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||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

AICTE Approved, Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME & CV), NIRF(151-300) in 2023,Gold Rated by QS I-Gauge

P.B. No.20, B.B Road, Chikkaballapur - 562 101, Karnataka

Estd : 1986

I & II Semester
Scheme & Syllabus of M.Tech Programme
Digital Communication and Networking
(2026 Scheme)

Core Values

Spiritual, **J**udicious, **C**ommitment, **I**ntegrity, **T**rustworthy



NATIONAL INSTITUTIONAL RANKING FRAMEWORK 151-300

A+ NAAC

QS I-GAUGE GOLD

INSTITUTION'S INNOVATION COUNCIL (Ministry of HRD Initiative) 4-Star Rating



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Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

(An Autonomus Institute Under VTU Belagavi & Approved by AICTE, New Delhi)

Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME & CV), NIRF (151-300), QS-I Gauge GOLD Rated

Post Box #20, B.B. Road, Chikkaballapur - 562 101, Karnataka

Estd.:1986

Scheme of Teaching and Examinations (2026) M.Tech.

(Specialization in Digital Communication & Networking)

Choice-Based Credit System (CBCS) and Outcome-Based Education (OBE)

I SEMESTER (Common to all specialized Programmes under ECE stream)

I SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching and Learning Scheme					Examination				Credits
					Classroom Instruction (CI) hours per semester		Laboratory Instruction (LI) hours Per semester	Term work s self -learning in hours	Teaching -Learning hours per semester = CI +LI+TW+SL	Duration in h ours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	TW+SL						
1	MAT	1MEC101	Applied Linear Algebra and Random Processes	Mathematics	42	0	0	48	90	3	50	50	100	3
2	PCC	1MEC102	AI for Electronics Engineers	ECE	42	0	0	48	90	3	50	50	100	3
3	PCC	1MEC103	Computational Methods for Electronic System Design	ECE	42	0	0	48	90	3	50	50	100	3
4	IPCC	1MEC104x	Integrated Professional Core Course-I	ECE	42	0	28	50	120	3	50	50	100	4
5	PEC	1MEC105x	Professional Elective Course-I	ECE	42	0	0	48	90	3	50	50	100	3
6	PEC	1MEC106x	Professional Elective Course-II	ECE	42	0	0	48	90	2	50	50	100	3
7	PCCL	1MECL107x	Professional Core Courses Labs	ECE	--	--	28	2	30	03	50	50	100	1
8	NCMC	1MRMI108	Research Methodology and IPR	Online	Online course (online.vtu.ac.in)									PP
								Total	**600**	--	**350**	**350**	**700**	**20**

Professional Elective Courses (PECs): Professional Elective Courses – PEC–I and PEC–II – are common to all branches of specialization within a particular Engineering stream. Students may choose the most appropriate elective based on their field of specialization and academic requirements.

Note: The number of courses listed under each PEC group may exceed four, depending on the specializations under one stream.

Integrated Professional Core Courses (IPCC): The 1MEC104x Group comprises specialization-specific core courses that are integrated with a practical component, ensuring application-oriented learning aligned with industry and research needs. The number of courses in the group depends on the number of specializations offered under a particular engineering stream.

Integrated Professional Core Course (IPCC)	
Code	**Title of the Course**
1MEC104A	Advanced Embedded Systems
1MEC104B	Industrial Automation & Process Control
1MEC104C	System Verilog
1MEC104D	Wireless System Design using FPGA

Professional Elective Courses-I	
Code	**Title of the Course**
1MEC105A	ASIC Design
1MEC105B	Advanced Computer Networks
1MEC105C	Wearable Health Monitoring Systems
1MEC105D	Electronic Power Converters

Professional Elective Courses-II	
Code	**Title of the Course**
1MEC106A	Low-Power VLSI Design
1MEC106B	Advanced Wireless Communication Systems
1MEC106C	Medical Image Processing and AI Diagnosis
1MEC106D	Software defined Vehicles

Professional Core Courses Lab (PCCL)	
Code	**Title of the Course**
1MECL107A	Python for Electronic System Design Lab
1MECL107B	Electronics & Communication Lab
1MECL107C	Digital IC Design Lab
1MECL107D	Advanced Signal Processing Lab

Specialization in -(Digital Communication & Networking)

II SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching and Learning Scheme					Examination				Credits
					Classroom Instruction (CI) hours per semester		Laboratory Instruction (LI) hours Per semester	Term work s self -learning in hours	Teaching -Learning hours per semester = CI +LI+TW+SL	Duration in h ours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	TW+SL						
1	PCC/IPCC	1MLDN201	Massive MIMO systems	ECE	42		28	50	120	03	50	50	100	4
2	PCC	1MLDN202	Error Control Coding	ECE	42	0	0	48	90	03	50	50	100	3
3	PCC	1MLDN203	Multimedia applications	ECE	42	0	0	48	90	03	50	50	100	3
4	PCC	1MLDN204	Antenna theory	ECE	42	0	0	48	90	03	50	50	100	3
5	PEC	1MLDN205x	Professional Elective Courses-III	ECE	42	0	0	48	90	03	50	50	100	3
6	PEC	1MLDN206x	Professional Elective Course-IV	ECE	42	0	0	48	90	03	50	50	100	3
7	PCCL	1MLDNL207	Professional Core Course- Lab (AEC Lab)	ECE	--	--	28	2	30	03	50	50	100	1
8	PCC	1MLDNS208	Minor Project /Ability Skill Development Project*	ECE	--				60	03	50	50	100	2
								Total	**660**	--	**400**	**400**	**800**	**22**

***** An Ability Enhancement Course Laboratory is a practical, skill-oriented lab course designed to strengthen students' practical abilities, professional competencies that support communication, environmental awareness, computational thinking, interdisciplinary learning, and application skills through hands-on learning experiences. The laboratory may pertain to disciplinary or interdisciplinary involving experiments, design tasks, and mini-projects aligned with current industry practices.

Professional Elective Courses (PECs)				
PEC-III			PEC-IV	
Code	Title of the Course		Code	Title of the Course
1MLDN205A	RF System Design		1MLDN206A	Wavelet Transforms and Applications
1MLDN205B	Wireless Sensor Networks		1MLDN206B	Cloud Networking
1MLDN205C	Advances in Image Processing		1MLDN206C	Array Signal Processing
1MLDN205D	Statistical Signal Processing		1MLDN206D	Photonic Networks

Professional Core Course- Lab (AEC Lab)	
1MLDN207A	Modelling and simulation using MATLAB
1MLDN207B	Advanced Digital Signal Processing

Overview of Courses, Credits, Projects, and Internships under M.Tech. - 2026 Curriculum

(A) Abbreviations Adopted in the Scheme of Teaching and Examinations

Course		General Terms		General Terms	
Acronyms	**Expanded Form**	**Acronyms**	**Expanded Form**	**Acronyms**	**Expanded Form**
AEC	Ability Enhancement Course	AICTE	All India Council of Technical Education	SEE	Semester End Evaluation
ASC	Applied Science Course	CCA	Continuous Comprehensive Assessment	SGPA	Semester Grade Point Average
BSC	Basic Science Course	CGPA	Cumulative Grade Point Average	SL	Self-Learning
HSMC	Humanities Studies and Management Course	CI	Classroom Instruction	SWAYAM	Study Webs of Active-Learning for Young Aspiring Minds
IPCC	Integrated Professional Core Course	CIE	Continuous Internal Evaluation	T	Tutorial
NCMC	Non-Credit Mandatory Course	COE	Centre for Online Education	TW	Term Work
OEC	Open Elective	CUL	Cultural	VTU online	VTU online courses
PCC	Professional Core Course	NCrF	National Credit Framework		
PCCL	Professional Core Course	L	Lecture		
PEC	Professional Elective	LI	Laboratory Instruction		
PE	Physical Education	NPTEL	National Programme for		
SEC	Skill Enhancement	NSS	National Service Scheme		
YOG	Yoga	P	Practical		

(B) Academic Credit Framework in accordance with the National Credit Framework (NCrF)

The National Credit Framework (NCrF), introduced under India's education reforms, serves as an umbrella framework for the creditisation of learning across school education, higher education, vocational education, and experiential learning.

NCrF credit levels are determined based on a combination of cumulative years of learning, the complexity of learning outcomes, and the rigor of assessment. These levels signify the degree of competence and complexity attained by the learner, progressing from foundational schooling to advanced doctoral research.

Levels 1 to 4 correspond to school education up to the 12th standard, while Levels 4.5 to 8 correspond to higher education, ranging from the undergraduate level to the Ph.D. level.

In the earlier system, credits were primarily based on contact time (lecture hours per week × number of weeks per semester/year), assuming that learning is directly proportional to time spent in classroom instruction.

However, the NCrF adopts a comprehensive and outcome-based approach by assigning credits to all forms of learning, including, (i) Classroom teaching, (ii)Laboratory work, (iii)Projects, (iv)Internships and apprenticeships, (v)Online and blended learning, (vi)Fieldwork and community engagement, (vii)Recognition of Prior Learning (RPL), (viii)Sports and arts activities, and (ix)On-the-job training.

Credits are thus based on notional learning hours, representing the total learner effort rather than only contact hours.

This definition aligns Indian education with Global outcome-based credit systems, and international credit transfer practices [e.g., European Credit Transfer and Accumulation System (ECTS)-like frameworks].

According to NCrF, one academic year of learning is equal 1,200 notional learning hours (not a scientifically-validated law or psychological constant, but a policy design hours) and includes classroom teaching, self-study, assignments, projects, laboratory work, co-curricular and extra-curricular activities, internships, apprenticeships and other assessed learning experiences. For these 1,200 hours a student is expected to earn 40 credits, which means 1 credit corresponds to approximately 30 hours of academic learning.

Although traditional university systems often equated 1 credit with approximately 13 to15 contact hours per semester, VTU, in alignment with NCrF, considers 14-weeks of structured academic interaction per semester with students is equivalent to approximately 30 notional hours per credit.

The learning methodologies include:

(i) Classroom Instruction (CI): Includes different instructional/implementation strategies, such as Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc., to deliver theoretical concepts within the classroom measured in Number of hours per semester.

(ii) Laboratory Instruction (LI): Expressed as number of hours per semester which Includes experiments/practical performances / problem-based experiences in laboratory, workshop, field or other locations using different instructional / Implementation strategies.

(iii) Term work (TW): Includes assignments, seminars, presentations, case studies, micro projects, field activities, industrial visits, academic preparation duration and any other student activities in Number of hours per semester.

(iv) Self-Learning (SL): MOOCs (SWAYAM/NPTEL/Industry certified courses), spoken tutorials, online educational resources, self-initiated projects, Learning through digital resources etc in Number of hours per semester.

VTU, in alignment with NCrF, considers 14-weeks of structured academic interaction per semester with students as equivalent to approximately 30 notional hours per credit.

Table below shows the credit structure, equivalent NCrF learning hours adopted by VTU:

Table 7.0.1 VTU adopted NCrF credit structure					
Particulars	**Classroom Instruction (CI) in Hours per semester**		**Laboratory Instruction (LI) in Hours per semester**	**Term work (TW) and Self-Learning (SL) in Hours per semester**	**Total number of Teaching-Learning hours per semester**
	L	**T**	**P**	**TW + SL**	
1 Credit theory course	14	-	-	16	30
1 Credit Practical course	-	-	28	02	30
2 Credit theory course	28	-	-	32	60
3 Credit theory course	42	-	-	48	90
3 Credit theory course with Tutorial	28	28	-	34	90
4 Credit theory course	56	-	-	64	120
4 Credit theory course with Tutorial	42	28	-	50	120
4 Credit Integrated Course	42	-	28	50	120
Project work	-	-	-	As per the type of project	
Internship	-	-	-	As per the type of Internship	

NCrF is designed to work with ABC for years, where, credits are digitally stored to accumulate, transfer, and redemption across institutions for vertical and horizontal mobility across sectors, which is essential for MEME.

(C) Details of Courses

(1) Integrated Professional Core Course (IPCC): The Integrated Professional Core Course (IPCC) refers to a core theory course that is integrated with a laboratory of the same subject. Each IPCC carries 4 credits, with Teaching–Learning hours structured (L : T : P) as either (3:0:2). The theory component of the IPCC shall be evaluated through both Continuous Internal Evaluation (CIE) and Semester End Examination (SEE). The laboratory part shall be assessed exclusively through CIE, with no SEE. However, questions derived from the laboratory part may be included in the SEE question paper to ensure comprehensive evaluation.

(2) Non-Credit Mandatory Courses (NCMC): are aimed at enhancing students' knowledge, skills, and awareness beyond the core curriculum. Successful completion of the NCMC is compulsory for fulfilling the requirements of the academic program. It shall not be considered for the computation of SGPA, CGPA

and vertical progression. Each student shall register for the prescribed NCMC(s) in the prescribed semester. A student who fails to qualify in the prescribed NCMC shall not be eligible for the conferment of the degree.

(3) **Professional Elective Courses (PEC):** A professional elective course (PEC) is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum of the same discipline.

(4) **Open Elective Courses (OEC):** A open elective course (OEC) is a course offered by departments other than a student's parent department. These interdepartmental /interdisciplinary courses allow students to explore disciplines beyond their core area of study. These courses are intended to promote interdisciplinary learning, broad-based education, thereby enhancing a student's overall knowledge, creativity, and employability. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor/Proctor.

(5) **Ability/Skill Enhancement Course Laboratory (AEC):** An Ability Enhancement Course Laboratory is a practical, skill-oriented lab course designed to strengthen students' practical abilities, professional competencies that support communication, environmental awareness, computational thinking, interdisciplinary learning, and application skills through hands-on learning experiences.
The laboratory may pertain to disciplinary or interdisciplinary involving experiments, design tasks, and mini-projects aligned with current industry practices.

(6) **Skill Enhancement Courses (SEC):** These courses are intended to develop specific practical skills and competencies that improve students' employability, technical proficiency, and professional readiness to bridge the gap between academic and industry requirements. These courses emphasize hands-on training, application of theoretical knowledge, and development of discipline-relevant and transferable skills required in industry and society, and develop entrepreneurship and start-up skills.

(7) **Online Courses:** Online courses are educational programs delivered over the Internet through a digital platform, allowing students to access lessons, assignments, and discussions from anywhere at any time. Most online courses offer flexibility, allowing students to access materials and complete assignments on their own schedule. However, students have to pass the course within a stipulated period as per the norms of the university.

(8) **VTU Online Courses:** VTU Online Courses are online courses offered by the Centre of Online Education (COE), Mysuru. A wide range of multidisciplinary courses is made available to learners anytime and anywhere, enabling them to earn University-prescribed credits through duly conducted proctored examinations for the award of the degree.
NPTEL/SWAYAM courses adopted by VTU shall be offered in accordance with the NPTEL/SWAYAM course delivery framework, wherein teaching–learning is carried out through the online MOOC platform, assignments are administered periodically, and assessment is completed through a centrally conducted proctored examination as prescribed by the respective platform.

(9) **NPTEL/SWAYAM Online Courses:** The National Programme on Technology Enhanced Learning (NPTEL)/SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) are the specific Indian platforms to host national Massive Open Online Courses (MOOCs). It offers online courses on a wide range of disciplines to learners anywhere, anytime, to earn university-prescribed credits through proctored examination for the award of a degree. All NPTEL/SWAYAM courses are MOOCs, but not all MOOCs are offered on these specific Indian platforms.

POs for the PG Course "Digital Communication & Networking"		
Sl No	**POs**	**Description**
1	**PO1**	An ability to independently carry out research/investigation and development work to solve practical problems
2	**PO2**	An ability to write and present a substantial technical report/document
3	**PO3**	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4	**PO4**	Proficiency to create, select, apply appropriate techniques, resources and modern tools to solve complex engineering activities with an understanding of their limitations.
5	**PO5**	Competency to apply professional ethics, responsibilities, and norms to contribute to sustainable development.
6	**PO6**	Capability to identify the need for continuous learning and independently enhance knowledge in digital communication and networking.

Semester: I						
Applied Linear Algebra and Random Processes						
Course Code	**:**	1MEC101		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Applied Linear Algebra and Random Processes
Knowledge on Fundamental Concepts	Linear Algebra, Probability
Knowledge on Connected Tools (If any)	Basic computer knowledge

Course Learning Objectives: This course will enable the students to	
CLO1	To develop the ability to **apply linear algebra concepts**, including matrices and vector spaces, to solve engineering problems.
CLO2	To develop the ability to **analyze eigenvalues, eigenvectors, and matrix decompositions** for solving engineering problems and applications.
CLO3	To develop the ability to **analyze orthogonal transformations and matrix factorization techniques** for engineering applications.
CLO4	To develop the ability to **apply probability theory and random variable models** to analyze uncertainty in engineering systems.
CLO5	To develop the ability to **evaluate random processes and stochastic models** for applications in communication and signal processing.

Module – 1	**08 Hrs**
Linear Algebra Fundamentals: Review of vectors and matrices, Matrix operations and properties, Rank, determinant, and trace, Systems of linear equations, Gaussian elimination, LU decomposition, Vector spaces and subspaces, Linear independence and basis and Dimension of vector spaces.	
Module – 2	**08 Hrs**
Eigenvalues and Eigenvectors: Eigenvalues and eigenvectors, Characteristic polynomial, Diagonalization of matrices, Similarity transformations, Cayley-Hamilton theorem, Positive definite matrices, Singular Value Decomposition (SVD) and Applications in engineering systems	
Module – 3	**08 Hrs**
Orthogonality and Matrix Factorization: Inner product spaces, Orthogonality andorthonormality, Gram-Schmidt orthogonalization, QR decomposition, Least squares approximation, Projection matrices, Applications in communications and machinelearning.	
Module – 4	**08 Hrs**
Probability Theory and Random Variables: Probability axioms, Conditional probability,Bayes' theorem, Random variables, Probability density function (PDF), Cumulative distribution function (CDF), Joint and marginal distributions and Expectation, variance,and moments	
Module – 5	**08 Hrs**
Random Processes: Classification of random processes, Stationary and ergodic processes **,**Correlation and covariance functions, Power Spectral Density (PSD) **,** Gaussian random processes White noise processes, Markov processes and Applications in communication systems	

Topics for Self learning	
Module-1	Elementary row and column transformations, Symmetric and skew-symmetric matrices
	Consistency of linear systems, Coordinate representation of vectors
Module-2	Geometrical Interpretation of Eigenvalues and Eigenvectors

	Spectral Properties of Matrices, Rank reduction
Module-3	Householder reflections
	Error minimization, Round-off errors
Module-4	Binomial and Poisson distribution
	Conditional probability distributions
Module-5	Cross-Correlation and Cross-Covariance
	Input-output correlation

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply linear algebra concepts to solve engineering problems involving matrices and vector spaces.
CO2	Analyze eigenvalues, matrix decompositions, and orthogonal transformations for engineering applications
CO3	Analyze orthogonal transformations and matrix factorization for engineering applications
CO4	Apply probability theory and random variable models to analyze uncertainty in engineering systems
CO5	Evaluate random processes and stochastic models for communication and signal processing applications.

Text Books	
1	D. C. Lay, S. R. Lay, and J. J. McDonald, *Linear Algebra and Its Applications*, 5th ed.Boston, MA, USA: Pearson, 2016, ISBN: 978-0-321-98238-4.
2	P. Z. Peebles, Jr., *Probability, Random Variables, and Random Signal Principles*, 4th ed.New York, NY, USA: McGraw-Hill, 2001, ISBN: 978-0-07-047428-4.

Reference Books	
1	G. R. Grimmett and D. R. Stirzaker, *Probability and Random Processes*, 3rd ed. Oxford,U.K.: Oxford University Press, 2001, ISBN: 978-0-19-857222-0.

Web links and Video Lectures (e – Resources)	
1	https://www.youtube.com/playlist?list=PLE7DDD91010BC51F8
2	https://www.youtube.com/playlist?list=PL221E2BBF13BECF6C
3	https://www.youtube.com/results?search_query=NPTEL+Probability+and+Random+Variables

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	--	--	--
CO2	3	3	1	--	--	--
CO3	3	3	2	--	--	--
CO4	3	3	2	--	--	--
CO5	3	3	1	1	--	--

Semester: I						
AI for Electronics Engineers						
Course Code	**:**	1MEC102		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Introduction to AI and Machine Learning
Knowledge on Fundamental Concepts	ANN, CNN, LLM etc
Knowledge on Connected Tools (If any)	

Course Learning Objectives: This course will enable the students to	
CLO1	**Explain** fundamental AI paradigms, neural network architectures, and modern AI models relevant to electronics engineering applications.
CLO2	**Apply** Generative AI, foundation models, LLMs, multimodal AI, and AI-agent techniques to solve engineering problems.
CLO3	**Design and optimize** deep learning and Edge/TinyML models for signal processing, vision, communication, and embedded AI applications.
CLO4	**Develop and evaluate** intelligent electronic systems using Agentic AI, hardware acceleration, and responsible AI principles.
CLO5	**Evaluate** emerging AI technologies, including Explainable AI, Responsible AI, Federated Learning, Green AI, and AI governance, for their suitability in future intelligent electronic systems.

Module – 1	**08 Hrs**
AI Ecosystem and Intelligent Computing: Introduction to foundation-model-based AI, AI paradigms: Symbolic AI, Statistical AI, Cognitive AI, Hybrid AI, and Intelligent Agent architectures, along with the complete AI development lifecycle, Fundamental neural network architectures: Perceptron, Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), Long ShortTerm Memory (LSTM), Gated Recurrent Units (GRU), Autoencoders, Generative Adversarial Networks (GANs), Diffusion Models, and Transformer architectures. **Textbook 1: Ch.1: 1.1-1.7, Ch.2: 2.1-2.5**	
Module – 2	**08 Hrs**
Generative AI, Foundation Models, and Large Language Models : principles of generative modeling, prompt engineering, prompt chaining, AI agents, RetrievalAugmented Generation (RAG), tool calling, and AI workflow orchestration. The architecture and capabilities of modern LLMs including GPT, Llama, Claude, Gemini, Gemma, Phi, and Falcon, will be examined. The module further introduces Vision Language Models (VLMs), multimodal AI systems, image generation models, speech models, video generation models, and code generation models **Textbook 1: Ch.2: 2.6-2.8, 2.10, Ch. 3: 3.3, 3.4, 3.6**	
Module – 3	**08 Hrs**
Deep Learning and Modern AI Architectures: Deep Neural Networks (DNNs), Residual Networks (ResNet), EfficientNet, Vision Transformers (ViTs), attention mechanisms, encoder-only, decoder-only, and encoder-decoder Transformer architectures. Modern scalable architectures such as Mixture of Experts (MoE), sparse neural networks, graph neural networks, diffusion networks **Textbook 1: Ch.4: 4.2-4.5, Ch.5: 5.1-5.3, 5.5-5.7, Ch.6: 6.1, 6.2**	
Module – 4	**08 Hrs**
Edge Intelligence, TinyML, and Embedded AI: Edge AI architectures, TinyML principles, embedded machine learning pipelines, model compression, quantization, pruning, knowledge distillation, and inference optimization techniques, Hardware acceleration using GPUs, TPUs,	

NPUs, FPGAs, ASIC-based AI accelerators, and neuromorphic processors**.**
Textbook 1: Ch.8: 8.1-8.4, Ch.10: 10.1-10.5, 10.9-10.11
Module – 5 **08 Hrs**
Agentic AI and Future Intelligent Electronic Systems: concepts of Agentic AI, autonomous decision-making, reasoning systems, planning algorithms, multi-agent systems, collaborative AI, and AI orchestration frameworks. Emerging technologies such as Explainable AI (XAI), Responsible AI, Green AI, Federated Learning, Swarm Intelligence, Embodied AI, Physical AI, and AI governance
Textbook 1: Ch.13: 13.1-13.6, Ch.14: 14.1-14.10

Topics for Self learning	
Module-1	Evolution of AI: From Expert Systems to Foundation Models
	Applications of Neural Networks in Engineering and Electronics
Module-2	Advanced Prompting Techniques and Prompt Optimization
	Applications of Multimodal Generative AI
Module-3	Transfer Learning and Fine-Tuning of Deep Learning Models
	Applications of Graph Neural Networks
Module-4	TinyML Applications in IoT and Sensor Networks
	Energy-Efficient AI and Hardware–Software Co-Design
Module-5	AI Agents for Autonomous Electronic Systems
	Explainable and Responsible AI for Safety-Critical Applications

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply machine learning techniques for preprocessing, modeling, and analyzing engineering datasets.
CO2	Analyze and evaluate learning algorithms for electronics engineering applications.
CO3	Design AI integrated models for signal processing, communication, vision, and embedded AI applications.
CO4	Develop intelligent solutions for real-world electronics systems using modern AI frameworks and deployment platforms.
CO5	Evaluate and apply emerging AI technologies and responsible AI principles to develop sustainable, explainable, and intelligent electronic systems.

