Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Bachelor of Technology

in

Electronics & Telecommunication Engineering

Final Year Scheme and Syllabus (R-2022)

(As per AICTE guidelines, with effect from the Academic Year 2025-26)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Therefore, autonomy for Vidyalankar Institute of Technology is not merely a transition from pre-cooked syllabi to self-designed curriculum. The autonomous curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability and problem-solving approach which leads to improving competency level of learners with diverse strengths. In line with this, the curriculum framework designed is **Choice-Based Credit and Grading System (CBCGS)**. The number of credits for each category of courses learnt by learners, internships and projects is finalized considering the scope of study and the ability that a learner should gain through the programme. The overall credits and approach of curriculum proposed are in line with AICTE model curriculum.

The curriculum comprises courses from various categories like basic sciences, humanities and social sciences, engineering sciences, general education and branch specific courses including professional electives and open electives. The curriculum has core courses of branch of engineering positioned and sequenced to achieve sequential and integral learning of the entire breadth of the specific branch. These courses are completed by the third year of the engineering programme that enables learners to prepare for higher education during their final year. Professional elective courses, that begins from third year of programme, offer flexibility and diversity to learners to choose specialization from a basket of recent developments in their field of technology. The selection of unique professional elective courses based on industrial requirements and organizing them into tracks is a salient feature of this curricula ensuring employability. Open Elective courses cover multi-disciplinary, special skill development, project management and similar knowledge that make learners capable of working in industrial environment.

For holistic development of learners, apart from technical courses, Humanities and Social Science courses develop the required soft-skills and attitude amongst learners. Our curriculum also introduces Social Service Internship and Internship with institutes abroad along with courses like Design Thinking, Wellness - Body, Mind & Spirit, Indian Traditional Knowledge System under General Education category. These general education courses aim to create balance in brain hemispheres and hence improve learners' clarity in thoughts and responses.

Additionally, curriculum provides add-on Honours/Minor degree that involves field/ domain study. Learner can avail themselves of this degree by completing requirement of additional 18 credits.

Thus, the academic plan of VIT envisages a shift from summative to formative and competency-based learning system which will enhance learner's ability towards higher education, employability and entrepreneurship.

Chairman, Board of Studies
Department of Electronics & Telecommunication Engineering
Vidyalankar Institute of Technology

Chairman, Academic Council
Vidyalankar Institute of Technology

Final Year B. Tech. Electronics & Telecommunication Engineering **Preferred Semester: VII**

Course Structure and Assessment Guidelines

Course		**Head of Learning**	**Credits**	**Assessment guidelines (Marks)**			**Total marks (Passing@40% of total marks)**
Code	**Name**			**ISA**	**MSE**	**ESE**	
ET12T	RF and Microwave Engineering	Theory	3	20	30	50	100
ET12P	RF and Microwave Engineering Lab	Practical	1	25	-	25	050
OEXX	Any one from the offered Open Elective courses	Theory	3	20	30	50	100
ETXXT	Professional Elective-4	Theory	2	15	20	40	075
ETXXP	Professional Elective-4 Lab	Practical	1	25	-	25	050
ETXXT	Professional Elective-5	Theory	2	15	20	40	075
ETXXP	Professional Elective-5 Lab	Practical	1	25	-	25	050
ETXXT	Professional Elective-6	Theory	2	15	20	40	075
ETXXP	Professional Elective-6 Lab	Practical	1	25	-	25	050
ET48	Project 1 (Synopsis)	Theory	3	50	-	50	100
		Total	**19**				
Credits completed in previous inter semester break course that will appear in this semester mark sheet							
ET47	Industry Internship	Practical	4	50	-	75	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Guidelines for Professional Elective Courses and Specialization Certificate – Refer Appendix-A

Important Note 1: Learners are required to go through the Appendix-A carefully before selecting the professional elective courses. Detailed guidelines regarding professional elective courses, specialization tracks and courses relevant to each track are given in Appendix-A. We have total four tracks. The learners can choose one track from the tracks offered by the department.

List of Professional Elective-4 courses:

Specialization Track Name#	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Communication Engineering (CE)	ET23T	OFDM and MIMO Technology	Theory	2	15	20	40	075
	ET23P	OFDM and MIMO Technology Lab	Practical	1	25	-	25	050
Data Science (DS)	ET29T	Data Mining	Theory	2	15	20	40	075
	ET29P	Data Mining Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	ET35T	Internet of Things and Edge Computing	Theory	2	15	20	40	075
	ET35P	Internet of Things and Edge Computing Lab	Practical	1	25	-	25	050
Very Large Scale Integration Design (VLSID)	ET41T	ASIC and Verification	Theory	2	15	20	40	075
	ET41P	ASIC and Verification Lab	Practical	1	25	-	25	050

List of Professional Elective-5 courses:

Specialization Track Name#	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Communication Engineering (CE)	ET24T	Satellite Communication	Theory	2	15	20	40	075
	ET24P	Satellite Communication Lab	Practical	1	25	-	25	050
Data Science (DS)	ET30T	Big Data Analytics	Theory	2	15	20	40	075
	ET30P	Big Data Analytics Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	ET36T	Internet of Things Security and Trust	Theory	2	15	20	40	075
	ET36P	Internet of Things Security and Trust Lab	Practical	1	25	-	25	050
Very Large-	ET42T	System on Chip	Theory	2	15	20	40	075

