Ref: MITM/EC/CBS/2023-24/002

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 3rd 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

Dean Academics MIT Mysore

Principal MIT Mysore

General Contents of Competency Based Syllabus Document

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3rd Semester	Professional course (PC) ADAPTIVE SIGNAL PROCESSING	M23MSP301

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Signals and Systems	Understanding of continuous-time and discrete-time signals, systems, and transforms (Fourier, Laplace, and Z-transforms).
2	Signal Processing	Understanding of signal processing concepts (e.g., Fourier transforms, filtering)
3	Digital Signal Processing (DSP)	Familiarity with DSP concepts, including filtering, convolution, and spectral analysis
4	Probability and Statistics:	Knowledge of probability theory, random processes, and statistical analysis
5	Linear Algebra	Understanding of vector spaces, linear transformations, and matrix operations
6	Calculus	Familiarity with differential equations and optimization techniques.
7	Basic understanding of Adaptive Filtering	Familiarity with adaptive filtering concepts, including Wiener filters and Least Mean Squares (LMS) algorithms.

2. Competencies

S/L	Competency	KSA Description
1	Adaptive Filtering	**Knowledge:** Adaptive filtering algorithms (LMS, NLMS, RLS), convergence analysis, and filter structures. **Skills:** Design and implement adaptive filters, analyze convergence behavior, and optimize filter performance. **Attitudes:** Curiosity, persistence, and attention to detail.
2	Signal Analysis	**Knowledge:** Spectral analysis, time-frequency analysis, and statistical signal processing. **Skills:** Analyze and interpret signals using various techniques, identify patterns and trends. **Attitudes:** Analytical thinking, curiosity, and problem-solving.
3	System Identification	**Knowledge:** System identification methods, adaptive filtering, and modeling techniques. **Skills:** Identify and model systems, estimate parameters, and validate models. **Attitudes:** Critical thinking, persistence, and attention to detail.
4	Noise Cancellation and Reduction	**Knowledge:** Noise cancellation algorithms, adaptive filtering, and spectral subtraction. **Skills:** Implement noise cancellation and reduction techniques, analyze performance. **Attitudes:** Persistence, attention to detail, and problem-solving.
5	Spectral Estimation and Modeling	**Knowledge:** Spectral estimation methods, ARMA modeling, and statistical signal processing. **Skills:** Estimate and model spectral densities, analyze and interpret results. **Attitudes:** Analytical thinking, curiosity, and attention to detail.
6	Signal Enhancement	**Knowledge:** Signal enhancement techniques, adaptive filtering, and spectral processing. **Skills**: Enhance signals using various techniques, analyze and interpret results. **Attitudes:** Creativity, analytical thinking, and attention to detail.

3. Syllabus

ADAPTIVE SIGNAL PROCESSING SEMESTER –3			
Course Code	**M23MSP301**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives: The objectives of this course are to:
1. To understand the adaptive filter concepts
2. To analyze the LMS algorithms and its applications

Module -1

Adaptive systems: Definitions and characteristics - applications - properties-examples - adaptive linear combiner input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering smoothing and prediction - linear optimum filtering – orthogonality - Wiener – Hopf equation performance Surface.

Module -2

Searching performance surface-stability and rate of convergence: learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants – mis adjustments.

Module -3

LMS algorithm convergence of weight vector: LMS/Newton algorithm - properties - sequential regression algorithm – adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals

Module -4

Applications-adaptive modeling: Multipath communication channel, geophysical exploration, FIR digital filter synthesis.

Module -5

Applications: inverse adaptive modeling, deconvolution and equalization, General Description of Inverse Modeling, Adaptive Equalization of Telephone Channels, Adapting Poles and Zeros for IIR Digital Filter Synthesis.

Suggested Learning Resources:

Text Books

1. 'Adaptive Signal Processing', Bernard Widrow and Samuel D Stearns, Pearson Education, 2005.
2. 'Theory and Design of Adaptive Filters', John R Treichler, C Richard Johnson, Michael G Larimore, Prentice Hall of India, 2002.

Reference Books:

1. 'Adaptive Signal Processing-Theory and Application', S Thomas Alexander, Springer-Verlag.
2. 'Statistical and Adaptive Signal Processing', D. G. Manolakis, V. K. Ingle and S. M. Kogar, McGraw Hill International Edition, 2000.
3. 'Adaptive Filter Theory', Simon Haykin, Pearson Education, 2003

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 1-3: Adaptive systems	Definitions and characteristics - applications - properties-examples - adaptive linear combiner input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering smoothing and prediction - linear optimum filtering – orthogonality - Wiener – Hopf equation performance Surface
2	Week 4-6: Searching performance surface-stability and rate of convergence	Learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants – mis adjustments.
3	Week 7-8: LMS algorithm convergence of weight vector	LMS/Newton algorithm - properties - sequential regression algorithm – adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals
4	Week 8-11: Applications-adaptive modelling	Multipath communication channel, geophysical exploration, FIR digital filter synthesis
5	Week 9-12: Applications-IIR and FIR	Inverse adaptive modelling, deconvolution and equalization, General Description of Inverse Modeling, Adaptive Equalization of Telephone Channels, Adapting Poles and Zeros for IIR Digital Filter Synthesis.

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 image processing concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the image processing concepts by simulating in MATLAB.

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

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. 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 eachmodule.
4. Marks scored will be proportionally scaled down to 50 marks.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Adaptive systems	To understand the adaptive filter concepts
2	Searching performance surface-stability and rate of convergence	To design and develop optimal minimum mean square estimators and, in particular, linear estimators
3	LMS algorithm convergence of weight vector	To analyze various adaptation algorithms and assess them in terms of convergence rate, computational complexity, robustness against noisy data, etc.,
4	Applications-adaptive modelling	To apply adaptive filter concepts in FIR and IIR digital filter synthesis

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

COs	Description
M23MSP301.1	**Understand** the basic concepts of adaptive signal processing.
M23MSP301.2	**Design** and develop optimal minimum mean square estimators and, in particular, linear Estimators
M23MSP301.3	**Evaluate** different search approaches for a noisy gradient estimator
M23MSP301.4	**Apply** the concepts of adaptation in adaptive modelling and system identification, inverse adaptive modelling, de-convolution, equalization, and digital filter synthesis.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3

M23MSP301.1	3	-	-
M23MSP301.2	3	3	-
M23MSP301.3	-	-	3
M23MSP301.4	-	3	-
M23MSP301	3	3	3

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:

Adaptive signal processing is a branch of statistical signal processing that deals with the challenging problem of estimation and tracking of time-varying systems.

It finds application in various field such as:

- Telecommunications: ASP will play a crucial role in optimizing signal transmission and reception in future wireless networks.
- Radar and sonar signal processing: ASP is used for precise target detection in Radar and sonar signal processing.
- Healthcare and Biomedical Signal Processing: ASP will improve diagnosis and treatment by analyzing and interpreting complex biomedical signals.
- Autonomous Vehicles and Robotics: ASP will enhance sensor processing and decision-making in autonomous systems.
- Smart Cities and Infrastructure: ASP will optimize signal processing for smart grid management, traffic control, and surveillance.

3rd Semester	Professional Core Course (PC) DSP SYSTEM DESIGN	M23MSP302

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Data Representation:	Proficiency in fixed- and floating-point number system and their formats, Binary Addition, Multiplication, Division, Finite word length effects, Rounding and Truncation.
2	Architecture and Instruction Set:	Proficiency in Boolean Algebra, Combinational and Sequential circuits, Data Path and Control Units, Interrupts, Ports, Pipeline. Proficiency in Different types of addressing modes and Instruction sets.
3	Fixed- and Floating-Point Digital Signal Processor:	Understanding of Assembler Directives. Proficiency in fixed- and floating-point numbers and circuits, Architecture, Memory organization and Addressing modes, Instruction sets, and debugging to understand different Fixed- and Floating-Point Digital Signal Processors.
4	Modulation Techniques	Familiarity with SNR, Quantization, Modulation techniques, Binary Coding and various Transformations.
5	Filters:	Proficiency in z-transform to understand the concepts of filters. Familiarity with Adaptive Filtering, transform techniques and Multirate Signal processing. Familiarity with characteristics, structure, working and designing of FIR and IIR Filter.
6	Simulations:	Familiarity with the simulation tools such as MATLAB, SCILAB or OCTAVE.

