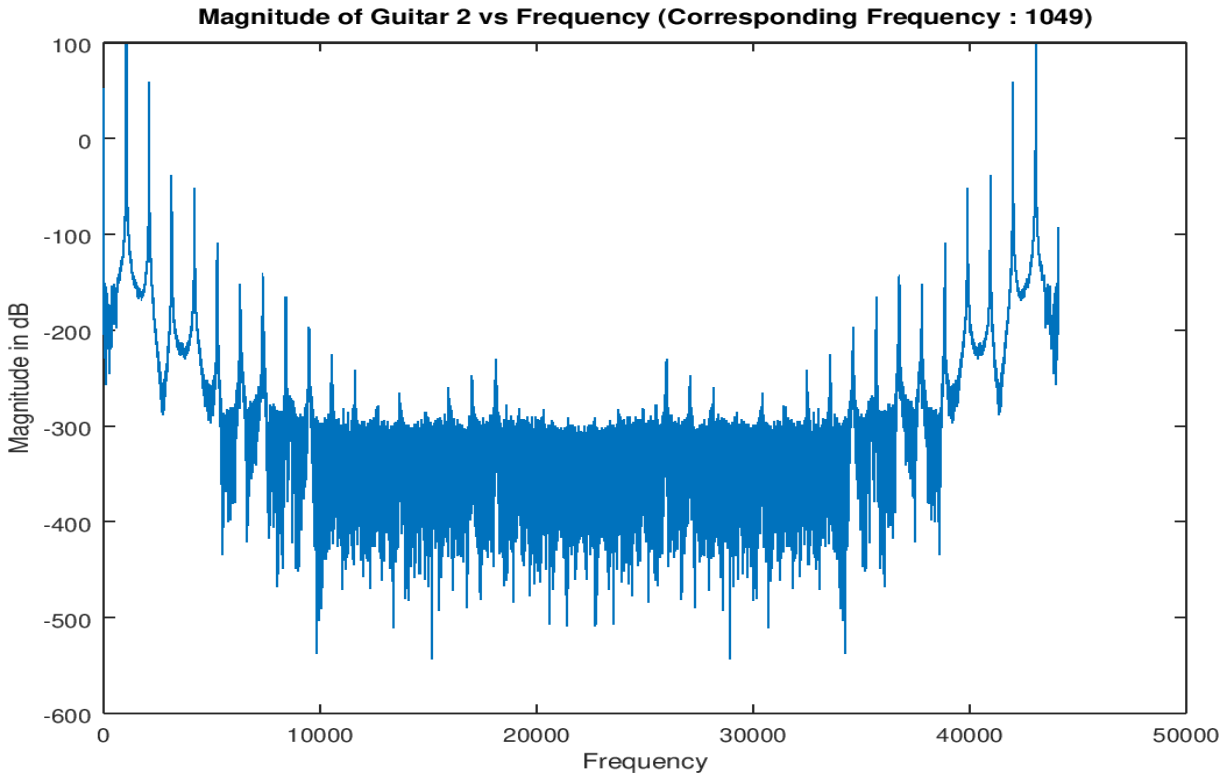

Figure 2: Guitar 2

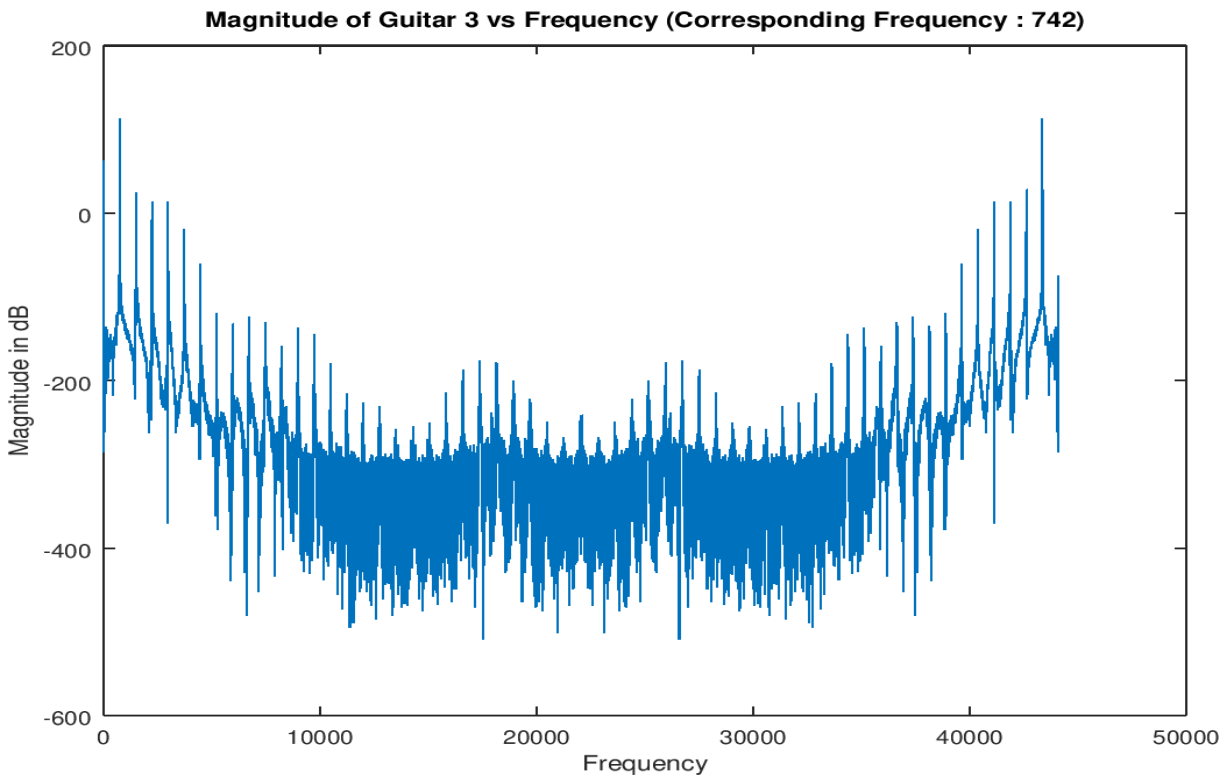

Figure 3: Guitar 3

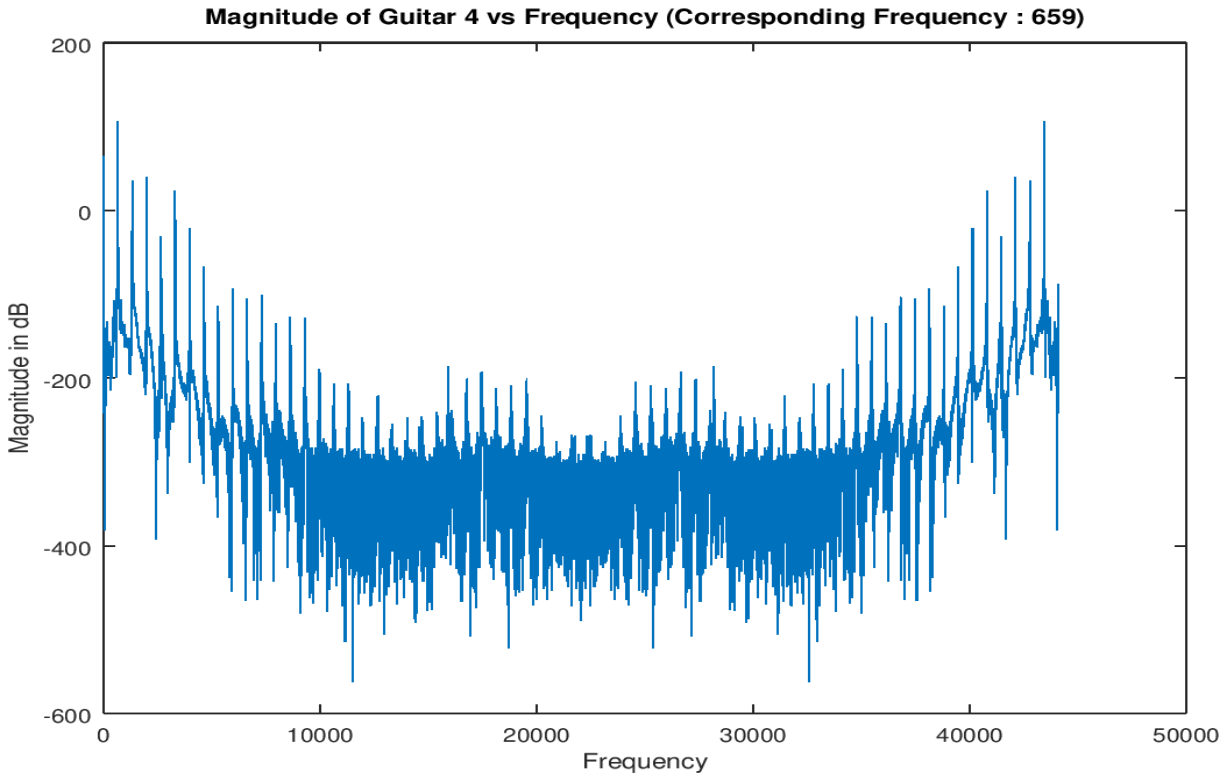

Figure 4: Guitar 4

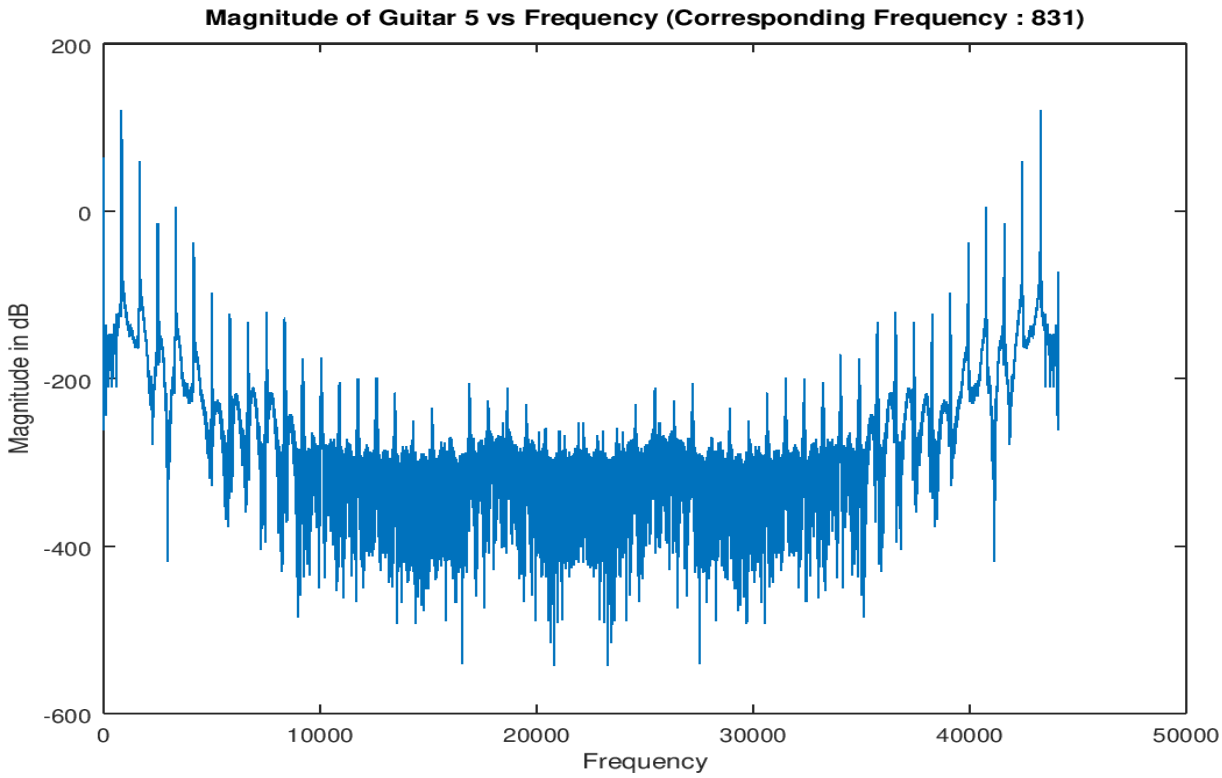

Figure 5: Guitar 5

Observations

- The fundamental of the Spectrum for Guitar 1 occurs at 933.44 Hz.
- The fundamental of the Spectrum for Guitar 2 occurs at 1048.9 Hz.
- The fundamental of the Spectrum for Guitar 3 occurs at 741.97 Hz.
- The fundamental of the Spectrum for Guitar 4 occurs at 659.45 Hz.
- The fundamental of the Spectrum for Guitar 5 occurs at 831.36 Hz.
- The frequency spectrums for these musical instruments contain several harmonics.