Scale Integration Design (VLSID)	ET42P	System on Chip Lab	Practical	1	25	-	25	050

#For details of Specialization Certificate, refer Appendix-A

List of Professional Elective-6 courses:

Specialization Track Name#	Course		Head of Learning	Credits	Assessment Guidelines (Marks)			Total marks (Passing@40% of total marks)
	Code	Name			ISA	MSE	ESE	
Communication Engineering (CE)	ET25T	Wireless Sensor Networks	Theory	2	15	20	40	075
	ET25P	Wireless Sensor Networks Lab	Practical	1	25	-	25	050
Data Analytics and Machine Learning (DAML)	ET31T	Deep Learning	Theory	2	15	20	40	075
	ET31P	Deep Learning Lab	Practical	1	25	-	25	050
Internet of Things (IoT)	ET37T	Industrial Internet of Things	Theory	2	15	20	40	075
	ET37P	Industrial Internet of Things Lab	Practical	1	25	-	25	050
Very Large-Scale Integration (VLSI)	ET43T	Mixed Signal VLSI	Theory	2	15	20	40	075
	ET43P	Mixed Signal VLSI Lab	Practical	1	25	-	25	050

#For details of Specialization Certificate, refer Appendix-A

List of Open Elective Courses:

Sr. No.	Course Code	Course Title	Hours Per Week			Credits	Preferred Semester
			Theory	Practical	Tutorial		
1	OE21	Cyber Law	3	-	-	3	6 to 8
2	OE22	Project Management	3	-	-	3	6 to 8
3	OE23	Product Lifecycle Management	3	-	-	3	6 to 8
4	OE24	Sustainability Management	3	-	-	3	6 to 8
5	OE25	Operation Research	3	-	-	3	6 to 8
6	OE26	IPR and Patenting	3	-	-	3	6 to 8
7	OE27	Research Methodology	3	-	-	3	6 to 8
8	OE28	Renewable Energy Management	3	-	-	3	6 to 8
9	OE29	Energy Audit and Management	3	-	-	3	6 to 8
10	OE30	Bioinformatics	3	-	-	3	6 to 8
11	OE31	Nanotechnology	3	-	-	3	6 to 8

For details of Specialization Certificate, refer Appendix - A

Third Year B. Tech. Electronics & Telecommunication Engineering **Preferred Semester: VIII**

Course Structure and Assessment Guidelines

Course		**Head of Learning**	**Credits**	**Assessment guidelines (Marks)**			**Total marks (Passing@40% of total marks)**
Code	**Name**			**ISA**	**MSE**	**ESE**	
ET13T	Optical Communication	Theory	3	20	30	50	100
ET13P	Optical Communication Lab	Practical	1	25	-	25	050
OEXX	Any one from the offered Open Elective courses	Theory	3	20	30	50	100
OEXX	Any one from the offered Open Elective courses	Theory	3	20	30	50	100
ET49	Project 2- (Final)	Practical	4	75	-	50	125
		Total	**14**				

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESA= End Semester Examination

*Selection based on the subset of OE courses made available by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

List of Open Elective Courses:

Sr. No.	Course Code	Course Title	Hours Per Week			Credits	Preferred Semester
			Theory	Practical	Tutorial		
1	OE21	Cyber Law	3	-	-	3	6 to 8
2	OE22	Project Management	3	-	-	3	6 to 8
3	OE23	Product Lifecycle Management	3	-	-	3	6 to 8
4	OE24	ıstainability Management	3	-	-	3	6 to 8
5	OE25	Operation Research	3	-	-	3	6 to 8
6	OE26	IPR and Patenting	3	-	-	3	6 to 8
7	OE27	Research Methodology	3	-	-	3	6 to 8
8	OE28	Renewable Energy Management	3	-	-	3	6 to 8
9	OE29	Energy Audit and Management	3	-	-	3	6 to 8
10	OE30	Bioinformatics	3	-	-	3	6 to 8
11	OE31	Nanotechnology	3	-	-	3	6 to 8

Detailed syllabus of Final Year
Semester - VII

Course Name: RF and Microwave Engineering

Course Code: ET12T

Category: Core

Preamble:

This course aims to provide a comprehensive introduction to the principles and practices of RF and Microwave Engineering. It will cover principles and design concepts of impedance matching circuits, microwave filters and microwave active and passive devices and circuits. The emphasis is on the concepts necessary for the analysis and design of RF and microwave circuits such as modern communication systems, satellite, radar, navigation, and sensing technologies etc.

Pre-requisites: Electromagnetics and Antenna

Course Objectives:

The objective of the course is to equip students with the necessary knowledge and skills to excel in the field of RF and microwave engineering. The followings are course objectives-

- Introduce the fundamental principles, concepts and practices of RF and Microwave engineering
- Designing impedance matching circuits at high frequency using lumped and distributed elements.
- Study the characteristics and operation of microwave passive and active devices such as waveguides, cavities, filters, microwave tubes and semiconductor devices.
- Characterization and estimation of noise and its effects in rf and microwave systems.
- Familiarize students with practical measurement techniques and modern simulation tools used in RF engineering.
- Develop an understanding of real-world applications in communication systems, radar, and satellite technologies.