2. Competencies

S/L	Competency	KSA Description
1	Data Representation	**Knowledge:** Formats of Fixed point and Floating-point arithmetic numbers, Binary Addition, Multiplication, Division, Finite word length effects, Rounding and Truncation. **Skills:** Assessing the different formats of data representation and perform Binary Addition, Multiplication, Division and also assessing finite word length effects. **Attitudes:** Mathematical Aptitude, Problem Solving ability.
2	Architecture and Instruction Set	**Knowledge:** Basics of Combinational and Sequential circuits, Data Path and Control Units, Interrupts, Ports, Pipeline, types of addressing modes and Instruction sets. **Skills:** Applying the knowledge of Interrupts, Ports, addressing modes and Instruction sets to write programs. **Attitudes:** Mathematical Aptitude, Programming skills.
3	Fixed- and Floating-Point Digital Signal Processor	**Knowledge:** Understanding of Assembler Directives. Proficiency in fixed- and floating-point numbers and circuits, Architecture, Memory organization and Addressing modes, Instruction sets, and Debugging **Skills:** Applying the concepts of fixed- and floating-point numbers and circuits, Architecture, Memory organization and Addressing modes to understand the working of Fixed- and Floating-Point Digital Signal Processor. **Attitudes:** Mathematical Aptitude, Problem Solving ability, Critical Thinking.
4	Modulation Techniques	**Knowledge:** Understanding of Quantization, Laws of Companding, Signal to Noise Ratio, various modulation and demodulation techniques, Binary coding and

		transformations. **Skills:** Analyzing various modulation and demodulation techniques and their applications. **Attitudes:** Mathematical Aptitude, Problem Solving ability, Analytical Thinking.
5	FIR and IIR Filters	**Knowledge:** Understanding of Z-transforms, Bilinear transformation, types and characteristics of filters. **Skills:** Developing the structures and Designing of Finite Impulse response filter and Infinite Impulse response filter. **Attitudes:** Mathematical Aptitude, Problem Solving ability, Analytical Thinking.

3. Syllabus

DSP SYSTEM DESIGN
SEMESTER – III

Course Code	**M23MSP302**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives:

1. To understand data representation, Finite word length effects and Programming issues.
2. To get familiar with Architecture and Instruction sets of C6x processors.
3. To get familiar with Fixed point and Floating-point Digital signal processors.
4. To analyzing structures of FIR and IIR filters.
5. To Implement FIR using Fourier Series and Window functions, IIR filters using Bilinear transformation and their implementation in MATLAB.
6. To get familiar with various modulation techniques, applications, and their implementation in MATLAB.

Module -1

Implementation Consideration: Introduction, Data representation, and arithmetic, Finite word length effects, Programming issues, Real-time implementation consideration, Hardware interfacing, and Experiments.

Module -2

Architecture and Instruction Set of the C6x processors: Introduction, TMS320C6x Architecture, Functional units, Linear and Circular Addressing modes, TMS320C6x Instruction sets, Interrupts, Multichannel Buffered Serial Ports, Memory Considerations, Fixed and Floating-Point Format, Constraints.

Module -3

Fixed Point Digital Signal Processor: Introduction, Architecture overview, Central processing unit, addressing modes, Instruction sets, Memory status of TMS320C2000, TMS320C54X, TMS320C55X, TMS320C62X and TMS320C64X.

Floating Point Digital Signal Processor: Introduction, Architecture overview, Central processing unit, Instruction sets, Memory organization and Addressing modes of TMS320C3X, TMS320C67X.

Module -4

Finite Impulse Response Filters: Introduction of Z transform, Discrete signals, FIR filters, FIR lattice structure, FIR implementation using Fourier Series and Window functions, Implementation using MATLAB.

Infinite Impulse Response Filters: Introduction, IIR filters structure, Bilinear Transformation, Implementation using MATLAB.

Module -5

Waveform Quantization and Compression: Linear Midtread quantization, µLaw Companding, DPCM, Delta Modulation and Adaptive DPCM, DCT, Modified DCT and Transform Coding in MPEG audio, Examples of Signal quantization using TMS320CX713DSK, MATLAB Programs.

TEXTBOOKS:

1. 'Digital Signal Processors and Application with C6713 and C6416 DSK', Rulph Chassaing, Donald Reay Wiley, Interscience Publication.
2. 'Digital Signal Processing Fundamentals and Applications', Li Tan, Jean Jiang, Elsevier, 2nd Edition.

REFERENCE BOOKS:

1. 'Digital Signal Processing Principles, Algorithm and Applications', John G Proakis, Dimitris G Manolokis, Pearson -4th edition.
2. 'Digital Signal Processing', Salivahanan , A Vallavaraj, C Gnanapriya, Ta Ta McGrawl Hill,2007.
3. 'Digital Signal Processing with MATLAB Programs, Dr. Sanjay Sharma, SK Kataria & Sons,6th edition.

VIDEO LINKS:

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

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Implementation Consideration and Architecture	Understanding the representation of data representation, Finite word length effects, Programming issues, Real time implementation consideration, Hardware interfacing, Experiments. Understanding the TMS320C6x Architecture and Functional units.
2	Week 3-5: Architecture and Instruction Set of the C6x processors	Studying different types of Addressing modes, Instruction sets, Interrupts, Multichannel Buffered Serial Ports, Memory Considerations, Fixed and Floating-Point Format, Constraints.
3	Week 6-7: Fixed- and Floating-Point Digital Signal Processor	Studying the different families of Fixed Point and Floating-Point Digital Signal Processor.
4	Week 8-10: FIR and IIR Filters	Introduction to the concepts of Z-transform, Discrete signals, different structures of FIR and IIR Filters. Applying Fourier Series and Window Functions to design FIR filters and Bilinear transformation to design IIR filters. Implementation in MATLAB.
5	Week 11-12: Waveform Quantization and Compression	Introduction to Laws of companding, Delta modulation, waveform Quantization and Compression, Transform Coding in MPEG audio and MATLAB examples.

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	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the behavior of the materials by performing few experiments.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

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

CIE Split up

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)

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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. 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 eachmodule.
4. Marks scored will be proportionally scaled down to 50 marks.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Implementation Consideration and	Understanding the representation of data representation, Finite word length effects, Programming issues, Real time implementation consideration, Hardware interfacing, Experiments.
2	Architecture and Instruction Set	Grasp the architecture and functional units, different types of addressing modes and Instruction sets, Interrupts, Multichannel Buffered Serial Ports, Memory Considerations, Fixed and Floating-Point Format, Constraints of C6x processor.
3	Fixed- and Floating-Point Digital Signal Processor	Get familiar with various families of Fixed Point and Floating-Point Digital Signal Processors such as TMS320C2000, TMS320C54X, TMS320C55X, TMS320C62X and TMS320C64X, TMS320C3X, TMS320C67X, TMS320C6713 Digital Signal Processor, TMS320C6416 Digital Signal Processor.
4	FIR Filters	Understand Z transform, Discrete signals, characteristics and working of FIR filters, FIR lattice structure, FIR implementation using Fourier Series and Window functions, Implementation of FIR filter using MATLAB.
5	IIR Filters	Get familiar with the characteristics and working of IIR filter, IIR filter's structure, designing IIR filter using Bilinear Transformation, Implementation of IIR filter using MATLAB.
6	Waveform Quantization and Compression	Understand types of Quantizers, Laws of companding, different modulation techniques such as DPCM, Delta modulation, Adaptive DPCM , DCT, Modified DCT and Transform Coding in MPEG audio, Examples of Signal quantization using TMS320CX713DSK.

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

Course Outcomes (COs)

Cos	Description
M23MSP302.1	**Apply** the fundamental concepts of Implementation considerations to understand different families of Fixed and Floating Point Digital signal processors.
M23MSP302.2	**Apply** the concepts c6x processors for implementation of architecture and instruction set.
M23MSP302.3	**Analyze** the structures, characteristics, working and design of FIR and IIR filters and implement FIR and IIR filters using "MATLAB" and "signal processing toolboxes".
M23MSP302.4	**Analyze** various Modulation techniques.

CO-PO-PSO Mapping

COs/Pos	PO1	PO2	PO3
M23MSP302.1	2	-	-
M23MSP302.2	2	3	-
M23MSP302.3	2	-	3
M23MSP302.4	2	2	-
M23MSP302	**2**	**2.5**	**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	**20**	**10**	**10**	**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	**40**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- ❖ **Integration with AI and Machine Learning**: DSP system are increasingly incorporating AI and ML to adapt to the environmental changes in real time. As well as Machine Learning models are used to optimize DSP algorithms, enabling more efficient and accurate processing of complex signals.
- ❖ **Quantum DSP**: Research in Quantum DSP is beginning, exploring how quantum computing can be applied to signal processing.
- ❖ **Energy Efficiency and Green Computing**: With the emphasis on sustainability, future DSP systems are designed with energy efficiency in mind, particularly for battery powered and portable devices. Research is focusing more on optimizing the energy consumption of DSP operation, which is crucial for both environmental impact and operational costs.
- ❖ **Advanced computing technologies**: The use of FPGA’s and custom ASIC’s is growing for DSP tasks, offering high performance and efficiency. Neuromorphic computing is the emerging field which aims to mimic the human brain capabilities, which could lead to highly efficient DSP system for specific task.

