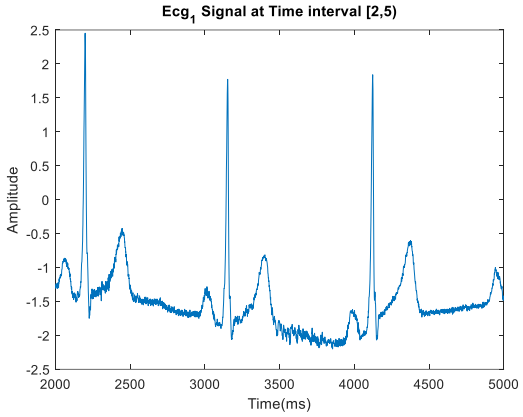
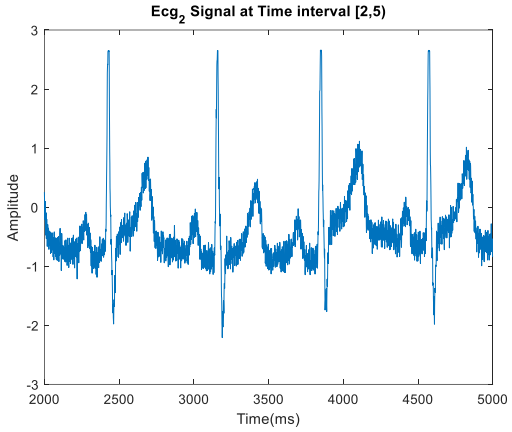
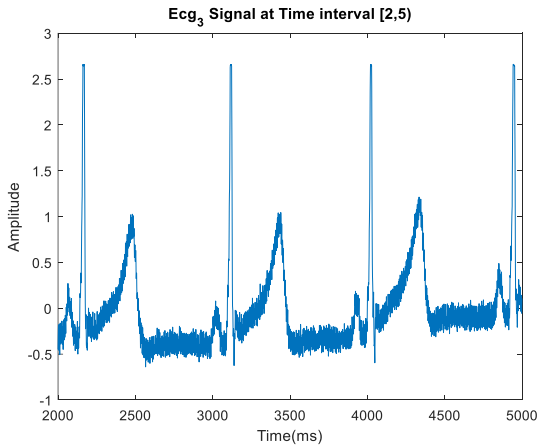
Answers:

Question 1

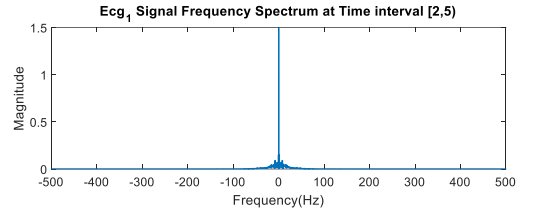
a) There are 1000 samples for 1 second since we have sampling frequency as 1000.
b) Durations can be calculated by length(ecg_i)/Fs formula where i represent file number.
    a. Duration of ecg_1 is 23.4840 seconds.
    b. Duration of ecg_2 is 8.5680 seconds.
    c. Duration of ecg_3 is 10.6960 seconds.
c) There are 3000 samples since each second represents 1000 samples. Graphs can be seen below:

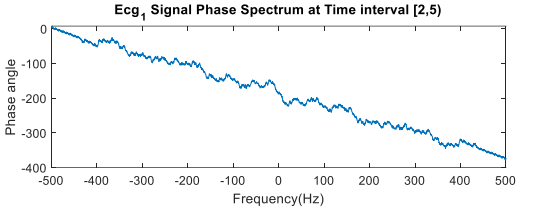


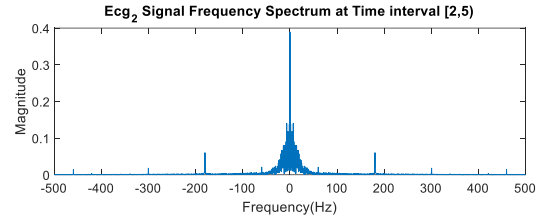


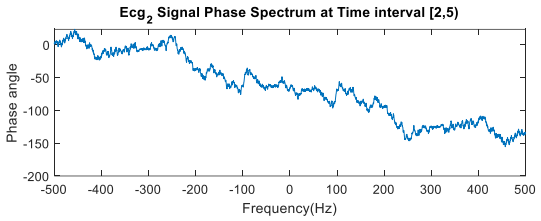


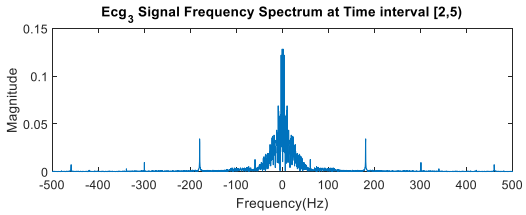
d) The graphs can be seen below:

