Course Code: MET-A101
Course Name: ENGLISH FOR RESEARCH PAPER WRITING

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	**ENGLISH**
Objectives:	1. Understand that how to improve your writing skills and level of readability 2. Learn about what to write in each section 3. Understand the skills needed when writing a Title 4. Ensure the good quality of paper at very first-time submission
Course Coordinator	Mr. Prasant Kaushik

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	**04**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	**04**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
Total No. of Hours			**24**		

Learning Outcomes:	After completing this course, the student will be able to 1. Plan and structure academic writing clearly and concisely. 2. Clarify authorship, highlight findings, and avoid plagiarism. 3. Write all major sections of a research paper effectively. 4. Develop strong Titles, Abstracts, and Introductions. 5. Apply skills to write Methods, Results, and Conclusions. 6. Use phrases and editing strategies for quality submissions.

Suggested books:

S.	Name of Authors /Books /Publisher	Year of

No.		Publication
1.	Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)	
2.	Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press	2006
3.	Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .	1998
4.	Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011	2011

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-C101

Course Name: Advanced Communication System

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Basic Communication Theory
Objectives:	1. **Understand** advanced concepts of modern communication systems, including modulation and coding techniques. *(Understanding)* 2. **Explain** the principles and applications of MIMO, OFDM, and wireless technologies such as 4G, 5G, and beyond. *(Understanding)* 3. **Analyze** the performance of various communication system architectures and protocols. *(Analyzing)* 4. **Design** efficient and high-performance communication systems for real-world applications. *(Creating)* 5. **Evaluate** communication system designs in terms of efficiency, reliability, and adaptability for academic and industrial use. *(Evaluating)* 6. **Apply** theoretical knowledge to simulate and develop components of modern wireless systems. *(Applying)*
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Review of Communication Fundamentals:** Overview of analog and digital communication systems, Channel models: AWGN, Rayleigh, Rician, Random processes, and noise characterization, Performance metrics: SNR, BER, capacity, Review of digital modulation: BPSK, QPSK, QAM, FSK, MSK	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Information Theory and Source Coding:** Entropy, mutual information, and channel capacity, Shannon's source and channel coding theorems, Discrete memoryless channels, Source coding: Huffman, Arithmetic, Lempel-Ziv coding, Rate-Distortion theory basics	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Channel Coding and Error**	07	PO2/	PSO1/

		Control: Linear block codes: Hamming, BCH, Reed-Solomon**,** Convolutional codes: encoding and Viterbi decoding**,** Turbo codes, and iterative decoding**,** Low-Density Parity-Check (LDPC) codes**,** Performance comparison of coding schemes		PO3/ PO4/	PSO2/..
UNIT-4	*Module-4*	**Advanced Modulation and Multicarrier Techniques:** M-ary modulation schemes and constellation design**,** Adaptive modulation and coding (AMC)**,** Multicarrier modulation: OFDM principles and implementation**,** Peak-to-Average Power Ratio (PAPR) and mitigation**,** OFDM in 4G and 5G systems	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	**MIMO and Wireless Communication Systems:** Fading channels and diversity techniques**,** MIMO systems: spatial diversity, spatial multiplexing**,** Channel state information and capacity analysis, Massive MIMO and beamforming**,** Applications in LTE, 5G NR	05	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Emerging Topics and Applications:** Cognitive radio and dynamic spectrum access, Software-Defined Radio (SDR) architecture and applications**,** Millimeter wave communication and 6G concepts**,** Internet of Things (IoT) communication protocols**,** AI/ML applications in communication systems	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. Understand and analyze various channel models and evaluate the performance of digital modulation schemes in the presence of noise. 2. Apply principles of information theory to compute channel capacity and design efficient source coding techniques. 3. Design and evaluate error control coding schemes such as block codes, convolutional codes, and LDPC to improve communication reliability. 4. Analyze and implement multicarrier modulation techniques like OFDM, and understand their application in modern wireless systems. 5. Evaluate the performance benefits of MIMO systems and apply diversity and beamforming techniques in wireless communication. 6. Demonstrate an understanding of emerging technologies such as SDR, cognitive radio,

	and the role of AI/ML in future communication networks.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	**John G. Proakis and Masoud Salehi**, *"Digital Communications"*, 5th Edition, McGraw-Hill Education, New York, 2007, ISBN-9780072957167.	2007
2.	**Simon Haykin**, *"Communication Systems"*, 5th Edition, Wiley India Pvt. Ltd., New Delhi, 2013, ISBN-9788126554232.	2013
3.	**David Tse and Pramod Viswanath**, *"Fundamentals of Wireless Communication"*, Cambridge University Press, New York, 2005, ISBN-9780521845274.	2005
4.	**Theodore S. Rappaport**, *"Wireless Communications: Principles and Practice"*, 2nd Edition, Pearson Education, New Delhi, 2010, ISBN-9788131701805.	2010
5.	**Andrea Goldsmith**, *"Wireless Communications"*, Cambridge University Press, Cambridge, 2005, ISBN-9780521837163.	2005
6.	**Robert G. Gallager**, *"Information Theory and Reliable Communication"*, Wiley, New York, 1968, ISBN-9780471290483.	1968

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	N	Y
PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-C102
Course Name: Advance Microprocessor & Microcontroller

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	**Microprocessor**
Objectives:	1. Able to Understand the microprocessor ISA architectures 2. Able to Programme with high level programming 3. Able to communicate processors with I/O devices 4. Able to design a microprocessor-based system design
Course Coordinator	Mr. Ashish Nainwal

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Design of Basic Microprocessor Architectural Concepts Microprocessor architecture, word Lengths, addressable memory, Microprocessor's speed architectural characteristics, registers, instruction, memory addressing architecture ,ALU, GPR's Control logic & internal data bus.	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Instruction Set, Mnemonics, Basic Instruction Types, Addressing modes, Microprocessor I/O connecting I/O put to Microprocessor, Polling and Interrupts, Interrupt and OM. Controllers.**	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Introduction 8051 architecture and programming model. Internal RAM and registers, I/O ports, Interrupt system &Instruction set.**	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	lntel X86 family of advanced Microprocessor, programming model for 86 family. X86 addressing modes, instruction set, hardware of 186, 286, 386, 486 & Pentium processors. Motorola 68 XXX family of microprocessor, 68 XXX addressing modes, instruction set, hardware.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Data Communication, parallel I/O serial communication, Serial interface and UART, modems, I/O devices, D/A, A/D interface, special I/O devices.	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Developing Microprocessor Based Products Introduction to the Design Process, Preparing the specifications, Developing a design, Implementing and Testing and design, Regulatory Compliance Testing, design tool for Microprocessor Development.	**06**		
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Familiarize 32bit, 64bit and multi core architectures. 2. 2. Compare the features of various microprocessors.

	3. Learn the architecture and programming with 8O51 microcontroller. 4. Explain the basic architecture and features of PIC microcontrollers. 5. Develop microcontroller programs. 6. Familiarize basics of interfacing.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	C.M. Gilmore, "Microprocessors Principals and Application" McGraw-Hill 2nd Edition 1995	1995
2.	2. Rajkamal, "Embedded System, Architecture &Programming",Tata McGraw- Hill 2nd Edition 2008	2008
3.	D. V. Hall, "Microprocessor &Interfacing", McGraw-Hill 2nd Edition 2005	2005
5.		

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-C103
Course Name: Research Methodology and IPR

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Analog and Digital communication,
Objectives:	1. Understand research problem formulation. 2. Analyze research related information. 3. Follow research ethics 4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow's world will be ruled by ideas, concepts, and creativity. 5. Understanding that when IPR would take such an important place in the growth of an individual nation, it is needless to emphasize the need for information about Intellectual Property rights to be promoted among students in general & engineering in particular. 6. Understanding that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about economic growth and social benefits.
Course Coordinator	Mr. Shiv Kumar Singh

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Effective literature studies approaches, analysis, Plagiarism, Research ethics,.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	**05**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	**04**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**35**		

Learning Outcomes:	After completion of course, students would be able to: 1.You will gain the ability to formulate well-defined research questions, identify relevant research methodologies (quantitative, qualitative, mixed methods), and design effective research plans. 2.You will learn to identify potential biases in research and develop strategies for ensuring the objectivity and validity of your own research findings. 3. You will develop skills in creating presentations to present your research in a clear and engaging manner.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"	
2.	Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"	
3.	Ranjit Kumar, 2 ndEdition, "Research Methodology: A Step by Step Guide for beginners"	2005
5.	Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.	2007
6.	Mayall, "Industrial Design", McGraw Hill, 1992.	1992

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-C111
Course Name: Advanced Communication Lab

MM : 100 **Sessional : 30**
Time : 2Hr **ESE : 70**
L T P **Credit : 2**
0 0 2

Prerequisites:	Communication Theory basics
Objectives:	1. Simulate and analyze channel models and modulation schemes in digital communication systems. 2. Implement source and channel coding techniques and assess coding gain. 3. Develop and evaluate multicarrier modulation systems including OFDM. 4. Model MIMO systems and assess performance under different fading environments. 5. Explore emerging technologies such as SDR, cognitive radio, and 5G frameworks using simulation tools and hardware kits.
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	Student can Choose any 8 Experiment.