3rd Semester	Professional Elective Course (PE) ADVANCED COMPUTER ARCHITECTURE	M23MSP303A

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Solid Understanding of Computer Architecture	This includes knowledge of pipelining, cache memory, instruction set architecture (ISA), and CPU design.
2	Knowledge of Parallel Processing	Understanding of parallelism, multi-core processors, and parallel execution models.
3	Proficiency in Hardware-Software Co-Design	Familiarity with co-design principles, embedded systems, and their interaction in computer architecture.
4	Knowledge of Memory Hierarchy Design	Basic understanding of memory hierarchy, cache coherence, memory access patterns, and optimization techniques.
5	Proficiency in Performance Analysis	Skills in evaluating and analyzing the performance of computer architectures using tools and benchmarks.
6	Familiarity with Modern Processor Architectures	Knowledge of advanced architectures like superscalar, VLIW (Very Long Instruction Word), and out-of-order execution.
7	Experience with Simulation Tools	Proficiency in using computer architecture simulators such as Gem5, Simple Scalar, or similar tools for performance evaluation and design exploration.

2. Competencies

S/L	Competency	KSA Description
1	Computer Architecture	**Knowledge**: Understanding of core concepts such as pipelining, instruction set architecture (ISA), and CPU design principles. **Skills**: Ability to design and optimize pipelined architectures for various performance metrics. **Attitudes**: Appreciation for the balance between complexity and performance in processor design.
2	Parallel Processing	**Knowledge**: Proficiency in concepts of parallelism, multi-core processors, and parallel execution models. **Skills**: Ability to implement parallel algorithms and analyze their performance on different architectures. **Attitudes**: Recognition of the importance of parallelism in modern computing systems.
3	Memory Hierarchy Design	**Knowledge**: Understanding of memory hierarchy, cache design, and memory access patterns. **Skills**: Ability to design and optimize memory hierarchies for improved performance. **Attitudes**: Appreciation for the role of memory architecture in overall system performance.
4	Hardware-Software Co-Design	**Knowledge**: Understanding of the principles of hardware-software co-design and its significance in embedded systems. **Skills**: Ability to co-design hardware and software components for optimized system performance. **Attitudes**: Appreciation for the synergy between hardware and software in system design.
5	Performance Analysis	**Knowledge**: Proficiency in performance metrics, benchmarking, and analysis techniques for computer systems. **Skills**: Ability to use simulation tools to evaluate and optimize system performance. **Attitudes**: Appreciation for the importance of thorough performance analysis in system design.

3. Syllabus

ADVANCED COMPUTER ARCHITECTURE SEMESTER – III			
Course Code	**M23MSP303A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**03**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:
1. Understand the concepts of parallel computing and hardware technologies.
2. Illustrate and contrast the parallel architectures.
3. Recall parallel programming concepts.

Module -1

Theory of Parallelism: Parallel Computer Models, The State of Computing, Multiprocessors and Multicomputer, Multivector and SIMD Computers, PRAM and VLSI Models, Program and Network Properties, Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architectures, Principles of Scalable Performance, Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches.

Module-2

Hardware Technologies: Processors and Memory Hierarchy, Advanced Processor Technology, Superscalar and Vector Processors, Memory Hierarchy Technology, Virtual Memory Technology.

Module-3

Bus, Cache, and Shared Memory, Bus Systems, Cache Memory Organizations, Shared Memory Organizations, Sequential and Weak Consistency Models, Pipelining and Superscalar Techniques, Linear Pipeline Processors, Nonlinear Pipeline Processors, Instruction Pipeline Design, Arithmetic Pipeline Design (to 6.4).

Module-4

Parallel and Scalable Architectures: Multiprocessors and multi computers, Multiprocessor System Interconnects, Cache Coherence and Synchronization Mechanisms, Three Generations of Multi computers, Message-Passing Mechanisms, Multivector and SIMD Computers, Vector Processing Principles, Multivector Multiprocessors, Compound Vector Processing, SIMD Computer Organizations (Upto 8.4), Scalable, Multithreaded, and Dataflow Architectures, Latency-Hiding Techniques, Principles of Multithreading, Fine-Grain Multi computers, Scalable and Multithreaded Architectures, Dataflow and Hybrid Architectures.

Module-5

Software for parallel programming: Parallel Models, Languages, and Compilers, Parallel Programming Models, Parallel Languages and Compilers, Dependence Analysis of Data Arrays, Parallel Program Development and Environments, Synchronization and Multiprocessing Modes. Instruction and System Level Parallelism, Instruction Level Parallelism, Computer Architecture, Contents, Basic Design Issues, Problem Definition, Model of a Typical Processor, Compiler-detected Instruction Level Parallelism, Operand Forwarding, Reorder Buffer, Register Renaming, Tomasulo‟s Algorithm, Branch Prediction, Limitations in Exploiting Instruction Level Parallelism, Thread Level Parallelism.

TEXT BOOKS:
1. Kai Hwang and Naresh Jotwani, Advanced Computer Architecture (SIE): Parallelism, Scalability, Programmability, McGraw Hill Education 3/e. 2015
2. Smruti R. Sarangi, Advanced Computer Architecture, Ebook.

REFERENCE BOOKS:
1. John L. Hennessy and David A. Patterson, Computer Architecture: A quantitative approach, 5th edition, Morgan Kaufmann Elseveir, 2013

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Sensors	Students will study the Introduction to Computer Architecture including instruction set architecture (ISA), basic CPU design, and pipelining techniques.
2	Week 3-5: Sensor Technologies	Students will explore Advanced Pipelining and Parallelism concepts, focusing on instruction-level parallelism (ILP) and resolving data hazards.
3	Week 6-8: Actuator Principles	Students will study Memory Hierarchy Design, focusing on cache memory, memory hierarchy, and techniques to optimize memory

		performance.
4	Week 9-10: Smart Sensors and Interfaces	Students will learn about Multi-Core and Parallel Processing, covering multi-core processors, parallel computing models, and shared-memory multiprocessors.
5	Week 11-12: Sensor and Actuator Applications	Students will study Advanced Processor Architectures such as superscalar, VLIW (Very Long Instruction Word), and out-of-order execution architectures.

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	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the behavior of the materials by performing few experiments.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

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

CIE Split up

	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 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 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 Computer Architecture Fundamentals	Students will grasp the fundamental concepts of computer architecture, including instruction set architecture (ISA), CPU design, and pipelining techniques.
2	Analyzing Performance Metrics	Students will learn to analyze and evaluate performance metrics of different processor architectures, including throughput, latency, and power consumption.
3	Advanced Pipelining Techniques	Understand the principles of advanced pipelining, including techniques to overcome data hazards, control hazards, and optimize instruction-level parallelism (ILP).
4	Memory Hierarchy Design	Students will explore the design and optimization of memory hierarchies, including cache design, memory latency reduction techniques, and trade-offs in memory organization.
5	Multi-Core and Parallel Processing	Learn about multi-core processors, parallel computing models, and the challenges associated with designing and programming multi-core systems.

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

COs	Description
M23MSP303A.1	Comprehend the principles of parallel computing, system architectures, and performance scalability.
M23MSP303A.2	Apply hardware technologies like superscalar processors, memory hierarchy, and pipelining techniques.
M23MSP303A.3	Analyze parallel and scalable architectures for their effectiveness in handling synchronization and dataflow.
M23MSP303A.4	Evaluate software techniques in parallel programming and instruction-level parallelism for optimizing performance.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MSP303A.1		-	-
M23MSP303A.2	3		-
M23MSP303A.3	-	3	
M23MSP303A.4	-	-	3
M23MSP303A	**3**	**3**	3

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:

- ❖ Quantum computing promises to revolutionize computer architecture by enabling computational capabilities far beyond current classical systems. Future architectures may need to integrate quantum processors with classical ones, posing challenges in designing hybrid systems that leverage the strengths of both technologies.
- ❖ Neuromorphic computing, which mimics the neural structure of the human brain, is gaining traction. This approach can lead to more efficient and adaptive computing architectures, particularly for tasks involving pattern recognition and learning. Future computer architectures may increasingly incorporate neuromorphic elements to enhance performance and energy efficiency for specific applications.
- ❖ Processor design is continuously evolving with new architectures such as RISC-V and heterogeneous computing models. Future processors will likely feature increased core counts, specialized accelerators (like GPUs and TPUs), and more advanced interconnect technologies to improve performance and handle diverse workloads.

3rd Semester	Professional Elective Course (PE) MEDICAL IMAGING	M23MSP303B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Proficiency in differential and integral calculus, including applications. Basic Knowledge of Statistics and Linear Algebra.
2	Signals and systems	Basic Knowledge of different types of signals and their operations. Proficiency in different properties of signals and systems.
3	Digital Signal Processing	Basic Knowledge of Discrete Fourier Transform and their Properties. Proficiency in Fourier analysis of signals and filtering technique.
4	Digital Image Processing	Basic Knowledge about the histogram, different Image operations. Proficiency in Representation of images as a matrix and image filtering techniques.
5	Basics of Anatomy and Physiology	Basic knowledge about EEG, ECG and EMG,CT,MRI etc.

