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MAHARAJA INSTITUTE OF TECHNOLOGY MYSORE

Autonomous Institution Affiliated to VTU

Competency Based Syllabus (CBS)

for

Electronics and Communication Engineering

(Under Outcome Based Education (OBE) and

Choice-Based Credit System (CBCS))

Offered from 1st to 4th Semesters of Study

in

Partial Fulfillment for the Award of Masters of Technology in

Signal Processing

2023 Scheme

Scheme Effective from the academic year 2023-24

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1st Semester	Basic Science Course (BS) ADVANCED ENGINEERING MATHEMATICS	M23MSP101

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Linear Algebra - I	Strong knowledge of linear combinations, vector spaces, lines, planes, matrices of linear equations and some mappings are required to perform the linear transformations. It includes vectors, matrices and linear functions. It is the study of linear sets of equations and its transformation properties. Familiarity with fundamental knowledge of algebra course.
2	Linear Algebra – II	Knowledge regarding the diagonalization of the matrices, system of linear equations to find the Eigen values and the corresponding Eigen vectors. Eigen values and the Eigen vectors are the special set of scalar values that is associated with the set of linear equations most probably in the matrix equations. Basic knowledge of orthogonality needed to solve Gram-Schmidt Orthogonalization process.
3	Probability Theory	Knowledge of basic probability, fundamentals properties related to probability theory. Probability distribution of random variables with discrete and continuous random variables and also the joint distribution involving two random variables w.r.t discrete and continuous variables. Familiarity with identify the random variables
4	Random Process	Strong knowledge of basic probability distributions separation of variables to solve distribution problems.
5	Calculus of Variations	Knowledge of partial differential equations w.r.t to specific variables, identification of dependent and independent variables, initial and boundary value conditions should be known.
6	Previous Coursework	Completion of introductory courses in Mathematics or a related field.

2. Competencies

S/L	Competency	KSA Description
1	Linear Algebra	**Knowledge**: Understanding the concept of matrices, linear algebra, simultaneous system of linear equations, eigen values and eigen vectors, diagonalization and orthogonalization of the matrices. **Skills**: Arithmetic operations, elementary row operations, roots of equation. **Attitudes:** Apply the concept of linear algebra for the analysis of a structure in equilibrium involves writing down many equations in several unknowns. Structural Analysis, Balancing equations. Modeling and Analysis: Linear algebra empowers engineers to create mathematical models of complex systems. Electrical circuits, for instance, can be represented by systems of linear equations involving voltages, currents, and resistances.
2	Probability Theory	**Knowledge:** Understanding of concept of distribution related to probability **Skills:** Should be able to apply the necessary probability distribution. **Attitudes:** The concept of probability allows us to know numerous applications in ECE, including channel capacity estimation, signal processing, wireless communication, image and video compression, error control coding, network routing, and information theory.
3	Random Process	**Knowledge**: Identification of random process and classification **Skills**: Concept of probability distribution. **Attitudes:** Random processes are used in control systems to model the behavior of the system. Random process constitutes a fundamental component in the design analysis and optimization of communication s systems.
4	Calculus of Variations	**Knowledge**: Identification of differential equation, Factorization of equations, familiar with dependent and independent variables. **Skills:** Concept of finding real and complex roots using various methods. **Attitudes:** Calculus of variations is a form of calculus that deals with maximizing or minimizing functional values. Euler's formula, in engineering, is generally used for the analysis of complex numbers and waveforms

3. Syllabus

ADVANCED ENGINEERING MATHEMATICS SEMESTER-I			
Course Code	**M23MSP101**	CIE Marks	**50**
Teaching Hours/Week(L:P:SDA)	**3:0:0**	SEE Marks	**50**
Total Hours of Pedagogy	**40**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**
Teaching-LearningProcess:Chalkandtalkmethod/PowerPointPresentation			
Module-1 Linear Algebra-1			
Introduction to vector spaces and subspace, illustrative examples on vector space over a field of real numbers. Linear independent and dependent vectors- Basis and four fundamental subspace of matrices - examples. Linear transformations, geometry of linear transformations, matrix of linear transformations and rank-nullity -theorem -illustrative examples.			
Module-2 Linear Algebra-2			
Computation of Eigen values and Eigen vectors, Eigen values and vectors of real symmetric Matrices Givens method. Orthogonal vectors and orthogonal basis- Gram-Schmidt Orthogonalization process. Matrix decomposition- diagonalization, orthogonal diagonalization, quadratic forms and SVD.			
Module-3 Probability Theory			
Introduction, Random variables and probability distributions, Probability mass and density functions, expectations operators, illustrative examples. Moments, central moments, characteristic functions, probability generating functions, Poisson, Gaussian and Erlang distributions, pair of random variables, Joint probability distributions of discrete random and continuous random variables.			
Module-4 Random Process			
Introduction, classification of random process, stationary, WSS and ergodic random process. Auto-correlation functions and its properties. Gaussian random process. Engineering applications of random process.			
Module-5 Calculus of Variations			
Concept of functional- Euler's equation. Functional dependent on first and higher order derivatives, Functional on several dependent variables. Isoperimetric problems-variation problems with moving boundaries.			

Text Book

1. A. Papoulis and S U Pillai, "Probability, Random variables and stochastic processes", McGraw Hill 2002
2. Roy D. Yates and David J. Goodman, Probability and Stochastic Processes: A friendly introduction for Electrical & Computer Engineers/

Reference books:

1.. MIT Open courseware, Introduction to Linear Algebra, Course 20.06
2. Nausing Deo, "Graph Theory with applications to Engineering and Computer Science", Prentice Hall of India, 1999.
3.'Differential Equations and Calculus of Variations', Elsgolts L, MIR Publications, 3rd Edition, 1977

MOOC / e-resources:
MIT Open courseware:
https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-041-probabilisticsystems-analysis-and-applied-probability-fall-2010/
NPTEL course by IIT Delhi and IIT Madras:
https://nptel.ac.in/courses/111/102/111102111/
https://nptel.ac.in/courses/111/106/111106112/
https://nptel.ac.in/courses/111/101/111101115/

4. Syllabus Timeline:

S/L	Syllabus Timeline	Description
1	Week 1-2: Linear Algebra - I	Introduction to vector spaces and subspace Illustrative examples on vector space over a field of real numbers. Linear independent and dependent vectors Basis and four fundamental subspace of matrices -examples. Linear transformations, geometry of linear transformations, Matrix of linear transformations Rank-nullity -theorem -illustrative examples.
2	Week 3-4: Linear Algebra - II	Computation of eigen values and Eigen vectors Eigen values and vectors of real symmetric Matrices Eigen values and vectors - Givens method. Orthogonal vectors and orthogonal basis - Gram-Schmidt Orthogonalization process. Matrix decomposition– Problems related Diagonalization– Problems related Orthogonal diagonalization– Problems related Quadratic forms and SVD – Problems related
3	Week 5-6: Probability Theory	Random variables and probability distributions Probability mass and density functions, expectations operators, illustrative examples. Moments, central moments, characteristic functions, probability generating functions, Poisson, Gaussian and Erlang distributions, pair of random variables, Joint probability distributions of discrete random and continuous random variables.
4	Week 7-8: Random Process	Classification of random process Stationary and WSS and ergodic random process. Auto-correlation functions and its properties Gaussian random process. Engineering applications of random process.
5	Week 9-10: Calculus of Variation	Concept of functional- Euler's equation. Functional dependent on first and higher order derivatives, Functional on several dependent variables Isoperimetric problems - variation problems with moving boundaries.
6	Week 11-12	Apply learned concepts and competencies to real-world scenarios. Hands-on practice.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce Competencies.
2	Video/Animation	Incorporate visual aids like videos/animation stoenhance Understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	PoseHOTSquestionstostimulatecriticalthinkingrelatedtoeachcompetency.
5	Problem-Based Learning(PBL)	Implement PBL to enhance analytical skills and practical application of Competencies
6	Multiple	Introduce to pics in various representation store in force competencies

6. Assessment Details (both CIE and SEE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10

(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Averageinternalassessmentsshallbetheaverageofthebesttwotestmarksfromthe2testsconducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selection gone full question from each module
4. Marks scored will be proportionally scaled down to 50marks

7. **Learning Objectives**

S/L	Learning Objectives	Description
1	Understanding polar curves and its Fundamentals	Students will learn the use of polar coordinates in solving various curves in different systems equation movement of flow of liquids and other fields of engineering.
2	Understanding Fundamentals of Series solution and partial derivatives	Students will become proficient in writing a series expansion of function of one variable and also know the concept of partial derivatives using standard techniques.
3	Proficiency in ODE and higher order ODE	Students will become proficient in calculating the roots of the equation of higher order by using various basic techniques.
4	Project-Based Learning	Through hands-on projects, students will apply their knowledge ofMake use of the Linear algebra to analyze structure in equilibrium involves writing down many equations in several unknowns.

8. **Course Outcomes (COs) and Mapping with POs/ PSOs**

Course Outcomes (COs)

COs	Description
M23MSP101.1	Demonstrate knowledge and understanding of the underlying concepts of random variables and stochastic processes
M23MSP101.2	Demonstrate knowledge of the mathematical concepts and computational aspects of linear algebra and calculus of variation
M23MSP101.3	Analyze domain-related engineering problems and develop analytical problem-solving approach making use of the theoretical concepts

COs	PO1	PO2	PO3
M23MSP101.1			3
M23MSP101.2			3
M23MSP101.3	1	2	3
M23MSP101	**1**	**2**	**3**

9. **Assessment Plan**

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	10			**10**
Module 2		10		**10**
Module 3			10	**10**
Module 4		10		**10**
Module 5			10	**10**
Total	10	20	20	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	**Total**
Module 1	**20**			**20**
Module 2		**20**		**20**
Module 3			**20**	**20**
Module 4		**20**		**20**
Module 5			**20**	
Total	**20**	**40**	**40**	**100**

Conditions for SEE Paper Setting:

Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

The "Advanced Engineering Mathematics "course in the first semester of the M. Tech program laysa strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of digital systems. Here are some notable contributions:

- **Linear Algebra:** Linear algebra is considered a basic concept in the modern presentation of geometry. It is mostly used in Physics and Engineering as it helps to define the basic objects such as planes, lines and rotations of the object. It allows us to model many natural phenomena, and also it has a computing efficiency. Systems of linear equations are used to determine the currents through various branches of electrical networks. Junction: All the current flowing into a junction must flow out of it. Path: The sum of the IR terms in any direction around a closed path is equal to the total voltage in the path in that direction.
- **Probability Theory:** Probability in ECE refers to the likelihood or chance of an event occurring in the field of electronics and communication. It is used to analyze and predict the behavior of electronic systems and communication networks, taking into account the uncertainty and randomness associated with various factors. Probability theory is the foundation for the reliability theory of technical systems and for many other applied scientific theories. The chapter presents several examples to provide an overview of probabilities of complex events. Like any phenomena, random phenomena are caused by quite definite reasons.
- **Random Process:** A random process is a collection of time functions or signals corresponding to various outcomes of a random experiment. The random process represents the mathematical model of these random signals. A random process (or stochastic process) is a collection of random variables (functions) indexed by time. Random processes, also known as stochastic processes, are widely used in electronic and communication engineering. These processes describe the behavior of random variables over time, which is an important consideration in many electronic and communication systems.
- **Calculus of Variations**: Calculus of variations is a form of calculus that deals with maximizing or minimizing functional values. This branch of mathematics finds immense application in several complex problems in fields such as civil, mechanical, electrical, and aerospace engineering. Calculus of variations helps to formulate geodesic problems on a plane and sphere. There are many laws of Physics which are written as variation principles. The Principle of Least action is equivalent to Newton Second Law of motion in a mechanical system.

1st Semester	Integrated Professional Course(IPC) ADVANCED DIGITAL SIGNAL PROCESSING	M23MSP102

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Calculus, Linear Algebra and Differential Equations.
2	Signals and Systems	Basics types of signals like analog and digital signals, periodic and aperiodic signals, basic operations of signals like addition, shifting and scaling.
3	DSP	Fourier Analysis and Z Transform
4	Filters	Analog and Digital filters.
5	MATLAB	Basics of MATLAB Programming.

2. Competencies

S/L	Competency	KSA Description
1.	DFT and Z transform.	**Knowledge:** The discrete-time Fourier transform provides insight into the frequency composition of discrete signals, enabling analysis and manipulation in the spectral domain for tasks such as filtering, modulation, and signal characterization. The Z-transform provides knowledge about representing discrete-time signals and systems in the complex frequency domain, facilitating analysis, design, and implementation of digital signal processing algorithms and systems. **Skills:** Studying the discrete-time Fourier transform develops skills in interpreting signal spectra, identifying frequency components, and applying frequency-domain techniques for signal processing and system analysis in digital domains. Studying the Z-transform enhances skills in analyzing discrete-time signals and systems in the complex frequency domain, enabling efficient representation, manipulation, and analysis of discrete-time systems. **Attitudes:** Studying the discrete-time Fourier transform cultivates skills in analyzing signals' frequency content, identifying dominant spectral components, and applying frequency-domain techniques for various signal processing applications in digital systems. Studying the Z-transform fosters an appreciation for the versatility of complex frequency-domain analysis in digital signal processing, encouraging a systematic approach to understanding and solving discrete-time system problems.
2.	Linear prediction and Optimum Linear Filters	**Knowledge:** Studying Linear Prediction and Optimum Linear Filters equips students to analyze signals. They learn how to predict future signal values and remove unwanted noise using filters designed to minimize error. This knowledge translates to practical skills in areas like speech coding, noise cancellation, and signal filtering for various engineering applications. **Skills:** Linear prediction and filters teach students to analyze signals, predict future values, and design filters to remove noise. This translates to signal processing skills for tasks like noise cancellation and filtering information in engineering. **Attitudes:** After tackling Linear Prediction and Filters, students gain a "signal detective" attitude. They see the world as full of hidden information and develop the tools to extract it and predict what's next.
3.	Adaptive filters	**Knowledge:** Adaptive Filters empower students with knowledge of "learning filters." They understand how filters can analyze noise patterns and adjust themselves to constantly improve signal extraction, making them experts in handling non-stationary signals. **Skills:** Studying adaptive filters equips students to design "smart filters." These filters can adjust automatically to cancel noise and extract signals that change over time, making them masters of dynamic environments.

		Attitudes: Adaptive Filters turn students into "signal ninjas!" They can now tackle unpredictable environments, adjusting their methods on the fly to extract the clearest signal from ever-changing noise
4.	Power Spectral Estimation	**Knowledge:** Power spectral estimation equips students to see the world through "frequency glasses." They learn to analyze signals not just in time, but also in terms of their hidden frequency content, gaining a deeper understanding of a signal's composition and behavior. **Skills:** Power spectral estimation equips students as "spectral spies." They develop the skills to crack the code of hidden frequencies within a signal. By analyzing patterns, they can map out a signal's energy distribution, uncovering its secret composition. **Attitudes:** After power spectral estimation, students become "signal detectives of the unseen." They can't directly observe hidden frequencies, but by analyzing patterns, they unlock the secrets of a signal's energy distribution, revealing its hidden composition.
5.	Wavelet Transform	**Knowledge:** Wavelet transformation equips students to see signals like a "time-frequency microscope." They can zoom in on specific parts of a signal, analyzing both its high-frequency details and low-frequency trends simultaneously, leading to a deeper understanding of complex data. **Skills:** After mastering wavelet transformation, students become "signal surgeons." They can dissect signals into time and frequency components, removing unwanted noise and isolating specific features with pinpoint accuracy, leading to better data analysis and manipulation. **Attitudes:** Wavelet transformation cultivates a "data detective" mentality in students. They see hidden patterns within complex signals, analyzing them like a fingerprint, with the ability to zoom in on specific details while still understanding the bigger picture.

3. Syllabus

ADVANCED DIGITAL SIGNAL PROCESSING **SEMESTER – I**			
Course Code	**M23MSP102**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**3:2:0**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory + 10-12 Lab slots**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course objectives: This course will enable students to:
Understand Multirate digital signal processing principles and its applications.
Estimate the various spectral components present in the received signal using different spectral estimation methods such as Parametric and Nonparametric.
Design and implement an optimum adaptive filter using LMS and RLS algorithms.
Understand the concepts and mathematical representations of Wavelet transforms

Module -1

Review of transforms, Z-Transform, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Short Time Fourier Transform (STFT).

Module -2

Linear prediction and Optimum Linear Filters: Random signals, Correlation Functions and Power Spectra, Innovations Representation of a Stationary Random Process. Forward and Backward Linear Prediction. Solution of the Normal Equations. The Levinson-Durbin Algorithm. Properties of the Linear Prediction-Error Filters.

Module -3

Adaptive filters: Applications of Adaptive Filters-Adaptive Channel Equalization, Adaptive noise cancellation, Linear Predictive coding of Speech Signals, Adaptive direct form FIR filters-The LMS algorithm, Properties of LMS algorithm. Adaptive direct form filters- RLS algorithm.

Module -4

Power Spectrum Estimation: Non parametric Methods for Power Spectrum Estimation - Bartlett Method, Welch Method, Blackman and Tukey Methods. Parametric Methods for Power Spectrum Estimation: Relationship between the auto correlation and the model parameters, Yule and Walker methods for the AR Model Parameters, Burg Method for the AR Model parameters, Unconstrained least-squares method for the AR Model parameters, Sequential estimation methods for the AR Model parameters, ARMA Model for Power Spectrum Estimation.

Module -5

Wavelet Transforms: Wavelet Transform, Haar Wavelet and Multiresolution Analysis,Daubechies Wavelets, Standard Wavelets and Applications of Wavelet Transform.

PRACTICAL COMPONENT OF IPCC

1. Write a program in Matlab implement the Levinson – Durbin algorithm of prediction.
2. Write a program in Matlab to implement LMS adaptive filter.
3. Write a program in Matlab to implement RLS filter
4. Write a program in Matlab to compute the power spectrum estimation using Bartlett method,Welch method, Blackman and Tukey method.
5. Write a program in Matlab to estimate AR model parameters.
6. Write a program in Matlab to estimate ARMA model parameters
7. Write a program in Matlab to compress the signal using the DWT.
8. Write a program in Matlab to estimate the signal from corrupted signal, also compute the SNR

Demonstration Experiments (For CIE)

1. Design a simulink using Matlab to implement LMS and RLS filter.
2. Design a simulink using Matlab to implement power spectrum estimation.

Text Books:

1. 'Digital Signal Processing, Principles, Algorithms and Applications', John G. Proakis, Dimitris G.Manolakis, Pearson, Fourth edition, 2007
2. 'Insight into Wavelets- from Theory to Practice', K P Soman, Ramachandran, Resmi, PHI, Third Edition, 2010

Reference Books:

3. Digital Signal Processing,2nd Edition Dr.ShailaD.Apte

Web links and Video Lectures (e-Resources):

https://www.mooc.org/ https://onlinecourses.nptel.ac.in/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Mini project in the area of digital signal processing using modern tools like MATLAB, Python, scilab

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Simple Transforms.	Teach transformation techniques by emphasizing visual aids like diagrams and animations. Begin with basi concepts, demonstrating translations, rotations, and reflections with concrete examples. Encourage hands-on practice through interactive exercises. Reinforce understanding with real-world applications, fostering curiosity and problem-solving skills to enhance comprehension and retention.
2	Week 3-4: Linear prediction and Optimum Linear Filters	Teach linear filters by illustrating their purpose in signal processing and image enhancement. Begin with simple examples, explaining concepts like convolution and frequency domain representation. Engage students with interactive demonstrations and practical exercises. Emphasize real-world applications to demonstrate their relevance in fields like image processing, audio filtering, and data analysis.
3	Week 5-6: Adaptive filters:	Teach adaptive filters by first elucidating their role in dynamically adjusting to changing input environments. Start with fundamental concepts like least mean squares algorithm and recursive least squares method. Utilize simulations and real-world scenarios to demonstrate applications in noise cancellation, echo reduction, and equalization. Encourage experimentation and problem-solving for deeper understanding.
4	Week 7-8: Power Spectrum Estimation:	Introduce power spectrum estimation by elucidating its significance in analyzing signals' frequency content. Start with basics like periodograms and Fourier analysis. Use interactive tools and simulations to demonstrate windowing techniques and trade-offs. Encourage hands-on experimentation with real-world signals to reinforce understanding of spectral analysis principles and applications.

5	Week 9-10: Wavelet Transforms	Teach wavelet transforms by first explaining their role in analyzing signals at different resolutions. Begin with wavelet basics, illustrating the concept of scaling and shifting. Employ visual aids and interactive examples to demonstrate wavelet decomposition and reconstruction. Encourage exploration of various wavelet families and applications in signal processing, compression, and denoising.
6	Week 11-12: IPCC	Teach advanced digital signal processing in MATLAB by integrating theory with practical implementation. Start with fundamental DSP concepts, then transition to MATLAB coding for filtering, spectral analysis, and modulation techniques. Utilize hands-on exercises with real-world datasets, encouraging experimentation and problem-solving to reinforce understanding of complex DSP algorithms and their MATLAB implementation.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of signal processing and communication concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)
Core CIE Split up for Integrated Professional Course (IPC)

Components		Number	Weightage	Max. Marks	Min. Marks
Theory(A)	Internal Assessment-Tests(A)	2	60%	15	06
	Assignments/Quiz/Activity(B)	2	40%	10	04
		Total Marks	100%	25	10
Components		Number	Weightage	Max. Marks	Min. Marks
Laboratory(B)	Record Writing	Continuous	60%	15	06
	Test at the end of the semester	1	40%	10	04
		Total Marks	100%	25	10

Final CIE Marks = (A) + (B) CIE Assessment

SEE for IPCC

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. The question paper may include at least one question from the laboratory component.
5. Marks scored will be proportionally scaled down to 50marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Proficiency in simple Transforms.	Students will be able to understand the basics of signals transformation techniques.
2	Proficiency Adaptive Filters	Students will learn to analyze use of adaptive filters in different applications.
3	Proficiency in Wavelet Transforms.	Students will develop proficient skills for accurate transformation analysis and processing of digital signals using wavelet transforms.
4	Project-Based Learning	Through hands-on projects, Students will be able to tackle real-world problems by applying theory to design solutions and fostering critical thinking, collaboration, and practical skills in engineering and communication technologies.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP102.1	Able to understand and **analyze** the linear prediction and optimum linear filters
M23MSP102.2	Able to understand and **analyze** LMS and RLS adaptive filter algorithms
M23MSP102.3	Able to **analyze** and **implement** the parametric and non-parametric methods of power spectrum estimation

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP102.1	2	2	3	3	3
M23MSP102.2	2	2	3	3	3
M23MSP102.3	3	3	3	3	3
M23MSP102	**2.33**	**2.33**	**3**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	10			**10**
Module 2		10		**10**
Module 3			10	**10**
Module 4		10		**10**
Module 5			10	**10**
Total	10	10	10	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	20			**20**
Module 2		20		**20**
Module 3			20	**20**
Module 4		20		**20**
Module 5			20	**20**
Total	**20**	**40**	**40**	**100**

10. Future with this Subject

- **Digital Signal Processing (DSP):** Signals and systems concepts form the foundation for understanding DSP algorithms and techniques
- **Communication Systems:** Knowledge of signals and systems is essential for analyzing and designing communication systems, including modulation, demodulation, and channel coding
- **Control Systems**: Understanding signal processing and system dynamics is crucial for analyzing and designing control systems for various applications
- **Image Processing**: Signals and systems principles are fundamental to image processing techniques such as filtering, compression, and enhancement
- **Biomedical Engineering**: Signal processing techniques are essential for analyzing physiological signals in biomedical applications like medical imaging and biosignal analysis

Project Work and Research: Signals and systems provide foundational knowledge and analytical tools essential for project work and research across various domains. They enable precise analysis and design of systems, facilitating tasks such as signal processing, control systems, and communications. Mastery of these concepts allows for the development and implementation of efficient algorithms and models. They support interdisciplinary applications, enhancing projects in fields like biomedical engineering, robotics, and telecommunications. Overall, they equip researchers with the skills to tackle complex problems and innovate in technology-driven areas.

1st Semester	Professional Course (PC) PATTERN RECOGNITION AND MACHINE LEARNING	M23MSP103

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Strong foundation in linear algebra, calculus, probability theory, and statistics is essential.
2	Programming	Proficiency in programming languages commonly used in machine learning such as Python, R, or Julia.
3	Data Structures and Algorithms	Understanding of fundamental data structures and algorithms is crucial for efficient implementation of machine learning algorithms.

2. Competencies

S/L	Competency	KSA Description
1.	Introduction, concept Learning	**Knowledge:** Understanding of techniques for data cleaning, feature scaling, and feature engineering. **Skills:** Ability in analyzing and developing learning algorithms. **Attitudes:** Appreciation for the importance of Understanding basic techniques for data cleaning, feature scaling, and feature engineering.
2.	Supervised Learning	**Knowledge:** Understanding how these supervised algorithms works and performance evaluation using the metrics. **Skills:** Analyzing the data preparation, model implementation, cross-validation, model interpretation and ensemble method. **Attitudes:** Appreciation being meticulous in data preprocessing, model training, and evaluation to ensure accuracy and reliability.
3.	Learning Models	**Knowledge:** Understanding how these supervised algorithms works and performance evaluation using the metrics. **Skills:** Analyzing the data preparation, model implementation, cross-validation, model interpretation and ensemble method. **Attitudes:** Appreciation being meticulous in data preprocessing, model training, and evaluation to ensure accuracy and reliability.
4.	Deep Learning	**Knowledge:** Deep learning deals with neural network architecture, optimization algorithms and unsupervised algorithms. **Skills:** Development of unsupervised algorithms and optimization of algorithms. **Attitudes:** Appreciation for the role of unsupervised algorithms in learning model.
5.	Application, Special Topic	**Knowledge:** Understanding concept of ML and DL in Computer Vision. **Skills:** Development of supervised and unsupervised learning algorithms. **Attitudes:** Appreciation for the role of supervised and unsupervised learning algorithms.

3. Syllabus

PATTERN RECOGNITION AND MACHINE LEARNING SEMESTER – I			
Course Code	**M23MSP103**	CIE Marks	**50**

Number of Lecture Hours/Week(L: T: P: S)	**3:0:2**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course objectives: This course will enable students to:
To understand the basic theory underlying machine learning.
To be able to formulate machine learning problems corresponding to different applications.
To understand a range of machine learning algorithms along with their strengths and weaknesses.
To be able to apply machine learning algorithms to solve problems of moderate complexity.
To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

Module -1	
Introduction, concept Learning: Well posed learning problems, Designing a Learning system Perspective and Issues in Machine Learning. **Concept Learning**: Concept learning task, Concept learning as search,Find-S algorithm, Version space, Candidate Elimination algorithm, Inductive Bias	L1, L2
Module -2	
Supervised Learning: Linear Regression (Gradient Descent, Normal Equations), Weighted Linear Regression (LWR), Logistic Regression, Perceptron, Newton's Method, KL-divergence, (cross-) Entropy.	L1, L2, L3
Module -3	
Natural Gradient, Exponential Family and Generalized Linear Models, Generative Models (Gaussian Discriminant Analysis, Naive Bayes), Kernel Method (SVM, Gaussian Processes), Tree Ensembles (Decision trees, Random Forests, Boosting and Gradient Boosting), Learning Theory, Regularization, Bias-Variance Decomposition and Tradeoff, Concentration Inequalities, Generalization and Uniform Convergence, VC-dimension.	L1, L2, L3
Module -4	
Deep Learning: Neural Networks, Back propagation, Deep Architectures, Unsupervised Learning, K-means, Gaussian Mixture Model (GMM), Expectation Maximization (EM), Variational Auto-encoder (VAE), Factor Analysis, Principal Components Analysis (PCA), Independent Components Analysis (ICA), Reinforcement Learning (RL) : Markov Decision Processes (MDP), Bellmans Equations, Value Iteration and Policy Iteration, Value Function Approximation, Q-Learning.	L1, L2,
Module -5	
Application: Advice on structuring an ML project, Evaluation Metrics, Missing data techniques and tracking, Special Topic: Computer Vision. Special Topic: NLP **Special topic:** Machine listening and Music Information Retrieval, Special Topic: Speech, Special Topic: Compressive Sensing, Special topics: Array processing, beam forming, independent component analysis, MIMO/SIMO models, under constrained separation, spectral factorizations.	L1, L2,

Text Books:
1. “Pattern Recognition and Machine Learning”, C.M. Bishop, 2nd Edition, Springer, 2011.
2. Probabilistic machine learning by Kevin P Murphy

Reference Books:
1. Pattern recognition by Duda and Hart
2. Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics, Max A. Little
3. Deep Learning By Ian Goodfellow, Yoshua Bengio, Aaron Courville Online book, 2017

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction, concept Learning	Well posed learning problems, Designing a Learning System Perspective and Issues in Machine Learning. Concept learning task, Concept learning as search, Find-S algorithm, Version space, Candidate Elimination algorithm, Inductive Bias.
2	Week 3-4: Supervised Learning	Linear Regression (Gradient Descent, Normal Equations), Weighted Linear Regression (LWR), Logistic Regression, Perceptron, Newton's Method, KL-divergence, (cross-) Entropy.
3	Week 5-6: Learning Models	Natural Gradient, Exponential Family and Generalized Linear Models, Generative Models (Gaussian Discriminant Analysis, Naive Bayes), Kernel Method (SVM, Gaussian Processes), Tree Ensembles (Decision trees, Random

		Forests, Boosting and Gradient Boosting), Learning Theory, Regularization, Bias-Variance Decomposition and Tradeoff, Concentration Inequalities, Generalization and Uniform Convergence, VC-dimension.
4	Week 7-8: Deep Learning	Neural Networks, Back propagation, Deep Architectures, Unsupervised Learning, K-means, Gaussian Mixture Model (GMM), Expectation Maximization (EM), Variational Auto-encoder (VAE), Factor Analysis, Principal Components Analysis (PCA), Independent Components Analysis (ICA), Reinforcement Learning (RL) : Markov Decision Processes (MDP), Bellmans Equations, Value Iteration and Policy Iteration, Value Function Approximation, Q-Learning.
5	Week 9-10: Application, Special Topic	Advice on structuring an ML project, Evaluation Metrics, Missing data techniques and tracking, Special Topic: Computer Vision. Special Topic: NLP . Special topic: Machine listening and Music Information Retrieval, Special Topic: Speech, Special Topic: Compressive Sensing, Special topics: Array processing, beam forming, independent component analysis, MIMO/SIMO models, under constrained separation, spectral factorizations.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Power electronics concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Averageinternalassessmentshallbetheaverageofthebesttwotestmarksfromthe2testsconducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selectin gone full question from each module.
5. Marks scored will be proportionally scaled down to 50marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding	Students will grasp the fundamental concepts and principles of machine

	Foundations of Machine Learning.	learning, including supervised learning, unsupervised learning, and reinforcement learning.
2	Analyzing Probability and Statistics.	Students will gain a solid understanding of probability theory, statistical inference, and their applications in machine learning algorithms.
3	Pattern Recognition Techniques.	Students will Learn about various pattern recognition techniques such as feature extraction, dimensionality reduction, and clustering.
4	Model Evaluation and Selection	Understand techniques for evaluating and selecting machine learning models, including cross-validation, performance metrics, and model selection criteria.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP103.1	Understand a very broad collection of machine learning algorithms and problems.
M23MSP103.2	To Demonstrate knowledge in the application/analysis of Machine Learning algorithms to solve various types of learning tasks
M23MSP103.3	Learn algorithmic topics of machine learning and mathematically deep enough to introduce the required theory
M23MSP103.4	Carry out research/Investigation for a given Machine Learning Technique

CO-PO-PSO Mapping

COs	PO1	PO2	PO3	PSO1	PSO2
M23MSP103.1	2	2	-	2	2
M23MSP103.2	2	2	3	2	2
M23MSP103.3	2	-	-	2	-
M23MSP103.4	-	-	3	-	-
M23MSP103	**2**	**2**	**3**	**2**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	Total
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5			**10**		**10**
Total	**10**	**10**	**20**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	Total
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5			**20**		**20**
Total	**20**	**20**	**40**	**20**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks.

10. Future with this Subject

The future with pattern recognition and machine learning is incredibly promising, with advancements expected across various industries and applications. Here are some potential developments and opportunities:

Industry Applications:

1. **Healthcare**: Machine learning algorithms will continue to revolutionize healthcare by improving disease diagnosis, personalized treatment plans, drug discovery, and patient monitoring.
2. **Finance**: Pattern recognition and machine learning will enhance fraud detection, risk assessment, algorithmic trading, and customer service in the financial sector.

3. **Retail**: Companies will use machine learning to optimize inventory management, recommend products to customers, personalize marketing campaigns, and enhance the shopping experience.
4. **Automotive**: Autonomous vehicles will benefit from machine learning algorithms for perception, decision-making, and control, leading to safer and more efficient transportation systems.
5. **Manufacturing**: Machine learning techniques will optimize production processes, predict equipment failures, and improve quality control in manufacturing industries.

Research Areas:

1. **Deep Learning**: Advancements in deep learning architectures and algorithms will enable more complex and efficient models for various tasks, including image recognition, natural language processing, and reinforcement learning.
2. **Interpretability and Explainability**: There will be a focus on developing interpretable and explainable machine learning models to enhance trust, accountability, and adoption in critical applications.
3. **Transfer Learning and Few-shot Learning**: Techniques for transferring knowledge between tasks and learning from limited data will become increasingly important, especially in scenarios with scarce labeled data.
4. **Adversarial Robustness**: Research will focus on developing robust machine learning models that are resilient to adversarial attacks, ensuring security and reliability in real-world deployments.
5. **Ethical AI**: There will be a growing emphasis on ethical considerations in machine learning, including fairness, accountability, transparency, and privacy, to address societal concerns and mitigate potential risks.

Career Opportunities:

1. **Machine Learning Engineer**: Design, implement, and deploy machine learning models and systems in various domains.
2. **Data Scientist**: Extract insights from data using statistical analysis, machine learning, and data visualization techniques.
3. **AI Researcher**: Conduct research in cutting-edge areas of artificial intelligence, including pattern recognition, deep learning, and reinforcement learning.
4. **AI Ethicist**: Ensure that machine learning systems are developed and deployed ethically, considering societal impacts and minimizing biases and risks.
5. **AI Product Manager**: Lead the development and implementation of AI-powered products and services, understanding both technical and business requirements.

Overall, pattern recognition and machine learning will continue to play a transformative role in shaping the future of technology, society, and the economy, offering exciting opportunities for innovation, research, and career growth.

1st Semester	**Professional Elective(PE) APPLICATION SPECIFIC INTEGRATED CIRCUIT DESIGN**	**M23MSP104A**

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Solid Understanding of Digital Design:	This includes knowledge of logic gates, flip-flops, registers, combinational and sequential circuits, Boolean algebra, and digital design methodologies.
2	Knowledge of VLSI Design Concepts:	Understanding of CMOS (Complementary Metal-Oxide-Semiconductor) technology, ASIC design flow, IC fabrication processes, and chip architecture
3	Electronic Design Automation (EDA) Tools Proficiency:	Familiarity with EDA tools like Cadence, Synopsys, Mentor Graphics, or similar software suites for ASIC design, simulation, synthesis, and verification.
4	Integrated Circuit Fabrication Knowledge:	Basic understanding of IC fabrication processes such as photolithography, etching, doping, and metallization.
5	Computer-Aided Design (CAD) Skills:	Proficiency in CAD tools for layout design, physical verification, and extraction.
6	Programming Skills:	Often required for writing and debugging RTL (Register Transfer Level) code, which describes the behavior of digital circuits.
7	Knowledge of Hardware Description Languages (HDLs):	Proficiency in HDLs like Verilog or VHDL for RTL coding.

2. Competencies

S/L	Competency	KSA Description
1	Digital Design:	**Knowledge:** Understanding of Boolean algebra principles. A deep understanding of digital design principles, including combinational and sequential logic, finite state machines (FSMs), datapath design, and arithmetic circuits. **Skills:** Students can apply minimization techniques for Boolean expression simplification. **Attitudes:** Appreciation for the importance of logical simplification in digital system design.
2	RTL Design:	**Knowledge:** Proficiency in Register Transfer Level (RTL) coding using hardware description languages (HDLs) like Verilog or VHDL to describe the behavior of digital circuits. **Skills:** Designing Register Transfer Level (RTL) coding circuits based on specifications. Analyzing and evaluating the performance of Register Transfer Level (RTL) coding circuits. **Attitudes:** Appreciation for the role of Register Transfer Level (RTL) coding in digital systems.

3	Combinational and Sequential Logic Circuits	**Knowledge:** Understanding of flip-flops, registers, and sequential logic principles. **Skills:** Designing sequential logic circuits with flip-flops. Optimizing the behavior of sequential circuits. **Attitudes:** Valuing the importance of sequential logic in digital system functionality
4	Verilog HDL	**Knowledge:** Understanding the structure of Verilog modules. Knowledge of Verilog operators and data types. **Skills:** Applying Verilog for digital system design. Describing digital systems using Verilog data flow and behavioral models. **Attitudes:** Openness to learning and using hardware description languages for design.
5	Logic Design with MSI Components and PLDs	**Knowledge:** Understanding of MSI components and PLDs. **Skills:** Implementing binary adders, subtractors, comparators, and multiplexers. Utilizing programmable logic devices (PLDs) in logic design. **Attitudes:** Appreciation for the versatility of MSI components and PLDs in digital logic design.
6	Flip-Flops	**Knowledge:** Understanding the characteristics of flip-flops. **Skills:** Designing and analyzing binary ripple counters and synchronous binary counters. Implementing mod-n counters using different flip-flops. **Attitudes:** Recognizing the significance of flip-flops in sequential logic circuits
7	Introduction to Verilog	**Knowledge:** Understanding the structure of Verilog modules. Knowledge of Verilog operators and data types. **Skills:** Applying Verilog for digital system design. Describing digital systems using Verilog data flow and behavioral models. **Attitudes:** Openness to learning and using hardware description languages for design.
8	Behavioral and Structural Description	**Knowledge:** Understanding of Verilog behavioral and structural description. **Skills:** Writing Verilog behavioral descriptions. Implementing loop statements and structural descriptions in Verilog. **Attitudes:** Appreciation for the role of clear and well-structured Verilog code in design.
9	EDA Tools:	**Knowledge:** Familiarity with Electronic Design Automation (EDA) tools for synthesis, simulation, and verification, such as ModelSim, Xilinx Vivado, or Synopsys VCS. **Skills:** Simulation Analysis: Skill in running simulations, analyzing waveforms, and interpreting simulation results. **Attitudes:** **Adaptability**: Ability to adapt to different EDA tools, FPGA platforms, and project requirements.
10	ASIC Design Flow:	**Knowledge**: of the entire ASIC design flow, from specification. **Skills:** architecture to synthesis, place-and-route, and timing closure.

11	ASIC Synthesis:	**Knowledge:** Understanding of logic synthesis techniques to optimize the design for area, power, and performance goals. **Skills:** Ability to perform static timing analysis (STA) and optimize the design to meet timing constraints. **Attitudes:** Appreciation for the role of clear and well-structured ASIC Synthesis design.

3. **Syllabus**

APPLICATION SPECIFIC INTEGRATED CIRCUIT DESIGN

SEMESTER – I

Course Code	**M23MSP104A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:

At the end of the course the student will be able to:

1. Describe the concepts of ASIC design methodology, data path elements, logical effort and FPGA architectures.
2. Analyze the design of FPGAs and ASICs suitable for specific tasks, perform design entry and explain the physical design flow.
3. Design data path elements for ASIC cell libraries and compute optimum path delay.
4. Create floor plan including partition and routing with the use of CAD algorithms.
5. Design CAD algorithms and explain how these concepts interact in ASIC design.

Module-1

Introduction to ASICs: Full custom, Semi-custom and Programmable ASICs, ASIC Design flow, ASIC cell libraries.

CMOS Logic: Data path Logic Cells: Data Path Elements, Adders: Carry skip, Carry bypass, Carry save, Carry select, Conditional sum, Multiplier (Booth encoding), Data path Operators, I/O cells, Cell Compilers.

Module-2

ASIC Library Design: Logical effort: Predicting Delay, Logical area and logical efficiency, Logical paths, Multistage cells, Optimum delay and number of stages, library cell design.

Programmable ASIC Logic Cells: MUX as Boolean function generators, Acted ACT: ACT 1, ACT 2 and ACT 3Logic Modules, Xilinx LCA: XC3000 CLB, Altera FLEX and MAX, Programmable ASIC I/O Cells: Xilinx andAltera I/O Block

Module-3

Low-level design entry: Schematic entry: Hierarchical design, The cell library, Names, Schematic Icons &Symbols, Nets, Schematic Entry for ASICs, Connections, vectored instances & buses, Edit in place, attributes, Netlist screener.

ASIC Construction: Physical Design, CAD Tools System partitioning, Estimating ASIC size.

Partitioning: Goals and objectives, Constructive Partitioning, Iterative Partitioning Improvement, KL, FM and Look Ahead algorithms.

Module-4

Floor planning and placement: Goals and objectives, Measurement of delay in Floor planning, Floor planningtools, Channel definition, I/O and Power planning and Clock planning.