	EXP	Course Content Using MATLAB\SCILAB & DSK kit	No. of Hours	POs mapped	PSOs mapped
	1	Simulation of AWGN, Rayleigh, and Rician channel models.	**2**		
	2	BER vs SNR performance analysis of BPSK, QPSK, and QAM under various channels.	**2**		
	3	Implementation of source coding techniques: Huffman, Lempel-Ziv, and Arithmetic coding.	**2**		
	4	Simulation of channel capacity using mutual information under different noise conditions.	**2**		
	5	Encoding and decoding using Hamming, BCH, and Convolutional codes with Viterbi decoding.	**2**		
	6	BER performance comparison of Turbo and LDPC codes in fading environments.	**2**		
	7	Design and simulation of an OFDM system with PAPR analysis.	**2**		
	8	Implementation of Adaptive Modulation and Coding (AMC) schemes.	**2**		
	9	Simulation of MIMO systems using spatial multiplexing and diversity techniques.	**2**		
	10	Beamforming and Massive MIMO system design using CSI.	**2**		
	11	Implementation of spectrum sensing techniques in cognitive radio.	**2**		
	12	Development of an SDR-based transceiver chain using GNU Radio.	**2**		
			24		

Learning Outcomes:	On the completion of this laboratory course, the students will be able to have hands on experience on, 1. **Model** and simulate analog and digital modulation schemes using communication toolboxes. *(Applying)* 2. **Implement** and **analyze** entropy-based source coding and various channel coding schemes. *(Analyzing)* 3. **Design** an OFDM system and assess performance in multipath channels. *(Creating)*

	4. **Simulate** MIMO systems with diversity and spatial multiplexing techniques. *(Applying)* 5. **Experiment** with SDR tools to explore cognitive radio and 5G signal flow. *(Applying / Evaluating)*

Course Code: MET-C113
Course Name: Wireless and Mobile Communication Lab

MM : 100 **Sessional : 30**
Time : 2Hr **ESE : 70**
L T P **Credit : 2**
0 0 2

Prerequisites:	Communication Theory basics
Objectives:	1. Understand and model wireless channel impairments like fading and path loss. 2. Analyze the performance of digital modulation schemes under different channel conditions. 3. Simulate and evaluate multiple access techniques and cellular network parameters. 4. Explore handoff mechanisms, call management, and resource allocation in mobile systems. 5. Apply knowledge of wireless protocols and standards through simulation and measurement tools.
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	Student can Choose any 8 Experiment.

	EXP	Course Content Using MATLAB\SCILAB & DSK kit	No. of Hours	POs mapped	PSOs mapped
	1	Simulation of AWGN and multipath fading channels (Rayleigh, Rician).	**2**		
	2	BER performance analysis of digital modulation techniques (BPSK, QPSK, 16-QAM) in fading conditions.	**2**		
	3	Implementation of Direct Sequence Spread Spectrum (DSSS) technique.	**2**		
	4	Implementation of Frequency Hopping Spread Spectrum (FHSS) system.	**2**		
	5	Design and simulation of OFDM-based transmission with PAPR analysis.	**2**		
	6	Simulation and analysis of SNR, BER, and channel capacity under various scenarios.	**2**		
	7	Simulation of MIMO systems using spatial diversity and multiplexing.	**2**		
	8	Measurement of received signal strength (RSS) using SDR or mobile-based tools.	**2**		
	9	Simulation of mobility models and path loss in different propagation environments.	**2**		
	10	Calculation and simulation of call blocking probabilities using Erlang B and C models.	**2**		
	11	Channel assignment algorithms: fixed and dynamic channel allocation.	**2**		
	12	Handoff detection and delay simulation in mobile environments.	**2**		
			24		

Learning Outcomes:	On the completion of this laboratory course, the students will be able to have hands on experience on,

	1. **Simulate** various wireless channels and assess their impact on system performance. *(Applying)* *2.* **Analyze** the performance of modulation and multiple access schemes in mobile environments. *(Analyzing)* *3.* **Design** and evaluate spread spectrum and OFDM systems. *(Creating / Evaluating)* *4.* **Implement** resource allocation and handoff strategies in cellular networks. *(Applying)* *5.* **Demonstrate** understanding of real-time mobile protocols, signal strength, and QoS metrics. *(Understanding / Applying)*

Course Code: MET-C201

Course Name: Antennas and communication Systems

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Basic Communication Theory
Objectives:	1. Understand the fundamental principles of antennas and electromagnetic radiation. *(Understanding)* 2. Analyze the design and performance of various antennas used in communication systems. *(Analyzing)* 3. Apply antenna theory to modern wireless systems including satellite, radar, and 5G. *(Applying)* 4. Evaluate communication system performance using link budgets and system-level analysis. *(Evaluating)* 5. Design and simulate antenna structures using modern electromagnetic tools. *(Creating)*
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Fundamentals of Antennas:** Electromagnetic radiation principles**,** Radiation fields and power density**,** Antenna parameters: gain, directivity, efficiency, beamwidth, polarization**,** Impedance and bandwidth concepts**.**	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Wire and Aperture Antennas:** Dipole, monopole, loop, and helical antennas**,** Slot and horn antennas**,** Reflector antennas: parabolic reflectors and feeds**,** Radiation resistance and efficiency calculations.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Antenna Arrays:** Array factor and pattern multiplication**,** Uniform linear arrays: broadside and end-fire arrays, Array synthesis: Binomial, Dolph-Chebyshev techniques**,** Mutual coupling and beam steering.	07	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**Microstrip and Broadband Antennas:** Microstrip patch antennas: design and analysis**,**	05	PO1/ PO2/ PO3	PSO1/ PSO2/..

		Feeding methods: inset, coaxial, proximity, Bandwidth enhancement techniques, Log-periodic, Yagi-Uda, spiral and fractal antennas.			
UNIT-5	*Module-5*	**Communication System Fundamentals:** System model: transmitter, channel, receiver, Modulation schemes: analog and digital, Noise in communication systems: SNR, BER, Link budget analysis: free-space loss, antenna gains, noise figure.	05	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Advanced Antenna Applications and Measurements,** Antennas for radar, satellite, and mobile communications, MIMO and smart antennas in 4G/5G systems, Antenna testing and measurement techniques: anechoic chambers, pattern plotting, Antenna simulation tools: HFSS, CST, IE3D, FEKO.	09	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. **Explain** the basic concepts of radiation, antenna parameters, and electromagnetic wave propagation. *(Understanding)* 2. **Analyze** the radiation characteristics of wire antennas, arrays, and aperture antennas. *(Analyzing)* 3. **Design** antennas such as dipoles, microstrip patches, and reflectors for specific applications. *(Creating)* 4. **Evaluate** the performance of antennas using gain, efficiency, directivity, and bandwidth metrics. *(Evaluating)* 5. **Apply** communication system concepts to link design including noise, modulation, and propagation effects. *(Applying)* 6. **Demonstrate** the use of antenna measurement systems and simulation tools. *(Applying)*

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	**John G. Proakis and Masoud Salehi**, *"Digital Communications"*, 5th Edition, McGraw-Hill Education, New York, 2007, ISBN-9780072957167.	2007
2.	**Simon Haykin**, *"Communication Systems"*, 5th Edition, Wiley India Pvt. Ltd., New Delhi, 2013, ISBN-9788126554232.	2013
3.	**David Tse and Pramod Viswanath**, *"Fundamentals of Wireless Communication"*, Cambridge University Press, New York, 2005, ISBN-9780521845274.	2005
4.	**Theodore S. Rappaport**, *"Wireless Communications: Principles and Practice"*, 2nd Edition, Pearson Education, New Delhi, 2010, ISBN-9788131701805.	2010
5.	**Andrea Goldsmith**, *"Wireless Communications"*, Cambridge University Press, Cambridge, 2005, ISBN-9780521837163.	2005
6.	**Robert G. Gallager**, *"Information Theory and Reliable Communication"*, Wiley,	1968

	New York, 1968, ISBN-9780471290483.	

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	N	Y
PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-C202
Course Name: Advance Digital Signal Processing

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Signal and system
Objectives:	1. Introduce the fundamentals of DSP. 2. Develop proficiency in digital filter design. 3. **Explain multirate DSP techniques** 4. **Students will know linear prediction and optimum filter design**, 5. **Explore advanced topics and applications**
Course Coordinator	Mr. SHIV KUMAR SINGH

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Overview of DSP,Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters,IIR filters by impulse invariance, bilinear transformation,FIR/IIR Cascaded lattice structures, and Parallel all pass realization of IIR.	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding.	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction..	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Adaptive Filters, Applications, Gradient Adaptive Lattice,Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm,	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation,Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigenanalysis Algorithms for Spectrum Estimation. Application of	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications	**04**	PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. To understand theory of different filters and algorithms

	2. To understand theory of multirate DSP, solve numerical problems and write algorithms 3. To understand theory of prediction and solution of normal equations 4. To know applications of DSP at block level.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice Hall, 2007.	2007.
2.	N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks – Wavelets", 1st Edition, John Wiley and Sons Ltd, 1999.	1999
3.	M. H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons Inc., 2002.	2002
5.	D.G.Manolakis, V.K. Ingle and S.M.Kogon, "Statistical and Adaptive Signal Processing", McGraw Hill, 2000.	2000

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-C211
Course Name: Microwave Systems lab

MM : 100 **Sessional : 30**
Time : 2Hr **ESE :70**
L T P **Credit : 2**
0 0 2

Prerequisites:	Basic EM Theory
Objectives:	1. Understand the practical aspects of microwave measurement and circuit design. 2. Perform S-parameter analysis and impedance matching using tools and instruments. 3. Design and simulate microwave components using CAD tools. 4. Gain hands-on experience with microwave test benches, antennas, and high-frequency amplifiers. 5. Integrate theoretical knowledge with hardware implementation and validation.
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	Student can Choose any 8 Experiment.