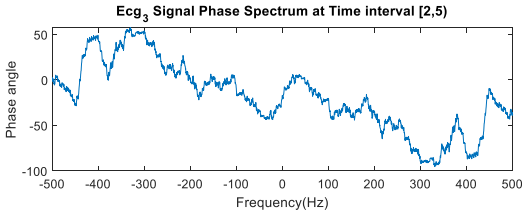








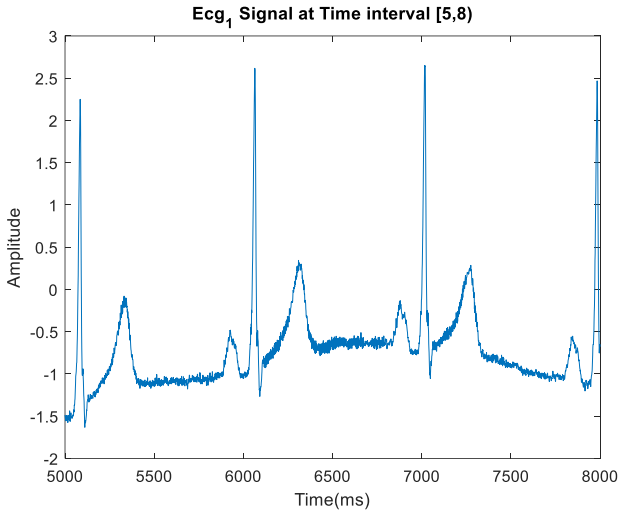


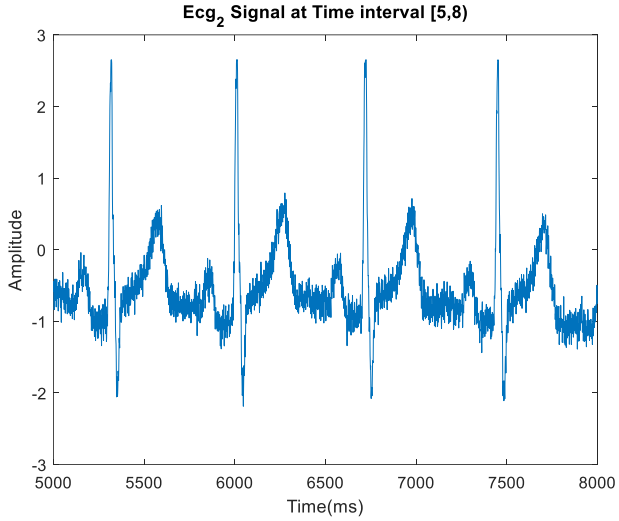


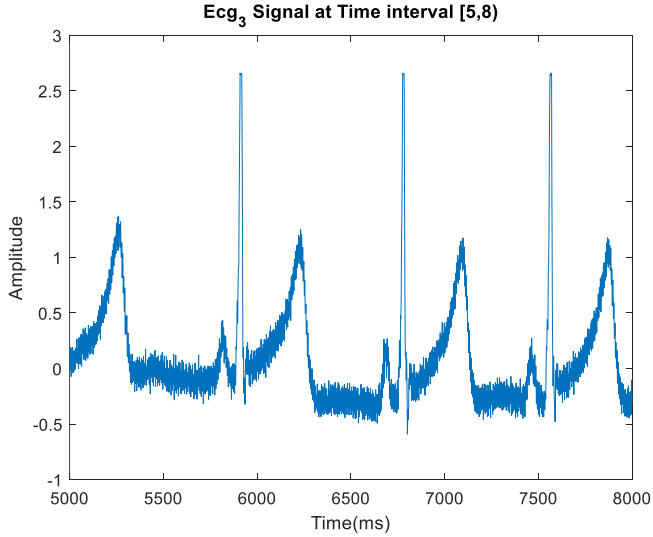
I) There are high band noises because hearth beats frequency response should be between 0.05 and 150Hz but we have components further than 150 Hz So It should be High frequency noises. But there are also powerline noises (50-60 Hz) so this can be counted as bandlimited frequency noises and there are Baseline Wander which is around 0.5Hz this can be counted as Low frequency noise. Thus, we have all kinds of noise in our data.