Placement: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement Improvement, Time driven placement methods, Physical Design Flow

Module-5

Routing: Global Routing: Goals and objectives, Global Routing Methods, Global routing between blocks, Back annotation. Detailed Routing: Goals and objectives, Measurement of Channel Density, Left-Edge Algorithm, Area-Routing Algorithms, Multilevel routing, Timing –Driven detailed routing, Final routing steps, Special Routing, Circuit extraction and DRC.

Suggested Learning Resources:

Text Books:

1. Michael John Sebastian Smith, "Application - Specific Integrated Circuits" Addison Wesley Professional; 2005.
2. H.Gerez, "Algorithms for VLSI Design Automation", John Wiley,1999.

Reference Books:

1. S. Pasricha and N. Dutt," On Chip Communication Architectures System on Chip Interconnect, Elsveir",2008.

Web links and Video Lectures (e-Resources):https://www.mooc.org/ https://onlinecourses.nptel.ac.in/

2. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2:	Student will study Introduction to ASICs: Full custom, Semi-custom and Programmable ASICs CMOS Logic
2	Week 3-4:	Students will use ASIC Library Design principles to Study Logical effort: Predicting Delay, Logical area and logical efficiency. Programmable ASIC Logic Cells
3	Week 5-6:	Students will use Low-level design entry principles to Study Schematic entry: Hierarchical design, The cell library, Names, Schematic Icons. ASIC Construction Partitioning
4	Week 7-8:	Students will use Floor planning and placement principles to Study Power planning and Clock planning.
5	Week 9-10:	Students will study Placement related topics: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement Improvement, placement methods, Physical Design Flow
6	Week 11-12:	Students will study Routing concepts

3. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.
9	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.

4. Assessment Details

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.

3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

6. **Learning Objectives**

S/L	Learning Objectives	Description
1	Understanding Digital Design Fundamentals	Students will grasp the fundamental concepts of digital logic design, including Boolean algebra, logic gates, combinational and sequential circuits, and finite state machines.
2	Designing Combinational and Sequential Circuits	Students will learn to design and implement combinational circuits such as adders, multiplexers, and decoders, as well as sequential circuits such as flip-flops, registers, and counters using Verilog
3	Fundamental Concepts of VLSI Design:	Understand the basic principles and concepts of VLSI design, including semiconductor physics, CMOS technology, and IC fabrication processes.
4	ASIC Design Methodologies:	Learn various ASIC design methodologies, including RTL design, synthesis, place-and-route, and timing closure.
5	ASIC Synthesis	Optimization: Understand logic synthesis techniques to optimize the design for area, power, and performance goals.
6	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
7	Physical Design Concepts:	Familiarize with physical design concepts such as floorplanning, placement, clock tree synthesis, routing, and power grid design.
8	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
9	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

7. **Course Outcomes and Mapping with POs/ PSOs**

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP104.1	Able to understand ASIC design flow and the significance of ASIC cell libraries.
M23MSP104.2	Able to understand CMOS logic, including data path logic cells like adders and Multipliers, as well as I/O cells and cell compilers.
M23MSP104.3	Able to Apply logical effort principles for predicting delay and optimizing logical area, and master the design of multistage cells.
M23MSP104.4	Demonstrate proficiency in low-level design entry, physical design considerations, floor planning, placement, and routing techniques, including global and detailed routing methods, to achieve optimized ASIC designs.

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP104.1	3	3	-	3	-
M23MSP104.2	3	-	3	3	-
M23MSP104.3	3	-	-	-	-
M23MSP104.4	3	3	3	-	-
M23MSP104	**3**	**3**	**3**	**3**	**-**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5			**10**		**10**
Total	**10**	**10**	**20**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5			**20**		**20**
Total	**20**	**20**	**40**	**20**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

8. **Future with this Subject**

The future of ASIC design in VLSI is promising, driven by advancements in technology, evolving design methodologies, and emerging application areas. Here's how the subject is expected to evolve:

1. Technology Advancements: As semiconductor technology continues to advance, with the transition to smaller process nodes and the integration of novel materials and structures, ASIC designers will have access to more advanced and efficient building blocks. This will enable the development of ASICs with higher performance, lower power consumption, and increased integration levels.
2. Specialized ASICs for Emerging Applications: With the proliferation of emerging technologies such as artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and autonomous systems, there will be a growing demand for specialized ASICs tailored to these applications. ASIC designers will need to innovate and develop customized solutions optimized for specific use cases, offering improved performance, efficiency, and cost-effectiveness compared to general-purpose processors.
3. Heterogeneous Integration: The integration of diverse technologies, such as digital logic, analog circuits, MEMS (Micro-Electro-Mechanical Systems), and photonics, into a single ASIC will become more prevalent. This trend towards heterogeneous integration will require ASIC designers to possess expertise in integrating and optimizing diverse components, enabling the development of highly integrated and multifunctional systems-on-chip (SoCs).
4. Design for Security and Trustworthiness: With the increasing concerns about cybersecurity and intellectual property protection, ASIC designers will need to prioritize security and trustworthiness in their designs. This includes implementing hardware security features, such as encryption, authentication, and secure boot mechanisms, as well as ensuring the integrity and confidentiality of sensitive data processed by ASICs.
5. Advanced Design Methodologies: Future ASIC design methodologies will likely leverage advanced automation techniques, machine learning algorithms, and predictive analytics to streamline the design process, improve design productivity, and optimize design outcomes. Additionally, there will be a continued shift towards higher levels of abstraction and design reuse, enabling faster time-to-market and greater design scalability.
6. Energy-Efficient Computing: As energy efficiency becomes a critical consideration in both mobile and data center applications, ASIC designers will focus on developing energy-efficient designs that minimize power consumption without compromising performance. This will involve the adoption of low-power design techniques, dynamic voltage and frequency scaling, and architectural innovations aimed at maximizing energy efficiency.

Overall, the future of ASIC design in VLSI is characterized by innovation, specialization, and adaptability to evolving technological trends and application requirements. ASIC designers will play a crucial role in driving the development of cutting-edge semiconductor solutions that power the next generation of electronic devices and systems.

1st Semester	Professional Elective (PE) BIOMEDICAL SIGNAL PROCESSING	M23MSP104B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Calculus, Linear algebra and statistics.
2	Signals and systems	Basic types of signals like Analog and digital, Energy and power etc.
3	Digital Signal Processing	Fourier analysis and filtering
4	Sensor and Instrumentation	Signal acquisition method
5	Basics of Anatomy and Physiology	Basic Definitions of ECG,EEG,EMG etc

2. Competencies

S/L	Competency	KSA Description
1.	Types of Biomedical signals	**Knowledge:** By studying various biomedical signals like EEG (brain), ECG (heart), and EMG (muscle), students unlock the ability to analyze these electrical whispers of the body. They learn to filter out noise and interpret the signals' characteristics, revealing vital health information. This knowledge equips them to develop applications for disease diagnosis, treatment monitoring, and even brain-computer interfaces for prosthetic control. **Skills:** Studying diverse biomedical signals like EEG, ECG, and EMG equips students with a powerful skill set. They can dissect complex electrical signals from the body, filtering out noise and interpreting hidden patterns. This translates to the ability to analyze health metrics, diagnose diseases, and even monitor treatment progress. Furthermore, students gain expertise in signal processing techniques, paving the way for developing innovative applications like brain-computer interfaces for prosthetics or AI-powered disease detection tools. **Attitudes:** After delving into the world of biomedical signals, students develop a profound appreciation for the body's intricate electrical language. They move from seeing the body as a machine to recognizing it as a complex symphony of electrical signals. This fosters a curiosity to decode these messages, leading to a problem-solving mindset. Students become driven to translate their newfound knowledge into solutions, fueling a desire to improve healthcare through better diagnostics, monitoring, and potentially even human-machine interfaces.
2.	Signal Averaging	**Knowledge:** **Noise Reduction:** They understand how averaging repetitive signals can significantly reduce random, unwanted noise. This allows them to extract the underlying, weaker signal of interest, leading to clearer and more accurate data analysis **Skills:** Studying biomedical signal averaging equips students to **clean noisy data** by separating weak signals from background interference. They can also **boost specific responses** in brainwaves or other signals, unlocking hidden information. These skills improve analysis for better diagnosis and potential applications like brain-computer interfaces. **Attitudes:** Studying biomedical signal averaging fosters a **data detective mindset**. Students learn to see past noise and unearth hidden patterns in biological signals. This empowers them to extract crucial information for better diagnoses and potentially unlock new possibilities in brain-computer interfaces
3.	Adaptive Noise Cancellation	**Knowledge:** By studying biomedical adaptive noise cancellation, students learn how to silence the chatter in biological signals. They gain knowledge of how to design filters that can automatically adjust to cancel out unwanted noise, revealing the weak but important signal underneath. This allows for clearer analysis of heartbeats, brainwaves, and other vital signs. **Skills:**

		Studying biomedical adaptive noise cancelling equips students to be **signal ninjas**. They can design smart filters that constantly adapt to silence background noise, allowing them to extract faint but crucial information from heartbeats, brainwaves, and other biological signals. This leads to sharper analysis for better diagnoses and potential advancements in medical devices. **Attitudes:** After studying biomedical adaptive noise cancelling, students develop a **“deeper listening” mindset**. They see biological signals as complex conversations with hidden messages. This fosters a desire to craft ever-more-sophisticated tools to “hear” the body clearly, leading to breakthroughs in diagnosis, monitoring, and potentially even communication with the brain
4.	ECG	**Knowledge:** Studying biomedical ECG equips students to decipher the electrical language of the heart. They gain knowledge of the heart’s electrical cycle reflected in ECG waves, allowing them to analyze rhythm, rate, and potential abnormalities for accurate diagnosis of heart conditions. **Skills:** By studying biomedical ECG, students become **heart detectives**. They develop the skills to analyze ECG wave patterns, acting like detectives deciphering electrical clues. This allows them to diagnose heart rhythm issues, measure heart rate, and potentially identify abnormalities for better patient care. **Attitudes:** Studying biomedical ECG fosters a deep appreciation for the heart’s silent symphony. Students move from seeing it as a pump to recognizing its intricate electrical language. This curiosity fuels a desire to translate these messages into improved diagnoses and potentially even communication with the heart.
5.	EEG	**Knowledge:** Studying biomedical EEG equips students to understand the brain’s electrical whispers. They learn to interpret brainwave patterns, revealing information about activity, sleep stages, and even potential neurological issues. **Skills:** Studying biomedical EEG turns students into **brain wave wranglers**. They develop the skills to analyze and interpret complex EEG patterns, acting like wranglers deciphering the electrical whispers of the brain. This allows them to assess brain activity, sleep stages, and potentially diagnose neurological conditions. **Attitudes:** Studying biomedical EEG cultivates a sense of awe for the brain’s hidden chatter. Students see beyond the skull to a world of electrical conversations, fostering a desire to decode these messages and unlock the brain’s secrets for better diagnoses and potential mind-machine interfaces.
6.	EMG	**Knowledge:** By studying biomedical EMG, students gain the ability to translate muscle murmurs. They learn to interpret electrical signals from muscles, revealing information about muscle activity, strength, and potential nerve disorders. **Skills:** Studying biomedical EMG equips students as muscle codebreakers. They develop the skills to analyze electrical signals, deciphering the language of muscle activity, strength, and even nerve issues. This allows them to assess muscle function, rehabilitation progress, and potentially diagnose neurological disorders. **Attitudes:** Studying biomedical EMG fosters a respect for the body’s silent dialogue. Students see muscles not just as tissue, but as electrical messengers, sparking a desire to translate their whispers and improve diagnoses, rehabilitation, and potentially even human-machine interaction.

3. Syllabus

BIOMEDICAL SIGNAL PROCESSING
SEMESTER – I

Course Code	**M23MSP104B**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:
To understand the biomedical signals acquisition and its analysis
To analyze the various mathematical tools used in biomedical signal analysis

Module -1

Introduction-The nature of Biomedical Signals, ECG, EEG, EMG and their monitoring and measurement, Spectral analysis.

Module -2

Signal Averaging: Basics of Signal averaging, signal averaging as a digital filter, a typical average, software for signal averaging, limitations of signal averaging.
Adaptive Noise Cancelling: Principal noise canceller model, 60-Hz adaptive cancelling using a sine wave model, other applications of adaptive filtering.

Module -3

ECG-Pre-processing, Measurements of amplitude and time intervals, Classification, QRS detection, ST segment analysis, Base line wander removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression, Evoked potential estimation.

Module -4

EEG: Evoked responses, Epilepsy detection, Spike detection, Hjorth parameters, averaging techniques, removal of Artifacts by averaging and adaptive algorithms, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages.

Module -5

EMG-Wave pattern studies, bio feedback, Zero crossings, Integrated EMG. Time-frequency methods and Wavelets in Biomedical Signal Processing.

Text Books:
1. Biomedical Digital Signal Processing', Willis J Tompkins, Prentice Hall of India, 1996.
2. Rangaraj M. Rangayyan, "Biomedical Signal Analysis" , John Wiley & Sons, Inc, reprint 2000,

Reference Books:
1. 'Biomedical Signal Processing (in IV parts)', R E Challis and RI Kitney, Medical and Biological Engg. And current computing, 1990-91.
2. Special issue on 'Biological Signal Processing', Proc. IEEE 1972.
3. 'Biomedical Signal Processing', Arnon Cohen, Volumes I & II, CRC Press.
4. 'Time frequency and Wavelets in Biomedical Signal Processing', Metin Akay, IEEE Press, 1999. Current Published literature.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Biomedical signals	Introduce basics of biomedical signals, like ECG, EEG, and EMG, emphasizing acquisition methods and signal processing techniques. Use practical demonstrations, real-world examples, and interactive sessions to engage students. Encourage hands-on projects, simulations, and case studies to deepen understanding. Foster critical thinking about signal interpretation and applications in healthcare.
2	Week 3-4: Signal Averaging	Teach principles of signal averaging, emphasizing its role in noise reduction and enhancing signal quality. Demonstrate techniques such as ensemble averaging and time averaging with practical examples and simulations. Encourage students to explore applications in various fields, including biomedical engineering, telecommunications, and digital signal processing.
3	Week 5-6: Adaptive signal cancelling	Introduce adaptive signal cancellation, focusing on its applications in noise reduction and interference removal. Teach algorithms like LMS and NLMS, illustrating their implementation in real-world scenarios through simulations and case studies. Emphasize the importance of parameter tuning and adaptive filter design principles for optimal performance in diverse signal environments.

4	Week 7-8: Analysis of ECG	Teach ECG signal analysis by covering basics of cardiac physiology, waveform interpretation, and common abnormalities. Utilize practical exercises with real ECG recordings and interactive software for rhythm identification and morphological analysis. Emphasize clinical relevance, guiding students to understand ECG's diagnostic value in cardiovascular diseases and patient care.
5	Week 9-10: Analysis of EEG	Introduce EEG signal analysis by covering brainwave types, electrode placement, and recording techniques. Use interactive tools and real EEG datasets for practical analysis of neural oscillations, event-related potentials, and spectral features. Encourage exploration of EEG applications in neuroscience, cognitive science, and clinical diagnosis to deepen understanding.
6	Week 11-12: Analysis of EMG	Teach EMG signal analysis by explaining muscle physiology, electrode placement, and signal acquisition methods. Engage students with practical exercises using EMG recordings to identify muscle activity patterns, analyze motor unit recruitment, and assess muscle function. Highlight applications in biomechanics, rehabilitation, and prosthetics to demonstrate real-world relevance.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of signal processing and communication concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Average internal assessment shall be the average of the best two test marks from the 2 tests conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module(with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. Thestudentshavetoanswer5fullquestionsselectingonefullquestionfromeachmodule.
5. Marks scored will be proportionally scaled down to 50marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Biomedical signal Fundamentals	Students will be able to understand the basics of biomedical signals.
2	Proficiency in Signal Averaging and Adaptive filters.	Students will learn to analyze signal averaging and filtering.
3	Proficiency in ECG, EEG and EMG	Students will develop proficient skills for accurate analysis and processing of biomedical signals ECG, EEG and EMG.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP104B.1	Apply Advanced Engineering Science in significance of bio electric potentials, AR/ARMA models for power spectral estimation
M23MSP104B.2	Analyze the EEG pattern recognition, epilepsy detection, Hjorth parameters,
M23MSP104B.3	Implement the QRS detection, ST segment analysis, evoked potential estimation

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP104B.1	2	2	2	3	3
M23MSP104B.2	2	2	3	3	3
M23MSP104B.3	3	3	3	3	3
M23MSP104B	**2.33**	**2.33**	**2.66**	**3**	**3**

9.Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	10			**10**
Module 2		10		**10**
Module 3			10	**10**
Module 4		10		**10**
Module 5			10	**10**
Total	**10**	**20**	**20**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	20			**20**
Module 2		20		**20**
Module 3			20	**20**
Module 4		20		**20**
Module 5			20	**20**
Total	**20**	**40**	**40**	**100**

10. Future with this Subject

The "Biomedical Signal Processing" course in the first semester of the M tech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Biomedical signal processing. Here are some notable contributions:

- **Machine Learning and AI:** Machine learning algorithms are already being incorporated into biomedical signal processing for tasks like automated analysis of EEG (brainwaves) or ECG (heart signals) data. This trend is expected to continue, leading to more sophisticated analysis and the ability to detect subtle changes that might be missed by human doctors.

- **Sensor Technology:** The development of miniaturized, wearable and even ingestible sensors will allow for continuous, long-term monitoring of a wider range of biological signals. This will provide a much richer dataset for analysis and could enable the detection of diseases at earlier stages.
- **Internet of Things (IoT):** With the growth of IoT, medical devices will become increasingly interconnected, allowing for real-time data transmission and remote patient monitoring. This could revolutionize healthcare delivery, enabling more personalized care and earlier intervention.
- **Personalized Medicine:** Biomedical signal processing can be used to develop personalized treatment plans based on an individual's unique biological data.
- **Early Disease Detection:** By continuously monitoring physiological signals, healthcare professionals may be able to identify diseases like heart failure or even cancer much earlier, leading to better treatment outcomes.
- **Improved Prosthetic Limbs:** Advanced signal processing techniques can be used to create more intuitive and responsive prosthetic limbs that can better integrate with the nervous system.

Overall, the future of biomedical signal processing is bright. With the help of new technologies, this field has the potential to transform healthcare delivery and improve the lives of millions of people.

1st Semester	Professional Elective (PE) SPEECH AND AUDIO PROCESSING	M23MSP104C

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Linear algebra	Understanding concepts such as matrices, vectors, matrix operations, eigenvectors, and Eigen values is crucial for various signal processing techniques.
2	Calculus	Basic Knowledge of calculus, including differential and integral calculus, is important for understanding concepts like Fourier transforms, Laplace transforms, and signal analysis.
3	Discrete mathematics	Concepts from discrete mathematics such as sequences, series, and difference equations are fundamental for digital signal processing (DSP).
4	atistical measures	Understanding probability distributions, statistical measures, and random processes is important for analyzing and modeling signals and noise in audio processing.
5	Signals and Systems	Knowledge of signal theory, including concepts like sampling theory, aliasing, and signal representation, is essential for processing and analyzing audio signals.
6	Digital signal processing (DSP)	Understanding Fourier series and Fourier transforms is important for analyzing the frequency content of audio signals and for applying techniques like spectral analysis. Familiarity with DSP concepts like discrete Fourier transforms (DFT), fast Fourier transforms (FFT), digital filters, and convolution is crucial for working with digital audio signals.
7	Fundamentals of speech processing	Fundamentals of speech processing: familiarity with waveforms, spectra, spectrograms, resonance, formants, human speech production and perception., perceptually-motivated frequency scales, time vs. frequency representations; conversion between the two, the Fourier transform, source-filter model of speech, hands on experience.
8	Automatic Speech recognition:	Components of a typical recognizer, parameterization of the speech signal, dynamic time warping, distance measures, the Hidden Markov Model, the generative model paradigm, simple probability theory, conditional and joint probabilities, Bayes theorem, Gaussian probability density function, continuous density HMMs, monophone models with Gaussian observation densities, Viterbi algorithm for recognition, training from fully labelled data, Viterbi training, bigram language models.

2. Competencies

S/L	Competency	KSA Description
1	Digital Models for the Speech Signal	**Knowledge:** Knowledge of acoustic phonetics and the anatomy of speech organs. Grasping various methods of speech signal representation (time-domain and frequency-domain). Knowledge of linear predictive coding (LPC), formant analysis, and other speech analysis techniques. **Skills:** Ability to analyze and interpret speech signals. Skills in programming languages and software development, particularly for DSP applications. **Attitudes:** Dedication to high-quality work and thorough testing of algorithms and models.

2	Digital Representations of the Speech Waveform	**Knowledge**: Understanding Speech Production and Acoustics: Knowledge of how speech sounds are produced, the anatomy involved, and the basic principles of acoustics. Understanding cepstrum and its role in distinguishing the source and filter components of speech. **Skills:** Ability to analyze and interpret speech waveforms in both time and frequency domains. **Attitude:** Openness to learning new techniques and staying updated with advancements in speech signal processing.
3	Homomorphic Speech Processing	**Knowledge**: Knowledge of the mathematical principles underlying homomorphic systems, particularly their application in signal processing. Knowledge of how homomorphic processing is used in speech analysis, synthesis, and enhancement. **Skills**: Proficiency in analyzing speech signals using homomorphic techniques to extract meaningful features. **Attitude**: Willingness to continuously update knowledge and skills in the rapidly evolving field of speech processing.
4	Speech Enhancement	**Knowledge**: Knowledge of the spectral subtraction method for noise reduction. Familiarity with statistical methods such as Gaussian Mixture Models (GMM) and Hidden Markov Models (HMM) for speech enhancement. **Skills**: Ability to extract relevant features from speech signals for enhancement purposes. **Attitude**: Willingness to stay updated with advancements in speech enhancement technologies.
5	Automatic Speech & Speaker Recognition	**Knowledge**: Knowledge of phonetics (study of speech sounds) and phonology (systematic organization of sounds in languages). Familiarity with techniques such as Mel-frequency cepstral coefficients (MFCCs), spectrograms, and linear predictive coding (LPC) for feature extraction. **Skills**: Ability to evaluate and interpret the performance of speech and speaker recognition models using appropriate metrics. **Attitude**: Willingness to stay updated with advancements in speech and speaker recognition technologies.

3. Syllabus

SPEECH AND AUDIO PROCESSING			
Course Code	**M23MSP104C**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**2:0:2**	SEE Marks	**50**
Total Hours of Pedagogy	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:

- Familiarize the basic mechanism of speech production and get an overview of articulatory and acoustic Phonetics.
- Learn the basic concepts of methods for speech analysis and parametric representation of speech.
- Acquire knowledge about various methods used for speech and audio coding.
- Get an overall picture about various applications of speech and audio processing.

Module-1

Digital Models for the Speech Signal: Process of speech production, Acoustic theory of speech production, Lossless tube models, and Digital models for speech signals (Text 1). Time Domain Models for Speech Processing: Time dependent processing of speech, Short time energy and average magnitude, Short time average zero crossing rate, Speech vs silence discrimination using energy & zero crossings, Pitch period estimation, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function, Median smoothing.
Module-2
Digital Representations of the Speech Waveform: Sampling speech signals, Instantaneous quantization, Adaptive quantization, Differential quantization, Delta Modulation, Differential PCM, Comparison of systems, direct digital code conversion. Short Time Fourier Analysis: Linear Filtering interpretation, Filter bank summation method, Overlap addition method, Design of digital filter banks, Implementation using FFT, Spectrographic displays, Pitch detection, Analysis by synthesis, Analysis synthesis systems.
Module-3
Homomorphic Speech Processing: Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. Linear Predictive Coding of Speech: Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Synthesis of speech from linear predictive parameters, Applications.
Module-4
Speech Enhancement: Spectral subtraction & filtering, Harmonic filtering, parametric re-synthesis, Adaptive noise cancellation. Speech Synthesis: Principles of speech synthesis, Synthesizer methods, Synthesis of intonation, Speech synthesis for different speakers, Speech synthesis in other languages, Evaluation, Practical speech synthesis.
Module-5
Automatic Speech & Speaker Recognition: Basic pattern recognition approaches, Parametric representation of speech, Evaluating the similarity of speech patterns, Isolated digit Recognition System, Continuous digit Recognition System Hidden Markov Model (HMM) for Speech: Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMS, Speaker Recognition: Recognition techniques, Features that distinguish speakers, Speaker Recognition Systems: Speaker Verification System, Speaker Identification System.
Suggested Learning Resources: **Books** 1. L. R. Rabiner and R. W. Schafer, 'Digital Processing of Speech Signals', Pearson Education (Asia) Pvt. Ltd., 2004. 2. L. R. Rabiner and B. Juang, 'Fundamentals of Speech Recognition', Pearson Education (Asia) Pvt. Ltd., 2004. **Reference Books:** 1. Z. Li and M.S. Drew, 'Fundamentals of Multimedia', Pearson Education (Asia) Pvt. Ltd., 2004. 2. D. O'Shaughnessy, 'Speech Communications: Human and Machine', Universities Press, 2001.1. 3. Discrete Time Speech Signal Processing: Principles and Practice - Thomas F. Quateri, 1st Ed., PE 4. Speech & Audio Signal Processing- Ben Gold & Nelson Morgan, 1st Ed., Wiley.
Web links and Video Lectures (e-Resources): https://www.mooc.org/ https://onlinecourses.nptel.ac.in/
Skill Development Activities Suggested 1. Design and implement the hardware circuit to acquire the speech signals. **2.** Design and implement using the software to process the speech signals
Web links and Video Lectures (e-Resources): https://www.mooc.org/ https://onlinecourses.nptel.ac.in/
Skill Development Activities Suggested Design and implement the hardware circuit to acquire the speech signals Design and implement using the software to process the speech signals

4. Syllabus Timeline

S/L	Syllabus Timeline	Description

1	Week 1-3:	Grasping various methods of speech signal representation (time-domain and frequency-domain). Understanding different speech coding techniques and their applications. Knowledge of linear predictive coding (LPC), formant analysis, and other speech analysis techniques. Understanding of noise reduction, echo cancellation, and other speech enhancement techniques.
2	Week 4-5:	Knowledge of how speech can be represented in the time domain, including waveform plotting and characteristics such as amplitude and duration. Knowledge of how spectrograms are used to represent the speech waveform in terms of time, frequency, and amplitude. Understanding cepstrum and its role in distinguishing the source and filter components of speech.
3	Week 6-7:	Knowledge of how homomorphic processing is used in speech analysis, synthesis, and enhancement. Understanding applications in voice conversion, speaker recognition, and verification. Understanding the concepts of convolution in the time domain and its relation to multiplication in the frequency domain.
4	Week 8-9:	Understanding deep learning techniques (e.g., DNNs, RNNs, CNNs) for enhancing speech. Understanding deep learning techniques (e.g., DNNs, RNNs, CNNs) for enhancing speech. Knowledge of the spectral subtraction method for noise reduction.
5	Week 10-12:	Familiarity with techniques such as Mel-frequency cepstral coefficients (MFCCs), spectrograms, and linear predictive coding (LPC) for feature extraction. Knowledge of language models and their role in predicting the sequence of words.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up for Professional Elective Course (PE)

Components		Number Weightage	Min.	Max	Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	5 0%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the best two test marks conducted.

Semester End Examinations

1. Question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.

3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have a mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Speech and audio processing in both time and frequency domains.	Students will grasp the concepts of different Speech and audio processing techniques.
2	Working principle of speech and audio processing.	Students will learn about the working principle of speech and audio processing techniques.
3	Project-Based Learning	Through hands-on projects, students will apply the concepts of speech and audio processing techniques in the future scope.
4	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
5	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

7. Course Outcomes (COs) and Mapping with POs/ PSOs
Course Outcomes (COs)

COs	Description
M23MSP104C.1	An ability to independently conduct research /investigation and development work to solve practical problems related to speech production and speech analysis.
M23MSP104C.2	An ability to apply various speech and audio processing algorithms in time and frequency domain.
M23MSP104C.3	Analyze and Design speech recognition and audio processing systems.
M23MSP104C.4	Students should be able to demonstrate a degree of mastery over the area of speech recognition and various methods used for speech and audio coding.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP104C.1	3	2	3	3	3
M23MSP104C.2	2	2	3	3	3
M23MSP104C.3	2	1	3	3	3
M23MSP104C.4	2	2	3	3	3
M23MSP104C	**2.25**	**1.75**	**3**	**3**	**3**

8. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	Total
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5			**10**		**10**
Total	**10**	**10**	**20**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	Total
Module 1	**20**				**20**

Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5			**20**		**20**
Total	**20**	**20**	**40**	**20**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10.Future with this Subject
The "speech and audio processing" course in the first semester of the Mtech program lays a strong foundation for several future courses. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of Automatic speech recognition Here are some notable contributions:

1. Speech and audio coding: Developing efficient algorithms for compressing speech and audio signals while maintaining high quality.
2. Speech recognition and synthesis: Creating systems that can recognize and synthesize human speech accurately.
3. Music information retrieval: Developing algorithms for analyzing and organizing music data, such as genre classification, music recommendation systems, and automatic music transcription.
4. Audio effects processing: Designing algorithms for applying various effects to audio signals, such as reverb, equalization, and noise reduction.
5. Spatial audio processing: Researching techniques for creating immersive audio experiences, such as virtual surround sound and spatial audio rendering.
6. Virtual Assistants: Voice-activated virtual assistants like Siri, Alexa, and Google Assistant help users perform various tasks, such as setting reminders, checking the weather, or controlling smart home devices, using voice commands.
7. Dictation and Transcription: Voice recognition technology enables users to dictate text messages, emails, or documents, as well as transcribe spoken words into written text with high accuracy.
8. Customer Service Automation: Many businesses are using voice recognition technology to automate customer service interactions through interactive voice response (IVR) systems, chatbots, and virtual agents.

1st Semester	Professional Elective (PE) ADVANCED EMBEDDED SYSTEM	M23MSP104D

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Microcontrollers and Microprocessors	Understanding the architecture of microcontrollers and microprocessors. Basic knowledge of assembly language programming
2.	Programming	Proficiency in C/C++ as these are the primary languages used in embedded systems, Specific knowledge of programming microcontrollers using Embedded C, Understanding the basics of RTOS, task scheduling, and inter-task communication.
3.	Communication Protocols	Knowledge of UART, SPI, I2C, Understanding TCP/IP, MQTT, CAN, Modbus for networked embedded systems.
4.	Hardware Design	Basics of PCB design, understanding how to read and create electronic schematics
5.	Mathematics	Understanding various algorithms used in signal processing,

2. Competencies

S/L	Competency	KSA Description
1	Embedded system core	**Knowledge:** Understanding of microcontrollers/microprocessors and their architectures, familiarity with electronic components and circuits, Proficiency in programming languages, Knowledge of real-time operating systems, Understanding of communication protocols and interfaces **Skills:** Proficiency in embedded system programming and debugging, Ability to design and develop embedded hardware, Experience with PCB design and schematic creation, Skills in interfacing sensors, actuators, and communication module : Precision in hardware and software design, Ability to troubleshoot and resolve issue, Dedication to completing tasks and solving complex problems
2	Hardware-Software Co-Design optimization	**Knowledge: U**nderstanding the principles of co-design and the need for simultaneous development of hardware and software **Skills:** proficiency in using co-design tools and environment **Attitudes:** Open to iterative design processes and feedback, Focused on system optimization and efficiency
3	ARM - 32 architecture and registers	**Knowledge:** Understanding that Thumb-2 is a mixed 16/32-bit instruction set architecture that offers improved code density and performance over the original ARM and Thumb instruction sets. **Skills:** Proficiency in using development tools that support Thumb-2 technology **Attitudes:** Appreciation for the balance between performance and code size offered by Thumb-2 technology
4	ARM-32 instructions and exceptions	**Knowledge:** Understanding the fundamentals of assembly language, which is a low-level programming language that provides direct control over hardware. **Skills:** Proficiency in converting high-level code to assembly for optimization and debugging purposes **Attitudes:** Thoroughness in learning and applying the full range of available instructions. Analytical mindset to select the best instructions for a given task.

3. Syllabus

ADVANCED EMBEDDED SYSTEM SEMESTER – I			
Course Code	**M23MSP104D**	CIE Marks	b
Teaching Hours/Week (L:P:SDA)	**2:0:2**	SEE Marks	50
Total Hours of Pedagogy	**40hoursTheory**	Total Marks	100
Credits	**03**	Exam Hours	03

Course Learning objectives:

Understand the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.

Describe the hardware software co-design and firmware design approaches

Explain the architectural features of ARM CORTEXM3, a 32-bit microcontroller including memory map, interrupts and exceptions.

Program ARM CORTEXM3 using the various instructions, for different applications

Module-1

Embedded System: Embedded vs General computing system, classification, application and purpose of ES. Core of an Embedded System, Memory, Sensors, Actuators, LED, Opt coupler, Communication Interface, Reset circuits, RTC, WDT, Characteristics and Quality Attributes of Embedded Systems

Module-2

Hardware Software Co-Design, embedded firmware design approaches, computational models, embedded firmware development languages, Integration and testing of Embedded Hardware and firmware, Components in embedded system development environment (IDE), Files generated during compilation, simulators, emulators, and debugging

Module-3

ARM 32-bit Microcontroller: Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence

Module-4

Instruction Sets: Assembly basics, Instruction list and description, useful instructions, Memory Systems, Memory maps, Cortex M3 implementation overview, pipeline and bus interface

Module-5

Exceptions, Nested Vector interrupt controller design, Systick Timer, Cortex-M3ProgrammingusingassemblyandClanguage,CMSIS

Suggested Learning Resources:

Text Books:

1. K.V.Shibu, “Introduction to embedded systems”, TMH Education Pvt.Ltd.2009.
2. Joseph Yiu, “The Definitive Guide to the ARM Cortex-M3”,2nd (Elsevier),2010.

Reference Book:

1. James K. Peckol, “Embedded systems contemporary design tool”, John Wiley,2008.

Web links and Video Lectures (e-Resources):

https://www.mooc.org/

https://onlinecourses.nptel.ac.in/

Skill Development Activities Suggested

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Embedded System: Embedded vs General computing system	Embedded system with general purpose embedded system, classification and purpose of the embedded system. With core of the embedded system with memory, characteristics and embedded system
2	Week 3-4: Hardware Software Co Design	Deals with embedded firmware approaches, integration and testing of embedded system, component of the embedded of system, files of the generation, simulation
3	Week 5-6: ARM-32bitMicrocontroller	Technology and applications, architecture of ARM processor, general purpose registers, special registers and exceptions

4	Week 7-8: Instruction Sets	Deals with the instruction list and description, memory systems and memory maps, cortex m3 implementations, pipeline and bus interface
5	Week 9-10: Exceptions	Deals with nested vector interrupt, system 3 timer, cortex m3 programming language and CMSIS
6	Week 11-12: Integration and Practical Applications	Apply learned concepts and competencies to real-world scenarios. Hands-on practice with programming assignments

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

CIE Split up for Professional Elective Course (PE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examinations

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Embedded system fundamentals	Students will grasp the fundamental concepts of Embedded systems, core of embedded systems, memory, communication interface, quality attributes of embedded system.

2	Hardware software co design	Students will learn to embedded design approaches, components of hardware and software embedded systems,files during the compilation
3	Proficiency in ARM 32 Microcontroller architecture and instructions and programming	Students will become proficient in architecture of ARM 32 microcontroller, with the instruction set memory maps and exceptions
4	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP104D.1	**Conduct** research and solve the practical problems in embedded systems
M23MSP104D.2	**Apply** the knowledge of the architectural features of ARMCORTEX M3 32 bit microcontroller including memory map, interrupts and exceptions. The hardware and software co-design and firmware design approaches and present in document format
M23MSP104D.3	**Apply** the knowledge gained for Programming ARMCORTEX M3 for different applications.
M23MSP104D.4	**Analyze** the behavior of simulations for cortex ARM32 instructions and programming

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP104D.1	3	-	-	3	-
M23MSP104D.2		3	-	3	-
M23MSP104D.3	-	3	-	3	-
M23MSP104D.4	-	-	3	3	-
M23MSP104D	**3**	**3**	**3**	**3**	**-**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**2**	**3**	**2**	**3**	**10**
Total	**12**	**13**	**12**	**13**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**4**	**6**	**4**	**6**	**20**
Total	**24**	**26**	**24**	**26**	**100**

10. Future with this Subject

The "Advanced embedded system" course in the First Semester of the Mtech program lays a strong foundation for several future courses in the undergraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of digital systems. Here are some notable contributions:

Internet of Things (IoT)

1. Smart Homes and Cities: Embedded systems will be the backbone of smart infrastructure, enabling automation, energy management, and enhanced public services.
2. Industrial IoT (IIoT): Integration of embedded systems in manufacturing for predictive maintenance, asset tracking, and improved operational efficiency.
3. Artificial Intelligence and Machine Learning (AI/ML)
4. Edge AI: Deploying AI algorithms on embedded devices for real-time data processing, reducing latency, and enhancing privacy.
5. Autonomous Systems: Development of autonomous vehicles, drones, and robots with advanced decision-making capabilities.
6. Healthcare and Biomedical Engineering
7. Wearable Health Devices: Embedded systems in wearable devices for continuous health monitoring and personalized medicine.
8. Medical Imaging and Diagnostics: Advanced embedded systems for high-precision imaging, data analysis, and automated diagnosis.
9. Automotive Industry
10. Electric and Autonomous Vehicles: Embedded systems for electric vehicle management, autonomous driving, and V2X communication.
11. Advanced Driver Assistance Systems (ADAS): Development of systems for collision avoidance, lane-keeping, and adaptive cruise control.
12. Cybersecurity
13. Secure IoT Devices: Developing secure IoT solutions to protect against cyberattacks and data breaches.
14. Trusted Execution Environments: Implementing secure environments within embedded systems to protect sensitive operations.
15. Energy and Environmental Monitoring
16. Smart Grid: Embedded systems for intelligent energy distribution, demand response, and integration of renewable energy sources.
17. Environmental Sensing: Deploying embedded sensors for real-time monitoring of air quality, water quality, and climate conditions.

1st Semester	Professional Elective (PE) WIRELESS SENSOR NETWORKS	M23MSP104E

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1.	Basic knowledge of Computer Networks	Familiarity with fundamentals of computer Networks and data communication. Understanding of various layers of computer communication network layers.
2.	Fundamental of sensor devices	Basic understanding of various sensing devices, components, circuits, and their behavior
3.	Mathematics	Proficiency in basic mathematics so solve networks related problems
4.	Programming Fundamentals	Basic programming skills Basic understanding of programming concepts (C/C++)
5.	Basics of Timing and Synchronization circuits	Basic Knowledge of time synchronization in networks to detect movement, location, and proximity
6.	Previous Coursework	Completion of introductory courses in computer networks, Data communication system

2. **Competencies**

S/L	Competency	KSA Description
1.	Wireless Sensor Network Structure	**Knowledge:** Understanding the structure of Wireless Sensor Network topology Knowledge of communication Networks. **Skills:** Describing network components /structure at different levels **Attitudes:** Learning and using concepts for different applications
2.	Wireless Network Layers	**Knowledge:** Understanding various Network layers they help in seamless communication between diverse devices. **Skills:** Analyzing and evaluating. functions and responsibilities of different layers and its access mechanism **Attitudes:** Visualizing the interconnection between the layers, data, and information movement between them
3.	Routers and gateways	**Knowledge:** Understanding the operation of routers gateways **Skills:** Setting up routers, switches, firewalls, and other network equipment. **Attitudes:** Optimizing the behavior of routers and gateways and switches
4.	Network Topology	**Knowledge:** Security principles, authentication, authorization, and access control mechanisms. **Skills:** Deploying and integrating network hardware and software. **Attitudes:** Visualizing the physical connection of devices and the data flow within the network.
5.	Network	**Knowledge:**

	Communication Protocol	Security principles, authentication, authorization, and access control mechanisms. **Skills:** Deploying and integrating network protocol and software **Attitudes:** Visualizing the physical connection of devices and the data flow within the network.
6.	Synchronization and Localization	**Knowledge:** Virtual memory, paging, segmentation, and demand paging. **Skills:** Optimizing resource allocation to ensure efficient utilization of CPU, memory, and I/O devices **Attitudes:** determine the location of sensor node, low-cost, scalable, and efficient localization mechanisms for WSNs

3. Syllabus

WIRELESS SENSOR NETWORKS SEMESTER – I			
Course Code	**M23MSP104E**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory+10 Hrs SDA**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- Understand the basic WSN technology and supporting protocols, with emphasis placed on standardization basic sensor systems and provide a survey of sensor technology
- Understand factors influencing WSN design and learn MAC, network and physical layer issues
- Learn key routing protocols for sensor networks and main design issues
- Learn transport layer protocols and application layer for sensor networks, and design requirements.
- Understand the Sensor management, sensor network middleware, operating systems.
- Time Synchronization and Localization

Module -1	
Introduction: Sensor Mote Platforms, WSN Architecture and Protocol Stack (Text 1: Chap. 1). **WSN Applications:** Military Applications, Environmental Applications, Health Applications, Home Applications, Industrial Applications	L1, L2, L3
Module -2	
Factors Influencing WSN Design: Hardware Constraints Fault Tolerance Scalability Production Costs WSN Topology, Transmission Media, Power Consumption (Text 1: Chap. 3). **Physical Layer:** Physical Layer Technologies, Overview of RF Wireless Communication, Channel Coding (Error Control Coding), Modulation, Wireless Channel Effects, PHY Layer Standards.	L1, L2, L3
Module -3	
Medium Access Control: Challenges for MAC, CSMA Mechanism, Contention-Based Medium Access, Reservation-Based Medium Access, Hybrid Medium Access (Text 1: Chap 5). **Network Layer**: Challenges for Routing, Data-centric and Flat Architecture Protocols, Hierarchical Protocols, Geographical Routing Protocols (Text1: Chap. 7)	L1, L2, L3
Module -4	
Transport Layer: Challenges for Transport Layer, Reliable Multi Segment Transport (RMST) Protocol, Pump Slowly, Fetch Quickly (PSFQ) Protocol, Congestion Detection and Avoidance (CODA) Protocol, Event-to-Sink Reliable Transport (ESRT) Protocol, GARUDA (Chap8 Text 1). **Application Layer:** Source Coding (Data Compression), Query Processing, Network Management (Chap. 9 Text 1).	L1, L2, L3
Module -5	
Time Synchronization: Challenges for Time Synchronization, Network Time Protocol, Timing-Sync Protocol for Sensor Networks (TPSN), Reference- Broadcast Synchronization (RBS), Adaptive Clock Synchronization (ACS) (Text 1: Chap.11).	L1, L2, L3

Localization; Challenges in Localization, Ranging Techniques, Range-Based Localization Protocols, Range-Free Localization Protocols. (Text 1: Chap. 12)

Text Books:

1. Wireless Sensor Networks, Ian F. Akyildiz and Mehmet Can Vuran, John Wiley & Sons Ltd. ISBN 978-0- 470-03601-3 (H/B), 2010
2. Wireless Sensor Networks: Signal Processing and Communications Perspectives', Ananthram Swami, et. al., John Wiley & Sons Ltd.