	EXP	Course Content Using MATLAB\SCILAB & DSK kit	No. of Hours	POs mapped	PSOs mapped
	1	Measurement of VSWR, reflection coefficient, and return loss using microwave bench.	**2**		
	2	Calibration and use of Vector Network Analyzer (VNA) for S-parameter measurements.	**2**		
	3	Characterization of directional couplers and isolators.	**2**		
	4	Determination of attenuation using fixed and variable attenuators.	**2**		
	5	Design and testing of impedance matching networks using Smith Chart.	**2**		
	6	Design and simulation of microstrip transmission lines and stubs (quarter-wave, open/short).	**2**		
	7	Design and realization of low-pass, high-pass, and band-pass microwave filters.	**2**		
	8	Measurement of insertion loss and isolation of circulators.	**2**		
	9	Design and simulation of a single-stage low-noise amplifier (LNA) using CAD tools.	**2**		
	10	Design of power dividers and hybrid couplers (Wilkinson, 90° hybrid).	**2**		
	11	Measurement of gain and noise figure of an RF amplifier.	**2**		
	12	Design and simulation of a microwave oscillator.	**2**		
			24		

Learning Outcomes:	On the completion of this laboratory course, the students will be able to have hands on experience on, 1. **Measure** key microwave parameters using VNA and test benches. *(Applying)*

	2. **Design** impedance matching circuits using Smith Chart and practical components. *(Creating)* 3. **Simulate** microwave circuits (filters, amplifiers) using RF simulation tools. *(Applying)* 4. **Analyze** S-parameters of passive and active microwave components. *(Analyzing)* 5. **Implement** RF layouts and identify performance-limiting parasitics. *(Creating / Evaluating)*

Course Code: MET-C213
Course Name: Advance Digital Signal Processing Lab

MM : 100 **Sessional : 30**
Time : 2Hr **ESE : 70**
L T P **Credit : 2**
0 0 2

Prerequisites:	Basic Programming , DSP theory
Objectives:	1. To implement Linear and Circular Convolution 2. To implement FIR and IIR filters 3. To study the architecture of DSP processor. 4. To study the PSD
Course Coordinator	Dr. Gorav Malik

NOTE:	Student can Choose any 8 Experiment.

	EXP	Course Content Using MATLAB\SCILAB & DSK kit	No. of Hours	POs mapped	PSOs mapped
	1	Generate various fundamental discrete time signals.	**2**		
	2	Basic operations on signals (Multiplication, Folding, Scaling).	2		
	3	Find out the DFT & IDFT of a given sequence.	2		
	4	Interpolation & decimation of a given sequence.	2		
	5	Generation of DTMF (Dual Tone Multiple Frequency) signals.	2		
	6	Estimate the PSD of a noisy signal using periodogram and modified periodogram.	2		
	7	To design FIR filters	2		
	8	Design of Chebychev Type I,II Filters.	2		
	9	Digital IIR Filter Realization.	2		
	10	Parallel Realization of IIR filter.	2		
	11	Estimation of power spectrum using parametric methods	2		
	12	Time-Frequency Analysis with the Continuous Wavelet Transform.	2		
			24		

Learning Outcomes:	On the completion of this laboratory course, the students will be able to have hands on experience on, • Filter design. • Filter Realization • Signal Manipulations • Wavelet Transforms • Estimating PSD using various techniques

Course Code: MET-C214
Course Name: RTL Simulation and Synthesis with PLDs Lab

MM : 100 **Sessional : 30**
Time : 2Hr **ESE : 70**
L T P **Credit : 2**
0 0 2

Prerequisites:	Digital Logic Design, Basic HDL Programming
Objectives:	1. To design and simulate digital circuits using Verilog/VHDL. 2. To synthesize RTL models using EDA tools. 3. To verify logic and timing of synthesized designs. 4. To implement digital designs on FPGA/CPLD boards.
Course Coordinator	Dr. Ashish Nainwal

NOTE:	Student can Choose any 8 Experiment.

	EXP	Course Content	Tools Used	No. of Hours	POs mapped	PSOs mapped
	1	Design and simulate basic logic gates and multiplexers in Verilog/VHDL	ModelSim/Vivado	2		
	2	Design and simulate 4-bit adder/subtractor using structural modeling	Vivado/Quartus	2		
	3	Write and simulate a 4-bit synchronous counter	ModelSim	2		
	4	RTL modeling of Mealy and Moore Finite State Machines	Vivado/ModelSim	2		
	5	Synthesize a 4x4 multiplier using behavioral modeling	Vivado	2		
	6	Perform logic synthesis and analyze area, delay and power using synthesis tools	Vivado/Synplify	2		
	7	Map and implement an HDL design on FPGA/CPLD development board	Spartan-6/Artix-7/MAX V	2		
	8	Implement clock divider and PWM generator on FPGA	Vivado/Quartus	2		
	9	Design and simulate simple memory modules: ROM, RAM	Vivado	2		
	10	Realize a UART design with Verilog and test on FPGA	Vivado/ModelSim	2		
	11	Study and apply power optimization techniques at RTL level	Vivado Power Analyzer	2		
	12	Mini project: Design and implement a digital system (e.g., calculator, traffic light controller)	FPGA Board	2		
				24		

Learning Outcomes:	On the completion of this laboratory course, the students will be able to have hands on experience on: • Design and simulate digital systems at RTL level. • Synthesize and optimize HDL code for area, delay, and power. • Realize and verify designs on PLD hardware.

	• Understand synthesis constraints and timing analysis. • Gain exposure to industry-standard FPGA design tools.

Course Code: MET-PE 101
Course Name: Wireless Sensor Network

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	wireless communication, sensors, communication,network
Objectives:	1. Introduce the fundamentals of Wireless Sensor Networks. 2. Understand sensor node hardware and software components. 3. Equip students with practical skills in programming and simulation 4. Explore communication protocols and standards.. 5. Analyze data dissemination, in-network processing,. 6. Investigate advanced research challenges.
Course Coordinator	Dr. Tanuj Garg

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Overview and architecture of wireless sensor networks, Applications of WSNs in various domains (environmental monitoring, healthcare, industrial automation, smart cities), Comparison with Ad Hoc networks and other wireless systems, Sensor node architecture: hardware and software components , Recent developments: Integration of WSNs with IoT and Cyber-Physical Systems (CPS)	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Hardware platforms: mica2, micaZ, telosB, tmote, Imote2, btnode, and modern platforms like Raspberry Pi and ESP32-based nodes, Sensor hardware interfacing basics, Operating systems for WSNs: TinyOS, Contiki-NG, RIOT, Zephyr, Emerging software platforms for WSNs and IoT integration, Energy harvesting and low-power hardware design trends .	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Overview of WSN protocol stack, Protocols across layers (Physical, MAC, Routing):MAC: S-MAC, T-MAC, B-MAC, Network/ Routing: LEACH, Directed Diffusion, RPL, Node discovery, synchronization, and data aggregation techniques,Communication standards: IEEE 802.15.4, Zigbee, Bluetooth, BLE, LoRaWAN, NB-IoT, Advances in mesh networking and low-power wide-area networks (LPWAN) .	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Programming tools and languages: C, nesC, Python (for data processing and integration), Sensor node programming basics, Simulation and performance analysis tools: NS-2, NS-3, Cooja (Contiki), OMNeT++, TOSSIM, Comparative study of open-source and commercial tools (QualNet, Opnet),	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..

