GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150310
Semester – V
Subject Name: Biomedical Signals and Systems

Type of course: Core

Prerequisite: Fourier series, Ordinary differential equations, system models: input output, description, Linear system concepts, Laplace transform, Fundamentals of Biomedical Signals

Rationale: To prepare the students with basics of Signals and Systems, understand various frequency transformation techniques and also structure of digital IIR and FIR systems

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Signal & Systems:** **Signals:** Definition of Signal, Various Types of Signals and its classification, Standard Test Signals, Representation of signals in continuous and discrete domain, Basic Signal Operations - Shifting, Time Scaling and Amplitude Scaling Operations, signal sampling and quantization, discretization of continuous time signals, Sampling Theorem, Nyquist Criteria, Aliasing and Quantization as a error in Sampling Process, Reconstruction of Sampled Signals, Various types of 1D and 2D signals **Systems:** Definition of System, Types of Systems and its classification, Difference between continuous and discrete time domain systems **Biomedical Aspects in Signal and Systems:** Classification of Various Biosignals, Types of Biological systems, Types of 1D and 2D signals arising/captured from human body, Deciding Sampling Rate - Nyquist Criteria for various Biomedical Signals, Various Noises in Biomedical Signals	08
2	**Time Domain Analysis of Discrete Time System:** Introduction of discrete time signal and systems, Properties of discrete time systems, Classification of discrete time systems, Systems characterized by Linear Time Invariance property, Convolution of LTI Systems using Mathematical method, Tabular method and Graphical method, Circular Convolution, LTI system characterized by differential equation: Homogeneous and Particular Solution of differential equation, Correlation of	10

	Signals - Cross correlation and Autocorrelation **Biomedical Case Study:** Convolution of 1D and 2D signals of Biomedical origin, Correlation of signals of Biomedical origin	
3	**Frequency Domain Characterization of Signals & Systems by Transform Techniques (PART-I):** Frequency Domain analysis of First and Second Order LTI Systems **Z-Transform:** Introduction to Z-Transform, Region of Convergence (ROC), Properties of Z – Transform, Z-Transform of Standard Sequences, one sided & Two sided Z –Transform, Solution of Differential Equation using Z-Transform, Frequency Response from poles and zero locations, Connection between Laplace Transform & Z - Transform, Inverse Z - Transform	09
4	**Frequency Domain Characterization of Signal & System by Transform Techniques (PART-II):** **Discrete Fourier Transform:** Representation of Periodic Sequence by Fourier Series, Introduction to Discrete Fourier Transform (DFT), Properties of DFT, DFT of Standard Signals, Implementation of DFT for Frequency domain analysis of discrete signals, Linear Convolution using DFT **Fast Fourier Transform:** Introduction to Fast Fourier Transform, Radix-2 FFT algorithm, Radix-2 Decimation in Time FFT (DIT-FFT), Radix -2 Decimation in Frequency FFT (DIF-FFT), Goertzel Algorithm Spectrum Power, Spectral Density and its Importance **Relation between Discrete Fourier Transform (DFT) and Z- Transform, Importance of DFT and FFT as a primary tool for Biomedical Signal Analysis**	10
5	**Structures for Linear Time Invariant System & system characterized by Linear Constant Coefficient Differential Equation (Structure for Digital Filters):** System classification based on the impulse response – IIR & FIR system, System classification bases on output response – Recursive & Non – Recursive System **IIR Filter Structure:** Direct Form I & II Realizations, Cascade combination of Second Order System, Parallel combination of Second Order Systems **FIR Filter Structure:** Direct form realization, Cascade form, Frequency Sampling form and Lattice Structure, Representation and dependency of Zero-pole plot on nature of IIR/FIR systems	08

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Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
25%	25%	20%	20%	10%	0%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from the above table.

Reference Books:

1. **Principles of Linear Systems and Signals , B. P. Lathi, 2nd Edition, Oxford Press (2009)**
2. **Signals and Systems, A. Anand Kumar, 2nd Edition, PHI Learning Private Limited**
3. **Signals and Systems, Alan V. Oppenheim and Alan Wilsky, 2nd Edition, Prentice Hall Signal Processing Series**
4. **Signals and Systems for Bioengineers - A MATLAB based Introduction, 2nd Edition, John Semmlow, Academic Press**
5. **Signals and Systems in Biomedical Engineering, 2nd Edition, Robert P. Northrop, 2nd Edition, CRC Press**
6. **Digital Signal Processing, N. G. Palan, TechMax Publications**

Course Outcomes:

At the end of this course students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand various types of Signal and Systems and its basic operations	15%
CO-2	Implement various time domain operations on Signals and observe the effects	20%
CO-3	Perform the Z domain transformation for time domain representation	20%
CO-4	Study various types of frequency domain transformation techniques and its significance	25%
CO-5	Understand various IIR and FIR systems structure and its implementation	20%

Suggested List of Experiments:

1. To generate common periodic and aperiodic waveforms.
2. To perform convolution of various signals
3. To implement correlation and linear filtering of sequences.
4. To analyze and plot the impulse response of a discrete time system.
5. To analyze and plot step response of discrete time system.
6. To plot the frequency response of a discrete time system.
7. To calculate homogeneous and particular solutions of the LCCDE system.
8. To compute Z Transform of various time domain system
9. To compute Inverse Z Transform of given sequence or system
10. To compute the DFT of the sequence and plot the magnitude and phase response.
11. To compute the IDFT of the sequence and plot the magnitude and phase response.
12. To compute the DIT-FFT of the given sequence and plot the magnitude and phase response
13. To compute the DIF-FFT of the given sequence and plot the magnitude and phase response

Case Study: Take Biological Signal(s) (from database or recorded) with noise in it, perform following operations on it and justify need of each

a. Convolution
b. Correlation/Autocorrelation
c. DFT
d. Power Spectral Density
e. Frequency Spectra

List of Suggested Tutorials:

1. Examples related to signal operations
2. Examples related to determination of types of systems
3. Examples related to Convolution
4. Examples related to Correlation
5. Examples related to Z Transform and Inverse Z Transform
6. Examples related to Discrete Fourier Transform & Inverse Discrete Fourier Transform
7. Examples related to DIT – FFT and DIF – FFT
8. Examples related to Structure of Digital Filters

List of Open Source Software/learning website:

https://nptel.ac.in/courses/108/106/108106163/

https://nptel.ac.in/courses/117101055/