Reference Books:

1. Kazem Sohraby, Daniel Minoli,TaiebZnati, "Wireless Sensor Networks: Technology, Protocols, and Applications", John wiley& Sons.
2. Holger Karl, Andreas Willig, "Protocols and architectures for wireless sensor networks", John Wiley & Sons

Web links and Video Lectures (e-Resources):
https://www.youtube.com/watch?v=IR4jIFiHwgc
https://www.youtube.com/watch?v=TNXS05Efumo
https://www.youtube.com/watch?v=7h5Wwk_mheg
https://www.youtube.com/watch?v=sx0UPzztC5o
https://www.youtube.com/watch?v=SHO9eeWxPxY
https://www.youtube.com/watch?v=ZYIdYIt7W_g&t=24s

https://www.mooc.org/
https://onlinecourses.nptel.ac.in/

Skill Development Activities Suggested
Mini project group-wise on implementation of Sensor Networks using Simulation Tools

Skill development activities: Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modeling systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze, and authenticate the output to interpret and conclude
8. All activities should enhance student's abilities for employment and self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc. Students and the course instructor/s to be involved either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities that will enhance their skills.
9. The prepared report shall be evaluated for CIE marks

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction and Applications	Wireless Sensor Network Architecture and Protocol Stack, WSN Applications
2	Week 3-4: WSN design Influencing factors and Physical Layer	Wireless Sensor Network Design Hardware Constraints Fault Tolerance Scalability, Wireless Sensor Network Topology, Power Consumption, Physical Layer Technologies, Channel Coding, Modulation, Physical Layer Standards
3	Week 5-6: MAC Layer and Network Layer	Medium Access Control layer Challenges, types of access technique, Network Layer routing Challenges and types of c protocols

4	Week 7-8: Transport Layer and Application Layer	Challenges for Transport Layer, Transport layer protocols, Application Layer: Source Coding (Data Compression), Query Processing, Network Management
5	Week 9-10: Time Synchronization and Localization:	Challenges for Time Synchronization, Network Time Protocol, Timing-Sync Protocol for Sensor Networks (TPSN), Localization; Challenges in Localization, Ranging Techniques
6	Week 11-12: Integration and Applications	Integration of wireless sensor networks and its implementation

5. Teaching-Learning Process Strategies

Sl.No	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

The minimum CIE marks requirement is 40%of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Averageinternalassessmentshallbetheaverageofthebesttwotestmarksfromthe3tests conducted.

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding	Students will grasp the fundamental concepts of wireless sensor networks

	Fundamentals	and its applications.
2	Understanding Functionalities	Student understand the basic functionalities of different Layers, synchronization and localization
4	Understanding Algorithms	To analyze the usage of different algorithms for different layers for time synchronization and localization
5	Understanding Implementation	Student will understand the factors influencing the design of wireless sensor networks
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with wireless sensor networks including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP104E	**Describe** basic concepts of Wireless sensor networks architecture and protocols.
M23MSP104E	**Analyze** function of different network layers protocols
M23MSP104E	**Understand** the challenges in designing a Wireless sensor network layers and protocols
M23MSP104E	**Analyze** the synchronization and localization of wireless sensor network system for different applications

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP104E.1	3	3	3	3	2
M23MSP104E.2	-	3	3	3	3
M23MSP104E.3	-	3	2	3	2
M23MSP104E.4	3	3	2	3	2
M23MSP104E	**2**	**3**	**2.5**	**3**	**2.25**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	Total
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5			**5**	**5**	**10**
Total	**10**	**15**	**15**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	Total
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5			**10**	**10**	**20**
Total	**20**	**20**	**30**	**30**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

The future developments in sensor nodes must produce very powerful and cost-effective devices, so that they may be used in applications like underwater acoustic sensor systems, sensing based cyber physical systems, time critical applications, cognitive sensing and spectrum management, and security and privacy. Sensor Networks has become one of the technologies for the future. Advancements in communication and computing technologies make it possible to fabricate sensor nodes, which are small in size and reduced in cost and at the same time consume very less energy while operational. It is also possible to deploy them very easily. Such sensor nodes are involved in almost every field of life.

1. **Terrestrial WSNs:**Terrestrial WSNs are located easily on the land area which are capable of communicating base stations efficiently. It consists of hundreds to thousands of wireless sensor nodes that can be deployed either in unstructured (ad hoc) or structured (preplanned) manner. The battery is equipped with solar cells as a backup power source.
2. **Underground WSNs:**As the deployment, maintenance, equipment cost is high in comparison to other types of WSNs, the underground wireless sensor networks seem to be more expensive than the terrestrial WSNs. These sensor network consist of a number of sensor nodes that are hidden in the ground to monitor underground conditions whereas the additional sink nodes are located above the ground so that the underground sensor relay information from the sensor nodes to the base station
   The underground wireless sensor networks deployed under the ground are difficult to recharge as it is not possible to have backup energy source like solar power in terrestrial WSNs. Also, the underground environment makes wireless communication a challenge due to high level of attenuation and signal loss.
3. **Underwater WSNs:**The underwater networks consist of a number of sensor nodes and vehicles deployed under water. A challenge of underwater communication is a long propagation delay, bandwidth and sensor failures and energy back-up. The Underwater WSNs also face the problem in underwater communication and networking techniques.
4. **Multimedia WSNs:**Multimedia WSNs mainly consist of low-cost sensor nodes equipped with microphones and cameras. The main purpose of multimedia WSN is to enable tracking and monitoring of events in the form of multimedia, such as imaging, video, and audio. These nodes are interconnected with each other over a wireless connection for data compression and data retrieval
   High energy consumption, High bandwidth requirements, Data processing and Compressing techniques are some of the challenges of multimedia WSNs.
5. **Mobile WSNs:**The Mobile WSNs is a network having the collection of sensor nodes that can be moved on their own and can be interacted with the physical environment. The sensor nodes attached to Unmanned Aerial Vehicles (UAVs) for surveillance, environment monitoring is also categorized under the mobile WSNs. Because of having the ability to computer, move, sense and communicate, wireless sensor networks are much more versatile than the static sensor networks. The advantages of mobile wireless sensor network over the static wireless sensor networks include better and improved coverage, better energy efficiency, superior channel capacity, and so on.
6. **Internet of Things (IoT) Integration:**As the Internet of Things (IoT) continues to expand, operating systems are evolving to accommodate the increasing number of connected devices. Future operating system will need to seamlessly integrate with IoT devices, enabling users to control and monitor their smart homes, wearables, and other IoT devices from a central interface. For instance, Apple's HomeKit and Google's Android Things are platforms that allow users to manage their IoT devices through their operating system, providing a unified and convenient user experience.

1st Semester	Professional Elective (PE) DIGITAL VLSI DESIGN	M23MSP105A

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Digital Logic Design	Understanding of digital logic gates, combinational and sequential circuits, Boolean algebra, and truth tables.
2.	Circuit Theory	Familiarity with circuit analysis techniques such as Kirchhoff's laws, nodal and mesh analysis, Thevenin's and Norton's theorems.
3.	Electronic Devices and Circuits	Knowledge of semiconductor devices like MOSFETs and CMOS technology, including their characteristics, behavior, and basic operation.
4.	Computer Architecture	Understanding of computer organization and architecture, including CPU components, memory systems, and I/O interfaces.
5.	Digital Signal Processing (DSP)	Understanding of digital signal processing concepts, especially relevant for courses focusing on DSP ASIC design.

2. Competencies

S/L	Competency	KSA Description
1.	Digital Design:	**Knowledge**: Understanding of fundamental digital logic concepts, including Boolean algebra, logic gates, flip-flops, registers, and memory elements. **Skills**: Students can apply minimization techniques for Boolean expression simplification. **Attitudes**: Appreciation for the importance of logical simplification in digital system design.
2.	RTL Design:	**Knowledge**: Proficiency in Register Transfer Level (RTL) coding using hardware description languages (HDLs) like Verilog or VHDL to describe the behavior of digital circuits. **Skills**: Designing Register Transfer Level (RTL) coding circuits based on specifications. Analyzing and evaluating the performance of Register Transfer Level (RTL) coding circuits. **Attitudes**: Appreciation for the role of Register Transfer Level (RTL) coding in digital systems.
3.	Combinational and Sequential Logic Circuits	**Knowledge**: Understanding of flip-flops, registers, and sequential logic principles. **Skills**: Designing sequential logic circuits with flip-flops. Optimizing the behavior of sequential circuits. **Attitudes**: Valuing the importance of sequential logic in digital system functionality
4.	Verilog HDL	**Knowledge**: Understanding the structure of Verilog modules. Knowledge of Verilog operators and data types. **Skills**: Proficiency in writing synthesizable RTL code using HDLs like Verilog or VHDL. **Attitudes**: Openness to learning and using hardware description languages for design.
5.	Logic Design with MSI Components and PLDs	**Knowledge**: Understanding of MSI components and PLDs. **Skills**: Implementing binary adders, subtractors, comparators, and multiplexers. Utilizing programmable logic devices (PLDs) in logic design. **Attitudes**: Appreciation for the versatility of MSI components and PLDs in digital logic design.

3. **Syllabus**

DIGITAL VLSI DESIGN SEMESTER – I			
Course Code	**M23MSP105A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**

Course Learning Objectives:
At the end of the course, the student will be able to:
1. Explain VLSI Design Methodologies
2. Learn Static and Dynamic operation principles, analysis, and design of inverter circuits.
3. Infer state-of-the-art semiconductor memory circuits.
4. Outline the comprehensive coverage of Methodologies and Design practices that are used to reduce the Power Dissipation of large-scale digital circuits.
5. Illustrate VLSI and ASIC design

Module-1

MOS Transistor: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor, MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects.
MOS Inverters-Static Characteristics: Introduction, Resistive-Load Inverter, Inverters with type MOSFET Load.

Module-2

MOS Inverters-Static Characteristics: CMOS Inverter.
MOS Inverters: Switching Characteristics and Interconnect Effects: Introduction, Delay-Time Definition, Calculation of Delay Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitics, Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters

Module-3

Semiconductor Memories: Introduction, Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM), Nonvolatile Memory, Flash Memory, Ferroelectric Random Access Memory (FRAM).

Module-4

Dynamic Logic Circuits: Introduction, Basic Principles of Pass Transistor Circuits, Voltage Bootstrapping, Synchronous Dynamic Circuit Techniques, Dynamic CMOS Circuit Techniques, High Performance Dynamic CMOS circuits.
BiCMOS Logic Circuits: Introduction, Bipolar Junction Transistor (BJT): Structure and Operation, Dynamic Behavior of BJTs, Basic BiCMOS Circuits: Static Behavior, Switching Delay in BiCMOS Logic Circuits, BiCMOS Applications.

Module-5

Chip Input and Output (I/O) Circuits: Introduction, ESD Protection, Input Circuits, Output Circuits and L(di/dt) Noise, On Chip Clock Generation and Distribution, Latch-Up and Its Prevention.
Design for Manufacturability: Introduction, Process Variations, Basic Concepts and Definitions, Design of Experiments and Performance Modeling

Suggested Learning Resources: Books

1. Sung Mo Kang & Yosuf Leblebici, "CMOS Digital Integrated Circuits: Analysis and Design", Tata McGraw-Hill, Third Edition.
2. D.A.Hodges, "Analysis and Design of Digital Integrated Circuits (3/e)", MGH 2004.

Reference Book:

1. Hoi-Jun Yoo, Kangmin Lee and Jun Kyong Kim," Low-Power NoC for High-Performance SoC Design", CRC Press,2008.

Web links and Video Lectures (e-Resources):
https://www.mooc.org/
https://onlinecourses.nptel.ac.in/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2:	The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias Structure and Operation of MOS Transistor MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects. Introduction, Resistive-Load Inverter, Inverters with type MOSFET Load
2	Week 3-4:	Students will study MOS Inverters-Static Characteristics CMOS Inverter. Switching Characteristics and Interconnect Effects: Introduction, Delay-Time Definition, Calculation of Delay Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitic Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters.
3	Week 5-6:	Students will study Dynamic Logic Circuits: Introduction, Dynamic Random ASIC Construction Dynamic CMOS Circuit Techniques, High Performance Dynamic CMOS circuits Basic BiCMOS Circuits
4	Week 7-8:	Students will use Chip Input and Output (I/O) Circuits ESD Protection, Input Circuits, Design for Manufacturability
5	Week 9-10:	Students will study Design of Experiments and Performance Modeling Design of Experiments and Performance Modeling
6	Week 11-12:	Design of Experiments and Performance Modeling

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.
9	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.

6. Assessment Details

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10

(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)
Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:
Theory Course with 4, 3 and 2 Credits: Professional Core Course (PC)/Professional Elective/Open Elective

1. Question paper pattern will be ten questions.
2. Each question is set for 20marks.
3. The medium of the question paper shall be English unless otherwise it is mentioned.
4. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
5. The students have to answer 5 full questions selecting one full question from each module. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Digital Design Fundamentals	Students will grasp the fundamental concepts of digital logic design, including Boolean algebra, logic gates, combinational and sequential circuits, and finite state machines
2	Designing Combinational and Sequential Circuits	Students will learn to design and implement combinational circuits such as adders, multiplexers, and decoders, as well as sequential circuits such as flip-flops, registers, and counters using Verilog
3	Fundamental Concepts of VLSI Design:	Understand the basic principles and concepts of VLSI design, including semiconductor physics, CMOS technology, and IC fabrication processes.
4	ASIC Design Methodologies:	Learn various ASIC design methodologies, including RTL design, synthesis, place-and-route, and timing closure.
5	ASIC Synthesis and	Optimization: Understand logic synthesis techniques to optimize the design for area, power, and performance goals.
6	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
7	Physical Design Concepts:	Familiarize with physical design concepts such as floor planning, placement, clock tree synthesis, routing, and power grid design.
8	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
9	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes and Mapping with POs/ PSOs

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP105A.1	**Understanding** of semiconductor devices, including MOS transistors, CMOS inverters, dynamic logic circuits, BiCMOS circuits, and chip input/output circuits.
M23MSP105A.2	**Develop** proficiency in designing semiconductor circuits, including CMOS inverters, dynamic logic circuits, BiCMOS circuits, and chip input/output circuits, considering factors such as scaling, interconnect effects, and manufacturability.
M23MSP105A.3	**Analyze** and evaluate semiconductor circuits' static and dynamic characteristics, including current-voltage characteristics, delay times, power dissipation, and performance trade-offs, using appropriate analytical and simulation tools.
M23MSP105A.4	**Demonstrate** semiconductor device and circuit concepts using various teaching methods, such as chalk and talk or PowerPoint presentations, demonstrating clarity, coherence, and engagement with the subject matter.

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP105A.1	3	3	-	3	-
M23MSP105A.2	3	-	3	3	-
M23MSP105A.3	3	-	-	-	-
M23MSP105A.4	3	3	3	-	-
M23MSP105A	**3**	**3**	**3**	**3**	**-**

9.Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**2**	**3**	**2**	**3**	**10**
Total	**12**	**13**	**12**	**13**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**4**	**6**	**4**	**6**	**20**
Total	**24**	**26**	**24**	**26**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

The future of ASIC design in VLSI is promising, driven by advancements in technology, evolving design methodologies, and emerging application areas. Here's how the subject is expected to evolve:

1. Technology Advancements: As semiconductor technology continues to advance, with the transition to smaller process nodes and the integration of novel materials and structures, ASIC designers will have access to more advanced and efficient building blocks. This will enable the development of ASICs with higher performance, lower power consumption, and increased integration levels.
2. Specialized ASICs for Emerging Applications: With the proliferation of emerging technologies such as artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and autonomous systems, there will be a growing demand for specialized ASICs tailored to these applications. ASIC designers will need to innovate and develop customized solutions optimized for specific use cases, offering improved performance, efficiency, and cost-effectiveness compared to general-purpose processors.
3. Heterogeneous Integration: The integration of diverse technologies, such as digital logic, analog circuits, MEMS (Micro-Electro-Mechanical Systems), and photonics, into a single ASIC will become more prevalent. This trend towards heterogeneous integration will require ASIC designers to possess expertise in integrating and optimizing diverse components, enabling the development of highly integrated and multifunctional systems-on-chip (SoCs).
4. Design for Security and Trustworthiness: With the increasing concerns about cybersecurity and intellectual property protection, ASIC designers will need to prioritize security and trustworthiness in their designs. This includes implementing hardware security features, such as encryption, authentication, and secure boot mechanisms, as well as ensuring the integrity and confidentiality of sensitive data processed by ASICs.

5. Advanced Design Methodologies: Future ASIC design methodologies will likely leverage advanced automation techniques, machine learning algorithms, and predictive analytics to streamline the design process, improve design productivity, and optimize design outcomes. Additionally, there will be a continued shift towards higher levels of abstraction and design reuse, enabling faster time-to-market and greater design scalability.
6. Energy-Efficient Computing: As energy efficiency becomes a critical consideration in both mobile and data center applications, ASIC designers will focus on developing energy-efficient designs that minimize power consumption without compromising performance. This will involve the adoption of low-power design techniques, dynamic voltage and frequency scaling, and architectural innovations aimed at maximizing energy efficiency.

Overall, the future of ASIC design in VLSI is characterized by innovation, specialization, and adaptability to evolving technological trends and application requirements. ASIC designers will play a crucial role in driving the development of cutting-edge semiconductor solutions that power the next generation of electronic devices and systems.

1st Semester	Professional Elective (PE) MULTIRATE SYSTEMS AND FILTERS BANKS	M23MSP105B

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1	Linear Algebra & Calculus:	Understanding vector spaces, matrices, eigenvalues, eigenvectors, and linear transformations. Proficiency in differential and integral calculus, including multivariable calculus.
2	Complex Analysis & Probability and Statistics	Basics of complex numbers, complex functions, and their properties. Basic concepts of probability, random variables, and statistical methods.
3	Signals and Systems	Knowledge of continuous and discrete-time signals and systems, including convolution, Fourier series, and Fourier transforms. Concepts of linear time-invariant (LTI) systems, impulse response, and frequency response.
4	Digital Signal Processing (DSP)	Understanding of z-transform, discrete Fourier transforms (DFT), and fast Fourier transforms (FFT).
5	Programming Skills	Familiarity with a programming language such as MATLAB, Python, or any other language commonly used for signal processing tasks.

2. **Competencies**

S/L	Competency	KSA Description
1	Mathematical Proficiency	**Knowledge:** Ability to manipulate and analyze multivariate data using matrix and vector operations. **Skill**: Proficiency in handling complex variables and functions crucial for signal transformation and analysis. **Attitude**: Understanding of calculus in higher dimensions, essential for analyzing multivariate systems.
2	Signal Processing Skills	**Knowledge**: Competence in analyzing and processing signals in multiple dimensions (e.g., spatial, temporal, or frequency). **Skill**: Ability to design and implement various types of filters, including FIR and IIR filters, for different signal processing applications. **Attitude:** Understanding wavelet transforms and multirate processing techniques, including down-sampling, up-sampling, and polyphase decomposition.
3	System Theory and Applications	**Knowledge** Modeling complex systems using state-space representations and understanding their behavior. **Skill**: Ability to analyze and ensure the stability and control of multivariate systems. **Attitude:** Competence in dealing with signals from multiple sources or channels, which is crucial in applications like MIMO (Multiple Input Multiple Output) systems in communications.
4	Computational and Programming Skills	**Knowledge**: Ability to develop and implement algorithms for signal processing tasks using programming languages like MATLAB, Python, or C++. **Skills:** Using software tools for simulating and analyzing multivariate systems and filter banks. **Attitude:** Proficiency in handling large datasets and performing multivariate statistical analysis.

5	Application-Specific Knowledge	**Knowledge**: Understanding the role of filter banks and multivariate processing in modern communication systems, including modulation, demodulation, and data compression. **Skills:** Applying multivariate techniques to process and analyze images and videos, essential in fields like computer vision and multimedia. **Attitude:** Analyzing multichannel biomedical signals (e.g., EEG, ECG) for medical diagnosis and research.
6	Problem-Solving and Analytical Skills	**Knowledge**: Developing strong analytical skills to approach and solve complex problems in signal processing and system analysis. **Skills:** Ability to innovate and apply theoretical knowledge to practical and real-world problems in various industries.
7	Interdisciplinary Knowledge	**Knowledge**: Integrate knowledge from other disciplines such as machine learning, data science, and electrical engineering to enhance signal processing techniques. **Skills:** Working on projects that involve designing, simulating, and implementing multivariate systems and filters. **Attitude:** Conducting research to stay updated with the latest advancements and applying new techniques to existing problems.

3. Syllabus

MULTIRATE SYSTEMS AND FILTERS BANKS SEMESTER – I			
Course Code	**M23MSP105B**	CIE Marks	**50**
Number of Lecture Hours/Week (L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**
Course Learning objectives: Describe the need of multi-rate systems and it applications. Understand the theory of multi-rate DSP, solve numerical problems and write algorithms. Understand theory of prediction and solution of normal equation			
Module -1			
Fundamentals of Multirate Systems: Basic multi-rate operations, interconnection of building blocks, poly-phase representation, multistage implementation, applications of multi-rate systems, special filters and filter bank .			L2, L4
Module -2			
Maximally decimated filter banks: Errors created in the QMF bank, alias-free QMF system, power symmetric QMF banks, M-channel filter banks, poly-phase representation, perfect reconstruction systems, alias-free filter banks, tree structured filter banks, trans-multiplexers			L2, L4
Module -3			
Para-unitary Perfect Reconstruction Filter Banks: Lossless transfer matrices, filter bank properties induced by para-unitariness, two channel Para-unitary lattices, M-channel FIR Para-unitary QMF banks, transform coding			L2, L4
Module-4			
Linear Phase Perfect Reconstruction QMF Banks: Necessary conditions, lattice structures for linear phase FIR PR QMF banks, formal synthesis of linear phase FIR PR QMF lattice Cosine Modulated Filter Banks: Pseudo-QMF bank and its design, efficient poly-phase structures, properties of cosine matrices, cosine modulated perfect reconstruction systems			L2, L4
Module-5			
Multi resolution Signal Processing: Introduction, Relationship between Functions, Sequences, Vectors, Need for Transformations, Inability of Simultaneous Time and Band Limitedness, Conjugate Quadrature Filter Bank, Z-domain Analysis of Filter Bank, Aliasing Cancellation, Perfect Reconstruction: Conjugate Quadrature, Condition for Perfect Reconstruction, Polynomial as an Input, Conjugate Quadrature Filter Bank Exercises(Text 2, chapter 1,chapter 5)			L2, L4

Suggested Learning Resources:
Books
1. P.P.Vaidyanathan, "Multirate Systems and Filter Banks", Pearson Education (Asia) Pte. Ltd, 2004.
2. Vikram Gadre & Aditya Abhyankar "Multi resolution and Multirate Signal Processing: Introduction, Principles and Applications" McGraw Hill Education, First edition (2017).
1. N.J.Fliege, "Multirate Digital Signal Processing‖, John Wiley & Sons, USA, 2000.
2. Steven M. Kay "Modern Spectral Estimation" Pearson Education, First edition (2017)

Web links and Video Lectures (e-Resources):
https://www.mooc.org/ **https://onlinecourses.nptel.ac.in/**

Skill Development Activities Suggested
To implement the filter bank and its spectrum using Mat lab software

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Fundamentals of Multirate Systems:	Fundamentals of Multirate Systems involve techniques that process signals at multiple sampling rates. Key concepts include down-sampling (reducing the sampling rate) and up-sampling (increasing the sampling rate), essential for efficient signal processing. Polyphase decomposition is a critical method that simplifies the implementation of multirate filters. Applications include sub band coding, where a signal is split into different frequency bands for more efficient compression and transmission. Designing systems that balance performance and computational efficiency in various signal processing tasks.
2	Week 3-4: Maximally decimated filter banks:	Explain maximally decimated filter banks decompose a signal into sub bands, each processed at a lower sampling rate. Introduce the concept of perfect reconstruction, where the original signal can be exactly reconstructed from the sub bands. Highlight the concept of perfect reconstruction, where the original signal can be precisely recovered from the sub bands after up sampling and filtering. Introduce key components: analysis filters, which split the input signal, and synthesis filters, which recombine the sub bands. Emphasize the role of down sampling and up sampling in reducing the data rate and maintaining the original signal's bandwidth. Conclude with practical applications, such as data compression and multi-resolution analysis, showcasing their significance in signal processing.
3	Week 5-6 Para-unitary Perfect Reconstruction Filter Banks:	Define para-unitary perfect reconstruction filter banks as filter banks that ensure perfect reconstruction with filters that are para-unitary, meaning their filter matrices are unitary. Explain that this unitary property implies energy preservation and orthogonality, ensuring no information loss during decomposition and reconstruction. Illustrate how analysis filters decompose the signal into sub bands, and synthesis filters reconstruct the original signal from these sub bands, maintaining perfect reconstruction due to the para-unitary condition. Highlight the mathematical foundation, where the product of the analysis and synthesis filter matrices equals the identity matrix. Finally, demonstrate their applications in areas like signal compression and multi-resolution analysis, emphasizing their
4	Week 7-8-9: Linear Phase Perfect Reconstruction QMF Banks:	Linear phase filters are characterized by constant group delay across all frequencies. In QMF banks, analysis filters decompose a signal into sub bands, and synthesis filters reconstruct the original signal with linear phase properties. The key to perfect reconstruction lies in ensuring the synthesis filters are time-reversed versions of the analysis filters. Quadrature mirror filters, with mirrored frequency responses about the Nyquist frequency, are integral to maintaining perfect reconstruction in QMF banks. Through these methods, QMF banks facilitate efficient signal decomposition and reconstruction with minimal distortion, crucial in various signal processing applications.

5	Week 10-11-12: Multi resolution Signal Processing:	Explain sequences, vectors, and the need for transformations; start with intuitive examples illustrating how signals can be represented as sequences or vectors in different domains. Highlight the limitations of simultaneously achieving time and band limitedness in signal processing tasks, motivating the use of transformation techniques like filter banks. Introduce the concept of Conjugate Quadrature Filter Bank (CQFB) and its advantages in signal decomposition. Dive into Z-domain analysis to illustrate the behavior of filter banks in the digital domain, emphasizing aliasing cancellation and perfect reconstruction properties. Engage students with exercises that involve analyzing the conditions for perfect reconstruction, applying polynomial inputs, and designing Conjugate Quadrature Filter Banks for specific signal processing tasks.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Multivariate Systems and Filters Banks Concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate a deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up for Professional Course (PC)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examinations (SEE):

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description

1	Understanding the fundamentals of multirate signal processing	Understanding the fundamentals of multirate signal processing, which involves analyzing and processing signals with multiple dimensions or variables.
2	Filter banks in multirate signal processing	Exploring the theory and applications of filter banks in multirate signal processing, including their role in decomposition, reconstruction, and feature extraction from multirate signals.
3	Perfect reconstruction filter banks	Mastering the principles of perfect reconstruction filter banks in the multivariate domain, ensuring an understanding of the conditions required for faithful signal reconstruction.
4	implementation of multivariate filter banks	Learning about the design and implementation of multivariate filter banks, including techniques for designing analysis and synthesis filters to achieve specific signal processing goals.
5	applying multivariate filter banks to various signal processing tasks	Developing practical skills in applying multivariate filter banks to various signal processing tasks, such as image and video compression, biomedical signal analysis, and multichannel audio processing.
4	Gaining insights into advanced topics in multivariate signal processing	Gaining insights into advanced topics in multivariate signal processing and filter bank design, such as adaptive filtering, wavelet transforms, and applications in machine learning and data analysis.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP105B.1	Analyze the multirate systems
M23MSP105B.2	Analyze decimated filter banks and reconstruction filter banks
M23MSP105B.3	Design QMF banks and efficient poly–phase structures
M23MSP105B.4	Implement multi rate systems

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP105B.1	2	-	-	2	2
M23MSP105B.2	3	-	-		
M23MSP105B.3	3	2	-	2	2
M23MSP105B.4	3	3	2	3	3
M23MSP105B	2.75	2.33	2	2.33	2.33

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**

Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

10. Future with this Subject

The future of studying Multirate Systems and Filter Banks is promising and multifaceted:

1. **Advanced Signal Processing**: As technology progresses, there will be an increasing demand for advanced signal processing techniques to handle complex multivariate data arising from diverse fields such as neuroscience, finance, and environmental monitoring. Studying multivariate systems and filter banks equips researchers and practitioners with the tools to extract meaningful information from these complex datasets.
2. **Machine Learning and AI**: Multiratesystems and filter banks play a crucial role in feature extraction and dimensionality reduction, which are essential steps in many machine learning and artificial intelligence algorithms. Future research will likely focus on integrating Multiratesignal processing techniques with machine learning models to enhance their performance in tasks such as pattern recognition, classification, and anomaly detection.
3. **Data Fusion and Integration**: With the proliferation of sensors and data sources in various applications, there is a growing need for methods to integrate and fuse Multiratedata streams effectively. Studying filter banks enables researchers to develop algorithms for combining information from different modalities while preserving relevant features and reducing noise.
4. **Biomedical Engineering and Healthcare**: In biomedical engineering and healthcare, Multi rate systems and filter banks are vital for analyzing complex physiological signals such as EEG, ECG, and fMRI data. Future advancements in this field will involve developing innovative signal processing techniques to improve diagnostic accuracy, patient monitoring, and personalized healthcare.
5. **Communication Systems**: In communication systems, Multiratefilter banks are essential for signal modulation, demodulation, and channel equalization in modern wireless communication technologies. Future research will focus on developing robust and efficient filter bank designs to meet the increasing demands for high-speed data transmission and reliable communication in wireless networks.

1st Semester	Professional Elective (PE) MICRO ELECTRO MECHANICAL SYSTEMS	M23MSP105C

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Understanding of MEMS and Microsystems	Basic knowledge of electronics and microelectronics. Understanding of fundamental physics concepts, including atomic structure and molecular theory. Background in electrical engineering principles.
2.	Analyzing Working Principles of Microsystems	Knowledge of the working principles of various MEMS components such as micro sensors, actuators, accelerometers, and microfluidics.
3.	Applying Engineering Science to Microsystems Design and Fabrication	Apply engineering science principles such as atomic structure, ionization, molecular theory, doping, diffusion, plasma physics, and electrochemistry to the design and fabrication of MEMS. Introduction to semiconductor devices and fabrication techniques.
4.	Conducting Mechanical Analysis for Microsystems Design	Familiarity with principles of mechanics and materials science.
5.	Designing Microsystems Using Finite Element Methods	Introduction to computer-aided design (CAD) tools. Basic knowledge of electronics and microelectronics. Familiarity with principles of mechanics and materials science.

2. Competencies

S/L	Competency	KSA Description
1.	Research and Problem-Solving in MEMS	**Knowledge:** In-depth understanding of MEMS technology and its applications. Advanced research methodologies and experimental design. **Skills:** Critical thinking and problem-solving. Data analysis and interpretation. Experimentation and innovation in MEMS. **Attitudes:** Curiosity and motivation for independent research. Persistence in solving complex problems. Ethical conduct in research.
2.	Advanced Analysis and Design of MEMS Components and Systems	**Knowledge:** Principles of mechanical analysis, scaling laws, and micro-manufacturing. Advanced design methodologies for MEMS. **Skills:** Application of theoretical knowledge to practical design. Use of design and simulation software. Optimization techniques for MEMS components. **Attitudes:** Attention to detail and precision in design. Openness to innovative design approaches. Commitment to continuous improvement and learning.
3.	Application of Advanced Engineering Science in MEMS Fabrication	**Knowledge:** Atomic and molecular theory, ionization, and electrochemistry. Micro-manufacturing processes and techniques. **Skills:** Application of scientific principles to MEMS fabrication. Use of FEM and other advanced simulation tools. Precision in manufacturing and fabrication processes. **Attitudes:** Commitment to precision and accuracy. Innovation in applying scientific principles to practical problems. Collaboration and teamwork in research and fabrication.
4.	Technical	**Knowledge:**

	Communication and Documentation in MEMS	Best practices in technical writing and documentation. Presentation skills and techniques. **Skills:** Writing detailed and comprehensive technical reports. Delivering clear and effective presentations. Summarizing complex technical information for various audiences. **Attitudes:** Clarity and precision in communication. Confidence in presenting technical information. Responsiveness to feedback and willingness to improve.

3. Syllabus

MICRO ELECTRO MECHANICAL SYSTEMS **SEMESTER-I**			
Course Code	**M23MSP105C**	CIE Marks	**50**
Teaching Hours/Week (L:P:S DA)	**2:0:2**	SEE Marks	**50**
Total Hours of Pedagogy	**25 hours Theory + 10-12 slots for SDA**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning Objectives:

To explain MEMS

To understand the working principles of micro systems

To analyze the scaling laws in miniaturization

Understand the technologies related to Micro Electro Mechanical Systems.

Analyse MEMS devices and develop suitable mathematical models

Understanding of application areas for MEMS devices

Fabrication processes involved with MEMS devices.

Module-1

Overview of MEMS and Microsystems: MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Microfabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems, Miniaturization. Applications and Markets.

Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.

Module-2

Working Principles of Microsystems: Introduction, Microsensors, Micro actuation, MEMS with Micro actuators, Micro accelerometers, Microfluidics.

Engineering Science for Microsystems Design and Fabrication: Introduction, Atomic Structure of Matters, Ions and Ionization, Molecular Theory of Matter and Inter-molecular Forces, Doping of Semiconductors, The Diffusion Process, Plasma Physics, Electrochemistry

Teaching-Learning Process	Chalk and Talk / Power Point Presentations.

Module-3

Engineering Mechanics for Microsystems Design: Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermo mechanics, Fracture Mechanics, Thin Film Mechanics, Overview on Finite Element Stress Analysis.

Teaching-Learning Process	Chalk and Talk / Power Point Presentations.

Module-4

Scaling Laws in Miniaturization: Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling of Electromagnetic Forces, Scaling in Electricity, Scaling in Fluid Mechanics, Scaling in Heat Transfer.

Teaching-Learning Process	Chalk and Talk / Power Point Presentations.

Module-5

Overview of Micro-manufacturing: Introduction, Bulk Micro-manufacturing, Surface Micromachining, The LIGA Process, Summary on Micro manufacturing.

Microsystem Design: Introduction, Design Considerations, Process Design, Mechanical Design, Using Finite Element Method.

Teaching-Learning Process	Chalk and Talk / Power Point Presentations.

Suggested Learning Resources:

Text Book:

1. ‘MEMS and Micro systems: Design, Manufacture and Nanoscale Engineering’, Tai-Ran Hsu, John Wiley & Sons, ISBN: 978-0470-08301-7, 2nd Edition, 2008
2. ‘Micro and Nano Fabrication: Tools and Processes’, Hans H. Gatzen, Volker Saile, Jurg Leuthold, Springer, 2015

Reference Books:
1. 'Micro Electro Mechanical Systems (MEMS)', Dilip Kumar Bhattacharya, Brajesh Kumar Kaushik, Cengage Learning.
Web links and Video Lectures (e-Resources):
https://www.mooc.org/ **https://onlinecourses.nptel.ac.in/**
Skill Development Activities Suggested To set up the MEMS model Interact with industry (small, medium, and large). Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem. Involve in case studies and field visits/ fieldwork. Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1.	Week 1-2: Overview of MEMS and Microsystems Typical MEMS Products	Introduction to MEMS and Microsystems Evolution and applications Market trends Learning Objectives: Understand the significance and applications of MEMS technology Case studies of common MEMS products Discussion on miniaturization Learning Objectives: Identify and describe real-world MEMS products.
2.	Week 3-4: Working Principles of Micro Sensors and Actuators Micro Accelerometers and Micro Fluidics	Introduction to micro sensors and actuators Learning Objectives: Explain the working principles of various MEMS components. Detailed study on micro accelerometers and fluidics Learning Objectives: Analyze the design and functionality of accelerometers and fluidic systems.
3.	Week 5-6: Engineering Science for Microsystems Design Molecular Theory and Inter-molecular Forces	Atomic structure, ions, and ionization Learning Objectives: Apply basic scientific principles to microsystem design. Doping, diffusion process, plasma physics Learning Objectives: Understand and apply molecular and plasma principles in MEMS.
4.	Week 7-8: Mechanics for Microsystems Design Fracture and Thin Film Mechanics	Static bending, vibrations, and thermo mechanics Learning Objectives: Perform mechanical analysis of MEMS components. Fracture mechanics and thin film mechanics overview Learning Objectives: Evaluate the mechanical integrity of MEMS.
5.	Week 9-10: Scaling Laws in Miniaturization Scaling in Various Domains	Introduction to scaling laws Learning Objectives: Predict system behavior based on scaling principles. Scaling in dynamics, electrostatics, electromagnetics, fluid mechanics, and heat transfer Learning Objectives: Apply scaling laws to different physical phenomena.
6.	Week 11-12: Micro-manufacturing Techniques Microsystem Design Considerations	Bulk manufacturing, surface micromachining, LIGA process Learning Objectives: Understand and implement micro-manufacturing processes. Process design, mechanical design, and FEM Learning Objectives: Utilize FEM in MEMS design and optimize design processes.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1.	Lecture Method	Utilize various teaching methods within the lecture format to reinforce

		competencies.
2.	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3.	Collaborative Learning	Encourage collaborative learning for improved competency application.
4.	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5.	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies.
6.	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7.	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate a deeper understanding of competencies.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation (CIE):

The minimum CIE marks requirement is 40% of the maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
i.	Internal Assessment-Tests (A)	2	50%	25	10
ii.	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

The average internal assessment shall be the average of the two test marks scored.

Semester End Examination:

1. The question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub-questions), may have a mix of topics under that module if necessary.
4. The students have to answer five full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1.	Understanding MEMS and Microsystems	Gain a comprehensive understanding of the history, evolution, significance, applications, and market trends of MEMS and Microsystems. This includes an exploration of how miniaturization impacts technology and the various fields in which MEMS are applied.
2.	Analyzing Working Principles of Microsystems	Analyze and describe the working principles of various MEMS components such as micro sensors, actuators, accelerometers, and microfluidics. This involves understanding how these components operate and are utilized in different MEMS devices.
3.	Applying Engineering Science to Microsystems Design and Fabrication	Apply principles from engineering science, including atomic structure, ionization, molecular theory, doping, diffusion, plasma physics, and electrochemistry, to the design and fabrication processes of MEMS. This knowledge forms the foundation for creating functional and efficient MEMS devices.
4.	Conducting Mechanical Analysis for Microsystems Design	Perform detailed mechanical analysis of MEMS components, focusing on static bending, vibrations, thermo mechanics, fracture mechanics, and thin film mechanics. This objective ensures that students can evaluate the mechanical integrity and behavior of MEMS under various conditions.
5.	Utilizing Scaling Laws in Miniaturization	Understand and utilize scaling laws in geometry, dynamics, electrostatic forces, electromagnetic forces, fluid mechanics, and heat transfer to predict and design MEMS systems. This knowledge helps in designing MEMS that function effectively at micro and nano scales.

