GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Technology (Mechatronics)
Level: UG
Branch: Mechatronics
Subject Code: BE05020041
Subject Name: Mechatronics Signal Processing

w.e.f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	Nil
Rationale:	The course is designed to provide fundamental and advanced knowledge of signal processing techniques used in modern mechatronic, communication, automation, biomedical, and intelligent control systems. The course introduces concepts of discrete-time signals and systems, frequency domain analysis, digital filter design, adaptive filtering, multirate signal processing, and DSP processor architectures for real-time engineering applications. Signal processing plays a crucial role in industrial automation, robotics, smart sensing, predictive maintenance, communication systems, medical instrumentation, renewable energy systems, autonomous vehicles, and intelligent monitoring systems. This course helps students develop analytical, computational, and programming skills necessary for designing and implementing efficient digital signal processing solutions for real-world engineering problems.

Course Objectives: This course provides an understanding of the fundamental concept of Signal and System with its properties and operations. It is also aimed to develop better insight among the students regarding Frequency domain approach with its application along with digital filter design. Further it explores the domain of multi-rate and adaptive signal processing with architecture of DSP processors and applications.

Course Outcomes:

Sr.No.	COstatement	Marks% weightage
CO-1	Understand the basic signal processing concepts and their applications.	**25**
CO-2	Understand the digital system design.	**25**
CO-3	Analyse signals and systems in time and frequency domain.	**25**
CO-4	Design and simulate digital filters and their applications.	**25**

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Content:

Sr.No.	Content	Total Hrs
1	**Introduction to Signal Processing:** Signals, Systems and Signal Processing, classification of signals, Elements of analog/digital signal processing system, concept of frequency in continuous and discrete time signals, Periodic Sampling, Frequency domain representation of sampling, Reconstructions of band limited signals from its samples, Signal processing for mechatronics.	**06**
2	**Discrete Time Signals and Systems:** Discrete Time Signals – representation, classification, mathematical operations; Discrete Time Systems – representation, classification, convolution, correlation.	**06**
3	**Frequency Domain Analysis:** Discrete Time Fourier Series – representation, properties; Discrete Time Fourier Transform - representation, properties; Z-Transforms - representation, properties, Inverse z-Transform, Pole-Zero Plot, Discrete Fourier Transform and Fast Fourier Transform - representation, properties, Applications, and examples.	**11**
4	**Digital Filter Design Techniques:** Introduction, Classification of filters – LPF, HPF, BPF, BSF; Types of filters – Butterworth, Chebyshev, Elliptic, Bessel; FIR and IIR filters – basic structure and design techniques.	**11**
5	**Advance DSP Techniques:** Multi-rate Signal Processing: Decimation, Interpolation, Applications. Adaptive filters: Introduction, Principles of Forward Linear Predictive filter and applications.	**6**
6	**DSP Processors & Applications:** Harward architecture, pipelining, Multiplier-accumulator (MAC) hardware, architectures of fixed and floating point (various Texas processors such as TMS320C6713, TMS320C6416) DSP processors. Applications.	**5**
	TOTAL	**45**

Suggested Specification table with Marks(Theory):(ForB.E.only)

Distribution ofTheory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
15%	40%	10%	15%	10%	10%

R:Remembrance;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create and above Levels (Revised Bloom's Taxonomy)

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

The syllabus of: Mechatronics Signal Processing directly contributes to

SDG 3	Good health and well being through biomedical signal processing applications such as ECG, EEG, patient monitoring, and medical diagnostic systems.
SDG 4	By enhancing computational thinking, simulation skills, and interdisciplinary engineering knowledge in DSP and intelligent systems.
SDG 7	Affordable and clean energy through signal analysis and monitoring techniques used in smart grids, renewable energy systems, and power quality assessment.
SDG 8	Decent work and Economic growth by preparing students for careers in automation, embedded systems, communication, AI-based systems, and industrial signal analysis..
SDG9	Industry Innovation and Infrastructure through development of intelligent automation systems, real-time digital controllers, sensor data processing, and smart industrial infrastructure..
SDG11	Sustainable cities by supporting smart transportation, intelligent surveillance, noise monitoring, and smart city communication systems.
SDG12	Responsible consumption through predictive maintenance, fault diagnosis, efficient signal monitoring, and optimized industrial operations.
SDG13	Climate action through environmental signal monitoring, weather data analysis, seismic signal analysis, and climate-related sensing applications.