Text Books	
1	Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 3rd Edition, O'Reilly Media, 2023.
2	Christopher M. Bishop and Hugh Bishop, Deep Learning: Foundations and Concepts, Springer, 2024.

Reference Books	
1	Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.
2	Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education, 2009.

Web links and Video Lectures (e – Resources)	
1	DeepLearning.AI (Andrew Ng) – Machine Learning & Deep Learning DeepLearning.AI YouTube Channel
2	StatQuest with Josh Starmer – Statistics and Machine Learning Concepts StatQuest YouTube Channel

3	3Blue1Brown – Linear Algebra, Neural Networks, and Mathematical Foundations of ML 3Blue1Brown YouTube Channel
4	NPTEL (IIT Madras/IIT Kharagpur/IIT Delhi) – Machine Learning and Deep Learning Courses NPTEL YouTube Channel

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	2
CO2	3	1	3	3	-	2
CO3	3	2	3	3	1	2
CO4	3	2	3	3	2	2
CO5	2	2	3	3	3	3

Semester: I					
Computational Methods for Electronic System Design					
Course Code	**:**	1MEC103	**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3	**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs.	**SEE**	**:**	50 Marks
Course Type	**:**	PCC	**SEE Duration**	**:**	3 Hours

Pre-requisites:	
Courses	Engineering Mathematics I/II Basic Electronics & Network Analysis Basic Programming Skills -C/Python
Knowledge on Fundamental Concepts	Basic principles of computational methods, mathematical and numerical techniques for solving electronic engineering problems, circuit analysis, modeling, and simulation methods, fundamentals of algorithms and programming used in electronic system,basic concepts of numerical solutions, optimization, and data analysis for electronic systems.
Knowledge on Connected Tools (If any)	Network Simulator

Course Learning Objectives: This course will enable the students to	
CLO1	**Understand** the need for computation methods and apply numerical techniques to solve problems arising in electronics system design
CLO2	**Develop** mathematical and numerical techniques for solving electronic engineering problems.
CLO3	**Apply** computational tools and algorithms to analyze and design electronic circuits and systems.
CLO4	**Use** simulation and programming techniques for modelling electronic components and **Analyse** circuit performance using numerical methods and computational simulations.
CLO5	**Develop Problem-Solving Skills** for real-world electronic engineering applications.

Module – 1	**09Hrs**
Mathematical Foundations and Numerical Computing: Numerical errors, floating-point arithmetic, conditioning and stability of algorithms, numerical differentiation and integration, root-finding techniques (Bisection, Newton-Raphson), systems of linear equations, matrix operations, eigenvalue problems, interpolation methods, and curve fitting. Applications in circuit analysis and electronic system modelling.	
Module – 2	**09Hrs**
Computational Modelling of Electronic Circuits and Systems: Nodal and meshanalysis using matrix methods, state- space representation of electronic systems, transient and steady-state analysis, numerical solutions of ordinary differential equations (Euler, Runge-Kutta methods), nonlinear circuit analysis, and simulation methodologies. Electronic Design Automation (EDA) tools and SPICE-based simulation concepts are introduced with practical examples.	
Module – 3	**08Hrs**

Optimization Techniques for Electronic System Design: Unconstrained and constrained optimization, gradient-based optimization methods, linear programming, nonlinear programming, convex optimization fundamentals, heuristic optimization techniques such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO), Simulated Annealing (SA), and multi-objective optimization.
Module – 4 **08 Hrs**
Computational Signal Processing and Data-Driven Design: Discrete-time signal processing algorithms, Fast Fourier Transform (FFT), wavelet transforms, adaptive filtering, statistical signal analysis, machine learning-assisted signal processing, feature extraction, dimensionality reduction, and computational techniques for sensor data analytics. Applications in communication systems, biomedical electronics, radar systems, and IoT platforms.
Module – 5 **08 Hrs**
Advanced Computational Techniques and Emerging Trends: High-performance computing for electronics, parallel and distributed computing, GPU acceleration, hardware-software co-design, FPGA-based acceleration, AI-assisted electronic design automation (EDA), Reinforcement learning for adaptive systems, and computational approaches for 6G communication networks and smart electronic systems.

Topics for Self learning	
Module-1	Applications of matrices in circuit analysis
	Failure cases of Newton -Raphson method
Module-2	Numerical differentiation using forward/backward/central differences
	Least squares method for curve fitting linear and polynomial fit
Module-3	1-D optimization techniques
	Machine learning based optimization & cases studies
Module-4	Z-Transform & filter stability
	Real time filtering challenges
Module-5	Fuzzy logic systems
	Neural networks for electronic design

Course Outcomes: After completing the course, the students will be able to	
CO1	**Understand** the mathematical models of electronic systems using linear algebra, differential equations and numerical techniques.
CO2	**Apply** numerical and optimization techniques to solve computational problems related tocircuit analysis and device modeling.
CO3	**Analyze** electronic systems using state space models, transfer function and stability analysis using computational algorithm tools.
CO4	**Design** computational solutions for signal processing, communication, vlsi, and embedded system applications.
CO5	**Evaluate** the performance and accuracy of computational models using modern software tools for electronic system design.

Text Books	
1	S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, 8th ed. NewYork, NY, USA: McGraw-Hill Education, 2021.

2	S. S. Rao, Engineering Optimization: Theory and Practice, 5th ed. Hoboken, NJ, USA: Wiley, 2019.

Reference Books	
1	A. Gilat and V. Subramaniam, Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, 4th ed. Hoboken, NJ, USA: Wiley, 2018.
2	Wen-mei W. Hwu, David B. Kirk and Izzat El Hajj, Programming Massively Parallel Processors: A Hands-on Approach, 5th Edition, Morgan Kaufmann-Elsevier, 2026

Web links and Video Lectures (e – Resources)	
1	Steve Brunton - Scientific Computing, Linear Algebra, Numerical Methods, Optimization, Machine Learning for Engineers https://www.youtube.com/@Eigensteve
2	NPTEL - Numerical Methods, Scientific Computing, Optimization, MATLAB Programming https://www.youtube.com/@nptelhrd

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	
CO2	3	3	2	2	2	
CO3	3	3	2	2	3	
CO4	3	2	3	2	3	1
CO5	2	3	3	2	3	1

Semester: I						
ADVANCED EMBEDDED SYSTEMS						
Course Code	**:**	**1MEC104A**		**Credits**	**:**	04
Hours/Week (L: T:P)	**:**	3:0:2:3		**CIE**	**:**	50 Marks
Total Hours	**:**	42L + 28P		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Basic Embedded Systems.
Knowledge on Fundamental Concepts	Basic Electronics and Digital Logic, Microprocessors and Microcontrollers, Programming Languages (C/C++ and Assembly).
Knowledge on Connected Tools (If any)	Keil MDK-ARM µVision, GCC on Linux.

Course Learning Objectives: This course will enable the students to	
CLO1	Introduce the embedded system design space, including design metrics, processor and IC technologies, and the selection of a suitable platform.
CLO2	Impart knowledge of hardware-software co-design, embedded firmware design approaches and RTOS-based system design.
CLO3	Familiarize students with the ARM Cortex-M3 architecture, instruction set, memory map, exceptions and interrupt handling.
CLO4	Provide hands-on exposure to assembly and embedded C programming on an ARM Cortex-M3 platform using the Keil MDK tool chain.
CLO5	Expose students to the RISC-V instruction set architecture as an open and emerging processor standard.

Module – 1	**08 Hrs**
Embedded System Design Space: Embedded systems overview. Design metrics and their trade-offs: unit cost, NRE cost, size, performance, power, flexibility and time-to-market. Processor technology: general-purpose, single-purpose and application-specific processors (microcontrollers, DSPs). IC technology: ASIC and PLD. Selecting a processor. Heterogeneous platforms: multi-core processors and multiprocessor systems on chip with hardware accelerators. **Text Book 4: 1.1, 1.2, 1.3, 1.4, 2.5, 2.6; Reference Book 3: 3.3.2**	
Module – 2	**09 Hrs**
Hardware Software Co-Design and RTOS: Fundamental issues in hardware software co-design, computational models in embedded design, embedded firmware design approaches and development languages. Operating system basics, types of operating systems, tasks, processes and threads, multiprocessing and multitasking, task scheduling, task communication (shared memory, message passing), task synchronization issues (racing, deadlock) and techniques (mutex, binary and counting semaphores). **Text Book 1: 7.1, 7.2, 9.1, 9.2, 10.1, 10.2, 10.3, 10.4, 10.5, 10.7, 10.8**	
Module – 3	**08 Hrs**
ARM 32-bit Microcontroller: Thumb-2 technology and applications of ARM, Architecture of ARM Cortex-M3, Various units in the architecture, General Purpose Registers, Special Registers, exception types and vector table, interrupts, stack operation. System components: reset circuit, brown-out protection, oscillator, real-time clock and watchdog timer. **Text Book 2: 1.4, 1.5, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.4, 3.6; Text Book 1: 2.6**	
Module – 4	**09 Hrs**
Instruction Sets: Assembly basics, Instruction list and description, useful instructions, Memory Systems, Memory maps, Cortex-M3 implementation overview, pipeline and bus interface, Exception handling, Nested Vectored Interrupt Controller, SysTick Timer. **Text Book 2: 4.1, 4.2, 4.3, 4.4, 5.2, 5.3, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.5**	

Module – 5	08 Hrs
Introduction to RISC-V: Operations of the Computer Hardware, Operands of the Computer Hardware, Signed and Unsigned Numbers, Representing Instructions in the Computer, Logical Operations, Instructions for Making Decisions, RISC-V Addressing for Wide Immediates and Addresses, Parallelism and Instructions: Synchronization. **Text Book 3: 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.10, 2.11**	

Practical Component Modules 1, 3 and 4: ARM Cortex-M3 evaluation board with Keil MDK-ARM µVision 5. Module 2: Linux host with GCC and POSIX threads. Module 5: RARS RISC-V simulator. Experiments marked (Open-ended) are assessed through a rubric.	
Module-1	a) Interface a switch with the ARM Cortex-M3 and indicate its status through an LED, a relay and a buzzer.
	b) Design a sensor-based monitoring and alarm system of the student's choice, and justify the choice of platform using the selection parameters.
Module-2	a) Create child processes and threads, observe their scheduling order, and change the priority of a thread at run time.
	b) (Open-ended) Design a multitask application of the student's choice, such as a data logger, using shared memory or a message queue with semaphore synchronization.
Module-3	a) Examine the general-purpose and special registers (xPSR, PRIMASK, CONTROL) and switch between the main and process stack pointers using the debugger.
	b) Demonstrate stack operations and exception entry and exit by triggering an SVC exception and observing the stacked registers.
Module-4	a) Sort a series of 32-bit numbers in ascending and descending order using Cortex-M3 assembly instructions and verify the result in memory.
	b) Configure the SysTick timer and the NVIC to generate a periodic interrupt that toggles an LED.
Module-5	a) Perform arithmetic and logical operations on signed and unsigned numbers using RISC-V instructions and observe the instruction encoding.
	b) Find the largest of N numbers stored in memory using RISC-V branch and loop instructions.

Topics for Self-learning	
Module-1	1. Case study: platform selection for an application using a weighted decision matrix.
	2. Sensors and actuators: types and interfacing.
Module-2	1. UML-based modelling of embedded systems.
	2. Functional and non-functional requirements for choosing an RTOS.
Module-3	1. Reset sequence and boot process of the Cortex-M3.
	2. Debug support in the Cortex-M3: CoreSight, JTAG and Serial Wire Debug interfaces.
Module-4	1. CMSIS-Core: structure and use in embedded C programs.
	2. Bit-band operations and unaligned memory access in the Cortex-M3.
Module-5	1. Supporting procedures in hardware: RISC-V calling convention and stack usage.
	2. RISC-V standard extensions (M, A, F, D, C) and Indian open-source cores such as SHAKTI.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain how hardware building blocks, 32-bit RISC processor features and operating system services work together in an embedded system.
CO2	Apply the instruction set, memory organization and exception handling concepts of 32-bit RISC processors to write and interpret assembly and embedded C programs.
CO3	Apply concurrency, timing and event-handling concepts to design responsive embedded software.
CO4	Analyze application requirements to select a suitable processor architecture, firmware design approach and operating system for an embedded system.
CO5	Design embedded solutions for experiments and open-ended tasks using industry-standard tools, with documented results.

Text Books	
1	Introduction to Embedded Systems, K. V. Shibu, McGraw Hill Education (India), 2nd Edn., 2017.
2	The Definitive Guide to the ARM Cortex-M3, Joseph Yiu, Newnes (Elsevier), 2nd Edn., 2010.
3	Computer Organization and Design: The Hardware/Software Interface, RISC-V Edition, David A. Patterson and John L. Hennessy, Morgan Kaufmann, 2017, ISBN: 9780128122761.
4	Embedded System Design: A Unified Hardware/Software Introduction, Frank Vahid and Tony Givargis, John Wiley & Sons, 2002.

Reference Books	
1	Embedded Systems: A Contemporary Design Tool, James K. Peckol, John Wiley, 2008.
2	Real-Time Systems: Theory and Practice, Rajib Mall, Pearson Education, 2007.
3	Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things, Peter Marwedel, Springer, 4th Edn., 2021.

Web links and Video Lectures (e – Resources)	
1	https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ee98
2	https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_cs93
3	https://nptel.ac.in/courses/106105172
4	https://training.linuxfoundation.org/training/introduction-to-riscv-lfd110x/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**1**	**-**	**2**	**-**	**-**	**1**
CO2	**2**	**-**	**3**	**2**	**-**	**1**
CO3	**2**	**-**	**3**	**2**	**-**	**1**
CO4	**3**	**-**	**3**	**2**	**-**	**1**
CO5	**3**	**2**	**2**	**3**	**1**	**2**

Semester: I						
Industrial Automation & Process Control						
Course Code	**:**	1MEC104B		**Credits**	**:**	4
Hours/Week(L:T:P:SL)	**:**	3:0:2:3		**CIE**	**:**	50 Marks
Total Hours	**:**	120 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Engineering Mathematics, Basic Electrical and Electronics Engineering, Control Systems
Knowledge on Fundamental Concepts	Basic understanding of electrical and electronic circuits, measurement of physical quantities, sensors and transducers, control-system concepts, signals, and basic programming/logic
Knowledge on Connected Tools (If any)	Basic familiarity with MATLAB/Simulink or equivalent simulation tools, PLC programming/simulation software, and spreadsheet/data-analysis tools

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamental principles of industrial automation, instrumentation, sensors, actuators, control valves, and industrial safety standards.
CLO2	Analyze the dynamic behavior of industrial processes and apply suitable process control strategies for industrial applications.
CLO3	Describe the architecture and programming of PLC, DCS, SCADA, and HMI systems and the role of industrial communication protocols in automation.
CLO4	Interpret IIoT, CPS, edge and cloud computing, digital twins, AI/ML, predictive maintenance, and cybersecurity concepts for smart factory applications.
CLO5	Illustrate the applications of robotics, machine vision, VFDs, motion control, CNC, FMS, MES, and enterprise integration in intelligent manufacturing.

Module – 1	**08 Hrs**
Industrial Automation Systems and Instrumentation: Evolution of Industrial Automation and Industry 4.0, Process industries and manufacturing automation, Industrial Automation Architecture (ISA-95), Sensors, Smart Sensors and Industrial Transmitters, Signal Conditioning and Data Acquisition Systems, Actuators: Pneumatic, Hydraulic and Electric Actuators, Industrial Control Valves and Final Control Elements, Industrial Standards and Safety (IEC, ISA) **Textbook 1:** Ch.1, Ch.3, Ch.6, Ch.7 **Textbook 2:** Ch.2: 2.1–2.6, Ch.3: 3.1–3.6, Ch.4: 4.1–4.6, Ch.5: 5.1–5.6, Ch.6: 6.1–6.6, Ch.7: 7.1–7.6	
Module – 2	**08 Hrs**
Process Dynamics and Advanced Process Control: Mathematical Modelling of Industrial Processes, Dynamic Characteristics of First and Higher Order Systems, PID Controller Design and Tuning Techniques, Cascade, Ratio, Feedforward and Override Control, Model Predictive Control (MPC), Adaptive and Robust Control, Process Performance Evaluation and Control Loop Optimization **Textbook 1:** Ch.2 **Textbook 2:** Ch.9: 9.1–9.6, Ch.10: 10.1–10.5, Ch.12: 12.1–12.6 **Textbook 3:** Ch.1, Ch.2, Ch.3, Ch.4, Ch.5	
Module – 3	**08 Hrs**

PLC, DCS and Industrial Communication: PLC Architecture and its Programming Languages, Ladder Logic, Function Block Diagram and Sequential Function Chart, Distributed Control Systems (DCS), SCADA Architecture and Human Machine Interface (HMI), Industrial Communication Protocols: Modbus, Profibus, Profinet, EtherNet/IP, OPC UA, CAN and Industrial Ethernet, Remote Monitoring and Data Acquisition. **Text Book 1:** Ch.4, Ch.5. **Text Book 2:** Ch.11: 11.1–11.6. **Text Book 4:** Ch.1: 1.1–1.5; Ch.2: 2.1–2.3; Ch.4: 4.1–4.6; Ch.5: 5.1–5.7; Ch.6: 6.1–6.3; Ch.13–14
Module – 4 **08 Hrs**
Smart Factory Technologies: Industrial Internet of Things (IIoT), Cyber-Physical Systems (CPS), Edge Computing and Cloud-based Automation, MQTT and OPC UA Integration, Digital Twin for Process Industries, Industrial Data Analytics, AI and Machine Learning for Process Monitoring, Predictive Maintenance and Condition Monitoring Cybersecurity for Industrial Control Systems. **Text Book 1:** Ch.1, Ch.2, Ch.3, Ch.4, Ch.5. **Text Book 2:** Ch.3; Ch.11: 11.1–11.6. **Text Book 4:** Ch.4: 4.1–4.4; Ch.13–14
Module – 5 **08 Hrs**
Intelligent Automation and Industrial Applications: Robotics and Collaborative Robots (Cobots), Vision-Based Inspection Systems, Variable Frequency Drives (VFDs) and Motion Control, CNC and Flexible Manufacturing Systems, Manufacturing Execution Systems (MES), Enterprise Integration (ERP–MES–SCADA), Industrial Case Studies: Chemical Plants, Oil & Gas, Power Plants, Semiconductor Manufacturing, Smart Manufacturing. **Text Book 1:** Ch.7, Ch.8. **Text Book 2:** Ch.7: 7.1–7.6; Ch.8: 8.1–8.5. **Text Book 4:** Ch.2: 2.1–2.3; Ch.13–14

Practical Component	
Module-1	a) Develop PLC programs using Ladder Logic for basic logic operations, timers, counters, and latching circuits using OpenPLC
	b) Design and implement sequential control of an industrial process using Ladder Diagram and Function Block Diagram (FBD).
Module-2	a) Interface OpenPLC with Arduino/ESP32 for digital input and output monitoring and control.
	b) Implement PID-based process control for temperature, level, or flow using analog input/output modules.
Module-3	a) Develop a SCADA-based Human Machine Interface (HMI) for real-time monitoring and control using OpenPLC and ScadaBR/OpenSCADA.
	b) Configure and implement Modbus TCP/RTU communication between OpenPLC and industrial devices.
Module-4	a) Develop an MQTT-based Industrial IoT application for remote monitoring and control using Node-RED and OpenPLC.
	b) Simulate an industrial automation process (tank filling, conveyor, traffic signal, or bottle filling) using OpenPLC integrated with Factory I/O or OpenModelica.
Module-5	a) Perform industrial data acquisition, visualization, and predictive maintenance analysis using Python and sensor data collected from OpenPLC.
	b) Design and implement an Industry 4.0 mini project integrating PLC, SCADA, IIoT, industrial communication protocols, and cloud-based monitoring.

Topics for Self learning	
Module-1	Industrial Instrumentation Calibration and Smart Sensor Networks
	Industrial Wireless Sensor Networks and WirelessHART
Module-2	Dead-Time Compensation and Smith Predictor Control
	Control Loop Performance Monitoring and Fault Diagnosis
Module-3	OPC UA-Based Interoperability in Industrial Automation
	PLC Troubleshooting, Diagnostics and Fault Handling
Module-4	Digital Twin Applications for Predictive Process Optimization
	AI-Based Anomaly Detection in Industrial Control Systems
Module-5	Autonomous Mobile Robots (AMRs) in Smart Manufacturing
	Human–Robot Collaboration and Safety in Industry 4.0

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify the architecture and components of industrial automation and instrumentation systems, including sensors, actuators, control valves, and data acquisition systems.
CO2	Analyze industrial process dynamics and select appropriate control strategies for achieving desired process performance.
CO3	Develop and implement PLC-based automation programs and integrate PLCs with HMI, SCADA, DCS, and industrial communication networks.
CO4	Evaluate the performance of automated process-control systems using simulation, data acquisition, visualization, and data-analysis tools.
CO5	Integrate IIoT, CPS, AI/ML, digital twins, predictive maintenance, robotics, and cybersecurity technologies for smart manufacturing applications.

Text Books	
1	Instrument Engineers' Handbook: Process Control and Optimization,, B. G. Lipták, 5th ed. Boca Raton, FL, USA: CRC Press, 2019.
2	Process Control Instrumentation Technology, C. D. Johnson, 8th ed. Upper Saddle River, NJ, USA: Pearson, 2014.