6.	Implementing Micro-manufacturing Techniques	Implement various micro-manufacturing techniques including bulk manufacturing, surface micromachining, and the LIGA process. This objective covers the practical aspects of producing MEMS and the methods used to achieve precision at micro scales.
7.	Designing Microsystems Using Finite Element Methods	Design and optimize MEMS components using finite element methods (FEM) and other computer-aided design (CAD) tools. This objective focuses on equipping students with the skills to use advanced simulation and design software for developing MEMS devices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP105C	Conduct Research and Solve Practical Problems in MEMS.
M23MSP105C	Apply Advanced Engineering Science in MEMS Fabrication.
M23MSP105C	Analyze and Design MEMS Components and Systems.
M23MSP105C	Communicate Technical Findings in MEMS.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP105C.1	3	2	3	3	3
M23MSP105C.2	2	1	3	3	3
M23MSP105C.3	2	1	3	3	3
M23MSP105C.4	1	3	2	3	3
M23MSP105C	**2**	**1.75**	**2.75**	**3**	**3**

9. Assessment Plan

10. Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

11.

12. Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

10. Future with this Subject

By understanding MEMS technology, students can apply these principles across various engineering disciplines, leading to innovations and advancements in multiple fields. The interdisciplinary nature of MEMS ensures that its principles and applications are relevant and beneficial to a wide range of courses and industries.

1st Semester	Professional Elective (PE) RECONFIGURABLE COMPUTING	M23MSP105D

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Digital Logic Design	Understanding digital circuits and logic gates is fundamental. This includes Boolean algebra, combinational logic, sequential logic, and basic digital design principles.
2.	Field-Programmable Gate Arrays (FPGAs)	FPGAs are a common platform for reconfigurable computing, knowledge of FPGA architecture, programming (using hardware description languages like Verilog or VHDL), and the concept of logic blocks, routing resources, and configuration memory is essential.
3.	Embedded Systems	Familiarity with embedded systems concepts is beneficial, as reconfigurable computing often involves integrating hardware and software components tightly.
4.	Computer Architecture	Understanding computer architecture basics helps in grasping how reconfigurable computing fits into the broader landscape of computing systems.
5.	Digital Signal Processing	Knowledge of DSP algorithms and techniques is valuable since FPGAs are often used for real-time signal processing applications.
6.	Programming Skills	While traditional software programming (like C/C++) is useful, familiarity with hardware description languages (HDLs) such as Verilog or VHDL is crucial for programming FPGAs.

2. Competencies:

S/L	Competency	KSA Description
1.	Digital Logic Design	**Knowledge:** Understanding and designing digital circuits using logic gates, flip-flops, registers, and other digital components. **Skills:** Proficiency in Boolean algebra, designing of logic gates, K-map, flip flops, etc. **Attitudes:** Commitment to writing error-free design and adhering to Boolean expression.
2.	Hardware Description Languages	**Knowledge:** Students should be configuring and tune the HDL, VHDL or Verilog to get good or better performance. **Skills:** Proficiency in HDLs like Verilog or VHDL for programming and configuring FPGAs. **Attitudes:** Appreciation for the role of VHDL and HDL algorithms in an efficient and organized way.
3.	FPGA Architecture and Tools	**Knowledge:** Familiarity with FPGA architectures, including logic blocks, routing resources, configuration memory, and tools like Xilinx Vivado or Intel Quartus. **Skills:** Skill to using tools like Xilinx, ASIC, etc. **Attitudes:** Selecting and preparing a modern tools and using it to make predictions on new design.
4.	Embedded Systems Design	**Knowledge:** Ability to integrate FPGA-based designs into embedded systems, including interfacing with processors, memory, and peripherals. **Skills:** Demonstration of RISC and CISC tools for using problem domains and specific

		problem instances where the techniques may perform well or even be state-of-the-art. **Attitudes:** embedded systems concepts is beneficial, as reconfigurable computing often involves integrating hardware and software components tightly
5.	Parallel Computing Concepts	**Knowledge:** Understanding parallel computing principles and how they apply to reconfigurable computing architectures. **Skills:** Reconfigurable computing often involves parallel processing and concurrent execution. **Attitudes:** Domain-specific knowledge in areas such as telecommunications, image processing, cryptography, etc., to effectively apply reconfigurable computing solutions.

3. Syllabus

RECONFIGURABLE COMPUTING
SEMESTER – I

Course Code	**M23MSP105D**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours Theory 10-12 slots for SDA**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- Understand the fundamental principles and practices in reconfigurable architecture.
- Simulate and synthesize the reconfigurable computing architectures.
- Understand the FPGA design principles and logic synthesis
- Integrate hardware and software technologies for reconfiguration computing focusing on partial reconfiguration design.
- Design digital systems for various applications on signal processing, image, video, and network security.

Module -1	
Introduction: History, Reconfigurable vs Processor based system, RC Architecture, Domains of RC, Fields of Application. **Reconfigurable Logic Devices:** Reconfigurable Processing Fabric (RPF) Architectures: Fine-grained, Field Programmable Gate Array, Coarse Grained Reconfigurable Arrays. **Reconfigurable Computing System:** Parallel Processing on Reconfigurable Computers, A survey of Reconfigurable Computing System, Integration of RPF into Traditional Computing Systems.	L2, L3
Module -2	
Languages and Compilation: Design Cycle, Languages, HDL, High-Level Compilation, Low-level Design Flow, Debugging Reconfigurable Computing Applications.	L2, L3
Module -3	
Implementation: Integration, FPGA Design flow, Logic Synthesis. **High-Level Synthesis for Reconfigurable Devices:** Modelling, Temporal Partitioning Algorithms, Offline and Online Temporal Placement, Managing the Device’s Free Space with Empty Rectangles, Managing the Device’s Occupied Space, NoC, Dynamic NoC.	L2, L3
Module -4	
Partial Reconfiguration Design: Partial Reconfiguration Design, Bitstream Manipulation with J Bits, the modular Design flow, The Early Access Design Flow, Creating Partially Reconfigurable Designs, Partial Reconfiguration using Hansel-C Designs, Platform Design.	L2, L3
Module -5	
Signal Processing Applications: Reconfigurable computing for DSP, DSP application building blocks, Examples: Beamforming, Software Radio, Image and video processing, Local Neighborhood functions, Convolution, Cryptographic Applications, RC Cryptographic Algorithm Implementations	L2, L3

Text Books:

1. 'Reconfigurable Computing: Accelerating Computation with Field Programmable Gate Arrays', M. Gokhale and P. Graham, Springer, ISBN: 978-0-387-26105-8, 2005.
2. 'Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications', C. Bobda, Springer, ISBN: 978-1-4020-6088-5, 2007.

Reference Books:

1. 'Practical FPGA Programming in C', D. Pellerin and S. Thibault, Prentice-Hall, 2005.
2. 'FPGA Based System Design', W. Wolf, Prentice-Hall, 2004.
3. 'Rapid System Prototyping with FPGAs: Accelerating the Design Process', R. Cofer and B. Harding, Newnes, 2005.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction, Reconfigurable logic devices	History, Reconfigurable vs Processor based system, RC Architecture, Domains of RC, Fields of Application. Reconfigurable Processing Fabric (RPF) Architectures: Fine-grained, Field Programmable Gate Array, Coarse Grained Reconfigurable Arrays.
2	Week 3-4: Reconfigurable Computing System, Languages and Compilation	Parallel Processing on Reconfigurable Computers, A survey of Reconfigurable Computing System, Integration of RPF into Traditional Computing Systems. Design Cycle, Languages, HDL, High-Level Compilation, Low-level Design Flow, Debugging Reconfigurable Computing Applications.
3	Week 5-6: Implementation, High-Level Synthesis for Reconfigurable Devices	Integration, FPGA Design flow, Logic Synthesis. Modeling, Temporal Partitioning Algorithms, Offline and Online Temporal Placement
4	Week 7-8: High-Level Synthesis for Reconfigurable Devices	Managing the Device's Free Space with Empty Rectangles, Managing the Device's Occupied Space, NoC, Dynamic NoC.
5	Week 9-10: Partial Reconfiguration Design	Partial Reconfiguration Design, Bitstream Manipulation with J Bits, the modular Design flow, The Early Access Design Flow, Creating Partially Reconfigurable Designs, Partial Reconfiguration using Hansel-C Designs, and Platform Design.
6	Week 11-12: Signal Processing Applications	Reconfigurable computing for DSP, DSP application building blocks, Examples: Beamforming, Software Radio, Image and video processing, Local Neighborhood functions, Convolution, Cryptographic Applications, RC Cryptographic Algorithm Implementations

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application
4	Higher Order Thinking (HOTS)	Pose HOTS questions to stimulate critical thinking related to each competency

	Questions:	
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation (CIE):

The minimum CIE marks requirement is 40% of the maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
i.	Internal Assessment-Tests (A)	2	50%	25	10
ii.	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

The average internal assessment shall be the average of the two test marks scored.

Semester End Examination:

1. The question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub-questions), may have a mix of topics under that module if necessary.
4. The students have to answer five full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Reconfigurable Computing Concepts	Define reconfigurable computing and its significance in modern computing paradigms. Explain the differences between fixed hardware and reconfigurable hardware architectures. Understand the advantages and limitations of reconfigurable computing compared to traditional computing paradigms.
2	FPGA Architecture and Programming	Describe the architecture of Field-Programmable Gate Arrays (FPGAs), including logic blocks, routing resources, and configuration memory. Learn to use Hardware Description Languages (HDLs) such as Verilog or VHDL to program FPGAs. Understand the synthesis, place-and-route, and timing analysis processes involved in FPGA design.
3	Digital Logic and Circuit Design	Acquire foundational knowledge in digital logic design principles, Boolean algebra, combinational and sequential logic circuits. Design and implement basic digital circuits using logic gates, flip-flops, and registers. Apply these principles to design more complex digital systems on FPGAs.
4	Applications of Reconfigurable Computing	Explore various application domains where reconfigurable computing is beneficial, such as signal processing, cryptography, telecommunications, and embedded systems. Understand how reconfigurable computing can be used to accelerate specific algorithms or tasks compared to traditional CPU or GPU implementations. Study case studies and examples of successful applications of reconfigurable

		computing in real-world scenarios.
5	Performance Optimization and Parallelism	Learn techniques for optimizing designs on FPGAs for speed, resource utilization, and power efficiency. Understand parallel computing concepts and how they apply to FPGA-based designs. Experiment with parallelism strategies to maximize the performance of reconfigurable computing systems.
6	System Integration and Co-design	Integrate FPGA-based designs with software components, including embedded processors, operating systems, and application software. Design systems where hardware and software components interact efficiently, leveraging the strengths of reconfigurable computing.
7	Debugging, Testing, and Verification	Develop skills in debugging hardware designs on FPGAs, including simulation-based and hardware-based debugging techniques. Design and implement comprehensive testing strategies to verify the functionality and reliability of FPGA-based systems.
8	Research and Innovation	Explore current research trends and innovations in reconfigurable computing, including new architectures, algorithms, and applications. Conduct research projects or experiments to contribute to advancing the state-of-the-art in reconfigurable computing.
9	Ethical and Practical Considerations	Discuss ethical considerations related to the use of reconfigurable computing technologies, such as privacy, security, and environmental impact. Understand societal implications of deploying reconfigurable computing systems in various domains.
10	Professional Skills and Communication	Enhance communication skills for effectively presenting and explaining reconfigurable computing concepts and projects to diverse audiences. Collaborate effectively in interdisciplinary teams that include hardware engineers, software developers, and domain experts.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP105D.1	Understand the new paradigm of Computing which offers flexibility, scalability, and performance
M23MSP105D.2	Understand the notion of system/circuit redesign on the fly using dynamic reconfiguration
M23MSP105D.3	Able to optimize the given system specific to underlying reconfigurable hardware
M23MSP105D.4	Able to bring the notion of the evolvable circuit on Reconfigurable hardware
M23MSP105D.5	Designing reconfigurable computing and how to utilize it for solving challenging computational problems

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP105D.1	3	-	-	-	-
M23MSP105D.2	3	2	2	3	-
M23MSP105D.3	3	2	2	3	2
M23MSP105D.4	3	3	3	3	2
M23MSP105D.5	3	3	3	3	2
M23MSP105D	**3**	**2.33**	**2.33**	**3**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**

Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The future of reconfigurable computing holds significant promise and is poised to impact various aspects of technology and industry. Here are some key directions and potential advancements expected in the field:

1. **Performance Acceleration**: Reconfigurable computing, particularly using FPGAs, offers significant potential for accelerating specific algorithms and tasks compared to traditional CPUs and GPUs. Future advancements may focus on optimizing designs further to achieve even higher performance gains in applications such as artificial intelligence, data analytics, and scientific computing.
2. **Energy Efficiency**: With a growing emphasis on energy-efficient computing solutions, reconfigurable computing can play a crucial role. Future developments may include more efficient FPGA architectures and design methodologies that minimize power consumption while maximizing computational throughput.
3. **Customization and Adaptability**: The ability to reconfigure hardware after deployment offers unparalleled flexibility. Future trends may involve advancements in runtime reconfiguration techniques, allowing systems to dynamically adapt to changing workload requirements or operational conditions.
4. **Integration with AI and Machine Learning**: As AI and machine learning applications continue to expand, reconfigurable computing can support these domains by accelerating complex neural network inference tasks, optimizing algorithms, and enabling real-time processing at the edge.
5. **Heterogeneous Computing Architectures**: The future may see increased integration of FPGAs with other heterogeneous computing platforms such as CPUs, GPUs, and specialized accelerators. This integration could lead to more balanced and efficient computing systems tailored to specific application needs.
6. **Security and Resilience**: Reconfigurable computing offers potential benefits in terms of security through hardware-level customization and isolation. Future developments may focus on enhancing FPGA security features and developing resilient designs capable of mitigating hardware vulnerabilities.
7. **Domain-Specific Applications**: There will likely be continued exploration and development of reconfigurable computing solutions tailored to specific industries and applications. This includes areas such as telecommunications, automotive, healthcare, finance, and aerospace, where customizable hardware can address unique challenges and requirements.
8. **Education and Adoption**: As reconfigurable computing becomes more accessible and its benefits better understood, there may be increased integration into educational curricula and wider adoption by developers and researchers across various disciplines.
9. **Research and Innovation**: Ongoing research efforts will drive innovations in FPGA architectures, programming models, and application domains. This includes exploring novel design methodologies, advanced algorithms, and new use cases that leverage the strengths of reconfigurable computing.
10. **Market Growth**: The market for reconfigurable computing solutions is expected to expand as more industries recognize the value of customizable hardware for achieving performance, flexibility, and efficiency goals. This growth may lead to a broader availability of tools, libraries, and support ecosystems tailored to FPGA-based development.

In conclusion, reconfigurable computing is poised to shape the future of technology by enabling highly efficient, customizable, and adaptable computing solutions across a wide range of applications and industries. Continued advancements and innovations in FPGA technologies will further enhance its capabilities and expand its impact in the coming years.

1st Semester	Professional Elective (PE) DETECTION AND ESTIMATION	M23MSP105E

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Linear algebra:	Understanding concepts such as matrices, vectors, matrix operations, eigenvectors, and Eigen values is crucial for various signal processing techniques.
2	Probability and statistics	Understanding probability distributions, statistical measures, and random processes is important for analyzing and modeling signals and noise in audio processing.
3	Digital signal processing (DSP)	Understanding Fourier series and Fourier transforms is important for analyzing the frequency content of audio signals and for applying techniques like spectral analysis. Familiarity with DSP concepts like discrete Fourier transforms (DFT), fast Fourier transforms (FFT), digital filters, and convolution is crucial for working with digital audio signals.
4	Discrete mathematics	Concepts from discrete mathematics such as sequences, series, and difference equations are fundamental for digital signal processing (DSP).
5	Stochastic signal processing	Stochastic processes are classes of signals whose fluctuations in time are partially or completely random. Examples of signals that can be modelled by a stochastic process are speech, music, image, time-varying channels, noise, and any information bearing function of time.

2. Competencies

S/L	Competency	KSA Description
1	Classical Detection and Estimation Theory:	**Knowledge:** Understanding the fundamental principles of probability, random variables, probability distributions, and statistical inference. Basic principles of signal processing, including signal representation, transformation, and analysis. **Skills:** Ability to perform probability and statistical analysis relevant to detection and estimation tasks. **Attitudes:** Willingness to stay updated with advancements in detection and estimation theory and related technologies.
2	Representations of Random Processes:	**Knowledge:** Understanding the basic principles of probability theory, random variables, distributions, and statistical inference. **Skills**: Ability to perform spectral analysis and understand the implications of power spectral density in random processes. **Attitudes:** Willingness to stay updated with advancements in the theory and application of random processes.
3	Detection of Signals & Estimation of Signal Parameters:	**Knowledge**: In-depth understanding of probability theory, random variables, probability distributions, and statistical inference. **Skills**: Ability to perform statistical analysis relevant to detection and estimation tasks. **Attitude**: Willingness to stay updated with advancements in detection and estimation theory and related technologies.

4	Estimation of Continuous Waveforms:	**Knowledge**: Understanding the mathematical representation and properties of continuous waveforms, including sinusoidal signals, polynomials, and other functional forms. **Skills**: Ability to perform statistical analysis relevant to the estimation of continuous waveforms. **Attitude**: Willingness to stay updated with advancements in the estimation of continuous waveforms and related technologies.
5	Random parameter estimation	**Knowledge**: In-depth understanding of probability theory, random variables, probability distributions, statistical inference, and stochastic processes. **Skills**:. Ability to perform statistical analysis relevant to the estimation of random parameters. **Attitude**: Willingness to stay updated with advancements in estimation theory and related technologies**.**

3. Syllabus

DETECTION AND ESTIMATION			
Course Code	**M23MSP105E**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours Theory 10-12 slots for SDA**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:

- To explain the detection estimation theory
- To understand the linear estimation

Module-1

Classical Detection and Estimation Theory: Introduction, simple binary hypothesis tests, M Hypotheses, estimation theory, composite hypotheses, general Gaussian problem, performance bounds and approximations

Module-2

Representations of Random Processes: Introduction, orthogonal representations, random process characterization, homogenous integral equations and Eigen functions, periodic processes, spectral decomposition, vector random processes

Module-3

Detection of Signals & Estimation of Signal Parameters: Introduction, detection and estimation in white Gaussian
noise, detection and estimation in nonwhite Gaussian noise, signals with unwanted parameters, multiple channels and multiple parameter estimation

Module-4

Estimation of Continuous Waveforms: Introduction, derivation of estimator equations, lower bound on the mean- square estimation error, multidimensional waveform estimation, non-random waveform estimation

Module-5

Random parameter estimation – Bayesian estimation, Selection of prior pdf, Minimum Mean Square Error Estimation (MMSE), Maximum a Posteriori Estimation (MAP), Concept of method of moments.

Suggested Learning Resources: **Text Books** 1. **'**Detection, Estimation, and Modulation Theory**'**, Part I, Harry L. Van Trees, John Wiley & Sons, USA, 2001. 2. **'**Random Signals: Detection, Estimation and Data Analysis**'**, K Sam Shanmugam, Arthur M Breipohl, John Wiley & Sons, 1998. **Reference Books:** 1. 'Introduction to Statistical Signal Processing with Applications**'**, M.D. Srinath, P.K. Rajasekaran and R. Viswanathan, Pearson Education (Asia) Pvt. Ltd. /Prentice Hall of India, 2003. 2. **'**Fundamentals of Statistical Signal Processing,**'** Volume I: **'**Estimation Theory**'**, Steven M. Kay, Prentice Hall, USA, 1998. 3. H.L. Van Trees, "Detection , Estimation and Modulation Theory, Part I", Wiley. 4. H.V. Poor, "An introduction to Signal Detection and Estimation", 2nd edition, Springer.
Web links and Video Lectures (e-Resources):
https://www.mooc.org/https://onlinecourses.nptel.ac.in/
Skill Development Activities Suggested Perform experiment on various detection and estimation algorithms

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3:	Understanding the fundamental principles of probability, random variables, probability distributions, and statistical inference. Basic principles of signal processing, including signal representation, transformation, and analysis. Knowledge of hypothesis testing frameworks, including null and alternative hypotheses, Type I and Type II errors, and power of a test.
2	Week 4-5:	Comprehensive knowledge of random processes (or stochastic processes), including definitions, classifications (stationary vs. non-stationary, ergodic vs. non-ergodic), and examples (e.g., Gaussian processes, Poisson processes). Understanding the time-domain and frequency-domain representations of random processes, including auto-correlation functions, power spectral density, and Fourier transforms.
3	Week 6-7:	Familiarity with Bayesian and Neyman-Pearson criteria for decision making under uncertainty. Understanding of Receiver Operating Characteristic (ROC) curves and Area Under the Curve (AUC) as performance metrics.
4	Week 8-9:	Understanding the principles of point estimation (unbiasedness, consistency, efficiency, sufficiency) and interval estimation (confidence intervals). Principles and applications of MLE for continuous waveform estimation. Understanding of Least Squares (LS) and Minimum Mean Square Error (MMSE) estimation methods.
5	Week 10-12:	Knowledge of various models involving random parameters, such as Gaussian processes, Poisson processes, Markov models, and autoregressive (AR) models. Principles and applications of MLE for estimating random parameters. Techniques for Bayesian estimation, including prior and posterior distributions, and Bayes estimators.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.

4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**
Continuous Internal Evaluation (CIE):
The minimum CIE marks requirement is 40% of the maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
i.	Internal Assessment-Tests (A)	2	50%	25	10
ii.	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)
The average internal assessment shall be the average of the two test marks scored.

Semester End Examination:
1. The question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub-questions), may have a mix of topics under that module if necessary.
4. The students have to answer five full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	To Understand the detection estimation theory and linear estimation.	Students will grasp the concepts of different Detection and estimation techniques of signals.
2	Working principle of detection estimation theory and linear estimation.	Students will Know how to estimate the parameters of a signal that is detected in practical signal processing applications.
3	Project-Based Learning	Through hands-on projects, students will apply the concepts of detection and estimation techniques in the future scope.
4	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
5	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs
Course Outcomes (COs)

COs	Description
M23MSP105E.1	Conduct Research and Solve Practical Problems in classical detection and estimation theory.
M23MSP105E.2	Apply various detection and estimation algorithms for understanding of the detection of deterministic and random signals using statistical models
M23MSP105E.3	Analyze and design signal detection and estimation in discrete-time domain using filters.
M23MSP105E.4	Students should be able to demonstrate a degree of mastery over the area of detection and estimation of different signals.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP105E.1	**3**	**2**	**3**	**3**	**3**
M23MSP105E.2	**2**	**2**	**3**	**3**	**3**
M23MSP105E.3	**2**	**1**	**3**	**3**	**3**
M23MSP105E.4	**2**	**2**	**3**	**3**	**3**
M23MSP105E	**2.25**	**1.75**	**3**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

10. Future with this Subject
The "Detection and Estimation" course in the first semester of the Mtech program lays a strong foundation for several future courses in the Postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of signal processing. Here are some notable contributions:

Advanced Machine Learning and AI Integration
1. **Deep Learning Models**: The use of deep learning models such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformers for more accurate estimation and detection tasks. These models can learn complex patterns and improve performance in noisy or incomplete data scenarios.
2. **Transfer Learning and Domain Adaptation**: Techniques to transfer knowledge from one domain to another, improving estimation and detection in fields with limited labeled data.
3. **Big Data and Real-Time Processing**
4. **Scalability**: Development of algorithms that can handle massive datasets efficiently, enabling real-time processing and decision-making.
5. **Edge Computing**: Shifting computation closer to data sources to reduce latency and bandwidth usage, which is crucial for applications like autonomous vehicles and Internet of Things (IoT) devices.

Quantum Computing
1. **Quantum Algorithms**: Exploration of quantum algorithms for estimation and detection that can potentially solve problems faster than classical algorithms.
2. **Quantum Machine Learning**: Integration of quantum computing with machine learning to enhance the capabilities of estimation and detection systems.

Improved Algorithms and Techniques
1. **Adaptive Filtering and Estimation**: Advances in adaptive filtering techniques to improve performance in dynamic and non-stationary environments.
2. **Sparse Signal Processing**: Utilizing sparsity in signals for efficient estimation and detection, particularly in compressed sensing applications.

Enhanced Communication Systems
1. **5G and Beyond**: Development of advanced detection and estimation techniques for 5G and future communication systems, addressing challenges such as high mobility, massive connectivity, and low latency.
2. **Cognitive Radio**: Techniques for dynamic spectrum management and interference detection in cognitive radio networks.

Biomedical Applications
1. **Medical Imaging**: Improved detection and estimation methods for medical imaging modalities like MRI, CT scans, and ultrasound, leading to better diagnostic capabilities.
2. **Wearable Devices**: Enhanced algorithms for signal estimation and detection in wearable health monitoring devices, providing real-time health analytics and early disease detection.

Autonomous Systems and Robotics
1. **Sensor Fusion**: Advanced estimation techniques for fusing data from multiple sensors in autonomous systems, improving reliability and accuracy.
2. **Object Detection and Tracking**: Improved algorithms for detecting and tracking objects in real-time, essential for robotics and autonomous vehicles.

Environmental Monitoring and Remote Sensing
1. **Climate Change Analysis**: Enhanced estimation and detection methods for analyzing climate change data, leading to more accurate predictive models.
2. **Disaster Management**: Real-time detection and estimation techniques for monitoring natural disasters like earthquakes, floods, and wildfires, aiding in timely response and mitigation.

Security and Surveillance
1. **Anomaly Detection**: Advanced techniques for detecting anomalies in various contexts, from cyber security to physical security.
2. **Biometric Systems**: Improved estimation and detection in biometric systems, enhancing accuracy and reducing false positives/negatives.

Financial and Economic Analysis
1. **Market Prediction**: Advanced algorithms for estimating and predicting market trends, aiding in financial decision-making.
2. **Risk Management**: Improved detection techniques for identifying and mitigating risks in financial systems.

1st Semester	Mandatory Credit Course (MC) RESEARCH METHODOLOGY AND IPR	M23MSP106

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Research Design and Methodologies	Basic knowledge of scientific research principles and methods, typically gained through introductory research methods courses.
2	Statistical Analysis and Data Interpretation	Understanding of basic probability theory and statistical concepts, usually covered in introductory statistics course
3	Academic Writing and Communication:	Basic Skill in writing clear, well-structured research papers and reports, and effectively communicating research findings.
4	Knowledge of Intellectual Property Rights (IPR):	Knowledge of business law or legal studies, and basic understanding of legal terminology related to intellectual property.
5	Critical Thinking and Problem-Solving:	knowledge in the specific field of study (e.g., engineering, social sciences, life sciences), and experience with critical analysis and problem-solving techniques

2. Competencies

S/L	Competency	KSA Description
1	Research Design and Methodologies	**Knowledge:** Understanding various research designs, including experimental, correlational, and descriptive methodologies. **Skills:** Ability to design robust research studies, formulate research questions, and select appropriate methodologies. **Attitudes:** Valuing rigor and integrity in research design and execution
2	Statistical Analysis and Data Interpretation	**Knowledge:** Familiarity with statistical concepts such as hypothesis testing, regression analysis, and inferential statistics. **Skills:** Proficiency in using statistical software (e.g., SPSS, R) to analyze and interpret data. **Attitudes:** Appreciating the importance of accuracy and objectivity in data analysis..
3	Academic Writing and Communication	**Knowledge:** Understanding the structure and format of academic papers, including proper citation and referencing techniques. **Skills:** Ability to write clear, concise, and well-structured research papers and reports. **Attitudes:** Valuing clarity, precision, and ethical practices in academic writing.
4	Knowledge of Intellectual Property Rights (IPR)	**Knowledge:** Understanding the different types of intellectual property (patents, trademarks, copyrights) and the application processes for each. **Skills:** Ability to navigate the IP application process, including drafting and filing patents. **Attitudes:** Respecting the legal and ethical considerations in protecting intellectual property.
5	Ethical Considerations in Research	**Knowledge:** Understanding ethical guidelines and principles in conducting research, including issues related to consent, confidentiality, and data integrity. **Skills:** Ability to apply ethical principles in research design and execution. **Attitudes:** Commitment to upholding ethical standards and integrity in all research activities.

3. Syllabus

RESEARCH METHODOLOGY AND IPR			
Course Code	**M23MSP106**	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(3:0:0)**	SEE Marks	**50**
Total Hours of Pedagogy	**20 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:

At the end of the course the student will be able to:

1. To give an overview of the research methodology and explain the technique of defining a research problem
2. To explain the functions of the literature review in research.
3. To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
4. To explain various research designs and their characteristics.
5. To explain the details of sampling designs, and also different methods of data collections.
6. To explain the art of interpretation and the art of writing research reports.
7. To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
8. To discuss leading International Instruments concerning Intellectual Property Rights.

Module -1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India

Module -2

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in the research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Module -3

Research Design: Meaning of Research Design, need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

Design of Sample Surveys: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs

Module -4

Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout.

Interpretation and Report Writing (continued): of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Module -5

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

Text Books:

1. "Research methodology" Methods and techniques third edition, C R Kothari and Gaurav Garg, New sage publishers
2. Research Methods the concise knowledge base, Trochim, Atomic Dog publishing, 2005

e-Resources: https://www.mooc.org/https://onlinecourses.nptel.ac.in/

Reference Books:

1. Research methodology step by step guide for beginners, Ranjith kumar 4th edition, Sage , 2011.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Research Methodology	**Competency:** Ability to design and conduct rigorous and ethical research st studies. **Knowledge:** Understanding the principles and components of various research methodologies, including qualitative, quantitative, and mixed methods. **Skills:** Proficiency in formulating research questions, selecting appropriate research designs, and implementing data collection techniques.
2	Week 3-4: Defining the Research Problem	**Competency:** Ability to clearly define and articulate a research problem. **Knowledge**: Understanding the significance of a well-defined research problem and the criteria for selecting a viable research topic. **Skills:** Proficiency in identifying research gaps, formulating precise research questions, and developing problem statements.
3	Week 5-6: Reviewing the Literature	**Competency:** Ability to conduct a comprehensive and critical literature review. **Knowledge**: Understanding the purpose, structure, and methods of conducting a literature review, including identifying relevant sources and synthesizing existing research. **Skills:** Proficiency in searching academic databases, evaluating the credibility of sources, and summarizing and critiquing existing research findings.
4	Week 7-8: Research Design and Sample Surveys	**Competency:** Ability to design robust research studies and develop effective sampling strategies. **Knowledge:** Understanding the different types of research designs (e.g., experimental, correlational, descriptive). **Skills:** Proficiency in selecting appropriate research designs, developing sampling plans
5	Week 9-10: Data Collection and Interpretation	**Competency:** Ability to collect, interpret, and analyze data systematically. **Knowledge:** Understanding various data collection methods (e.g., surveys, interviews, observations) and basic data analysis techniques. **Skills:** Proficiency in designing data collection instruments, conducting data collection, and applying appropriate methods to interpret and analyze data.

6	Week 11-12: Intellectual Property	Apply learned concepts and competencies to real-world scenarios. Hands-on practice with programming assignments

5. Teaching learning process strategies

S/L	TLP Strategies	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Collaborative Learning	Encourage collaborative learning for improved competency application.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate a deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

The average internal assessment shall be the average of the 2 test marks conducted

Semester End Examinations(SEE):

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. The question paper may include at least one question from the laboratory component.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Formulate Research Questions:	Students should be able to Develop clear and focused research questions based on identified research gaps.
2	Design Research Studies:	Create robust research designs tailored to specific research questions using appropriate methodologies.
3	Conduct Literature Reviews:	Perform comprehensive and critical reviews of existing literature to support research objectives.
4	Apply Statistical Analysis:	Utilize statistical tools and techniques to analyze and interpret research data effectively.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on coding projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively in the context of error control coding.

6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with error control coding, including ensuring data integrity, maintaining confidentiality, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP106.1	Apply the Knowledge of basics of research methodology to learn the concepts of research and Literature review
M23MSP106.2	Design various research designs, sample surveys and their characteristics.
M23MSP106.3	Analyze the details of sample designs to interpret the art of report witting techniques
M23MSP106.4	Analyze the different case studies on intellectual properties, copyrights and patents.

CO-PO-PSO Mapping

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP106.1	2	-	-	2	-
M23MSP106.2	2	1	-	-	-
M23MSP106.3	-	2	-	-	-
M23MSP106.4	-	-	3	-	-
M23MSP106	**2**	**1.5**	**3**	**2**	**-**

9. Assessment Plan

10. Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

11.

12. Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

Conditions for SEE Paper Setting:

Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks.

10. Future with this Subject

1. **Advancing Innovation and Commercialization:** Future research could focus on enhancing methodologies for identifying patentable inventions and optimizing intellectual property strategies to facilitate innovation and commercialization.
2. **Ethical and Legal Considerations in Research:** There is a growing need for research into ethical frameworks and legal guidelines concerning intellectual property rights, ensuring responsible and fair practices in research and innovation.
3. **Global Intellectual Property Landscape:** Research could explore comparative studies of intellectual property systems across different countries and regions, addressing challenges and opportunities for international collaboration and protection.
4. **Emerging Technologies and IP Challenges:** With rapid advancements in fields like AI, biotechnology, and blockchain, future studies could examine how these technologies impact intellectual property laws and practices, requiring innovative approaches to IP management.
5. **Education and Capacity Building** here is a demand for developing educational programs and resources that equip researchers, innovators, and policymakers with the knowledge and skills to navigate complex intellectual property landscapes effectively.

1st Semester	Professional Core Laboratory (PCL) ADVANCED DIGITAL SIGNAL PROCESSING LAB	M23MSPL107

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1.	Mathematics	Calculus, Linear Algebra and Statistics.
2.	Signals and Systems	Basics types of signals like analog and digital signals, periodic and aperiodic signals, basic operations of signals like addition, shifting and scaling.
3.	Digital Signal Processing	Fourier analysis.
4.	Filters	Analog and Digital filters.
5.	MATLAB	Basics of MATLAB Programming.

2. **Competencies**

S/L	Competency	KSA Description
1.	Generation of elementary signals	**Knowledge**: Proficiency in basics of signals like exponential, periodic and sinusoidal. **Skills**: Applying basic mathematics and programming skills to find effective solutions. **Attitudes:** Methodical approach to problem-solving, Programming and Simulation Skills, Critical Thinking.
2.	Basic Operations of signals	**Knowledge:** Proficiency in applying basic mathematical operations like Multiplication, Folding, Scaling on signals. **Skills:** Studying basic operations on signals provides students with a strong foundation in both theoretical principles and practical applications, preparing them for careers in engineering, research, and technology development. **Attitudes:** Mastering MATLAB implementations for the attitude of a student studying basic operations on signals is characterized by a blend of curiosity, determination, and practicality, driving them to explore, learn, and apply their knowledge in meaningful ways.
3.	DFT and IDFT	**Knowledge:** Gaining knowledge in writing MATLAB code to generate sampled signals from discrete and continuous-time signals involves understanding sampling theory, signal discretization methods, and digital signal processing techniques, essential for accurately representing analog signals in digital systems. **Skills:** Developing skills in MATLAB coding for generating sampled signals from discrete and continuous-time signals enhances proficiency in signal processing, numerical methods, and digital-to-analog conversion, crucial for accurately capturing and representing analog phenomena in digital systems. **Attitudes:** Mastering the MATLAB implementation of generating sampled signals from discrete and continuous-time domains fosters an attitude of precision, creativity, and adaptability, encouraging a deeper understanding and appreciation for the interplay between theoretical concepts and practical applications in signal processing.
4.	Interpolation and Decimation	**Knowledge:** Both decimation and interpolation play essential roles in various signal processing applications, including audio processing, image processing, communications, and data compression. Understanding these concepts allow signal processing engineers to manipulate signals effectively while preserving important information and achieving specific performance goals. **Skills:** Proficiency in decimation and interpolation is essential for signal processing

		engineers working in fields such as telecommunications, audio and video processing, radar and sonar systems, and biomedical signal analysis. These skills enable engineers to efficiently process and analyze signals while preserving signal quality and achieving desired system performance. **Attitudes:** Proficiency in decimation and interpolation is essential for signal processing engineers working in fields such as telecommunications, audio and video processing, radar and sonar systems, and biomedical signal analysis. These skills enable engineers to efficiently process and analyze signals while preserving signal quality and achieving desired system performance.
5.	Dual Tone Multiple Frequency	**Knowledge:** Studying Multi-Frequencysignaling equips students to understand how tones encode information. They can decode signals like touch-tone phones and analyze how multiple frequencies combine to transmit data. **Skills:** After studying Dual-Tone Multi-Frequency (DTMF), students gain the skills to be "tone decoders." They can analyze how pushing buttons on a touch-tone phone creates unique combinations of tones, essentially cracking the code of how information is transmitted through sound. **Attitudes:** DTMF studies cultivate a "listen deeper" attitude. Students see everyday sounds like touch-tones not just as noise, but as a hidden language. They appreciate the ingenuity of how simple tones can encode complex information.
6.	Power Spectral Distribution	**Knowledge:** After studying power spectral distribution, students gain knowledge of the "hidden symphony" within signals. They learn to analyze how a signal's energy distributes across different frequencies, revealing its unseen tonal makeup. **Skills:** Power spectral distribution equips students as "frequency cartographers." They develop the skills to map a signal's energy across different frequencies, creating a "spectral map" that reveals the signal's hidden composition and dominant frequencies. **Attitudes:** Power spectral distribution fosters a "data artist" mentality in students. They learn to appreciate the hidden beauty within signals, seeing the world as a symphony of frequencies. By analyzing the power distribution, they can "paint" a picture of a signal's composition, revealing its unique fingerprint.
7.	Filters	**Knowledge:** After studying filters, students gain knowledge of "signal sculptors." They understand how to manipulate signals, removing unwanted noise and highlighting specific features. This allows them to "shape" the information they see for clearer analysis. **Skills:** After studying filters, students become "frequency tamers." They develop the skills to control which parts of a signal pass through and which are blocked. This allows them to rein in unwanted noise and extract the specific information they need. **Attitudes:** Filters cultivate a "signal whisperer" attitude in students. They see the world as a cacophony of information, but with filters, they learn to gently nudge the "right" signals to the forefront, understanding the power of shaping information for clearer understanding.

3. **Syllabus**

ADVANCED DIGITAL SIGNAL PROCESSING LAB SEMESTER – I			
Course Code	**M23MSPL107**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**1:0:2:0**	SEE Marks	**50**
Credits	**02**	Exam Hours	**03**

Course objectives: This course will enable the students to:

- T o understand the Matlab software for digital signal processing problems.
- To learn the various programming skills to implement the digital signal processing algorithms

Sl. No.	To realize the following programs using MATLAB software:
1.	Generate various fundamental discrete time signals.
2.	Basic operations on signals (Multiplication, Folding, Scaling).
3.	Find out the DFT & IDFT of a given sequence without using inbuilt instructions
4.	Interpolation & decimation of a given sequence.
5.	Generation of DTMF (Dual Tone Multiple Frequency) signals.
6.	Estimate the PSD of a noisy signal using periodogram and modified periodogram.
7.	Estimation Of PSD using different methods (Bartlett, Welch, BlackmanTukey).
8.	Design of Chebychev Type I, II Filters.
9.	Cascade Digital IIR Filter Realization.
10.	Parallel Realization of IIR filter.
11.	Estimation of power spectrum using parametric methods (Yule-Walker & Burg).
12.	Design of LPC filter using Levinson-Durbin algorithm.
	Demonstration Experiments (For CIE)
1.	To implement the LPC filter using Matlab Simulink
2.	To implement the Time-Frequency Analysis with the Continuous Wavelet Transform using Matlab Simulink
3.	To implement the Signal Reconstruction from Continuous Wavelet Transform Coefficients using Matlab Simulink

Suggested Learning Resources:

1. https://matlab.mathworks.com/
2. https://in.mathworks.com/help/simulink/design-model-architecture.html?s_tid=CRUX_lftnav

4. **Syllabus Timeline**

S/L	Syllabus Timeline	Description
1.	Week 1-2: Basic Fundamental Signals	Teach fundamental signals in MATLAB through interactive demonstrations. Start with an overview of signal types, then show how to generate and plot signals like sine waves and square waves. Introduce signal manipulation techniques like shifting and scaling. Encourage experimentation and provide hands-on exercises for reinforcement.
2.	Week 3-4: DFT and IDFT Interpolation and Decimation	Teach Discrete Fourier Transform (DFT) and Inverse DFT (IDFT) in MATLAB by explaining their importance in signal analysis. Show how to calculate DFT using fft and IDFT using IFFT functions. Illustrate applications such as spectral analysis and signal reconstruction. Provide examples and interactive exercises for better understanding. To teach decimation and interpolation in MATLAB, illustrate down sampling and up sampling processes using down sample and up sample functions. Explain concepts like aliasing in decimation and spectral images in interpolation. Provide hands-on exercises demonstrating their applications in signal processing, image processing, and data compression for better comprehension.
3.	Week 5-6: DTMF, PSD	Teach Dual-Tone Multi-Frequency (DTMF) signaling in MATLAB by simulating touch-tone phone dialing. Explain the concept of combining two sinusoidal signals to represent each digit. Show how to generate DTMF tones using MATLAB's signal generation functions. Provide examples of decoding received DTMF signals and practical applications like telephone communication and remote control systems. Teach Power Spectral Density (PSD) in MATLAB by demonstrating its importance in signal analysis. Use MATLAB's pwelch function to estimate PSD from a time series signal. Illustrate how to interpret PSD plots and analyze signal characteristics like frequency content and power distribution. Provide examples and exercises for practical understanding.
4.	Week 7-8: Filters	Teach PSD estimation with filters in MATLAB by demonstrating how to design and apply filters using functions like designfilt and filtfilt. Show students how to remove noise and extract desired signal components while preserving spectral

		characteristics. Provide hands-on examples and exercises for practical understanding and application.
6.	Week 11-12: Demonstration Experiments	To teach Linear Predictive Coding (LPC) in MATLAB, explain its use in speech and audio processing for compression and analysis. Demonstrate LPC coefficients estimation using MATLAB's functions like lpc or lpcauto. Show how to synthesize speech using LPC filters. Provide examples and practical exercises for comprehension and application. Teach wavelet transforms in MATLAB by demonstrating their applications in signal and image processing. Use functions like wavedec for decomposition and waverec for reconstruction. Illustrate multiscale analysis and feature extraction. Provide hands-on exercises for understanding wavelet properties and their advantages over traditional methods.