		Introduction to cloud-based WSN testbeds and emulation tool			
UNIT-5	*Module-5*	Data dissemination, in-network processing, and storage mechanisms, Query processing in sensor networks, Localization techniques and coverage models.	**05**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Security challenges: authentication, encryption, intrusion detection in WSNs, Edge computing and AI at the edge for smart sensor networks, Sensor cloud and fog computing, Open research issues and future directions in WSNs	**04**		
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Design wireless sensor network system for different applications under consideration. 2. Understand the hardware details of different types of sensors and select right type of sensor for various applications. 3. Understand radio standards and communication protocols to be used for wireless sensor network based systems and application. 4. Use operating systems and programming languages for wireless sensor nodes, performance of wireless sensor networks systems and platforms. 5. Handle special issues related to sensors like energy conservation and security challenges

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	H. Karl and A. Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, India, 2012.	2012
2.	C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Editors, "Wireless Sensor Networks",Springer Verlag, 1st Indian reprint, 2010.	2010
3.	F. Zhao and L. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann, 1stIndian reprint, 2013.	2013
5.	YingshuLi, MyT. Thai, Weili Wu, "Wireless sensor Network and Applications", Springer series on signals and communication technology, 2008.	2008

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-PE 102
Course Name: EMBEDDED SYSTEMS DESIGN

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit :3**

Prerequisites:	Microprocessor & interfacing
Objectives:	1. Understand the Fundamentals of Embedded Systems. 2. Develop Programming Skills for Embedded Systems. 3. Understand Real-Time Operating Systems (RTOS). 4. To explore serial, parallel, and wireless communication protocols. 5. To develop skills for real-world peripheral interfacing.
Course Coordinator	Mr. ANUJ KUMAR SHARMA

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Embedded systems and its applications, Embedded Operating system, Design parameters of an embedded system and its significance, design life cycle, tools introduction, hardware and software partitioning and co-design. Open collector outputs Tristate outputs I/O sinking and Sourcing, PLD's, Watchdog Timers, Hardware design and development.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Microcontroller families and classifications (8-bit, 16-bit, 32-bit), 8051 Microcontroller, AVR Microcontroller, Features of ATmega328 used in Arduino, PIC Microcontrollers, ARM Cortex-M Series (e.g., STM32), ESP32 / ESP8266 (Wi-Fi-enabled microcontrollers), Programming via Arduino IDE and ESP-IDF.	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Introduction to Microcontrollers and Micoprocessors, Embedded versus external memory devices, CISC and RISC processors, Harvard and Von Neumann Architectures.	**05**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	8051 Microcontrollers-Assembly language, architecture, registers, Addressing modes, Instruction set, I/O ports and memory organization Interrupts Timer/counter and serial communication.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-5	*Module-5*	RTOS-Tasks, states, Data, Semaphores and shared data, Operating system services, Message queues, Mailboxes. Advanced Processor-(only architectures) 80386, 80486 and ARM (References)	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-6	*Module-6*	Communication basics, Microprocessor	**10**	PO2/ PO4/	PSO1/ PSO2/..

		Interfacing I/O Addressing, Direct memory access, Arbitration, multilevel bus architecture, Serial protocols, Parallel protocols and wireless protocols. Real world Interfacing: LCD, Stepping Motor, ADC, DAC, LED, Push Buttons, Key board, Latch Interconnection, PPI.		PO5	
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. **Explain** the fundamentals of embedded systems and their applications in real-world scenarios. 2. **Develop** basic embedded programs using 8051, AVR (ATmega328), PIC, ARM Cortex-M, and ESP32/ESP8266 microcontrollers. 3. **Describe** the structure and functions of a Real-Time Operating System (RTOS), including tasks, semaphores, shared data, queues, and mailboxes. 4. **Compare** serial, parallel, and wireless communication protocols for use in embedded applications. 5. **Interface** real-world devices (LCD, stepper motors, ADC/DAC, LEDs, push buttons, keyboards) with microcontrollers.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Muhammad Ali Mazidi and Janice Gillispie"***The 8051 Microcontroller and embedded systems***" ISBN: 978-0131194021	1999
2.	Tony Givargis Frank Vahid"***Embedded System Design: A Unified Hardware / Software Introduction",*** IV, McGraw-Hill, ISBN-9780071371766	2006
3.	Kenneth Hintz, Daniel Tabak "***Microcontrollers (Architecture, Implementation & Programming)***" Tata McGraw-Hill,	2005
4.	Sampath Kr "***Microcontrollers & Embedded Systems 2nd Edition***" KatsonBooks	206

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	N	Y	Y	Y
PO2	Y	Y	N	Y	Y
PO3	Y	N	Y	Y	Y
PO4	N	Y	N	N	Y
PO5	Y	N	Y	Y	Y
PO6	Y	Y	N	Y	Y
PO7	N	N	N	N	Y
PO8	Y	Y	N	Y	Y
PO9	Y	N	Y	N	Y
PO10	Y	Y	N	Y	Y
PO11	Y	N	N	Y	Y
PO12	Y	Y	N	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5

PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-PE 103
Course Name: Advanced Mathematics for Engineers

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Engineering mathmatics
Objectives:	1. Learn distinct methods of solving simultaneous equations. 2. Well-versed with partial differential equations and their solutions and applications. 3. Acquire the knowledge of transformation to ease the complex problems. 4. Acquaintance with basics of random variables and their distribution for dealing with events by chance. 5. Study different mathematical domains to deal with real-time engineering problems.
Course Coordinator	Dr. Vivek Goel

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Probability and Random Processes, Probability spaces and Bayes theorem, Random variables and expectation, Common distributions (Gaussian, Exponential, Poisson, etc.), Random processes: stationarity, autocorrelation, and power spectral density, Noise models in communication systems Markov processes and applications, Parameter Estimation, Testing of Hypothesis, Goodness of Fit	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Linear Algebra and Matrix Theory, Vector spaces, basis, and dimension, Inner product spaces and orthogonality, Eigenvalues and eigenvectors, Diagonalization and Jordan canonical form, Singular value decomposition (SVD), Applications to signal processing and MIMO systems.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Graph Theory : Formal definition; Subgraphs, Walk, Path, Hamiltonian path, Cycle, Euler graph, Planar graph, Tree: Binary tree, Spanning tree, Fundamental circuits: Cutsets, Tie sets, Shortest path, Minimal spanning tree, Algorithms	**05**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Complex Analysis and Transforms, Analytic functions, Cauchy-Riemann equations, Contour integration and Cauchy's theorem, Residue theorem and applications, Laplace transform and inverse, Fourier series and Fourier transform, Z-transform for discrete systems	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Numerical Methods : Solution of matris equation by generalised inverse technique, Numerical evaluation of determinant; Computation of eigenvalues and eigenvectors, Matrix inversion by partitioning; Optimisation technique by conjugate gradient method and method of steepest descent	**06**		
UNIT-6	*Module-6*	Fast-Fourier Transformation (FFT) algorithms; FFT	**08**	PO2/	PSO1/

		of real functions; Convolution; correlation and auto-correlation using FET, STFT, Wavelet		PO4/ PO5	PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Comprehend with engineering problems in different mathematical realm. 2. Learn analytical and numerical methods to deal with mathematical problems. 3. Understand how to model the engineering problems and their solutions. 4. Implement the solutions to real-time complex engineering problems. 5. Apprehend with mathematical methodology.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, 10th edition, 2011.	2011
2.	R. K. Jain and S.R.K Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 5th edition, 2016.	2016
3.	Gilbert Strang, Linear Algebra, Cengage learning, 4th edition, 2006.	2006
5.	David Poole, Linear Algebra A Modern Introduction, Thomson, 4th edition, 2019.	2019

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-PE 104
Course Name: ANALOG AND DIGITAL CMOS VLSI DESIGN

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit :3**

Prerequisites:	Semiconductor Devices, Analog Electronics, Digital Circuits
Objectives:	1. To understand MOS transistor operation and modeling. 2. To design and analyze CMOS analog building blocks (amplifiers, current mirrors, etc.). 3. To explore digital CMOS design styles and combinational/sequential circuits. 4. To apply layout, design rules, and parasitic estimation principles. 5. To evaluate performance metrics such as speed, power, and noise in CMOS circuits.
Course Coordinator	Mr. Gorav Malik

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**MOS Transistor Theory**: Threshold voltage, I-V characteristics, second-order effects, body effect, short-channel effects, CMOS technology basics.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Analog CMOS Design**: Current mirrors, differential amplifiers, gain stages, output stages, biasing techniques, frequency response.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Digital CMOS Design**: Static CMOS logic, pass-transistor logic, transmission gates, sizing, dynamic logic, domino logic, noise margins.	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**Combinational and Sequential Building Blocks**: Latches, flip-flops, SRAM cells, timing analysis, setup/hold time, metastability.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Layout and Parasitics**: Layout design rules, stick diagrams, Euler paths, estimation of delay and capacitance, interconnect modeling.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Performance and Design Considerations**: Power-delay trade-offs, sizing for speed, power estimation, low-noise design, mixed-signal layout issues.	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Analyze and model MOS transistors for analog and digital operations. 2. Design basic analog circuits such as amplifiers and current mirrors in CMOS. 3. Implement digital CMOS logic with optimized sizing and logic style. 4. Evaluate the performance of combinational and sequential CMOS blocks. 5. Apply layout, parasitic estimation, and performance tuning in practical VLSI designs.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Weste, Neil H.E., and Harris, David, "***CMOS VLSI Design: A Circuits and Systems Perspective"***, 4th Edition, Pearson Education, ISBN: 978-0321547743	2010

2.	Razavi, Behzad, ***"Design of Analog CMOS Integrated Circuits"***, 1st Edition, McGraw-Hill, ISBN: 978-0072380322	2001
3.	Rabaey, Jan M., ***"Digital Integrated Circuits: A Design Perspective"***, 2nd Edition, Pearson Education, ISBN: 978-0130909961	2003
4.	Baker, R. Jacob, ***"CMOS: Circuit Design, Layout, and Simulation"***, 3rd Edition, Wiley, ISBN: 978-0470881323	2010
5.	Pucknell, D.A., and Eshraghian, Kamran, ***"Basic VLSI Design"***, 3rd Edition, PHI, ISBN: 978-8120309863	1994