Reference Books	
1	Process Control Systems: Application, Design, and Tuning, F. G. Shinskey, 4th ed. New York, NY, USA: McGraw-Hill Education, 1996.
2	Programmable Logic Controllers, W. Bolton,7th ed. Oxford, U.K.: Newnes (Elsevier), 2021

Web links and Video Lectures (e – Resources)	
1	https://nptel.ac.in/courses/101105090
2	https://nptel.ac.in/courses/108105063

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	2	1	2
CO2	2		3	3	1	2
CO3	3	2	3	3	1	2
CO4	3	2	3	3	1	3
CO5	3	2	3	3	2	3

Semester: I						
SYSTEM VERILOG						
Course Code	**:**	1MEC104C		**Credits**	**:**	4
Hours/Week(L:T:P:SL)	**:**	3:0:2:3		**CIE**	**:**	50 Marks
Total Hours	**:**	120 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	
Knowledge on Fundamental Concepts	Introduction to Verilog & VHDL
Knowledge on Connected Tools (If any)	XILINX and Cadence

Course Learning Objectives: This course will enable the students to	
CLO1	Understand Digital System Verification Using Object Oriented Methods
CLO2	Learn the System Verilog Language for Digital System Verification.
CLO3	Create/Build Test Benches for the Design/Methodology.
CLO4	Use Constrained Random Tests for Verification
CLO5	Understand Concepts of Functional Coverage

Module – 1	**08 Hrs**
Introduction to System Verilog: key system Verilog enhancements for hardware design, enhanced literal value assignments, external compilation unit declarations, simulation time units and precision. **Data Types:** Built-In Data Types, Fixed and Dynamic Arrays, Queues, Associative Arrays, Linked Lists, Array Methods, Choosing A Storage Type, Creating New Types With typedef, Creating User Defined Structures, Type Conversion, Enumerated Types, Constants and Strings, Expression Width. **TEXT BOOK:1 CH-1,2**	
Module – 2	**08 Hrs**
Procedural Statements and Routines: Procedural Statements, Tasks, Functions and Void Functions, Task and Function Overview, Routine Arguments, Returning from a Routine, Local Data Storage, Time Values. **Connecting the Test Bench and Design**: Separating the Test Bench and Design, The Interface Construct, Stimulus Timing, Interface Driving and Sampling, System Verilog Assertions. **TEXT BOOK:1CH-4,5**	
Module – 3	**08 Hrs**
System Verilog Procedural Blocks: system Verilog specialized procedural blocks, enhancements to tasks and functions **Randomization**: Introduction, Randomization in System Verilog, Constraint Details, Solution Probabilities, Valid Constraints, In Line Constraints, Random Number Functions, Common Randomization Problems, Random Control, Random Number Generators. **TEXT BOOK:1 CH 7,8**	
Module – 4	**08 Hrs**
Threads and Inter process Communication: Working with Threads, Disabling Threads, Inter Process Communication, Events, Semaphores, Mailboxes, Building A Test Bench with Threads and Inter Process Communication. **TEXT BOOK:2 CH-8**	
Module – 5	**08 Hrs**

Functional Coverage: Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, Anatomy of Cover Group, triggering a Cover Group, Data Sampling, Cross Coverage, Generic Cover Groups, Coverage Options, Analyzing Coverage Data, Measuring Coverage Statistics During Simulation.
Case Study: General Purpose Input Output (GPIO), Serial Peripheral Interface (SPI), ARM Advanced Microcontroller Bus Architecture (AMBA) and Universal Asynchronous Receiver Transmitter (UART) Verification IP (VIP) Development.
TEXT BOOK:2 CH-10

Practical Component	
Module-1	a) Develop System Verilog programs demonstrating built-in data types, enumerated types, constants, strings, and user-defined data types using typedef.
	b) Implement and simulate System Verilog programs using fixed arrays, dynamic arrays, queues, and associative arrays, and demonstrate commonly used array methods.
Module-2	a) Develop System Verilog tasks and functions with different types of arguments and return values for verification-oriented applications.
	b) Design a System Verilog test bench for a simple digital design using interfaces, stimulus generation, clocking/sampling mechanisms, and System Verilog Assertions (SVA).
Module-3	a) Develop System Verilog programs using constrained randomization to generate valid test stimulus for a digital design.
	b) Implement inline constraints, constraint blocks, random number generation, and random control techniques for functional verification.
Module-4	a) Develop a System Verilog test bench demonstrating inter-process communication using events, semaphores, and mailboxes.
	b) Implement thread-based stimulus generation and synchronization using concurrent processes and inter-process communication mechanisms.
Module-5	a) Develop functional coverage models using cover groups, cover points, bins, and cross coverage, and analyze coverage statistics during simulation.
	b) Develop a System Verilog verification environment for a GPIO, SPI, AMBA, or UART interface and demonstrate functional coverage of the selected design.

Topics for Self learning	
Module-1	Industrial Instrumentation Calibration and Smart Sensor Networks
	Industrial Wireless Sensor Networks and WirelessHART
Module-2	Dead-Time Compensation and Smith Predictor Control
	Control Loop Performance Monitoring and Fault Diagnosis
Module-3	OPC UA-Based Interoperability in Industrial Automation
	PLC Troubleshooting, Diagnostics and Fault Handling
Module-4	Digital Twin Applications for Predictive Process Optimization
	AI-Based Anomaly Detection in Industrial Control Systems
Module-5	Autonomous Mobile Robots (AMRs) in Smart Manufacturing
	Human–Robot Collaboration and Safety in Industry 4.0

Topics for Self learning	
Module-1	Practical applications of System Verilog data types, arrays and queues
	User-defined data types, structures and enumerated types
Module-2	Practical implementation of tasks, functions and System Verilog interfaces
	Introduction to System Verilog Assertions (SVA) in verification
Module-3	Constraint-based randomization and inline constraints
	Random number generation and practical randomization techniques
Module-4	Thread synchronization using events, semaphores and mailboxes

	Inter-process communication in System Verilog test benches
Module-5	Functional coverage, cover groups and cross coverage
	Verification of GPIO, SPI, AMBA and UART using System Verilog VIP

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the System Verilog concepts to verify the design.
CO2	Infer the constrained random tests benches inter process communication using System Verilog.
CO3	Interpret Functional Coverage.
CO4	Analyze a verification case and apply System Verilog to verify the design.
CO5	Engage in self-study to write program and demonstrate Verilog code using modern tool usage.

Text Books	
1	Chris Spear, "System Verilog for Verification – A guide to learning the Test bench language features", Springer Publications Second Edition, 2010.
2	Stuart Sutherland, Simon Davidmann, Peter Flake, "System Verilog for Design- A guide to using system Verilog for Hardware design and modelling", Springer Publications Second Edition, 2006.

Reference Books	
1	System Verilog for Design- A guide to using system Verilog for Hardware design and modeling Stuart Sutherland, Simon Davidmann, Peter Flake Springer Publications Second Edition, 2006

Web links and Video Lectures (e – Resources)	
1	https://www.asic-world.com/systemverilog/?utm_source
2	https://www.youtube.com/results?search_query=SystemVerilog+Assertions+SVA+tutorial&utm_source

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2		
CO2	2	1	2	1		
CO3	2	2	2	2		
CO4	2	1	3	1		
CO5	2	2	2	2	2	2

Semester: I						
Wireless System Design Using FPGA						
Course Code	**:**	1MEC104D		**Credits**	**:**	4
Hours/Week(L:T:P:SL)	**:**	3:0:2:3		**CIE**	**:**	50 Marks
Total Hours	**:**	120 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Wireless Communication, DSP
Knowledge on Fundamental Concepts	Modulation Types, Encoding, FFT
Knowledge on Connected Tools (If any)	MATLAB, VIVADO

Course Learning Objectives: This course will enable the students to	
CLO1	Understand fundamentals of Wireless Communication Systems, including wireless communication standards involved in space-based communications
CLO2	Develop proficiency in modeling and simulation of wireless communication systems using industry-standard tools like MATLAB/Simulink
CLO3	Configure and program FPGA/SoC platforms for wireless communications, utilizing industry-standard languages and tools such as VHDL, Verilog, and MATLAB
CLO4	Design, evaluate, and optimise wireless communication systems, transitioning from theoretical models to practical implementations on FPGA/SoC platforms
CLO5	Develop problem-solving skills to identify and address challenges encountered during implementation and integration of wireless systems

Module – 1	**08 Hrs**
Digital Communication Fundamentals and Digital Modulation: Basic signal representation and digital signal generation, Digital communication system model, AWGN and multipath fading channels, Rayleigh and Rician fading Bit Error Rate (BER) performance analysis, BPSK modulation and demodulation, QPSK modulation and demodulation, ASK and FSK modulation Comparison of modulation schemes, BER versus SNR analysis, MATLAB/Simulink-based communication system simulation **Textbook 1: Chapter 1-4,13**	
Module – 2	**08 Hrs**
Error Control Coding and Advanced Digital Modulation: Fundamentals of error detection and correction, Forward Error Correction (FEC), Hamming Code Hamming encoder and decoder, Single-bit error detection and correction, Coding gain and BER improvement Hard-decision and soft-decision concepts, Quadrature Amplitude Modulation (QAM),16-QAM and 64-QAM APSK modulation and demodulation, Constellation diagrams, BER performance of QAM/APSK, HDL implementation of modulation and coding blocks. **Textbook 1: Chapter 3,4,7,8,15**	
Module – 3	**08 Hrs**
OFDM and Adaptive Channel Equalization: Fundamentals and principles of OFDM, Orthogonality of subcarriers, OFDM transmitter and receiver IFFT and FFT implementation, Cyclic prefix, Multipath and frequency-selective fading OFDM performance analysis, OFDM transmitter/receiver implementation, Channel equalization, Linear and Decision Feedback Equalizers Adaptive equalization, LMS and RLS algorithms, BER improvement through equalization, HDL implementation of OFDM and adaptive filters **Textbook 1: Chapter 9-11, Textbook 2: Chapter 5 -10**	
Module – 4	**08 Hrs**
Carrier Recovery, Synchronization and Non-Coherent Detection: Synchronization in digital communication systems, Carrier synchronization, Carrier phase recovery, Phase-Locked Loop	

(PLL) Phase detector, loop filter and oscillator concepts, Costas loop, Carrier recovery for QPSK and other PSK systems OFDM synchronization, CORDIC-based carrier synchronization, Coherent and non-coherent detection, Non-coherent FSK detection Differential detection, Performance analysis of non-coherent receivers

Textbook 3: Chapter 3-5

Module – 5	**08 Hrs**

Navigation Communication and End-to-End Wireless System Design : Fundamentals of navigation communication systems, Navigation modulation techniques, Binary Offset Carrier (BOC) modulation Interplex multiplexing, NavIC waveform generation, GPS receiver acquisition and tracking, C/A-code-based receiver processing FPGA/HDL implementation of navigation receivers, End-to-end wireless communication system architecture System-level modeling and implementation, RF impairments and their correction, Link budget analysis Case studies and communication standards, FPGA/SoC-based system verification, MATLAB/Simulink-to-FPGA implementation FPGA-in-the-loop verification

Textbook 4: Chapter 1,10

Practical Component	
Module-1	a) BER Performance Analysis of Digital Modulation over AWGN and Multipath Fading Channels
	b) Design and Performance Analysis of BPSK, QPSK, ASK and FSK Communication Systems
Module-2	a) Implementation and Performance Analysis of Hamming Code-Based Error Detection and Correction
	b) BER Performance Analysis of QAM and APSK Modulation
Module-3	a) Design and Performance Analysis of an OFDM Transmitter and Receiver over a Multipath Channel
	b) Design and Performance Analysis of an LMS-Based Adaptive Channel Equalizer
Module-4	a) Design and Simulation of a PLL/Costas Loop-Based Carrier Recovery System
	b) Performance Analysis of Non-Coherent FSK Detection
Module-5	a) BOC Modulation and Navigation Signal Generation
	b) End-to-End Digital Communication System Design and Verification

Topics for Self learning	
Module-1	Performance Analysis of Digital Modulation under Rayleigh and Rician Fading
	Comparative Study of Digital Modulation Schemes
Module-2	Advanced Error-Control Coding Techniques
	High-Order QAM and APSK for Modern Wireless Systems
Module-3	PAPR Reduction Techniques in OFDM
	Advanced Adaptive Equalization
Module-4	Advanced Carrier and Timing Synchronization
	Software-Defined Radio Receiver Architectures
Module-5	GNSS/NavIC Signal Processing
	FPGA/SoC-Based End-to-End Wireless System Design

Course Outcomes: After completing the course, the students will be able to	
CO1	Analyze digital communication systems and modulation techniques under AWGN and

	multipath fading channels using BER-based performance measures
CO2	Implement error detection/correction and evaluate QAM/APSK modulation techniques for reliable digital communication.
CO3	Design and analyze OFDM and adaptive equalization techniques to mitigate multipath interference and channel impairments.
CO4	Design carrier recovery, synchronization, PLL and non-coherent detection techniques for digital communication receivers.
CO5	Develop and verify an end-to-end wireless communication system incorporating navigation techniques and FPGA/SoC-based implementation

Text Books	
1	J. G. Proakis and M. Salehi, *Digital Communications*, 5th Edition, McGraw-Hill.
2	S. Haykin, *Adaptive Filter Theory*, 5th Edition, Pearson
3	U. Mengali and A. N. D'Andrea, *Synchronization Techniques for Digital Receivers*, Springer
4	E. D. Kaplan and C. J. Hegarty, *Understanding GPS/GNSS: Principles and Applications*, Artech House

Reference Books	
1	**B. Sklar**, *Digital Communications: Fundamentals and Applications*, Pearson
2	**R. Prasad**, *OFDM for Wireless Multimedia Communications*, Artech House.
3	Shu Lin & Daniel J. Costello Jr., *Error Control Coding*, Pearson

Web links and Video Lectures (e – Resources)	
1	https://ocw.mit.edu/courses/6-450-principles-of-digital-communications-i-fall-2006/video_galleries/video-lectures/
2	https://www.ocw.mit.edu/courses/6-02-introduction-to-eecs-ii-digital-communication-systems-fall-2012/download/
3	https://ocw.mit.edu/courses/6-973-communication-system-design-spring-2006/pages/lecture-notes/
4	https://ocw.mit.edu/courses/6-450-principles-of-digital-communications-i-fall-2006/
5	https://in.mathworks.com/help/satcom/ug/gps-receiver-acquisition-and-tracking-using-ca-code.html
6	https://in.mathworks.com/products/hdl-coder.html

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2		2
CO2	3	2	3	3	1	2
CO3	3	2	3	3	1	2
CO4	3	2	3	3	1	2
CO5	3	2	3	3	2	2

Semester: I						
ASIC Design						
Course Code	**:**	1MEC105A		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Electronics, VLSI Design / Digital IC Design
Knowledge on Fundamental Concepts	Digital logic, Boolean algebra, CMOS logic, combinational and sequential circuits, and basic semiconductor concepts
Knowledge on Connected Tools (If any)	Basic knowledge of HDL/EDA tools such as Verilog and Cadence

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the fundamentals of ASIC design.
CLO2	Analyze ASIC library design concepts.
CLO3	Analyze ASIC physical design techniques.
CLO4	Apply ASIC routing and verification techniques.
CLO5	Develop skills for self-directed learning in emerging ASIC/VLSI technologies.

Module – 1	**08 Hrs**
Introduction to ASICs: Full custom, Semi-custom and Programmable ASICs, ASIC Design flow, ASIC cell libraries. CMOS Logic: Data path Logic Cells: Data Path Elements, Adders: Carry skip, Carry bypass, Carry save, Carryselect, Conditional sum, Multiplier (Booth encoding), Data path Operators, I/O cells, Cell Compilers. **Textbook 1: 1.1, 1.2, 1.5, 2.6, 2.6.1,2.6.2, 2.6.3, 2.6.4, 2.6.6, 2.7, 2.8**	
Module – 2	**08 Hrs**
ASIC Library Design: Logical effort: Predicting Delay, Logical area and logical efficiency, Logical paths, Multi stage cells, Optimum delay and number of stages, library cell design. Programmable ASIC Logic Cells: MUX as Boolean function generators, Acted ACT: ACT 1, ACT 2 and ACT 3 Logic Modules, Xilinx LCA: XC3000 CLB, Altera FLEX and MAX, Programmable ASIC I/O Cells: Xilinx and Altera I/O Block. **Textbook 1: 3.3, 3.3.1- 3.3.6, 3.4, 5.1.3, 5.1.4, 5.2, 5.2.1, 5.3, 5.4, 6.7, 6.8**	
Module – 3	**08 Hrs**
Low-level design entry: Schematic entry: Hierarchical design, The cell library, Names, Schematic Icons & Symbols, Nets, Schematic Entry for ASICs, Connections, vectored instances & buses, Edit in place, attributes, Netlist screener. ASIC Construction: Physical Design, CAD Tools System partitioning, Estimating ASIC size. Partitioning: Goals and objectives, Constructive Partitioning, Iterative Partitioning Improvement, KL, FM and Look Ahead algorithms. **Textbook 1: 9.1, 9.1.1-9.1.11, 15.1- 15.4, 15.6, 15.7**	
Module – 4	**08 Hrs**
Floor planning and placement: Goals and objectives, Measurement of delay in Floor planning, Floor planning tools, Channel definition, I/O and Power planning and Clock planning. Placement: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement	

Improvement, Time driven placement methods, Physical Design Flow. **Textbook 1: 16.1, 16.1.1-16.1.6, 16.2, 16.2.2, 16.2.5, 16.2.6, 16.2.8, 16.3**
Module – 5 **08 Hrs**
Routing: Global Routing: Goals and objectives, Global Routing Methods, Global routing between blocks, Back-annotation. Detailed Routing: Goals and objectives, Measurement of Channel Density, Left-Edge Algorithm, Area-Routing Algorithms, Multilevel routing, Timing –Driven detailed routing, Final routing steps, Special Routing, Circuit extraction and DRC. **Textbook 1: 17.1, 17.1.1- 17.1.7, 17.2.1- 17.2.9, 17.3, 17.4**

Topics for Self learning	
Module-1	Emerging ASIC technologies and advanced ASIC design flows
	Advanced CMOS logic styles and low-power datapath design
Module-2	Advanced logical-effort techniques and library optimization
	Modern FPGA architectures and programmable logic technologies
Module-3	Advanced ASIC partitioning algorithms and optimization techniques
	Modern EDA tools for schematic entry, netlist generation and verification
Module-4	Advanced floorplanning and congestion-aware placement techniques
	Timing-driven placement and power-aware physical design
Module-5	Advanced global and detailed routing techniques
	Timing-driven routing, circuit extraction and physical verification

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain ASIC technologies, ASIC design flow, CMOS logic, datapath elements and ASIC cell libraries.
CO2	Analyze ASIC library design, logical effort, delay optimization and programmable ASIC logic and I/O cells.
CO3	Analyze schematic-based design entry, ASIC partitioning, floor planning and placement techniques for effective physical design.
CO4	Apply global and detailed routing techniques, timing-driven routing, circuit extraction and design-rule checking in the ASIC physical design flow.
CO5	Develop the ability to study and present emerging ASIC/VLSI design techniques through assignments and self-directed learning.

Text Books	
1	Michael John Sebastian Smith, “Application - Specific Integrated Circuits”, Addison Wesley Professional, 2005

Reference Books	
1	Neil H.E. Weste, David Harris, and Ayan Banerjee, “CMOS VLSI Design: A Circuits and Systems Perspective”, Addison Wesley/ Pearson education 3rd edition, 2011
2	Vikram Arkalgud Chandrasetty, “VLSI Design: A Practical Guide for FPGA and ASIC Implementations” Springer, ISBN: 978-1-4614-1119-2. 2011
3	Rakesh Chadha, Bhasker J, “An ASIC Low Power Primer”, Springer, ISBN: 978-14614-4270-7.
4	Peter J. Ashenden Digital Design (Verilog): An Embedded Systems Approach Using Verilog,1st Edition, Kindle Edition

Web links and Video Lectures (e – Resources)	
1	https://www.youtube.com/watch?v=oZSv68esbgI
2	https://www.youtube.com/watch?v=4cPkr1VHu7Q
3	https://nptel.ac.in/courses/106105161

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	1		1
CO2	2		3	2		1
CO3	3		3	2		1
CO4	3		3	2	1	1
CO5	2	3	2		1	3

Semester: I					
ADVANCED COMPUTER NETWORKS					
Course Code	**:**	1MEC105B	**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3	**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs.	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Data Communication, Computer Organization, Operating Systems
Knowledge on Fundamental Concepts	Basic concepts of data communication, networking, IP addressing, protocols, packet switching, routing, and client-server communication.
Knowledge on Connected Tools (If any)	Network Simulator

Course Learning Objectives: This course will enable the students to	
CLO1	Understand computer network architectures, layers, and communication protocols.
CLO2	Configure and analyze IP networks using addressing, subnetting, and network-layer protocols.
CLO3	Analyze routing and transport protocols for efficient network communication.
CLO4	Understand modern networking using virtualization, NFV, and SDN technologies.
CLO5	Manage network traffic and services using congestion control and application-layer protocols.

Module – 1	**09 Hrs**
Foundation: Building a Network, Requirements, Perspectives, Scalable Connectivity, - Cost Effective Resource sharing, Internet, Protocol, Network Edge, Network Core, Access Networks and Physical Media, Delay and Loss in Packet-Switched Networks, Protocol Layers and Their Service Models, Internet Backbones, NAPs, and ISPs. Network models, OSI, TCP/IP Protocol layering, Performance, Bandwidth and Latency, Delay X Bandwidth Product, Stop-and-Wait, Sliding Window. **Text book 1: Ch.1: 1.1–1.5 Ch.2: 2.5.1, 2.5.2**	
Module – 2	**08 Hrs**
Internetworking-I: Switching and Bridging, Datagram's, Virtual Circuit Switching, Source Routing, Bridges and LAN Switches, Basic Internetworking (IP), Internetwork, Global Addresses, Datagram Forwarding in IP, Subnetting and classless addressing, Address Translation (ARP) Host Configuration (DHCP), Error Reporting(ICMP), Virtual Networks and Tunnels. **Text book 1: Ch.3: 3.1,3.2**	
Module – 3	**09 Hrs**
Internetworking- II: Network as a Graph, Distance Vector (RIP), Link State (OSPF), Metrics, The Global Internet, Routing Areas, Routing among Autonomous systems (BGP), IP Version 6(IPv6), Mobility and Mobile IP. **End-to-End Protocols:** Simple Demultiplexer (UDP), Reliable Byte Stream (TCP), End-to-End Issues, Segment Format, Connecting Establishment and Termination. **Text book 1: Ch.3: 3.3 Ch.4: 4.1 Ch.5: 5.1, 5.2.1–5.2.3**	

Module – 4	**08 Hrs**
Modern day Networking: Network Impasse, Network Ossification, Network Softwarization – Introduction, Network Virtualization, Network Function Virtualization (NFV)- Architecture and Concepts, Separation of control plane and data plane, Software Defined Networking (SDN). **Text book 2: Ch.3:3.2 Ch.7: 7.1–7.5.**	
Module – 5	**08 Hrs**
Congestion Control and Resource Allocation: Congestion-Avoidance Mechanisms, DEC bit, Random Early Detection (RED), Source-Based Congestion Avoidance. The Domain Name System (DNS), Electronic Mail (SMTP, POP, IMAP, MIME), World Wide Web (HTTP), Network Management (SNMP) . **Text book 1: Ch.6: 6.4 Ch.9: 9.1–9.1.2, 9.3–9.3.2**	

Topics for Self learning	
Module-1	Network Topologies
	Transmission Media
Module-2	Ethernet Frame Structure
	VLAN Trunking
Module-3	Routing Table Construction
	TCP Socket Programming
Module-4	Open Flow Protocol
	SDN Controller Architecture
Module-5	HTTP Cookies and Web Sessions
	SNMP Management Information Base (MIB)

Course Outcomes: After completing the course, the students will be able to	
CO1	**Explain** the fundamental concepts, architectures, models, and performance characteristics of computer networks.
CO2	**Apply** TCP/IP protocols, internetworking techniques, routing algorithms, and transport-layer protocols and their functionalities.
CO3	**Identify** the features of next-generation networks, including SDN, NFV, and network virtualization, and their applications.
CO4	**Analyze** and implement congestion-control mechanisms and application-layer protocols used in computer networks.
CO5	**Simulate** of different network configurations are performed using modern tools.

Text Books	
1	**Larry L. Peterson and Bruce S. Davie**, Computer Networks: A Systems Approach, 5th Edition, Morgan Kaufmann/Elsevier, 2011, ISBN-13:978-0123850591
2	**William Stallings**, Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud, 1st Edition, Pearson, 2015, ISBN-1378-0134175393: .

Reference Books	
1	**James F. Kurose and Keith W. Ross,** Computer Networking: A Top-Down Approach, 9th Edition, Pearson, 2025, ISBN-13: 978-0135415535.
2	**Andrew S. Tanenbaum, Nick Feamster and David J. Wetherall,** Computer Networks, 6th Edition, Pearson, 2021, ISBN-13: 978-1292374017.

Web links and Video Lectures (e – Resources)	
1	https://www.youtube.com/watch?v=lnU-Zw3NEEQ&list=PLbRMhDVUMngf-peFloB7kyiA40EptH1up&index=2
2	https://www.youtube.com/watch?v=V4QYffX9v60

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	1
CO2	3	3	2	2	2	1
CO3	3	2	3	2	2	2
CO4	3	3	2	3	2	1
CO5	3	2	2	2	3	2

Semester: I						
Wearable Health Monitoring System						
Course Code	**:**	1MEC105C		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Basic knowledge of Biomedical Instrumentation, Sensors and Transducers, Signals and Systems, Digital Electronics, Wireless Communication, IoT, Programming and Machine Learning.
Knowledge on Fundamental Concepts	Basic knowledge of physiological signals, biomedical sensors, signal processing, wireless communication, IoT, programming and machine learning.
Knowledge on Connected Tools (If any)	MATLAB/Simulink, Python, Jupyter Notebook, Arduino/ESP32, Wokwi and basic machine-learning tools.

