GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Biomedical Engineering
Subject Code: BE03000011
Subject Name: Biomedical Signals and Systems

w. e. f. Academic Year:	2024-2025
Semester:	3
Category of the Course:	Basic Science Course

Prerequisite:	Inclination to learn mathematics, basic knowledge of differential equations and difference equations.
Rationale:	The course will provide strong foundation on signals and systems which will be useful for creating the foundation of signal processing. The students will learn basic continuous time and discrete time signals and systems. Students will understand the application of various transforms for analysis of signals and systems both continuous time and discrete time.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand various types of signals, classify them and represent the signals with various forms and basics of biomedical signals	R, U, A
02	Understand about various types of systems, classify them, representation and response of the system.	R, U, A
03	Understand various methods of Convolution and Correlation of the signals.	R, U, A
04	Understand the concepts of Z-transform and its properties.	R, U, A, N, E
05	Understand the concepts of Discrete Fourier Transform and its properties.	R, U, A, N, E

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Definition of Signal, Classification of Signals, Characteristics of Continuous and Discrete Time signals, Representation of Discrete Time Signal (DTS), Standard Test Signals, Mathematical Operations on DTS, Sampling, Aliasing and Quantization, Nature & Examples of Biomedical signals, Various Noises in Biomedical Signals	8	15
2	Definition of System, Classification of Systems- Static & Dynamic, Time Invariant & Variant, Linear & Nonlinear, Causal & Non-causal, Stable & Unstable, FIR & IIR System, Recursive & Non-recursive System, Discrete Time System, Representation of Discrete Time System, Response of LTI (Linear Time Invariant) Discrete Time system in Time Domain	8	20
3	Discrete Convolution, Representation of DTS as summation of Impulse, Response of LTI Discrete Time System Using Discrete Convolution, Properties of Discrete Convolution, Methods of performing Discrete Convolution – mathematical, graphical, tabular, matrix, Correlation, Cross Correlation, Auto Correlation, Circular Convolution and Correlation **Case Study**: Convolution of 1D and 2D signals of Biomedical origin, Correlation of signals of Biomedical origin	10	25
4	Definition of Z-transform, Representation of Poles and Zeroes in Z-plane, Inverse Z- transform, Convergence of Z-transform, Properties of Z-transform, Poles and Zeros of Rational Function of Z and Examples of z-Transform	10	20
5	Fourier Series of DTS, Properties of Discrete Time Fourier Series (DTFS), Fourier Transform of DTS, Definition of DTFT, Frequency Spectrum of DTS, Inverse DTFT, Properties of DTFT and Examples of DTFT, case study on frequency spectrum of Biomedical signals	9	20
Total		**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	**25**	**20**	**25**	**5**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Digital Signal Processing by A. Nagoor Kani, Mc Graw Hill Education, 2nd Edition
2. Digital Signal Processing by N. G. Palan, Tech-Max Publication, 2013 Edition
3. Rangayyan, Rangaraj M.. Biomedical Signal Analysis. Germany, Wiley, 2015.
4. Signals and Systems by Alan V. Oppenheim, Alan S. Wilsky and Nawab, Prentice Hall
5. Signals and Systems by K. Gopalan, Cengage Learning (India Edition)
6. Signals and Systems by Michal J. Roberts and Govind Sharma, Tata Mc-Graw Hill Publications
7. Signals and Systems by Simon Haykin and Bary Van Veen, Wiley- India Publications
8. Linear Systems and Signals by B.P.Lathi, Oxford University Press
9. Signal, Systems and Transforms by Charles L. Philips, J. M. Parr and E. A. Riskin, Pearson Education
10. Digital Signal Processing Fundamentals and Applications by Li Tan, Elsevier, Academic Press
11. Signal and Systems By Anand Kumar, 3rd Edition, PHI
12. Najarian, Kayvan, and Splinter, Robert. Biomedical Signal and Image Processing. United States, CRC Press, 2016.

(b) Open source software and website:

1. NPTEL Learning website: https://nptel.ac.in/courses/108105101Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, Cengage India Publication
1. Raj Kamal, “Internet of Things: Architecture and Design Principles, Mc Graw Hill Education
2. Hanes et al “IoT Fundamentals”, Cisco Press
3. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, , Paperback, 2015.
4. A. McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
5. Yashwant Kanetkar, “21 Internet of Things Experiments”, Kindle edition
6. Adeel Javed, “Building Arduino projects for Internet of Things”, Apress publication
7. Donald Noris, “The Internet of Things: Do it yourself Projects with Arduino, Raspberry PI and BeagleBone Black” Mc Graw Hill Publication
8. Adrian McEwen & Hakim Cassimally, “Designing the Internet of things”, Willey publication
9. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, Cengage India Publication
10. Raj Kamal, “Internet of Things: Architecture and Design Principles, Mc Graw Hill Education
11. Hanes et al “IoT Fundamentals”, Cisco Press
12. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”, , Paperback, 2015.
13. A. McEwen, H. Cassimally, “Designing the Internet of Things”, Wiley, 2013.
14. Yashwant Kanetkar, “21 Internet of Things Experiments”, Kindle edition
15. Adeel Javed, “Building Arduino projects for Internet of Things”, Apress publication
16. Donald Noris, “The Internet of Things: Do it yourself Projects with Arduino, Raspberry PI and BeagleBone Black” Mc Graw Hill Publication

17. Adrian McEwen & Hakim Cassimally, "Designing the Internet of things", Willey publication
18. Rahul Dubey, "An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications", Cengage India Publication

Suggested Course Practical List:

1. To study and plot basic discrete time such as unit impulse, step, ramp, real and complex exponential and their representation using MATLAB.
2. To study and plot various operations on discrete time signals such as Addition, Multiplication, Scaling, Folding and shifting using MATLAB.
3. To study the discretization using different sampling rate and observing aliasing effect.
4. To study and observe the effects of lower sampling rate and higher sampling rate on Continuous Time signal.
5. To study and perform convolution of LTI system using two methods: (1) convolution sum method, (2) Circular convolution in MATLAB.
6. To study and perform auto correlation and cross correlation of LTI system using MATLAB.
7. To study and perform auto correlation and cross correlation of biomedical signal using MATLAB.
8. To study and perform z-transform and inverse z-transform of given sequence or system using MATLAB.
9. Write a MATLAB program to find poles and zeros of given discrete system.

List of Laboratory/Learning Resources Required:

1. MATLAB/SCILAB

Suggested Activities/ Project for Students:

- Poster presentation/power point presentation on application of various transforms on signals/biomedical signals.
- MOOC course on Biomedical Signal Processing
- Assignments/Mini project on Biomedical Signal Processing
- Simulations of signals for particular operations

- **List of suggested activities for Problem Based Learning:**

Sr. No.	Name of the activity	No. of hours per activity	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video	Duration of video = 5h	Report /presentation based on the

	based learning related to the subject	Report preparation = 5h Total = 10h	video learning outcomes.
3.	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding-based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
8	Discussion on research paper based on relevant subject	5 research paper = 20 h	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.

13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 h	Depending on the complexity of the Application/Software
15	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
16	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. All the suggested activity should be related to the subject.
2. Subject coordinator shall identify activities from above list as per the subject needs, they also declare list of activities wise hours, evaluation scheme and rubrics to students at the start of semester.
3. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
4. All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
5. Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

* * * * * * *