Conclusion

- After tallying with the frequencies with the table provided for closest corresponding values:-
  - Guitar1: A#, 5th octave
  - Guitar2: C, 6th octave
  - Guitar3: F#, 5th octave
  - Guitar4: E, 5th octave
  - Guitar5: G#, 5th octave
- Also, the spectrums have other harmonics representing noise and spectral leakage.
- The first peak represents the DC offset, so the second is the fundamental.

b) Graph

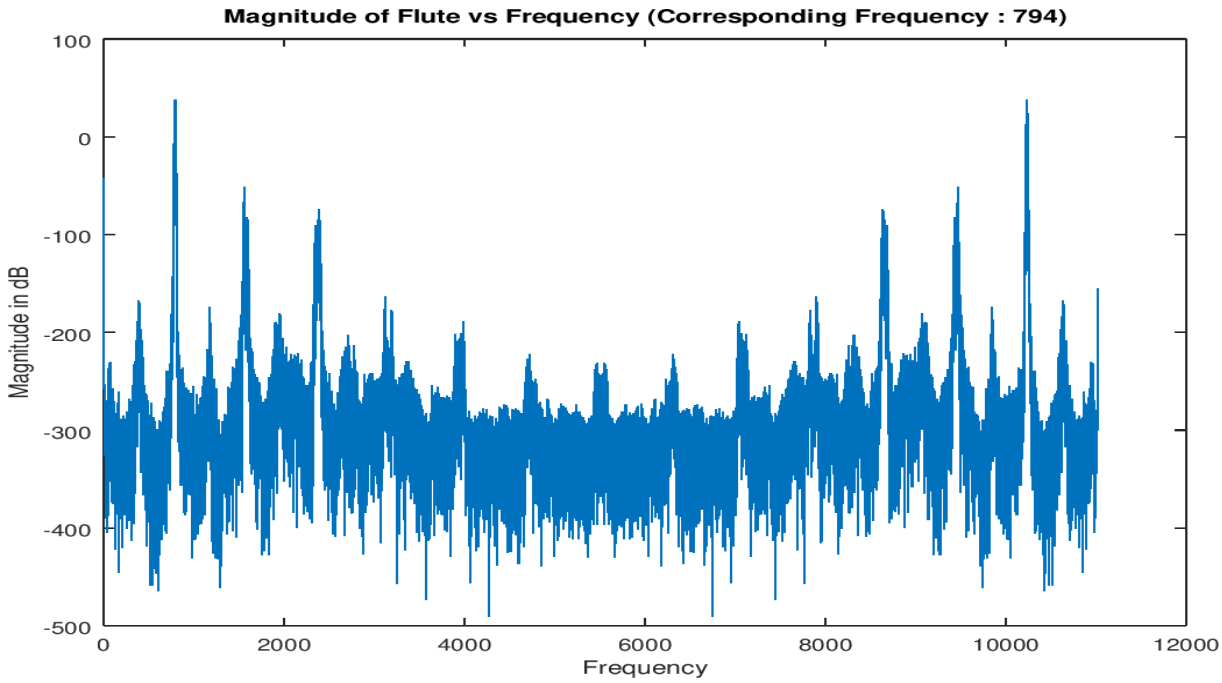

Figure 6: Flute

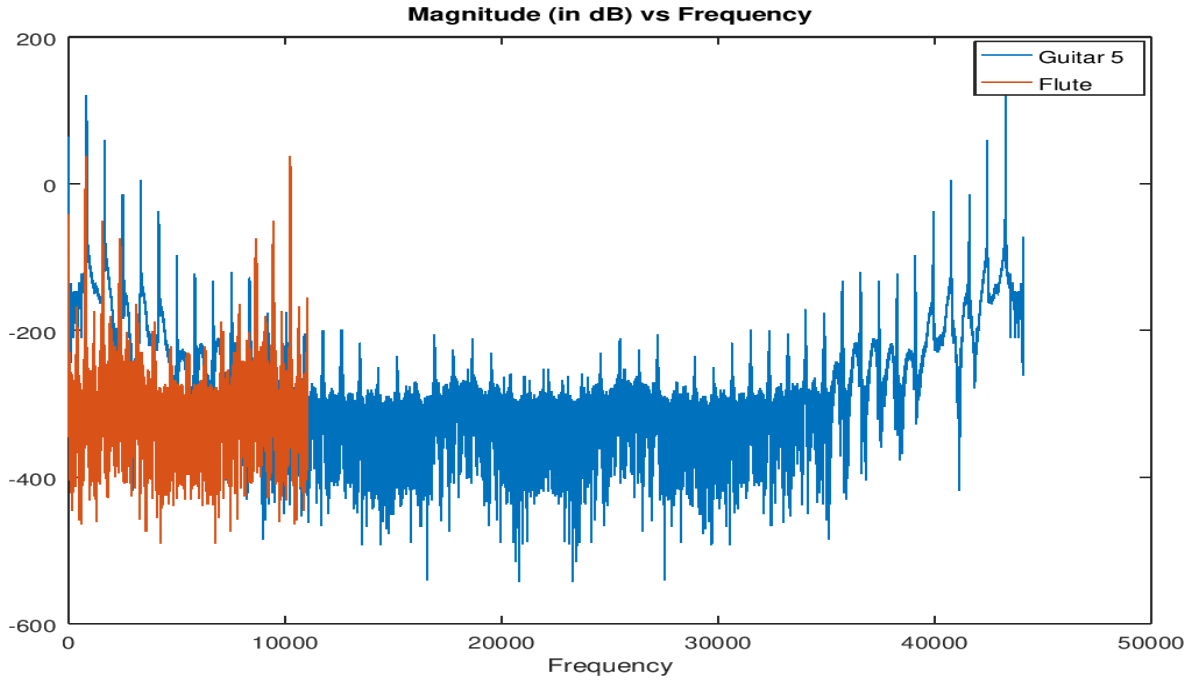

Figure 7: Flute and Guitar 5 in same plot

Observations

- The flute fundamental is at 793.50 Hz.
- This is closest to Guitar 5 note's frequency.

Conclusion

- The Flute's note is G, 5th octave.
- This is closest to Guitar 5 which was G#, 5th octave.
- The flute doesn't have higher frequency components unlike the guitar 5 closest to the flute's note as seen in Figure 7.

2.2 Question 2

An ECG signal record is given in the text file ECG_Data1.txt. The sampling rate for the signal is 720 samples/seconds.
(a) Plot the signal with respect to time.
(b) Plot the frequency spectrum of the signal.
(c) Can you find the heart rate of the person?
(d) Use FFT and IFFT to remove the DC value and the frequency content above 20 Hz (making the DFT values zero for those indices of k). Plot the filtered response. Compare it with the original signal. What do you observe?