Course Outcomes:

Student will be able to:

CO1: Design matching circuits using lumped and distributed elements.
CO2: Design passive RF and microwave filters for specific frequency responses and impedance requirements.
CO3: Analyse waveguide, waveguide components and planer circuit components using scattering parameters and Field theory.
CO4: Illustrate the concepts of noise and its impact on system performance in RF and microwave circuits.
CO5: Design basic RF amplifier and oscillator using semiconductor devices.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Transmission Lines Analysis and Matching Circuit Design	• Introduction to RF and Microwave Engineering • Review of Transmission line equations and its solution • Scattering parameters and its properties • Planer transmission lines: Strip line, Microstrip Line, Coplanar line • Impedance Matching using lumped element and stub lines	10
2	RF Filter Design	• Filter Specifications • Filter design by insertion loss method	6
3	Waveguide and Waveguide Components	• Types of waveguides • Rectangular waveguide analysis: TE and TM Mode • Characteristics of TE and TM wave • Waveguide components: E and H plane tee, Magic tee, rat race circuit, directional coupler, ferrite devices, attenuators and phase shifters • Power dividers and directional couplers using microstrip lines	8
4	Microwave Tubes	• Classification, fundamental principles, and significant applications of microwave vacuum tubes like two cavity klystron, reflex klystron, TWT and Magnetron	6
5	Noise and Microwave Solid State Devices	• Noise in microwave circuit: Dynamic range and source of noise, noise temperature, noise figure, intermodulation distortion, gain compression • Discussion on solid state devices such as Schottky diode, PIN diode, Varactor diode, Tunnel diode, Gunn diode and IMPATT diode	6
6	Introduction to RF Amplifier and Oscillator Design	• Introduction to two port gains, stability • Single stage transistor amplifier design for maximum gain • Design aspects of one port negative resistance oscillator	8
Total			**45**

Textbooks:

1. David M. Pozar, "Microwave Engineering", John Wiley and Sons, 3rd Edition.
2. Sushrut Das, 'Microwave Engineering', Oxford University Press. 1st Edition.
3. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Prentice Hall.
4. Guillermo Gonzalez, "Microwave Transistor Amplifiers: Analysis and Design", 2nd Edition, Prentice Hall.

Reference Books:

1. Robert E. Collin, "Foundations for Microwave Engineering", Second Edition, McGraw-Hill.
2. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics Illustrated" Prentice Hall.
3. George D. Vendelin, Anthony M. Pavio, and Ulrich L. Rohde, "Microwave Circuit Design: Using Linear and Nonlinear Techniques" 3rd Edition, John Wiley & Sons.

Course Name: RF and Microwave Engineering Laboratory

Course Code: ET12P

Category: Core

Preamble:

The RF and Microwave Engineering Lab is designed to provide hands-on experience in the measurement, analysis, and design of high-frequency circuits and components. This lab course enables students to explore the practical aspects of RF and microwave engineering, including the behaviour of transmission lines, impedance matching, and the characterization of passive and active components. Students will gain proficiency in using modern test and measurement equipment such as vector network analysers, spectrum analysers, and signal generators. They will also learn to use simulation tools for designing and analysing RF circuits. The lab emphasizes the development of practical skills necessary for careers in wireless communication, radar systems, satellite technology, and other high-frequency domains.

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Pre-requisites: RF and Microwave Engineering

Course Objectives:

This course familiarizes students with practical measurement techniques and modern simulation tools used in RF engineering. The objective of the RF and Microwave Engineering Lab is to provide students with practical knowledge and hands-on experience in the measurement, analysis, and design of high-frequency circuits and systems. The lab aims to reinforce theoretical concepts related to transmission lines, impedance matching, filters and RF/MW components, while developing proficiency in using modern RF test equipment and simulation tools.

Course Outcomes:

Students will be able to:

CO1: Design and implement impedance matching networks using lumped and distributed elements.
CO2: Design and implement microwave filter.
CO3: Apply simulation software tools to analyse and design RF and Microwave circuits.
CO4: Perform RF and Microwave measurements using laboratory equipment.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	**ISA**	**MSA**	**ESA**	**Total**
Practical	25	-	25	050

Suggested List of Practical:

List of problem statements for practical work. Make sure that practical is problem based. It should cover most of the course contents.

- Scattering parameters and its measurement
- Design and Analysis of matching circuit design using stubs
- Design and Analysis of matching circuit design using lumped element
- Filter design by insertion loss method
- Waveguide analysis using electromagnetic simulators.
- Characterization of planer circuit components like power divider, directional couplers etc.
- Experimentation of Gunn based test bench
- Experimentation of Klystron based test bench
- Class A amplifier design
- One port oscillator design

The above list is a mere suggestion. The course teacher may explore various ways to characterize RF/MW circuit performance. Suggested to refer course contents of theory course on 'RF and Microwave Engineering'.