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	Y	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	Y	Y	Y
PO4	N	Y	Y	Y	Y
PO5	N	N	Y	Y	Y
PO6	N	N	N	N	N
PO7	N	N	N	N	N
PO8	N	N	N	N	N
PO9	N	N	N	N	N
PO10	N	N	N	N	N
PO11	N	N	N	N	N
PO12	N	N	N	N	N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	Y
PSO3	N	Y	Y	Y	Y
PSO4	Y	Y	Y	Y	Y

Course Code: MET-PE 105

Course Name: COGNITIVE RADIOS

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Wireless Communication
Objectives:	1. Understand the principles and implementation of filter banks, discrete multitone modulation, and wavelet transforms for signal processing in cognitive radio systems. 2. Gain knowledge of digital frequency synthesis using DDFS and computation techniques like CORDIC for efficient signal processing. 3. Analyze and design software-defined radio (SDR) systems, including digital down converters, demodulators, CIC filters, and under-sampling techniques. 4. Comprehend the fundamentals of cognitive radio technology, its architecture, cognitive engine design, and the role of SDR in enabling cognitive capabilities. 5. Explore the operation of OFDM-based cognitive radio systems, including spectrum sensing, MIMO-OFDM systems, synchronization techniques, and advanced multi-band communication strategies.
Course Coordinator	Mr. Amrish

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Filter banks-uniform filter bank. direct and DFT approaches. Introduction to ADSL Modem. Discrete multitone modulation and its realization using DFT. QMF.STFT.Computation of DWT using filter banks.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	DDFS- ROM LUT approach. Spurious signals, jitter. Computation of special functions using CORDIC. Vector and rotation mode of CORDIC.CORDIC architectures.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Block diagram of a software radio. Digital down converters and demodulators Universal modulator and demodulator using CORDIC. Incoherent demodulation - digital approach for I and Q generation, special sampling schemes. CIC filters. Residue number system and high speed filters using RNS. Down conversion using discrete Hilbert	07	PO2/ PO3/ PO4/	PSO1/ PSO2/..

		transform. Under sampling receivers, Coherent demodulation schemes.			
UNIT-4	*Module-4*	Concept of Cognitive Radio, Benefits of Using SDR, Problems Faced by SDR, Cognitive Networks,Cognitive Radio Architecture. Cognitive Radio Design, Cognitive Engine Design.	05	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	A Basic OFDM System Model, OFDM based cognitive radio, Cognitive OFDM Systems, MIMO channel estimation, Multi-band OFDM, MIMO-OFDM synchronization and frequency offset estimation.	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Spectrum Sensing to detect Specific Primary System, Spectrum Sensing for Cognitive OFDMA Systems.	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. Describe the working principles of filter banks, discrete multitone modulation, and wavelet transform techniques for communication systems. 2. Demonstrate the design and implementation of digital frequency synthesizers using DDFS and analyze spurious effects and jitter. 3. Implement special mathematical functions using CORDIC algorithms and understand various CORDIC architectures. 4. Explain the architecture of software-defined radios and design digital modulation/demodulation systems using components like CIC filters and RNS-based filters. 5. Analyze and differentiate coherent and incoherent demodulation schemes, including discrete Hilbert transforms and under-sampling techniques. 6. Understand the architecture and components of cognitive radios and cognitive engines, and evaluate the challenges and advantages of SDR-based cognitive systems.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering", Pearson Education, New Jersey, 2002, ISBN-9780130422323.	2002
2.	Ulrich Meyer-Baese, "Digital Signal Processing with Field Programmable Gate Arrays", 2nd Edition, Springer, Berlin, 2004, ISBN-9783540208051.	2004
3.	Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, New York, 2007, ISBN-9781402066285.	2007

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	N	Y

PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-PE 106

Course Name: RF and Microwave Circuit Design

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Antenna Theory
Objectives:	1. Understand the behavior and analysis of RF and microwave transmission lines and components. *(Understanding)* 2. Analyze and design matching networks, filters, and amplifiers for RF applications. *(Analyzing)* 3. Apply S-parameter techniques and impedance matching strategies to high-frequency circuit design. *(Applying)* 4. Evaluate the performance of RF circuits such as oscillators, mixers, and low-noise amplifiers (LNAs). *(Evaluating)* 5. Develop skills in CAD tools and RF measurement techniques to model, simulate, and test microwave circuits. *(Creating / Applying)*
Course Coordinator	Dr. Vipul Sharma

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Transmission Line Theory and Components:** Review of transmission lines, waveguides, and distributed elements**,** Smith Chart: reflection coefficient, VSWR, return loss**,** Impedance transformation and quarter-wave transformers**,** Microstrip line design and implementation.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**S-Parameters and Network Analysis:** Definition and properties of S-parameters**,** Signal flow graph analysis**,** Multi-port network theory**,** Interconnection of networks and stability conditions.	05	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Impedance Matching and Coupling Techniques:** L-section, π and T matching networks**,** Stub matching (single and double)**,** Use of Smith Chart for design**,** Power dividers,	07	PO2/ PO3/ PO4/	PSO1/ PSO2/..

		directional couplers, and hybrid junctions.			
UNIT-4	*Module-4*	**RF Filters, Amplifiers and Oscillators:** RF/microwave filters: Butterworth, Chebyshev design**,** Stability analysis and gain-bandwidth considerations**,** Low-noise amplifier (LNA) design**,** Oscillator principles: negative resistance and feedback type.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Mixers and Nonlinear Circuit Elements:** Mixer fundamentals and types (diode and FET-based)**,** Conversion loss, isolation, and intermodulation distortion**,** Diode and transistor modeling at RF/microwave frequencies**,** Nonlinearities and linearization techniques.	05	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	**CAD and Measurement Techniques:** RF circuit design using simulation tools (ADS, HFSS, CST)**,** RF layout and parasitic effects**,** Network analyzer, spectrum analyzer, and signal generator usage**,** Practical design issues and measurement case studies**.**	09	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. **Explain** the concepts of transmission lines and waveguides used in RF circuits. *(Understanding)* 2. **Analyze** the scattering parameters and reflection coefficients in multi-port RF networks. *(Analyzing)* 3. **Design** impedance matching networks using Smith Chart and analytical techniques. *(Creating)* 4. **Apply** design procedures for filters, amplifiers, and oscillators in microwave frequency ranges. *(Applying)* 5. **Evaluate** circuit performance using S-parameters and gain stability techniques. *(Evaluating)* 6. **Demonstrate** proficiency in using RF circuit simulation tools and laboratory instrumentation. *(Applying)*

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design: Theory and Applications", 2nd Edition, Pearson Education, New Jersey, 2008, ISBN-9780131471375.	2008
2.	David M. Pozar, "Microwave Engineering", 4th Edition, Wiley, New York, 2012, ISBN-9780470631553.	2012
3.	Guillermo Gonzalez, "Microwave Transistor Amplifiers: Analysis and Design",	1996

	2nd Edition, Prentice Hall, New Jersey, 1996, ISBN-9780132543354.	
4.	Thomas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", 2nd Edition, Cambridge University Press, Cambridge, 2004, ISBN-9780521835398.	2004
5.	Ulrich L. Rohde and David P. Newkirk, "RF/Microwave Circuit Design for Wireless Applications", 2nd Edition, Wiley-Interscience, New Jersey, 2000, ISBN-9780470389621.	2000

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	N	Y
PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-PE 107
Course Name: Soft Computing

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Mathematics
Objectives:	1. To introduce soft computing concepts and techniques and foster their abilities in designing appropriate techniques for a given scenario. 2. To implement soft computing based solutions for real-world problems. 3. To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms. 4. To provide students with hand-on experience on MATLAB to implement various strategies.
Course Coordinator	Mr. Sanjay Singh

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Introduction to Soft Computing and Neural Networks: Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence : Machine Learning Basics.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Fuzzy Logic: Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Neural Networks: Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Genetic Algorithms: Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition	**04**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Matlab/Python Lib: Introduction to Matlab / Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic.	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Recent Trends in deep learning, various classifiers, neural networks and genetic algorithms. Implementation of recently proposed soft computing techniques	**06**		
Total No. of Hours			**35**		

Learning Outcomes:	After completing this course, the student will be able to 1. Identify and describe soft computing techniques and their roles in building intelligent machines. 2. Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems. 3. Apply genetic algorithms to combinatorial optimization problems. 4. Evaluate and compare solutions by various soft computing approaches for a given problem.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing , Prentice:Hall of India, 2003.	2003
2.	George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications , Prentice Hall, 1995.	1995
3.	MATLAB Toolkit Manual	

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-PE 108
Course Name: LOW POWER VLSI DESIGN

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit :3**

Prerequisites:	Digital Electronics, CMOS VLSI Design
Objectives:	1. To understand the sources of power dissipation in VLSI circuits. 2. To explore transistor, gate, and architecture-level low power techniques. 3. To learn about energy-efficient circuit design, modelling and analysis. 4. To apply power optimization methods during synthesis and physical design. 5. To study recent low power design methodologies and FPGA/ASIC implementations.
Course Coordinator	Mr. Prateek Agarwal