5. **Teaching-Learning Process Strategies**

S/L	TLP Strategies:	Description
1.	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2.	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of the concepts of Control System.
3.	Collaborative Learning	Encourage collaborative learning for improved competency application.
4.	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5.	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6.	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7.	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies.
8.	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**

Marks distribution for Program based Practical Course for CIE

Sl. No.	Description	% of Marks	In Marks
1	Observation, write-up, algorithm/program/execution	80% of the maximum	80
2	Viva-Voce	20% of the maximum	20
Total		100%	100

Marks scored by the student for 100 are scaled down to 50 marks.

Semester End Evaluation (SEE):

Marks distribution for Program based Practical Course for SEE

SL. No.	Description	% of Marks	Marks
1	Write-up, Procedure	20%	20
2	Conduction and result	60%	60
3	Viva-Voce	20%	20
Total		**100%**	**100**

1. SEE marks for practical course shall be 50 marks
2. See for practical course is evaluated for 100 marks and scored marks shall be scaled down to 50 marks.

3. Change of experiment/program is allowed only once and 20% marks allotted to the procedure/write-up part to be made zero.
4. Duration of SEE shall be 3 hours.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding signal and system Fundamentals	Students will be able to understand the basics of signals, their operation, systems, and properties.
2	Proficiency in DFT,IDFT and DTMF	Students will learn to analyze different transformation functions.
3	Proficiency in PSD, Filters and wavelet transforms.	Students will develop proficient skills for accurate analysis and processing of filters, PSD and wavelet transforms.
4	Project-Based Learning	Through hands-on projects, Students will be able to tackle real-world problems by applying theory to design solutions and fostering critical thinking, collaboration, and practical skills in engineering and communication technologies.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs
Course Outcomes (COs)

Cos	Description
M23MSPL107.1	**Apply** the Basics of signals and systems write MATLAB code for various applications.
M23MSPL107.2	**Conduct** the experiments either individually or in team.
M23MSPL107.3	**Present** experimental results/process both orally and in written form.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSPL107.1	3	3	3	3	3
M23MSPL107.2	3	3	3	3	3
M23MSPL107.3	3	3	3	3	3
M23MSPL107	**3**	**3**	**3**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	**Total**
Module 1	10			10
Module 2		10		10
Module 3			10	10
Module 4	5		5	10
Module 5		5	5	10
Total	15	15	20	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	**Total**
Module 1	20			20
Module 2		20		
Module 3			20	20

Module 4	10		10	20
Module 5		10	10	20
Total	30	30	40	**100**

10. Future with this Subject

The "Advanced Digital Signal Processing" course in the first semester of the MTech program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of signal processing. Here are some notable contributions:

1. **Digital Signal Processing (DSP):** Signals and systems concepts form the foundation for understanding DSP algorithms and techniques
2. **Communication Systems:** Knowledge of signals and systems is essential for analyzing and designing communication systems, including modulation, demodulation, and channel coding
3. **Control Systems**: Understanding signal processing and system dynamics is crucial for analyzing and designing control systems for various applications
4. **Image Processing**: Signals and systems principles are fundamental to image processing techniques such as filtering, compression, and enhancement
5. **Biomedical Engineering**: Signal processing techniques are essential for analyzing physiological signals in biomedical applications like medical imaging and bio signal analysis
6. **Project Work and Research:** Signals and systems provide foundational knowledge and analytical tools essential for project work and research across various domains. They enable precise analysis and design of systems, facilitating tasks such as signal processing, control systems, and communications. Mastery of these concepts allows for the development and implementation of efficient algorithms and models. They support interdisciplinary applications, enhancing projects in fields like biomedical engineering, robotics, and telecommunications. Overall, they equip researchers with the skills to tackle complex problems and innovate in technology-driven areas.

2nd Semester	Professional Core Course (PC) DIGITAL COMPRESSION	M23MSP201

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Compression techniques, Differential Entropy	Proficiency in probability distributions, random variables, and their properties, conditional probability, Information Theory, Compression Techniques and Rate Distortion Theory.
2.	Quantization	Proficiency in Range and Resolution and Digital Signal Processing Basics.
3.	Differential Encoding, Coding and Sub-band coding	Proficiency in Linear Algebra, Calculus, Probability and Statistics, Digital Signal Processing, Transforms, Entropy, Filter Banks, Wavelets and Quantization.
4.	Wavelet Based Compression	Proficiency in Mathematics and Signal Processing Foundations, Entropy, Filter Banks, Wavelet Theory and Quantization.
5.	Analysis/Synthesis Schemes: Speech compression	Proficiency in Linear Algebra, Calculus, Fourier Analysis, Numerical Methods, Transforms, Entropy, Filter Banks, Wavelet Theory and Quantization.
6.	Image and Video Compression	Proficiency in Mathematics and Signal Processing Foundations, Image Processing Basics, Video Processing Fundamentals, Information Theory and Coding Techniques, Video Compression Algorithms.
7.	Lossless Coding	Proficiency in Mathematics and Signal Processing Foundations, Image Processing Basics, Temporal Redundancy, Video Formats, Frame Types, Information Theory and Coding Techniques, Video Compression Algorithms.
8.	Previous Course	Completion of introductory courses in Mathematics, Programming Courses, Digital Signal Processing (DSP) Courses, Information Theory Courses, Image Processing, Audio Processing, Video processing.

2. Competencies

S/L	Competency	KSA Description
1.	Compression techniques, Differential Entropy, Quantization	**Knowledge**: Probability Theory, Information Theory, Compression Techniques, Range and Resolution and Digital Signal Processing Basics. **Skills**: Applying Probability Theory, Information Theory, Compression Techniques, Range and Resolution to understand basics of Digital compression and analyze various quantization techniques. **Attitudes:** Mathematical aptitude, Analytical Skills.
2.	Differential Encoding, Coding	**Knowledge:** Linear Algebra, Calculus, Probability and Statistics, Digital Signal Processing, Transforms and Quantization. **Skills:** Applying Probability and Statistics, Digital Signal Processing, Transforms, Entropy and Quantization to understand the basic differential encoding technique and prediction in different modulation techniques and also to analyze a supplication on speech coding, image compression and audio compression. **Attitudes:** Problem solving ability, Analytical Skills, Critical Thinking.
3.	Sub-band coding	**Knowledge:** Linear Algebra, Calculus, Probability and Statistics, Digital Signal Processing, Transforms, Entropy, Filter Banks and Quantization. **Skills:** Utilizing sub band coding to design filter banks and to analyze the application on speech Coding-G.722, audio coding- MPEG audio, image compression. **Attitudes:** Problem solving ability, Critical Thinking.

.	4.	Wavelet Based Compression, Speech compression, Video compression	**Knowledge:** Mathematics and Signal Processing Foundations, Entropy, Filter Banks, Wavelet Theory and Quantization. **Skills:** Apply the concepts of Wavelet Theory to analyze Image compression–EZW, SPIHT, JPEG2000, Speech compression–LPC–10, CELP, MELP. Algorithms for video conferencing & video phones – H.261, H.263, Asymmetric applications – MPEG4, MPEG7, Packet video. **Attitudes:** Problem solving ability, Analytical Skills, Critical Thinking.
.	5.	Lossless Coding	**Knowledge:** Mathematics and Signal Processing Foundations, Image Processing Basics, Temporal Redundancy, Video Formats, Frame Types, Information Theory and Coding Techniques, Video Compression Algorithms. **Skills:** Utilize the concept of Information Theory and Coding Techniques to understand the applications of Huffman coding, Arithmetic coding, LZ78–JBIG, JBIG2, CALIC, JPEG-LS. **Attitudes:** Mathematical aptitude, Problem solving ability, Analytical Skills, Critical Thinking.

3. Syllabus

DIGITAL COMPRESSION SEMESTER – II			
Course Code	**M23MSP201**	CIE Marks	**50**
Number of Lecture Hours/Week (L:P:SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 Hours of Teaching and 10 to 12 sessions of Skill Development Activities.**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students:
- To acquire contemporary knowledge in Data Compression and Coding.
- To equip with skills to analyze and evaluate different Data Compression and Coding methods.

Module -1

Introduction: Compression techniques, Modelling & coding, Distortion criteria, Differential Entropy, Rate Distortion Theory, Coding uniquely decodable codes, Prefix codes, Kraft McMillan Inequality.
Quantization: Quantization problem, Uniform Quantizer, Adaptive Quantization, Non-uniform Quantization; Entropy coded Quantization, Vector Quantization, LBG algorithm, Tree structured VQ, Structured VQ.

Module -2

Differential Encoding: Basic algorithm, Prediction in DPCM, Adaptive DPCM, Delta Modulation, Speech coding–G.726, Image coding Transform.
Coding: Transforms – KLT, DCT, DST, DWHT; Quantization and coding of transform coefficients, Application Image compression – JPEG, Application to audio compression.

Module -3

Sub-band Coding: Filters, Sub-band coding algorithm, Design of filter banks, Perfect reconstruction using two channel filter banks, M-band QMF filter banks, Poly-phase decomposition, Bit L1, L2 allocation, Speech coding – G.722, Audio coding–MPEG audio, Image compression.

Module -4

Wavelet Based Compression: Wavelets, Multi resolution analysis & scaling function, Implementation using filters, Image compression–EZW, SPIHT, JPEG2000.
Analysis/Synthesis Schemes: Speech compression–LPC–10, CELP, MELP.
Video Compression: Motion compensation, Video signal representation, Algorithms for video conferencing & video phones – H.261, H.263, Asymmetric applications – MPEG4, MPEG7, Packet video.

Module -5

Lossless Coding: Huffman coding, Adaptive Huffman coding, Golomb codes, Rice codes, Tunstall codes, Applications of Huffman coding, Arithmetic coding, Algorithm implementation, L1, L2 Applications of Arithmetic coding, Dictionary techniques–LZ77, LZ78, Applications of LZ78– JBIG, JBIG2, Predictive coding– Prediction with partial match, Burrows Wheeler Transform, Applications – CALIC, JPEG-LS.

Text Books:

1. K. Sayood, "Introduction to Data Compression", Harcourt India Pvt. Ltd. & Morgan Kaufmann Publishers, 1996.
2. N. Jayant and P. Noll, "Digital Coding of Waveforms: Principles and Applications to Speech and Video", Prentice Hall, USA,1984.

Reference Books:

1. D. Salomon, "Data Compression: The Complete Reference", Springer,2000.
2. Z.Li and M.S.Drew, "Fundamentals of Multimedia", Pearson Education (Asia) Pvt. Ltd.,2004.

Web links and Video Lectures (e-Resources):

https://www.mooc.org/ https://onlinecourses.nptel.ac.in/

Skill Development Activities Suggested:

Mini project to compress the signals and image using various algorithms

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1.	Week 1-2: Compression techniques, Differential Entropy, Kraft McMillan Inequality.	Basic of compression technique, Types of Compression techniques (Lossy and lossless), Modeling and coding, Mathematical Preliminaries for Lossless Compression which includes Average information, different models, DifferentialEntropy, different types of codes and Kraft McMillan Inequality theorem.
2.	Week 3-4: Quantization	Basic of quantization, Quantization problem, types of quantization which includes Uniform Quantizer, Adaptive Quantization, Non-uniform Quantization; Entropy coded Quantization, Vector Quantization, LBG algorithm, Tree structured VQ, Structured VQ
3.	Week 5-6: Differential Encoding, Coding	Basics of Differential Encoding, prediction in various modulation techniques, speech and video coding transforms.
4.	Week 7-8: Sub-band Coding	Basics of Sub-band Coding, design of filter banks, application of speech processing, poly-phase decomposition Bit allocation,
5.	Week 9-10: Wavelet Based Compression, Image compression, Speech compression, Video compression.	Basics of Wavelet Based Compression, multi resolution analysis and scaling functions Implementation of the application of Image compression, Speech compression, Video compression.
6.	Week 11-12: Lossless Coding	Different types of code, different coding format, Different types of coding techniques and their application.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies	Description
1.	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2.	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of the concepts of Control System.
3.	Collaborative Learning	Encourage collaborative learning for improved competency application.
4.	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5.	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6.	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7.	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies.
8.	Programming	Assign programming tasks to reinforce practical skills associated with

	Assignments	competencies.

6. **Assessment Details (both CIE and SEE)**
This section of regulations is applicable to all theory-based courses. The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up for Professional Course (PC)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	3	**50%**	**25**	**10**
(ii)	Assignments/Quiz/Activity (B)	2	**50%**	**25**	**10**
Total Marks				**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examination

1. Question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have a mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. **Learning Objectives**

S/L	Learning Objectives	Description
1	Understand the Fundamentals of Digital compression techniques and Quantization	Students will comprehend the fundamental concepts of Compression techniques, Modelling & coding, Distortion criteria, Differential Entropy calculations, Quantization problem and types of Quantizer, various quantization algorithms.
2	Proficiency in encoding, coding, sub-band coding and Lossless Coding,	Students will learn various encoding and coding algorithms, designing of filter banks, different types of lossless coding techniques and their applications.
3	Proficiency in Wavelet Based Compression, Image Compression, speech Compression, Video Compression	Students will learn different types of image compression, speech Compression, Video Compression techniques and their applications.
4	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital compression to design, implement, simulate, and verify complex systems, reinforcing their understanding of theoretical concepts.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with design of a system, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. **Course Outcomes (COs) and Mapping with POs/ PSOs**
Course Outcomes (COs)

Cos	Description
M23MSP201.1	Understand the working principles of various digital compression techniques, including lossless and lossy methods, and their applications in different domains such as audio, video, and data compression and also the different types of quantization techniques.
M23MSP201.2	Analyze the time domain and frequency domain transformation techniques of compression
M23MSP201.3	Analyze the wavelet-based compression, image compression, audio compression and video compression techniques.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP201.1	3	-	-	3	-
M23MSP201.2	2	-	-	2	-
M23MSP201.3	2	-	-	2	-
M23MSP201	**2.33**	**-**	**-**	**2.33**	**-**

9. **Assessment Plan**

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	**10**			**10**
Module 2		**10**		**10**
Module 3			**10**	**10**
Module 4		**5**	**5**	**10**
Module 5	**5**		**5**	**10**
Total	**15**	**15**	**20**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	**20**			**20**
Module 2		**20**		**20**
Module 3			**20**	**20**
Module 4		**10**	**10**	**20**
Module 5	**10**		**10**	**20**
Total	**30**	**30**	**40**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. **Future with this Subject**

The "Digital Compression" course in the second semester of the MTech. program lays a strong foundation for several future courses in the postgraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of deep learning. Here are some notable contributions:

1. **Deep Learning-Based Compression:** Use of neural networks and deep learning to develop more efficient compression algorithms that can adapt to different types of data and achieve higher compression ratios with minimal loss of quality.
2. **Adaptive Compression Techniques:** Algorithms that dynamically adjust compression parameters based on the content and context, leading to better performance across a variety of applications.
3. **Edge Compression:** Development of compression algorithms optimized for edge devices and Internet of Things (IoT) applications, where computational resources and bandwidth are limited.
4. **Distributed Compression Techniques:** Techniques that leverage distributed computing resources for more efficient data compression and decompression in IoT networks.
5. **Quantum Compression Algorithms:** Exploration of quantum computing's potential to revolutionize data compression techniques, offering new ways to achieve unprecedented compression ratios.
6. **Scalable Compression Techniques:** Techniques that can handle the vast amounts of data generated in big data and cloud environments, making storage and retrieval more efficient.
7. **Integration with Cloud Services:** Seamless integration of compression algorithms with cloud storage and processing services to optimize data handling.
8. **Project Work and Research:** The hands-on experience gained through programming assignments, problem-solving, and project work in digital compression prepares students for more extensive projects in their later years. It equips them with the skills needed for research in the field of deep learning.
9. **Industry Applications:** The course provides theoretical and programming skills that are directly applicable in industries related to deep learning. Graduates are well-prepared to contribute to various industrial developments.

2nd Semester	Professional Core Course (PC) IMAGE PROCESSING AND MACHINE VISION	M23MSP202

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Digital Signal Processing (DSP)	● Basics on how signals (including images) are processed, analyzed, and manipulated digitally. ● The basics of Fourier transform in the context of signals and images, including concepts of frequency domain representation and transformations. ● Signal processing concepts and techniques, in processing image data and extracting meaningful information from images. ● Digital images are represented (e.g., pixel values, color spaces), acquired (e.g., cameras, scanners), and processed (e.g., filtering, enhancement).
2.	Mathematics:	● Proficiency in algebra, calculus, and statistics is essential for understanding the mathematical models, transformations, and algorithms used in image processing ● Probability distributions, statistical methods, and noise models is crucial for tasks like histogram processing, noise reduction, and enhancement operations. ● Proficiency in algebra, geometry, and linear algebra (e.g., matrices, vectors) is essential for understanding geometric representations, transformations, and mathematical operations used in computer vision.
3.	Basic Programming:	● Familiarity with programming languages (e.g., Python, MATLAB or C++) helps in implementing image processing algorithms and understanding their practical applications. ● Familiarity with libraries and frameworks for image processing and computer vision.
4.	Linear Algebra:	● Concepts such as matrices, vectors, eigenvalues, and eigenvectors are fundamental for understanding transformations, filtering and operations performed on images.
5.	Pattern Recognition	● Knowledge of principles and techniques used in pattern recognition, such as feature extraction, classification methods, and object detection.

2. Competencies

S/L	Competency	KSA Description
1.	Digital Image Fundamentals	**Knowledge:** Understanding of basic image processing concepts, such as pixels, image representation, and color models. The mathematical foundations underlying in image processing techniques, including linear algebra and signal processing. **Skills:** ● Ability to implement image filtering techniques to remove noise and improve image quality. ● Competence in applying enhancement methods to adjust image contrast, brightness, and other visual aspects. ● To perform image segmentation and to isolate, analyze regions of interest within an image. **Attitudes:** ● Encouragement to experiment with different techniques and approaches to achieve optimal results. ● Willingness to innovate and think outside the box when confronted with complex image processing challenges.
2.	Image Enhancement	**Knowledge:** Understanding Image Enhancement by Point Processing, Gray Level Transformations, Histogram Processing and application of arithmetic (addition, subtraction) and logic operations (AND, OR, NOT) for image enhancement. **Skills:** ● Skills to apply gray-level transformations and histogram processing to enhance image quality.

		● Proficiency in using arithmetic and logic operations to manipulate images. ● Competence in designing and applying spatial filters for smoothing and sharpening. ● Proficiency in using image processing libraries and tools like MATLAB, Open CV, or Python for implementing these techniques. **Attitudes:** ● Developing a meticulous approach in applying image processing techniques, ensuring precise and accurate results. ● Encouragement to critically analyze image processing problems and develop innovative solutions. ● Willingness to experiment and iterate on different techniques to achieve optimal results.
3.	Image Restoration and Image Compression	**Knowledge:** Understanding different noise models (such as Gaussian, salt-and-pepper noise) and how this affect image quality. They will learn the theoretical and practical aspects of image degradation and restoration processes, including various filtering techniques like inverse filtering, Wiener filtering, and constrained least square filtering. **Skills:** ● To implement and utilize a variety of image compression algorithms. ● They will learn both lossless (e.g., Huffman Coding, LZW Coding, Run Length Coding) and lossy compression techniques, gaining practical experience in reducing image file sizes while maintaining acceptable quality levels. This skill will enable them to optimize the storage and transmission of image data effectively. **Attitudes:** ● A precise and analytical mindset is essential for tackling complex image processing challenges. This attitude will drive them to apply techniques for restoration and compression.
4.	Image Segmentation and Morphological Image Processing	**Knowledge:** Understanding of various segmentation techniques, including discontinuity-based methods (e.g., edge detection, edge linking), similarity-based methods (e.g., thresholding), and region-based methods. **Skills:** ● To implement segmentation algorithms (e.g., edge detection, thresholding, region growing) and morphological operations (e.g., dilation, erosion). ● Ability to combine techniques to achieve robust image segmentation results, effectively isolating regions or objects within an image for further analysis or processing. **Attitudes:** ● Problem-solving attitude, essential for tackling complex image segmentation challenges. ● Systematic approach to identify the most suitable segmentation method based on image characteristics and desired outcomes.
5.	Computer Vision Techniques	**Knowledge:** In-depth understanding of how to represent and describe objects within an image using boundary descriptors (e.g., chain codes) and regional descriptors. The principles and methods for capturing the shape, structure, and properties of objects, which are fundamental for various computer vision applications. **Skills:** ● To implement and apply fuzzy-neural algorithms to computer vision problems. ● To handle uncertainty and imprecision in image data, enhancing the capability of computer vision systems to perform tasks such as object recognition, classification, and decision-making in complex environments. **Attitudes:** ● Cultivate an innovative and interdisciplinary attitude, essential for advancing computer vision applications.

3. Syllabus

IMAGE PROCESSING & MACHINE VISION			
Course Code	**M23MSP202**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**3:2:0**	SEE Marks	**50**
Total Hours of Pedagogy	**40 hours Theory + 10-12 Lab slots**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Learning objectives:

- Be familiar with both the theoretical and practical aspects of computing with images.
- To understand image processing concepts like image enhancement, image restoration and compression algorithms, Image Segmentation and Morphological Image Processing
- To understand the computer vision techniques

Module-1

Introduction and Digital Image Fundamentals

Motivation & Perspective, Applications, Components of Image Processing System, Fundamentals Steps in Image Processing, Image Sampling and Quantization, Some basic relationships like Neighbors, Connectivity, Distance Measures between pixels

Module-2

Image Enhancement in the Spatial and Frequency Domain

Image enhancement by point processing, Image enhancement by neighborhood processing, Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Zooming, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Methods. Introduction to Fourier Transform and the frequency domain, Smoothing and Sharpening Frequency Domain
Filters, Homomorphic Filtering

Module-3

Image Restoration and Image Compression

Model of The Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter, Geometric Transformations. Data Redundancies, Image Compression models, Elements of Information Theory, Lossless and Lossy compression, Huffman Coding, Shanon-Fano Coding, Arithmetic Coding, Golomb Coding, LZW Coding, Run Length Coding, Loss less predictive Coding, Bit Plane
Coding, Image compression standards.

Module-4

Image Segmentation and Morphological Image Processing

Discontinuity based segmentation, similarity-based segmentation, Edge linking and boundary detection, 20%, Region based Segmentation, Introduction to Morphology, Dilation, Erosion, Some basic Morphological Algorithms

Module-5

Object Representation and description on Computer Vision Techniques

Representation, Boundary Descriptors, Regional Descriptors, Chain Code, Structural Methods. Review of Computer Vision applications; Fuzzy-Neural algorithms for computer vision applications.

PRACTICAL COMPONENT OF IPCC (May cover all / major modules)

1. Write a program in Matlab to compute the histogram of an Image
2. Write a program in Matlab to compute the logic operations on image
3. Write a program in Matlab to find the edge of an image
4. Write a program in Matlab to compute the Huffman coding
5. Write a program in Matlab to compute the bit plane slicing
6. Write a program in Matlab to lossless predictive coding

Demo experiments for CIE

1. Write a program in Matlab to implement the Fuzzy logic algorithm
2. Write a program in Matlab to implement the neural network algorithm

Suggested Learning Resources:

Books

1. Digital Image Processing Rafael C. Gonzalez Pearson Education3rd edition & Richard E. Woods
2. Computer Vision: A Modern David A. Forsyth, Prentice Hall Approach Jean Ponce

Reference Books:

1. Fundamental of Digital Image Processing A.K. Jain PHI 4
2. Digital Image Processing W K Pratt

Web links and Video Lectures (e-Resources):
https://www.mooc.org/ https://onlinecourses.nptel.ac.in/
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning
To do mini project in the field of Digital Image Processing and Machine vision

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2:	Introduction and Digital Image Fundamentals: Motivation & Perspective, Applications, Components of Image Processing System, Fundamentals Steps in Image Processing, Image Sampling and Quantization, Some basic relationships like Neighbors, Connectivity, Distance Measures between pixels Practical component: Introduction to MatLab and basic analysis of an image and its processing using MatLab 1. Write a program in Matlab to compute the histogram of an Image 2. Write a program in Matlab to compute the logic operations on image
2	Week 3-5:	Image Enhancement in the Spatial and Frequency Domain: Image enhancement by point processing, Image enhancement by neighbourhood processing, Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Zooming, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Methods. Introduction to Fourier Transform and the frequency domain, Smoothing and Sharpening Frequency Domain Filters, Homomorphic Filtering Practical component: 3. Write a program in Matlab to find the edge of an image
3	Week 6-7:	Image Restoration and Image Compression: Model of The Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter, Geometric Transformations. Data Redundancies,
4	Week 8-9:	Image Restoration and Image Compression: Image Compression models, Elements of Information Theory, Lossless and Lossy compression, Huffman Coding, Shanon-Fano Coding, Arithmetic Coding, Golomb Coding, LZW Coding, Run Length Coding, Loss less predictive Coding, Bit Plane. Coding, Image compression standards. Practical component: 4. Write a program in Matlab to compute the Huffman coding 5. Write a program in Matlab to compute the bit plane slicing
5	Week 10-11:	Image Segmentation and Morphological Image Processing: Discontinuity based segmentation, similarity-based segmentation, Edge linking and boundary detection, 20%Threshold, Region-based Segmentation, Introduction to Morphology, Dilation, Erosion, Some basic Morphological Algorithms Practical component: 6. Write a program in Matlab to lossless predictive coding
6	Week 12-13	Object Representation and description and Computer Vision Techniques: Representation, Boundary Descriptors, Regional Descriptors, Chain Code, Structural Methods. Review of Computer Vision applications; Fuzzy-Neural algorithms for computer vision applications. Demo Experiments: 1. Write a program in Matlab to implement the Fuzzy logic algorithm 2. Write a program in Matlab to implement the neural network algorithm

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative	Encourage collaborative learning for improved competency application.

	Learning	
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)
CIE Split up for Integrated Professional Core Course (IPC)

Components		Number	Weightage	Max. Marks	Min. Marks
Theory (A)	Internal Assessment-Tests (A)	3	60%	15	06
	Assignments/Quiz/Activity (B)	2	40%	10	04
	Total Marks		**100%**	**25**	**10**
Components		**Number**	**Weightage**	**Max. Marks**	**Min. Marks**
Laboratory(B)	Record Writing	Continuous	60%	15	06
	Test at the end of the semester	1	40%	10	04
	Total Marks		**100%**	**25**	**10**

Final CIE Marks = (A) + (B)   CIE Assessment
Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. The question paper may include at least one question from the laboratory component.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	**Digital Image Fundamentals**: A comprehensive grasp of both theoretical concepts and practical applications within the field of image processing.	To understand the foundational principles and practical applications of image processing, including motivation and perspective, components of image processing systems, fundamental steps in image processing, image sampling and quantization, as well as key concepts such as pixel relationships, connectivity, and distance measures
2	**Image Enhancement** : To designed to equip learners with a comprehensive understanding of both spatial and frequency domain techniques used in image enhancement and processing.	To develop proficiency in image enhancement techniques, encompassing point processing and neighborhood operations, basic gray level transformations, histogram processing, arithmetic and logical operations for enhancement, zooming methods, spatial filters for smoothing and sharpening, and combining spatial enhancement techniques. Additionally, to introduce Fourier transform and frequency domain concepts for image processing, including smoothing, sharpening filters, and

		homomorphic filtering.
3	**Image Restoration and Image Compression** : A comprehensive understanding and practical skills in both image restoration techniques and image compression methodologies, ensuring proficiency in handling a wide range of image processing challenges and applications	To master principles and techniques involved in the image degradation and restoration process, including understanding noise models and spatial filtering for noise reduction. Additionally, to comprehend periodic noise reduction through frequency domain filtering, address linear position-invariant degradations, and acquire skills in estimating degradation functions. Further, to explore advanced restoration methods such as inverse filtering, Wiener filtering, and constrained least square filtering. Moreover, to investigate geometric mean filtering and geometric transformations for image enhancement. Lastly, to gain insights into data redundancies, image compression models, elements of information theory, and various compression techniques including lossless (e.g., Huffman, Shannon-Fano, Arithmetic, Golomb, LZW, Run Length, Lossless Predictive, Bit Plane Coding) and lossy compression standards.
4	**Image Segmentation and Morphological Image Processing:** To equip learners with a solid understanding of various segmentation methods and morphological operations used in image processing, facilitating the ability to effectively segment images and extract meaningful features for further analysis or enhancement.	To develop expertise in image segmentation techniques, including discontinuity-based segmentation, similarity-based segmentation, edge linking, and boundary detection. Additionally, to master thresholding methods such as 20% thresholding, and understand region-based segmentation principles. Furthermore, to gain proficiency in morphological operations such as dilation and erosion, and to explore basic morphological algorithms for image processing applications.
5	**Computer Vision Techniques** : To provide learners with a thorough grasp of both traditional and advanced methods in image representation and processing, alongside insights into their practical applications and the potential of fuzzy-neural approaches in enhancing computer vision capabilities	To develop comprehensive understanding of image representation techniques, including boundary and regional descriptors, and chain code methodologies. Additionally, to explore structural methods for image analysis. Furthermore, to review prominent computer vision applications leveraging these techniques. Lastly, to investigate the application of fuzzy-neural algorithms in computer vision, aiming to understand their principles and effectiveness in addressing complex visual recognition and processing tasks.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP202.1	To understand the general digital image processing terminologies.
M23MSP202.2	Analyze the image enhancement in the spatial and frequency domain
M23MSP202.3	Evaluate the methodologies for Image Restoration and Image Compression
M23MSP202.4	Analyze image segmentation, morphological image processing and computer vision techniques
M23MSP202.5	Develop Matlab code to perform image processing and computer vision techniques.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP202.1	2	2	2	2	2
M23MSP202.2	2	3	3	2	2
M23MSP202.3	3	3	2	3	2
M23MSP202.4	3	3	2	3	2
M23MSP202.5	2	2	2	3	2
M23MSP202	**2.4**	**2.6**	**2.2**	**2.6**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The “**Image processing and machine vision** “course in the second semester of the M.Tech program lays a strong foundation for future research and innovation. The future of image processing and machine vision is incredibly promising, with continuous advancements driving innovation across a multitude of sectors.

Here are some notable contributions:

1. **Enhanced Capabilities**: The integration of deep learning and AI will continue to revolutionize image processing and machine vision. Advanced neural networks will provide more accurate and efficient image recognition, segmentation, and interpretation.
2. **Real-Time Processing**: AI algorithms, particularly those leveraging edge computing, will enable real-time image processing capabilities, crucial for applications like autonomous driving, real-time surveillance, and industrial automation.
3. **Depth Sensing and Reconstruction**: Advancements in 3D imaging technologies, such as LiDAR and structured light, will enable more accurate depth sensing and 3D reconstruction, benefiting applications in robotics, augmented reality (AR), and virtual reality (VR).
4. **Improved Object Recognition**: 3D vision systems will provide improved object recognition and spatial awareness, critical for autonomous navigation and advanced human-computer interaction.
5. **Higher Resolution and Sensitivity**: Continued development of image sensors will result in higher resolution, better low-light performance, and enhanced sensitivity, improving the quality of captured images and videos.
6. **Multispectral Imaging**: Sensors capable of capturing multispectral and hyperspectral data will enable applications that require more detailed analysis, such as precision agriculture, medical diagnostics, and environmental monitoring.
7. **Early Diagnosis and Treatment**: Advanced image processing techniques will improve the accuracy and efficiency of medical imaging, aiding in early diagnosis and treatment of diseases through techniques like automated image analysis and computer-aided diagnosis.
8. **Telemedicine**: Enhanced imaging capabilities will support telemedicine by providing high-quality visuals that can be remotely analyzed by healthcare professionals.
9. **Facial Recognition**: Improvements in facial recognition technology will enhance security measures, although ethical considerations and privacy concerns will need to be addressed.
10. **Precision Agriculture**: Machine vision systems will enable precision agriculture by monitoring crop health, detecting pests, and optimizing irrigation, contributing to sustainable farming practices.
11. **Augmented Reality (AR) and Virtual Reality (VR)**: Advances in image processing will enhance AR and VR experiences, providing more realistic and immersive environments for gaming, training, and education.
12. In summary, the “Image **processing and machine learning** " course serves as a stepping stone, to explore interdisciplinary research and for their future careers in various technology-related fields.

2nd Semester	Professional Elective (PE) STATIC TIMING ANALYSIS	M23MSP203A

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1.	Digital Logic Design	**Basic Logic Gates:** AND, OR, NOT, NAND, NOR, XOR, XNOR. Combinational **and Sequential Circuits:** Multiplexers, decoders, flip-flops, registers, counters, etc. **Finite State Machines (FSMs):** Design and analysis of FSMs.
2.	Basic Electronics:	**Semiconductor Physics:** Understanding of basic semiconductor properties, doping, and the pn-junction. **MOSFET Operation:** Working principles of MOSFETs, including nMOS and pMOS transistors.
3.	FPGA Design:	**FPGA Architecture:** Understanding the basic architecture of FPGAs. **FPGA Programming:** Familiarity with programming languages like VHDL or Verilog
4.	Mathematics:	**Algebra and Calculus:** Basic mathematical skills for circuit analysis. **Probability and Statistics:** Useful for understanding variations and reliability analysis.
5.	Software Skills:	**EDA Software Proficiency:** Experience with tools like SPICE, Cadence, Synopsys, or similar for circuit simulation and analysis. **Scripting Languages:** Knowledge of scripting languages like Python or TCL for automating analysis tasks.

2. **Competencies**

S/L	Competency	KSA Description
1.	STA Concepts	**Knowledge:** CMOS logic design and modelling. Learn about different operating conditions, such as voltage, temperature, and process variations that affect circuit performance and reliability. **Skills:** The ability to perform detailed timing analysis of digital circuits, using knowledge of propagation delay, slew rate, and timing paths. Proficiency in using EDA tools for timing analysis, enabling the student to assess and optimize circuit performance accurately. **Attitudes:** Develop a meticulous and precise approach to circuit design and analysis.
2.	Standard Cell Library	**Knowledge:** The student will gain in-depth knowledge of how to model and analyse the timing characteristics and noise behaviour of digital circuits. This includes understanding various timing models (linear, non-linear, and state-dependent), capacitance specifications, synchronous and asynchronous checks, delay and slew models, noise analysis, and power dissipation modelling. **Skills:** The ability to perform advanced timing analysis and create accurate timing models for both combinational and sequential circuits. The student will be proficient in using these models to ensure circuit reliability and performance under various operating conditions. **Attitudes:** Cultivate a problem-solving mindset and strong analytical thinking skills.
3.	Interconnect Parasitics & Delay calculation	**Knowledge:** Understanding interconnects (including RLC models) that affect signal propagation and timing in integrated circuits. Knowledge of wire load models, parasitic extraction, delay calculation methodologies (both pre-layout and post-layout), and the impact of interconnect resistance and capacitance on overall circuit performance **Skills:** The ability to perform advanced delay analysis and accurately model interconnect effects (delays using effective capacitance, Elmore delay, higher-order delay

		estimation, and full-chip delay calculation). To handle parasitic extraction formats and reduce parasitics for critical nets to ensure optimal circuit performance. **Attitudes:** Will learn to approach complex interconnect and delay-related challenges methodically, using theoretical knowledge to inform practical solutions.
4.	Configuring the STA Environment	**Knowledge:** To gain in-depth knowledge of how to set up and configure the STA environment for accurate timing analysis that includes, clock, DRC's etc. **Skills:** The ability to configure and optimize the STA environment effectively in setting up complex timing constraints, managing clock relationships, incorporating external design attributes, and applying DRCs. **Attitudes:** Will be able to work towards precise timing analysis and reliable circuit performance.
5.	Timing Verification: in STA	**Knowledge:** Understand about various aspects of timing verification, frequency histogram, fault path, hold time etc. **Skills:** To develop proficiency in troubleshooting timing issues and optimizing design performance through timing analysis. **Attitudes:** To appreciate the robust timing closure design and ensuring design reliability.

3. Syllabus

STATIC TIMING ANALYSIS			
Course Code	**M23MSP203A**	CIE Marks	**50**
Teaching Hours/Week(L:P:SDA)	**4:0:0**	SEE Marks	**50**
Total Hours of Pedagogy	**40hours**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Learning objectives:
At the end of the course the student will be able to:
Understand timing analyses at various process, environment and interconnect corners.
Apply the concepts of STA to evaluate the delay of the circuits.
Understand and analyze the signal integrity issues for the IC.
Generate the timing analysis report using the EDA tool.
Understand verification and analyze the generated report to identify issues for the violation
Learn different techniques to meet timing in an IC design.
Setup the timing analysis environment and perform the timing analysis for various cases.

Module-1

Introduction: Nanometer Designs, what is Static Timing Analysis? Why Static Timing Analysis? Cross talk and Noise, Design Flow, CMOS Digital Designs, FPGA Designs, Asynchronous Designs, STA at Different Design Phases, Limitations of Static Timing Analysis, Power Considerations, Reliability Considerations,
STA Concepts: CMOS Logic Design, Basic MOS Structure, CMOS Logic Gate, Standard Cells, Modelling of CMOS Cells, Switching Waveform, Propagation Delay, Slewofa Waveform, Skew between Signals, Timing Arcs and Unateness, Min and Max Timing Paths, Clock Domains, Operating Conditions.