Textbooks:

1. David M. Pozar, "Microwave Engineering", John Wiley and Sons, 3rd Edition.
2. Sushrut Das, 'Microwave Engineering', Oxford University Press. 1st Edition.
3. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Prentice Hall.
4. Guillermo Gonzalez, "Microwave Transistor Amplifiers: Analysis and Design", 2nd Edition, Prentice Hall.

Reference Books:

1. Robert E. Collin, "Foundations for Microwave Engineering", Second Edition, McGraw-Hill.
2. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics Illustrated" Prentice Hall.
3. George D. Vendelin, Anthony M. Pavio, and Ulrich L. Rohde, "Microwave Circuit Design: Using Linear and Nonlinear Techniques" 3rd Edition, John Wiley & Sons.

Course Name: OFDM and MIMO Technology

Course Code: ET23T

Category: Professional Elective – 4 (Communication Track)

Preamble:

This course introduces the fundamental issues, concepts, and design principles in "orthogonal frequency-division multiplexing" (OFDM) communications – modulation, demodulation, synchronization, peak-to-average power ratio (PAPR) reduction. This course also introduces the fundamental issues, concepts, and design principles in "multiple-input multiple-output" (MIMO) wireless communications – MIMO channel model, antenna diversity, space-time coding, MIMO detection algorithms.

Pre-requisites:

1. Digital Communications – Strongly Related
2. Digital Signal Processing- Strongly Related
3. Probability– Weakly Related
4. Linear Systems- Weakly Related

Course Objectives:

The main objective of the course is to

- To make learners familiar with fundamentals of wireless communication systems.
- To understand the diversity and spatial multiplexing phenomenon in MIMO system.
- To understand the receiver system design for MIMO.
- To become familiar with OFDM and MIMO-OFDM systems.

Course Outcomes:

Learner will be able to:

CO1: To understand OFDM's transceiver architecture.
CO2: To understand the problem of PAPR and how to reduce the PAPR.
CO3: To understand how the OFDM receiver performs synchronization and the adverse effects of mis-synchronization.
CO4: To understand MIMO channel models and space-time coding.
CO5: To understand the concept and methods of diversity reception.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment

methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	OFDM Basics	Multi-carrier transmission; OFDM modulation & demodulation, BER; coded-OFDM; Orthogonal frequency-division multiple-access (OFDMA).	8
2	OFDM Synchronization	Effect/estimation of symbol-time offset (STO); Effect/estimation of carrier-frequency offset (CFO); Effect/compensation of sampling clock offset (SCO).	5
3	Peak-to-Average Power Ratio Reduction (PAPRR)	Distribution of OFDM-signal amplitude; PAPR & oversampling; Mitigation methods: clipping & filtering, selective mapping (SLM), partial transmit sequence (PTS), tone reservation (TR), tone injection (TI), etc.	5
4	Multiple-Input Multiple-Output (MIMO) Channel Models	Small-scale vs. large-scale fading; time-dispersive vs. frequency-dispersive fading; Spatial correlation.	6
5	Antenna Diversity & Spatially Multiplexed MIMO Systems	Receive-antenna diversity; Transmit-antenna diversity. Space-time Coding, Detection for Spatially Multiplexed MIMO Systems	6
		Total	**30**

Textbooks:

1. MIMO-OFDM Wireless Communications with MATLAB , by Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , Wiley, 2010, ISBN: 978-0-470-82561-7
2. Mohinder Janakiram, "Space time Processing and MIMO systems", Artech House, First Edition, 2004
3. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2008.

Reference Books:

1. Hamid Jafarkhani, "Space Time coding-Theory and Practice", Cambridge University Press, First Edition, 2005.
2. Branka Vucetic, Jinhong Yuan, "Space Time coding", John Wiley and Sons, First Edition, 2003.
3. Andrea Goldsmith, "Wireless Communication", Cambridge University Press, First Edition. 2005.
4. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

Course Name: OFDM and MIMO Technology Laboratory

Course Code: ET23P

Category: Professional Elective – 4 (Communication Track)

Preamble:
This course introduces the fundamental issues, concepts, and design principles in "orthogonal frequency-division multiplexing" (OFDM) communications – modulation, demodulation, synchronization, peak-to-average power ratio (PAPR) reduction. This course also introduces the fundamental issues, concepts, and design principles in "multiple-input multiple-output" (MIMO) wireless communications – MIMO channel model, antenna diversity, space-time coding, MIMO detection algorithms.

Pre-requisites:

1. Digital Communications – Strongly Related
2. Digital Signal Processing- Strongly Related
3. Probability– Weakly Related
4. Linear Systems- Weakly Related

Course Objectives:
The main objective of the course is to

- To make learners familiar with fundamentals of wireless communication systems.
- To understand the diversity and spatial multiplexing phenomenon in MIMO system.
- To understand the receiver system design for MIMO.
- To become familiar with OFDM and MIMO-OFDM systems.