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the fundamentals of wearable and wireless healthcare systems, physiological sensing, movement disorders and Deep Brain Stimulation.
CLO2	Analyze the architecture, operation, programming and safety aspects of Deep Brain Stimulation systems.
CLO3	Evaluate wearable sensing, wireless communication and machine-learning techniques for healthcare monitoring and movement-disorder assessment.
CLO4	Apply wearable healthcare technologies in telehealth, home care, wellness and remote patient monitoring.
CLO5	Assess emerging technologies, cybersecurity, interoperability and regulatory aspects of wearable healthcare systems and adaptive Deep Brain Stimulation.

Module – 1	**08 Hrs**

Wearable and Wireless Systems for Movement Disorder Evaluation and Deep Brain Stimulation Systems: Movement Disorders: Parkinson's Disease and Essential Tremor—A General Perspective, Traditional Ordinal Strategies for Establishing the Severity and Status of Movement Disorders Such as Parkinson's Disease and Essential Tremor, Deep Brain Stimulation for the Treatment of Movement Disorder Regarding Parkinson's Disease and Essential Tremor with Device Characterization, Surgical Procedure for Deep Brain Stimulation Implantation and Operative Phase with Postoperative Risks, Preliminary Wearable and Locally Wireless Systems for Quantification of Parkinson's Disease and Essential Tremor Characteristics, Wearable and Wireless Systems with Internet Connectivity for Quantification of Parkinson's Disease and Essential Tremor Characteristics, Strategies for the Differentiation of Deep Brain Stimulation "On" and "Off" Status for Parkinson's Disease Using a Smartphone as a Wearable and Wireless Inertial Sensor for Quantified Feedback. Clinical Assessment of Parkinson's Disease, Clinical Assessment of Essential Tremor, Wearable and Wireless Systems for Quantifying Movement Disorder Tremor.

Textbook 1: Ch 2-2.1-2.4, Ch 3-3.1- 3.4, Ch 6-6.1-6.5, Ch 7-7.1-7.5

Module – 2	08 Hrs

Deep Brain Stimulation for the Treatment of Movement Disorder Regarding Parkinson's Disease and Essential Tremor with Device Characterization: Introduction, The Foundations of Deep Brain Stimulation, Long-Term Efficacy and the Quest to Define the Mechanisms of Deep Brain Stimulation, Benefit and Risk Consideration of Deep Brain Stimulation, Target Selection for Deep Brain Stimulation, Essential Tremor, Parkinson's Disease, Deep Brain Stimulation System Device Description, Electrode Leads and the Implantable Pulse Generator, Battery, Electrical Signal, Deep Brain Stimulation System Programmer, Attaining the Optimal Parameter Configuration for Deep Brain Stimulation an Issue with Tuning, Future Perspectives for Deep Brain Stimulation.

Surgical Procedure for Deep Brain Stimulation Implantation and Operative Phase with Postoperative Risks: General Surgical Perspective and Considerations for the Application of Deep Brain Stimulation, Deep Brain Stimulation Operative Risks and Complications, Postoperative Risk Regarding Energy Interaction, Adverse Neurological and Neuropsychological Effects for Deep Brain Stimulation, Operative Technique Advocated by Allegheny General Hospital, Applied Deep Brain Stimulation Programming from Allegheny General Hospital.

Textbook 1: Ch 4- 4.1- 4.5-4.5.1, 4.5.2, 4.6-4.6.1,4.6.2,4.6.3, 4.7,4.8, Ch 5-5.1-5.7

Module – 3	08 Hrs

Adaptive Deep Brain Stimulation: Introduction, Foundational Technology for Adaptive Deep Brain Stimulation, Optimization Incorporating Wearable Inertial Sensor Systems, Optimization Incorporating Electrode Recordings.

Advanced Concepts: Introduction, Metaverse for Healthcare, Smartwatch, Flexible Electronics, Neuromorphic Artificial Intelligence, Electromagnetic Interference for Deep Brain Stimulation, Discovery and Clarification of Biomarkers, Improved Ethics for Implementing Deep Brain Stimulation.

Textbook 1: Ch-15, 16, 14.2, 14.3.

Module – 4	08 Hrs

Current and Future Uses of Wearable Devices: A Diabetic's Story of Wearable Technology: A Spider Bites—Now You're a Type 1 Diabetic, The Adoption of Wearables, The Future of Wearables, Home Care and Wellness, Telehealth, Remote Patient Monitoring (RPM), RPM Data to Enable Improved Patient Care (Who Uses RPM Data?).

COMPONENTS OF WEARABLE DEVICES: Physiological Sensors, Wireless Communication, Batteries and Other Power Sources, Cybersecurity

Textbook 2: Ch- 1,2,3,4,5,6,7,11,12,13,14

Module – 5	08 Hrs

SUCCESSFUL APPLICATIONS: Voice Technology and Wearables: Remote Patient Monitoring, Connected Device for Improved Adherence, COVID-19 Wellness Monitoring Turns to Health Monitoring, Conclusion.

STANDARDS AND REGULATORY: Regulatory and Emerging Standards, Payment Strategies and Codes, Medical-Grade Interoperability

Textbook 2: Ch- 8,9,10,15,16,17

Topics for Self-learning	
Module-1	1. **Smartphone-Based Gait Analysis and Tremor Assessment**
	2. **Machine Learning for Movement Disorder Classification**
Module-2	1. **Closed-Loop Deep Brain Stimulation (DBS)**
	2. **Patient-Specific DBS Programming and Optimization**
Module-3	1. **AI-Assisted Adaptive Deep Brain Stimulation**
	2. **Digital Biomarkers for Parkinson's Disease and Essential Tremor**
Module-4	1. **Energy Harvesting for Wearable Healthcare Devices**
	2. **Security and Privacy in IoT-Enabled Wearable Healthcare Systems**
Module-5	1. **AI-Based Voice Technology in Healthcare Wearables**
	2. **Medical Device Standards and Interoperability**

Course Outcomes: After completing the course, the students will be able to	
CO1	**Explain** the principles of wearable and wireless healthcare systems, physiological sensing, movement disorders, and Deep Brain Stimulation for Parkinson's disease and essential tremor.
CO2	**Analyze** the architecture, operation, programming, implantation procedures, device components, and safety aspects of Deep Brain Stimulation systems.
CO3	**Evaluate** wearable sensing, wireless communication, adaptive Deep Brain Stimulation, and machine-learning techniques for movement-disorder monitoring and assessment.
CO4	**Apply** wearable healthcare technologies in telehealth, home care, wellness monitoring, remote patient monitoring, and digital healthcare applications.
CO5	**Assess** emerging wearable healthcare technologies with respect to cybersecurity, interoperability, biomarkers, ethical considerations, standards, and regulatory requirements.

Text Books	
1	Wearable and Wireless Systems for Healthcare II: Movement Disorder Evaluation and Deep Brain Stimulation Systems, Second Edition, Robert LeMoyneTimothy Mastroianni, Donald Whiting, Nestor Tomycz.
2	Closing the Care Gap with Wearable Devices: A Preface. Editors 1 Current and Uses of Wearable Innovating Healthcare with Wearable Patient Monitoring Routledge Taylor & Francis Group A PRODUCTIVITY PRESS BOOK Michael W Davis, Michael J Kirwan, Walter N. Maclay Harry P. Pappas

Reference Books	
1	U-Healthcare Monitoring Systems Design and Application, Volume One, AP, Volume Editors: Nilanjan Dey, Amira S. Ashour, Simon James Fong and Surekha Borra
2	Wearable and Nearable Biosensors and Systems for Healthcare, edited by Marco Di Rienzo and Ramakrishna Mukkamala. Printed Edition of the Special Issue Published in Sensors

Web links and Video Lectures (e – Resources)	
1	https://www.youtube.com/watch?v=wV_wDURdGqc
2	http://www.digimat.in/nptel/courses/video/102108344/L34.html

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2	1	2
CO2	2	1	3	3	2	2
CO3	3	2	3	3	1	3
CO4	2	2	3	3	2	3
CO5	3	2	3	3	3	3

Semester: I						
ELECTRONIC POWER CONVERTERS						
Course Code	**:**	1MEC105D		**Credits**	**:**	03
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Power Electronics
Knowledge on Fundamental Concepts	--
Knowledge on Connected Tools (If any)	--

Course Learning Objectives: This course will enable the students to	
CLO1	To understand the fundamental principles and operation of power electronic converters.
CLO2	To study the operation and characteristics of AC-DC, DC-DC, DC-AC, and AC-AC converters.
CLO3	To analyze the performance of power electronic converters under different operating conditions.
CLO4	To understand various power semiconductor devices and their applications in power conversion.
CLO5	To develop skills in designing and analyzing power electronic converter circuits for industrial and practical applications.

Module – 1	**08 Hrs**
Characteristics and switching behaviour of power diodes: SCRs, MOSFETs, IGBTs and IGCTs; comparison of silicon, silicon carbide and gallium nitride devices; static and dynamic characteristics; conduction and switching losses; safe operating area; device selection; series and parallel operation; gate-drive circuits; isolation techniques; snubber circuits; protection against overcurrent, overvoltage and thermal stress; heat sinks and thermal design; introduction to power converter classification and performance indices. **Textbook 1: Chapter 2,3,4**	
Module – 2	**08 Hrs**
AC DC Converters: Single-phase and three-phase uncontrolled rectifiers; semi-controlled and fully controlled converters; effect of source inductance and overlap angle; converter operation with R, RL and RLE loads; dual converters; performance parameters; input power factor and harmonic distortion; pulse-width-modulated rectifiers; active front-end converters; single-phase and three-phase AC voltage controllers; integral cycle control; cycloconverters; matrix converters; applications in heating, lighting and speed-control systems. **Textbook 1: Chapter 3,4**	
Module – 3	**08 Hrs**
DC-DC Converters: Principles of switch-mode DC–DC conversion; analysis and design of buck, boost, buck–boost, Cuk, SEPIC and Zeta converters; continuous and discontinuous conduction modes; converter ripple analysis; selection of inductors, capacitors and semiconductor devices; isolated converters—flyback, forward, push-pull, half-bridge and full bridge converters; transformer design considerations; current-mode and voltage-mode control; small-signal modelling; closed-loop control; interleaved and bidirectional converters; applications in battery charging and electric vehicles. **Textbook 1: Chapter 5,6**	
Module – 4	**08 Hrs**

DC- AC converters and Modulation techniques: Single-phase and three-phase voltage-source inverters; current-source inverters; square-wave, quasi-square-wave and pulse-width modulation techniques; sinusoidal PWM, space-vector PWM and selective harmonic elimination; inverter output-voltage control; harmonic analysis; dead-time effects; multilevel inverter topologies— diode-clamped, flying-capacitor and cascaded H-bridge converters; modulation and capacitor voltage balancing; grid-connected inverters; synchronization and current-control techniques; L, LC and LCL filter design.

Textbook 1: Chapter 5,7,8

Module – 5	**08 Hrs**

Resonant Converters and Emerging Applications: Principles of soft switching, zero-voltage switching and zero-current switching, resonant-switch, series-resonant, parallel-resonant and LLC resonant converters; soft-switched PWM converters; high-frequency converter design; electromagnetic interference and electromagnetic compatibility considerations; converters for solar photovoltaic and wind-energy systems; maximum power-point tracking; battery energy storage interfaces; electric-vehicle traction and charging converters; solid-state transformers; HVDC and FACTS converter applications; wide-bandgap-device-based high-frequency converters; efficiency and reliability evaluation.

Textbook 1: Chapter 7,8

Topics for Self learning	
Module-1	Power Semiconductor Devices: MOSFET, IGBT and GTO
	Thermal Management and Heat Sinks in Power Electronics
Module-2	Multilevel Inverters and Their Applications
	Space Vector PWM (SVPWM) Technique
Module-3	Matrix Converters
	Cycloconverters and High-Power Applications
Module-4	Active Front-End (AFE) Converters
	Power Factor Correction (PFC) Techniques
Module-5	Grid-Connected Power Converters
	Applications of Power Converters in Renewable Energy Systems

Course Outcomes: After completing the course, the students will be able to	
CO1	Use the knowledge of PWM techniques in controlling different power electronic converters.
CO2	Apply the knowledge of power electronics in design and analysis of DC–DC PWM converters.
CO3	Design and analyze DC –AC and AC – DC converters and control their operation using PWM techniques.
CO4	Design and analyze different resonant converters and their control circuits.
CO5	Analyze AC – AC converters and multilevel converters.

Text Books	
1	M. H. Rashid, Power Electronics: Devices, Circuits, and Applications, 4th ed. Harlow, U.K.: Pearson, 2014.
2	N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, 3rd ed. Hoboken, NJ, USA: Wiley, 2003.

Reference Books

1	R. W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 3rd ed. Cham, Switzerland: Springer, 2020.
2	D. W. Hart, Power Electronics. New York, NY, USA: McGraw-Hill, 2011
3	Muhammad H. Rashid (Ed.), *Power Electronics Handbook*, 5th Edition, Elsevier, 2023.

Web links and Video Lectures (e – Resources)	
1	https://youtu.be/HcwJKKG_LYY?si=JkJXmb7fovKu62le
2	https://youtu.be/WudcMRHjCmI?si=h2eepFIsXaZut0mV

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3			
CO2	2	2	3			
CO3	2	2	3			
CO4	2	2	3			
CO5	2	2	2	3		

Semester: I						
LOW POWER VLSI DESIGN						
Course Code	**:**	1MEC106A		**Credits**	**:**	3
Hours/Week(L:T:P:S)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	VLSI Design
Knowledge on Fundamental Concepts	CMOS Power Dissipation, Power Analysis
Knowledge on Connected Tools (If any)	**Cadence/LTSPice**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamental concepts and sources of power dissipation in CMOS circuits.
CLO2	Study various techniques for power estimation, analysis, and reduction in VLSI circuits
CLO3	Understand low-power circuit and logic design techniques, including transistor sizing, signal gating, and logic restructuring
CLO4	Study low-power architectural, system, clock, and memory design methodologies for reducing power consumption
CLO5	Analyze and apply algorithmic, architectural, and advanced low-power design techniques such as adiabatic computation and asynchronous circuits

Module – 1	**08 Hrs**
Introduction: Need for low power VLSI chips, charging and discharging capacitance, short circuit current in CMOS Circuit, CMOS leakage current, static current, basic principles of low power design, low power figure of merits. **Simulation power analysis:** SPICE circuit simulation, Monte Carlo simulation **Text book 1: Chapter 1, Chapter 2 – 2.1, 2.6**	
Module – 2	**08 Hrs**
Circuit: Transistor and gate sizing, equivalent pin ordering, network restructuring and reorganization, special latches and flip flops, low power digital cell library, adjustable device threshold voltage. **Text Book 1: Chapter 4**	
Module – 3	**08 Hrs**
Logic: Gate reorganisation, signal gating, logic encoding, state machine encoding, pre-computation logic. **Low power Clock Distribution**: Power Reduction in Clock Networks, CMOS Floating Node **Text Book 1: Chapter 5, Chapter 6 – 6.1, 6.2**	
Module – 4	**08 Hrs**
Low-power Architecture & Systems: Power & performance management, switching activity reduction, flow graph transformation. **Source of Power Dissipation:** Short Circuit Power Dissipation, Switching Power Dissipation, Glich in Power Dissipation **Text Book 1: Chapter 7 – 7.1, 7.2, 7.4, Text Book 2 : Chapter 6 – 6.1, 6.2, 6.3**	

Module – 5	08 Hrs
Algorithm & Architectural Level Methodologies: Introduction, design flow, algorithmic-level analysis & optimization, architectural-level estimation & synthesis. **Text Book 2: Chapter 3.1,3.2,3.3**	

Topics for Self-learning	
Module-1	FinFET and GAAFET-Based Low-Power CMOS Design
	Near-Threshold and Subthreshold Computing
Module-2	Multi-Threshold CMOS (MTCMOS) Technology
	Dynamic Voltage and Frequency Scaling (DVFS) at Circuit Level
Module-3	Advanced Clock-Gating Techniques
	Low-Power Encoding Techniques
Module-4	Approximate Computing for Energy-Efficient VLSI
	Energy-Efficient Memory Architectures
Module-5	ML-Based Power Estimation
	Low-Power Design for AI/ML Accelerators

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify and explain the major sources and mechanisms of power dissipation in CMOS circuits
CO2	Apply simulation-based and probabilistic approaches to analyse and estimate power consumption in VLSI circuits
CO3	Analyse low-power circuit and logic design techniques and evaluate their power–performance trade-offs
CO4	Apply low-power architectural, clock, and memory design methodologies to reduce power dissipation in VLSI systems
CO5	Evaluate and develop suitable low-power design solutions using algorithmic, architectural, and advanced techniques for VLSI applications

Text Books	
1	Gary K. Yeap, *Practical Low Power Digital VLSI Design*, Kluwer Academic, 1998.ISBN : 978-0792380092
2	Ajit K Pal, Low-Power VLSI Circuits and Systems, Springer,2015, ISBN 978-81-322-1937-8 (eBook)

Reference Books	
1	Jan M. Rabaey and Massoud Pedram, *Low Power Design Methodologies*, Kluwer Academic, 2010.
2	Kaushik Roy and Sharat Prasad, *Low-Power CMOS VLSI Circuit Design*, Wiley, 2000.
3	A. P. Chandrasekaran and R. W. Brodersen, *Low Power Digital CMOS Design*, Kluwer Academic, 1995

Web links and Video Lectures (e – Resources)	
1	https://nptel.ac.in/courses/106105193
2	https://www.youtube.com/watch?v=ORtlxpW_LMU
3	https://ocw.mit.edu/courses/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/
4	https://online.vtu.ac.in/v1/course-details/VLSI-Design-Flow-RTL-to-GDS
5	https://www.coursera.org/learn/fundamentals-of-digital-design-for-vlsi-chip-design

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		3	2	1	2
CO2	3	1	3	3		2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	2	2
CO5	3	2	3	3	2	3

Semester: 1						
Advanced Wireless Communication Systems						
Course Code	**:**	1MEC106B		**Credits**	**:**	3
Hours/Week(L/T/P/SL)	**:**	3:0:0:3		**CIE**	**:**	50Marks
Total Hours	**:**	42Hrs		**SEE**	**:**	50Marks
Course Type	**:**	**PEC**		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Wireless Communication
Knowledge on Fundamental Concepts	Multiple Access Techniques, Antenna and Propagation, Channel Models
Knowledge on Connected Tools (If any)	

CourseLearning Objectives:This course will enable the students to	
CLO1	Analyze advanced wireless channels, 4G–6G evolution, waveforms, and physical-layer performance metrics.
CLO2	Evaluate MIMO, beamforming, precoding, and radio-resource-management techniques for 5G and 5G-Advanced systems.
CLO3	Explain and evaluate advanced WLAN, IoT, and Open RAN solutions using contemporary standards and performance criteria.
CLO4	Apply AI/ML techniques to wireless communication problems and analyze emerging 6G and ISAC technologies.
CLO5	Investigate emerging non-terrestrial, secure, and future wireless networks using simulation, experimentation, and research-oriented approaches.

Module – 1	**10Hrs**
Advanced Wireless Channel and Physical Layer **Evolution and design context:** 4G, 5G, 5G-Advanced and 6G; IMT-2020/IMT-2030; eMBB, URLLC, mMTC, throughput-latency-reliability-energy-spectral-efficiency tradeoffs. **Channel modelling:** Large-/small-scale fading; frequency/time-selective channels; spatial correlation; MIMO, UMa, UMi and high-frequency propagation; ray tracing and geometry based stochastic models.Transport channel processing. **Text Book1:** Ch.1,1.1–1.3; Ch.5,5.1–5.2; Ch.7,7.1–7.4; Ch.8,8.1–8.3; Ch.11,11.1–11.3	
Module – 2	**08Hrs**
Adavnced MIMO **Advanced MIMO and RRM:** Massive MIMO, beam forming, pre coding, codebooks, beam management, MU-MIMO and coordinated transmission; scheduling, proportional-fair and QoS-aware scheduling, HARQ, link adaptation and dynamic spectrum allocation.**5G-Advanced:** AI/ML-assisted RAN, CSI feedback and beam management; MIMO evolution, Red Cap, positioning, side link, UAV/UAM communication and time-sensitive communication. **Text Book1:** Ch.11,11.1–11.3, Ch.12,12.1–12.5, Ch.14,14.1–14.5, Ch.15,15.1–15.2, Ch.22,22.1, Ch.8,8.1–8.6, Ch.9 9.1–9.5.2.	
Module – 3	**08 Hrs**
Advanced WLAN, IoT and Open RAN **Wi-Fi 6/6E/7:** IEEE 802.11ax, OFDMA, MU-MIMO, BSS colouring, TWT and 6-GHzoperation; IEEE 802.11be, 320-MHz channels, 4096-QAM, MLO, Multi-RU, preamble puncturing and low-latency Wi-Fi. **Advanced IoT:** NB-IoT, LTE-M, 5G Red Cap, industrial IoT, URLLC, TSN integration,	

wireless sensor networks, energy-efficient communication and edge intelligence.
Text Book1: Ch.21,21.1–21.9, Ch.22,22.1–22.2, Ch.30,0.1–30.7, Ch.4,4.1–4.5, Ch.7,7.1–7.7

Module – 4	**08 Hrs**

AI-Native Wireless and Emerging 6G
Machine learning for wireless: Supervised channel estimation; deep-learning signal detection; CNN/RNN/Transformer applications; reinforcement, multi-agent and federated learning;
AI-native RAN: AI-assisted scheduling, intelligent handover, traffic prediction, energy aware RAN, distributed intelligence and AI model lifecycle.
Textbook 3: Ch.1,1.1–1.2.5; Ch.2,2.1–2.5.3; Ch.3, Ch.5,.1–5.5.3; Ch.6,.1–6.5.2.
Textbook 1: Ch.30,30.1–30.7

Module – 5	**08 Hrs**

Non-Terrestrial, Secure and Future Wireless Networks
Non-terrestrial networks: NTN architecture; LEO/MEO/GEO; 3GPP NTN; satellite-U Elinks, Doppler compensation, timing advance, beam hopping, satellite handover, direct-to device and NTN-IoT.
Wireless security: Physical-layer security; jamming, spoofing and eavesdropping; zero-trust wireless networks.
Text Book 1: Ch.25,25.1–25.3, Ch.26,26.1–26.8, Ch.28,28.1–28.14, Ch.29,29.1–29.6, Ch.30,30.1–30.8

Topics for Self-learning	
Module-1	Wireless Channel Modeling – AWGN, Rayleigh fading
	BER Analysis of Digital Modulation Schemes over Wireless Channels
Module-2	OFDM System Design and Performance Analysis
	MIMO System Simulation and Performance Evaluation
Module-3	Massive MIMO Beam forming and Pre coding
	Radio Resource Allocation in 5G Networks
Module-4	5G NR Numerology and Physical-Layer Performance Analysis
	IoT Wireless Network Design and Performance Analysis
Module-5	Non-Terrestrial Network (NTN) Simulation and Link Performance Analysis
	AI/ML-Based Channel Estimation and Signal Detection

Course Outcomes: After completing the course, the students will be able to	
CO1	Analyze advanced wireless channels, waveforms, and link-performance metrics for contemporary communication systems
CO2	Evaluate 5G NR/5G-Advanced architectures, physical-layer procedures, massive-MIMO techniques, and radio-resource-management strategies.
CO3	Design and evaluate standards-based WLAN, IoT, and Open RAN solutions using appropriate performance criteria.
CO4	Apply AI/ML techniques to wireless communication problems and analyze emerging 6G and ISAC technologies.
CO5	Investigate non-terrestrial, secure, and emerging wireless networks using simulation, experimentation, and research-oriented approaches.

TextBooks	
1	Erik Dahlman, Stefan Parkvall and Johan Sköld, *5G/5G-Advanced: The New Generation Wireless Access Technology*, 3rd Edition, Academic Press–Elsevier, 2023.
2	Le Liang, Shi Jin, Hao Ye and Geoffrey Ye Li, *Wireless Communications and Machine Learning*, Cambridge University Press, 2025.