Module-2

Standard Cell Library: Pin Capacitance, Timing Modeling, Linear Timing Model, Non-Linear Delay Model, Example of Non-Linear, Delay Model Lookup, Threshold Specifications and Slew Derating Timing Models - Combinational Cells, Delay and Slew Models, Positive or Negative Unate, General Combinational Block, Timing Models - Sequential Cells, Synchronous Checks: Setup and Hold, Example of Setup and Hold Checks, Negative Values in Setup and Hold Checks, Asynchronous Checks, Recovery and Removal Checks Pulse Width Checks, Example of Recovery, Removal and Pulse Width Checks, Propagation Delay, State-Dependent Models XOR, XNOR and Sequential Cells, Interface Timing Model for a Black Box, Advanced Timing Modeling, Receiver Pin Capacitance, Specifying Capacitance at the Pin Level, Specifying Capacitance at the Timing Arc Level, Output Current, Models for Crosstalk Noise Analysis, DC Current, Output Voltage,, Propagated Noise, Noise Models for Two-

Stage Cells, Noise Models for Multi-stage and Sequential Cells, Other Noise Models, Power Dissipation Modeling,ActivePower,DoubleCountingClockPinPower,LeakagePower,OtherAttributesinCellLibrary, Area Specification, Function Specification, SDF Condition, Characterization and Operating Conditions, What is the Process Variable, Derating using K-factors, Library Units.
Module-3
Interconnect Parasitics: RLC for Interconnect, Wire load Models, Interconnect Trees, Specifying Wire load Models, Representation of Extracted Parasitic, Detailed Standard Parasitic Format, Reduced Standard Parasitic Format, Standard Parasitic Exchange Format, Representing Coupling Capacitances, Hierarchical Methodology, Block Replicated in Layout, Reducing Parasitics for Critical Nets, Reducing Interconnect Resistance, Increasing Wire Spacing, Parasitics for Correlated Nets. **Delay Calculation:** Overview, Delay Calculation Basics, Delay Calculation with Interconnect, Pre-layout Timing, Post-layout Timing, Cell Delay using Effective Capacitance, Interconnect Delay, Elmore Delay, Higher Order Interconnect Delay Estimation, Full Chip Delay Calculation, Slew Merging, Different Slew Thresholds, Different Voltage Domains, Path Delay Calculation, Combinational Path Delay, Path to a Flip-flop, Input to Flip-flop Path, Flip-flop to Flip-flop Path, Multiple Paths, Slack Calculation.
Module-4
Configuring the STA Environment: What is the STA Environment? Specifying Clocks, Clock Uncertainty, Clock Latency, Generated Clocks, Example of Master Clock at Clock Gating Cell Output, Generated Clock using Edge and Edge shift Options, Generated Clock using Invert Option, Clock Latency for Generated Clocks, Typical Clock Generation Scenario, Constraining Input Paths, Constraining Output Paths, Example A, Example B, Example C, Timing Path Groups, Modeling of External Attributes, Modeling Drive Strengths, Modeling Capacitive Load, Design Rule Checks, Virtual Clocks, Refining the Timing Analysis, Specifying Inactive Signals, Breaking Timing Arcs in Cells, Point-to-Point Specification, Path Segmentation.
Module-5
Timing Verification: Setup Timing Check, Flip-flop to Flip-flop Path, Input to Flip-flop Path, Input Path with Actual Clock, Flipflop to Output Path, Input to Output Path, Frequency Histogram, Hold Timing Check, Flip-flop to Flip-flop Path, Hold Slack Calculation, Input to Flip-flop Path, Flip-flop to Output Path, Flip-flop to Output Path with Actual Clock, Input to Output Path, Multicycle Paths, Crossing Clock Domains, False Paths, Half Cycle Paths, Removal Timing Check, Recovery Timing Check, Timing across Clock Domains, Slow to Fast Clock Domains, Fast to Slow Clock Domains, Half-cycle Path - Case 1, Half-cycle Path - Case 2, Fast to Slow Clock Domain, Slow to Fast Clock Domain, Multiple Clocks, Integer Multiples, Non-Integer Multiples, Phase Shifted.
Suggested Learning Resources: **Books:** 1. J. Bhasker, R Chadha, “Static Timing Analysis for Nanometer Designs: A Practical Approach”, Springer 2009. 2. Naresh Maheshwari and SachinSapatnekar, “Timing Analysis and Optimization of Sequential Circuits”, Springer Science and Business Media, 1999 **Reference Books**: 1. Sridhar Gangadharan, Sanjay Churiwala, “Constraining Designs for Synthesis and Timing Analysis – A Practical Guide to Synopsis Design Constraints (SDC)”, Springer, 2013 Web links and Video Lectures (e-Resources): https://www.mooc.org/ https://onlinecourses.nptel.ac.in/ https://www.youtube.com/watch?v=KlUn2GjNOfY&list=PLYdInKVfi0Ka5c6kraib5qiCFhPWE9G6e https://www.youtube.com/watch?v=yYR8BzysTmM&list=PLYdInKVfi0Ka5c6kraib5qiCFhPWE9G6e&ind ex=2

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction	**Introduction:** Nanometer Designs, What is Static Timing Analysis? Why Static Timing Analysis?, Cross talk and Noise, Design Flow, CMOS Digital Designs, FPGA Designs, Asynchronous Designs, STA at Different Design Phases, Limitations of Static Timing Analysis, Power Considerations, Reliability Considerations,

2	Week 3-5: STA Concepts	**STA Concepts:** CMOS Logic Design, Basic MOS Structure, CMOS Logic Gate, Standard Cells, Modeling of CMOS Cells, Switching Waveform, Propagation Delay, Slewofa Waveform, Skew between Signals, Timing Arcs and Unateness, Min and Max Timing Paths, Clock Domains, Operating Conditions .
3	Week 6-7: Standard cell library	**Standard Cell Library:** Pin Capacitance, Timing Modeling, Linear Timing Model, Non-Linear Delay Model, Example of Non-Linear, Delay Model Lookup, Threshold Specifications and Slew Derating Timing Models - Combinational Cells, Delay and Slew Models, Positive or Negative Unate, General Combinational Block, Timing Models - Sequential Cells,
4	Week 8-9: Synchronous checks	**Synchronous Checks:** Setup and Hold, Example of Setup and Hold Checks, Negative Values in Setup and Hold Checks, Asynchronous Checks, Recovery and Removal Checks Pulse Width Checks, Example of Recovery, Removal and Pulse Width Checks, Propagation Delay, State-Dependent Models XOR, XNOR and Sequential Cells, Interface Timing Model for a Black Box
4	Week 10-11: Synchronous checks	Advanced Timing Modeling, Receiver Pin Capacitance, Specifying Capacitance at the Pin Level, Specifying Capacitance at the Timing Arc Level, Output Current, Models for Crosstalk Noise Analysis, DC Current, Output Voltage, Propagated Noise, Noise Models for Two-Stage Cells, Noise Models for Multi-stage and Sequential Cells, Other Noise Models, Power Dissipation Modeling, Active Power, Double Counting Clock Pin Power, Leakage Power, Other Attributes in Cell Library, Area Specification, Function Specification, SDF Condition, Characterization and Operating Conditions, What is the Process Variable, Derating using K-factors, Library Units.
6	Week 12-13: Configuring the STA environment	**Configuring the STA Environment:** What is the STA Environment? Specifying Clocks, Clock Uncertainty, Clock Latency, Generated Clocks, Example of Master Clock at Clock Gating Cell Output, Generated Clock using Edge and Edge_shift Options, Generated Clock using Invert Option, Clock Latency for Generated Clocks, Typical Clock Generation Scenario, Constraining Input Paths, Constraining Output Paths, Example A, Example B, Example C, Timing Path Groups, Modeling of External Attributes, Modeling Drive Strengths, Modeling Capacitive Load, Design Rule Checks, Virtual Clocks, Refining the Timing Analysis, Specifying Inactive Signals, Breaking Timing Arcs in Cells, Point-to-Point Specification, Path Segmentation
7	Week 13-14: Timing verification	**Timing Verification:** Setup Timing Check, Flip-flop to Flip-flop Path, Input to Flip-flop Path, Input Path with Actual Clock, Flip flop to Output Path, Input to Output Path, Frequency Histogram, Hold Timing Check, Flip-flop to Flip-flop Path, Hold Slack Calculation, Input to Flip-flop Path, Flip-flop to Output Path, Flip-flop to Output Path with Actual Clock, Input to Output Path, Multi cycle Paths, Crossing Clock Domains, False Paths, Half Cycle Paths, Removal Timing Check, Recovery Timing Check, Timing across Clock Domains, Slow to Fast Clock Domains, Fast to Slow Clock Domains, Half-cycle Path - Case 1, Half-cycle Path - Case 2, Fast to Slow Clock Domain, Slow to Fast Clock Domain, Multiple Clocks, Integer Multiples, Non-Integer Multiples, Phase Shifted.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies

7	Real-World Application.	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**

CIE: The minimum CIE marks requirement is 40%of the maximum marks in each component.

CIE Split up for Professional Elective Course (PE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	3	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

The average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:

1. The question paper pattern will be ten questions. Each question is set for 20 marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), and a mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. **Learning Objectives**

S/L	Learning Objectives	Description
1	Introduction: Nanometric Designs	Understanding of the complexities involved in designing digital ICs. They will gain practical skills in design methodologies, analysis techniques, and problem-solving abilities required to address challenges related to timing, power, noise, reliability, and overall performance optimization in modern integrated circuits
2	STA Concepts	To develop a comprehensive understanding of the design, characterization, modeling, and optimization of standard cell libraries for efficient and reliable digital integrated circuit (IC) design.
3	Standard Cell Library	Understanding Interconnect Parasitics RLC Models, Wire load Models, Extracted Parasitics Representation, Interconnect Trees, Coupling Capacitances and Hierarchical Methodologies. Applying Techniques to Mitigate Parasitics and calculating delay.
4	Configuring the STA Environment	Mastering the Techniques for Accurate Timing Analysis and Constraint Specification in Clock and Path Management. Proficiency in managing generated clocks, constraining paths, and refining timing analysis, ensuring that the design meets all timing requirements with high accuracy and reliability
5	Timing Verification of STA	Ensuring Robust Timing Verification and Analysis Across Different Path Scenarios and Clock Domains. Comprehensive timing verification and analysis, ensuring that integrated circuits meet all timing requirements under various conditions and across different clock domains.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP203A.1	Evaluate the delay of any given digital circuits
M23MSP203A.2	Prepare the resources to perform the static timing analysis using the EDA tool.
M23MSP203A.3	Prepare timing constraints for the design based on the specification.
M23MSP203A.4	Generate the timing analysis report using the EDA tool for different checks.
M23MSP203A.5	Perform verification and analyze the generated report to identify critical issues and bottlenecks for the violation and suggest the techniques to make the design to meet the timing

CO-PO-PSO Mapping:

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP203A.1	3	3	-	2	2
M23MSP203A.2	3	2	2	2	2
M23MSP203A.3	3	2	2	2	2
M23MSP203A.4	3	2	2	2	2
M23MSP203A.5	3	2	2	2	2
M23MSP203A	**3**	**2.2**	**2**	**2**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	**10**			**10**
Module 2		**10**		**10**
Module 3			**10**	**10**
Module 4		**5**	**5**	**10**
Module 5	**5**		**5**	**10**
Total	**15**	**15**	**20**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	**20**			**20**
Module 2		**20**		**20**
Module 3			**20**	**20**
Module 4		**10**	**10**	**20**
Module 5	**10**		**10**	**20**
Total	**30**	**30**	**40**	**100**

10. Future with this Subject

The "**Static timing analysis** "course in the second semester of the M.Tech program lays a strong foundation for several future courses in research program. Static Timing Analysis (STA) continues to be a critical and evolving aspect of digital circuit design, with several future trends and areas of development. Here are some notable contributions:

1. Semiconductor technology advances to smaller process nodes (such as 7nm, 5nm, and beyond), STA becomes even more crucial.
2. In applications like AI/ML accelerators, 5G communications, and high-performance computing (HPC), STA plays a vital role in ensuring timing closure for high-speed designs.
3. STA convergence is essential for ensuring that timing constraints are met while optimizing for power consumption and maintaining signal integrity in high-speed and low-power designs.
4. Advanced Clocking Architectures (e.g., multi-domain, asynchronous, and self-timed designs), STA tools will need to support diverse clocking scenarios and analyze timing across different clock domains accurately.

5. Machine Learning and AI algorithms can help optimize timing closure by predicting critical paths, identifying timing violations, and recommending design optimizations based on historical data and simulations.
6. Timing-Aware Design Automation and integrated design flows to achieve seamless timing closure and faster design iterations.
7. In safety-critical applications (such as automotive and medical devices) and secure designs (IoT and cyber security), STA will play a crucial role in verifying timing constraints to ensure reliable and secure operation.
8. Future STA engineers will need to have interdisciplinary skills to address the complexities of modern digital designs. Are well-prepared to contribute to industries developing VLSI hardware and systems.

In summary, the “**Static timing analysis**" driven by advancements in semiconductor technology, design complexity, and the increasing demand for high-performance, low-power, and reliable integrated circuits across various applications and industries. This course serves as a stepping stone, to explore interdisciplinary research and for their future careers in various technology-related fields.

2nd Semester	Professional Elective (PE) VLSI IN SIGNAL PROCESSING	M23MSP203B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Digital Signal Processing (DSP):	Understanding of DSP concepts such as filtering, Fourier transforms, digital modulation techniques, and statistical signal processing is essential.
2	Analog and Digital Electronics:	Knowledge of both analog and digital electronics principles, including circuit design, semiconductor devices, logic design, and digital system design
3	VLSI Design:	Proficiency in VLSI design methodologies, including RTL (Register Transfer Level) design, synthesis, verification, timing analysis, and design for testability (DFT).
4	Computer Architecture:	Understanding computer architecture concepts, especially related to digital signal processing systems, such as pipelining, parallel processing, and memory architectures.
5	Programming Skills	Familiarity with programming languages commonly used in VLSI design and signal processing, such as Verilog, VHDL, and scripting languages (e.g., Python, TCL/TK) for automation and verification tasks.
6	Mathematics:	Proficiency in mathematical concepts such as linear algebra, probability, and discrete mathematics are often used in VLSI design algorithms and analysis.
7	Signal Processing Algorithms:	Knowledge of algorithms commonly used in signal processing applications, such as FFT (Fast Fourier Transform), digital filters (FIR and IIR), adaptive filtering, and algorithms for digital communications.
8	CAD Tools:	Familiarity with CAD (Computer-Aided Design) tools used in VLSI design, synthesis, and verification, such as EDA (Electronic Design Automation) tools like Cadence, Synopsys, Mentor Graphics, and scripting languages used for automation.

2. Competencies

S/L	Competency	KSA Description
1	Digital Signal Processing (DSP) Fundamentals:	Knowledge: A deep understanding of digital signal processing principles, including algorithms like FFT, digital filters, modulation techniques, and noise reduction methods. Skills: Students can apply algorithms like FFT, digital filtersetc. Attitudes: Appreciation for the importance of logical simplification in digital system design.
2	VLSI Design Methodologies:	Knowledge: Proficiency in VLSI design methodologies such as RTL (Register Transfer Level) design, synthesis, verification, timing analysis, and design for testability (DFT). Familiarity with EDA (Electronic Design Automation) tools like Cadence, Synopsys, and Mentor Graphics is crucial. Skills: Designing Register Transfer Level (RTL) coding circuits based on specifications. Analyzing and evaluating the performance of Register Transfer Level (RTL) coding circuits. Attitudes: Appreciation for the role of Register Transfer Level (RTL) coding in digital systems.

3	Combinational and Sequential Logic Circuits	Knowledge: Understanding of flip-flops, registers, and sequential logic principles. Skills: Designing sequential logic circuits with flip-flops. Optimizing the behavior of sequential circuits. Attitudes: Valuing the importance of sequential logic in digital system functionality
4	Signal Processing Algorithms:	Knowledge: Proficiency in implementing and optimizing signal processing algorithms on VLSI platforms. This includes knowledge of algorithms for filtering, image processing, audio processing, communication protocols, and sensor data processing. Skills: Proficiency in optimizing signal processing algorithms on VLSI platforms. Attitudes: Openness to learning and using of algorithms for filteringfor design.
5	System-Level Integration:	Knowledge: Ability to integrate various subsystems and components into a cohesive VLSI-based signal processing system. Skills: This involves understanding system-level trade-offs, interface standards, and performance metrics.
6	Logic Design with MSI Components and PLDs	Knowledge: Understanding of MSI components and PLDs. Skills: Implementing binary adders, subtractors, comparators, and multiplexers. Utilizing programmable logic devices (PLDs) in logic design. Attitudes: Appreciation for the versatility of MSI components and PLDs in digital logic design.
7	Flip-Flops	Knowledge: Understanding the characteristics of flip-flops. Skills: Designing and analyzing binary ripple counters and synchronous binary counters. Implementing mod-n counters using different flip-flops. Attitudes: Recognizing the significance of flip-flops in sequential logic circuits
8	EDA Tools:	Knowledge: Familiarity with Electronic Design Automation (EDA) tools for synthesis, simulation, and verification, such as ModelSim, Xilinx Vivado, or Synopsys VCS. Skills: Simulation Analysis: Skill in running simulations, analyzing waveforms, and interpreting simulation results. Attitudes: Adaptability: Ability to adapt to different EDA tools, FPGA platforms, and project requirements.
9	Design for Testability (DFT):	Knowledge: Knowledge of DFT techniques for enhancing testability and diagnosability of digital circuits. Skills: architecture to synthesis, place-and-route, and timing closure.
10	Digital design, ASIC and FPGA Architectures:	Knowledge: Understanding of logic synthesis techniques to optimize the design for area, power, and performance goals. Skills: Ability to perform static timing analysis (STA) and optimize the design to meet timing constraints. Attitudes: Appreciation for the role of clear and well-structured ASIC Synthesis design.

3. Syllabus

VLSI IN SIGNAL PROCESSING
SEMESTER – II

Course Code	**M23MSP203B**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:
At the end of the course the student will be able to:
1. To explain the VLSI applications
2. To understand the VLSI in signal processing

Module-1

Introduction to DSP Systems: Introduction; representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph. Iteration Bound: Data flow graph representations, loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs.

Module-2

Pipelining and Parallel Processing: Introduction, Pipelining of FIR Digital Filters, Parallel Processing. Pipelining and Parallel Processing for Low Power. Retiming: Introduction, Definition and Properties, Solving System of Inequalities, Retiming Techniques

Module-3

Unfolding: Introduction an Algorithms for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming Application of Unfolding. Folding: Introduction to Folding Transformation, Register Minimization Techniques, Register Minimization in Folded Architectures, Folding in Multirate Systems

Module-4

Systolic Architecture Design: Introduction, Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector, Matrix Multiplication and 2D Systolic Array Design, Systolic Design for Space Representations Containing Delays.

Module-5

Fast Convolution: Introduction, Cook, Toom Algorithm, Winogard Algorithm, Iterated Convolution, Cyclic Convolution, Design of Fast Convolution Algorithm by Inspection.

Suggested Learning Resources: Books
1. Keshab K. Parhi. VLSI Digital Signal Processing Systems, Wiley-Inter Sciences, 1999
2. Mohammed Ismail, Terri, Fiez, Analog VLSI Signal and Information Processing, McGraw Hill, 1994.

Reference Books:
3. Kung. S.Y., H.J. While house T.Kailath, VLSI and Modern signal processing, Prentice Hall, 1985.
4. Jose E. France, Yannis Tsividls, Design of Analog-Digital VLSI Circuits for Telecommunications and Signal Processing' Prentice Hall, 1994

Web links and Video Lectures https://www.mooc.org/ https://onlinecourses.nptel.ac.in/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2:	Introduction; representation of DSP algorithms: Structure and Operation of MOS Transistor Block Diagram, signal flow graph, data flow graph, dependence graph. Iteration Bound
2	Week 3-4:	Students will study Introduction, Pipelining of FIR Digital Filters Parallel Processing. Pipelining and Parallel Processing for Low Power. Retiming: Introduction, Definition and Properties. Solving System of Inequalities, Retiming Techniques
3	Week 5-6:	Unfolding: Introduction an Algorithms for Unfolding, Properties of Unfolding, Critical Path, Unfolding and Retiming Application of Unfolding Folding
4	Week 7-8:	Students will Systolic Architecture Design: Introduction, Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector, Matrix Multiplication and 2D Systolic Array Design, Systolic Design for Space Representations Containing Delays
5	Week 9-10:	Fast Convolution: Introduction, Cook, Toom Algorithm, Winogard Algorithm
6	Week 11-12:	Iterated Convolution, Cyclic Convolution, Design of Fast Convolution Algorithm by Inspection

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.
9	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.

6. Assessment Details

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)
Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have miqx of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding VLSI Fundamentals:	Gain a solid foundation in VLSI design principles, semiconductor technologies, and design methodologies specific to signal processing applications.
2	DSP Algorithms and Architectures:	Learn to implement digital signal processing (DSP) algorithms in hardware, focusing on efficient execution, parallelism, and optimization techniques.
3	ASIC and FPGA Design::	Acquire skills in designing Application-Specific Integrated Circuits (ASICs) and Field-Programmable Gate Arrays (FPGAs) for signal processing tasks, considering factors like performance, power consumption, and area efficiency.

4	Hardware-Software Co-design:	Explore techniques for co-designing hardware and software components to achieve optimal system performance and flexibility in signal processing applications.
5	Low-Power Design Techniques:	Understand methods for designing low-power VLSI circuits suitable for battery-operated devices and energy-efficient signal processing systems.
6	Advanced Signal Processing Architectures:	Study advanced architectures such as systolic arrays, pipelining, and parallel processing techniques tailored for signal processing applications.
7	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
8	Physical Design Concepts:	Familiarize with physical design concepts such as floorplanning, placement, clock tree synthesis, routing, and power grid design.
9	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
10	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes and Mapping with POs/ PSOs

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP203B.1	Able to Analyze novel approaches in representing DSP algorithms using advanced graph theory, exploring applications of complex networks and spectral graph theory to model signal processing systems.
M23MSP203B.2	Able to understand advanced algorithms methods and probabilistic analysis to determine iteration bounds in multi-rate DSP systems..
M23MSP203B.3	Able to understand cutting-edge techniques and dynamic scheduling algorithms to optimize FIR filter implementations on heterogeneous DSP architectures.
M23MSP203B.4	Explore advanced retiming strategies utilizing machine learning and optimization techniques, and performance enhancement in high-throughput DSP systems.

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP203B.1	3	3	-	3	-
M23MSP203B.2	3	-	3	3	-
M23MSP203B.3	-	3	-	-	
M23MSP203B.4	3	3	3	-	-
M23MSP203B	**3**	**3**	**3**	**3**	**-**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	**2**	**5**	**3**	**10**
Module 2	**2**	**5**	**3**	**10**
Module 3	**2**	**5**	**3**	**10**
Module 4	**2**	**5**	**3**	**10**
Module 5	**2**	**5**	**3**	**10**
Total	**10**	**25**	**15**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	**4**	**10**	**6**	**20**
Module 2	**4**	**10**	**6**	**20**

Module 3	**4**	**10**	**6**	**20**
Module 4	**4**	**10**	**6**	**20**
Module 5	**4**	**10**	**6**	**20**
Total	**20**	**50**	**30**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

Studying VLSI (Very Large Scale Integration) in the context of signal processing opens up a specialized and dynamic future. Here's how this subject can shape your career and contribute to technological advancements:

1. Specialized Expertise: VLSI in signal processing focuses on designing integrated circuits (ICs) that process signals efficiently. This niche expertise is highly sought after in industries requiring high-performance and low-power signal processing solutions.

2. Advanced Signal Processing Architectures: With VLSI skills, you can design custom hardware architectures tailored for specific signal processing tasks. This includes implementing DSP algorithms directly in hardware, optimizing for speed, power efficiency, and area constraints.

3. Emerging Technologies: As technology evolves, there's a growing demand for VLSI expertise in emerging areas such as artificial intelligence, machine learning, IoT devices, and biomedical engineering. These fields rely heavily on efficient signal processing capabilities, driving the need for innovative VLSI solutions.

4. Research and Development: VLSI in signal processing offers opportunities for cutting-edge research in novel architectures, algorithm acceleration, and hardware-software co-design. This involves pushing the boundaries of what's possible in terms of processing speed, energy efficiency, and integration complexity.

5. Industry Applications: Industries such as telecommunications, consumer electronics, automotive, aerospace, and healthcare benefit from advancements in VLSI signal processing. Your skills can contribute to developing next-generation communication systems, imaging devices, sensor networks, and more.

6. Global Impact: By specializing in VLSI for signal processing, you can contribute to solving global challenges, such as improving wireless communication networks, enhancing medical diagnostic tools, optimizing energy-efficient devices, and advancing scientific research through faster data processing capabilities.

In summary, studying VLSI in signal processing equips you with specialized skills that are not only in demand across industries but also enable you to drive innovation and make a significant impact in technological advancements worldwide.

2nd Semester	**Professional Elective (PE) DEEP LEARNING IN SIGNAL PROCESSING**	**M23MSP203C**

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Statistical Concepts	Understanding of concepts of Probability and Statistics. It is essential to have a fundamental statistical concept such as the Measure of central tendency, spread, standard normal distribution, skewness, central limit theorem, cumulative distributive function, probability density function, etc.
2.	Basic Mathematics	A good understanding of mathematics is essential for signal processing. Key mathematical topics include calculus, linear algebra, and complex numbers. Comfortable with concepts like calculus, differential equations, matrix operations, and Fourier analysis.
3.	Signals and systems	Knowledge of basic signals and systems theory is important for understanding the fundamentals of DSP. This includes understanding continuous and discrete signals, linear time-invariant systems, convolution, and Fourier transforms.
4.	Digital signal processing	A basic understanding of digital signal processing concepts like sampling, quantization, discrete-time signals, and frequency domain analysis can provide a solid foundation for further study.
5.	Programming skills	Knowledge of basic programming languages such as C, C++, Python, microcontroller programming, and MATLAB.
6.	Basic Electronics	Familiarity with basic electronics concepts, such as analog and digital signals, sampling, quantization, and filtering, can provide a practical context for learning DSP.

2. Competencies

S/L	Competency	KSA Description
1	Language fundamentals	**Knowledge:** Awareness of coding standards, design patterns, and software engineering principles relevant to deep learning in programming development. **Skills:** Proficiency in C, C++, Python, and Matlab syntax and semantics. **Attitudes:** Commitment to writing error-free code and adhering to coding standards.
2	Learning Competence	**Knowledge:** Students should be configuring and tune the hyper parameters of the learning algorithm in order to get good or better performance. **Skills:** Tuning hyper parameters of stochastic gradient descent, such as batch size, learning rate, learning rate schedules, adaptive learning rates, etc. **Attitudes:** Appreciation for the role of deep learning algorithms in an efficient and organized way.

3	Modeling	**Knowledge:** Recognizing real-world problems that can be solved efficiently using machine learning projects end-to-end using neural network models. **Skills:** Skill in preparing data, including feature selection, imputing missing values, scaling, and other transforms. **Attitudes:** Selecting and preparing a final model and using it to make predictions on new data.
4	Applications	**Knowledge:** Students can use deep learning neural network techniques in specialized problem domains. **Skills:** Demonstration of deep learning on the types of problem domains and specific problem instances where the techniques may perform well or even be state-of-the-art. **Attitudes:** Data Handling Competence. That you can load and prepare domain-specific data ready for modeling with neural networks. Technique Competence. You can compare and select appropriate domain-specific neural network models.
5	Practical Problem Solving	**Knowledge:** Solving a variety of problems using deep learning and DSP algorithms through programming assignments, and problem-solving sessions. **Skills:** Developing the ability to critically analyze problem scenarios and choose the most appropriate deep learning algorithms to solve them efficiently. **Attitudes:** Willingness to tackle challenging problems and persevere until solutions are found.

3. Syllabus

DEEP LEARNING in SIGNAL PROCESSING **SEMESTER – III**			
Course Code	**M23MSP203C**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**2:0:2**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours Theory + 10-12 slots for Skill Development Activities**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**
Course objectives: This course will enable students to: Understand the fundamental principles and practices in Deep learning. Analyze the various deep learning techniques in the real world. Design software algorithms for deep learning in signal processing applications.			
Module -1			
Review of Linear Models: Linear Regression, Linear Classifiers, Training a Linear Model, Perceptron Learning Rule, Activation Functions, Loss Functions. **Optimization:** Formulation of Objective Function, Convex Functions, Local Minima, Global Minima, Visualizing Gradient Descent, Stochastic Gradient Descent (SGD), Problems and Workarounds in SGD, Remedies, Adjusting **Derivatives for Descent:** Momentum-Based Learning, AdaGrad, RMSProp, Adam. **Multilayer Perceptron (MLP):** Feedforward Neural Networks, Bias Vector, Weight Matrix, Activation Vector, Types of Activation Functions, Feature Learning, Deep and Shallow Networks. **Back Propagation:** Multivariate Chain Rule, Representation using Computational Graph, Backpropagation Algorithm, Backpropagation on Multilayer Network.			L2, L3

Module -2	
Convolutional Neural Networks (CNN): Foundations on 2D Convolution, Convolutional Layers - Sparse Connectivity and Weight Sharing, CNN Architecture, Applications of CNN: Classification, Object Recognition. Generalization of Trained Model, Reasoning about Generalization, Bias and Variance, Remedies for Overfitting. Transfer learning.	L2, L3
Module -3	
Recurrent Neural Networks (RNN): Sequence to Sequence Prediction, Concept of RNN, Self-loops, Backpropagation through Time, Applications of RNN, Exploding/Vanishing Gradients: LSTM Networks. **Residual Networks**: Residual Blocks, Deep Residual Networks (ResNets), Residual Learning, Examples.	**L2, L3**
Module -4	
Attention and Transformer Networks: Encoder-Decoder Model, learning to Align and Translate, Attention Networks, **Transformers:** Encoder-Decoder Stacks, Scaled Dot-product Attention, Self-Attention, Multi-Head Attention, Transformer Architecture, Vision Transformer, Applications.	L2, L3
Module -5	
Signal Processing Applications: Long Short-Term Memory Models (LSTM's) for Human Activity Recognition, Applications of deep learning approaches in biomedical signal processing, and Signal classification by deep learning techniques.	L2, L3

Text Books:

1. Bengio, Yoshua, Ian Goodfellow, Aaron Courville, Deep learning, Vol. 1. Cambridge, MA, USA: MI press, 2017.
2. Nielsen, Michael A., Neural networks and Deep Learning, Vol. 25. San Francisco, CA, USA: Determination Press, 2015.

Reference Books:

1. Aggarwal, Charu C., Neural Networks and Deep Learning, Springer 10.978, 2020.
2. Lyla B. Das, Sudhish N. George, Anup Aprem Artificial Intelligence and Machine Learning: Theory and Practice, IK International Publishing House, 2022.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Linear Models, Optimization, Derivatives for Descent	Understanding the linear regression, Linear Classifiers, Training a Linear Model, perceptron learning rule, activation functions, and loss functions. Knowledge in the formulation of objective functions, Convex Functions, Local Minima, Global Minima, Visualizing Gradient Descent, Stochastic Gradient Descent (SGD), Problems and Workarounds in SGD, Remedies, and Adjusting. Understanding in Momentum-Based Learning, AdaGrad, RMSProp, Adam.
2	Week 3-4: Multilayer Perceptron (MLP), Back Propagation	Knowledge of Feedforward Neural Networks, Bias Vector, Weight Matrix, Activation Vector, Types of Activation Functions, Feature Learning, Deep and Shallow Networks. Multivariate Chain Rule, Representation using Computational Graph, Backpropagation Algorithm, Backpropagation on Multilayer Network.
3	Week 5-6: Convolutional Neural Networks and its applications	Foundations on 2D Convolution, Convolutional Layers - Sparse Connectivity and Weight Sharing, CNN Architecture. Classification, Object Recognition, Generalization of Trained Model, Reasoning about Generalization, Bias and Variance, Remedies for Overfitting. Transfer learning.

4	Week 7-8: Recurrent Neural Networks and Residual Networks	Sequence to Sequence Prediction, Concept of RNN, Self-loops, Backpropagation through Time, Applications of RNN, Exploding/Vanishing Gradients: LSTM Networks, Residual Blocks, Deep Residual Networks (ResNets), Residual Learning, Examples
5	Week 9-10: Attention and Transformer Networks and Transformers	Encoder-Decoder Model, learning to Align and Translate, Attention Networks, Encoder-Decoder Stacks, Scaled Dot-product Attention, Self-Attention, Multi-Head Attention, Transformer Architecture, Vision Transformer, Applications
6	Week 11-12: Signal Processing Applications	Long Short-Term Memory Models (LSTM's) for Human Activity Recognition, Applications of deep learning approaches in biomedical signal processing, and Signal classification by deep learning techniques.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.
9	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.

6. Assessment Details

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)
Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.
Semester End Examinations:
1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have miqx of topics under that module if necessary.

4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Deep Learning Fundamentals	Gain a solid understanding of neural network architectures relevant to signal processing, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and their variants. Learn about activation functions, loss functions, optimization algorithms (e.g., SGD, Adam), and regularization techniques (e.g., dropout, weight decay) used in deep learning.
2	Feature Extraction and Representation Learning	Learn how deep learning models can automatically extract meaningful features from signals, such as images, audio, time series data, etc. Understand techniques like transfer learning and fine-tuning for adapting pre-trained models to signal processing tasks.
3	Signal De-noising and Enhancement	Explore methods for using deep learning to denoise signals corrupted by noise or artifacts. Understand how autoencoders, CNNs, and RNNs can be applied to enhance signal quality and fidelity.
4	Time-Series Prediction and Forecasting	Understand how to apply deep learning models, such as LSTM (Long Short-Term Memory) networks, for time-series prediction. Learn about sequence-to-sequence models for tasks like forecasting future values based on historical data.
5	Applications in Audio and Speech Processing	Explore how deep learning is used for tasks such as speech recognition, speaker identification, audio synthesis, etc. Understand the architectures and techniques (e.g., WaveNet for audio synthesis, transformer models for speech recognition) specific to these applications.
6	Image and Video Processing	Gain skills in applying deep learning models to tasks like image classification, object detection, image segmentation, etc. Learn about advanced architectures like deep convolutional networks (DCNs), attention mechanisms, and their applications in visual signal processing.
7	Real-Time and Embedded Systems	Understand considerations for deploying deep learning models in real-time and resource-constrained environments. Explore techniques for optimizing model size, speed, and power consumption while maintaining performance.
8	Evaluation and Performance Metrics	Learn how to evaluate the performance of deep learning models in signal processing tasks using appropriate metrics (e.g., accuracy, precision, recall, F1-score). Understand the importance of validation techniques such as cross-validation and testing on unseen data.
9	Ethical and Practical Considerations	Consider ethical implications of using deep learning in signal processing, such as bias in training data and interpretability of models. Learn practical aspects of implementing deep learning solutions, including data preprocessing, model deployment, and ongoing maintenance.
10	Problem-Solving and Algorithmic Thinking	Develop problem-solving skills through hands-on coding exercises. Practice breaking down problems into smaller, manageable tasks, and implementing efficient deep learning algorithms and signal processing to solve them.

8. Course Outcomes and Mapping with POs/ PSOs

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP203C.1	**Apply** knowledge of linear systems, probability theory, statistics, and optimization theory for deep learning applications.
M23MSP203C.2	**Design** deep learning algorithms on real-world data.
M23MSP203C.3	**Evaluate** deep learning models to make sound decisions on real-world problems.
M23MSP203C.4	**Develop** skills to conduct independent research in neural networks and deep learning.

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP203C.1	3	-	-	-	3
M23MSP203C.2	3	2	2	3	3
M23MSP203C.3	3	2	2	3	3
M23MSP203C.4	3	3	3	3	3
M23MSP203C	**3**	**2.33**	**2.33**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**2**	**5**	**3**		**10**
Module 2	**2**	**-**	**3**	**5**	**10**
Module 3	**2**	**5**	**3**		**10**
Module 4	**2**	**5**	**-**	**3**	**10**
Module 5	**2**	**5**	**-**	**3**	**10**
Total	**10**	**20**	**9**	**11**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	**CO4**	**Total**
Module 1	**4**	**10**	**6**	**-**	**20**
Module 2	**4**	**-**	**6**	**10**	**20**
Module 3	**4**	**10**	**6**	**-**	**20**
Module 4	**4**	**10**	**-**	**6**	**20**
Module 5	**4**	**10**	**-**	**6**	**20**
Total	**20**	**40**	**18**	**22**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

Studying VLSI (Very Large Scale Integration) in the context of signal processing opens up a specialized and dynamic future. Here's how this subject can shape your career and contribute to technological advancements:

1. Specialized Expertise: VLSI in signal processing focuses on designing integrated circuits (ICs) that process signals efficiently. This niche expertise is highly sought after in industries requiring high-performance and low-power signal processing solutions.

2. Advanced Signal Processing Architectures: With VLSI skills, you can design custom hardware architectures tailored for specific signal processing tasks. This includes implementing DSP algorithms directly in hardware, optimizing for speed, power efficiency, and area constraints.

3. Emerging Technologies: As technology evolves, there's a growing demand for VLSI expertise in emerging areas such as artificial intelligence, machine learning, IoT devices, and biomedical engineering. These fields rely heavily on efficient signal processing capabilities, driving the need for innovative VLSI solutions.

4. Research and Development: VLSI in signal processing offers opportunities for cutting-edge research in novel architectures, algorithm acceleration, and hardware-software co-design. This involves pushing the boundaries of what's possible in terms of processing speed, energy efficiency, and integration complexity.

5. Industry Applications: Industries such as telecommunications, consumer electronics, automotive, aerospace, and healthcare benefit from advancements in VLSI signal processing. Your skills can contribute to developing next-generation communication systems, imaging devices, sensor networks, and more.

6. Global Impact: By specializing in VLSI for signal processing, you can contribute to solving global challenges, such as improving wireless communication networks, enhancing medical diagnostic tools, optimizing energy-efficient devices, and advancing scientific research through faster data processing capabilities.

In summary, studying VLSI in signal processing equips you with specialized skills that are not only in demand across industries but also enable you to drive innovation and make a significant impact in technological advancements worldwide.

2nd Semester	Professional Elective (PE) ARTIFICIAL NEURAL NETWORKS AND ITS APPLICATIONS	M23MSP203D

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Strong foundation in linear algebra, calculus, probability theory, and statistics is essential.
2	Programming	Proficiency in programming languages commonly used in machine learning such as Python, R, or Julia.
3	Data Structures and Algorithms	Understanding of fundamental data structures and algorithms is crucial for efficient implementation of machine learning algorithms.

2. Competencies

S/L	Competency	KSA Description
1.	Introduction, Architecture, Learning	**Knowledge:** Understanding of overview of neural network concept with historical milestone and basic learning models. **Skills:** Ability in analyzing and developing learning algorithms. **Attitudes:** Appreciation for the importance of Understanding basic neural network concept with historical milestone and its learning models.
2.	Supervised Learning, SVM and RBF	**Knowledge:** Understanding how these supervised algorithms works in neural network models like SVM and RBF. **Skills:** Analyzing the data preparation, model implementation, cross-validation, model interpretation and ensemble method. **Attitudes:** Appreciation being meticulous in data preprocessing, model training, and evaluation to ensure accuracy and reliability.
3.	Attractor Neural Networks	**Knowledge:** Understanding the mathematical models used to represent attractor neural networks, such as Hopfield networks and associative memory models. **Skills:** Describe the role of attractors in memory retrieval, pattern recognition, and decision-making. **Attitudes:** Appreciation the role of attractors in memory retrieval, pattern recognition, and decision-making.
4.	Self-organization Feature Map	**Knowledge:** Understanding the concepts of Self-Organizing Feature Maps and their role in unsupervised learning. **Skills:** Implement SOFMs using programming languages and libraries (e.g., Python with TensorFlow, MATLAB). **Attitudes:** Appreciation for the role of unsupervised algorithms in learning model.
5.	Application , Special Topic	**Knowledge:** Understanding concept of ML and DL in Computer Vision Applications. **Skills:** Development of supervised and unsupervised learning algorithms for various Applications. **Attitudes:** Appreciation for the role of supervised and unsupervised learning algorithms in various Applications.

3. Syllabus

ARTIFICIAL NEURAL NETWORKS AND ITS APPLICATIONS SEMESTER – I			
Course Code	**M23MSP203D**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- Understand the role of neural networks in engineering, artificial intelligence, and cognitive modelling.
- Understand the concepts and techniques of neural networks through the study of important neural network models.
- Evaluate whether neural networks are appropriate to a particular application.
- Apply neural networks to particular application.
- Analyze the steps needed to improve performance of the selected neural network.

Module -1

Introduction:
Biological Neuron- Artificial Neural Model- Types of activation functions-
Architecture:
Feedforward and Feedback, Convex Sets, Convex Hull and Linear Separability, Non-Linear Separable Problem. XOR Problem, Multilayer Networks.
Learning:
Learning Algorithms, Error correction and Gradient Descent Rules, Learning objective of TLNs, Perceptron Learning Algorithm, Perceptron Convergence Theorem.

Module -2

Supervised Learning:
Perceptron learning and Non Separable sets, a.-Least Mean Square Learning, MSE Error surface, Steepest Descent Search, JL-LMS approximate to gradient descent, Application of LMS to Noise Cancelling, Multi-layered Network Architecture, Back propagation Learning Algorithm, Practical consideration of BP algorithm.
Support Vector Machines and Radial Basis Function:
Learning from Examples, Statistical Learning Theory, Support Vector Machines, SVM application to Image Classification, Radial Basis Function Regularization theory, Generalized RBF Networks, Learning in RBFNs, RBF application to face recognition.

Module -3

Attractor Neural Networks:
Associative Learning Attractor Associative Memory, Linear Associative memory, Hopfield Network, application of Hopfield Network, Brain State in a Box neural Network, Simulated Annealing, Boltzmann Machine, Bidirectional Associative Memory.

Module -4

Self-organization Feature Map:
Maximal Eigenvector Filtering, Extracting Principal Components, Generalized Learning Laws, Vector Quantization, Self organization Feature Maps, Application of SOM, Growing Neural Gas.

Module -5

Application:
Computer Vision: Image classification, Object detection and localization, Image segmentation.
Natural Language Processing: Text classification, Language modeling, Machine translation.
Speech Recognition: Speech-to-text systems, Voice assistants and applications

Text Books:

1. Neural Networks A Classroom Approach- Satish Kumar, McGraw Hill Education (India) Pvt. Ltd, Second Edition.
2. Artificial Neural Networks-B. Yegnanarayana, PHI, New Delhi 1998.

Reference Books:

1. Introduction to Artificial Neural Systems-J.M. Zurada, Jaico Publications 1994.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction, Architecture, Learning	Biological Neuron- Artificial Neural Model- Types of activation functions- Feedforward and Feedback, Convex Sets, Convex Hull and Linear Separability, Non-Linear Separable Problem. XOR Problem, Multilayer Networks. Learning Algorithms, Error correction and Gradient Descent Rules, Learning objective of TLNs, Perceptron Learning Algorithm, Perceptron Convergence Theorem.
2	Week 3-4: Supervised Learning, SVM and RBF	Perceptron learning and Non Separable sets, a.-Least Mean Square Learning, MSE Error surface, Steepest Descent Search, JL-LMS approximate to gradient descent, Application of LMS to Noise Cancelling, Multi-layered Network Architecture, Back propagation Learning Algorithm, Practical consideration of BP algorithm. Learning from Examples, Statistical Learning Theory, Support Vector Machines, SVM application to Image Classification, Radial Basis Function Regularization theory, Generalized RBF Networks, Learning in RBFNs, RBF application to face recognition.
3	Week 5-6: Attractor Neural Networks	Associative Learning Attractor Associative Memory, Linear Associative memory, Hopfield Network, application of Hopfield Network, Brain State in a Box neural Network, Simulated Annealing, Boltzmann Machine, Bidirectional Associative Memory.
4	Week 7-8: Self-organization Feature Map	Maximal Eigenvector Filtering, Extracting Principal Components, Generalized Learning Laws, Vector Quantization, Self organization Feature Maps, Application of SOM, Growing Neural Gas.
5	Week 9-10: Application , Special Topic	Image classification, Object detection and localization, Image segmentation. Text classification, Language modeling, Machine translation. Speech-to-text systems, Voice assistants and applications

5. Teaching-Learning Process Strategies

S/L	TLP Strategies	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Power electronics concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Average internal assessment shall be the average of the best two test marks from the 2 tests conducted.