Course Outcomes:

Learner will be able to:

CO1: Operate and configure OFDM transceivers to generate and receive multicarrier signals with cyclic prefix and understand their time-frequency characteristics.
CO2: Implement and observe the effect of multipath fading and Doppler shifts on OFDM signals using simulation or hardware platforms.
CO3: Set up MIMO antenna systems to demonstrate spatial multiplexing and diversity techniques and measure their impact on system performance using MATLAB.
CO4: Analyse BER performance of OFDM and MIMO systems under varying channel conditions, noise levels and modulation schemes.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	25	-	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical:

Learners are expected to perform practical based on the following suggested topics.

Sr No	Suggested Topic(s)
1	Generate OFDM signals using IFFT/FFT blocks, add cyclic prefix, and perform demodulation to recover data.
2	Simulate multipath fading channels and analyze its impact on the BER and signal constellation of OFDM.
3	Implement pilot-based channel estimation and equalization techniques to mitigate channel impairments.
4	Set up a MIMO systems with multiple transmit and receive antennas and demonstrate spatial multiplexing.
5	Implement and analyze the performance improvements using MIMO diversity schemes like Alamouti coding.
6	Measure and compare BER for different modulation schemes and channel conditions.
7	Simulate mobile scenarios to observe Doppler effects on OFDM signals and analyze system robustness.
8	Demonstrate how adaptive modulation can improve throughput and reliability in varying channel conditions.

Textbooks:

1. MIMO-OFDM Wireless Communications with MATLAB , by Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , Wiley, 2010, ISBN: 978-0-470-82561-7
2. Mohinder Janakiram, "Space time Processing and MIMO systems", Artech House, First Edition, 2004
3. Arogyaswami Paulraj, Rohit Nabar, Dhananjay Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2008.

Reference Books:

1. Hamid Jafarkhani, "Space Time coding-Theory and Practice", Cambridge University Press, First Edition, 2005.
2. Branka Vucetic, Jinhong Yuan, "Space Time coding", John Wiley and Sons, First Edition, 2003.
3. Andrea Goldsmith, "Wireless Communication", Cambridge University Press, First Edition. 2005.
4. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

Course Name: Data Mining

Course Code: ET29T

Category: Professional Elective-4 (Data Analytics & ML Track)

Preamble:

This course aims to provide the learner advanced Data Manipulation techniques for enabling efficient data processing and analysis tasks. The course introduces process of extracting valuable knowledge and insights from large datasets using statistical and machine learning techniques.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Introduction to Data Analytics (ET27T Sem-6 EXTC)
- Machine Learning (ET28T Sem-6 EXTC)

Course Objectives:

- To understand the role of Data Mining in the knowledge discovery process.
- To familiarize various advanced data mining functionalities and their applications to real world Problems.
- To learn finding data characteristics and evaluating outcome of data mining process.
- To use and apply machine learning algorithms in data mining process.

Course Outcomes:

Student will be able to:

CO1: Apply Data dimensionality reduction technique in the process of data mining.
CO2: Analyse multiclass based data with multiple features using discriminant analysis.
CO3: Evaluate performance of Advanced Tree based prediction models on the given data.
CO4: Evaluate combined prediction power of ensemble methods and incremental impact with uplift model.
CO5: Evaluate relationship and patterns and predict preferences using association and collaborative Rules.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Head	**ISA**	**MSA**	**ESE**	**Total (Passing @40% of total)**
Theory	15	20	40	75
Lab	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Introduction & Dimension Reduction Techniques	Core ideas in Data Mining, Steps in Data Mining, Curse of Dimensionality, Aggregation and Pivot Tables, Correlation Analysis, reducing categories in categorical variables, Principal Component Analysis, Dimension Reduction using Regression Models	6
2	Discriminant Analysis	Introduction, Distance of record from a Class, Fisher's Linear Classification Functions, Classification Performance of Discriminant Analysis, Prior Probabilities, Unequal misclassification cost, classification for more than two classes	6
3	Classification and Regression Trees	Tree structure, Decision Rules, Measures of Impurity, Performance evaluation of tree, Sensitivity Analysis using Cross Validation, avoiding overfitting, controlling growth of tree (pruning), Fine tuning tree parameters, Random Forests, Boosted Trees	6
4	Ensemble Methods & Uplift Modelling	Ensemble Techniques for improvement of predictive power, simple averaging, Bagging, Boosting, Advantages and limitation of Ensembles, Uplift (Persuasion) modelling, A-B Testing, modelling individual uplift	6
5	Association Rule Mining & Collaborative Filtering	Association Rules, generating candidate rules, the Apriori algorithm, selecting strong rules, rule selection and interpretation of result, collaborative filtering, data types and format, user based and item based collaborative filtering, comparison of collaborative filtering and association rules	6
Total			**30**

Textbooks:

1. Galit Shmueli, Peter Bruce, Peter Gedeck, Nitin Patel, O P Wali, "Data Mining for Business Analytics: Concepts, Techniques and Applications in Python", 2023 Edition, Wiley India
2. Amin Zollanvari, "Machine Learning with Python Theory & Implementation", 1st Edition, Springer Publication
3. Han J, Pei J, Tong H, "Data Mining Concepts & Techniques", 4th Edition, Elsevier, New Delhi

Reference Books:

1. Sheldon M. Ross, "Introduction to Probability & Statistics for Engineers & Scientists", 5th Edition, Elsevier
2. D. Sarkar, Raghav Bali, Tushar Sharma, "Practical Machine Learning with Python- A Problem Solver Guide to Building Real World Intelligent Systems", Apress Publication
3. Fabio Nelli, "Python Data Analytics" , 2nd Edition, Apress Publication

Course Name: Data Mining Laboratory

Course Code: ET29P

Category: Professional Elective-4 (Data Analytics & ML Track)

Preamble:

This lab course work will enable students to develop analytical solutions to the real time large data mining with machine learning algorithm and advanced statistical techniques. This lab course will be exclusively designed on the real time case studies taken from different manufacturing industries like electrical, electronics, chemical, machine tool, material handling etc.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Engineering Mathematics – III (BS33 Sem-3 EXTC)
- Mathematical Theory of Communication (BS34T & BS34P Sem-4 EXTC)
- Introduction to Data Analytics (ET27T Sem-6 EXTC)
- Machine Learning (ET28T Sem-6 EXTC)

Course Objectives:

- To understand importance of data mining processing for improved information gain in the data analysis.
- To apply dimensionality reduction techniques and advanced tree-based models for improved performance of analysis.
- To study and apply combination ensemble techniques and study incremental impact on the datasets.
- To find hidden patterns and relationship and predict the preference rules in the datasets.

Course Outcomes:

Student will be able to:

CO1: Create reduced dataset records with dimensionality reduction techniques.
CO2: Create classification based on multiclass and multi feature environment in the given data.
CO3: Create advanced Tree based classifier and regressor models with hyper tuning techniques.
CO4: Create a combined model solution with ensembles and predict incremental impact on data.
CO5: Create an analysis on finding hidden relationship and pattern in the data & predict preferences

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

No	Experiment Title	Mapped CO
1	Reduce the given dataset using Principal Component Analysis	CO1
2	Reduce the given dataset using Regression Modeling	CO1
3	Apply Linear Discriminant Analysis with defined functions on the data	CO2
4	Linear Discriminant Analysis for classification of more than two classes	CO2
5	Design Decision Tree Random Forest Classifier on the data	CO3
6	Design Boosted Tree Regressor on the data	CO3
7	Design Ensemble method with Bagging Techniques	CO4
8	Design Ensemble method with Boosting Techniques	CO4
9	Design Uplift modeling for the data	CO4
10	Design A-B Testing model for the data	CO4
11	Design association rule for finding relationship and pattern in data	CO5
12	Design Collaborative filter technique for preference prediction in data	CO5

Textbooks:

1. Galit Shmueli, Peter Bruce, Peter Gedeck, Nitin Patel, O P Wali, "Data Mining for Business Analytics: Concepts, Techniques and Applications in Python", 2023 Edition, Wiley India
2. Amin Zollanvari, "Machine Learning with Python Theory & Implementation", 1st Edition, Springer Publication
3. Han J, Pei J, Tong H, "Data Mining Concepts & Techniques", 4th Edition, Elsevier, New Delhi

Reference Books:

1. Sheldon M. Ross, "Introduction to Probability & Statistics for Engineers & Scientists", 5th Edition, Elsevier
2. D. Sarkar, Raghav Bali, Tushar Sharma, "Practical Machine Learning with Python- A Problem Solver Guide to Building Real World Intelligent Systems", Apress Publication
3. Fabio Nelli, "Python Data Analytics" , 2nd Edition, Apress Publication

Course Name: Internet of Things and Edge Computing

Course Code: ET35T

Category: Professional elective - 4 (IoT Track)

Preamble:

This course explores the convergence of Internet of Things (IoT) and Edge Computing, delving into the technologies and applications that are transforming our world. This course delves into the rapidly evolving landscape where everyday objects are becoming intelligent and interconnected. Students will explore how sensors, actuators, and embedded systems are weaving a web of data, transforming how we live, work, and interact with the environment.
The course will equip students with a foundational understanding of IoT, its core technologies, and communication protocols. Students will delve into the power of Edge Computing, a paradigm shift that brings processing capabilities closer to the data source, enabling real-time analytics, faster decision-making, and improved efficiency.

Pre-requisites:

- C Programming
- Microprocessor and Microcontroller
- IoT Sensor Technology

Course Objectives:

- To understand the core concepts of the Internet of Things (IoT) and its key components & Levels.
- Analyze the role of Edge Computing in distributed processing and data analysis within the IoT ecosystem**.**
- Evaluate the security challenges and potential vulnerabilities within IoT deployments.
- Understand the fundamental concepts of IoT, CPS, and their convergence.