2. Competencies

S/L	Competency	KSA Description
1	X ray Generation and Detection	**Knowledge:** Students gain an understanding of the principles behind X-ray generation, including electron acceleration and target interaction. They learn how X-rays are emitted, interact with various tissues, and how detectors—such as film or digital sensors—capture and convert X-ray data into diagnostic images for medical evaluation and analysis. **Skills:** Students develop skills in operating X-ray equipment, adjusting settings for optimal image quality, and understanding the physics of X-ray production. They also gain expertise in interpreting X-ray images, recognizing different tissue densities, and using various detectors. Additionally, they learn to apply radiation safety measures effectively. **Attitudes:** Students cultivate a meticulous and safety-conscious attitude, emphasizing precision in equipment handling and image interpretation. They develop a commitment to ethical practices in radiation use and patient care, fostering an appreciation for the critical role of X-ray technology in diagnostics and a responsibility for maintaining high standards in medical imaging.
2	Tomography and Radiography	**Knowledge:** Students learn the principles and techniques of tomography and radiography, including how X-ray systems capture two-dimensional and cross-sectional images. They gain understanding of imaging physics, equipment operation, image processing, and interpretation. **Skills:** Students acquire skills in operating tomography and radiography equipment, optimizing image quality, and performing precise imaging techniques. They learn to interpret X-ray and cross-sectional images, identify anatomical structures, and apply quality control measures. **Attitudes:** Students develop a meticulous and detail-oriented attitude, emphasizing accuracy in imaging and analysis. They foster a commitment to patient care and safety, understanding the importance of high-quality images for accurate diagnosis.
3	Ultrasound Generation and Detection	**Knowledge:** Students gain knowledge of ultrasound physics, including how sound waves are generated, transmitted, and reflected within tissues. They understand the principles of image formation, the function of ultrasound transducers, and how reflected signals are converted into diagnostic images. **Skills:**

		Students develop skills in operating ultrasound equipment, adjusting settings for optimal imaging, and interpreting ultrasound images. They learn to correctly position transducers, obtain high-quality scans, and analyze reflections to diagnose conditions. **Attitudes:** Students develop a patient-centered attitude, emphasizing empathy and comfort during ultrasound procedures. They cultivate a meticulous approach to image acquisition and interpretation, understanding the importance of accuracy in diagnostics.
4	Generation and Detection of Nuclear Emission	**Knowledge:** Students gain knowledge of the principles of nuclear emission, including radioactive decay and the types of particles or photons emitted. They understand how these emissions are detected using scintillation counters or semiconductor detectors, and how the collected data is used for imaging or analysis in various applications. **Skills:** Students develop skills in operating detection equipment for nuclear emissions, such as scintillation counters and semiconductor detectors. They learn to accurately measure and analyze radioactive particles or photons, interpret emission data for diagnostic purposes, and apply safety protocols for handling radioactive materials and ensuring accurate data collection. **Attitudes:** Students develop a rigorous and safety-focused attitude, emphasizing precision in handling radioactive materials and operating detection equipment. They cultivate a strong sense of responsibility for accurate data analysis and adherence to safety protocols.
5	Generation and Detection of MRI.	**Knowledge:** Students gain knowledge of MRI principles, including how strong magnetic fields and radiofrequency pulses align and perturb hydrogen nuclei. They learn how emitted signals are detected and transformed into high-resolution images **Skills:** Students acquire skills in operating MRI machines, adjusting parameters for optimal image quality, and interpreting MRI scans of soft tissues. They become proficient in using contrast agents, performing accurate image reconstruction, and troubleshooting common issues. **Attitudes:** Students develop a meticulous and patient-centered attitude, prioritizing precision in MRI procedures and patient comfort. They cultivate a commitment to safety and ethical standards, recognizing the significance of accurate imaging for diagnosis.

3. Syllabus

MEDICAL IMAGING SEMESTER – III			
Course Code	**M23MSP303B**	CIE Marks	**50**
Number of Lecture Hours/Week (L: T: P: S)	**(3:0:0)**	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: 1. To understand the Medical Image acquisition and its analysis. 2. To analyze the various mathematical tools used in Medical Image analysis.			
Module -1			
Generation and Detection of X-Rays: X-Ray generation and X-Ray generators, Filters, Beam Restrictors and Grids, Screens, X-Ray Detectors. **X-Ray Diagnostic Methods:** Conventional X-Ray Radiography, Fluoroscopy, Angiography, Mammography, Xeroradiography, Image Subtraction. X-Ray Image Characteristics: Spatial Resolution, Image Noise, Image contrast. **Biological Effects of Ionizing Radiation:** Determination of biological effects, Short term and Long term			

effects.
Module -2
X-Ray Tomography: Conventional Tomography, Computed Tomography - Projection function, Algorithms for Image Reconstruction, CT number, Image Artifacts. **Digital Radiography:** Digital Subtraction Angiography (DSA), Dual Energy Subtraction, K-Edge subtraction, 3-D Reconstruction. **Recent Developments:** Dynamic Spatial Reconstructor (DSR), Imatron or Fastrac Electron Beam CT.
Module -3
Generation and Detection of Ultrasound: Piezoelectric effect, Ultrasonic Transducers, Transducer Beam Characteristics, Axial and Lateral resolution, Focusing and Arrays. **Ultrasonic Diagnostic Methods:** Pulse Echo systems - A mode, B mode, M mode and C mode, Transmission Methods, Doppler methods, Duplex Imaging. **Biological Effects of Ultrasound:** Acoustic phenomena at high intensity levels, Ultrasound Bioeffects.
Module -4
Generation and Detection of Nuclear Emission: Nuclear Sources, Radionuclide Generators, Nuclear Radiation Detectors, Collimators. **Diagnostic methods using Radiation Detector Probes**: Thyroid Function test, Renal function test, Blood volume measurement. **New Radio Nuclide Imaging methods:** Longitudinal Section Tomography, SPECT and PET **Characteristics of Radionuclide Images:** Spatial Resolution, Image contrast, Image Noise.
Module -5
Generation and Detection of NMR signal: The NMR Coil/Probe, The transmitter and the Receiver, Data acquisition. **Magnetic Resonance Imaging methods:** Spin Echo Imaging, Gradient Echo Imaging, Blood flow Imaging. **Characteristics of MRI images:** Spatial Resolution, Image Contrast. Imaging Safety
TEXTBOOKS: 1. ‘Principles of Medical Imaging’, Kirk Shung, Michael B Smith, Benjamin M W Tsui, Academic Press, 2012. 2. ‘Nuclear Medicine Introductory Text’, Peter Jose fell & Edwards Sydney, William Blackwell Scientific Publishers, London **REFERENCE BOOKS:** 1. ‘Fundamentals of Medical Imaging’, Zhong Hicho and Manbir Singh, John Wiley, 1993.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Generation and Detection of X ray	Introduction of X-ray generation by explaining the acceleration of electrons in a tube, their collision with a target, and the production of X-rays. Detection will be explained by how X-ray beams are captured by film or digital sensors, converting X-ray patterns into visible images for diagnostic use.
2	Week 4-6: Tomography and Radiography	Understanding tomography by cross-sectional images which are created using rotating X-ray sources and detectors to visualize internal structures. For radiography, X-rays will be pass through the body to produce two-dimensional images on film or digital sensors, emphasizing image interpretation and diagnostic applications.
3	Week 8-11: Generation and Detection of Ultrasound.	Studying about how sound waves are generated by a transducer, transmitted through tissues, eflected back to the transducer. Discussing how these reflections are detected and converted into images, highlighting the principles of frequency, wavelength, and image interpretation for diagnosing internal structures.
4	Week 7-8: Generation and Detection of Nuclear Emission	Understanding the concept of nuclear emission by radioactive isotopes decay, emitting particles or photons. For detection, understanding scintillation counters or semiconductor detectors to capture and measure these emissions. Emphasize how these signals are converted into data for imaging or analysis.
5	Week 9-12: Generation and Detection of MRI.	Introduction of MRI by strong magnetic fields and radiofrequency pulses align and perturb hydrogen nuclei in the body. Discussing how the emitted signals are detected and transformed into detailed images by the MRI scanner.

		Highlighting concepts like resonance, signal processing, and image reconstruction for diagnostic purposes.

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 Medical Image processing concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the behavior of the materials by performing few experiments.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

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

CIE Split up

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 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 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 X-ray generation and detection.	Students will be able to understand the basics of Basic Principles, X-ray Production, Tube Construction, and Detection Principles.
2	Proficiency in Tomography and Radiography.	Students will learn to analyze Principles and Techniques, Equipment and Imaging, Image Interpretation and Safety.
3	Proficiency in Ultrasound Imaging.	Analyze the basics of ultrasound physics, including sound wave propagation and image formation.
4	Proficiency in MRI.	Evaluate MRI physics, including magnetic fields and radiofrequency waves, Learn about MRI scanners and coil types.