ReferenceBooks	
1	'Digital Communications: Fundamentals and Applications: Fundamentals & Applications', Bernard Sklar, Pearson Education, ISBN:9788131720929, 2nd edition, 2009
2	'Digital Communications Systems', Simon Haykin, Wiley, ISBN:9788126542314, 1st edition, 2014

Web links and Video Lectures (e – Resources)	
1	https://www.3gpp.org/ https://www.itu.int/itu-r/en/
2	https://www.ieee802.org/11/ https://www.o-ran.org/ https://www.nsnam.org/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	2
CO2	3	1	1	2	2	
CO3	2	1	2	2	1	1
CO4	3	2	1	1	2	2
CO5	3	2	2	2	2	2

Semester: I					
Medical Image Processing and AI Diagnosis					
Course Code	**:**	1MEC106C	**Credit**	**:**	3
Hours/Semester (L:T:P:SL)	**:**	3:0:0:3	**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3

Prerequisites:	
Courses	Machine Learning Fundamentals, python fundamentals
Knowledge on Fundamental Concepts	Engineering Mathematics, Digital Image Processing, Signals and Systems / Basic Electronics, Machine Learning Fundamentals, programming Fundamentals
Knowledge on Connected Tools (If any)	**Python**

Course Learning Objectives: This course will enable the students to	
CLO1	**Elucidate** the fundamentals of medical imaging modalities, digital image representation, sampling, quantization, pixels/voxels, image-quality measures, DICOM and PACS.
CLO2	**Apply** image enhancement, filtering, denoising, segmentation, morphological operations and registration techniques to medical images.
CLO3	**Extract and analyse** radionics features and **apply** conventional machine-learning techniques for medical image classification and computer-aided diagnosis.
CLO4	**Develop and evaluate** deep-learning models such as CNNs and U-Net for medical image classification, detection and segmentation
CLO5	**Evaluate** AI-assisted medical imaging applications considering performance, bias, fairness, privacy, explainability, clinical validation, ethics and regulatory requirements.

Module – 1	**08 Hrs**
Medical Imaging Foundations and Digital Image Representation Imaging ecosystem: Role of medical imaging in screening, diagnosis and treatment planning; anatomical, functional and molecular imaging; clinical questions and engineering workflow. Digital medical images: Sampling and quantization, pixels/voxels, intensity distributions, colour and multidimensional images, image-quality measures (SNR, CNR, MSE, PSNR, SSIM); DICOM metadata, PACS, anonymization and basic visualization. **Textbook 1: 1.1, 1.2, 1.3, 2.1, 2.2, 2.3**	
Module – 2	**08 Hrs**
Medical Image Enhancement, Segmentation and Registration Pre-processing and enhancement: Intensity normalization, windowing, histogram methods, spatial and frequency-domain filtering, denoising, sharpening, bias-field correction and artefact reduction. Segmentation and morphology: Thresholding, region growing, edge-based methods, clustering, watershed, active contours/level sets, graph cuts; binary morphology, connected components and quantitative region analysis. **Textbook 1: 3.1, 3.2, 3.3, 4.1, 4.2, 10.1, 10.2**	
Module – 3	**08 Hrs**

Machine Learning, Radiomics and Computer-Aided Diagnosis Feature engineering: Shape, first-order statistics, texture features (GLCM/GLRLM), local descriptors, dimensionality reduction and feature selection; reproducibility and harmonization in radiomics. Learning methods: Supervised/unsupervised learning; logistic regression, k-NN, SVM, decision trees, random forests, clustering and ensemble methods; imbalanced data and data leakage.

Textbook 1: 2.6, 2.7, 2.8, 12.1, 12.2, 12.3

Module – 4	**08 Hrs**

Deep Learning for Medical Image Analysis Architectures: CNN fundamentals, transfer learning and fine-tuning; 2D/2.5D/3D CNNs; U-Net and variants; object-detection models; attention mechanisms and vision transformers. Training pipeline: Annotation formats, patch/slice/volume sampling, augmentation, loss functions (cross entropy, Dice, focal), optimization, regularization, hyperparameter tuning and experiment tracking.

Textbook 1: 12.4, 12.5, 12.6

Module – 5	**08 Hrs**

AI-Assisted Diagnosis, Clinical Translation and Responsible Deployment Diagnostic applications: Case studies in chest X-ray/CT, brain MRI, retinal imaging, mammography, ultrasound and digital pathology; lesion detection, organ/tumour segmentation, disease classification, triage and prognosis. Clinical translation: Workflow integration and decision-support interfaces; prospective versus retrospective evaluation; bias and fairness, privacy, cybersecurity, explainability, documentation, lifecycle monitoring, regulatory and ethical considerations. AI output as decision support—not autonomous clinical judgment.

Textbook 1: 12.7, 12.8

Topics for Self learning	
Module-1	DICOM structure, metadata, PACS workflow, anonymization and visualization
	SNR, CNR, MSE, PSNR and SSIM with practical examples
Module-2	Thresholding, region growing, watershed, active contours and graph cuts
	Histogram equalization, filtering, denoising, sharpening and bias-field correction
Module-3	Shape, intensity and texture features such as GLCM and GLRLM
	Comparison of SVM, k-NN, decision trees and random forests using medical datasets
Module-4	Architecture, encoder-decoder concept and skip connections
	Fine-tuning pretrained models such as ResNet, VGG or EfficientNet
Module-5	Case study of AI for chest X-ray, brain MRI, retinal imaging or mammography
	Bias, fairness, privacy, explainability, cybersecurity and regulatory/ethical issues

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain medical image-formation principles, modality characteristics, image quality, DICOM data and clinical imaging workflows.
CO2	Apply enhancement, restoration, segmentation, feature extraction and registration techniques to medical images

CO3	Develop and evaluate machine-learning and radiomics pipelines for computer-aided detection and diagnosis.
CO4	Design deep-learning models for medical image classification, detection and segmentation, with explainability and uncertainty assessment.
CO5	Evaluate AI-assisted medical imaging systems with respect to clinical translation, fairness, privacy, explainability, ethics and responsible deployment.

Text Books	
1	Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson, 2022.
2	Atam P. Dhawan, Medical Image Analysis, 2nd Edition, Wiley-IEEE Press, 2011.
3	Le Lu, Yefeng Zheng, Gustavo Carneiro and Lin Yang (Editors), Deep Learning and Convolutional Neural Networks for Medical Image Computing, Springer, 2017.

Reference Books	
1	Gobert Lee and Hiroshi Fujita (Editors), Deep Learning in Medical Image Analysis: Challenges and Applications, Springer, 2020.
2	The DICOM Standard, NEMA; MONAI documentation; 3D Slicer documentation; relevant peer-reviewed IEEE, MICCAI and medical-imaging literature.

Web links and Video Lectures (e – Resources)	
1	https://www.dicomstandard.org/ https://monai.io/ https://physionet.org/ https://www.kaggle.com/medmnist
2	https://www.slicer.org/ https://www.cancerimagingarchive.net/ https://opencv.org/ https://scikit-image.org/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	2	1
CO2	3	3	2	3	2	1
CO3	3	2	3	2		2
CO4	3	3	3	2	2	2
CO5	2	2	2	2	2	2

Semester: I						
SOFTWARE DEFINED VEHICLE						
Course Code	**:**	1MEC106D		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	
Knowledge on Fundamental Concepts	Basic knowledge of Automotive Electronics, Embedded Systems, Computer Networks, Programming and Software Engineering.
Knowledge on Connected Tools (If any)	

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamentals of Software Defined Vehicles (SDV) and the evolution from hardware-centric to software-centric automotive platforms.
CLO2	Analyze modern automotive E/E architectures, including distributed, domain, centralized, and zonal architectures.
CLO3	Apply service-oriented communication principles and protocols such as Automotive Ethernet, SOME/IP, DDS, and Protobuf in SDV applications.
CLO4	Understand AUTOSAR Classic and Adaptive Platforms, middleware, virtualization, OTA updates, and CI/CD approaches for SDV software development.
CLO5	Evaluate functional safety, cybersecurity, diagnostics, validation, and lifecycle management requirements in SDV-based automotive systems.

Module – 1	**08 Hrs**
Introduction to Software Defined Vehicles and E/E Architecture Evolution: Software Defined Vehicle fundamentals; need for SDV; vehicle software evolution; smartphone-on-wheels concept; digital-first vehicle lifecycle; cross-domain applications and data fusion; E/E architecture evolution; distributed ECU architecture; high compute platforms; traditional software architecture vs SDV software architecture. **Textbook 1: Ch:1-1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9, Ch:3-3.1,3.2,3.3.**	
Module – 2	**08 Hrs**
Service-Oriented Communication and Automotive Networking for SDV: In-vehicle networking evolution; CAN, LIN, MOST, FlexRay and Automotive Ethernet; Automotive Ethernet channels and PHY overview; IP, VLAN, switching/routing; QoS, AVB and TSN; middleware and SOME/IP; Service Discovery; Vehicle APIs; DDS and Protocol Buffers. **Textbook 3: : Ch:2-2.1.2.2, Ch:3-3.1,3.2,3.5, Ch:5-5.1,5.2, Ch:7-7.1.**	
Module – 3	**08 Hrs**
AUTOSAR Platforms and SDV Middleware: AUTOSAR overview and evolution; AUTOSAR Classic Platform; AUTOSAR Adaptive Platform; Classic reference architecture; Adaptive reference architecture; AUTOSAR methodology and meta-model; ECU middleware; Communication Management; Execution Management; Update and Configuration Management; Linux/QEMU-based platform realization concepts. **Textbook 2: Ch.3 – relevant sections; Ch.5 – AUTOSAR sections; Ch.6 – relevant sections**	
Module – 4	**08 Hrs**
Virtualization, OTA, Containers and Cloud-Native SDV Development: Virtualization in on-board automotive systems; hypervisor concept and types; mixed-criticality consolidation; containerization; on-board vs off board deployment; cloud-native development; open-source development; OTA updates; vehicle app store; value stream management; shift-left and shift-north engineering; CI/CD and software factory concepts**.**	

Textbook 1: h.2 – 2.1–2.2; Ch.3 – SDV Tech Stack, OTA and Vehicle App Store sections; Ch.4 – 4.1–4.3; Ch.5 – 5.1–5.3	
Module – 5	**08 Hrs**
Safety, Cybersecurity, Validation and Lifecycle Management of SDV: Functional safety and ISO 26262 lifecycle; ASIL concept; safety in Vehicle SOA; cybersecurity engineering and ISO/SAE 21434; threat and risk analysis; network security; validation and testing; SIL/MIL/HIL; architecture evaluation; metrics; diagnostics; lifecycle management and post-deployment monitoring.	
Textbook 2: Ch.8, Ch.10, Ch.11; TB1: Ch.3 – Functional Safety section; Ch.5 – 5.1–5.3	

Topics for Self learning	
Module-1	Smartphone-on-Wheels Concept
	Digital-First Vehicle Lifecycle
Module-2	Automotive Ethernet and TSN
	SOME/IP Service Discovery
Module-3	AUTOSAR Classic vs AUTOSAR Adaptive
	AUTOSAR Methodology and Meta-Model
Module-4	Hypervisors and Virtualization
	OTA Updates and Vehicle App Store
Module-5	ISO 26262 and ASIL Concept
	ISO/SAE 21434 Automotive Cybersecurity

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the concept of Software Defined Vehicle, E/E architecture evolution, high-compute platforms, zonal controllers and vehicle operating system requirements.
CO2	Analyse service-oriented communication and in-vehicle networking protocols such as Automotive Ethernet, SOME/IP, DDS, Protobuf and vehicle APIs.
CO3	Interpret AUTOSAR Classic and Adaptive Platform architecture and apply Adaptive AUTOSAR middleware concepts for SDV software realization.
CO4	Evaluate virtualization, hypervisors, containers, cloud-native development, OTA update mechanisms and CI/CD workflows for automotive systems.
CO5	Assess functional safety, cybersecurity, validation, diagnostics and lifecycle management issues in SDV-based automotive platforms.

Text Books	
1	Dirk Slama, Achim Nonnenmacher and Thomas Irawan, The Software-Defined Vehicle, O'Reilly Media, 2023, ISBN: 978-1098157814.
2	Miroslaw Staron, Automotive Software Architectures: An Introduction, 2nd Edition, Springer Cham, 2021, ISBN: 978-3-030-65939-4.
3	Kirsten Matheus and Thomas Königseder, Automotive Ethernet, 3rd Edition, Cambridge University Press, 2021, ISBN: 978-1108841955.

Reference Books	
1	AUTOSAR, SOME/IP Protocol Specification, AUTOSAR Foundation Standard, latest available release.
2	AUTOSAR, Adaptive Platform Specifications: Communication Management, Execution Management, Update and Configuration Management, State Management and Persistency, latest available release.

3	ISO 26262, Road vehicles - Functional safety, International Organization for Standardization, latest edition.
4	ISO/SAE 21434:2021, Road vehicles - Cybersecurity engineering
5	Thomas D. Nadeau and Ken Gray, Software Defined Networking, O'Reilly Media, 2013.
6	James Larminie and John Lowry, Electric Vehicle Technology Explained, 2nd Edition, Wiley, 2012.

Web links and Video Lectures (e – Resources)	
1	Official AUTOSAR documentation portal: https://www.autosar.org/standards
2	Eclipse Software Defined Vehicle resources: https://sdv.eclipse.org/
3	NPTEL / SWAYAM courses related to Automotive Electronics, Embedded Systems, IoT, Cloud Computing and Cybersecurity may be used as supplementary resources.
4	digital.auto / SDV guide resources for practical SDV architecture discussion: https://www.digital.auto/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	2	1
CO2	3	3	2	2	3	1
CO3	3	3	3	2	3	1
CO4	3	2	3	2	3	2
CO5	3	3	2	3	2	2

Semester: 1					
Python for Electronic System Design					
Course Code	**:**	1MECL107A	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:2	**CIE**	**:**	50 Marks
Total Hours	**:**	30Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Prerequisites:	
Courses	Basic knowledge of Engineering Mathematics and fundamental concepts of Electronics.
Knowledge on Fundamental Concepts	Basic knowledge of mathematics, algebra and elementary concepts of electrical and electronic systems. Basic understanding of signals and their graphical representation is desirable.
Knowledge on Connected Tools (If any)	**-**

Course Learning Objectives: This course will enable the students to	
CLO1	Develop basic Python programs using fundamental programming constructs for solving simple engineering and electronic-system related problems.
CLO2	Apply Python libraries such as NumPy and Pandas for numerical computation, matrix operations and processing of electronic-system data.
CLO3	Use Python and Matplotlib/SciPy to generate, visualize and perform basic analysis of electronic signals.
CLO4	Apply Python-based techniques for data analysis, visualization and basic digital signal processing of electronic-system data.
CLO5	Develop simple Python-based applications using basic machine-learning techniques for solving electronic-system related problems.

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory ....**
1.	**Introduction to Python for Electronic Applications:** Develop Python programs using variables, data types, operators, conditional statements, loops and functions for simple electronic calculations such as Ohm's law, power and resistor combinations.
2.	**Numerical Computing using NumPy:** Perform array operations, indexing, slicing, matrix operations and basic statistical computations using NumPy.
3.	**Data Visualization using Matplotlib:** Generate and visualize basic electronic signals such as sine, cosine and square waves using Matplotlib.
4.	**Basic Signal Processing using Python:** Generate discrete-time signals and perform basic operations such as addition, multiplication, shifting and scaling using NumPy/SciPy.
5.	**Convolution and Correlation:** Implement discrete-time convolution and correlation using Python and visualize the input and output signals.
6.	**Fourier Transform Analysis:** Generate sinusoidal signals and compute their frequency spectrum using Fast Fourier Transform (FFT) in Python.
7.	**Basic Digital Filtering:** Generate a noisy signal and implement a simple moving-average/low-pass filter using Python. Compare the original, noisy and filtered signals.
8.	**Electronic Data Analysis using Python:** Read voltage, current, temperature or other electronic-system data from a CSV file using Pandas and perform basic statistical analysis and visualization.
9.	**Introduction to Machine Learning for Electronic Applications:** Develop a simple

	classification or regression model using Scikit-learn and evaluate its performance using suitable metrics.
10.	**Mini Project –Python for Electronic System Design:** Develop a simple Python-based application for electronic-system data analysis, signal analysis, monitoring or basic fault classification using simulated or available datasets.

Open Ended Experiments	
1	Develop a Python-based application for analyzing and visualizing a selected electronic signal or sensor dataset.
2	Develop a simple intelligent electronic-system application using Python and basic machine-learning techniques.

Course Outcomes: After completing the course, the students will be able to	
CO1	**Implement** fundamental Python programming constructs to solve basic engineering and electronic-system related problems.
CO2	**Apply** NumPy and Pandas libraries for numerical computation, matrix operations and processing of electronic-system data.
CO3	**Examine** continuous-time and discrete-time signals using Python through appropriate visualization techniques.
CO4	**Interpret** electronic-system data using fundamental signal-processing, data-analysis and visualization techniques.
CO5	**Develop** a simple Python-based machine-learning application for solving an electronic-system related problem.

Text Books	
1	Mark Lutz, Learning Python, 6th Edition, O'Reilly Media, 2024.
2	Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter, 3rd Edition, O'Reilly Media, 2022.

Reference Books	
1	Luciano Ramalho, Fluent Python, 2nd Edition, O'Reilly Media, 2022.
2	Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python: A Guide for Data Scientists, 2nd Edition, O'Reilly Media, 2025.

Web links and Video Lectures (e – Resources)	
1	https://scikit-learn.org/stable/
2	https://numpy.org/learn/

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	3	-	1
CO2	2	-	2	3	-	2
CO3	2	1	2	3	-	2
CO4	3	2	3	3	-	2
CO5	3	3	3	3	2	3

Semester: I					
Electronics & Communication					
Course Code	**:**	1MECL107B	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:0	**CIE**	**:**	50 Marks
Total Hours	**:**	12 Practical Session	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Prerequisites:	
Courses	Analog Electronics, Digital Electronics, Signals and Systems, Communication Systems, and basic Programming
Knowledge on Fundamental Concepts	Basic knowledge of electronic circuits, semiconductor devices, signals, modulation, digital communication, frequency response, and electromagnetic waves
Knowledge on Connected Tools (If any)	Basic familiarity with MATLAB/Python, circuit simulation tools, GNU Radio, and microcontroller/wireless communication modules such as ESP32, BLE, LoRa, Wi-Fi, and ZigBee

Course Learning Objectives: This course will enable the students to	
CLO1	Apply fundamental principles of analog amplifiers, active filters, and RF communication circuits for circuit design and analysis.
CLO2	Implement ASK, FSK, PSK, and QAM digital modulation techniques and evaluate their performance.
CLO3	Apply error-control coding and decoding techniques using MATLAB/Python for reliable communication.
CLO4	Analyze antenna radiation characteristics and **implement** software-defined radio communication using GNU Radio.
CLO5	Interface and evaluate BLE, LoRa, Wi-Fi, and ZigBee communication modules for wireless data transmission applications.

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory.**
1.	Design and characterize analog amplifier circuits using simulation and hardware implementation.
2.	Analyze frequency response and stability of active filter circuits.
3.	Design RF communication circuits and evaluate performance using simulation tools.
4.	Implement digital communication techniques including ASK, FSK, PSK, and QAM modulation.
5.	Perform error control coding and decoding using MATLAB/Python.
6.	Design and analyze antenna radiation characteristics using simulation software.
7.	Implement software-defined radio (SDR) communication using GNU Radio.
8.	Evaluate wireless communication performance under noisy and fading channels.
9.	Interface communication modules (BLE, LoRa, Wi-Fi, ZigBee) for wireless data transmission.

10.	Interface communication modules (BLE, LoRa, Wi-Fi, ZigBee) for wireless data transmission.

Open Ended Experiments	
1	Design and analyze an analog amplifier circuit and discuss the effect of different circuit parameters on its performance.
2	Develop a MATLAB/Python program for error-control coding and decoding and analyze its performance in the presence of noise.

Course Outcomes: After completing the course, the students will be able to	
CO1	Design and analyze analog amplifier, active filter, and RF communication circuits using simulation tools and hardware implementation.
CO2	Implement and evaluate digital communication techniques such as ASK, FSK, PSK, and QAM under different channel conditions.
CO3	Apply error-control coding and decoding techniques using MATLAB/Python for reliable digital communication.
CO4	Design and analyze antenna radiation characteristics and implement software-defined radio (SDR) communication using GNU Radio.
CO5	Interface and evaluate wireless communication technologies such as **BLE, LoRa, Wi-Fi, and ZigBee** for practical data-transmission applications.

Text Books	
1	Lathi, B. P. and Ding, Z., *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford University Press, 2009, ISBN: 978-0-19-533145-5.
2	Pozar, D. M., *Microwave Engineering*, 5th Edition, John Wiley & Sons, 2024, ISBN: 978-1-394-15869-0.

Reference Books	
1	**Goldsmith, A.**, *Wireless Communications*, Cambridge University Press, 2005, ISBN: **978-0-521-83716-3**.
2	**Lin, S. and Costello, D. J.**, *Error Control Coding*, 2nd Edition, Pearson Prentice Hall, 2004, ISBN: **978-0-13-042672-7**.

Web links and Video Lectures (e – Resources)	
1	https://nptel.ac.in/courses/117102059?utm_source=chatgpt.com
2	https://wiki.gnuradio.org/index.php/Tutorials?utm_source=chatgpt.com

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	**3**	**3**	**3**	**3**	**2**	**2**	
CO2	**3**	**3**	**3**	**3**	**3**	**2**	
CO3	**3**	**3**	**2**	**3**	**3**	**2**	
CO4	**3**	**3**	**3**	**3**	**3**	**2**	**2**
CO5	**3**	**3**	**3**	**3**	**3**	**2**	**2**

Semester: I					
Digital IC Design					
Course Code	**:**	1MECL107C	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:2	**CIE**	**:**	50 Marks
Total Hours	**:**	30 Hrs.	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Prerequisites:	
Courses	Digital System Design using Verilog, Analog Circuits & Computer Organization and Architecture
Knowledge on Fundamental Concepts	Sequential logic theory, State machine design, NMOS and PMOS operation modes, Circuit Dynamics & Analysis
Knowledge on Connected Tools (If any)	Cadence Design Systems- Cadence Virtuoso Schematic Editor

Course Learning Objectives: This course will enable the students to	
CLO1	**Analyze** and evaluate the DC transfer characteristics, noise margins, propagation delay, dynamic/static power, and signal integrity of CMOS, transmission-gate, and pass-transistor logic circuits under process, voltage, and temperature (PVT) variations using industry-standard EDA tools.
CLO2	**Design** and verify combinational building blocks, parameterized sequential registers, and fault-tolerant Moore/Mealy finite-state machines by constructing structural, dataflow, and behavioral Verilog/System Verilog RTL alongside automated self-checking test benches.
CLO3	**Construct** and optimize high-performance arithmetic data paths—including advanced carry-propagate adders, tree multipliers, and configurable ALU's—by implementing pipelining and parameterized architectures to evaluate and trade off latency, throughput, area, and power.
CLO4	**Apply** and formulate logic synthesis strategies and comprehensive timing constraints (SDC/XDC) to identify critical paths, compute setup and hold slack, and execute timing closure using retiming and logic restructuring.
CLO5	**Implement** and validate digital RTL architectures onto physical FPGA hardware targets through placement, routing, and bit stream programming, diagnosing circuit operation via peripheral interfaces and embedded on-chip logic analyzers (ILA/Signal Tap).

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory ….**
1.	Design CMOS inverter, NAND and NOR gates using Cadence Virtuoso or an open source EDA tool. Analyse DC transfer characteristics, noise margins, propagation delay, power dissipation and process-voltage-temperature variations.
2.	Design and simulate complex static CMOS, transmission-gate and pass-transistor logic circuits. Compare transistor count, delay, power and signal integrity.
3.	Model multiplexers, encoders, decoders, comparators and code converters using structural, dataflow and behavioural Verilog/System Verilog. Develop self-checking test benches for functional verification.