Course Outcomes:

Student will be able to:
CO1: Understand the interaction between IoT devices, cloud platforms, and physical systems in CPS.
CO2: Apply principles of Edge Computing to analyze data at the network edge.
CO3: Analyze the role of Edge Computing in distributed processing and data analysis within the IoT ecosystem.
CO4: Identify and discuss security best practices for secure IoT deployments.
CO5: Analyze the role of cloud computing in managing and processing data from IoT device
CO6: Develop creative applications of IoT technology in chosen fields.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to IoT and CPS	1.1 Introduction to Cyber-Physical Systems (CPS) 1.2 Characteristics and applications of CPS 1.3 Convergence of IoT and CPS: creating intelligent systems	5
2	Introduction to Edge Computing	1. What is Edge Computing? 2. Benefits of Edge Computing in the IoT ecosystem (e.g., reduced latency, improved efficiency) 3. Edge Computing architectures (e.g., edge nodes, fog computing) Resource constraints and limitations of edge devices	5
3	Edge Computing Applications and Programming	3.1 Case studies of Edge Computing applications in IoT (e.g., predictive maintenance, autonomous vehicles) 3.2 Introduction to Edge Computing development tools and frameworks 3.3 Programming for edge devices (e.g., embedded systems programming)	5
4	Security Considerations in IoT	4.1 Security vulnerabilities in IoT deployments 4.2 Authentication and authorization mechanisms 4.3 Data encryption and privacy concerns 4.4 Secure coding practices for IoT devices	5
5	Cloud Computing for IoT	5.1 Cloud service models for IoT (IaaS, PaaS, SaaS) 5.2 Benefits of cloud computing in managing and processing IoT data (scalability, security, etc.) 5.3 Cloud platforms for IoT (e.g., AWS IoT, Azure IoT) 5.4 Data pipelines for transferring and processing sensor data in the cloud	5
6	Future Trends in IoT CPS and Edge Computing	6.1 Emerging technologies (e.g., Artificial Intelligence, Block chain) in IoT 6.2 Impact of 5G on IoT and Edge Computing 6.3 Ethical considerations and responsible development of CPS solutions	5
Total			**30**

Text Books:

1. "Cyber-Physical Systems: Design and Analysis" by Lee E. Miller (2013)
2. "Cloud Computing for Cyber Physical Systems: Enabling Technologies and Applications" by Vijayakumar Gayathri, et al. (2019)
3. "Hands-On Internet of Things with Arduino and Raspberry Pi: Building Practical Applications" by Dr. Srinivas Upputuri (2020)
4. "Building IoT Projects with ESP8266 and ESP32" by Pradeeka Kumar (2020)
5. "Edge Computing for the Internet of Things: Secure and Scalable Distributed Intelligence" by Michael Dieterich (2020)
6. "Cyber-Physical Systems Prototyping with Lego Mindstorms" by Wesley Plugge et al. (2014)

Reference Books:

1. "Designing the Internet of Things" by Adrian McEwen and Hakim Cassimally (2014)
2. "Edge Computing: Networking and Security for the Internet of Things" by Yuhui Xu, et al. (2018)
3. "Fog Computing: Theory, Practice, and Applications" by Tom Pfeifer and Dominic Grulich (2019)

Course Name: Internet of Things and Edge Computing Laboratory

Course Code: ET35P

Category: Professional elective - 4 (IoT track)

Preamble:

This laboratory course delves into the practical applications of the Internet of Things (IoT), Edge Computing, Cloud Computing, and Cyber-Physical Systems (CPS). Students will gain hands-on experience by working with real-world scenarios and exploring the interaction between these technologies
The lab will equip students with the skills to:

- Design and implement basic IoT systems
- Utilize Edge Computing platforms for data processing closer to the source
- Leverage cloud services for data storage, analysis, and visualization
- Integrate IoT devices with Cyber-Physical Systems for real-world applications

Pre-requisites:

- C Programming
- Microprocessor and Microcontroller
- IoT Sensor Technology

Course Objectives:

- Gain practical experience in setting up and configuring IoT devices.
- Understand and implement data collection and processing techniques on edge devices.
- Analyze and visualize data generated by IoT devices using cloud platforms.
- Design and implement basic Cyber-Physical Systems using IoT and cloud integration.
- Apply security best practices in developing and deploying IoT solutions.

Course Outcomes:

Student will be able to:
CO1: Successfully configure and program various IoT devices (sensors, actuators).
CO2: Utilize Edge Computing platforms for data processing tasks on edge nodes.
CO3: Develop data pipelines to transfer data from IoT devices to the cloud.
CO4: Analyze and visualize sensor data using cloud-based tools and services.
CO5: Design and prototype a basic Cyber-Physical System with IoT and cloud integration.
CO6: Implement secure communication protocols for data transmission in an IoT system.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	**ISA**	**MSE**	**ESE**	**Total**
Practical	25	-	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

List of Practical's:

Experiment 1: Setting Up an IoT Development Environment

- Familiarize with development boards (e.g., Arduino, Raspberry Pi)
- Install necessary software and libraries

Experiment 2: Sensor Interfacing and Data Acquisition

- Interface various sensors (e.g., temperature, humidity) with the development board
- Write code to collect and record sensor data

Experiment 3: Communication Protocols for IoT

- Experiment with different communication protocols (e.g., Wi-Fi, Bluetooth)
- Develop code to send and receive data between devices

Experiment 4: Introduction to Edge Computing Platforms

- Explore popular Edge Computing platforms (e.g., AWS Greengrass, Azure IoT Edge)
- Deploy simple applications for data processing on edge devices

Experiment 5: Cloud Integration for IoT Data

- Connect IoT devices to a cloud platform (e.g., AWS IoT, Azure IoT Hub)
- Develop code to send sensor data to the cloud