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

Course Outcomes (COs)

COs	Description
M23MSP303B.1	**Apply** the basic mathematical, scientific and computational skills necessary to understand X-ray generation and Detection.
M23MSP303B.2	**Apply** classical and modern filtering for Tomography and Radiography.
M23MSP303B.3	**Apply** the basic mathematical, scientific and computational skills necessary to understand Ultrasound generation and detection.

M23MSP303B.4	**Apply** the basic mathematical, scientific and computational skills necessary to understand Nuclear Emission and NMR generation and detection.
M23MSP303B.5	**Simulate** different Medical Imaging techniques using modern tool.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PSO1	PSO2
M23MSP303B.1	3	3	-	3	-
M23MSP303B.2	3	3	-	-	3
M23MSP303B.3	3	3	-	3	-
M23MSP303B.4	3	3	-	-	3
M23MSP303B.5	-	-	-	-	-
M23MSP303B	3	3	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	10					10
Module 2		05		05		10
Module 3		05			10	15
Module 4			05			05
Module 5			05	05		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			10		10	20
Module 4				10	10	20
Module 5			10	10		20
Total	20	20	20	10	20	100

10. Future with this Subject:

❖ **Artificial Intelligence (AI) and Machine Learning:**
- Enhanced Image Analysis**:** AI algorithms will improve the accuracy of image interpretation, automate diagnostic processes, and identify patterns not easily detectable by human eyes.
- Predictive Analytics: AI will help in predicting disease progression and patient outcomes based on imaging data.

❖ **Advanced Imaging Technologies:**
- High-Resolution Imaging: Advances in technology will enable even finer resolution, providing clearer and more detailed images of tissues and organs.
- Multimodal Imaging: Combining data from different imaging modalities (e.g., PET/MRI) will enhance diagnostic accuracy and provide a more comprehensive view of patient conditions.

❖ **Personalized Medicine:**
- Tailored Diagnostics: Imaging technologies will be increasingly used to tailor treatments to individual patients based on their specific physiological and genetic profiles.
- Precision Imaging: Targeted imaging techniques will focus on specific biomarkers or disease pathways, enhancing the precision of diagnosis and treatment.

❖ **Real-Time Imaging and Monitoring:**
- Intra operative Imaging: Real-time imaging during surgeries will improve precision and outcomes by allowing surgeons to see structures and changes as they occur.
- Wearable and Portable Devices: Development of portable imaging devices and wearable's will enable continuous monitoring of health conditions outside traditional clinical settings.

3rd Semester	**Professional Elective Course (PE)** **ARRAY SIGNAL PROCESSING**	**M23MSP303C**

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Linear Algebra:	Understanding vectors, matrices, and operations on them is crucial, as array signal processing often involves matrix manipulations and eigenvalue problems.
2	Probability and Statistics:	Knowledge of random variables, probability distributions, statistical estimation, and hypothesis testing is important for analyzing signal noise and making inferences.
3	Signal Processing Fundamentals:	Basic concepts such as Fourier transforms, filtering, and sampling are essential. This includes understanding both continuous and discrete signal processing.
4	Digital Signal Processing (DSP):	Familiarity with discrete-time signals and systems, including techniques for filtering, spectral analysis, and digital filter design.
5	Electromagnetics:	For applications involving antennas and sensor arrays, understanding electromagnetic theory and antenna principles is useful.
6	Mathematical Analysis:	Skills in calculus and differential equations are beneficial for understanding signal behaviors and transformations..
7	Numerical Methods:	Knowledge of numerical techniques for solving mathematical problems is useful for practical computations and algorithm development.

2. Competencies

S/L	Competency	KSA Description
1	Mathematics and Linear Algebra	**Knowledge:** Understanding of vectors, matrices, eigenvalues, and eigenvectors **Skills:** Familiarity with matrix decompositions (e.g., SVD, QR).. **Attitudes:** A propensity for detailed analysis and critical thinking to solve complex signal processing problems.
2	Signal Analysis	**Knowledge:** Spectral analysis, time-frequency analysis, and statistical signal processing. **Skills:** Analyze and interpret signals using various techniques, identify patterns and trends. **Attitudes:** Analytical thinking, curiosity, and problem-solving.
3	Signal Processing Theory	**Knowledge:** Knowledge of Fourier transforms (both discrete and continuous). **Skills:** Concepts of filtering, convolution, and correlation. **Attitudes:** Sampling theory and Nyquist-Shannon sampling theorem
4	Noise Cancellation and Reduction	**Knowledge:** Noise cancellation algorithms, adaptive filtering, and spectral subtraction. **Skills:** Implement noise cancellation and reduction techniques, analyze performance. **Attitudes:** Persistence, attention to detail, and problem-solving.
5	Electromagnetics and Antenna Theory	**Knowledge:** Basic principles of wave propagation, antenna radiation patterns, and array geometry **Skills:** Estimate and model spectral densities, analyze and interpret results. **Attitudes:** Analytical thinking, curiosity, and attention to detail.
6	Signal Enhancement	**Knowledge:** Signal enhancement techniques, adaptive filtering, and spectral processing. **Skills**: Enhance signals using various techniques, analyze and interpret results. **Attitudes:** Creativity, analytical thinking, and attention to detail.

3. Syllabus

ARRAY SIGNAL PROCESSING SEMESTER –3			
Course Code	**M23MSP303**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives: The objectives of this course are to:

3. Understand various aspects of array signal processing.
4. Explain the Concepts of Spatial Frequency along with the Spatial Samplings
5. Describe array design methods and direction of arrival estimation techniques.

Module -1

Spatial Signals: Signals in space and time, Spatial Frequency Vs Temporal Frequency, Review of Co-ordinate Systems, Maxwell's Equation, Wave Equation. Solution to Wave equation in Cartesian Co-ordinate system –Wave number vector, Slowness vector.

Module -2

Wave number-Frequency Space Spatial Sampling: Spatial Sampling Theorem-Nyquist Criteria, Aliasing in Spatial frequency domain, Spatial sampling of multidimensional signals.

Module -3

Sensor Arrays: Linear Arrays, Planar Arrays, Frequency – Wave -number Response and Beam pattern, Array manifold vector, Conventional Beam former, Narrowband beam former.

Module -4

Uniform Linear Arrays: Beam pattern in θ, u and ψ -space, Uniformly Weighted Linear Arrays. Beam Pattern Parameters: Half Power Beam Width, Distance to First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering.

Module -5

Array Design Methods: Visible region, Duality between Time - Domain and Space -Domain Signal Processing, Schelkunoff's Zero Placement Method, Fourier Series Method with windowing, Woodward - Lawson Frequency-Sampling Design. Non-parametric method -Beam forming, Delay and sum Method, Capons Method.

Suggested Learning Resources:

Text Books

1. Harry L. Van Trees "Optimum Array Processing Part IV of Detection, Estimation, and Modulation Theory" John Wiley & Sons, 2002, ISBN: 9780471093909.
2. Don H. Johnson Dan E. Dugeon, "Array Signal Processing: Concepts and Techniques", Prentice Hall Signal Processing Series, 1st Edition, ISBN-13: 978-0130485137.

Reference Books

3. Petre Stoica and Randolph L. Moses "Spectral Analysis of Signals" Prentice Hall, 2005, ISBN: 0-13-113956-8.
4. Sophocles J. Orfanidis, "Electromagnetic Waves and Antennas", ECE Department Rutgers University, 94 Brett Road Piscataway, NJ 08854- 8058. http://www.ece.rutgers.edu/~orfanidi/ewa/

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 1-3: Signals in space and time	Signals in space and time, Spatial Frequency Vs Temporal Frequency, Review of Co-ordinate Systems, Maxwell's Equation, Wave Equation. Solution to Wave equation in Cartesian Co-ordinate system –Wave number vector, Slowness vector.
2	Week 4-6: Wave number-Frequency Space Spatial Sampling:	Spatial Sampling Theorem-Nyquist Criteria, Aliasing in Spatial frequency domain, Spatial sampling of multidimensional signals.
3	Week 7-8: Sensor Arrays	Linear Arrays, Planar Arrays, Frequency – Wave number Response and Beam pattern, Array manifold vector, Conventional Beam former, Narrowband beam former.
4	Week 8-11: Uniform Linear	Uniform Linear Arrays: Beam pattern in θ, u and ψ -space, Uniformly Weighted Linear Arrays. Beam Pattern Parameters: Half Power Beam Width,

	Arrays	Distance to First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering.
5	Week 9-12: Array Design Methods:	Visible region, Duality between Time - Domain and Space -Domain Signal Processing, Schelkunoff's Zero Placement Method, Fourier Series Method with windowing, Woodward -Lawson Frequency-Sampling Design. Non parametric method -Beam forming, Delay and sum Method, Capons Method.