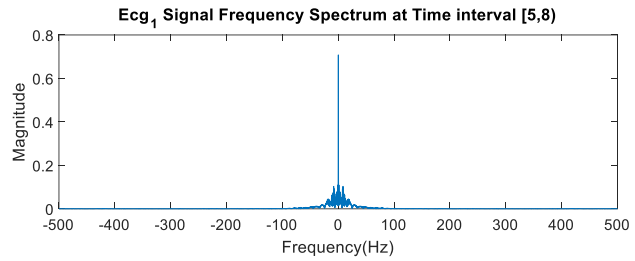
II) There are non-linear phases in our data since there is no linear lines there is irregularities. But most linear-like phase is the phase of ecg_1 signal.

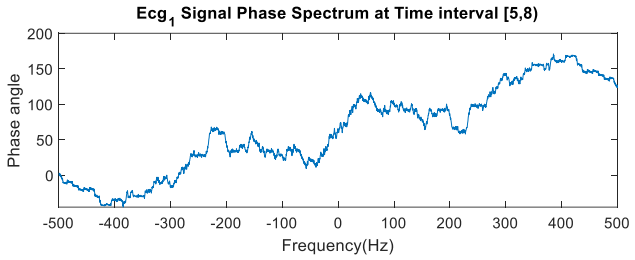
e) The graphs can be seen below:

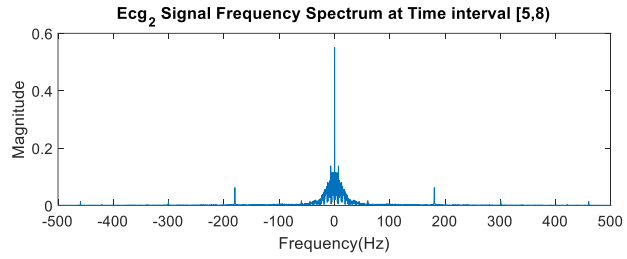


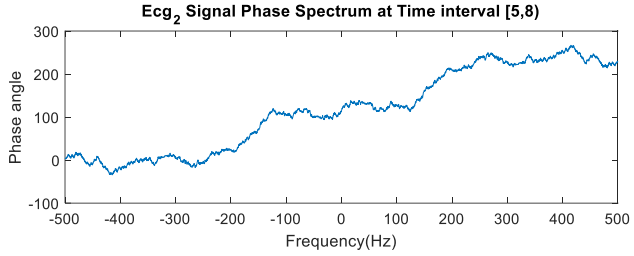


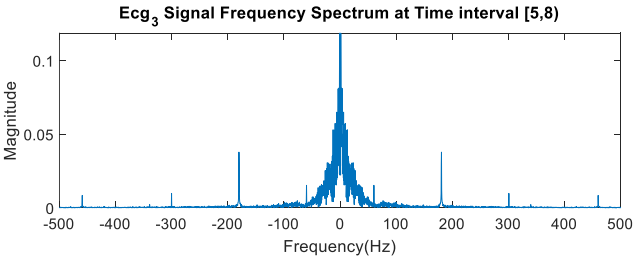


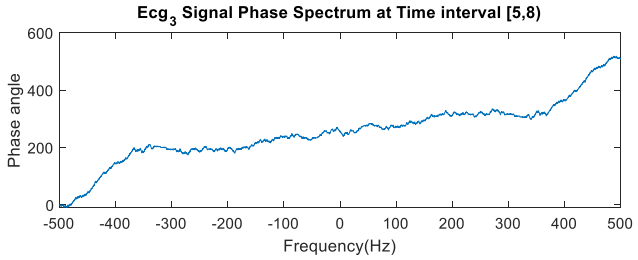

Ecg1 Signal Frequency Spectrum at Time interval [5,8)
Magnitude
Frequency(Hz)


Ecg1 Signal Phase Spectrum at Time interval [5,8)
Phase angle
Frequency(Hz)


Ecg2 Signal Frequency Spectrum at Time interval [5,8)
Magnitude
Frequency(Hz)


Ecg2 Signal Phase Spectrum at Time interval [5,8)
Phase angle
Frequency(Hz)

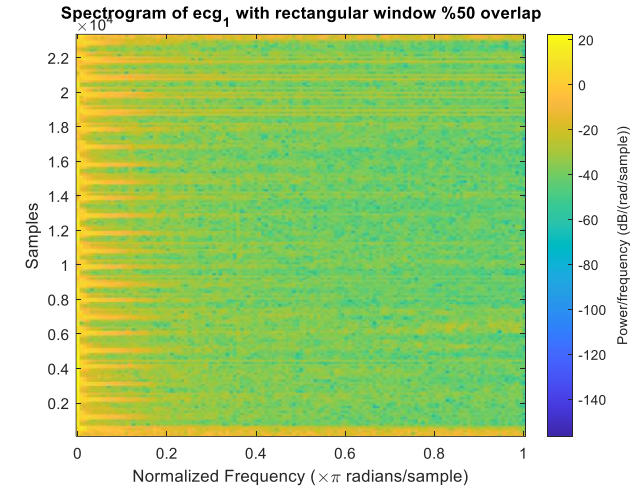

Ecg3 Signal Frequency Spectrum at Time interval [5,8)
Magnitude
Frequency(Hz)