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Introduction to Low Power VLSI:** Need for low power design, power dissipation sources (dynamic, short-circuit, leakage), impact of technology scaling, power estimation techniques.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Low Power Circuit Techniques:** Transistor sizing, voltage scaling, threshold voltage control, subthreshold design, MTCMOS, power gating, body biasing, clock gating.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Combinational and Sequential Circuit Optimization:** Logic level power optimization, glitch reduction, pipelining, latching techniques, latch vs flip-flop design, switching activity reduction.	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**Memory and Interconnect Power Management:** Low power SRAM and DRAM design, CAMs, sense amplifiers, interconnect modeling, bus encoding techniques, clock distribution networks.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Design Methodologies and Tools for Low Power:** Power analysis at RTL and gate level, low power synthesis techniques, floor planning, power-aware placement and routing, leakage minimization in physical design.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Advanced Topics and Case Studies:** Power reduction in FPGA vs ASIC, dynamic voltage/frequency scaling (DVFS), near-threshold computing, real-world low power design case studies in mobile, IoT, and edge devices.	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to: 1. Identify sources of power dissipation and apply power estimation techniques. 2. Use circuit and logic-level techniques for low power design. 3. Analyze and design power-optimized sequential and combinational circuits. 4. Implement low power memory and interconnect architectures. 5. Apply EDA tools for low power synthesis and perform real-time power analysis.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Roy, Kaushik, and Prasad, Sharat C., ***"Low Power CMOS VLSI Circuit Design"***,1st Edition,Wiley,ISBN: 978-0471333654	2000
2.	Yeap, Gary K., ***"Practical Low Power Digital VLSI Design"***, 1st Edition, Springer,ISBN: 978-0792398462	1997
3.	Rabaey, Jan M., ***"Digital Integrated Circuits: A Design Perspective"***, 2nd Edition, Pearson Education,ISBN: 978-0130909961	2003
4.	Rabaey, Jan M., and Pedram, Massoud, ***"Low Power Design Methodologies"***, 1st Edition,Springer, ISBN: 978-1461371261	1996
5.	Kang, Sung-Mo, and Leblebici, Yusuf, ***"CMOS Digital Integrated Circuits: Analysis and Design"***, 4th Edition, McGraw-Hill,ISBN: 978-0073380628	2011

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	Y	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	Y	Y	Y
PO4	N	Y	Y	Y	Y
PO5	N	N	Y	Y	Y
PO6	N	N	N	N	N
PO7	N	N	N	N	N
PO8	N	N	N	N	N
PO9	N	N	N	N	N
PO10	N	N	N	N	N
PO11	N	N	N	N	N
PO12	N	N	N	N	N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	Y
PSO3	N	Y	Y	Y	Y
PSO4	Y	Y	Y	Y	Y

Course Code: MET-PE 201

Course Name: SATELLITE COMMUNICATION

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Basic Communication Theory
Objectives:	1. **Understand** the fundamentals of satellite communication, including orbital mechanics, launch systems, and geostationary orbits. *(Understanding)* 2. **Analyze** satellite subsystems and link design parameters for effective satellite communication. *(Analyzing)* 3. **Apply** modulation, multiplexing, and multiple access techniques in satellite communication systems. *(Applying)* 4. **Evaluate** error control mechanisms and assess the effects of propagation on satellite links. *(Evaluating)* 5. **Explore** modern satellite systems and applications including VSAT, GNSS, DBS, and LEO systems. *(Remembering / Understanding / Applying)*
Course Coordinator	Mr. Anuj Kumar Sharma

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Elements of Satellite Communication, Orbital mechanics, look angle and orbit determination,launches & launch vehicle, orbital effects, Geostationary Orbit.	**05**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Satellite subsystems, attitude and orbit control systems, TTC&M, communication subsystem, satellite antenna, satellite link design: basic transmission theory, system noise temperature and G/T ratio, downlink design, uplink design, satellite systems using small earth station, design for specified C/N.	09	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Modulation and multiplexing techniques for satellite links: FM, pre-emphasis and de-emphasis, S/N ratios for FM video transmission, digital transmission, digital modulation and demodulation, TDM. Multiple access: FDMA, TDMA, DAMA and CDMA.	05	PO2/ PO3/ PO4/	PSO1/ PSO2/..

UNIT-4	*Module-4*	Error control for digital satellite links: error detection and correction, channel capacity, error control coding, convolutional codes, linear and cyclic block codes.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Propagation effects and their impact on satellite-earth links: attenuation and depolarization, atmospheric absorption, rain, cloud and ice effects etc.	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Introduction of various satellite systems: VSAT, low earth orbit and non-geostationary, direct broadcast satellite television and radio, satellite navigation and the global positioning systems. Pseudo-satellite, brief about satellite pay loads.	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. **Describe** the principles of orbital mechanics, orbit types, look angles, and launch systems for satellite deployment. *(Understanding)* 2. **Explain** various satellite subsystems including attitude control, TTC&M, communication systems, and antennas. *(Understanding)* 3. **Design** uplink and downlink communication links based on transmission theory, noise temperature, and C/N ratio. *(Creating)* 4. **Apply** analog and digital modulation schemes as well as multiple access techniques like TDMA, FDMA, and CDMA. *(Applying)* 5. **Analyze** the performance of satellite links under various propagation conditions including rain attenuation and depolarization. *(Analyzing)* 6. **Evaluate** error correction coding techniques and their impact on digital satellite communication reliability. *(Evaluating)*

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	**Timothy Pratt,** Charles Bostian, and Jeremy Allnutt, *"Satellite Communications"*, 2nd Edition, John Wiley & Sons, New York, 2003, ISBN	2003
2.	**Dennis Roddy,** *"Satellite Communications"*, 4th Edition, McGraw-Hill, New York, 2006, ISBN-9780071462983.	2006
3.	**Tri T. Ha,** *"Digital Satellite Communications"*, 2nd Edition, McGraw-Hill, New York, 1990, ISBN-9780070252349.	1990

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y

PO5	Y	Y	Y	N	Y
PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-PE 202
Course Name: Internet of Things

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Basic Electronics communication and networking
Objectives:	1. Able to understand the application areas of IOT. 2. Able to realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks. 3. Able to understand building blocks of Internet of Things and characteristics 4. Students conceptualize and develop IoT-based projects
Course Coordinator	Mr. Sanjay Singh

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Introduction to the Internet of Things: What is IoT? History, evolution, and key characteristics of IoT. Applications of IoT: Exploring diverse applications across various industries (e.g., smart cities, healthcare, agriculture). Building Blocks of IoT Systems: Sensors, actuators, microcontrollers, communication modules. IoT Architectures: Layered architectures (perception, network, application, management)	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Hardware Platforms and Communication Technologies: Popular IoT Development Boards: Introduction to platforms like Arduino, Raspberry Pi, and ESP8266. Sensors and Actuators: Types of sensors (temperature, humidity, motion) and actuators (relays, motors, LEDs). Interfacing Sensors and Actuators: Connecting sensors and actuators to microcontroller boards. Wireless Communication Protocols: Wi-Fi, Bluetooth, Zigbee, LoRaWAN for IoT communication	**08**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Data Acquisition, Processing, and Analytics : Data Acquisition Strategies: Techniques for collecting data from sensors in IoT devices. Data Storage and Management: Cloud platforms and databases for storing and managing IoT data. Data Processing Techniques: Stream processing, time-series analysis, data visualization for IoT data. Machine Learning for IoT: Introduction to using machine learning for anomaly detection and predictive maintenance in IoT applications.	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Security and Privacy in IoT: Security Challenges in IoT: Vulnerability to cyberattacks, data breaches, and privacy concerns. Authentication and Authorization: Implementing secure access control mechanisms for IoT devices. Data Security and Encryption: Techniques for securing data at rest, in transit, and in	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..

		use. Security Best Practices: Guidelines for secure development, deployment, and management of IoT devices			
UNIT-5	*Module-5*	Interface Electronic Circuit for Smart Sensors and Challenges forInterfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor.	**05**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Advanced Topics and Future of IoT: IoT Cloud Platforms: Exploring popular cloud platforms for developing and managing IoT applications. Edge Computing for IoT: Decentralized processing and decision-making at the edge of the network. Artificial Intelligence for IoT: Exploring the integration of AI techniques for advanced IoT functionalities. Emerging Trends in IoT: Discussing recent advancements and the future direction of IoT technology	**04**	PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**35**		

Learning Outcomes:	After completing this course, the student will be able to 1. Understand the vision of IoT from a global context. 2. Determine the Market perspective of IoT. 3. Use of Devices, Gateways and Data Management in IoT. 4. Application of IoT in Industrial and Commercial Building Automation and Real World Design Constraints. 5. Building state of the art architecture in IoT

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L., Smart Sensors at the IoT Frontier, Springer International Publishing	
2.	Kyung, C.-M., Yasuura, H., Liu, Y., Lin, Y.-L., Smart Sensors and Systems, Springer International Publishing	
3.	*Cuno Pfister,* Getting Started with the Internet of Things, Oreilly	2022
4.	Donald Norris, THE INTERNET OF THINGS	2020

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-PE 203
Course Name: Machine Learning

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Mathematics ,AI,.
Objectives:	1. To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes. 2. To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances. 3. Explore supervised and unsupervised learning paradigms of machine learning. 4. To explore Deep learning technique and various feature extraction strategies.
Course Coordinator	Mr. Atul Varshney