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 image processing concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the image processing concepts by simulating in MATLAB.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

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

CIE Split up

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 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 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	Array Geometry:	Learn about different array configurations (e.g., linear, planar, circular) and their properties.
2	Signal and Noise Models:	Develop an understanding of how signals and noise are represented in array systems.
3	Spatial Sampling	: Learn how signals from different spatial locations are sampled and represented.
4	Array Response:	Comprehend how the array's geometry affects the signal received.

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

Course Outcomes (COs)

COs	Description
M23MSP303C.1	Analyze and distinguish between spatial and temporal signals, including their frequency domains.
M23MSP303C.2	Apply the spatial sampling theorem to determine the required sampling rates for multidimensional signals. estimators

M23MSP303C.3	Designing and analyzing various sensor arrays, including linear and planar arrays.
M23MSP303C.4	Evaluate and design beam patterns for uniform linear arrays, including understanding parameters such as beamwidth, side lobes, and grating lobes.
M23MSP303C.5	Apply various array design methods, including Schelkunoff's zero placement method, Fourier series method with windowing, and Woodward-Lawson frequency-sampling design.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MSP303C.1	3	-	-
M23MSP303C.2	3	3	-
M23MSP303C.3	-	-	3
M23MSP303C.4	-	3	-
M23MSP303C.5	3	3	
M23MSP303C	3	3	3

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:

Adaptive signal processing is a branch of statistical signal processing that deals with the challenging problem of estimation and tracking of time-varying systems.

It finds application in various field such as:

- Advancements in Communication Systems,5G and Beyond: Array signal processing is crucial for the development and optimization of 5G networks, including advanced beamforming techniques and massive MIMO (Multiple Input Multiple Output) systems. Future communication technologies will leverage these techniques for enhanced data rates, reliability, and coverage.
- Satellite Communications: Improved array processing techniques will enhance satellite communication systems, enabling better beam steering, signal tracking, and interference management.
- Enhanced Radar and Sonar Systems, Autonomous Vehicles: In autonomous driving, radar and sonar systems equipped with advanced array signal processing will provide accurate object detection, tracking, and collision avoidance.
- Military and Defense: Enhanced radar systems for surveillance, target tracking, and reconnaissance will benefit from improved array processing techniques, offering better resolution and detection capabilities.
- Medical Imaging and Diagnostics Ultrasound Imaging: Array signal processing will advance imaging techniques in ultrasound, improving image quality, resolution, and real-time diagnostics.

3rd Semester	Professional Elective Course (PE) FIN FETS AND OTHER MULTI GATE TRANSISTOR	M23MSP303D

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Digital Logic Design:	Understanding basic digital logic circuits, Boolean algebra, flip-flops, and combinational circuits.
2	Semiconductor Physics:	Knowledge of semiconductor devices, particularly MOSFETs, is essential for understanding multi-gate transistors.
3	VLSI Design Fundamentals:	Basic understanding of CMOS technology, transistor scaling, and the impact on performance and power.
4	Device Physics:	Familiarity with carrier mobility, threshold voltage, and channel length modulation in transistors.
5	Circuit Design:	Understanding of analog and digital circuit design principles, including transistor behavior and power dissipation.
6	Nanotechnology:	Basic knowledge of nanofabrication techniques and challenges in scaling down devices to nanometer dimensions.
7	Mathematics:	Proficiency in calculus and differential equations for analyzing device characteristics and behavior.
8	Software Tools and Simulation:	Experience with EDA tools for device simulation and layout, such as TCAD and SPICE, is beneficial.

2. Competencies

S/L	Competency	KSA Description
1	Device Scaling	**Knowledge:** Concepts of device scaling, short-channel effects, and limitations of traditional MOSFETs. **Skills:** Analyzing the effects of scaling on device performance and power **Attitudes:** Curiosity about advancements in semiconductor technology and openness to new design paradigms.
2	Multi-Gate Transistor Design	**Knowledge:** Understanding of FinFETs architecture, SOI technology, and the concept of multiple gates controlling a single channel. **Skills:** Designing and optimizing multi-gate devices for various applications. **Attitudes:** Attention to detail in device modeling and simulation.
3	Fabrication Techniques	**Knowledge:** Knowledge of advanced lithography, etching, and deposition techniques for FinFETs fabrication. **Skills:** Understanding fabrication process flows and the impact of process variations on device performance. **Attitudes:** Precision in following fabrication protocols and curiosity about emerging fabrication technologies.
4	Electrical Characterization	**Knowledge:** Principles of electrical characterization, including I-V characteristics, threshold voltage, and subthreshold slope. **Skills:** Analyzing and interpreting electrical measurements of FinFETs. **Attitudes:** Persistence in experimental data analysis and validation of simulation models.
5	Circuit Applications	**Knowledge:** Application of FinFETs in digital, analog, and RF circuits, and their impact on power, performance, and area (PPA). **Skills:** Designing circuits using FinFETs and other multi-gate transistors. **Attitudes:** Interest in optimizing circuit designs for emerging technologies.

3. Syllabus

FINFETS AND OTHER MULTI-GATE TRANSISTORS SEMESTER – III			
Course Code	M23MSP303D	CIE Marks	50
Number of Lecture Hours/Week(L: T: P: S)	(3:0:0)	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 learn the evolution of SOI MOS transistor.
2. To have an insight into thin film formation techniques and advanced gate stack deposition.
3. To enable the students to analyze physics behind BSIM-CMG.
4. To analyze the electrostatics of the multi-gate MOS system.
5. To realize the interrelationship between the multi-gate FET device properties and digital and analog circuits

Module-1

SOI MOSFET: From Single Gate to MultiGate:
MOSFET scaling and Moore's law, Short-Channel Effects, Gate Geometry and Electrostatic Integrity, A brief history of Multiple - Gate MOSFETs: Single-gate SOI MOSFETs, Double-gate SOI MOSFETs, Triple-gate SOI MOSFETs, MultiGate MOSFET physics.

Module-2

Multigate MOSFET Technology: Introduction, Active Area: Fins: Fin Width, Fin Height and Fin Pitch, Fin Surface Crystal Orientation, Fin Surface, Fins on Bulk Silicon, Gate Stack: Gate Patterning, Threshold Voltage and Gate Work function Requirements, Polysilicon Gate, Metal Gate, Tunable Work function Metal Gate, Gate EWF and Gate Induced Drain Leakage (GIDL), Independently Controlled Gates.

Module-3

BSIM- CMG: A Compact Model for Multi-Gate Transistors : Introduction, Framework for Multi-Gate FET Modeling, Multi-Gate Models, BSIM-CMG and BSIM-IMG, BSIM-CMG: The BSIM-IMG Model, BSIM-CMG, Core Model, Surface Potential ,I-V Model, C-V Model ,Modeling Physical Effects of Real Devices, Quantum Mechanical Effects (QME) ,Short-channel Effects (SCE), Experimental Verification, The BSIM-IMG Model, Surface Potential of independent DG-FET, BSIM-IMG features.

Module-4

Physics of the MultiGate MOS system: Device electrostatics, Double gate MOS system, Modeling assumptions, Gate voltage effect, Semiconductor thickness effect, Asymmetry effects, Oxide thickness effect, Electron tunnel current Two-dimensional confinement.

Module-5

Multi-Gate MOSFET circuit Design: Introduction, Digital Circuit Design, Impact of device performance on digital circuit design, Large-scale digital circuits, Leakage-performance trade-off and energy dissipation, Multi-VT devices and mixed-VT circuits, High-temperature circuit operation, SRAM design, Analog Circuit Design: Device figures of merit and technology related design issues, Transconductance, Intrinsic transistor gain, Matching behavior, Flicker noise, Transit and maximum oscillation frequency.

Suggested Learning Resources:

TEXTBOOKS:
1. Colinge, J.P., "FinFETs and Other Multi-Gate Transistors," Springer, 2008.
2. Yuan Taur and Tak H. Ning, "Fundamentals of Modern VLSI Devices," Cambridge University Press, 2013.

REFERENCE BOOKS:
1. S. M. Sze and Kwok K. Ng, "Physics of Semiconductor Devices," Wiley-Interscience, 2006.
2. Massoud Pedram and Jan M. Rabaey, "Power Aware Design Methodologies," Springer, 2002.

Video Lectures (e-Resources): https://onlinecourses.nptel.ac.in/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to MOSFET Scaling	Discuss limitations of traditional MOSFETs, short-channel effects, and the need for FinFETs and multi-gate transistors.
2	Week 3-4: FinFET Design and Fabrication	Study the structure, operation, and fabrication process of FinFETs, including challenges and process variations.

3	Week 5-6: Electrical Characteristics	Analyze the electrical characteristics of FinFETs and compare with planar MOSFETs. Learn device modeling and simulation techniques.
4	Week 7-8: Circuit Applications of FinFETs	Explore the application of FinFETs in digital, analog, and RF circuits. Study their impact on PPA metrics.
5	Week 9-11: Advanced Topics	Delve into advanced topics such as GAA transistors, nanosheets, and future trends in transistor technology.