4.	Design registers, shift registers, synchronous/asynchronous counters and Moore/Mealy finite-state machines. Verify reset behaviour, state transitions and illegal-state recovery.
5.	Implement ripple-carry, carry-look-ahead and carry-select adders. Compare area, delay and power through synthesis and timing reports.
6.	Develop array, Booth and Wallace-tree multipliers and a configurable ALU. Evaluate architectural trade-offs in latency, throughput, area and power.
7.	Develop reusable parameterized RTL modules and pipeline a computation-intensive data path. Verify functional equivalence and quantify the improvement in maximum operating frequency.
8.	Synthesize a Verilog/System Verilog design using Xilinx Vivado, Intel Quartus, Yosys or a commercial synthesis tool. Define clocks and I/O constraints and analyse resource utilization, timing and inferred hardware.
9.	Perform setup and hold analysis, identify critical paths and evaluate clock uncertainty, input/output delays and timing exceptions. Apply pipelining, logic restructuring and constraint refinement to achieve timing closure.
10.	Implement an RTL design on an FPGA, including synthesis, placement, routing and bit stream generation. Validate the hardware using switches, LEDs, UART or on-chip logic analysers such as ILA/Signal Tap.

Open Ended Experiments	
1	Write Verilog Code for the following circuits and their Test Bench for verification, observe the waveform and synthesize the code with technological library with given Constraints*. Do the initial timing verification with gate level simulation. I. An inverter II. A Buffer III. Transmission Gate IV. Basic/universal gates V. Flip flop -RS,D, JK,MS, T VI. Serial & Parallel adder VII. 4-bitcounter[Synchronous and Asynchronous counter]
2	Design an op-amp with given specification* using given differential amplifier Common source and Common Drain amplifier in library** and completing the design flow mentioned below: a. Draw the schematic and verify the following (i) DC Analysis (ii) AC Analysis (iii) Transient Analysis b. Draw the Layout and verify the DRC, ERC c. Check for LVS d. Extract RC and back annotate the same and verify the Design.

Course Outcomes: After completing the course, the students will be able to	
CO1	Characterize and evaluate the DC transfer curves, noise margins, transient propagation delays, dynamic/static power dissipation, and PVT variations of custom CMOS, transmission-gate, and pass-transistor logic circuits using transistor-level EDA schematic capture and SPICE simulation suites.
CO2	Model and verify modular combinational units, parameterized registers, counters, and fault-tolerant finite-state machines by writing synthesizable structural/dataflow/behavioral Verilog/System Verilog RTL and developing self-checking test benches with automated assertion checks.

CO3	Design, pipeline, and benchmark high-speed arithmetic architectures—including carry-look-ahead/select adders, Booth/Wallace-tree multipliers, and configurable ALUs—quantifying structural trade-offs in area, cell count, latency, and maximum operating frequency.
CO4	Synthesize, constrain, and optimize RTL designs using industry-standard synthesis tools by formulating SDC/XDC clock and I/O constraints, analyzing timing reports, diagnosing critical paths, and resolving setup/hold slack violations through retiming and logic restructuring.
CO5	Implement and debug digital systems on target FPGA evaluation boards by executing synthesis, placement, routing, and bit stream generation, validating physical operation using hardware I/O peripherals (switches, LEDs, UART) and embedded on-chip logic analyzers (ILA/Signal Tap).

Text Books	
1	Michael John Sebastian Smith, “Application - Specific Integrated Circuits”, Addison-Wesley Professional, 2005
2	Chris Spear, “System Verilog for Verification– A guide to learning the Test bench language features”, Springer Publications Second Edition,2010.

Reference Books	
1	Vikram Arkalgud Chandrasetty, “VLSI Design: A Practical Guide for FPGA and ASIC Implementations” Springer, ISBN: 978-1-4614-1119-2. 2011
2	Naveed A. Sherwani, “Algorithms for VLSI Physical Design Automation”, Springer, ISBN: 978-0792383932.3rd Edition,1999.

Web links and Video Lectures (e – Resources)	
1	https://www.youtube.com/watch?v=oZSv68esbgI
2	https://www.youtube.com/watch?v=g6CCJAbdkK8&list=PLyqSpQzTE6M-ceKpZZSTa0uNOuCjSubd2
3	https://learn.swayam2.ac.in/learn/noc21_ee22
4	https://online.vtu.ac.in/v1/course-details/Digital-IC-Design

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**2**	**3**	**3**	**2**
CO2	**3**	**2**	**3**	**2**	**3**	**2**
CO3	**3**	**3**	**3**	**3**	**3**	**2**
CO4	**3**	**3**	**2**	**3**	**3**	**2**
CO5	**3**	**2**	**3**	**2**	**3**	**3**

Semester: I					
Advanced Signal Processing					
Course Code	**:**	1MECL107D	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:2	**CIE**	**:**	50 Marks
Total Hours	**:**	30 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Pre requisites:	
Courses	Signals & System, DSP,DIP
Knowledge on Fundamental Concepts	DSP, Discrete time signals, digital filtering, biomedical signals, Wavelet, Speech Processing
Knowledge on Connected Tools (If any)	MATLAB/SCILAB/OCTAVE/PYTHON

Course Learning Objectives: This course will enable the students to	
CLO1	**Understand** the fundamental concepts of discrete-time signals, systems, and digital signal processing techniques using MATLAB
CLO2	**Develop skills** in designing and analyzing FIR and IIR digital filters using different approximation and windowing techniques.
CLO3	**Apply** adaptive filtering, spectral estimation, and wavelet transform techniques for practical signal processing applications.
CLO4	**Implement** DSP techniques for speech, image, biomedical, communication, and other real-world signal processing applications.
CLO5	**Develop practical skills** in MATLAB/Python-based DSP implementation and design a signal processing mini-project.

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory**
1.	Generate and analyze discrete-time signals.
2.	Design FIR filters using windowing and optimization techniques.
3.	Design IIR filters using Butterworth and Chebyshev.
4.	Implement adaptive filtering using LMS and RLS algorithms.
5.	Perform spectral estimation using FFT, periodogram, and Welch methods.
6.	Implement wavelet transform for signal denoising and feature extraction.
7.	Develop speech processing algorithms for enhancement and recognition.
8.	Perform image enhancement and restoration using digital signal processing techniques.
9.	Implement real-time DSP applications using MATLAB and DSP hardware.
10.	Design and evaluate a signal processing application for biomedical, communication, or radar systems as a mini project.

Open Ended Experiments	
1	Design and Development of a Real-Time Noise Cancellation

	System
2	Biomedical Signal Denoising and Feature Extraction using Wavelet Transform Select an **ECG/EEG or other biomedical signal**, introduce or use existing noise, and develop a wavelet-based denoising and feature-extraction system. Compare different wavelets and decomposition levels and evaluate the quality of the processed signa

Course Outcomes: After completing the course, the students will be able to	
CO1	Generate, analyze, and manipulate discrete-time signals and systems using MATLAB.
CO2	Design and evaluate FIR and IIR digital filters using appropriate design techniques and performance measures.
CO3	Implement adaptive filtering, spectral estimation, and wavelet-based signal processing algorithms.
CO4	Apply DSP techniques to process and analyze speech, image, biomedical, communication, and radar signals.
CO5	Develop and evaluate a practical DSP application using MATLAB and, where applicable, real-time DSP hardware.

Text Books	
1	Alan V. Oppenheim and Ronald W. Schafer, *Discrete-Time Signal Processing*, 3rd Edition, Pearson, 2009, ISBN: 978-0-13-198842-2.
2	Raguveer M. Rao and Ajith S. Bopardikar, Wavelet Transforms: Introduction to Theory and Applications, Addison-Wesley, 1998.

Reference Books	
1	Li Tan and Jean Jiang, Digital Signal Processing: Fundamentals and Applications, 3rd Edition, Academic Press, 2019, ISBN: 978-0-12-815071-9.
2	Michael Weeks, *Digital Signal Processing Using MATLAB and Wavelets*, 2nd Edition, Jones & Bartlett Learning, 2011, ISBN: 978-0-7637-8422-5.

Web links and Video Lectures (e – Resources)	
1	NPTEL Digital Signal Processing and its Applications – IIT Bombay https://nptel.ac.in/courses/108101174
2	NPTEL Digital Signal Processing – IIT Delhi https://www.nptel.ac.in/courses/117102060

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	**-**	**1**	**1**	**1**
CO2	**2**	**1**	**2**	**2**	**1**	**1**
CO3	**3**	**1**	**2**	**3**	**1**	**1**
CO4	**3**	**1**	**2**	**3**	**2**	**2**
CO5	**3**	**2**	**3**	**3**	**2**	**2**

Semester: II						
Massive MIMO Systems						
Course Code	**:**	1MLDN201		**Credits**	**:**	4
Hours/Week(L:T:P:AL)	**:**	3:0:2:3		**CIE**	**:**	50 Marks
Total Hours	**:**	120 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Communication; Wireless Communication; Probability and Random Processes; Linear Algebra
Knowledge on Fundamental Concepts	Signals and systems, probability, random processes, matrices, complex numbers, communication theory and fading channels
Knowledge on Connected Tools (If any)	MATLAB / Python / NumPy / SciPy; basic simulation and plotting

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the principles, architecture and performance advantages of Massive MIMO in modern wireless communication systems.
CLO2	Analyze channel models, channel estimation, pilot contamination and spatial signal processing techniques for large-scale antenna arrays.
CLO3	Apply linear and nonlinear precoding, combining and power-control techniques to multi-user Massive MIMO systems.
CLO4	Design and simulate Massive MIMO transceivers and evaluate spectral efficiency, energy efficiency, outage and BER performance.
CLO5	Interpret emerging research directions of Massive MIMO for 5G-Advanced, 6G, cell-free networks, mmWave and intelligent wireless systems.

Module – 1	**08 Hrs**
Introduction to Massive MIMO: Evolution from SISO to MIMO and Massive MIMO; system architecture; favorable propagation; channel hardening; asymptotic orthogonality; coherent and non-coherent transmission; spectral efficiency and energy efficiency; single-cell and multi-cell Massive MIMO; TDD and FDD operation; uplink and downlink signal models.	
Module – 2	**08 Hrs**
Channel Modeling and Estimation: Small-scale and large-scale fading; spatial correlation; i.i.d. and correlated Rayleigh channels; Rician and geometric channel models; uplink pilot transmission; least-squares and MMSE channel estimation; pilot reuse; pilot contamination; channel reciprocity and calibration; channel hardening and favorable propagation analysis.	
Module – 3	**08 Hrs**
Multiuser Detection, Precoding and Combining: Maximum-ratio (MR) combining/precoding; zero-forcing (ZF); regularized ZF; MMSE processing; successive interference cancellation; uplink detection; downlink precoding; achievable rates; inter-user interference; power control; pilot-aware processing; complexity and scalability of linear processing.	
Module – 4	**08 Hrs**
Performance Analysis and Practical Issues: Spectral and energy efficiency; power allocation; hardware impairments; low-resolution ADC/DAC; amplifier nonlinearity; phase noise; mutual coupling; antenna correlation; channel estimation errors; pilot contamination mitigation; beamforming and hybrid beamforming; mmWave Massive MIMO; system-level performance metrics.	
Module – 5	**08 Hrs**
Advanced and Emerging Massive MIMO: Cell-free Massive MIMO; distributed and user-centric architectures; XL-MIMO; RIS-assisted Massive MIMO; Massive MIMO for 5G-Advanced and 6G; integrated sensing and communication; AI/ML-assisted beamforming and resource allocation; joint communication and sensing; open research challenges and standardization perspectives.	

Practical Component	
Module-1	a) Simulate SISO, conventional MIMO and Massive MIMO links and compare BER and spectral efficiency.
	b) Demonstrate channel hardening and favorable propagation for increasing numbers of base-station antennas.
Module-2	a) Implement LS and MMSE channel estimation for a Massive MIMO uplink and compare estimation error.
	b) Demonstrate pilot contamination using pilot reuse in a multi-cell Massive MIMO model.
Module-3	a) Implement MR, ZF and MMSE uplink combining and compare achievable sum-rate.
	b) Implement MR, ZF and regularized-ZF downlink precoding and study inter-user interference.
Module-4	a) Evaluate spectral efficiency and energy efficiency under different transmit-power and antenna configurations.
	b) Simulate the effect of hardware impairments, antenna correlation or low-resolution ADCs on system performance.
Module-5	a) Simulate a simple cell-free Massive MIMO network and compare it with a centralized cellular Massive MIMO system.
	b) Mini-project: AI/ML-assisted beamforming, RIS-assisted Massive MIMO, XL-MIMO or 6G use-case simulation.

Topics for Self learning	
Module-1	Massive MIMO in 5G NR; TDD frame structure; practical base-station deployments.
	Advanced pilot contamination mitigation and blind/semi-blind channel estimation.
Module-2	Distributed MMSE processing, user scheduling and scalable precoding algorithms.
	mmWave/THz Massive MIMO, hybrid beamforming and hardware-efficient architectures.
Module-3	Cell-free Massive MIMO, RIS, XL-MIMO, integrated sensing and AI/ML for 6G.
	Massive MIMO in 5G NR; TDD frame structure; practical base-station deployments.
Module-4	Advanced pilot contamination mitigation and blind/semi-blind channel estimation.
	Distributed MMSE processing, user scheduling and scalable precoding algorithms.
Module-5	mmWave/THz Massive MIMO, hybrid beamforming and hardware-efficient architectures.
	Cell-free Massive MIMO, RIS, XL-MIMO, integrated sensing and AI/ML for 6G.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the architecture, operating principles and fundamental performance characteristics of Massive MIMO systems.
CO2	Analyze channel estimation, spatial correlation, channel hardening, favorable propagation and pilot contamination.
CO3	Apply and compare MR, ZF, MMSE and regularized-ZF detection/precoding techniques for multiuser systems.
CO4	Evaluate spectral efficiency, energy efficiency and robustness under practical hardware and propagation constraints.
CO5	Design and simulate an advanced Massive MIMO application and interpret results for 5G-Advanced/6G wireless systems.

Text Books	
1	Marzetta, T. L., Larsson, E. G., Yang, H., Ngo, H. Q., Fundamentals of Massive MIMO, Cambridge University Press, 2016.
2	Emil Björnson, Jakob Hoydis and Luca Sanguinetti, Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency, Foundations and Trends in Signal Processing, 2017.

Reference Books	
1	Lu, L., Li, G. Y., Swindlehurst, A. L., Ashikhmin, A., Zhang, R., "An Overview of Massive MIMO: Benefits and Challenges," IEEE Journal of Selected Topics in Signal Processing, 2014.

2	Hoydis, J., ten Brink, S., Debbah, M., "Massive MIMO in the UL/DL of Cellular Networks: How Many Antennas Do We Need?", IEEE JSAC, 2013.
3	Larsson, E. G., Edfors, O., Tufvesson, F., Marzetta, T. L., "Massive MIMO for Next Generation Wireless Systems," IEEE Communications Magazine, 2014.

Web links and Video Lectures (e – Resources)	
1	IEEE Xplore – Massive MIMO research and tutorial papers: https://ieeexplore.ieee.org/
2	Wireless Communications Research Laboratory / Massive MIMO educational resources: https://massivemimo.net/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	1
CO2	3	3	2	2	1	1
CO3	3	3	3	2	2	1
CO4	2	3	3	3	2	1
CO5	2	3	3	3	3	2

Semester: II						
Error Control Coding						
Course Code	**:**	1MLDN202		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Communication, Probability and Random Processes, Linear Algebra
Knowledge on Fundamental Concepts	Fundamentals of digital communication, binary arithmetic, matrices and probability
Knowledge on Connected Tools (If any)	MATLAB/Python (optional) for coding and decoding simulations

Course Learning Objectives: This course will enable the students to	
CLO1	Explain information-theoretic concepts and algebraic foundations used in error-control coding.
CLO2	Analyze and design linear block codes for error detection and correction.
CLO3	Construct and decode cyclic and BCH codes using polynomial and finite-field methods.
CLO4	Apply Reed–Solomon and convolutional coding and explain their decoding algorithms.
CLO5	Evaluate modern coding techniques and their applications in communication and storage systems.

Module – 1	**08 Hrs**
Introduction to error control coding; redundancy and reliability; entropy, conditional entropy and mutual information; discrete memoryless channels; channel capacity and channel coding theorem; groups, fields and vector spaces; binary field arithmetic; Galois fields GF(2^m).	
Module – 2	**08 Hrs**
Block-code parameters; Hamming weight and distance; generator and parity-check matrices; systematic encoding; minimum distance and error-correction capability; syndrome calculation and decoding; standard array; Hamming codes; coding bounds and applications.	
Module – 3	**08 Hrs**
Polynomial representation of codes; cyclic shifts; generator and parity-check polynomials; systematic cyclic encoding; syndrome computation; CRC; cyclic-code decoding; BCH code construction; designed distance; finite-field based decoding.	
Module – 4	**08 Hrs**
Reed–Solomon code properties and construction; encoding over GF(2^m); error-locator and error-evaluator polynomials; decoding overview; convolutional encoders; state and trellis diagrams; free distance; Viterbi algorithm and sequential decoding.	
Module – 5	**08 Hrs**
Turbo codes and iterative decoding; low-density parity-check (LDPC) codes; Tanner graphs; belief-propagation decoding; hard- and soft-decision decoding; interleaving; coding gain; applications in wireless, satellite communication and data storage.	

Topics for Self learning	
Module-1	Shannon limit and capacity of binary symmetric and AWGN channels.
	Finite-field arithmetic and primitive polynomials.
Module-2	Implementation of Hamming encoder and syndrome decoder.
	Comparison of cyclic codes and CRC error detection.
Module-3	Worked BCH decoding example using syndromes.
	Reed–Solomon applications in QR codes and storage.
Module-4	Viterbi decoding using a trellis diagram.
	Soft-decision versus hard-decision decoding.
Module-5	LDPC Tanner-graph construction and iterative decoding.
	Comparison of coding techniques in modern communication standards.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain information-theoretic and algebraic foundations of error-control coding.
CO2	Design and analyze linear block codes and determine their error-control capability.
CO3	Construct and decode cyclic and BCH codes using polynomial and finite-field techniques.
CO4	Analyze Reed–Solomon and convolutional codes and apply suitable decoding algorithms.
CO5	Evaluate modern error-control coding methods and identify their communication and storage applications.

	Text Books
1	Shu Lin and Daniel J. Costello Jr., Error Control Coding: Fundamentals and Applications, 2nd ed., Pearson, 2004.
2	Todd K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley, 2005.

Reference Books	
1	Richard E. Blahut, Algebraic Codes for Data Transmission, Cambridge University Press, 2003.
2	W. E. Ryan and S. Lin, Channel Codes: Classical and Modern, Cambridge University Press, 2009.
3	Robert H. Morelos-Zaragoza, The Art of Error Correcting Coding, 2nd ed., Wiley, 2006.

Web links and Video Lectures (e – Resources)	
1	MIT OpenCourseWare – Information Theory and Coding: https://ocw.mit.edu/
2	Error Control Coding resources and lecture materials: https://nptel.ac.in/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	—
CO2	3	3	2	2	2	—
CO3	3	3	2	2	1	—
CO4	3	3	2	2	2	—
CO5	2	3	3	2	3	—

Semester: II						
Multimedia Applications						
Course Code	**:**	1MLDN203		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Computer Networks, Digital Signal Processing, Programming Fundamentals
Knowledge on Fundamental Concepts	Basic knowledge of data representation, digital media, networks and programming
Knowledge on Connected Tools (If any)	Computer with multimedia authoring/editing tools; MATLAB/Python or equivalent (optional)

Course Learning Objectives: This course will enable the students to	
CLO1	Explain multimedia concepts, media types, characteristics and multimedia system architectures.
CLO2	Analyze digital audio, image and video representation, compression and coding techniques.
CLO3	Describe multimedia communication, networking protocols, synchronization and quality-of-service requirements.
CLO4	Apply multimedia authoring, storage, retrieval and streaming concepts to application development.
CLO5	Evaluate multimedia applications and emerging trends with respect to performance, usability and delivery.

Module – 1	**08 Hrs**
Introduction to multimedia; elements and characteristics of multimedia; applications and requirements; multimedia systems architecture; media representation; text, graphics, images, audio, video and animation; multimedia hardware and software; multimedia data formats; media acquisition, digitization, sampling and quantization.	
Module – 2	**08 Hrs**
Digital audio representation; audio sampling and quantization; audio coding concepts; image representation and color models; image enhancement fundamentals; video representation and frame formats; spatial and temporal redundancy; image and video compression principles; JPEG, MPEG family and contemporary codecs (overview).	
Module – 3	**08 Hrs**
Multimedia networking requirements; packet-switched networks; Internet protocols for multimedia; RTP, RTCP, SIP and streaming protocols; client-server and peer-to-peer delivery; multimedia transport; delay, jitter, packet loss and bandwidth; Quality of Service (QoS); admission control; error resilience and congestion considerations.	
Module – 4	**08 Hrs**
Multimedia database concepts; metadata and indexing; content-based retrieval fundamentals; multimedia file systems and storage; media servers; on-demand and live streaming; buffering and adaptive bitrate streaming; synchronization of audio, video and data; multimedia authoring and integration; web and mobile multimedia delivery.	
Module – 5	**08 Hrs**
Multimedia application design and development; interactive multimedia and user interfaces; web and mobile multimedia; video conferencing and collaborative systems; e-learning, telemedicine, digital entertainment and surveillance applications; immersive media (AR/VR); 360-degree video; cloud and edge multimedia; AI-enabled media analysis and personalization;	

evaluation of multimedia quality and user experience.

Topics for Self learning	
Module-1	Compare common multimedia file formats and their use cases.
	Explore sampling rate, bit depth and audio file size calculations.
Module-2	Study RGB, HSV and YCbCr color models with sample images.
	Compare JPEG and video compression workflows.
Module-3	Examine the role of RTP and RTCP in real-time media delivery.
	Investigate the effect of delay, jitter and packet loss on streaming.
Module-4	Prepare a short report on metadata and content-based multimedia retrieval.
	Demonstrate buffering and adaptive streaming using a sample platform.
Module-5	Compare multimedia delivery for mobile, web and smart-TV platforms.
	Review an application of AR/VR or AI-based multimedia processing.

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe multimedia components, data types, formats and system architectures.
CO2	Explain audio, image and video representation and analyze basic compression concepts.
CO3	Identify multimedia network protocols and analyze delivery requirements including QoS.
CO4	Explain multimedia storage, retrieval, synchronization and streaming mechanisms.
CO5	Assess multimedia application designs and emerging technologies for specific use cases.

Text Books	
1	Ralf Steinmetz and Klara Nahrstedt, Multimedia: Computing, Communications and Applications, Pearson.
2	Fred Halsall, Multimedia Communications: Applications, Networks, Protocols and Standards, Addison-Wesley.

Reference Books	
1	John F. Koegel Buford (Ed.), Multimedia Systems, ACM Press.
2	Nalin K. Sharda, Multimedia Information Networking, Prentice Hall.
3	Tay Vaughan, Multimedia: Making It Work, 9th ed., McGraw-Hill.

Web links and Video Lectures (e – Resources)	
1	ITU-T Recommendations (multimedia coding and communication): https://www.itu.int/rec/
2	NPTEL – Multimedia Systems / Multimedia Communication course resources: https://nptel.ac.in/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	—
CO2	3	3	2	2	2	—
CO3	3	3	2	2	1	—
CO4	3	3	2	2	2	—
CO5	2	3	3	2	3	—

Semester: II						
Antenna Theory						
Course Code	**:**	1MLDN204		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Electromagnetic Field Theory, Vector Calculus, Engineering Mathematics
Knowledge on Fundamental Concepts	Fundamentals of electromagnetic waves, Maxwell's equations, transmission lines and phasor analysis
Knowledge on Connected Tools (If any)	MATLAB/Python or antenna simulation software (optional)

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the fundamental principles of radiation, antenna parameters and electromagnetic field behavior.
CLO2	Analyze wire, loop, aperture and array antennas using appropriate field and circuit models.
CLO3	Evaluate antenna arrays, radiation patterns, polarization, impedance and bandwidth characteristics.
CLO4	Describe antenna measurement techniques and the effects of propagation environments.
CLO5	Apply antenna theory to the analysis and selection of antennas for modern wireless systems.