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	Supervised Learning (Regression/Classification) Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Naïve, Bayes. Linear models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods, Beyond Binary Classification: Multi-class/Structured Outputs, Ranking.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)	**05**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	Scalable Machine Learning (Online and Distributed Learning) A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference.	**06**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.	**05**		
Total No. of Hours			**35**		

Learning Outcomes:	After completing this course, the student will be able to 1. Extract features that can be used for a particular machine learning approach in

	various IOT applications. 2. To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.To study the design of Earth station and tracking of the satellites. 3. To mathematically analyse various machine learning approaches and paradigms. Students will be able to explain the key elements of robot cell design and identify potential applications of robots in various industries

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012	2012
2.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)	2009
3.	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.	2007

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y/N	Y/N	Y/N	Y/N	Y/N
PO2	Y/N	Y/N	Y/N	Y/N	Y/N
PO3	Y/N	Y/N	Y/N	Y/N	Y/N
PO4	Y/N	Y/N	Y/N	Y/N	Y/N
PO5	Y/N	Y/N	Y/N	Y/N	Y/N
PO6	Y/N	Y/N	Y/N	Y/N	Y/N
PO7	Y/N	Y/N	Y/N	Y/N	Y/N
PO8	Y/N	Y/N	Y/N	Y/N	Y/N
PO9	Y/N	Y/N	Y/N	Y/N	Y/N
PO10	Y/N	Y/N	Y/N	Y/N	Y/N
PO11	Y/N	Y/N	Y/N	Y/N	Y/N
PO12	Y/N	Y/N	Y/N	Y/N	Y/N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y/N	Y/N	Y/N	Y/N	Y/N
PSO2	Y/N	Y/N	Y/N	Y/N	Y/N
PSO3	Y/N	Y/N	Y/N	Y/N	Y/N
PSO4	Y/N	Y/N	Y/N	Y/N	Y/N

Course Code: MET-PE 204
Course Name: VLSI Design Verification and Testing

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit :3**

Prerequisites:	Digital Design, CMOS VLSI Design, HDL Programming
Objectives:	1. Understand the challenges and techniques for verifying complex VLSI systems. 2. Explore functional and formal verification methodologies. 3. Learn various fault models and test generation algorithms. 4. Apply Design for Testability (DFT), scan design, and BIST techniques. 5. Evaluate testing strategies and implement using modern CAD tools.
Course Coordinator	Mr. Prateek Agarwal

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Introduction to VLSI Testing and Verification**: Importance of verification and testing, yield and defects, fault types (stuck-at, bridging, open, delay), fault modeling, observability and controllability, fault simulation basics.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Functional Verification and Simulation**: Testbench architecture, directed vs constrained-random simulation, assertions (SystemVerilog), code and functional coverage, introduction to UVM methodology.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Design for Testability (DFT)**: Scan chain design, ATPG basics, boundary scan (JTAG IEEE 1149.1), test compression, insertion of test points, scan cell architecture, stuck-at and transition delay ATPG.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**BIST and Memory Testing**: Built-In Self-Test for combinational and sequential logic, LFSR/MISR, signature analysis, aliasing, memory fault models (stuck-at, coupling), MARCH test algorithms, BIST for memory.	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Formal Verification and Equivalence Checking**: Model checking, symbolic simulation, SAT/BDD-based equivalence checking, assertion-based verification, comparison with simulation-based techniques.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Post-Silicon Debug and Industry Practices**: Scan diagnosis, layout-aware debugging, validation strategies, functional ECO flow, ATE, overview of industrial verification tools (VCS, JasperGold, Tessent, etc.).	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to:

	1. Understand fault models and test generation principles. 2. Develop testbenches and simulation-based verification strategies. 3. Apply DFT techniques such as scan chains and boundary scan. 4. Design BIST architecture and perform memory testing. 5. Use formal verification tools and identify silicon-level faults. 6. Apply industry-grade EDA tools for VLSI testing and debug.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Abramovici, M., Breuer, M. A., and Friedman, A. D., ***"Digital Systems Testingand Testable Design"***, 1st Edition,Springer,ISBN: 978-8181280911	1999
2.	Bushnell, M. L., and Agrawal, V. D., ***"Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits"***,1st Edition,Springer,ISBN: 978-0387950340	2006
3.	Spear, Chris, ***"SystemVerilog for Verification: A Guide to Learning the Testbench Language Features"***, 1st Edition, Springer, ISBN: 978-0387275061	2005
4.	Hachtel, G. D., and Somenzi, F., ***"Functional Verification of Digital Hardware: From Simulation to Formal Methods"***, 1st Edition,Springer, ISBN: 978-0387310045	2006

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	N	Y	N
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	Y	Y	Y
PO4	N	Y	Y	N	Y
PO5	N	N	Y	Y	Y
PO6	N	N	N	N	N
PO7	N	N	N	N	N
PO8	N	N	N	N	N
PO9	N	N	N	N	N
PO10	N	N	N	N	N
PO11	N	N	N	N	N
PO12	N	N	N	N	N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	Y
PSO3	N	Y	Y	N	Y
PSO4	N	Y	Y	Y	Y

Course Code: MET-PE 205

Course Name: MIMO System

MM: 100 **Time: 3 Hr.** **L T P** **3 0 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Basic Antenna Theory
Objectives:	1. Understand the fundamental principles of MIMO systems and their role in modern wireless communications. *(Understanding)* 2. Analyze capacity, channel modeling, and spatial techniques used in MIMO environments. *(Analyzing)* 3. Apply beamforming, diversity, and precoding techniques for performance optimization in practical systems. *(Applying)* 4. Evaluate the performance of MIMO systems under real-world constraints such as fading and imperfect channel knowledge. *(Evaluating)* 5. Explore MIMO applications in standards such as LTE and 5G including massive MIMO and mmWave technologies. *(Understanding / Analyzing)*
Course Coordinator	Dr. Vipul Sharma

NOTE:	The question paper shall consist of two sections (Section A and Section B). Section A shall contain ten (10) short answer type questions of six (06) marks each and the student shall be required to attempt any five (05) questions. Section B shall contain eight (08) long answer-type questions of ten (10) marks each and the student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Introduction to MIMO Systems:** Evolution of wireless communication and MIMO motivation, MIMO system model and types (SIMO, MISO, MIMO), Benefits: capacity, reliability, and spectral efficiency, Diversity techniques: time, frequency, and space diversity.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**MIMO Channel Modeling and Capacity:** Fading channel models: Rayleigh, Rician, Channel correlation and keyhole effects, MIMO channel capacity: with and without channel state information (CSI), Capacity analysis under practical constraints, Water-filling algorithm.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Spatial Multiplexing and Space-Time Coding:** Spatial multiplexing and trade-offs**,** V-BLAST architecture and detection methods	07	PO2/ PO3/ PO4/	PSO1/ PSO2/..

		(ZF, MMSE, SIC), Alamouti code and orthogonal space-time block codes (OSTBC), Channel estimation and detection strategies.			
UNIT-4	*Module-4*	**Beamforming and Precoding:** Beamforming at the transmitter and receiver, Linear precoding: ZF, MMSE, SVD-based techniques, Codebook-based feedback techniques, Hybrid beamforming for mmWave MIMO.	07	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Applications and Standard Implementations:** MIMO in LTE and 5G NR, Massive MIMO: concept, challenges, and performance gains, MIMO in mmWave communication, Practical issues: channel estimation errors, pilot contamination, hardware constraints	05	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Emerging Topics and Research Trends in MIMO:** Cell-free massive MIMO and coordinated multipoint (CoMP), Intelligent Reflecting Surfaces (IRS) and reconfigurable metasurfaces, Machine learning and AI techniques in MIMO systems, MIMO in 6G and terahertz communications, Open research challenges and testbeds	07	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	1. **Explain** the basic architecture and advantages of MIMO communication systems. *(Understanding)* 2. **Analyze** MIMO channel models such as Rayleigh and Rician fading channels. *(Analyzing)* 3. **Compute** MIMO channel capacity under various channel conditions and CSI assumptions. *(Applying)* 4. **Apply** spatial multiplexing, diversity, and OFDM techniques in MIMO frameworks. *(Applying)* 5. **Design** and evaluate beamforming and linear precoding methods like ZF and MMSE. *(Creating / Evaluating)* 6. **Assess** the performance of MIMO technologies in LTE, 5G, and Massive MIMO environments. *(Evaluating)*

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Ezio Biglieri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, and H. Vincent Poor, "MIMO Wireless Communications", Cambridge University Press, Cambridge, 2007, ISBN-	2007

	9780521877688.	
2.	Arogyaswami Paulraj, Rohit Nabar, and Dhananjay Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, Cambridge, 2003, ISBN-9780521826150.	2003
3.	Claude Oestges and Bruno Clerckx, “MIMO Wireless Communications: From Real-world Propagation to Space-time Code Design”, Academic Press, London, 2010, ISBN-9780123850559.	2010
4.	David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, New York, 2005, ISBN-9780521845274.	2005
5.	Robert G. Gallager, “Information Theory and Reliable Communication”, Wiley, New York, 1968, ISBN-9780471290483.	1968