Reference Books:

1	J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson, 4th edition, 2007.
2	A. V. Oppenheim and R. W. Shafer, Discrete-Time Signal Processing; Pearson, 3rd edition, 2010.
3	A. Nagoor Kani, Digital Signal processing, Mc Graw Hill Publication, 2nd edition, 2012.
4	S. K. Mitra, Digital Signal Processing: A Computer-Based Approach, Tata McGraw Hill, 4th edition, 2013.
5	Ifeachor and Jervis, Digital Signal Processing: A Practical Approach, Pearson Education, 2nd edition, 2001.

List of Experiments:

1	Introduction to MATLAB/SCILAB/Python: Signal Processing Toolbox, Simulink
2	To study Discrete-Time Signals &Operation on Signals using MATLAB
3	To study Linear Convolution of Discrete-Time Signals
4	To study System Responses
5	To study Z-Transform and inverse-Z-Transform
6	To study Up-sampling and Down-sampling
7	To study Discrete Fourier Transform (DFT) & Inverse DFT
8	Design FIR filter using windowing method
9	Design Digital filter: IIR Butterworth filter
10	DSP Processor study (Using DSP Kit)
11	To study the various DSP Applications

Major Equipment:

Nil

List of Open Source Software

Nil

List of learning website:

1	NPTEL and CourseraVideo lectures.
2	MIT courseware material.
3	Research papers from reputed Journals (IEEE, Elsevier, Springer etc.).

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits
- Course Projects

Listofsuggested activities for Problem-based Learning (PBL):

Sr. No.	PBL category	Name of the activity	No. of hours	Evaluation Criteria
1.	Complex Problem-Solving targeting relevant SDGs / Mini	Mini Project	15h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, report

	Project			quality and presentation
2.	Case Study Analysis / Seminar	Seminar	15h (need to be changed as per total PBL hours)	Based on the quality of report and presentation, technical understanding
3.	Micro project	Micro project	8h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, quality of report and demonstration
4.	Industry/Research laboratory visit	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.
5.	Video Based Learning	Technical video-based learning related to the subject	Duration of video =5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
6.	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 4 h each Total = 20h	Based on the correctness of submitted assignment
7.	Group Discussion / Quiz / Simulation	Problem solving/Coding using C, C++,MATLAB, Python, SCILAB,modeling and Analysis software or any other software	5 small coding-based assignment of 2h each Total = 10h	Based on the coding solution submitted.
8.	Video Based Learning	Self-learning online course	Minimum duration of the course should be 10h	Examination based assessment at the end of course. Based on the certificate produced.
9.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total =10h	Based on the depth of the solution submitted.
10.	Video Based Learning	Videos on Industrial	Duration of video = 5h Report preparation = 5h	Based on quiz/report submitted

		safety/Disaster Management aspects based on subject	Total = 10h	
11.	Research Paper Review / Analysis	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20h	Summarize research paper and evaluation critical parameters
12.	Poster/Chart/PowerPoint presentation	Poster/chart/power point preparation on technical topics	Duration = 6h	Based on poster/chart preparation and presentation skills
13.	Industry/Research laboratory visit	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15h for industrial exposure Problem identification and tentative solution = 10h Total = 20h	Based on evaluation of critical problems and solutions
14.	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1h – 3hper topic	Based on performance in group discussion, technical depth, knowledge etc.
15.	Case Study Analysis / Seminar	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.
16.	Group Discussion / Quiz / Simulation	Application/Software development	Duration = 10h	Depending on the complexity of the Application/Software
17.	Assignment / Technical Writing / Research Writing	Research paper publication	Duration = 10h	Based on submission of proof of publication
18.	Micro project	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10h	Based on the performance of the equipment
19.	Industry/Research laboratory visit	Expert lecture/session	Duration 3h For attending the lecture/session– 2h and for report writing 1h	Based on the proof of attendance and report submitted

20.	Video Based Learning	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
21.	Assignment / Technical Writing / Research Writing	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
22.	Assignment / Technical Writing / Research Writing	Preparation of a report on Indian Standard(s)	10h (study of Indian Standard(s) + report	Based on report quality and understanding of the relevant Indian Standard(s).

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Quality and Reliability Engineering compulsorily incorporates Micro Project and 5 marks as PBL activities for PEC and Seminar and Mini Project for PCC.**
   These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activity should be related to the subject.
4. 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.
5. Rubrics for the evaluation can be prepared by the faculty.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

****