Module – 1	**08 Hrs**
Review of electromagnetic field theory; Maxwell's equations and wave equation; radiation mechanism; retarded potentials; radiation from elementary current element (Hertzian dipole); near-field and far-field regions; radiation pattern; radiation intensity; directivity, gain, efficiency, beamwidth, bandwidth and effective aperture; reciprocity and Friis transmission equation.	
Module – 2	**08 Hrs**
Infinitesimal and finite dipoles; half-wave dipole; monopole antennas; current distribution and radiation resistance; input impedance; folded dipole; small loop and circular loop antennas; helical antenna; antenna loading and matching concepts.	
Module – 3	**08 Hrs**
Two-element and N-element arrays; array factor; pattern multiplication; uniform and non-uniform excitation; broadside and end-fire arrays; binomial and Dolph–Tschebyscheff arrays; beam steering; phased arrays; mutual coupling; sidelobe control and array synthesis.	
Module – 4	**08 Hrs**
Huygens' principle and aperture radiation; slot antennas; horn antennas; reflector antennas; microstrip patch antennas; antenna bandwidth and impedance matching; broadband and frequency-independent antennas; log-periodic and spiral antennas; introduction to dielectric resonator antennas.	
Module – 5	**08 Hrs**
Antenna measurement ranges and anechoic chambers; radiation pattern and gain measurement; impedance and VSWR measurement; polarization and axial ratio; antenna factor; near-field and far-field measurement; ground and environmental effects; link budget basics; antenna selection for cellular, satellite, radar, WLAN, IoT and emerging communication systems.	

Topics for Self learning	
Module-1	Derive the far-field expressions for a Hertzian dipole.
	Compare half-wave dipole and monopole antenna characteristics.
Module-2	Study the radiation pattern and impedance of loop antennas.
	Simulate two-element arrays with different element spacing and phase.
Module-3	Compare broadside, end-fire and phased-array configurations.
	Explore sidelobe reduction using amplitude tapering.
Module-4	Study the effect of substrate parameters on microstrip patch antennas.
	Compare horn, reflector and slot antenna applications.
Module-5	Prepare a report on antenna measurement setups and calibration.
	Review antenna design considerations for 5G, satellite or IoT applications.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain radiation mechanisms and determine fundamental antenna parameters.
CO2	Analyze the radiation and impedance characteristics of wire and loop antennas.
CO3	Determine array factors and evaluate antenna-array radiation patterns and synthesis methods.
CO4	Explain the operating principles and characteristics of aperture, patch and broadband antennas.
CO5	Describe antenna measurement methods and relate antenna characteristics to communication applications.

	Text Books
1	Constantine A. Balanis, Antenna Theory: Analysis and Design, 4th ed., Wiley, 2016.
2	John D. Kraus and Ronald J. Marhefka, Antennas for All Applications, 3rd ed., McGraw-Hill, 2002.

Reference Books	
1	Warren L. Stutzman and Gary A. Thiele, Antenna Theory and Design, 3rd ed., Wiley, 2012.
2	Robert S. Elliott, Antenna Theory and Design, Revised ed., Wiley-IEEE Press, 2003.
3	R. C. Johnson (Ed.), Antenna Engineering Handbook, 4th ed., McGraw-Hill, 2007.

Web links and Video Lectures (e – Resources)	
1	IEEE Antennas and Propagation Society: https://www.ieeeaps.org/
2	NPTEL – Antennas and Wave Propagation course resources: https://nptel.ac.in/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	—
CO2	3	3	3	2	2	—
CO3	3	3	3	2	2	—
CO4	2	3	2	3	2	—
CO5	2	3	3	2	3	—

Semester: II						
RF System Design						
Course Code	**:**	1MLDN205A		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Electromagnetic Field Theory, Analog and Digital Communication
Knowledge on Fundamental Concepts	Basic knowledge of electromagnetics, circuit analysis, transmission lines and frequency-domain concepts
Knowledge on Connected Tools (If any)	MATLAB/Python and RF circuit simulation software (e.g., ADS, AWR or equivalent; optional)

Course Learning Objectives: This course will enable the students to	
CLO1	Explain RF system parameters, high-frequency circuit behavior and RF transceiver architectures.
CLO2	Analyze transmission lines, scattering parameters and impedance-matching networks for RF applications.
CLO3	Design and evaluate RF passive components including filters, couplers, power dividers and attenuators.
CLO4	Analyze RF active circuits such as amplifiers, mixers and oscillators using gain, noise, stability and linearity measures.
CLO5	Apply RF system design principles to communication front ends and evaluate performance using simulation or measurement.

Module – 1	**08 Hrs**
Introduction to RF system design and wireless transceivers; RF spectrum and frequency bands; transmitter and receiver architectures; RF system specifications; gain, noise figure, sensitivity, dynamic range, 1-dB compression point, IIP3 and spurious-free dynamic range; high-frequency behavior of resistors, capacitors and inductors; transmission-line equations; characteristic impedance, reflection coefficient, VSWR, return loss and insertion loss; microstrip and other planar transmission lines; Smith chart; scattering (S), ABCD and impedance parameters.	
Module – 2	**08 Hrs**
Impedance matching fundamentals; lumped-element and distributed matching networks; single-stub and double-stub tuning; quarter-wave transformers; matching bandwidth and quality factor; resonators; RF and microwave filter specifications; low-pass, high-pass, band-pass and band-stop filters; Butterworth and Chebyshev responses; lumped and distributed filter realizations; impedance transformers; power dividers and combiners; branch-line and coupled-line couplers; hybrids, isolators and circulators; attenuators and RF switches.	
Module – 3	**08 Hrs**
RF transistor models and high-frequency device parameters; two-port amplifier analysis; gain definitions and gain circles; stability factors and stability circles; unconditional and conditional stability; conjugate matching; maximum-gain and specified-gain design; noise in RF circuits; noise figure and cascaded noise figure; low-noise amplifier (LNA) design; broadband and distributed amplifiers; power amplifier classes and efficiency; gain compression, intermodulation distortion, linearity and power-added efficiency.	
Module – 4	**08 Hrs**

Frequency conversion and mixer fundamentals; conversion gain/loss; image frequency and rejection; single-balanced and double-balanced mixers; active and passive mixer concepts; oscillator principles and feedback; resonator-based oscillators; negative-resistance oscillators; voltage-controlled oscillators (VCOs); frequency stability and phase noise; phase-locked loops (PLLs); phase detectors, loop filters and frequency dividers; integer-N frequency synthesizers; RF frequency planning and spurious responses.
Module – 5 **08 Hrs**
RF front-end architecture and link budget; cascaded gain and noise calculations; receiver sensitivity and dynamic-range budgeting; transmitter output power and spectral requirements; duplexers and front-end filtering; RFIC and microwave integrated circuit (MIC/MMIC) overview; layout and packaging effects, parasitics, grounding and shielding; RF system simulation workflow; S-parameter and noise simulation; harmonic-balance and transient analysis overview; design trade-offs among noise, linearity, gain, power and bandwidth; RF testing and measurement fundamentals; applications in cellular, WLAN, satellite, radar and IoT systems.

Topics for Self learning	
Module-1	Calculate link budget and receiver sensitivity for a sample wireless link.
	Use a Smith chart to solve impedance-matching problems.
Module-2	Compare lumped and distributed matching network implementations.
	Design a basic RF filter and examine its frequency response.
Module-3	Analyze a two-port RF amplifier using S-parameters and stability criteria.
	Estimate cascaded noise figure and third-order intercept point.
Module-4	Compare mixer topologies and evaluate conversion loss and image response.
	Explore phase noise and frequency stability in an oscillator.
Module-5	Simulate a simple RF front-end chain and document gain/noise budgets.
	Review RF design considerations for a selected cellular, WLAN, satellite or IoT application.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain RF system specifications, transceiver architectures and high-frequency circuit behavior.
CO2	Analyze transmission-line networks and design impedance-matching circuits using suitable methods.
CO3	Design and assess RF passive networks such as filters, couplers and power dividers.
CO4	Evaluate RF amplifiers, mixers and oscillators in terms of gain, noise, stability and linearity.
CO5	Develop and assess an RF front-end design using system-level calculations, simulation and measurement concepts.

Text Books	
1	David M. Pozar, Microwave Engineering, 4th ed., John Wiley & Sons, 2012.
2	Reinhold Ludwig and Pavel Bretchko, RF Circuit Design: Theory and Applications, 2nd ed., Prentice Hall, 2000.

Reference Books	
1	C. Bowick, RF Circuit Design, 2nd ed., Newnes, 2007.
2	Guillermo Gonzalez, Microwave Transistor Amplifiers: Analysis and Design, 2nd ed., Prentice Hall, 1996.

3	Thomas H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, 2nd ed., Cambridge University Press, 2004.

Web links and Video Lectures (e – Resources)	
1	NPTEL – RF and Microwave Engineering course resources: https://nptel.ac.in/
2	IEEE Microwave Theory and Technology Society: https://mtt.org/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	—
CO2	3	3	3	2	2	—
CO3	3	3	3	2	2	—
CO4	3	3	3	2	2	—
CO5	2	3	3	3	3	—

Semester: II						
Wireless Sensor Networks						
Course Code	**:**	1MLDN205B		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Wireless Communication, Computer Networks, Embedded Systems (basic)
Knowledge on Fundamental Concepts	Basic understanding of wireless communication, networking, digital systems and data communication
Knowledge on Connected Tools (If any)	Computer with network simulation tools; sensor nodes/Arduino or equivalent (optional)

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the architecture, components, design goals and applications of wireless sensor networks.
CLO2	Analyze sensor-node hardware, wireless communication characteristics and energy constraints.
CLO3	Compare medium access control and routing protocols used in wireless sensor networks.
CLO4	Explain data dissemination, aggregation, localization, coverage and quality-of-service mechanisms.
CLO5	Evaluate security, reliability and application-specific design issues in wireless sensor networks.

Module – 1	**08 Hrs**
Introduction, motivation and history of WSNs; characteristics, applications and requirements; comparison with mobile ad hoc networks; challenges and design factors; sensor-network architecture and protocol stack; single-node architecture; sensor-node hardware components (sensing, processing, communication and power units); sensor platforms and operating systems; energy consumption and resource constraints; deployment models and performance metrics.	
Module – 2	**08 Hrs**
Wireless channel characteristics; radio propagation, path loss, fading and interference; physical-layer considerations and transceiver design; MAC design goals and challenges; contention-based, schedule-based and hybrid MAC protocols; duty cycling, sleep/wake scheduling and low-power listening; S-MAC, T-MAC and B-MAC; IEEE 802.15.4 MAC; Zigbee overview; link quality and energy-efficient communication	
Module – 3	**08 Hrs**
Routing challenges and design issues; data-centric, hierarchical, location-based and QoS-aware routing; flooding and gossiping; directed diffusion; sensor protocols for information via negotiation (SPIN); cluster-based routing and LEACH overview; geographic and energy-aware routing; data gathering and dissemination; in-network processing; aggregation and duplicate suppression; topology control and network scalability.	
Module – 4	**08 Hrs**
Localization and positioning; range-based and range-free techniques; triangulation, trilateration and beacon-based methods; time synchronization; sensing coverage and network connectivity; deployment and topology control; QoS requirements and performance metrics; reliability, latency and packet delivery; energy-management techniques; power control, duty cycling, energy harvesting overview; fault tolerance and network lifetime optimization.	

Module – 5	08 Hrs
Security requirements and threat models; common attacks and countermeasures; key management, authentication, confidentiality and integrity; lightweight security protocols and SPINS overview; middleware and operating-system support; sensor-network programming and simulation tools; gateway concepts and WSN–Internet integration; sensor web and IoT convergence; applications in environmental monitoring, healthcare, agriculture, industrial automation and smart infrastructure; emerging research trends.	

Topics for Self learning	
Module-1	Compare WSN and MANET architectures and application requirements.
	Prepare a sensor-node block diagram and estimate its energy budget.
Module-2	Compare IEEE 802.15.4, Zigbee and other low-power wireless technologies.
	Study duty-cycled MAC protocols and their energy/latency trade-offs.
Module-3	Compare data-centric, hierarchical and geographic routing approaches.
	Illustrate data aggregation and dissemination using a sample network.
Module-4	Work through a simple range-based or range-free localization example.
	Evaluate coverage, connectivity and network lifetime for a deployment scenario.
Module-5	Identify security threats and suitable lightweight countermeasures for a WSN.
	Review a real-world WSN application and summarize its architecture and constraints.

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe WSN architecture, components, design goals, constraints and applications.
CO2	Analyze wireless channel and sensor-node characteristics with emphasis on energy use.
CO3	Compare and select suitable MAC and routing protocols for given WSN requirements.
CO4	Explain and assess data dissemination, localization, coverage, QoS and energy-management techniques.
CO5	Identify security and reliability concerns and evaluate WSN solutions for practical applications.

Text Books	
1	Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, 2005.
2	Waltenegus Dargie and Christian Poellabauer, Fundamentals of Wireless Sensor Networks: Theory and Practice, John Wiley & Sons, 2010.

Reference Books	
1	Feng Zhao and Leonidas J. Guibas, Wireless Sensor Networks: An Information Processing Approach, Morgan Kaufmann, 2004.
2	Kazem Sohraby, Daniel Minoli and Taieb Znati, Wireless Sensor Networks: Technology, Protocols, and Applications, Wiley, 2007.
3	C. Siva Ram Murthy and B. S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, 2nd ed., Pearson, 2008.

Web links and Video Lectures (e – Resources)	
1	IEEE 802.15 Working Group (Wireless Personal Area Networks): https://www.ieee802.org/15/
2	NPTEL – Wireless Sensor Networks and IoT course resources: https://nptel.ac.in/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	—
CO2	3	3	3	2	2	—
CO3	3	3	3	2	2	—
CO4	2	3	3	3	2	—
CO5	2	3	3	2	3	—

Semester: II						
Advances in Image Processing						
Course Code	**:**	1MLDN205C		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Image Processing, Linear Algebra, Probability and Programming
Knowledge on Fundamental Concepts	Fundamentals of digital images, transforms, filtering and basic image analysis
Knowledge on Connected Tools (If any)	Python/MATLAB with image-processing libraries or equivalent tools (optional)

Course Learning Objectives: This course will enable the students to	
CLO1	Analyze advanced image representation, transforms and multi-resolution processing methods.
CLO2	Apply advanced enhancement, denoising, restoration and reconstruction techniques to digital images.
CLO3	Evaluate image segmentation, registration and feature-extraction methods for image analysis.
CLO4	Explain advanced image compression, color and multi-spectral image-processing techniques.
CLO5	Apply machine-learning-based image analysis methods and assess their performance in practical applications.

Module – 1	**08 Hrs**
Review of image formation, sensing, sampling and quantization; imaging geometry and pixel relationships; 2-D signals and systems; 2-D convolution and correlation; 2-D Discrete Fourier Transform (DFT) and FFT; Discrete Cosine Transform (DCT); Walsh–Hadamard, Haar and wavelet transforms; Karhunen–Loève transform; scale-space and multi-resolution representation; image pyramids.	
Module – 2	**08 Hrs**
Advanced point and histogram operations; spatial and frequency-domain enhancement; linear and nonlinear filtering; adaptive and edge-preserving smoothing; noise models and estimation; denoising methods; degradation and restoration models; inverse, Wiener and constrained least-squares filtering; deblurring and blind deconvolution; image reconstruction from projections; quality metrics including MSE, PSNR and structural similarity (SSIM).	
Module – 3	**08 Hrs**
Advanced edge and boundary detection; global, adaptive and Otsu thresholding; region growing, splitting and merging; watershed, graph-cut and clustering-based segmentation; Markov random field concepts; mathematical morphology and grayscale morphology; image registration and alignment; geometric transformations; feature correspondence; similarity measures and registration evaluation.	
Module – 4	**08 Hrs**
Texture analysis and descriptors; boundary and region descriptors; shape representation; SIFT, SURF, ORB and HOG feature descriptors; dimensionality reduction and feature selection; image classification fundamentals; lossless and lossy compression; Huffman and arithmetic coding; transform and wavelet coding; JPEG and JPEG 2000 overview; color models and transformations; color enhancement and segmentation; multispectral and hyperspectral image-processing fundamentals.	

Module – 5	08 Hrs
Machine-learning workflow for image analysis; dataset preparation, augmentation and evaluation; classical statistical classifiers; introduction to neural networks and convolutional neural networks; transfer learning overview; deep-learning-based image classification, object detection and semantic segmentation; image fusion and super-resolution; medical, remote-sensing, industrial and surveillance applications; explainability, robustness, computational considerations and responsible use of image-analysis systems.	

Topics for Self learning	
Module-1	Implement 2-D DFT and compare frequency-domain filtering with spatial filtering.
	Compare wavelet transforms for multi-resolution image representation.
Module-2	Evaluate adaptive denoising filters on images corrupted by different noise models.
	Compare inverse, Wiener and constrained least-squares restoration.
Module-3	Experiment with Otsu thresholding, watershed and graph-based segmentation.
	Study image registration using feature matching and geometric transformation.
Module-4	Extract and compare SIFT, ORB and HOG features on sample images.
	Compare JPEG and JPEG 2000 compression in terms of quality and file size.
Module-5	Explore color-space selection for a color image-segmentation task.
	Develop a small image-classification or segmentation experiment and report evaluation metrics.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain advanced image representations, transforms and multi-resolution techniques.
CO2	Select and apply enhancement, denoising and restoration methods for image-quality improvement.
CO3	Analyze and compare segmentation, registration and morphological image-processing techniques.
CO4	Apply feature extraction, compression and color-processing methods to image-analysis problems.
CO5	Evaluate machine-learning-based image-processing approaches for selected real-world applications.

Text Books	
1	Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th ed., Pearson, 2018.
2	Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989.

Reference Books	
1	Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, Digital Image Processing Using MATLAB, 3rd ed., Gatesmark, 2020.
2	Scott E. Umbaugh, Digital Image Processing and Analysis: Computer Vision and Image Analysis, CRC Press.
3	Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd ed., Springer, 2022.

Web links and Video Lectures (e – Resources)	
1	NPTEL – Image Processing and Computer Vision course resources: https://nptel.ac.in/
2	OpenCV Documentation – Image Processing: https://docs.opencv.org/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	—
CO2	3	3	3	2	2	—
CO3	3	3	3	2	2	—
CO4	2	3	3	2	2	—
CO5	2	3	3	3	3	—

Semester: II						
Statistical Signal Processing						
Course Code	**:**	1MLDN205D		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Probability and Random Variables; Linear Algebra; Random Processes; Digital Signal Processing
Knowledge on Fundamental Concepts	Knowledge of probability distributions, correlation, Fourier analysis, and linear systems
Knowledge on Connected Tools (If any)	MATLAB/Python for numerical computation and signal analysis

Course Learning Objectives: This course will enable the students to	
CLO1	Explain stochastic processes, stationarity, ergodicity, and statistical descriptions of random signals.
CLO2	Analyze power spectral density and model random signals using parametric and non-parametric methods.
CLO3	Formulate signal detection problems and evaluate decision rules under noise.
CLO4	Apply classical and Bayesian methods for parameter estimation and assess estimator performance.
CLO5	Design and analyze Wiener, Kalman, and adaptive filtering techniques for signal processing applications.

Module – 1	**08 Hrs**
Random Processes and Statistical Characterization: Review of probability, random variables and random vectors; discrete-time stochastic processes; ensemble and time averages; strict-sense and wide-sense stationarity; cyclostationarity and ergodicity; autocorrelation and cross-correlation; linear systems with random inputs; covariance matrices and their properties.	
Module – 2	**08 Hrs**
Spectral Analysis and Random Signal Modeling: Power spectral density and its properties; Wiener–Khinchin theorem; cross-power spectral density; spectral factorization; white-noise synthesis; linear prediction; non-parametric spectral estimation using periodogram and modified periodogram; parametric models: AR, MA and ARMA; Yule Walker equations.	
Module – 3	**08 Hrs**
Detection Theory: Detection problem formulation; binary and M-ary hypothesis testing; likelihood ratio tests; Neyman–Pearson, Bayesian and minimax criteria; false alarm and detection probabilities; receiver operating characteristics; detection of known signals in Gaussian noise; composite hypotheses and generalized likelihood ratio test.	
Module – 4	**08 Hrs**
Parameter Estimation Theory: Estimation problem and estimator properties: bias, variance, consistency and mean-square error; sufficient statistics; maximum likelihood and least-squares estimation; minimum variance unbiased estimation; Bayesian, MAP and MMSE estimation; Fisher information and Cramér–Rao lower bound; estimation of sinusoidal and random signal parameters.	
Module – 5	**08 Hrs**

Optimal and Adaptive Filtering: Orthogonality principle; Wiener–Hopf equations and Wiener filtering; linear prediction and Levinson–Durbin algorithm; Kalman filtering and state-space models; adaptive filtering; steepest-descent method; LMS and normalized LMS algorithms; recursive least squares (RLS); convergence and applications in tracking, noise cancellation and communications.

Topics for Self learning	
Module-1	Simulation of stationary and non-stationary random sequences.
	Estimation of mean, autocorrelation and covariance from finite data.
Module-2	PSD estimation using periodogram and Welch methods.
	AR model identification using Yule–Walker equations.
Module-3	ROC curves and threshold selection for binary detection.
	Detection of a sinusoid in additive white Gaussian noise.
Module-4	Compare ML, MAP and MMSE estimators for a simple parameter.
	Numerical evaluation of the Cramér–Rao lower bound.
Module-5	Implement a Wiener filter for noise reduction.
	Compare LMS and RLS convergence for system identification.

Course Outcomes: After completing the course, the students will be able to	
CO1	Characterize random signals using statistical measures and stochastic-process properties.
CO2	Estimate and interpret spectral characteristics and fit random signal models.
CO3	Develop and evaluate statistical signal detectors for noisy observations.
CO4	Select and apply suitable estimation methods and quantify estimation accuracy.
CO5	Implement optimal and adaptive filters and interpret their performance.

Text Books	
1	S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993.
2	M. H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley, 1996.

Reference Books	
1	S. M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998.
2	H. V. Poor, An Introduction to Signal Detection and Estimation, 2nd ed., Springer, 1994.
3	S. Haykin, Adaptive Filter Theory, 5th ed., Pearson, 2014.

Web links and Video Lectures (e – Resources)	
1	IIT Guwahati – Statistical Signal Processing: https://www.iitg.ac.in/eee/syllabus-details.php
2	NPTEL – Digital Signal Processing / Statistical Signal Processing course resources: https://nptel.ac.in/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	--	--	--
CO2	2	3	2	1	--	--
CO3	2	3	3	2	--	--
CO4	2	3	3	2	1	--
CO5	2	3	3	2	2	1

Semester: II						
Wavelet Transforms and Applications						
Course Code	**:**	1MLDN206A		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Signal Processing; Linear Algebra; Fourier Analysis
Knowledge on Fundamental Concepts	Knowledge of signals and systems, transforms, sampling, and basic programming
Knowledge on Connected Tools (If any)	MATLAB/Python for signal and image processing

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the mathematical foundations and properties of continuous and discrete wavelet transforms.
CLO2	Analyze multiresolution representations and construct wavelet filter banks.
CLO3	Apply wavelet-based methods for denoising, compression, and feature extraction.
CLO4	Evaluate wavelet packet and time-frequency methods for non-stationary signals.
CLO5	Implement wavelet techniques in signal, image, biomedical, and communication applications.

Module – 1	**08 Hrs**
Foundations of Wavelet Transforms: Motivation and limitations of Fourier analysis; time-frequency localization; basis functions and scaling; continuous wavelet transform (CWT); admissibility condition; wavelet families; dyadic wavelets; discrete wavelet transform (DWT); inverse transforms and reconstruction.	
Module – 2	**08 Hrs**
Multiresolution Analysis and Filter Banks: Multiresolution analysis (MRA); scaling and wavelet spaces; two-scale equations; orthogonality and biorthogonality; quadrature mirror filters; analysis and synthesis filter banks; perfect reconstruction; Haar, Daubechies, Symlets and Coiflets; boundary handling.	
Module – 3	**08 Hrs**
Wavelet Design and Advanced Representations: Wavelet construction and properties; vanishing moments; regularity and support; lifting scheme; wavelet packets and best-basis selection; stationary/undecimated wavelet transform; dual-tree complex wavelets; 2-D wavelet transform and separable decomposition.	
Module – 4	**08 Hrs**
Wavelet-Based Signal and Image Processing: Wavelet-domain thresholding; hard and soft thresholding; noise estimation and denoising; wavelet-based compression and rate-distortion; multiscale edge detection; texture analysis; feature extraction; image fusion and restoration; performance measures.	
Module – 5	**08 Hrs**
Applications of Wavelets: Analysis of non-stationary and transient signals; biomedical signal analysis (ECG/EEG); fault and condition monitoring; speech and audio processing; communications and channel analysis; image/video applications; wavelets in numerical methods and machine learning; case studies and implementation.	