Semester End Examination:
1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. Thestudentshavetoanswer5fullquestionsselectingonefullquestionfromeachmodule.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Foundations of Learning Models.	Students will grasp the fundamental concepts and principles of machine learning, including supervised learning, unsupervised learning, and reinforcement learning.
2	Analyzing Probability and Statistics.	Students will gain a solid understanding of probability theory, statistical inference, and their applications in machine learning algorithms.
3	Pattern Recognition Techniques.	Students will Learn about various pattern recognition techniques such as feature extraction, dimensionality reduction, and clustering.
4	Model Evaluation and Selection based on Application	Understand techniques for evaluating and selecting machine learning models, including cross-validation, performance metrics, and model selection criteria.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP203D.1	Understand a very broad collection of learning algorithms and problems.
M23MSP203D.2	To Demonstrate knowledge in the application/analysis of Learning algorithms to solve various types of learning tasks
M23MSP203D.3	Learn algorithmic topics of learning and mathematically deep enough to introduce the required theory
M23MSP203D.4	Carry out research/Investigation for a given Learning Technique

CO-PO-PSO Mapping

CO No	PO No			PSO	
	1	2	3	1	2
M23MSP203D.1	2	2	-	2	2
M23MSP203D.2	2	2	3	2	2
M23MSP203D.3	2	-	-	2	-
M23MSP203D.4	-	-	3	-	-
M23MSP203D	**2**	**2**	**3**	**2**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

10.

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**

Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks.

11. Future with this Subject

The Artificial Neural Networks (ANNs) have seen tremendous growth and application across various fields, and their future holds even more promise as technology advances. Here's a look at how ANN learning is evolving and its applications:

1. **Deep Learning Advancements**: ANNs will continue to benefit from advancements in deep learning techniques. This includes more sophisticated architectures such as Convolutional Neural Networks (CNNs) for image processing and Recurrent Neural Networks (RNNs) for sequential data.
2. **Transfer Learning**: Future ANN applications will increasingly leverage transfer learning, where knowledge gained from one task is transferred to another related task. This improves efficiency and reduces the need for large datasets.
3. **Explainability and Interpretability**: There's a growing need to understand why ANNs make specific decisions. Future research will likely focus on developing models that are more interpretable, enabling users to trust and understand their outputs better.
4. **AutoML and Neural Architecture Search (NAS)**: Automation in model design and optimization will become more prevalent. AutoML and NAS techniques will evolve to automatically discover optimal network architectures for specific tasks.
5. **Reinforcement Learning Integration**: ANNs will be increasingly integrated with reinforcement learning techniques, enabling autonomous decision-making systems in complex environments.

Applications of ANN in Various Fields:

1. **Healthcare**: ANNs are already used for medical image analysis, disease prediction, and personalized treatment recommendations. Future applications might include real-time patient monitoring and automated diagnosis systems.
2. **Finance**: In finance, ANNs are used for fraud detection, algorithmic trading, and risk assessment. Future developments could enhance these applications with more accurate predictive models.
3. **Autonomous Vehicles**: ANN-based systems will play a crucial role in the development of self-driving cars, enabling them to perceive the environment, make decisions, and navigate safely.
4. **Natural Language Processing (NLP)**: ANNs are central to NLP tasks such as language translation, sentiment analysis, and chatbots. Future advancements may lead to more context-aware and human-like interactions.
5. **Environmental Monitoring**: ANNs can help analyze environmental data for climate modeling, pollution prediction, and disaster management. Future applications may focus on real-time monitoring and adaptive response systems.

Challenges and Considerations:

1. **Data Privacy and Security**: As ANNs are deployed in more critical applications, ensuring data privacy and security will be paramount.
2. **Ethical AI**: Addressing biases in data and ensuring fairness in ANN applications will be crucial to maintaining trust and ethical standards.
3. **Computational Efficiency**: Developing more efficient training algorithms and hardware accelerators will be necessary to handle the increasing complexity and scale of ANN models.

In conclusion, the future of learning with ANNs is bright, with ongoing advancements in deep learning techniques, increasing application across diverse fields, and addressing challenges related to interpretability, automation, and ethical considerations. Continued research and development will drive further innovation, making ANNs integral to future technological advancements.

2nd Semester	Professional Elective (PE) NANO ELECTRONICS	M23MSP203E

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Analog and Digital Electronics Knowledge	Must have studied the subjects in BE undergraduate course
2	Solid-state Electronics Knowledge	Must have studied the subject or associated subjects in BE undergraduate course
3	Electronics Measurements	Precise measurement associated techniques knowledge

2. Competencies

S/L	Competency	KSA Description
1	Fundamentals of Nano electronics	**Knowledge:** Understanding Nanoscale Phenomena: Knowledge of how materials and devices behave at the nanoscale is crucial. This includes understanding quantum mechanics, surface effects, and quantum confinement, which govern nanoelectronic behavior. **Skills** in precise manipulation and handling of materials and devices at the nanoscale. This includes proficiency in operating specialized equipment and tools used in nanofabrication**.** **Attitudes:** A proactive attitude towards innovation and pushing the boundaries of what is possible with nanoelectronics. This involves a willingness to explore unconventional ideas and approaches.
2	Characterization	**Knowledge** Computer Modeling and Simulation: Knowledge of computational tools and techniques used to simulate and predict the behavior of nanoelectronic devices. This includes finite element analysis, molecular dynamics simulations, and quantum mechanical calculations **Skills** in precise manipulation and handling of materials and devices at the nanoscale. This includes proficiency in operating specialized equipment and tools used in nanofabrication**.** **Attitudes:** A proactive attitude towards innovation and pushing the boundaries of what is possible with nanoelectronics. This involves a willingness to explore unconventional ideas and approaches.
3	Fabrication Techniques	**Knowledge:** Fabrication Techniques: Knowledge of various nanofabrication techniques such as photolithography, molecular beam epitaxy, and atomic layer deposition. This includes understanding how to manipulate materials at the atomic and molecular levels to create nanoelectronic devices. **Skills** in precise manipulation and handling of materials and devices at the nanoscale. This includes proficiency in operating specialized equipment and tools used in nanofabrication**.** **Attitudes:** A proactive attitude towards innovation and pushing the boundaries of what is possible with nanoelectronics. This involves a willingness to explore unconventional ideas and approaches.
4	Advanced Knowledge and Applications	**Knowledge:** Computer Modeling and Simulation: Knowledge of computational tools and techniques used to simulate and predict the behavior of nanoelectronic devices. This includes finite element analysis, molecular dynamics simulations, and quantum mechanical calculations. **Skills** in precise manipulation and handling of materials and devices at the nanoscale. This includes proficiency in operating specialized equipment and tools used in nanofabrication**.** **Attitudes:** A proactive attitude towards innovation and pushing the boundaries of what is possible with nanoelectronics. This involves a willingness to explore unconventional ideas and approaches.

3. Syllabus

NANO ELECTRONICS SEMESTER – II			
Course Code	**M23MSP203E**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**2:0:2**	SEE Marks	**50**
Total Hours of Pedagogy	**40hoursTheory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:
To analyze the Moore's law
To understand the spectroscopy techniques
To understand the fabrication techniques

Module-1

Introduction: Overview of nanoscience and engineering. Development milestones in microfabrication and electronic industry. Moores' law and continued miniaturization, Classification of Nanostructures, Electronic properties of atoms and solids: Isolated atom, bonding between atoms, Giant molecular solids, Free electron models and energy bands, crystalline solids, Periodicity of crystal lattices, Electronic conduction, effects of nanometer length scale, Fabrication methods: Top down processes, Bottom up processes methods for templating the growth of nanomaterials, ordering of nano systems
Self-Learning: IC Manufacturing progress in India

Module-2

Characterization: Classification, Microscopic techniques, Field ion microscopy, scanning probe techniques, diffraction techniques: bulk and surface diffraction techniques,
Spectroscopy techniques: photon, radiofrequency, electron, surface analysis and dept profiling: electron, mass, Ion beam, Reflectometry, Techniques for property measurement: mechanical, electron, magnetic, thermal properties
Self-Learning: Opportunities and Challenges in IC manufacturing domain in India

Module-3

Inorganic semiconductor nanostructures: overview of semiconductor physics. Quantum confinement in semiconductor nanostructures: quantum wells, quantum wires, quantum dots, super-lattices, band offsets, electronic density of states
Carbon Nanostructures: Carbon molecules, Carbon Clusters, Carbon Nanotubes
Self-Learning: Application of Carbon Nanotubes

Module-4

Fabrication techniques: requirements of ideal semiconductor, epitaxial growth of quantum wells, lithography and etching, cleaved-edge over growth, growth of vicinal substrates, strain induced dots and wires, electrostatically induced dots and wires, Quantum well width fluctuations, thermally annealed quantum wells, semiconductor nanocrystals, colloidal quant um dots, self-assembly techniques.
Physical processes: modulation doping, quantum hall effect, resonant tunnelling, charging effects, ballistic carrier transport, Inter band absorption, intra band absorption, Light emission processes, phonon bottleneck, quantum confined stark effect, nonlinear effects, coherence and dephasing.
Self-Learning: Characterization of semiconductor nanostructures: optical electrical and structural

Module-5

Methods of measuring properties: atomic, crystallography, microscopy, spectroscopy
Applications: Injection lasers, quantum cascade lasers, single-photon sources, biological tagging, optical memories, coulomb blockade devices, photonic structures
Self-Learning: QWIPs, NEMS, MEMS

Text Book:
1. Maria Benelmekki, Introduction to nano particles and nanotechnology, Published May 2021 • Copyright © IOP Publishing Ltd 2021
2. Chris Binns, Introduction to Nanoscience and Nanotechnology, John Wiley & Sons, 2021

Reference Book:
1. Jeremy Ramsden, Nanotechnology: An Introduction, William Andrew, 2016

https://www.mooc.org/
,https://onlinecourses.nptel.ac.in/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description

1	Week 1-2: Overview	Overview of nanoscience and engineering. Development milestones in microfabrication and electronic industry. Moores' law and continued miniaturization, Classification of Nanostructures, Electronic properties of atoms and solids: Isolated atom, bonding between atoms, Giant molecular solids, Free electron models and energy bands, crystalline solids, Periodicity of crystal lattices, Electronic conduction, effects of nanometer length scale,
2	Week 3-4: Fabrication and Characterization	Fabrication methods: Top down processes, bottom up processes methods for templating the growth of nanomaterials, ordering of nano systems **Characterization**: Classification, Microscopic techniques, Field ion microscopy, scanning probe techniques, diffraction techniques: bulk and surface diffraction techniques,
3	Week 5-6: Spectroscopy and Inorganic semiconductor nanostructures	Spectroscopy techniques: photon, radiofrequency, electron, surface analysis and dept profiling: electron, mass, Ion beam, Reflectometry, Techniques for property measurement: mechanical, electron, magnetic, thermal properties Overview of semiconductor physics. Quantum confinement in semiconductor nanostructures: quantum wells, quantum wires, quantum dots, super-lattices, band offsets, electronic density of states.
4	Week 7-8: Carbon nanostructures	Carbon molecules, Carbon Clusters, Carbon Nanotubes
5	Week 9-10: Fabrication techniques and Physical Processes	**Fabrication techniques**: requirements of ideal semiconductor, epitaxial growth of quantum wells, lithography and etching, cleaved-edge over growth, growth of vicinal substrates, strain induced dots and wires, electrostatically induced dots and wires, Quantum well width fluctuations, thermally annealed quantum wells, semiconductor nanocrystals, colloidal quant um dots, self-assembly techniques. **Physical processes**: modulation doping, quantum hall effect, resonant tunneling, charging effects, ballistic carrier transport, Inter band absorption, intra band absorption, Light emission processes, phonon bottleneck, quantum confined stark effect, nonlinear effects, coherence and dephasing.
6	Week 11-12: Measuring properties and applications	**Methods of measuring properties**: atomic, crystallography, microscopy, spectroscopy **Applications**: Injection lasers, quantum cascade lasers, single-photon sources, biological tagging, optical memories, coulomb blockade devices, photonic structures

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

This section of regulations is applicable to all theory-based courses. The minimum CIE marks requirement is 40%of maximum marks in each component.

CIE Split up for Professional Elective Course (PE)

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Averageinternalassessmentshallbetheaverageofthebesttwotestmarksfromthe3testsconducted.

Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
Thestudentshavetoanswer5fullquestionsselectingonefullquestionfromeachmodule.
Marks scored will be proportionally scaled down to 50marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Moore's law and Fundamentals of Nano electronics	Students will grasp the fundamental concepts of nano electronics and Moore's law and different types of fabrication techniques.
2	Spectroscopy techniques	Students will learn about spectroscopy techniques, magnetic and thermal properties etc..,
3	Fabrication techniques and applications	Students will understand about fabrication techniques and about potential applications
5	Collaboration and Communication Skills	Students will work collaboratively in teams on mini projects/assignments, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP203E.1	Able to understand the Moore's law, bottom-up process
M23MSP203E.2	Able to understand and analyze the microscopic and spectroscopy techniques
M23MSP203E.3	Able to understand the carbon nanostructures
M23MSP203E.4	Able to understand and analyze the fabrication techniques and applications

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP203E.1	**3**	**-**	**-**	**--**	**-**
M23MSP203E.2	**-**	**3**	**-**	**3**	**-**
M23MSP203E.3	**-**	**3**	**-**	**3**	**-**
M23MSP203E.4	**-**	**-**	**3**	**3**	**-**
M23MSP235	**3**	**3**	**3**	**3**	**-**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

Conditions for SEE Paper Setting:

Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject

1. **Smaller and Faster Devices**: Nanoelectronics enable the fabrication of smaller, more efficient electronic components. This could lead to faster computers, smaller and more powerful smartphones, and more compact medical devices.
2. **Energy Efficiency**: Nano electronic devices often consume less power than their larger counterparts. This could contribute to more energy-efficient electronics overall, reducing both costs and environmental impact.
3. **Advanced Sensors**: Nanoelectronics can enable highly sensitive sensors capable of detecting minute changes in the environment, such as in healthcare for diagnostics or in environmental monitoring.
4. **Flexible Electronics**: Nanotechnology allows for the creation of flexible electronics that can be integrated into wearable devices, bendable displays, and even smart fabrics.
5. **Medical Applications**: Nanoelectronics hold potential in medical diagnostics, drug delivery systems, and even neural interfaces for brain-computer interfaces (BCIs), enabling new treatments and diagnostic techniques.
6. **Quantum Computing**: Nanoelectronics are crucial for the development of quantum computing, which promises exponentially faster processing speeds for certain types of problems compared to classical computers.
7. **Environmental Impact**: The smaller size and increased efficiency of nanoelectronic devices could potentially reduce electronic waste and contribute to sustainability efforts.

2nd Semester	Professional Elective ADVANCES IN VLSI DESIGN	M23MSP204A

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Digital Logic Design	Understanding of digital logic gates, combinational and sequential circuits, Boolean algebra, and truth tables.
2.	Circuit Theory	Familiarity with circuit analysis techniques such as Kirchhoff's laws, nodal and mesh analysis, Thevenin's and Norton's theorems.
3.	Electronic Devices and Circuits	Knowledge of semiconductor devices like MOSFETs and CMOS technology, including their characteristics, behavior, and basic operation.
4.	Computer Architecture	Understanding of computer organization and architecture, including CPU components, memory systems, and I/O interfaces.
5.	Programming	Basic programming skills in languages like C/C++ or Verilog/VHDL for hardware description and simulation.
6.	Mathematics	Proficiency in mathematical concepts such as linear algebra, probability, and discrete mathematics, which are often used in VLSI design algorithms and analysis.
7.	Digital Signal Processing (DSP)	Understanding of digital signal processing concepts, especially relevant for courses focusing on DSP ASIC design.
8.	Analog and Digital Electronics	Basic understanding of analog electronics principles, digital electronics, and their integration in VLSI systems.

2. Competencies

S/L	Competency	KSA Description
1	Digital Design:	Knowledge: Understanding of fundamental digital logic concepts, including Boolean algebra, logic gates, flip-flops, registers, and memory elements. Skills: Students can apply minimization techniques for Boolean expression simplification. Attitudes: Appreciation for the importance of logical simplification in digital system design.
2	RTL Design:	Knowledge: Proficiency in Register Transfer Level (RTL) coding using hardware description languages (HDLs) like Verilog or VHDL to describe the behavior of digital circuits. Skills: Designing Register Transfer Level (RTL) coding circuits based on specifications. Analyzing and evaluating the performance of Register Transfer Level (RTL) coding circuits. Attitudes: Appreciation for the role of Register Transfer Level (RTL) coding in digital systems.
3	Combinational and Sequential Logic Circuits	Knowledge: Understanding of flip-flops, registers, and sequential logic principles. Skills: Designing sequential logic circuits with flip-flops. Optimizing the behavior of sequential circuits. Attitudes: Valuing the importance of sequential logic in digital system functionality

4	Verilog HDL	Knowledge: Understanding the structure of Verilog modules. Knowledge of Verilog operators and data types. Skills: Proficiency in writing synthesizable RTL code using HDLs like Verilog or VHDL. Attitudes: Openness to learning and using hardware description languages for design.
5	Logic Design with MSI Components and PLDs	Knowledge: Understanding of MSI components and PLDs. Skills: Implementing binary adders, subtractors, comparators, and multiplexers. Utilizing programmable logic devices (PLDs) in logic design. Attitudes: Appreciation for the versatility of MSI components and PLDs in digital logic design.
6	Flip-Flops	Knowledge: Understanding the characteristics of flip-flops. Skills: Designing and analyzing binary ripple counters and synchronous binary counters. Implementing mod-n counters using different flip-flops. Attitudes: Recognizing the significance of flip-flops in sequential logic circuits
7	Introduction to Verilog	Knowledge: Understanding the structure of Verilog modules. Knowledge of Verilog operators and data types. Skills: Applying Verilog for digital system design. Describing digital systems using Verilog data flow and behavioral models. Attitudes: Openness to learning and using hardware description languages for design.
8	Behavioral and Structural Description	Knowledge: Understanding of Verilog behavioral and structural description. Skills: Writing Verilog behavioral descriptions. Implementing loop statements and structural descriptions in Verilog. Attitudes: Appreciation for the role of clear and well-structured Verilog code in design.
9	EDA Tools:	Knowledge: Familiarity with Electronic Design Automation (EDA) tools for synthesis, simulation, and verification, such as ModelSim, Xilinx Vivado, or Synopsys VCS. Skills: Simulation Analysis: Skill in running simulations, analyzing waveforms, and interpreting simulation results. Attitudes: Ability to adapt to different EDA tools, FPGA platforms, and project requirements.
10	Design for Testability (DFT):	Knowledge: Knowledge of DFT techniques for enhancing testability and diagnosability of digital circuits. Skills: architecture to synthesis, place-and-route, and timing closure.
11	Digital design, ASIC and FPGA Architectures:	Knowledge: Understanding of logic synthesis techniques to optimize the design for area, power, and performance goals. Skills: Ability to perform static timing analysis (STA) and optimize the design to meet timing constraints. Attitudes: Appreciation for the role of clear and well-structured ASIC Synthesis design.

3. Syllabus

ADVANCES IN VLSI DESIGN
SEMESTER – II

Course Code	**M23MSP204A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2)**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**

Course Learning objectives:
At the end of the course the student will be able to:
1. Learn circuit-oriented approach towards digital design
2. Illustrate the impact of interconnect wiring on the functionality and performance of a digital gate.
3. Infer different approaches to digital timing and clocking circuits
4. Understand the impact of clock skew on the behaviour of digital synchronous circuits.
5. Explain the role of peripheral circuitry such as the decoders, sense amplifiers, drivers and control circuitry in the design of reliable and fast memories.

Module-1

Implementation Strategies For Digital ICS: Introduction, From Custom to Semicustom and Structured Array Design Approaches, Custom Circuit Design, Cell-Based Design Methodology, Standard Cell, Compiled Cells, Macrocells, Megacells and Intellectual Property, Semi-Custom Design Flow, Array-Based Implementation Approaches, Pre-diffused (or Mask-Programmable) Arrays, Pre-wired Arrays, Perspective-The Implementation Platform of the Future.

Module-2

Coping With Interconnect: Introduction, Capacitive Parasitics, Capacitance and Reliability-Cross Talk, Capacitance and Performance in CMOS, Resistive Parasitics, Resistance and Reliability-Ohmic Voltage Drop, Electromigration, Resistance and Performance-RC Delay, Inductive Parasitics, Inductance and Reliability-Voltage Drop, Inductance and Performance-Transmission Line Effects, Advanced Interconnect Techniques, ReducedSwing Circuits, Current-Mode Transmission Techniques, Perspective: Networks-on-a-Chip

Module-3

Timing Issues In Digital Circuits: Introduction, Timing Classification of Digital Systems, Synchronous Interconnect, Mesochronous interconnect, Plesiochronous Interconnect, Asynchronous Interconnect, Synchronous Design — An In-depth Perspective, Synchronous Timing Basics, Sources of Skew and Jitter, Clock-Distribution Techniques, Latch-Base Technique, Completion-Signal Generation, Self-Timed Signaling, Practical Examples of Self-Timed Logic, Synchronizers, and Arbiters, Synchronizers-Concept and Implementation, Arbiters, Clock Synthesis and Synchronization Using a Phase-Locked Loop, Basic Concept, Building Blocks of a PLL. d Clocking, Self-Timed Circuit Design, Self-Timed Logic - An Asynchronous

Module-4

Design of testable sequential circuits: Controllability and observability, Ad-Hoc design rules for improving testability, design of diagnosable sequential circuits, the scan-path technique for testable sequential circuit design, Level Sensitive Scan Design(LSSD), Random Access Scan Technique, Partial scan, testable sequential circuit design using Nonscan Techniques, Crosscheck, Boundary Scan

Module-5

Designing Memory and Array Structures: Memory Reliability and Yield, Signal-to-Noise Ratio, Memory yield, Power Dissipation in Memories, Sources of Power Dissipation in Memories, Partitioning of the memory, Addressing the Active Power Dissipation, Data retention dissipation, Case Studies in Memory Design: The Programmable Logic Array (PLA), A 4 Mbit SRAM, A 1 Gbit NAND Flash Memory, Perspective: Semiconductor Memory Trends and Evolutions.

Suggested Learning Resources:

Text Books
1. Jan M Rabey, Anantha Chandrakasan, Borivoje Nikolic, ―Digital Integrated Circuits-A Design Perspective‖, PHI, 2nd Edition.
2. S. Pasricha and N. Dutt," On ChipCommunication Architectures System on Chip Interconnect, Elsveir", 2008.

Reference Books
1. M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated Circuit Design Perspective (2/e)", PHI2003.
2. D.A.Hodges,"Analysis and Design of Digital Integrated Circuits (3/e)", MGH 2004.

Web links and Video Lectures (e-Resources):https://www.mooc.org/ https://onlinecourses.nptel.ac.in/

Skill Development Activities Suggested
Mini project group wise on implementation of Machine learning algorithm using python

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2:	Students will study The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias Structure and Operation of MOS Transistor MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects. Introduction, Resistive-Load Inverter, Inverters with type MOSFET Load
2	Week 3-4:	Students will study MOS Inverters-Static Characteristics CMOS Inverter. Switching Characteristics and Interconnect Effects: Introduction, Delay-Time Definition, Calculation of Delay Times, Inverter Design with Delay Constraints, Estimation of Interconnect Parasitics Calculation of Interconnect Delay, Switching Power Dissipation of CMOS Inverters.
3	Week 5-6:	Students will study Dynamic Logic Circuits: Introduction, Dynamic Random ASIC Construction Dynamic CMOS Circuit Techniques, High-Performance Dynamic CMOS circuits Basic BiCMOS Circuits
4	Week 7-8:	Students will use Chip Input and Output (I/O) Circuits ESD Protection, Input Circuits, Design for Manufacturability
5	Week 9-10:	Students will study Design of Experiments and Performance Modeling Design of Experiments and Performance Modeling
6	Week 11-12:	Students will design Experiments and Perform Modeling

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.
9	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.

6. Assessment Details

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max.Marks	Min.Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10

(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)
Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding Digital Design Fundamentals	Students will grasp the fundamental concepts of digital logic design, including Boolean algebra, logic gates, combinational and sequential circuits, and finite state machines
2	Designing Combinational and Sequential Circuits	Students will learn to design and implement combinational circuits such as adders, multiplexers, and decoders, as well as sequential circuits such as flip-flops, registers, and counters using Verilog
3	Fundamental Concepts of VLSI Design:	Understand the basic principles and concepts of VLSI design, including semiconductor physics, CMOS technology, and IC fabrication processes.
4	ASIC Design Methodologies:	Learn various ASIC design methodologies, including RTL design, synthesis, place-and-route, and timing closure.
5	ASIC Synthesis and	Optimization: Understand logic synthesis techniques to optimize the design for area, power, and performance goals.
6	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
7	Physical Design Concepts:	Familiarize with physical design concepts such as floor-planning, placement, clock tree synthesis, routing, and power grid design.
8	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
9	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes and Mapping with POs/ PSOs

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP204A.1	**Analyze** the Digital IC Design fundamentals of digital integrated circuit design, including various design methodologies and implementation strategies from custom to structured arrays
M23MSP204A.2	**Analyze** addresses interconnect challenges in digital circuits, including capacitance, resistance and inductance.
M23MSP204A.3	**Apply** the advanced techniques concept such as reduced-swing circuits and current mode transmission, and gain the proficiency in timing issues in digital circuits.
M23MSP204A.4	**Design** and implement testable Digital circuits including scan-path insertion methods like LSSD and boundary scan ensuring robustness and diagnosability in sequential circuit designs

CO's	PO1	PO2	PO3	PSO1	PSO2
M23MSP204A.1	3	3	-	3	-
M23MSP204A.2	3	-	-	3	-
M23MSP204A.3	3	-	-		-
M23MSP204A.4	3	3	3	3	3
M23MSP204A	**3**	**3**	**3**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

10.

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

Conditions for SEE Paper Setting:

Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks.

10. Future with this Subject

The future of ASIC design in VLSI is promising, driven by advancements in technology, evolving design methodologies, and emerging application areas. Here's how the subject is expected to evolve:

1. Technology Advancements: As semiconductor technology continues to advance, with the transition to smaller process nodes and the integration of novel materials and structures, ASIC designers will have access to more advanced and efficient building blocks. This will enable the development of ASICs with higher performance, lower power consumption, and increased integration levels.

2. Specialized ASICs for Emerging Applications: With the proliferation of emerging technologies such as artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and autonomous systems, there will be a growing demand for specialized ASICs tailored to these applications. ASIC designers will need to innovate and develop customized solutions optimized for specific use cases, offering improved performance, efficiency, and cost-effectiveness compared to general-purpose processors.

3. Heterogeneous Integration: The integration of diverse technologies, such as digital logic, analog circuits, MEMS (Micro-Electro-Mechanical Systems), and photonics, into a single ASIC will become more prevalent. This trend towards heterogeneous integration will require ASIC designers to possess expertise in integrating and optimizing diverse components, enabling the development of highly integrated and multifunctional systems-on-chip (SoCs).

4. Design for Security and Trustworthiness: With the increasing concerns about cybersecurity and intellectual property protection, ASIC designers will need to prioritize security and trustworthiness in their designs. This includes implementing hardware security features, such as encryption, authentication, and secure boot mechanisms, as well as ensuring the integrity and confidentiality of sensitive data processed by ASICs.

5. Advanced Design Methodologies: Future ASIC design methodologies will likely leverage advanced automation techniques, machine learning algorithms, and predictive analytics to streamline the design process, improve design productivity, and optimize design outcomes. Additionally, there will be a

continued shift towards higher levels of abstraction and design reuse, enabling faster time-to-market and greater design scalability.

6. Energy-Efficient Computing: As energy efficiency becomes a critical consideration in both mobile and data center applications, ASIC designers will focus on developing energy-efficient designs that minimize power consumption without compromising performance. This will involve the adoption of low-power design techniques, dynamic voltage and frequency scaling, and architectural innovations aimed at maximizing energy efficiency.

Overall, the future of ASIC design in VLSI is characterized by innovation, specialization, and adaptability to evolving technological trends and application requirements. ASIC designers will play a crucial role in driving the development of cutting-edge semiconductor solutions that power the next generation of electronic devices and systems.

2nd Semester	**Professional Elective CRYPTOGRAPHY AND NETWORK SECURITY**	**M23MSP204B**

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Transport Level Security	Knowledge of Secure Sockets Layer, Transport Layer Security, HTTPS, Secure Shell (SSH) .
2	Firewalls	Firewalls are security devices or software that monitor and control incoming and outgoing network traffic based on predetermined security rules. They act as a barrier between trusted internal networks and un-trusted external networks
3	Intrusion Detection and Prevention Systems (IDPS)	IDPS monitor network traffic for signs of malicious activity or policy violations. They can alert administrators or take automated actions to block suspicious traffic.
4	Access Control	Managing who can access the network and its resources. This involves authentication (verifying the identity of users and devices), authorization (granting appropriate access privileges), and accounting (tracking and logging actions).
5	Malicious Software	Malicious software, often referred to as malware, is a broad term used to describe any type of software intentionally designed to cause damage to a computer, server, client, or computer network.

2. Competencies

S/L	Competency	KSA Description
1	Steganography	**Knowledge:** Knowledge of various steganographic methods such as LSB substitution, spread spectrum techniques, digital watermarking, and whitespace steganography. **Skills:** Proficiency in using steganography tools and software to embed and extract hidden messages within various types of digital media **Attitudes:** A curiosity-driven mindset to explore new steganographic techniques, tools, and research developments, and a commitment to staying updated with advancements in the field.
2	Symmetric Cipers	**Knowledge:** Knowledge of how symmetric encryption algorithms work, including the processes of encryption and decryption using a shared secret key. Familiarity with common symmetric encryption algorithms such as AES (Advanced Encryption Standard), DES (Data Encryption Standard), 3DES (Triple DES), and Blowfish. **Skills:** Ability to implement symmetric encryption algorithms in programming languages and platforms, ensuring secure handling of keys and data. **Attitudes:** A commitment to best practices in symmetric encryption, including strong key management, secure implementation, and adherence to cryptographic standards.
3	Block chain	**Knowledge:** Understanding the basic concepts of block chain technology, including decentralized consensus mechanisms, distributed ledger technology, blocks, and transactions. **Skills:**Proficiency in developing blockchain applications and smart contracts using programming languages like Solidity (for Ethereum) or other blockchain-specific languages (e.g., Chaincode for Hyperledger Fabric). **Attitudes:** A mindset focused on exploring new possibilities and adapting to the evolving landscape of blockchain technology, including emerging trends and advancements.
4	One-Way Hash Functions	**Knowledge:** Understanding of hash functions as mathematical algorithms that transform input data (messages of arbitrary length) into a fixed-size output (hash value or digest). **Skills:** Proficiency in implementing hash functions in programming languages (e.g., Python, Java, C++) for applications such as data integrity checking,

		password hashing, and digital signatures. **Attitudes:** A commitment to best practices in the secure use of hash functions, including proper key management, salted hashing for passwords, and adherence to cryptographic standards.

3. Syllabus

CRYPTOGRAPHY AND NETWORK SECURITY
SEMESTER – II

Course Code	**M23MSP204B**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- To explain the crypto systems
- To describe IP security

Module -1

Foundations: Terminology, Steganography, substitution ciphers and transpositions ciphers, Simple XOR, One-Time Pads, Computer Algorithms (Text 2: Chapter 1: Section 1.1 to 1.6). **SYMMETRIC CIPHERS:** Traditional Block Cipher structure, Data encryption standard (DES), The AES Cipher. (Text 1: Chapter 2: Section2.1, 2.2, Chapter 4).

Module-2

Introduction to modular arithmetic, Prime Numbers, Fermat's and Euler's theorem, primality testing, Chinese Remainder theorem, discrete logarithm. Principles of Public-Key Cryptosystems, The RSA algorithm, Diffie - Hellman Key Exchange, Elliptic Curve Arithmetic,Elliptic Curve Cryptography

Module-3

Block Chain: Introduction to Blockchain Technology, blockchain vs conventional distributed database, Evolution of Blockchain, Merkle Tree, Mining techniques,Blockchain Application Lifecycle, Cryptocurrency- Bitcoin, Distributed Ledger, Bitcoin protocols, Ethereum, Smart Contract, Consensus Mechanisms (Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn), Blockchain Applications- IoT, Healthcare, Finance, Supply chain, Identity Management.

Module-4

One-Way Hash Functions: Background, Snefru, N-Hash, MD4, MD5, Secure Hash Algorithm [SHA], One way hash functions using symmetric block algorithms, Using public key algorithms, Choosing a one-way hash functions, Message Authentication Codes. Digital Signature Algorithm, Discrete Logarithm Signature Scheme

Module-5

E-mail Security: Pretty Good Privacy-S/MIME
IP Security: IP Security Overview, IP Security Policy, Encapsulation Security Payload (ESP), Combining security Associations.
Web Security: Web Security Considerations, SSL

Suggested Learning Resources:

Text Books:

1. 'Cryptography and Network Security Principles and Practice', William Stallings, Pearson Education Inc., ISBN: 978-93325-1877-3, 6th Edition, 2014
2. 'Applied Cryptography Protocols, Algorithms, and Source code in C', Bruce Schneier, Wiley Publications ISBN: 9971-51348-X, 2nd Edition.

Reference Books:

1. 'Cryptography and Network Security', Behrouz A. Forouzan, TMH, 2007
2. 'Cryptography and Network Security', Atul Kahate, TMH, 2003
3. 4. Blocks and Chains: Introduction to Bitcoin, Cryptocurrencies and Their Consensus Mechanisms - AljoshaJudmayer, Nicholas Stifter, Katharina Krombholz, and Edgar Weippl [Morgan & Claypool]

Web links and Video Lectures (e-Resources):
https://www.mooc.org/
https://onlinecourses.nptel.ac./

4. Syllabus Timeline

S/L	**Syllabus Timeline**	**Description**

1	Week 1-2: Foundations	Terminology, Steganography, substitution ciphers and transpositions ciphers, Simple XOR, One-Time Pads, Computer Algorithms
2	Week 3-4:SymetricCipers	Traditional Block Cipher structure, Data encryption standard (DES), The AES Cipher
3	Week 5-6:Introduction to cryptography	Introduction to modular arithmetic, Prime Numbers, Fermat's and Euler's theorem, primality testing, ChineseRemainder theorem, discrete logarithm. Principles of Public-Key Cryptosystems, The RSA algorithm, Diffie - Hellman Key Exchange, Elliptic Curve Arithmetic,Elliptic Curve Cryptography
4	Week 7-8:Block Chain	Introduction to Blockchain Technology, blockchain vs conventional distributed database, Evolution of Blockchain, Merkle Tree, Mining techniques,Blockchain Application Lifecycle, Cryptocurrency- Bitcoin, Distributed Ledger, Bitcoin protocols, Ethereum, Smart Contract, Consensus Mechanisms (Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn), Blockchain Applications- IoT, Healthcare, Finance, Supply chain, Identity Management.
5	Week 9-10: One-Way Hash Functions	Background, Snefru, N-Hash, MD4, MD5, Secure Hash Algorithm [SHA], One way hash functions using symmetric block algorithms, Using public key algorithms, Choosing a one-way hash functions, Message Authentication Codes. Digital Signature Algorithm, Discrete Logarithm Signature Scheme
6	Week 11-12: One-Way Hash Functions	Background, Snefru, N-Hash, MD4, MD5, Secure Hash Algorithm [SHA], One way hash functions using symmetric block algorithms, Using public key algorithms, Choosing a one-way hash functions, Message Authentication Codes. Digital Signature Algorithm, Discrete Logarithm Signature Scheme

5. Teaching-Learning Process Strategies

S/L	**TLP Strategies:**	**Description**
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

Components		**Number**	**Weightage**	**Max. Marks**	**Min. Marks**
(i)	Internal Assessment-Tests(A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity(B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks=(A) +(B)

Averageinternalassessmentshallbetheaverageofthebesttwotestmarksfromthe3testsconducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise itis mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. Thestudentshavetoanswer5fullquestionsselectingonefullquestionfromeach module.
5. Marks scored will be proportionally scaled down to 50marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	crypto systems	Students will learn Symmetric Cryptography and Symmetric Cryptography
2	Symmetric ciphers	Students will learn Traditional Block Cipher structure, Data encryption standard (DES), The AES Cipher
3	Project-Based Learning	Through hands-on projects, students will apply their knowledge of digital design and Verilog to design, implement, simulate, and verify complex digital systems, reinforcing their understanding of theoretical concepts
4	Collaboration and Communication Skills	Students will work collaboratively in teams on design projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively.
5	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with digital design, including respecting intellectual property rights, ensuring design reliability and security, and adhering to industry standards and best practices.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP204B.1	Able to understand the fundamentals of data encryption standard.
M23MSP204B.2	Able to understand and analyze the E – mail security and web security
M23MSP204B.3	Able to understand and analyze the Block chain technology

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP204B.1	3	-	-	--	-
M23MSP204B.2	-	3	-	3	-
M23MSP204B.3	-	3	-	3	-
M23MSP204B	3	3	3	3	-

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Module 1	10			10
Module 2		10		10
Module 3			10	10
Module 4		5		10
Module 5		5	5	10
Total	10	20	20	50

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Module 1	20			20
Module 2		20		20
Module 3			20	20
Module 4		10		20
Module 5		10	10	20
Total	20	50	30	100

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject
The "Cryptography and network security"course in the second Semester of the MTech program lays a strong foundation for several future courses in the undergraduate program. The contributions of this subject extend across various areas, enhancing the students' understanding and skills in the field of network security. Here are some notable contributions:

1. Internet of Things (IoT)
   a. Smart Homes and Cities: Embedded systems will be the backbone of smart infrastructure, enabling automation, energy management, and enhanced public services.
   b. Industrial IoT (IIoT): Integration of embedded systems in manufacturing for predictive maintenance, asset tracking, and improved operational efficiency.
2. Artificial Intelligence and Machine Learning (AI/ML)
   a. Edge AI: Deploying AI algorithms on embedded devices for real-time data processing, reducing latency, and enhancing privacy.
   b. Autonomous Systems: Development of autonomous vehicles, drones, and robots with advanced decision-making capabilities.
3. Healthcare and Biomedical Engineering
4. Wearable Health Devices: Embedded systems in wearable devices for continuous health monitoring and personalized medicine.
5. Medical Imaging and Diagnostics: Advanced embedded systems for high-precision imaging, data analysis, and automated diagnosis.
6. Cybersecurity
7. Secure IoT Devices: Developing secure IoT solutions to protect against cyberattacks and data breaches.
8. Trusted Execution Environments: Implementing secure environments within embedded systems to protect sensitive operations.
9. Homomorphic Encryption:
10. Homomorphic encryption allows computations to be performed on encrypted data without decrypting it first. This capability is crucial for preserving privacy while enabling secure computation in scenarios such as cloud computing, data analytics, and collaborative data processing.

2nd Semester	Professional Elective ERROR CONTROL CODING	M23MSP204C

1. **Prerequisites**

S/L	Proficiency	Prerequisites
1	Probability and Statistics	Understanding of basic probability theory and statistical concepts.
2	Digital Communication Systems	Knowledge of basic digital communication concepts, including modulation and demodulation techniques.
3	Information Theory	Basic understanding of entropy, mutual information, and channel capacity concepts.
4	Signal Processing	Knowledge of basic signal processing techniques and Fourier transforms.
5	Basic Coding Theory	Introduction to coding theory, including understanding of error detection and correction codes (e.g., Hamming codes).

2. **Competencies**

S/L	Competency	KSA Description
1	Error Detection and Correction Codes	Knowledge: Understanding of various error detection and correction codes (e.g., parity, CRC, Hamming codes, Reed-Solomon codes). Skills: Proficiency in designing and implementing error detection and correction algorithms. Attitudes: Valuing the reliability and integrity of data transmission and storage.
2	Information Theory	Knowledge: Knowledge of entropy, mutual information, and channel capacity. Skills: Ability to apply information theory concepts to analyze and design coding systems. Attitudes: Appreciation for the theoretical foundations of coding and communication systems.
3	Linear Block Codes	Knowledge: Understanding of the structure and properties of linear block codes. Skills: Proficiency in encoding and decoding linear block codes. Attitudes: Interest in exploring advanced coding techniques for error control.
4	Convolution Codes	Knowledge: Knowledge of convolutional codes and their implementation. Skills: Ability to design and analyze convolutional encoders and decoders. Attitudes: Recognition of the importance of convolutional codes in communication systems.
5	Code Performance Analysis	Knowledge: Understanding of metrics for evaluating code performance (e.g., bit error rate, code rate). Skills: Ability to analyze and compare the performance of different coding schemes. Attitudes: Recognition of the importance of performance analysis in the design of coding systems.

3. Syllabus

ERROR CONTROL CODING
SEMESTER – II

Course Code	**M23MSP204C**	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Hours of Pedagogy	**40 hours Theory + 10-12slots for SDA**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives: This course will enable students to:

- Understand the concepts of Entropy, information rate and capacity of the discrete Memory less Channel.
- Apply modern algebra and probability theory for coding.
- Understand and Compare Block codes such as Linear Block Codes, Cyclic codes, etc. and Convolutional codes.
- Understand error detection and correction for different data communication and storage systems.
- Analyze and implement different Block code encoders and decoders, and also convolutional encoders and decoders including soft and hard Viterbi algorithm.