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 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 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.

8. Course Outcomes and Mapping with POs/ PSOs

CO's	DESCRIPTION OF THE OUTCOMES
M23MSP303D.1	Analyze and evaluate the advantages and challenges of Multi-gate FETs by understanding their underlying physics, including thin film formation, gate stack deposition, and issues related to crystal orientation and mobility.
M23MSP303D.2	Describe thin film formation technique, gate stack deposition and issues related to fin crystal orientation and mobility enhancement.
M23MSP303D.3	Apply the compact models to describe physics beyond BSIMCMG to enable fast computer analysis of device/circuit behavior..
M23MSP303D.4	Analyze electrostatics of multi-gate MOS system using quantum-mechanical concepts and describe the effects of tunneling through thin gate dielectrics.
M23MSP303D.5	Correlate multigate FET device properties and elementary digital and analog circuits

CO's	PO1	PO2	PO3
M23MSP303D.1	3	3	-
M23MSP303D.2	3	-	3
M23MSP303D.3	3		
M23MSP303D.4	3	3	3
M23MSP303D	**3**	**3**	**3**

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**

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

- **Enhanced Scaling**: FinFET technology has been pivotal in continuing Moore's Law by enabling further scaling of transistor sizes beyond the limits of planar transistors. As we approach and eventually exceed the 3nm node, further refinements in FinFET design will continue to push performance and power efficiency.
- **Performance Boosts**: Innovations in FinFET architecture, such as optimizing fin height, width, and spacing, will further enhance switching speeds and drive currents, leading to higher performance chips.
- **Gate-All-Around (GAA) Transistors**: The evolution beyond FinFETs includes Gate-All-Around (GAA) transistors, like the nanowire or nanosheet transistors. GAA transistors offer better electrostatic control over the channel and can help in further reducing leakage currents and improving performance at smaller nodes.
- **MBCFETs (Multi-Bridge-Channel FETs)**: Another promising technology, MBCFETs combine the benefits of fin-like structures with new channel materials to improve electrostatics and drive currents, potentially offering better performance and power efficiency.
- **Beyond-Silicon Technologies**: Research into beyond-silicon technologies, such as using new materials or hybrid devices that combine silicon with other semiconductors, will influence the future of multi-gate transistors. These innovations may lead to novel transistor designs that address current limitations.

3rd Semester	Professional Elective Course (PE) INTERNET OF THINGS (IOT)	M23MSP303E

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Networking Knowledge:	Understanding of fundamental networking concepts and protocols.
2	Introduction to IoT:	Familiarity with the basics of IoT, including its purpose and applications.
3	Programming Skills:	Proficiency in programming languages commonly used in IoT (e.g., Python, C++).
4	Embedded Systems:	Basic knowledge of embedded systems and microcontrollers.
5	Wireless Communication:	Familiarity with wireless communication technologies and protocols.
6	Electronics and Sensors:	Basic knowledge of electronics, sensors, actuators, and MEMS (Microelectromechanical Systems).

2. Competencies

S/L	Competency	KSA Description
1	Understanding IoT Fundamentals	**Knowledge:** Basics of IoT, its genesis, digitization, impact, and challenges. Understanding connected roadways and buildings. **Skills:** Ability to explain IoT concepts and evaluate its impact on various sectors. **Attitudes:** Curiosity about emerging technologies and a proactive approach to understanding IoT challenges and opportunities.
2	IoT Network Architecture and Design	**Knowledge:** IoT network layers, functional stack, M2M architecture, IoT World Forum standards, and reference models. **Skills:** Design and compare IoT architectures, implement simplified IoT models. **Attitudes:** Analytical mindset towards network design and an innovative approach to solving architectural challenges.
3	Core IoT Functional Stack	**Knowledge:** Detailed understanding of IoT layers (sensors, communication, network management, applications). **Skills:** Ability to design and manage IoT systems, analyze data management and compute stacks. **Attitudes:** Systematic approach to managing and integrating different IoT layers and components.
4	Engineering IoT Networks	**Knowledge:** IoT components (sensors, actuators, MEMS), sensor networks, communication protocols, and access technologies. **Skills:** Design and optimize IoT networks, understand and apply various communication protocols, manage constrained devices and networks. **Attitudes:** Technical proficiency and problem-solving skills in network engineering.

5	Application Protocols and Data Management	**Knowledge:** IoT application protocols, transport layers, SCADA, web-based protocols, structured and unstructured data management. **Skills:** Implement and optimize application protocols, manage and analyze IoT data effectively. **Attitudes:** Detail-oriented approach to application development and data handling, and commitment to effective data management practices.
6	IoT in Industry and Smart Cities	**Knowledge:** IoT strategies for manufacturing, smart city architectures, and connected utilities. **Skills:** Develop and implement IoT strategies for various use cases, design smart city solutions. **Attitudes:** Visionary thinking for industrial and urban IoT applications, and a collaborative approach to solving real-world problems.

3. Syllabus

INTERNET OF THINGS (IOT)
SEMESTER – III

Course Code	**M23MSP303E**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:

1. Apply IoT fundamentals to understand its origins, impact, digitization, and challenges in connected environments.
2. Analyze IoT network architecture by evaluating new designs, comparing architectures, and understanding core functional stacks.
3. Design IoT networks focusing on sensors, protocols, IP optimization, and data management strategies for industrial applications.
4. Evaluate IoT strategies and implementations across connected manufacturing and smart cities for effectiveness and optimization.

Module -1

What is IoT?
Genesis, Digitization, Impact, Connected Roadways, Buildings, Challenges
IoT Network Architecture and Design
Drivers behind new network Architectures, Comparing IoT Architectures, M2M architecture, IoT world forum standard, IoT Reference Model, Simplified IoT Architecture.
Self-Learning : Scope of IoT in India

Module -2

IoT Network Architecture and Design
Core IoT Functional Stack, Layer1 (Sensors and Actuators), Layer 2 (Communications Sublayer), Access network sublayer, Gateways and backhaul sublayer, Network transport sublayer, IoT Network management. Layer 3 (Applications and Analytics) – Analytics vs Control, Data vs Network Analytics, IoT Data Management and Compute Stack
Self-Learning: Role of IC manufacturing in development of IoT

Module -3

Engineering IoT Networks
Things in IoT – Sensors, Actuators, MEMS and smart objects. Sensor networks, WSN, Communication protocols for WSN Communications Criteria, Range, Frequency bands, power consumption,Topology, Constrained Devices, Constrained Node Networks IoT Access Technologies, IEEE 802.15.4
Competitive Technologies – Overview only of IEEE 802.15.4g, 4e, IEEE 1901.2a
Self-Learning: Standard Alliances – LTE Cat 0, LTE-M, NB-IoT

Module -4

Engineering IoT Networks
IP as IoT network layer, Key Advantages, Adoption, Optimization, Constrained Nodes, Constrained Networks, IP versions, Optimizing IP for IoT.
Application Protocols for IoT – Transport Layer, Application Transport layer, Background only of SCADA, Generic web based protocols, IoT Application Layer Data and Analytics for IoT – Introduction, Structured

and Unstructured data
Self-Learning: IoT Data Analytics overview and Challenges.

Module -5

IoT in Industry (Three Use cases)
IoT Strategy for Connected manufacturing, Architecture for Connected Factory Utilities – Power utility, IT/OT divide, Grid blocks reference model, Reference Architecture, Primary substation grid block and automation.
Smart and Connected cities –Strategy, Smart city network Architecture, Street layer, city layer, Data center layer, services layer.
Self-Learning: Smart city security architecture, Smart street lighting.

TEXT BOOKS:
1. 'CISCO, IoT Fundamentals – Networking Technologies, Protocols, Use Cases for IoT', David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, Pearson Education, ISBN: 978-9386873743, First edition, 2017
2. 'Internet of Things – A Hands on Approach', Arshdeep Bahga and Vijay Madisetti, Orient Blackswan Private Limited - New Delhi, First edition, 2015.

VIDEO LINKS:
1. https://onlinecourses.nptel.ac.in/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: IoT Network Architecture and Design	Introduction to IoT, Genesis, Digitization, Impact, Connected Roadways, Buildings, Challenges of IOT, IoT Network Architecture and Design concepts.
2	Week 4-6: IoT Network Architecture and Design	Understanding the concepts of IoT Network Architecture and Design of different layers.
3	Week 7-8: Engineering IoT Networks	Study IoT foundations, including sensors, actuators, MEMS, devices, networks, IEEE 802.15.4, and competitive standards like IEEE 802.15.4g.
4	Week 9-10: Engineering IoT Networks	Understand IP's role in IoT, including advantages, adoption, optimization, application protocols, SCADA, web protocols, and data analytics.
5	Week 11-12: IoT in Industry	Study IoT use cases in connected manufacturing, smart cities, including strategies, architectures, utilities, grid models, and data layers.