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	N	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	N	N	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	N	Y
PO6	Y	N	Y	N	Y
PO7	Y	Y	N	Y	Y
PO8	N	Y	Y	N	Y
PO9	Y	Y	Y	Y	Y
PO10	Y	N	Y	N	Y
PO11	N	Y	Y	Y	Y
PO12	Y	Y	Y	Y	Y

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	Y	Y	Y	Y
PSO2	Y	Y	Y	Y	N
PSO3	Y	N	N	Y	Y
PSO4	Y	Y	Y	Y	N

Course Code: MET-PE 206
Course Name: Artificial Intelligence

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit : 3**

Prerequisites:	Mathematics , Machine Learning
Objectives:	1. To introduce the fundamental concepts, history, and scope of Artificial Intelligence (AI). 2. To develop an understanding of intelligent agents and their architecture. 3. To explore various problem-solving strategies including uninformed, informed, and adversarial search techniques. 4. To familiarize students with knowledge representation, logical reasoning, and uncertainty handling through probabilistic models. 5. To introduce machine learning approaches including supervised and unsupervised methods, and expert systems. 6. To provide insight into pattern recognition, perception, and the use of AI programming languages like LISP and PROLOG.
Course Coordinator	Mr. Shiv Kumar Singh

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**Introduction:** Introduction to Artificial Intelligence, Foundations and History of Artificial Intelligence, Applications of Artificial Intelligence, Intelligent Agents, Structure of Intelligent Agents. Computer vision, Natural Language Processing.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**Introduction to Search**: Searching for solutions, Uniformed search strategies, Informed search strategies, Local search algorithms and optimistic problems, Adversarial Search, Search for games, Alpha - Beta pruning.	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Knowledge Representation & Reasoning**: Propositional logic, Theory of first order logic, Inference in First order logic, Forward & Backward chaining, Resolution, Probabilistic reasoning, Utility theory, Hidden Markov Models (HMM), Bayesian Networks.	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**Machine Learning**: Supervised and unsupervised learning, Decision trees, Statistical learning models, Learning with complete data - Naive Bayes models. **Expert System:** Existing Systems (DENDRAL, MYCIN) domain exploration Meta Knowledge, Self-Explaining System.	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..

UNIT-5	*Module-5*	**Pattern Recognition:** Introduction to Pattern Recognition, Structured Description, Symbolic Description, Machine perception, Line Finding, Interception Semantic & Model, Object Identification, Speech Recognition. Programming Language Introduction to programming Language, LISP, PROLOG.	**06**	PO2/ PO4/ PO5	PSO1/ PSO2/..
UNIT-6	*Module-6*	Classical planning, planning graphs, partial-order planning, hierarchical planning, Concepts, reward signals, Markov Decision Processes (MDPs), Q-learning, exploration vs. exploitation.	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Understand the fundamentals of Artificial Intelligence, its history, applications, and the structure of intelligent agents. 2. Apply various search algorithms including uninformed, informed, and adversarial strategies to solve AI problems. 3. Represent and reason with knowledge using propositional and first-order logic, and handle uncertainty with probabilistic models. 4. Analyze and implement basic machine learning techniques including decision trees, Naive Bayes, and clustering methods. 5. Demonstrate understanding of pattern recognition, machine perception, and the use of AI programming languages like LISP and PROLOG. 6. Evaluate advanced AI topics such as planning, reinforcement learning, multi-agent systems, and ethical implications of AI technologies.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	**Stuart Russell and Peter Norvig**, *Artificial Intelligence: A Modern Approach*, Pearson Education, 3rd Edition, **2010**	2010
2.	**Elaine Rich, Kevin Knight, and Shivashankar B. Nair**, *Artificial Intelligence*, McGraw Hill Education, 3rd Edition, **2008**.	2008
3.	**Nils J. Nilsson**, *The Quest for Artificial Intelligence: A History of Ideas and Achievements*, Cambridge University Press, **2010**.	2010
4.	**Ethem Alpaydin**, *Introduction to Machine Learning*, MIT Press, 3rd Edition, **2014**.	2014
5	**Christopher M. Bishop**, *Pattern Recognition and Machine Learning*, Springer, **2006**.	2006

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	Y	Y
PO2	Y	Y	Y	Y	Y
PO3	N	N	Y	Y	Y
PO4	Y	Y	Y	N	Y
PO5	Y	Y	Y	Y	Y
PO6	Y	N	Y	Y	Y
PO7	N	Y	Y	N	Y
PO8	Y	Y	Y	Y	N

PO9	Y	Y	Y	Y	N
PO10	N	Y	Y	Y	N
PO11	Y	Y	N	Y	N
PO12	N	Y	Y	Y	N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	N	N	N	Y	Y
PSO2	Y	Y	Y	N	Y
PSO3	Y	Y	N	N	N
PSO4	Y	N	N	N	Y

Course Code: MET-PE 207
Course Name: RTL Simulation and Synthesis with PLDs

MM: 100 **Time: 3 Hr.** **L T P** **3 1 0**	**Sessional: 30** **ESE: 70** **Credit :3**

Prerequisites:	Digital Logic Design, VLSI Design, HDL (VHDL/Verilog) Basics
Objectives:	1. Understand the principles of Register Transfer Level (RTL) design. 2. Learn behavioral and structural modeling using VHDL/Verilog. 3. Gain proficiency in RTL simulation, testbenches, and debugging. 4. Explore synthesis process and constraints with PLDs (CPLDs, FPGAs). 5. Implement digital systems from HDL to hardware using simulation and synthesis tools.
Course Coordinator	Mr. Ashish Nainwal

NOTE:	The question paper shall consist of two sections (Section-A and Section-B). Section-A shall contain of ten (10) short answer type questions of six (06) mark each and student shall be required to attempt any five (05) questions. Section-B shall contain eight (08)long answer type questions of ten (10) marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus

UNIT	Module	Course Content	No. of Hours	POs mapped	PSOs mapped
UNIT-1	*Module-1*	**RTL Design Fundamentals:** Introduction to RTL abstraction, hierarchy, dataflow, control path, clocking strategies, metastability, register balancing, timing issues	**06**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-2	*Module-2*	**HDL Coding for RTL Design:** Behavioral, dataflow, structural modeling, combinational and sequential circuits, FSM modeling, synthesisable vs. non-synthesisable constructs (Verilog/VHDL)	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-3	*Module-3*	**Simulation &Testbenches:** Writing testbenches, simulation models, event-driven simulation, functional verification, waveform analysis, code coverage	**06**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-4	*Module-4*	**Synthesis with PLDs:** Synthesis flow, constraints, timing analysis, logic optimization, netlists, technology mapping, FPGA-specific optimizations	**07**	PO2/ PO3/ PO4/	PSO1/ PSO2/..
UNIT-5	*Module-5*	**Programmable Logic Devices:** Architecture and features of PLDs (PAL, GAL, CPLD, FPGA), internal structure, logic blocks, interconnects, configuration memory	**07**	PO1/ PO2/ PO3	PSO1/ PSO2/..
UNIT-6	*Module-6*	**Case Studies and Tools:** RTL-to-GDSII flow overview, synthesis using tools (Vivado/Quartus), implementing counters, ALUs, UARTs, GPIO controllers, debouncing logic, project-based hardware design	**07**	PO2/ PO4/ PO5	PSO1/ PSO2/..
Total No. of Hours			**40**		

Learning Outcomes:	After completing this course, the student will be able to 1. Understand and describe RTL-level digital system design and abstraction. 2. Model and simulate combinational/sequential logic using HDLs. 3. Write and debug synthesizable code for digital circuits. 4. Perform synthesis for PLD targets and apply constraints effectively. 5. Develop complete RTL-to-PLD hardware implementation projects using industry tools.

Suggested books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Palnitkar, Samir, ***"Verilog HDL"***, 2nd Edition, Pearson Education, ISBN: 978-0130449115	2003
2.	Bhasker, J., ***"VHDL Primer"***, 2nd Edition,Pearson Education, ISBN: 978-0130335647	2001
3.	Perry, Douglas L., ***"VHDL Programming by Example"***, 4th Edition,McGrawHill,ISBN: 978-0071400701	2002
4.	Brown, Stephen, and Vranesic, Zvonko, ***"Fundamentals of Digital Logic with VHDL Design"***, 3rd Edition,McGraw Hill,ISBN: 978-0073380544	2008
5.	Roth, Charles H., and John, Lizy Kurian, ***"Digital Systems Design using VHDL"***, 3rd Edition,CengageLearning,ISBN: 978-1305635142	2017

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PO1	Y	Y	Y	Y	Y
PO2	Y	Y	Y	Y	Y
PO3	Y	Y	Y	Y	Y
PO4	N	Y	Y	Y	Y
PO5	Y	Y	Y	Y	Y
PO6	N	N	Y	N	Y
PO7	N	N	N	N	N
PO8	N	N	N	N	N
PO9	N	N	N	N	N
PO10	N	N	N	N	N
PO11	N	N	N	N	N
PO12	N	N	N	N	N

	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	Learning Outcome 4	Learning Outcome 5
PSO1	Y	Y	Y	N	Y
PSO2	Y	Y	Y	Y	Y
PSO3	N	Y	Y	Y	Y
PSO4	Y	Y	Y	Y	Y