



VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN
 [AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY, CHENNAI]
 Elayampalayam – 637 205, Tiruchengode, Namakkal Dt., Tamil Nadu.

Question Paper Code: 120015

B.E. / B.Tech. DEGREE END-SEMESTER EXAMINATIONS – NOV. / DEC. 2025

Fifth Semester

Biomedical Engineering

U23BM514 – BIO SIGNAL PROCESSING

(Regulation 2023)

Time: Three Hours

Maximum: 100 Marks

Answer ALL the questions

Knowledge Levels (KL)	K1 – Remembering	K3 – Applying	K5 - Evaluating
	K2 – Understanding	K4 – Analyzing	K6 - Creating

PART – A

(10 x 2 = 20 Marks)

Q.No.	Questions	Marks	KL	CO
1.	Define Nyquist rate.	2	K1	CO1
2.	Distinguish between energy signal and power signal.	2	K1	CO1
3.	Mention the significance of Fourier Series in representing periodic biosignals like ECG.	2	K2	CO2
4.	Fourier Transform is used to identify frequency components in EEG signals. Give justification for the statement and explain how?	2	K2	CO2
5.	Indicate the significance of circular convolution in the context of Discrete Fourier Transform.	2	K2	CO3
6.	How does FFT improve the efficiency of ECG signal filtering compared to direct DFT computation?	2	K2	CO3
7.	List the key characteristic of a Butterworth filter, and indicate why it is preferred in biomedical signal processing?	2	K2	CO4
8.	Write the purpose of bilinear Z-transform in converting analog filters to digital form.	2	K2	CO4
9.	Identify two key advantages of using FIR filters over IIR filters in biomedical signal processing applications.	2	K2	CO5
10.	Define decimation and interpolation in multirate signal processing and mention one biomedical application for each.	2	K2	CO5

PART – B

(5 x 13 = 65 Marks)

Q.No.	Questions	Marks	KL	CO
11. a)	Signals encountered in biomedical engineering vary widely in their characteristics and applications. Give a detailed explanation of classification of signals and also explain how signal classification aids in selecting appropriate processing techniques.	13	K1	CO1
	(OR)			
b)	Describe the origin and components of the ECG waveform with suitable illustration and also explain the electrode placement and signal acquisition process.	13	K1	CO1
12. a)	Derive the Fourier Transform of a continuous-time signal and explain its key properties. Also illustrate how these properties are used to extract frequency components from ECG signals.	13	K4	CO2
	(OR)			
b)	Discrete-time LTI systems are often analyzed using Z-Transform and DTFT. Define the Z-Transform and explain the concept of Region of Convergence (ROC) with examples. Also compare Z-Transform and DTFT in terms of their application to system stability and frequency analysis in biomedical signal processing.	13	K4	CO2
13. a)	Explain the properties of the Discrete Fourier Transform and discuss how magnitude and phase spectra are interpreted in EMG signal.	13	K3	CO3
	(OR)			
b)	Describe the Decimation-in-Time and Decimation-in-Frequency algorithms used in Fast Fourier Transform and compare their computational steps and efficiency.	13	K3	CO3
14. a)	Design a 3rd-order Butterworth low-pass filter and explain its frequency response characteristics and discuss the relevance of such filters in removing baseline wander and powerline noise from ECG signals.	13	K5	CO4
	(OR)			
b)	Elucidate the Impulse Invariant Method and Bilinear Z-Transform for converting analog filters into digital filters with suitable example and compare their advantages and limitations.	13	K5	CO4
15. a)	Design an FIR filter using the windowing method and explain the steps involved in selecting the window type and filter order.	13	K5	CO5

(OR)

- b) Explain the principles of multirate signal processing, including decimation and interpolation. Derive the mathematical expressions for both operations and discuss their impact on signal resolution and computational efficiency. 13 K5 CO5

PART – C

(1 x 15 = 15 Marks)

Q.No.	Questions	Marks	KL	CO
16. a)	You are tasked to design a Discrete-Time Low Pass Filter for a voice signal. The specifications are:	15	K4	CO2

- Passband frequency (F_p) = 4 kHz, with 0.8 dB ripple
- Stopband frequency (F_s) = 4.5 kHz, with 50 dB attenuation
- Sampling frequency (F_s) = 22 kHz

Determine the discrete-time Passband frequency, Stopband frequency (in radians/sample), maximum and minimum values of $|H(\omega)|$ in the Passband and the Stopband. Where $H(\omega)$ is the filter's frequency response.

(OR)

- b) A Biomedical engineer is designing a digital filter to process fetal ECG signals contaminated by maternal interference. The system's transfer function is given by 15 K4 CO2

$$H(z) = \frac{z(z^2 - z + 2)}{(z + 1)(z - 1)^2}$$

Perform the inverse Z-transform of $H(z)$ to obtain the impulse response $h[n]$. Explain how the derived impulse response can be used to filter fetal ECG signals.