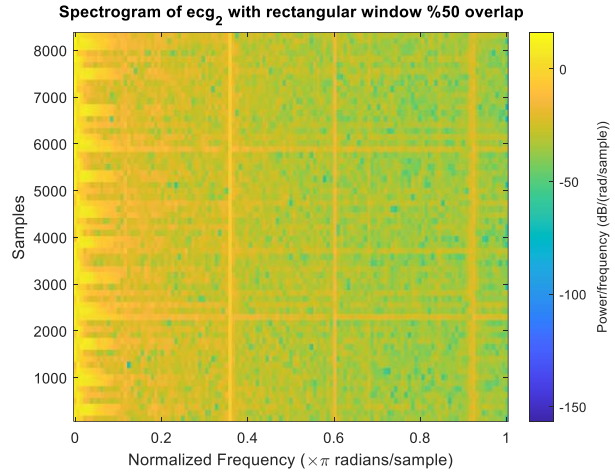

Ecg3 Signal Phase Spectrum at Time interval [5,8)
Phase angle
Frequency(Hz)

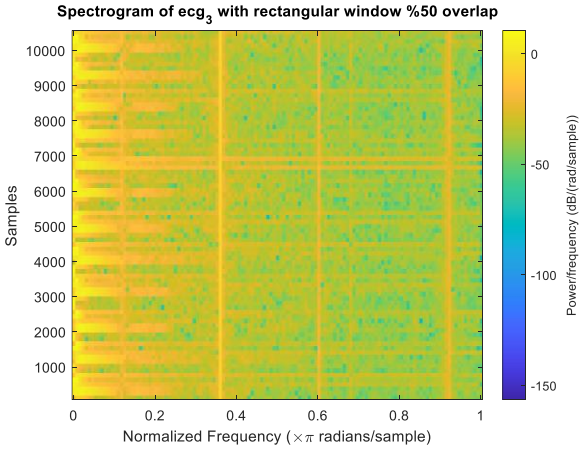
f) There are magnitude differences in frequency domain This can be caused by noise (electrodes, powerline etc.) or simply condition of the patient has been changed but frequency values are similar. In phase domain nothing changed but direction of phases (bottom to up) we got non-linear phases both ways.

Question 2

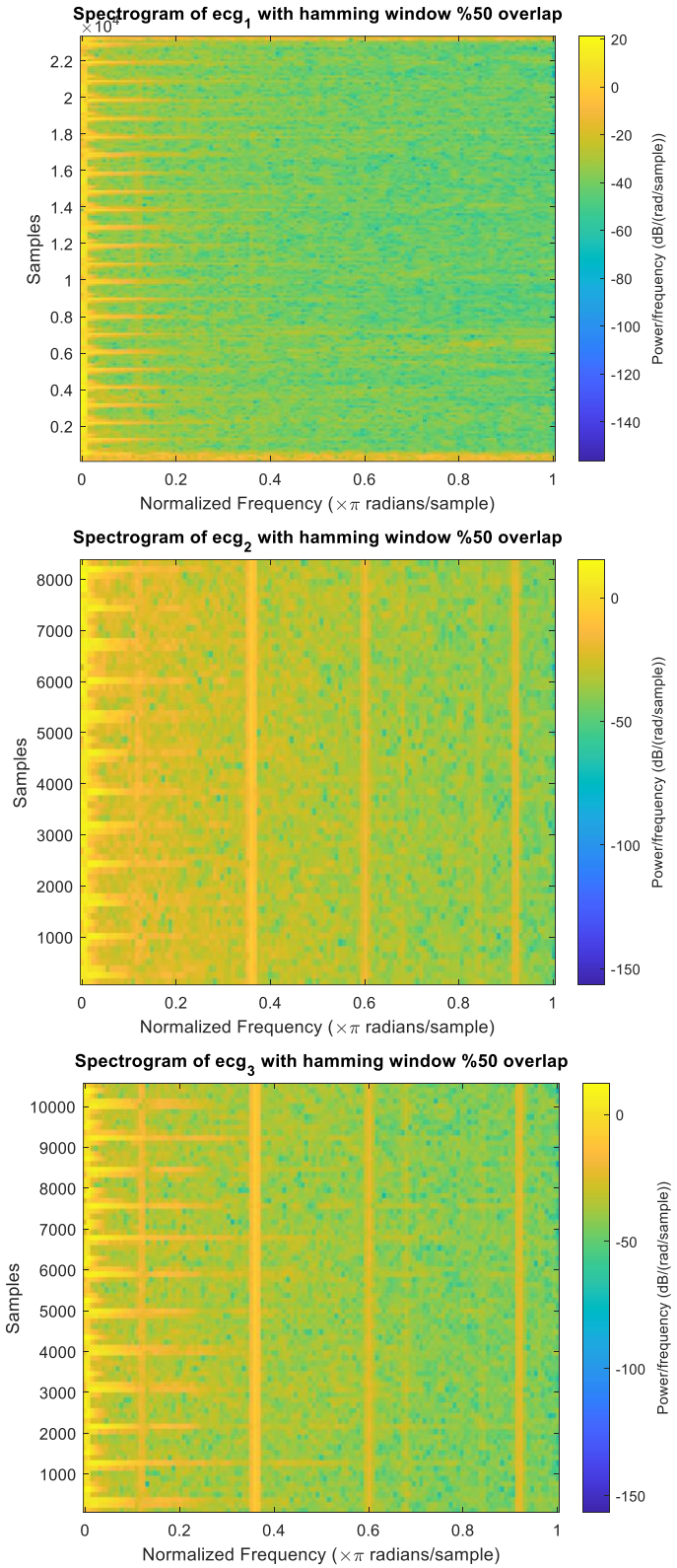
a) The graphs for spectrogram with rectangular window can be seen below:







b) The graphs for spectrogram with hamming window can be seen below:



c) If we compare part graphs and part b graphs for ecg_1 signal, spectrogram with rectangular window has more distinguished horizontal lines than spectrogram with hamming window at further samples from 1900 (1.9 seconds). Comparing for ecg_2 signal provides little different results. Spectrogram with rectangular window has more horizontal lines than Spectrogram with hamming window but spectrogram with hamming window has thicker vertical lines. More vertical lines mean we have same frequency components all the time (this could be noises) and more horizontal lines mean that we have greater frequency resolution. In our case, we can better distinguish frequency differences easier by using hamming windows rather than the rectangular window. The ecg_3 signal has different results, in this spectrogram vertical lines are more distinguishable for hamming windows rather than a rectangular window, but still vertical lines are thinner (sharper) for the rectangular window. This is caused by main lobe width is higher on hamming window than rectangular window and if we compare side lobes rectangular has more side lobes than hamming window this provides less leakage for hamming window. As result hamming is more suitable if we want high frequency resolution. If we want better time resolution, then using rectangular window rather than hamming window give us better results. The graphs from Wikipedia which explains more clearly has been given below:

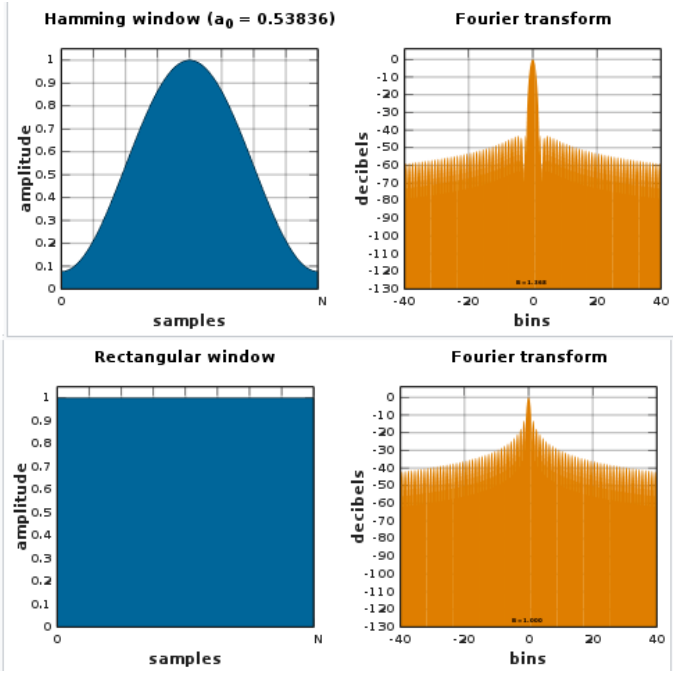


Figure 1:https://en.wikipedia.org/wiki/Window_function

d) Spectrograms give time information but sacrifice frequency information at some point while spectrums are giving perfect frequency resolution but cannot provide any time information while doing so.