Module -1

Information theory: Introduction, Entropy, Source coding theorem, discrete memoryless channel, Mutual Information, Channel Capacity Channel coding theorem (Chap. 5 of Text 1).
Introduction to algebra: Groups, Fields, binary field arithmetic, Construction of Galois Fields GF (2m) and its properties, (Only statements of theorems without proof) Computation using Galois field GF (2m) arithmetic, Vector spaces and Matrices (Chap. 2 of Text 2).

Module -2

Linear block codes: Generator and parity check matrices, Encoding circuits, Syndrome and error detection, Minimum distance considerations, Error detecting and error correcting capabilities, Standard array and syndrome decoding, Single Parity Check Codes (SPC), Repetition codes, Self dual codes, Hamming codes, Reed-Muller codes. Product codes and Interleaved codes (Chap. 3 of Text 2).

Module -3

Cyclic codes: Introduction, Generator and parity check polynomials, Encoding of cyclic codes, Syndrome computing and error detection, Decoding of cyclic codes, Error trapping Decoding, Cyclic hamming codes, Shortened cyclic codes (Chap. 4 of Text 2).

Module -4

BCH codes: Binary primitive BCH codes, Decoding procedures, Implementation of Galois field arithmetic. (6.1, 6.2, 6.7 of Text 2) Primitive BCH codes over GF (q), Reed -Solomon codes (7.2, 7.3 of Text 2).
Majority Logic decodable codes: One -step majority logic decoding, Multiple-step majority logic (8.1, 8.4 of Text 2).

Module -5

Convolution codes: Encoding of convolutional codes: Systematic and Nonsystematic Convolutional Codes, Feed forward encoder inverse, A catastrophic encoder, Structural properties of convolutional codes: state diagram, state table, state transition table, tree diagram, trellis diagram. Viterbi algorithm, Sequential decoding: Log Likelihood Metric for Sequential Decoding (11.1, 11.2, 12.1,13.1 of Text 2).

Text Books:
1. 'Digital Communication systems', Simon Haykin, Wiley India Private. Ltd, ISBN 978-81-265- 4231-4, First edition, 2014
2. 'Error control coding', Shu Lin and Daniel J. Costello. Jr, Pearson, Prentice Hall, 2nd edition, 2004

e-Resources: https://www.mooc.org/https://onlinecourses.nptel.ac.in/

Reference Books:
1. 'Theory and practice of error control codes', Blahut. R. E, Addison Wesley, 1984
2. 'Introduction to Error control coding', Salvatore Gravano, OxfordUniversity Press, 2007
3. 'Digital Communications - Fundamentals and Applications', Bernard Sklar, PearsonEducation (Asia) Pvt. Ltd., 2nd Edition, 2001

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Error Control Coding	**Competency:** Understanding the fundamentals of error detection & correction codes. **Knowledge:** Understanding of basic error control concepts, including parity checks, checksums, and simple error correction codes. **Skills:** Ability to design and implement basic error detection and correction schemes.
2	Week 3-4: Linear Block Codes	**Competency:** Proficiency in designing and decoding linear block codes. **Knowledge:** Knowledge of the structure, properties, and construction of linear block codes. **Skills:** Capability to encode and decode messages using linear block codes and perform error detection and correction.
3	Week 5-6: Cyclic Codes	**Competency:** Expertise in implementing and optimizing cyclic codes. **Knowledge:** Understanding of cyclic codes, including CRC (Cyclic Redundancy Check) and BCH codes. **Skills:** Ability to design, analyze, and optimize cyclic code-based error detection and correction systems.
4	Week 7-8: Convolutional Codes	**Competency:** Ability to design and implement convolutional coding systems. **Knowledge:** Understanding the principles of convolutional codes and their applications. **Skills:** Proficiency in encoding and decoding convolutional codes using various algorithms (e.g., Viterbi algorithm).
5	Week 9-10: Advanced Coding Techniques	**Competency:** Mastery of advanced error control coding techniques. **Knowledge:** Knowledge of advanced coding methods, such as Turbo codes and Low-Density Parity-Check (LDPC) codes. **Skills:** Ability to design, implement, and analyze advanced coding techniques for enhanced error correction performance.
6	Week 11-12: Practical Applications and Projects	Apply learned concepts and competencies to real-world scenarios. Hands-on practice with programming assignments

5. Teaching learning process strategies

S/L	TLP Strategies	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Collaborative Learning	Encourage collaborative learning for improved competency application.
3	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Multiple Representations	Introduce topics in various representations to reinforce competencies
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
8	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. **Assessment Details (both CIE and SEE)**

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20 marks.
2. The Medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 questions from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have a mix of topics under that module if necessary.
4. Thestudentshavetoanswer5fullquestionsselectingonefullquestionfromeachmodule.
5. Marks scored will be proportionally scaled down to 50 marks.

7. **Learning Objectives**

S/L	Learning Objectives	Description
1	Understanding Error Control Codes	Students should be able to identify and explain the function of essential error control codes such as parity checks, checksums, and more advanced codes like Hamming and Reed-Solomon codes.
2	Coding Theory Principles	Gain insights into the theoretical principles underlying error control coding, including concepts such as entropy, mutual information, and channel capacity.
3	Proficiency in Coding Techniques	Explore how various error control coding techniques are implemented and applied, including block codes, cyclic codes, and convolutional codes.
4	Project-Based Learning	Through hands-on projects, students will apply their knowledge of error control coding to design, implement, and test coding schemes, reinforcing their understanding of theoretical concepts.
5	Collaboration and Communication Skills	Students will work collaboratively in teams on coding projects, enhancing their ability to communicate effectively, share ideas, and solve problems collectively in the context of error control coding.
6	Ethical and Professional Responsibility	Students will understand the ethical and professional responsibilities associated with error control coding, including ensuring data integrity, maintaining confidentiality, and adhering to industry standards and best practices.

8. **Course Outcomes (COs) and Mapping with POs/ PSOs**

Course Outcomes (COs)

COs	Description
M23MSP204C.1	Apply the principles of block and convolutional codes for reliable data transmission and storage.
M23MSP204C.2	Design and implement various block code encoders and decoders.
M23MSP204C.3	Evaluate and improve the performance of different error correction techniques.
M23MSP204C.4	Analyze and implement different Block code encoders and decoders, as well as convolutional encoders and decoders, including soft and hard Viterbi algorithms.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP204C.1	2	-	-	2	-
M23MSP204C.2	2	1	-	-	-
M23MSP204C.3	-	2	-	-	-

M23MSP204C.4	-	-	3	-	-
M23MSP204C	2	1.5	3	2	-

9. **Assessment Plan**

10. **Continuous Internal Evaluation (CIE)**

	CO1	CO2	CO3	CO4	**Total**
Module 1	**10**				**10**
Module 2		**10**			**10**
Module 3			**10**		**10**
Module 4				**10**	**10**
Module 5	**3**	**2**	**3**	**2**	**10**
Total	**13**	**12**	**13**	**12**	**50**

11.

12. **Semester End Examination (SEE)**

	CO1	CO2	CO3	CO4	**Total**
Module 1	**20**				**20**
Module 2		**20**			**20**
Module 3			**20**		**20**
Module 4				**20**	**20**
Module 5	**5**	**5**	**2**	**5**	**20**
Total	**25**	**25**	**25**	**25**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks.

10. **Future with this Subject**
1. **Next-Generation Communication Systems:** Understanding error control coding will provide a foundation to grasp advancements in communication systems, such as 5G, 6G, and beyond, where robust error correction is crucial for reliable data transmission.
2. **Data Integrity and Security:** Knowledge in this field will be essential for developing methods to ensure data integrity and security in various applications, including cloud storage, blockchain technology, and secure communication channels.
3. **Quantum Communication:** With the rise of quantum computing, error control coding will play a significant role in developing quantum error correction codes to maintain coherence and fidelity in quantum information systems.
4. **Advanced Storage Solutions:** Skills in error control coding are critical for designing and optimizing storage solutions, such as SSDs, HDDs, and emerging memory technologies, to enhance data reliability and efficiency.
5. **Autonomous Systems:** Expertise in error control coding will be vital for ensuring the reliability and safety of autonomous systems, including self-driving cars, drones, and robotics, which require robust communication and data processing capabilities.
6. **Internet of Things (IoT):** As IoT devices proliferate, there will be a growing need for efficient error correction mechanisms to ensure reliable data transmission and processing in low-power, resource-constrained environments.

2nd Semester	**Professional Elective** **BUSINESS INTELLIGENCE AND ITS APPLICATIONS**	**M23MSP204D**

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Programming	Learn Python or R for data analysis and manipulation. Understand how to use libraries like Pandas, NumPy, Matplotlib (Python), or ggplot2 (R).
2.	SQL	Learn advanced SQL for complex queries and data manipulation.
3.	ETL processes and visualization	Understand the principles of effective data visualization. Learn to create meaningful and interactive dashboards and reports.
4.	BI tools	Learn to use popular BI tools such as Tableau, Microsoft Power BI, Qlik View, SAP Business Objects, and Looker.

2. Competencies

S/L	Competency	KSA Description
1	Data Management	**Knowledge:** Understanding of database design, normalization, and indexing. **Skills:** Ability to write complex SQL queries for data extraction and manipulation. **Attitudes:** Knowledge of relational databases (e.g., MySQL, PostgreSQL, Oracle) and NoSQL databases (e.g., MongoDB, Cassandra).
2	Data Warehousing and ETL	**Knowledge:** Expertise in Extract, Transform, Load (ETL) processes for data integration. **Skills:** Familiarity with ETL tools like Talend, Informatica, Apache Nifi, or Microsoft SSIS. **Attitudes:** Understanding of data warehouse architecture, design principles, and schemas (e.g., star, snowflake).Experience with data warehousing solutions such as Amazon Redshift, Google Big Query, or Snowflake.
3	Data Analysis and Visualization	**Knowledge:** Ability to create interactive dashboards, reports, and data visualizations. **Skills:** Proficiency in BI tools like Tableau, Microsoft Power BI, QlikView, Looker, or SAP Business Objects **Attitude**s: Knowledge of effective data visualization techniques to present data insights clearly. Skills in using visualization libraries (e.g., D3.js, Matplotlib, ggplot2).

3. Syllabus

BUSINESS INTELLIGENCE AND ITS APPLICATIONS **SEMESTER - II**			
Course Code	**M23MSP204D**	CIE Marks	**50**
Teaching Hours/Week (L:P:SDA)	**3:0:0**	SEE Marks	**50**
Total Hours of Pedagogy	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**
Course Learning objectives: To understand the business intelligence steps To analyze the growth development and information technology applications.			
Module-1			
Development Steps, BI Definitions, BI Decision Support Initiatives, Development Approaches, Parallel Development Tracks, BI Project Team Structure, Business Justification, Business Divers, Business Analysis Issues, Cost – Benefit Analysis, Risk Assessment, Business Case Assessment Activities, Roles Involved In These Activities, Risks Of Not Performing Step, Hardware, Middleware, DBMS Platform, Non-Technical Infrastructure Evaluation			
Module-2			
Managing The BI Project, Defining And Planning The BI Project, Project Planning Activities, Roles And Risks, Involved In These Activities, General Business Requirement, Project Specific Requirements, Interviewing Process			
Module-3			
Differences in Database Design Philosophies, Logical Database Design, Physical Database Design, Activities, Roles And Risks Involved In These Activities, Incremental Rollout, Security Management,			

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Database Backup And Recovery, Data analysis, Business-Focused Data Analysis Top-Down Logical Data Modeling, Bottom-Up Source Data Analysis, Data Cleansing Data Analysis Activities, Deliverables Results
Module-4
Application prototyping, purpose, best practices, types of prototyping, application prototyping activities Growth Management, Application Release Concept, Post Implementation Reviews, Release Evaluation Activities, The Information Asset and Data Valuation, Actionable Knowledge – ROI, BI Applications, The Intelligence Dashboard.
Module-5
Business View of Information technology Applications: Business Enterprise excellence, Key purpose of using IT, Type of digital data, basics of enterprise reporting, BI road ahead.
Suggested Learning Resources: **Text Books:** 1. 'Business Intelligence Roadmap: The Complete Project Lifecycle for Decision Support Applications', Larissa T Moss and ShakuAtre, Addison Wesley Information Technology Series, 2003. 2. 'Fundamentals of Business Analytics', R N Prasad, Seema Acharya, Wiley India, 2011. **Reference Books:** 1. 'Business Intelligence: The Savvy Manager's Guide', David Loshin, Publisher: Morgan Kaufmann, ISBN 1-55860-196-4. 2. 'Delivering Business Intelligence with Microsoft SQL Server 2005', Brian Larson, McGraw Hill, 2006. 3. 'Foundations of SQL Server 2008', Lynn Langit, Business Intelligence – Apress, ISBN13: 978-14302-3324-4, 2011. **Web links and Video Lectures (e-Resources):** **https://www.mooc.org/** **https://onlinecourses.nptel.ac.in/** **Skill Development Activities Suggested** To learn SQL and implement various DBMS algorithms

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Development Steps, BI Definitions Business Case Assessment Activities	Understand basic steps and the development steps of BI and business case assessment activities.
2	Week 3-4: Managing The BI Project	Describes the planning activities, roles and risks, project specification.
3	Week 5-6: Database Design Philosophies Data analysis and recovery	Describes the Differences in Database Design Philosophies, Logical Database Design, Physical Database Design, Activities, RolesAnd Risks Incremental Rollout, Security Management, Database Backup And Recovery, Data analysis, Modeling, Bottom-Up Source Data Analysis, Data Cleansing Data Analysis Activities.
4	Week 7-8: Application prototyping, Growth Management	Explains Post Implementation Reviews, Release Evaluation Activities,
5	Week 9-10: Growth Management	Describes information Asset and Data Valuation, Actionable Knowledge – ROI, BI Applications
6	Week 11-12: Digital data and BI road ahead	Understanding the digital data Actionable Knowledge – ROI, BI Applications

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.

4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	Introduce topics in various representations to reinforce competencies
7	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
8	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
9	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			50	20

Final CIE Marks = (A) + (B)

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understanding the BI	Students able to understand the business intelligence development approaches
2	Analyze the data , growth and application release concept	Students able to understand and analyze data, growth management, application release concept ,intelligence dashboard
3	BI view of IT	Students able to understand the business view of information technology applications

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP204D.1	Understand the basic of BI
M23MSP204D.2	Apply the knowledge of BI to data and growth management, application release and BI dashboard.
M23MSP204D.3	Analyze the BI view of IT applications.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP204D.1	**3**	**-**	**-**	**--**	**-**
M23MSP204D.2	**3**	**-**	**-**	**3**	**3**
M23MSP204D.3	**-**	**3**		**3**	**3**
M23MSP204D	**3**	**3**	**-**	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	**Total**

Module 1	**10**			**10**
Module 2		**10**		**10**
Module 3			**10**	**10**
Module 4		**5**	**5**	**10**
Module 5	**6**	**4**		**10**
Total	**16**	**19**	**15**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	**Total**
Module 1	**20**			**20**
Module 2		**20**		**20**
Module 3			**20**	**20**
Module 4		**10**	**10**	**20**
Module 5	**12**	**10**		**20**
Total	**32**	**40**	**30**	**100**

Conditions for SEE Paper Setting:
Each module of SEE question paper should be allocated with questions for 20% of the total SEE marks

10. Future with this Subject
1. **Enhanced Predictive Analytics**: AI and machine learning models can analyze vast amounts of data to predict future trends, customer behavior, and market shifts with higher accuracy.
2. **Automated Decision-Making**: AI can help automate routine decisions, freeing up human resources for strategic tasks.
3. **Natural Language Processing (NLP)**: Enables more intuitive data interaction, allowing users to query data using conversational language.
4. **Self-Service Analytics**: Empowering business users with tools that automatically prepare data, generate insights, and suggest actions without needing deep technical knowledge.
5. **Insight Generation**: Automatically uncovering hidden patterns, correlations, and insights in data without manual intervention.
6. **Instant Decision Making**: Providing real-time data analysis and reporting, crucial for industries like finance, healthcare, and retail where timely decisions are critical.
7. **Dynamic Dashboards**: Live dashboards that update in real time to reflect the most current data.
8. **Scalability**: Cloud platforms can scale resources up or down based on demand, offering flexibility and cost-efficiency.
9. **Accessibility**: Cloud BI tools can be accessed from anywhere, facilitating remote work and collaboration.
10. Data Governance and Security
11. **Enhanced Security Measures**: As data privacy becomes more critical, BI platforms will integrate more robust security protocols.
12. **Compliance**: Ensuring BI processes comply with evolving data protection regulations like GDPR and CCPA.
13. **Seamless Integration**: Embedding BI capabilities directly into business applications to provide users with contextual insights within their workflow.
14. **Enhanced User Experience**: Making analytics a part of everyday business processes without switching between systems.
15. Advanced Visualization
16. **Interactive Dashboards**: More sophisticated and interactive visualizations to explore data intuitively.
17. **VR and AR**: Virtual and augmented reality to visualize complex data sets in immersive environments.

2nd Semester	Professional Elective CYBER SECURITY	M23MSP204E

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Computer Fundamentals	Understanding basic computer hardware, software, and operating system concepts, including file systems, memory management, and input/output operations.
2	Networking Concepts	Familiarity with computer networking principles, including network topologies, protocols, and network services.
3	Information Security Principles	Introduction to information security concepts, including confidentiality, integrity, availability, authentication, and access control mechanisms.
4	Ethics and Cyber laws	Awareness of ethical considerations in cyber security, as well as relevant laws and regulations related to cybercrime and data protection.
5	Previous Coursework	Completion of Introductory courses in computer networks, computer organization, cryptography, or a related field

2. Competencies

S/L	Competency	KSA Description
1	Understanding the fundamentals of cybercrime and relevant laws.	**Knowledge:** Definition and origins of cybercrime. Information security and its relationship with cybercrime. Classifications of cybercrimes. Methods used by cybercriminals to plan attacks **Skill:** Identifying different types of cybercrimes and their classifications. Analyzing how cybercrimes are planned and executed. **Attitude:** Awareness of the ethical implications of cyber activities. Understanding the importance of legal frameworks in cybersecurity.
2	Managing security challenges in mobile and wireless environments.	**Knowledge:** Security challenges specific to mobile devices. Credit card frauds in the era of mobile and wireless computing. Security measures and policies for mobile devices. **Skill:** Ability to identify and mitigate security risks associated with mobile devices Understanding mobile device configurations and settings for security **Attitude:** Recognizing the evolving nature of mobile threats. Commitment to maintaining up-to-date security practices.
3	Identifying and mitigating various cybercrime tools and methods.	**Knowledge:** Understanding of proxy servers, anonymizers, and password cracking. Different types of malware and their functionalities Recognizing the impact of denial-of-service attacks on businesses and individuals. **Skills:** Detecting and counteracting the use of various cybercrime tools. Applying technical measures to prevent and mitigate cyberattacks. **Attitudes:** Curiosity to stay updated with emerging cybercrime tools and techniques
4	Preventing and responding to phishing and identity theft incidents.	**Knowledge:** Methods and techniques of phishing. Different types of identity theft and their characteristics. **Skill:** Identifying phishing emails and websites through critical analysis. Protecting personal information from phishing scams. **Attitude:** Maintaining a sense of personal responsibility for protecting one's identity. Emphasizing the importance of online safety and responsible behavior.

5	Conducting thorough and effective computer forensic investigations.	**Knowledge:** Historical background and development of computer forensics. The need for computer forensics in investigating cybercrime. Understanding the digital forensics life cycle **Skill:** Conducting forensic analysis using specialized tools and techniques. Applying forensic methods to social networking sites and addressing privacy threats. **Attitude:** Recognizing the importance of ethical handling of digital evidence.

3. Syllabus

CYBER SECURITY SEMESTER – II			
Course Code	**M23MSP204E**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: SDA)	**(2:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours and 10 to 12 sessions of SDA.**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- To understand cyber-crime and laws and computer forensics
- To explain the phishing and identity theft

Module -1	
Introduction to Cybercrime and Laws Introduction, Cybercrime: Definition and Origins of the word, Cybercrime and Information Security, who are Cybercriminals? Classifications of Cyber Crimes. How Criminals Plan Them – Introduction, How Criminals Plan the Attacks, Cybercafé and Cybercrimes, Botnets, Attack Vector, The Indian IT ACT 2000 and amendments.	
Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.
Module -2	
Cybercrime: Mobile and Wireless Devices Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for organizations, Organizational Measures for Handling Mobile, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	
Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.
Module -3	
Tools and Methods used in Cybercrime Introduction, Proxy Server and Anonymizers, Password Cracking, Key loggers and Spyware, Viruses and Warms, Trojan and backdoors, Steganography, DOS and DDOS attack, SQL injection, Buffer Overflow	
Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.
Module -4	
Phishing and Identity Theft Introduction, Phishing – Methods of Phishing, Phishing Techniques, Phishing Toolkits and Spy Phishing. Identity Theft – PII, Types of Identity Theft, Techniques of ID Theft. Digital Forensics Science, Need for Computer Cyber forensics and Digital Evidence, Digital Forensics Life Cycle.	
Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.
Module -5	
Understanding Computer Forensics Introduction, Historical Background of Cyber forensics, Digital Forensics Science, The Need for Computer Forensics, Cyber forensics and Digital Evidence, Forensics Analysis of E-Mail, Digital Forensics Life Cycle, Chain of Custody Concept, Network Forensics, Approaching a Computer Forensics Investigation, Setting up a Computer Forensics Laboratory: Understanding the Requirements, Computer Forensics and Steganography, Relevance of the OSI 7Layer Model to Computer Forensics, Forensics and Social Networking Sites: The Security/Privacy Threats, Computer Forensics from Compliance Perspective, Challenges in Computer Forensics, Special Tools and Techniques, Forensics Auditing, Anti forensics.	

Teaching-Learning Process	Chalk and Talk / PowerPoint Presentations.

Text Books:

1. Sunit Belapure and Nina Godbole, "Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", Wiley India Pvt Ltd, ISBN: 978-81- 265-21791, 2011, First Edition
2. Uryaa Prakash Triputhi, Ritendra Goyal, P. Shukla, Introduction to information security and cyber laws, 2015.

Reference Books

1. Marjie T. Briz, Computer forensics and cybercrime- An introduction, Pearson Publications.
2. Thomas J. Mowbray, Cyber security: Managing systems, conducting testing and investigating intrusions, Wiley and Sons.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Cybercrime and Laws	Introduction, Definition, and Origins of the word - Cybercrime, Cybercrime and Information Security, Classifications of Cybercrimes. How Criminals Plan the Attacks, Cybercafé and Cybercrimes, Botnets, Attack Vector, The Indian IT ACT 2000 and amendments.
2	Week 3-5: Cybercrime: Mobile and Wireless Devices	Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for organizations, Organizational Measures for Handling Mobile, Organizational Security Policies and Measures in Mobile Computing Era, Laptops
3	Week 6-8: Tools and Methods used in Cybercrime	Introduction, Proxy Server and Anonymizers, Password Cracking, Key loggers and Spyware, Viruses and Warms, Trojan and backdoors, Steganography, DOS and DDOS attack, SQL injection, Buffer Overflow
4	Week 9-11: Phishing and Identity Theft	Knowing about Phishing, Methods of Phishing, Phishing Techniques, Phishing Toolkits and Spy Phishing. Identity Theft, Types of Identity Theft, Techniques of ID Theft. Digital Forensics Science, Need for Computer Cyber forensics and Digital Evidence, Digital Forensics Life Cycle.
5	Week 12-14: Understanding Computer Forensics	Historical Background of Cyber forensics, Digital Forensics Science, The Need for Computer Forensics, Cyber forensics and Digital Evidence, Forensics Analysis of E-Mail, Digital Forensics Life Cycle, Chain of Custody Concept, Network Forensics, Approaching a Computer Forensics Investigation, Setting up a Computer Forensics Laboratory: Understanding the Requirements, Computer Forensics and Steganography, Relevance of the OSI 7 Model to Computer Forensics, Forensics and Social Networking Sites: The Security/Privacy Threats, Computer Forensics from Compliance Perspective, Challenges in Computer Forensics, Special Tools and Techniques, Forensics Auditing, Anti forensics.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of cybercrime, security attacks, and the prevention of attacks.
3	Collaborative Learning	Encourage students to work in pairs or small groups to foster collaboration and peer-to-peer learning.
4	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5	Guest Speakers	Invite law enforcement personnel or cybersecurity professionals to share their experiences.
6	Case study Assignments	Assign case study tasks to reinforce practical skills associated with competencies.
7	Role-Playing Exercises	Conduct role-playing exercises where students act out phishing scenarios, identifying red flags and practicing appropriate responses.

6. **Assessment Details (both CIE and SEE)**

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the best two test marks from the 3 tests conducted.

Semester End Examinations:

1. Question paper pattern will be ten questions. Each question is set for 20marks.
2. The medium of the question paper shall be English unless otherwise it is mentioned.
3. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
4. The students have to answer 5 full questions selecting one full question from each module.
5. Marks scored will be proportionally scaled down to 50 marks

7. **Learning Objectives**

S/L	Learning Objectives	Description
1	Understand Cybercrime and Laws and Involving Mobile and Wireless Devices	Students will gain a foundational understanding of what constitutes cybercrime, the history and evolution of cybercrime, knowledge of various types of cybercrimes, the methods used by cybercriminals, and the legislative measures. The course will also cover the proliferation of mobile and wireless devices and the unique security challenges they present
2	Explain Phishing and Identity Theft	Students will learn about phishing and identity theft, including the techniques used in these crimes and the impact they have on individuals and organizations.
3	Identify Tools and Methods Used in Cybercrime	Students will be introduced to various tools and methods used by cybercriminals. This includes understanding how proxy servers, anonymizers, password cracking tools, keyloggers, spyware, viruses, worms, Trojans, backdoors, steganography, and various types of attacks such as DOS, DDOS, SQL injection, and buffer overflow are used in cybercrime.
4	Understand and Conduct Computer Forensics	This objective focuses on the field of computer forensics, providing students with the knowledge and skills needed to conduct forensic investigations.

8. **Course Outcomes (COs) and Mapping with POs/ PSOs**

Course Outcomes (COs)

COs	Description
M23MSP204E.1	Comprehend the fundamentals of cybercrime, phishing techniques, identity theft, and the basics of digital forensics.
M23MSP204E.2	Analyze the cybercrime with the support tools and methods
M23MSP204E.3	Identify the requirement of security and various issues at wireless and mobile network
M23MSP204E.4	Examine possible research opportunities and challenges within the cyber laws and security.
M23MSP204E.5	Preparing and presenting case studies on cybercrime and forensics.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP204E.1	2		2	2	
M23MSP204E.2	2		2	2	
M23MSP204E.3	2	2	2	2	2

M23MSP204E.4	2	3	2	2	2
M23MSP204E.5		3		2	3
M23MSP204E	**2**	**1.6**	**2**	**2**	**1.4**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

Looking into the future of cyber security, based on the current trends and the course content, we can project several developments and areas of focus:

1. AI and ML in Cyber Security: Understanding how to implement and manage AI/ML-based security solutions.
2. Advanced Threat Detection: Skills in using advanced tools and methods for detecting and mitigating cyber threats.
3. Mobile and IoT Security: Expertise in securing a wide range of devices and understanding the specific challenges they present.
4. Zero Trust Networks: Knowledge of designing and managing networks based on zero trust principles.
5. Digital Forensics: Advanced skills in digital forensics, including forensics in cloud and social networking environments.
6. Regulatory Compliance: Staying updated with the latest regulations and ensuring compliance in all cyber security practices.
7. Quantum Cryptography: Understanding and implementing new cryptographic techniques that can withstand quantum computing threats.

2nd Semester	Mini Project with Seminar (MPS) MINI PROJECT	M23MSP205

1. Syllabus

MINI PROJECT SEMESTER – II			
Course Code	M23MSP205	CIE Marks	50
Number of Lecture Hours/Week(L: P: SDA)	(0:4:2)	SEE Marks	50
Total Number of Lecture Hours	3	Total Marks	100
Credits	03	Exam Hours	-

Course objectives: This course will enable students to:
To support independent learning and to Conduct independent research & propose a solution to a real-world problem.
Demonstrate effective time management & project organization for individual execution.
Develop intellectual capacity, credibility, judgement, intuition & concise communication skills for written project reports & presentations.
Critically analyze & ethically utilize information from varied resources.

"Mini Project" course provides hands-on experience through a chosen project activity. This could involve building a device, analyzing data, coding simulations, visiting a relevant facility, or other options. You'll present your findings through a seminar, developing communication and critical thinking skills as you delve into a specific area of electronics and communication engineering.

2. Assessment Details:

1. The CIE marks awarded for mini project shall be based on the evaluation of mini-project work by the guide, report writing and viva-voce in the ratio 50:25:25.
2. Marks awarded for the mini Project report shall be the same for all the student of the batch. The faculty guide/mentor guiding the mini project shall evaluate the performance for 50% of the maximum marks of CIE for the report.

Mini Project evaluation for CIE

SL. No.	Description	% of Marks	In Marks
1	Project work by the guide	50%	50
2	Report writing	25%	25
3	Viva-Voce	25%	25
Total		**100%**	**100**

3. Learning Objectives

S/L	Learning Objectives	Description
1	Apply core engineering knowledge	Students will select a project activity that allows them to apply the principles of signal processing or other core electronics engineering disciplines.
2	Develop hands-on skills	Through project activities like building a device, conducting experiments, or working with simulations, students will gain practical experience in relevant electronics and communication engineering techniques.
3	Enhance data analysis and interpretation skills	Students will learn to collect and analyze data related to their chosen project, identifying trends and drawing meaningful conclusions.
4	Refine critical thinking and problem-solving abilities	The project selection and execution process will require students to critically assess challenges, propose solutions, and adapt their approach as needed.
5	Strengthen communication and presentation skills	Students will present their project findings in a seminar setting, effectively communicating technical information to a peer audience.

4. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23MSP205.1	Design and execute a mini-project that utilizes core electronics and communication engineering principles to address a specific challenge or problem.
M23MSP205.2	Critically evaluate the data and findings generated from the project, identifying key trends, limitations, and potential for further investigation.
M23MSP205.3	Effectively communicate the project's objectives, methodology, results, and conclusions in a well-organized seminar presentation, demonstrating clear technical understanding and engaging the audience.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MSP205.1	3	-	-
M23MSP205.2	-	-	3
M23MSP205.3	-	3	-
M23MSP205	**3**	**3**	**3**

2nd Semester	Professional Core Lab (PCL) IMAGE PROCESSING LABORATORY	M23MSPL206

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basics numerical for Image processing	Fundamentals of mathematics concepts like Matrix, Trigonometric functions etc.,
2.	Image Processing complex algorithms	Basics of digital Image processing operations.
3.	Filters	Analog and Digital filters designs.
4.	Fast Fourier Transform	Computation of Fourier transforms using FFT algorithms.
5.	MATLAB	Basics of MATLAB commands.

2. Competencies

S/L	Competency	KSA Description
1.	Binary manipulation and Grayscale quantization	**Knowledge**: Enhanced techniques for binary image manipulation and feature extraction and Improved methods for image compression and grayscale detail preservation **Skills**: Binary image processing techniques and Grayscale image quantization methods **Attitudes:** Analytical approach and precision in binary image processing tasks and careful enhancement and optimization of grayscale image quality.
2.	Histogram-based contrast enhancement proficiency	**Knowledge:** Understanding contrast enhancement through histogram equalization and histogram stretching techniques. **Skills:** Histogram analysis, equalization, and stretching for contrast enhancement. **Attitudes:** Understanding contrast improvement through histogram equalization and stretching techniques.
3.	Graph-based connectivity analysis	**Knowledge:** Understanding pixel connectivity and graph representation in image analysis. **Skills:** Graph construction, pixel connectivity analysis, algorithm implementation for image processing. **Attitudes:** Attention to detail, systematic approach, problem-solving through algorithmic thinking
4.	Global and Adaptive thresholding	**Knowledge:** it helps to understand how to convert a grayscale image into a black and white image (binary image) using two different thresholding techniques. **Skills:** Proficiency in analyzing the effects of different thresholding methods on image binarization. **Attitudes:** Analytical thinking, Experimentation and Problem-solving.
5.	spatial transformation	**Knowledge:** Different spatial transformation techniques (e.g., translation, rotation, scaling). **Skills:** Applying spatial transformations to manipulate images. **Attitudes:** Analytical thinking to choose appropriate transformations for specific tasks.
6.	2D FFT Image Filtering	**Knowledge:**2D FFT for image frequency **Skills:** analysis Frequency domain filtering **Attitudes:** Problem-solving with frequency domain techniques
7.	Homo - morphic Filters	**Knowledge:** Understanding limitations of homomorphic filtering with low-pass filters for non-uniform illumination correction. **Skills:** Analyzing image characteristics to choose appropriate filtering techniques. **Attitudes:** Careful consideration of filter type and its impact on image enhancement goals.

8.	Image Restoration Techniques	**Knowledge:** Different image restoration techniques (inverse, Wiener, Regularized, Lucy-Richardson). **Skills:** Applying algorithms for noise reduction and image deblurring. **Attitudes:** Persistence in trying different approaches for optimal restoration
9.	Edge Detection Techniques	**Knowledge:** Edge detection in noisy images (motion blur, Gaussian noise, filtered noise). **Skills:** Evaluating edge detectors for robustness against various noise types. **Attitudes:** Adaptability in choosing methods for specific noise characteristics.
10.	Shape recognition algorithm	**Knowledge:** Understanding the principles of geometric feature extraction (circles & triangles). **Skills:** Implementation of shape recognition algorithms. **Attitudes:** Persistence in solving problems algorithmically.
11.	Fuzzy logic and neural network algorithm	**Knowledge:** Proficiency in Fuzzy Logic & Neural Networks for image segmentation/classification. **Skills:** Understanding and utilizing Fuzzy logic and neural network libraries in MATLAB. **Attitudes:** Adaptability in applying different computational approaches

3. Syllabus

IMAGE PROCESSING LABORATORY SEMESTER – II			
Course Code	**M23MSPL206**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**1:2:0**	SEE Marks	**50**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable the students to:
To understand the Matlab commands to compose code for complex algorithm
To implement Image processing algorithms

Sl. No.	Experiments
1.	Study the effects of a) Boolean operations on binary images b) Quantization of gray level images
2.	Study the effects of Contrast enhancement using a) Histogram equalization b) Histogram stretching.
3.	Using connected component labelling algorithms, express Pixel neighbourhood relationships in terms of a graph
4.	Create a binary image from image by replacing all values above a determined threshold level using a) global thresholding b) adaptive thresholding technique
5.	Transform an image given using Spatial Transformation
6.	Study how to compute forward 2D FFT and a) Find the log magnitude & phase and the inverse 2D FFT of an image. b) Compute the forward 2D FFT of the filter kernel. c) Design a Laplacian High Pass Filter d) Study the Two Dimensional Filter Design using filter design functions
7.	Determine the suitability of homo - morphic filtering using a low pass filter for image enhancement to fix non- uniform of illumination
8.	Implement inverse, Wiener, Regular, and Lucy-Richardson for image restoration. And formulate how noise information in an image can be used to restore a degraded image.
9.	Study different methods of edge detection for use on noisy images, specifically, a) Motion blur b) Gaussian noise c) Filtered Gaussian noise via averaging.
10.	Write an algorithm for recognizing of circles and triangles.
Demonstration Experiments (For CIE) if any	
11.	Write a program in Matlab to implement the Fuzzy logic algorithm

12.	Write a program in Matlab to implement the neural network algorithm
Suggested Learning Resources: www.mathworks.com	

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1.	Week 1-2: Image Fundamentals and Enhancement	Teach Boolean operations and quantization for image segmentation, which is crucial in various applications like object recognition and medical imaging. Also to teach contrast enhancement techniques like histogram equalization and stretching techniques to improve image quality for better analysis and visualization.
2.	Week 3-4: Image Representation and Analysis	Teach Understanding connected component labeling and expressing pixel relationships as graphs opens doors to advanced object recognition and tracking algorithms.
3.	Week 5-6: Image Segmentation Image Manipulation	To teach thresholding concepts with global and adaptive methods helps in separating foreground objects from the background, a fundamental step in many image processing tasks. Also to teach spatial transformations empowers manipulation of images for various purposes like image registration (aligning multiple images) and correction of perspective distortions.
4.	Week 7-8: Frequency Domain Analysis and Image Restoration	To teach 2D FFT, log-magnitude/phase analysis, and filter design unlocks functions for image filtering, noise reduction, and feature extraction. Also implementing image restoration techniques like inverse filtering, Wiener filtering etc to recover degraded images corrupted by noise or blur.
5.	Week 9-10: Edge Detection in Noisy Images Shape Recognition	To teach edge detection methods for noisy images which prepares for tackling real-world scenarios where perfect image quality is often unattainable and Developing algorithms for recognizing specific shapes like circles and triangles is a stepping stone towards more complex object recognition tasks using machine learning.
6.	Week 11-12: Demonstration Experiments	To teach Fuzzy Logic & Neural Networks for image segmentation/classification for understanding and utilizing libraries in MATLAB.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1.	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2.	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of the concepts of Image processing operations.
3.	Collaborative Learning	Encourage collaborative learning for improved competency application.
4.	Higher Order Thinking (HOTS) Questions:	Pose HOTS questions to stimulate critical thinking related to each competency.
5.	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
6.	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
7.	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies.
8.	Programming Assignments	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

Marks distribution for Program based Practical Course for CIE

Sl.No.	Description	% of Marks	In Marks
1	Observation, write-up, algorithm/program/execution	80%ofthe maximum	80
2	Viva-Voce	20%ofthe maximum	20
Total		**100%**	**100**

Marks scored by the student for100 are scaled down to 50marks.

Semester End Evaluation (SEE):

1. SEE marks for practical course shall be 50 marks
2. See for practical course is evaluated for 100 marks and scored marks shall be scaled down to 50 marks.
3. Change of experiment/program is allowed only once and 20% marks allotted to the procedure/write-up part to be made zero.
4. Duration of SEE shall be 3 hours.

Marks distribution for Program based Practical Course for SEE

SL. No.	Description	% of Marks	Marks
1	Write-up, Procedure	20%	20
2	Conduction and result	60%	60
3	Viva-Voce	20%	20
Total		**100%**	**100**

7. Learning Objectives

S/L	Learning Objectives	Description
1	Image fundamentals	Exploring basic concepts like image representation, pixel values, and common image formats.
2	Image enhancement	Learning techniques to improve image quality for better analysis and visualization.
3	Image segmentation	Mastering methods to separate objects of interest from the background.
4	Image representation and analysis	Understanding how to represent and analyze image structures using techniques like connected component labeling.
5	Image manipulation	Learning how to manipulate images through spatial transformations (translation, rotation, scaling).
6	Frequency domain analysis	Utilizing the power of the frequency domain for image filtering, noise reduction, and feature extraction using 2D FFT and filter design methods
7	Image restoration	Implementing algorithms to recover degraded images affected by noise or blur.
8	Edge detection	Investigating various methods to detect and extract edges from images, even in the presence of noise.
9	Shape recognition	Developing algorithms for recognizing specific shapes, introducing the concept of object recognition.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

Cos	Description
M23MSPL206.1	Apply the fundamentals of Image processing to analyze various algorithms
M23MSPL206.2	Conduct the experiments individually using MATLAB tool.
M23MSPL206.3	Present experimental results/process both orally and in written form.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSPL206.1	3	3	3	3	3

M23MSPL206.2	3	-	3	-	2
M23MSPL206.3	-	3	-	-	-
M23MSPL206	**3**	**3**	**3**	**3**	**2.5**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

Experiments	CO1	CO2	CO3	**Total**
1	**10**	**20**	**20**	**50**
2	**10**	**20**	**20**	**50**
3	**10**	**20**	**20**	**50**
4	**10**	**20**	**20**	**50**
5	**10**	**20**	**20**	**50**
6	**10**	**20**	**20**	**50**
7	**10**	**20**	**20**	**50**
8	**10**	**20**	**20**	**50**
9	**10**	**20**	**20**	**50**
10	**10**	**20**	**20**	**50**
11	**10**	**20**	**20**	**50**
12	**10**	**20**	**20**	**50**
Total	**10**	**20**	**20**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	**Total**
	20	**40**	**40**	
Total	**20**	**40**	**40**	**100**

10. Future with this Subject

The "Image Processing" course in the second semester of the MTech program lays a strong foundation for several future courses in the postgraduate program. The image processing lab curriculum provides a strong foundation for various future applications, including:

1. Medical image analysis: Assisting doctors in diagnosing diseases by analyzing medical
2. Medical image analysis: Assisting doctors in diagnosing diseases by analyzing medical scans.
3. Autonomous vehicles: Enabling self-driving cars to navigate by recognizing objects and their positions on the road.
4. Robotics: Empowering robots to interact with their environment by understanding visual data.
5. Surveillance and security: Identifying suspicious activity in video footage.
6. Consumer electronics**:** Enhancing image quality in smart phones and cameras.