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	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

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

CIE Split up

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 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 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	Understand IoT Fundamentals	Explain IoT's origins, impact, digitization, and challenges in connected environments.
2	Analyze IoT Network Architecture	Compare IoT architectures, M2M models, and the IoT Reference Model.
3	Design Core IoT Functional Stack	Develop knowledge of IoT layers, including sensors, communication, and network management.
4	Engineer IoT Networks	Implement and optimize sensor networks, communication protocols, and IoT access technologies.
5	Apply IP in IoT	Utilize IP optimization for IoT, including versions, advantages, and constrained networks
6	Implement IoT Application Protocols	Understand and apply transport and application protocols, including SCADA and web-based systems.
7	Evaluate IoT Data and Analytics	Analyze structured and unstructured data for effective IoT data management and analytics
8	Assess IoT Industry Applications	Develop strategies for connected manufacturing and smart city architectures in real-world use cases.

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

Course Outcomes (COs)

COs	Description
M23MSP303E.1	Apply IoT principles to design architectures, stacks, and data strategies.
M23MSP303E.2	Analyze IoT impact, architectures, functional stacks, and data management applications.
M23MSP303E.3	Design IoT solutions integrating architectures, functional stacks, and data management.
M23MSP303E.4	Evaluate IoT impact, architecture, data management, and applications in industries.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
M23MSP303E.1	3	2	2
M23MSP303E.2	3	3	3
M23MSP303E.3	2	3	3
M23MSP303E.4	2	2	3
M23MSP303E	2.5	2.5	2.75

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:

- ❖ Infrastructure Management: IoT will enable more efficient management of utilities and infrastructure, such as smart grids for electricity, water, and gas. Sensors can detect issues like leaks or outages in real time.
- ❖ Traffic and Transportation: Smart traffic lights and connected vehicles can optimize traffic flow and reduce congestion. Public transportation systems can become more responsive to real-time conditions.
- ❖ Public Safety: Surveillance cameras and environmental sensors can enhance safety and emergency response systems.

3rd Semester	Project Work (PW) PROJECT WORK PHASE I	M23MSP304

1. Syllabus

PROJECT WORK PHASE I SEMESTER – III			
Course Code	**M23MSP304**	CIE Marks	**100**
Number of Lecture Hours/Week (L: P: SDA)	**(0:6:0)**	SEE Marks	**50**
Total Number of Lecture Hours		Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organization, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgment, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instill responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted. Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

2. Assessment Details:

Continuous Internal Evaluation

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 mechanical engineering knowledge	Students will select a project activity that allows them to apply the principles of mechanics, thermodynamics, materials science, or other core mechanical 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 mechanical 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
M23MSP304.1	Conduct a comprehensive literature survey and demonstrate understanding of the research landscape:
M23MSP304.2	Develop a well-defined project proposal with clear objectives and preliminary plans
M23MSP304.3	Effectively communicate project plans and findings through an introductory document and seminar presentation

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
CO1	3	-	-
CO2	3	-	-
CO3	-	3	-

3rd Semester	SOCIETAL PROJECT (SP)	M23MSP305

1. Syllabus

SOCIETAL PROJECT (M23MSP305) SEMESTER – III			
Course Code	**M23MSP305**	CIE Marks	**100**
Number of Lecture Hours/Week(L: P: SDA)	**(0:0:6)**	SEE Marks	**-**
Total Number of Lecture Hours		Total Marks	**100**
Credits	**03**	Exam Hours	**03**
Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology to workout/proposing viable solutions for societal problems.			

2. Assessment Details:

Continuous Internal Evaluation

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.

3. Learning Objectives

S/L	Learning Objectives	Description
1	Identify and analyze a pressing societal problem	Students will demonstrate the ability to critically evaluate social issues and pinpoint a specific problem that technology can potentially address.
2	Explore existing technological solutions and research emerging trends:	Students will effectively research and analyze existing technology-based solutions for similar societal challenges.
3	Develop a creative and feasible technological solution	By leveraging their understanding of the problem and the technological landscape, students will propose an innovative solution that utilizes technology effectively.
4	Effectively communicate the proposed solution through a project report and presentation	Students will craft a well-structured project report that clearly outlines the identified problem, the proposed solution (including its technological aspects), and its potential benefits for society.

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

Course Outcomes (COs)

COs	Description
M23MSP305.1	Develop a technology-driven solution for a real-world societal problem
M23MSP305.2	Critically evaluate existing technological solutions and emerging trends
M23MSP305.3	Effectively communicate the proposed solution and its societal impact

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
CO1	3	-	-
CO2	-	-	3
CO3	-	3	-

3rd Semester	INTERNSHIP (INT)	M23MSP306

1. Syllabus

INTERNSHIP (M23MSP306) SEMESTER – III			
Course Code	**M23MSP306**	CIE Marks	**50**
Number of Lecture Hours/Week(L: P: SDA)		SEE Marks	**50**
Total Number of Lecture Hours	**06 weeks**	Total Marks	**100**
Credits	**03**	Exam Hours	**-**

Course Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.

The objectives are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.

Internship:

Students under the guidance of an internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship. Each student is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and be involved in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall participate in discussion to foster a friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

2. Assessment Details:

Continuous Internal Evaluation

CIE marks for the Internship report, presentation and question and answer session shall be awarded in the ratio of 50:25:25 for the total CIE of 50 marks by the committee constituted by the Head of the Department. The committee shall consist of three faculties from the department with a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any), and a senior faculty of the concerned departments.

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded in the ratio of 50:25:25 for the total SEE of 50 marks (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

3. Learning Objectives:

S/L	Learning Objectives	Description
1	Apply Classroom Knowledge to Practical Work	Description: Students will demonstrate the ability to utilize theoretical knowledge gained in coursework to solve real-world problems encountered during the internship. This may involve applying specific skills to a project or task, like budgeting or marketing principles.
2	Enhance Professional Skillset	Description: Students will actively participate in learning opportunities that expand their existing skillset. This could include developing presentation skills, mastering time management techniques, or honing interpersonal communication abilities.
3	Bridge the Gap	Description: Students will gain a deeper understanding of professional practices

	Between Theory and Practice	in their field by observing and interacting with experienced professionals. This may involve shadowing colleagues, attending client meetings, or participating in project discussions.
4	Develop Professional Responsibility and Ethics	Description: Students will learn about and adhere to professional standards and ethical codes relevant to their field. This may involve understanding confidentiality protocols, managing liability risks, or completing paperwork with accuracy and attention to detail.
5	Foster Self-Directed Learning and Initiative	Description: Students will take on independent tasks and demonstrate initiative in seeking out learning opportunities. This may involve proposing new ideas, conducting research relevant to their work, or managing personal workload effectively.

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

Course Outcomes (COs)

COs	Description
M23MSP306.1	Apply the academic knowledge to solve practical problems encountered during the internship.
M23MSP306.2	Gain industry experience, explore career options, and refine professional goals.
M23MSP306.3	Enhance Communication and Self-Directed Learning

CO-PO-PSO Mapping.

COs/POs	PO1	PO2	PO3
CO1	3	-	-
CO2	-	-	3
CO3	-	3	-

4th Semester	Project Work (PW) PROJECT WORK PHASE 2	M23MSP401

1. Syllabus

PROJECT WORK PHASE II SEMESTER – IV			
Course Code	**M23MSP401**	CIE Marks	**100**
Number of Lecture Hours/Week(L: P: SDA)	**10**	SEE Marks	**100**
Total Number of Lecture Hours		Total Marks	**200**
Credits	**19**	Exam Hours	**03**

Course Objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organization, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instill responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar. CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.
SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

2. Assessment Details:

CIE

The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

SEE

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

3. Learning Objectives

S/L	Learning Objectives	Description
1	Independent Learning & Ethical Research	Develop skills to research effectively, critically evaluate information, and use sources ethically to support independent learning.
2	Effective Communication & Organization	Learn to organize information logically, present findings clearly (citing sources), and communicate effectively through written and oral formats.
3	Time Management & Teamwork	Develop time management skills to meet deadlines and collaborate effectively within teams, fostering flexibility and adaptability.
4	Seminar Presentation & Public Speaking	Gain confidence in public speaking, overcome stage fright, and present project work effectively in a seminar setting.
5	Critical Thinking & Professionalism	Sharpen critical thinking skills, demonstrate sound judgment and intuition, and cultivate a sense of responsibility towards oneself and others.

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

Course Outcomes (COs)

COs	Description
M23MSP401.1	Conduct In-Depth Research and Develop a Comprehensive Project
M23MSP401.2	Effectively Communicate Project Findings and Defend Methodology
M23MSP401.3	Demonstrate Advanced Knowledge and Critical Thinking Skills:

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3
CO1	3	-	-
CO2	-	3	-
CO3	-	-	3