Topics for Self learning	
Module-1	Compare time-frequency localization of Fourier, STFT and wavelet methods.
	Plot common mother wavelets and examine their properties.
Module-2	Implement CWT scalograms for chirp and transient signals.
	Perform multilevel DWT and reconstruct a signal.
Module-3	Compare Haar and Daubechies filter-bank outputs.
	Study boundary effects and perfect reconstruction.
Module-4	Implement wavelet packet decomposition and basis selection.
	Compare hard and soft thresholding for noisy signals.
Module-5	Compress a test image using 2-D DWT and measure PSNR.
	Analyze an ECG or vibration signal using wavelet coefficients.

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe wavelet transform principles and select suitable wavelet representations.
CO2	Analyze MRA structures and implement perfect-reconstruction filter banks.
CO3	Design or select wavelets based on signal characteristics and application needs.
CO4	Apply wavelet methods to denoising, compression, and multiscale feature extraction.
CO5	Develop and assess wavelet-based solutions for practical engineering signals and images.

	Text Books
1	I. Daubechies, Ten Lectures on Wavelets, SIAM, 1992.
2	S. Mallat, A Wavelet Tour of Signal Processing: The Sparse Way, 3rd ed., Academic Press, 2009.

Reference Books	
1	C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.
2	M. Vetterli and J. Kovačević, Wavelets and Subband Coding, Prentice Hall, 1995.
3	P. S. Addison, The Illustrated Wavelet Transform Handbook, 2nd ed., CRC Press, 2017.

Web links and Video Lectures (e – Resources)	
1	MathWorks – Wavelet Toolbox documentation: https://www.mathworks.com/help/wavelet/
2	PyWavelets documentation: https://pywavelets.readthedocs.io/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	--	--	--
CO2	2	3	2	1	--	--
CO3	2	3	3	2	--	--
CO4	2	3	3	2	2	--
CO5	2	3	3	3	2	1

Semester: II						
Cloud Networking						
Course Code	**:**	1MLDN206B		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Computer Networks; Operating Systems; Basic Cloud Computing concepts
Knowledge on Fundamental Concepts	Knowledge of TCP/IP, routing, virtualization, and network security fundamentals
Knowledge on Connected Tools (If any)	Basic Linux command line; familiarity with network simulation or cloud platforms

Course Learning Objectives: This course will enable the students to	
CLO1	Explain cloud networking architectures, service models, and virtualized network components.
CLO2	Analyze cloud data-center networks, addressing, routing, and traffic engineering mechanisms.
CLO3	Configure and evaluate virtual networks, software-defined networking, and network functions.
CLO4	Assess cloud network security, connectivity, performance, and reliability.
CLO5	Design cloud networking solutions for scalable, resilient, and distributed applications.

Module – 1	**08 Hrs**
Cloud Networking Fundamentals and Architecture: Cloud computing overview and networking requirements; IaaS, PaaS and SaaS networking; cloud regions, zones and edge locations; data-center network architecture; underlay and overlay networks; virtualization, virtual switches and virtual NICs; cloud network reference models; public, private, hybrid and multi-cloud connectivity.	
Module – 2	**08 Hrs**
Virtual Networks, Addressing and Routing: Virtual private cloud (VPC/VNet) concepts; subnetting and CIDR; private and public IP addressing; route tables and gateways; virtual routing and switching; VLANs, VXLAN and tunneling; internet, NAT and egress connectivity; peering and transit networks; load balancing; DNS and service discovery.	
Module – 3	**08 Hrs**
Software-Defined and Programmable Cloud Networks: Software-defined networking (SDN) architecture; control and data planes; OpenFlow concepts; network virtualization and network slicing; APIs and infrastructure as code; network orchestration; virtual network functions (VNFs) and cloud-native network functions (CNFs); service chaining; Kubernetes networking, CNI and service meshes.	
Module – 4	**08 Hrs**
Cloud Network Security, Reliability and Performance: Shared-responsibility model; security groups, network ACLs and firewalling; segmentation and zero-trust principles; VPNs and dedicated connectivity; encryption in transit; DDoS mitigation; identity-aware access; redundancy and high availability; latency, throughput and congestion; QoS, monitoring, logging and troubleshooting.	
Module – 5	**08 Hrs**

Advanced Cloud Networking and Applications: Multi-region and hybrid-cloud network design; interconnection and WAN architectures; edge computing and content delivery networks; data-center fabrics and spine-leaf topology; cloud network automation and observability; cost and performance optimization; disaster recovery; case studies for enterprise, IoT, AI and distributed applications.

Topics for Self learning	
Module-1	Draw and compare public, private, hybrid and multi-cloud network architectures.
	Design a VPC/VNet with subnets, CIDR blocks and route tables.
Module-2	Explore virtual switches, overlays and VXLAN encapsulation.
	Configure route propagation, NAT and internet gateways in a lab environment.
Module-3	Study SDN control-plane and data-plane separation using a simple topology.
	Explore Kubernetes CNI networking and service discovery.
Module-4	Develop security-group and network-ACL rules for a sample application.
	Measure latency, throughput and packet loss across network paths.
Module-5	Create a high-availability network design across multiple zones.
	Prepare a multi-region connectivity and disaster-recovery case study.

Course Outcomes: After completing the course, the students will be able to	
CO1	Summarize cloud networking concepts and identify network components in cloud architectures.
CO2	Design addressing, routing and connectivity for virtual cloud networks.
CO3	Explain programmable networking and apply SDN and cloud-native networking concepts.
CO4	Analyze security, availability and performance requirements of cloud networks.
CO5	Develop and justify a scalable cloud network design for a given application scenario.

Text Books	
1	Thomas A. Limoncelli, Strata R. Chalup and Christina J. Hogan, The Practice of Cloud System Administration, 2nd ed., Addison-Wesley, 2014.
2	Thomas Erl, Ricardo Puttini and Zaigham Mahmood, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 2013.

Reference Books	
1	Russ White and Ethan Banks, Computer Networking Problems and Solutions, Addison-Wesley, 2018.
2	Paul Goransson and Chuck Black, Software Defined Networks: A Comprehensive Approach, 2nd ed., Morgan Kaufmann, 2016.
3	James Bond, The Enterprise Cloud: Best Practices for Transforming Legacy IT, O'Reilly Media, 2015.

Web links and Video Lectures (e – Resources)	
1	AWS – Amazon VPC documentation: https://docs.aws.amazon.com/vpc/
2	Microsoft Learn – Azure Virtual Network documentation: https://learn.microsoft.com/azure/virtual-network/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	--	--	--
CO2	2	3	3	2	--	--
CO3	2	3	3	3	2	--
CO4	2	3	2	3	2	1
CO5	3	3	3	3	2	2

Semester: II						
Array Signal Processing						
Course Code	**:**	1MLDN206C		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Digital Signal Processing; Linear Algebra; Probability and Random Processes
Knowledge on Fundamental Concepts	Knowledge of Fourier transforms, complex vectors and matrices, and random signal models
Knowledge on Connected Tools (If any)	MATLAB/Python for numerical computing and signal processing

Course Learning Objectives: This course will enable the students to	
CLO1	Explain array geometries, steering vectors, and the spatial characteristics of signals.
CLO2	Analyze beam patterns and evaluate beamforming methods for different array configurations.
CLO3	Apply statistical and adaptive techniques for direction-of-arrival (DOA) estimation.
CLO4	Evaluate high-resolution subspace methods and their assumptions and limitations.
CLO5	Design and assess array-processing solutions for radar, sonar, wireless communications, and sensor systems.

Module – 1	**08 Hrs**
Fundamentals of Sensor Arrays and Spatial Signal Models: Introduction to array signal processing; applications and motivation; array geometries: uniform linear, planar and circular arrays; narrowband and broadband signal models; steering vectors and array manifold; spatial frequency; beampatterns and array gain; grating lobes, side lobes and spatial aliasing; mutual coupling and calibration basics.	
Module – 2	**08 Hrs**
Conventional Beamforming and Array Design: Delay-and-sum beamforming; conventional beamformers; phase-shift and time-delay steering; main-lobe width and side-lobe control; windowing and shading; null steering; broadside and end-fire arrays; beam steering and scanning; broadband beamforming; design trade-offs in aperture, element spacing and number of sensors.	
Module – 3	**08 Hrs**
Statistical DOA Estimation: DOA estimation problem and signal/noise covariance matrices; sample covariance estimation; maximum likelihood DOA estimation; Bartlett and Capon/MVDR spatial spectrum; minimum variance distortionless response; performance measures and resolution; effects of finite snapshots, SNR and coherent sources.	
Module – 4	**08 Hrs**
High-Resolution Subspace Methods: Eigenvalue decomposition and signal/noise subspaces; MUSIC algorithm and pseudospectrum; Root-MUSIC; ESPRIT and rotational invariance; model order selection; spatial smoothing for coherent sources; forward-backward averaging; comparison of subspace methods and sensitivity to array imperfections.	
Module – 5	**08 Hrs**

Adaptive and Advanced Array Processing: Adaptive beamforming; LMS and RLS-based array adaptation; linearly constrained minimum variance (LCMV); robust beamforming and steering-vector mismatch; interference suppression and jammer nulling; sparse and compressive array processing; wideband and space-time adaptive processing overview; applications in radar, sonar, wireless and acoustic arrays.

Topics for Self learning	
Module-1	Plot steering vectors and array factors for a uniform linear array.
	Investigate element spacing effects and spatial aliasing.
Module-2	Compare beam patterns using uniform and tapered amplitude weights.
	Simulate beam steering and null placement for multiple sources.
Module-3	Estimate sample covariance matrices under different snapshot counts.
	Implement Bartlett and Capon DOA spectra for a simulated array.
Module-4	Implement MUSIC and examine resolution versus SNR and snapshots.
	Compare MUSIC and ESPRIT estimates for closely spaced sources.
Module-5	Study spatial smoothing for coherent signal sources.
	Simulate adaptive beamforming to suppress an interfering signal.

Course Outcomes: After completing the course, the students will be able to	
CO1	Develop spatial signal models and characterize the response of common sensor arrays.
CO2	Design and evaluate conventional beamformers and array configurations.
CO3	Apply statistical methods to estimate signal directions and assess estimation performance.
CO4	Implement high-resolution subspace algorithms for multi-source DOA estimation.
CO5	Evaluate adaptive and robust array-processing methods for practical applications.

Text Books	
1	H. L. Van Trees, Optimum Array Processing, Part IV of Detection, Estimation, and Modulation Theory, Wiley, 2002.
2	Don H. Johnson and Dan E. Dudgeon, Array Signal Processing: Concepts and Techniques, Prentice Hall, 1993.

Reference Books	
1	R. O. Schmidt, “Multiple Emitter Location and Signal Parameter Estimation,” IEEE Transactions on Antennas and Propagation, vol. 34, no. 3, pp. 276–280, 1986.
2	R. Roy and T. Kailath, “ESPRIT—Estimation of Signal Parameters via Rotational Invariance Techniques,” IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. 37, no. 7, pp. 984–995, 1989.
3	J. Capon, “High-Resolution Frequency-Wavenumber Spectrum Analysis,” Proceedings of the IEEE, vol. 57, no. 8, pp. 1408–1418, 1969.

Web links and Video Lectures (e – Resources)	
1	MathWorks – Phased Array System Toolbox documentation: https://www.mathworks.com/help/phased/
2	PySDR – Introduction to DOA and beamforming: https://pysdr.org/

CO – PO MAPPING

CO-PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	--	--	--
CO2	2	3	3	2	--	--
CO3	2	3	3	2	1	--
CO4	2	3	3	3	2	--
CO5	2	3	3	3	2	2

Semester: II						
Photonic Networks						
Course Code	**:**	1MLDN206D		**Credits**	**:**	3
Hours/Week(L:T:P:SL)	**:**	3:0:0:3		**CIE**	**:**	50 Marks
Total Hours	**:**	90 Hrs		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Optical Fiber Communication / Optical Communication
Knowledge on Fundamental Concepts	Optical fibers, lasers and LEDs, photodetectors, modulation, multiplexing, and basic computer communication networks.
Knowledge on Connected Tools (If any)	Basic knowledge of MATLAB/Python or network simulation tools is desirable.

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the architecture, components, performance parameters, and design principles of photonic networks.
CLO2	Analyze optical transmission impairments, link budgets, power penalties, and wavelength-division multiplexing techniques.
CLO3	Evaluate optical switching, routing, wavelength assignment, and network protection/restoration mechanisms.
CLO4	Design and analyze WDM, wavelength-routed, and reconfigurable optical network architectures for different traffic requirements.
CLO5	Assess emerging photonic networking technologies, including elastic optical networks, software-defined optical networks, and photonic data-center/interconnect applications.

Module – 1	**08 Hrs**
Photonic Network Fundamentals: Evolution and architecture of photonic networks; optical network components and topologies; optical transmitters, receivers and amplifiers; network performance parameters; basic optical switching concepts; network design principles and applications.	
Module – 2	**08 Hrs**
Optical Transmission And Wdm: Optical transmission impairments; power and loss budget; receiver sensitivity; dispersion and nonlinear effects; OSNR and power penalties; Wavelength Division Multiplexing (WDM); CWDM and DWDM; WDM system architecture and channel planning; dispersion compensation.	
Module – 3	**08 Hrs**
Optical Switching, Routing And Wavelength Assignment: Optical circuit, packet and burst switching; wavelength-routed optical networks; routing and wavelength assignment (RWA); static and dynamic routing; wavelength assignment strategies; blocking probability; traffic grooming; multicast routing and network performance analysis.	
Module – 4	**08 Hrs**
Protection, Restoration And Network Control: Optical network survivability and reliability; protection and restoration techniques; link, path and segment protection; ring and mesh protection; p-Cycle protection; fault detection and localization; dynamic restoration; optical network monitoring; GMPLS-based control and management.	
Module – 5	**08 Hrs**
Advanced Photonic Networks: Elastic optical networks and flexible-grid technology; routing and spectrum assignment; software-defined optical networks (SDON); network programmability and virtualization; spatial-division multiplexing; multi-core fiber; silicon photonics; photonic data-	

center networks and optical interconnects; emerging trends in photonic networking.

Topics for Self learning	
Module-1	Optical network evolution; optical amplifiers and receiver sensitivity; practical selection of network topologies.
	Case study: comparison of ring, mesh and point-to-point optical networks.
Module-2	DWDM channel planning; OSNR estimation; dispersion compensation techniques.
	Case study: nonlinear impairments in long-haul WDM transmission.
Module-3	RWA algorithms and blocking analysis using small network examples.
	Traffic grooming and multicast routing in wavelength-routed networks.
Module-4	p-Cycle protection and survivability analysis; GMPLS control-plane concepts.
	Optical network monitoring, fault localization and dynamic restoration.
Module-5	Elastic optical networking and spectrum assignment; SDON architecture.
	Silicon photonics, multi-core fiber and optical data-center interconnects.

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the architecture, components, and performance parameters of photonic networks.
CO2	Analyze WDM transmission impairments and determine key optical link performance measures.
CO3	Apply routing, wavelength assignment, switching, and traffic-grooming concepts to optical network design problems.
CO4	Evaluate protection, restoration, survivability, and control mechanisms for reliable optical networks.
CO5	Design and assess advanced photonic network solutions using elastic, software-defined, spatial-division, and integrated photonic technologies.

Text Books	
1	R. Ramaswami, K. N. Sivarajan and G. H. Sasaki, Optical Networks: A Practical Perspective, 3rd ed., Morgan Kaufmann, 2010.
2	G. P. Agrawal, Fiber-Optic Communication Systems, 4th ed., Wiley, 2010.

Reference Books	
1	B. Mukherjee, Optical WDM Networks, Springer, 2006.
2	J. M. Senior and M. Y. Jamro, Optical Fiber Communications: Principles and Practice, 3rd ed., Pearson, 2009.
3	J. E. Midwinter, Optical Fibers for Transmission, 2nd ed., Wiley, 1991.

Web links and Video Lectures (e – Resources)	
1	IEEE Communications Society — Optical Networking resources: https://www.comsoc.org/
2	Optica Publishing Group — Journal and conference resources in optical communications and networking: https://opg.optica.org/

CO – PO MAPPING

CO-PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1

CO2	3	3	3	2	2	1
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	2

Semester: II					
Modelling and Simulation using MATLAB					
Course Code	**:**	1MLDN207A	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:2	**CIE**	**:**	50 Marks
Total Hours	**:**	28	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Prerequisites:	
Courses	Engineering Mathematics, Programming Fundamentals / Numerical Methods
Knowledge on Fundamental Concepts	Basic linear algebra, differential equations, numerical methods, algorithms, programming concepts and engineering mathematics.
Knowledge on Connected Tools (If any)	**-**

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the principles of mathematical modelling, numerical computation and simulation using MATLAB.
CLO2	Develop MATLAB scripts, functions and programs for solving mathematical and engineering problems.
CLO3	Construct and simulate continuous-time and dynamic-system models using MATLAB and Simulink.
CLO4	Analyze, visualize and interpret simulation results using numerical, graphical and statistical techniques.
CLO5	Apply MATLAB-based modelling and simulation to an engineering case study and evaluate the effect of model parameters.

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory ....**
1.	Introduction to MATLAB: command window, workspace, scripts/live scripts, variables, arrays, operators and basic visualization.
2.	MATLAB programming: conditional statements, loops, user-defined functions, anonymous functions and structured programming.
3.	Matrix-based modelling: solution of simultaneous linear equations, eigenvalues/eigenvectors and matrix-based engineering computations.
4.	Numerical methods using MATLAB: interpolation, curve fitting, numerical differentiation and numerical integration.
5.	Numerical solution of ordinary differential equations using MATLAB ODE solvers and visualization of system responses.
6.	Modelling first- and second-order dynamic systems using transfer-function and state-space representations.
7.	Simulation of dynamic systems using Simulink: blocks, subsystems, scopes, signal routing and model configuration.
8.	Frequency-domain modelling and analysis using Bode plots, Nyquist plots, pole-zero maps and parameter variation.
9.	Parameter estimation, regression and optimization of an engineering model using MATLAB.
10.	Monte Carlo simulation and statistical analysis of an engineering system, followed by a mini case study and interpretation of results.

Open Ended Experiments	
1	Develop and validate a MATLAB/Simulink model for a user-selected engineering system; investigate the effect of at least three parameters and compare the simulation results.
2	Formulate an engineering problem as a mathematical model, implement the model in MATLAB, perform simulation-based analysis, and present conclusions with appropriate plots and performance measures.

Course Outcomes: After completing the course, the students will be able to	
CO1	Develop MATLAB programs for mathematical and engineering computations.
CO2	Formulate mathematical models for engineering systems using MATLAB.
CO3	Simulate continuous-time and dynamic systems using MATLAB and Simulink.
CO4	Analyze and visualize simulation outputs using appropriate numerical and graphical methods.
CO5	Apply modelling and simulation techniques to an engineering case study and communicate the findings.

Text Books	
1	Stormy Attaway, MATLAB: A Practical Introduction to Programming and Problem Solving, 7th ed., Elsevier, 2022.
2	Amos Gilat, MATLAB: An Introduction with Applications, 7th ed., Wiley, 2023.

Reference Books	
1	Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 4th ed., McGraw-Hill, 2023.
2	Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Oxford University Press.

Web links and Video Lectures (e – Resources)	
1	MathWorks, MATLAB Documentation and Tutorials – https://www.mathworks.com/help/matlab/
2	MathWorks, Simulink Documentation and Tutorials – https://www.mathworks.com/help/simulink/

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1	2	1
CO2	2	3	2	1	2	1
CO3	2	2	3	2	2	1
CO4	2	2	2	3	2	1
CO5	3	3	3	2	3	2

Semester: II					
Advanced Digital Signal Processing Laboratory					
Course Code	**:**	1MLDN207B	**Credit**	**:**	01
Hours/Semester (L:T:P:SL)	**:**	0:0:2:2	**CIE**	**:**	50 Marks
Total Hours	**:**	28	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	03

Prerequisites:	
Courses	Signals and Systems; Digital Signal Processing
Knowledge on Fundamental Concepts	Discrete-time signals, Fourier analysis, Z-transform, sampling and basic digital filter concepts
Knowledge on Connected Tools (If any)	MATLAB / Python (NumPy, SciPy, Matplotlib) or equivalent DSP simulation tools

Course Learning Objectives: This course will enable the students to	
CLO1	Review and apply advanced discrete-time signal processing concepts using computational tools.
CLO2	Analyze signals in time, frequency and transform domains using FFT, DFT and related techniques.
CLO3	Design and implement FIR and IIR digital filters using appropriate specifications and structures.
CLO4	Apply multirate signal processing, spectral analysis and adaptive filtering techniques to practical problems.
CLO5	Evaluate DSP algorithms through simulation, interpretation of results and open-ended problem solving.

Experiments	
Sl. No.	**List of Experiments to execute in the Laboratory ....**
1.	Generation, visualization and analysis of discrete-time signals; basic operations and system response.
2.	Computation and analysis of DFT and FFT; comparison of computational complexity and spectral resolution.
3.	Power spectral density estimation using periodogram and Welch methods for stationary signals.
4.	Design and implementation of FIR filters using windowing and frequency-sampling techniques.
5.	Design and implementation of IIR filters using Butterworth and Chebyshev approximations.
6.	Comparison of FIR and IIR filters based on magnitude/phase response, stability and computational requirements.
7.	Implementation of multirate DSP operations: decimation, interpolation and sampling-rate conversion.
8.	Implementation and analysis of adaptive noise cancellation using LMS adaptive filtering.
9.	Implementation of digital filter structures and evaluation using fixed-point/finite-precision considerations.
10.	Mini application: speech/audio or biomedical signal enhancement using advanced DSP techniques.

Open Ended Experiments

1	Design a DSP-based solution for removal of noise/interference from a real-world signal and justify the selected algorithm.
2	Develop and evaluate an application such as ECG denoising, speech enhancement, vibration analysis or audio equalization.

Course Outcomes: After completing the course, the students will be able to	
CO1	Implement advanced DSP algorithms using suitable computational tools and interpret the generated results.
CO2	Analyze frequency-domain characteristics and spectral content of discrete-time signals.
CO3	Design, implement and compare FIR/IIR digital filters for specified applications.
CO4	Apply multirate and adaptive signal processing techniques to practical signal-processing problems.
CO5	Develop, test and document a DSP-based solution for an open-ended engineering application.

Text Books	
1	John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, Pearson.
2	Sanjit K. Mitra, Digital Signal Processing: A Computer-Based Approach, McGraw-Hill.

Reference Books	
1	Alan V. Oppenheim and Ronald W. Schafer, Discrete-Time Signal Processing, Pearson.
2	Richard G. Lyons, Understanding Digital Signal Processing, Pearson.

Web links and Video Lectures (e – Resources)	
1	https://www.mathworks.com/help/signal/
2	https://docs.scipy.org/doc/scipy/reference/signal.html

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	2	3	1
CO2	3	3	2	2	2	1
CO3	3	3	3	2	3	1
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2



Institute Vision

Preparing Competent Engineering and Management Professionals to Serve the Society

Institute Mission

- Providing Students with a Sound Knowledge in Fundamentals of their branch of Study.
- Promoting Excellence in Teaching, Training, Research and Consultancy.
- Exposing Students to Emerging Frontiers in various domains enabling Continuous Learning.
- Developing Entrepreneurial acumen to venture into Innovative areas.
- Imparting Value based Professional Education with a sense of Social Responsibility.

Department Vision

Transforming Individuals into Competent Electronics and Communication Engineers for Technological and Societal Advancements

Department Mission

- Strengthening Fundamental Knowledge for Academic and Professional Excellence.
- Empowering innovation through Research in Emerging Technologies.
- Fostering Industry-Institute Collaboration for Technical & Entrepreneurial Progress.
- Equipping Students with Technical Skills and Ethical Values to cater Societal Needs.
- Nurturing Supportive Environment for Lifelong Learning.

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

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