Code : task2.m

a) Graph

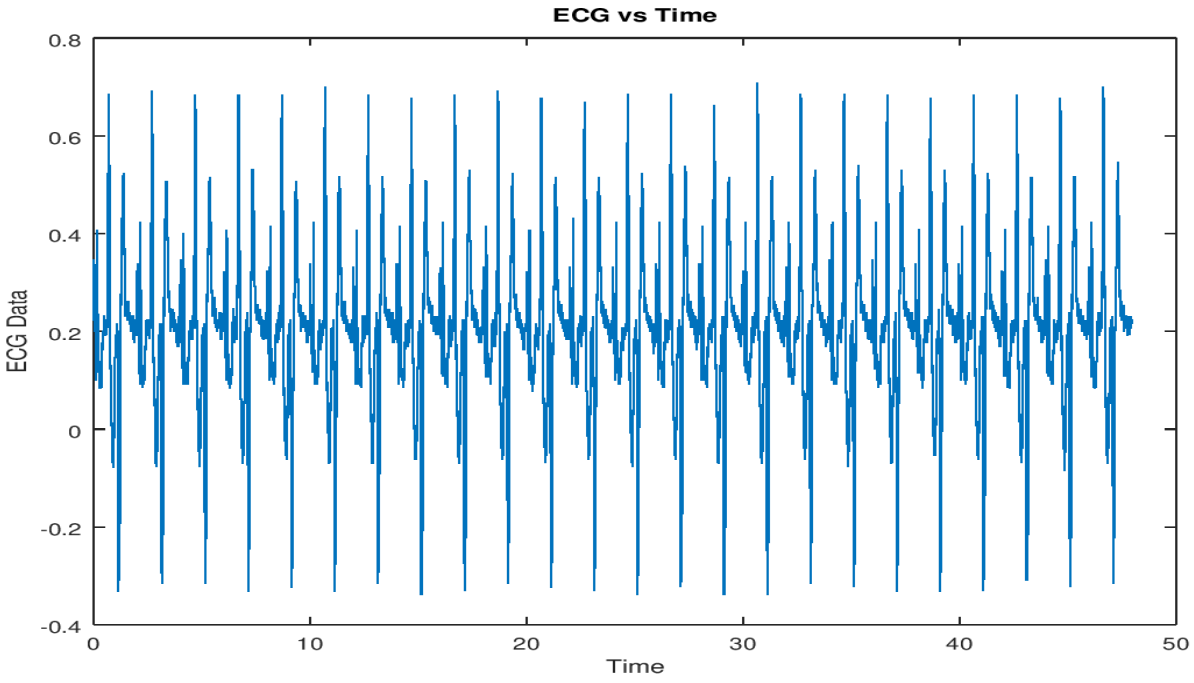

Figure 8: ECG Data vs Time

b) Graph

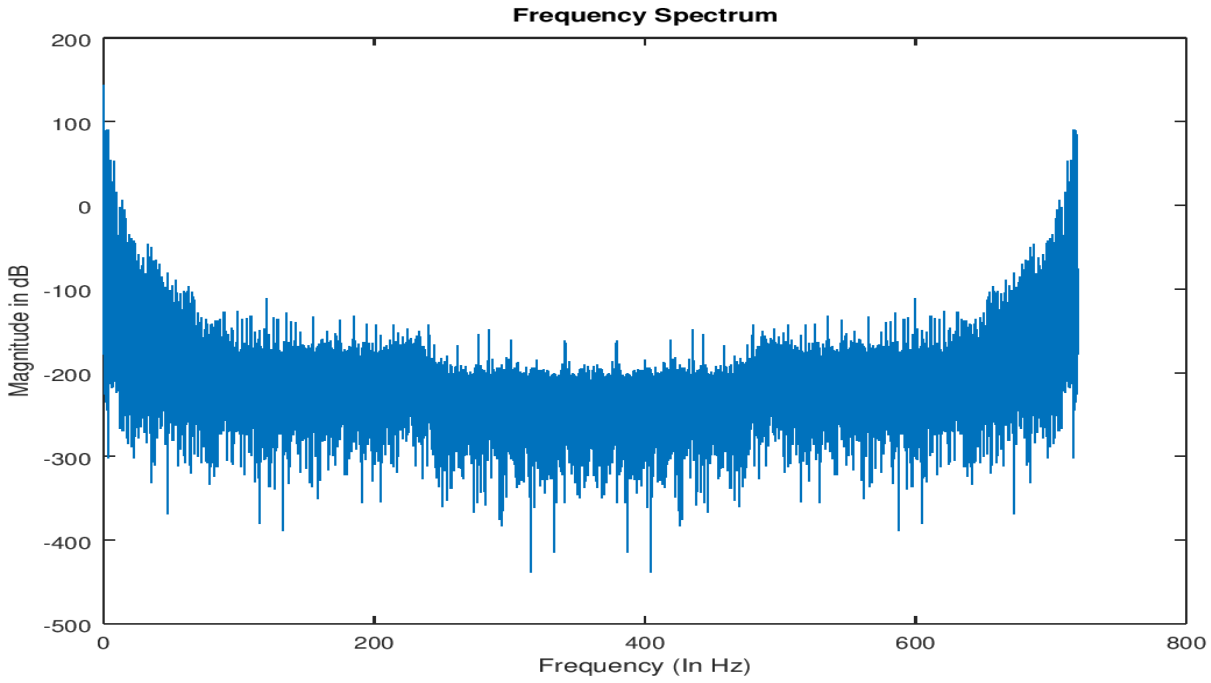

Figure 9: Frequency Spectrum of the ECG Data

d) Graph

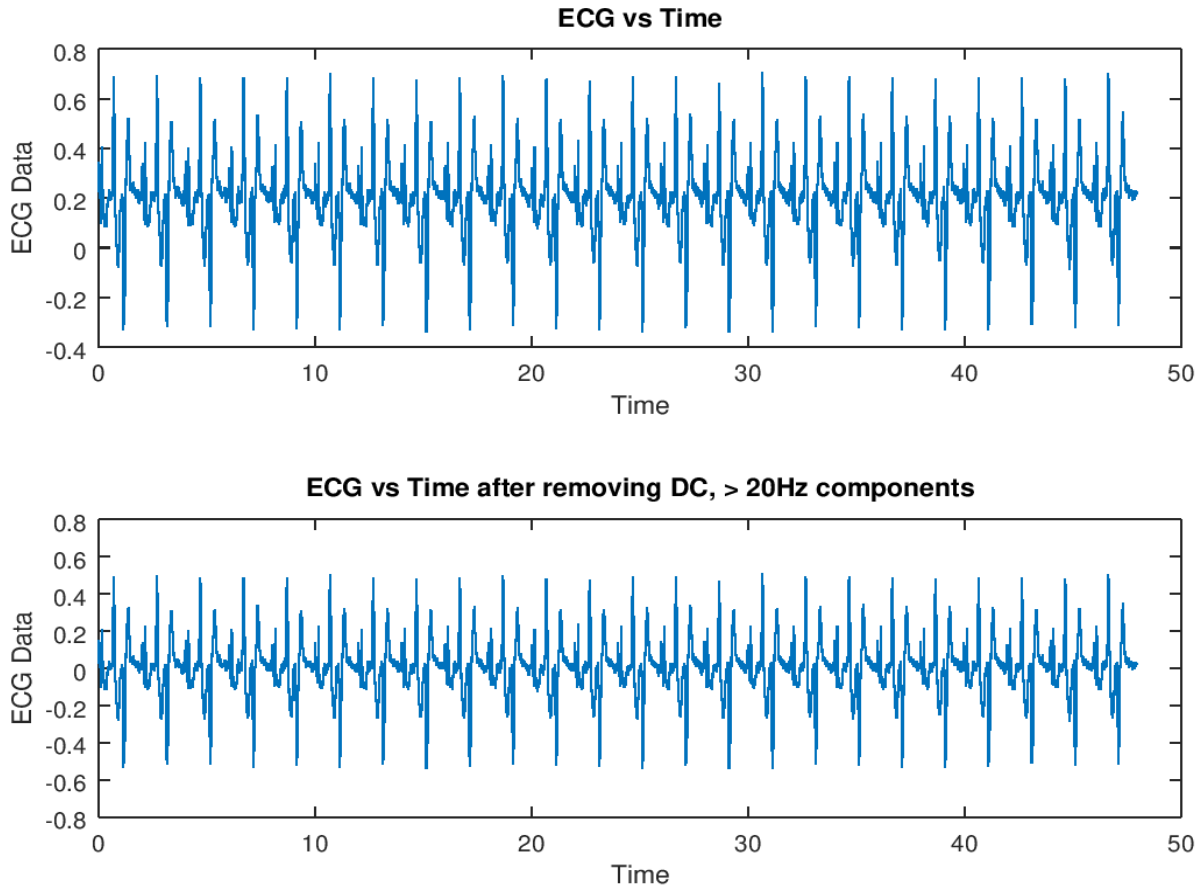

Figure 10: Comparison of Original Data to the ECG Data after removal of DC and frequencies above 20 Hz

Observations

- Plot of part (a) is a normal looking ECG spectrum with information about heart rate, rhythmn of heart beat and other points.
- Upon taking the Fourier transform, the second highest peak after the initial DC offset at 0 Hz representing the fundamental or the dominant frequency occurs at approximately 1.5 Hz.
- The heart rate is found to be 90.128 beats/minute or 1.50213 beats/second.

Conclusion

- The DC offset is removed by making X(0) =0 in the DFT as X(0)= DC Offset Value.
- The symmetry about the x axis arises as DC offset=$\sum$x(n)=0 and the graphs horizontal axis of symmetry gets shifted to the x axis.
- The heart rate is obtained by highest peak in the last DFT plot or the second highest peak in the first one(peak is DC offset). The frequency at which it occurs is heart rate in beats per second.