Experiment 6: Data Visualization with Cloud Services

- Utilize cloud platform tools to visualize sensor data in real-time (e.g., dashboards, charts)

Experiment 7: Introduction to Cyber-Physical Systems (CPS)

- Simulate a basic CPS scenario (e.g., smart home, industrial automation)
- Integrate IoT devices with actuators to control physical processes

Experiment 8: Security Considerations in IoT Systems

- Implement secure communication protocols (e.g., encryption)
- Understand best practices for securing data transmission and storage in IoT

Mini Projects / Case Study:-

Design and develop a complete IoT-based system with Edge Computing and Cloud integration

Text Books:

1. "Cyber-Physical Systems: Design and Analysis" by Lee E. Miller (2013)
2. "Cloud Computing for Cyber Physical Systems: Enabling Technologies and Applications" by Vijayakumar Gayathri, et al. (2019)
3. "Hands-On Internet of Things with Arduino and Raspberry Pi: Building Practical Applications" by Dr. Srinivas Upputuri (2020)
4. "Building IoT Projects with ESP8266 and ESP32" by Pradeeka Kumar (2020)
5. "Edge Computing for the Internet of Things: Secure and Scalable Distributed Intelligence" by Michael Dieterich (2020)
6. "Cyber-Physical Systems Prototyping with Lego Mindstorms" by Wesley Plugge et al. (2014)

Reference Books:

1. "Designing the Internet of Things" by Adrian McEwen and Hakim Cassimally (2014)
2. "Edge Computing: Networking and Security for the Internet of Things" by Yuhui Xu, et al. (2018)
3. "Fog Computing: Theory, Practice, and Applications" by Tom Pfeifer and Dominic Grulich (2019)

Course Name: **ASIC and Verification.**

Course Code: ET23T

Category: Professional track – 4 (VLSI track)

Preamble:

This course introduces students about different methods used for Verification of digital circuits using System VERILOG. This course gives guidelines for building of Test-bench helps to understand how and why to use classes, randomization, and functional coverages.

Pre-requisites:

- Electronics Devices and Circuits.
- Logic circuits.
- Digital VLSI.
- Digital system design with VERILOG & FPGA.

Course Objectives:

The aim of this course is,

- To highlight the System Verilog Verification Language Construct.
- A profound understanding of creating test-bench for verification of digital circuits.
- Use of classes, randomization, and functional coverages.

Course Outcomes:

CO1: Students will be able to understand. Verification techniques to serve as a foundation for learning and using the System Verilog language.
CO2: Students will be able to illustrate various data types such as arrays, structures, enumerated types.
CO3: Students will be able to Design the various Test-benches for verification.
CO4: Students will be able to understand the concept of randomization, threads and Inter process communication.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Verification Guidelines	1.1 Verification Process, Verification Methodology, Basic Test-Benches functionality. Test bench components, Layered testbench.	4
2	Basics of System Verilog	2.1 Introduction to System Verilog, Data types, Built in data types, Fixed size arrays, Dynamic arrays, queues, and associative arrays. Array methods. 2.2 Types, creating new types, enumerated types, Type conversion, Static and Dynamic cast.	8
3	System Verilog control flow.	3.1 Loops: while/do while, for each loop, for loop, forever loop. Case statements. 3.2 Functions, Tasks, Blocking and Non-Blocking. Randomization, System Verilog interfaces.	5
4	System Verilog object-oriented programming.	4.1Introduction, Class, creating new object, object declaration, class methods. Defining methods outside the class. Static and Global variables. Class inside class. Dynamic objects, copying objects.	8
5	System Verilog threads and communication	5.1 fork_join and begin_ end. Semaphores and events. Mail-boxes etc.	5
Total			**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	System Verilog for Verification.	Chris spear and Greg Tumbush.	Springer.	3rd Edition.	All.
2	System Verilog Assertions and Functional coverage.	Ashok Mehta.	Springer.	3rd Edition.	1,2,3,4

Reference Books:

1. System Verilog for design by Stuart Sutherland, Simon David Mann, Peter flake.2nd edition. Springer Publications.

Course Name: ASIC and Verification Laboratory

Course Code: ET23P

Category: Professional Track – 4 (VLSI track)

Preamble:

This course introduces students about different methods used for Verification of digital circuits using System VERILOG. This course gives guidelines for building of Test-bench helps to understand how and why to use classes, randomization, and functional coverage's.

Pre-requisites:

- Electronics Devices and Circuits.
- Logic circuits.
- Digital VLSI.
- Digital system design with VERILOG & FPGA.

Course Objectives:

The aim of this course is:
• To highlight the System Verilog Verification Language Construct.
• A profound understanding of creating test-bench for verification of digital circuits.
• Use of classes, randomization, and functional coverage's.

Course Outcomes:

CO1: Students will be able to understand basics of System Verilog, including data types, operators, and language constructs.
CO2: Students will be able to create test benches to verify ASIC designs using System Verilog.
CO3: Students will be able to Design assertions and constraints to ensure ASIC designs and meet required specifications.
CO4: Students will be able to understand the various stages of ASIC design, including RTL design, synthesis, and verification.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	25	-	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment

methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

1. Handling variables, types, and basic operations in System Verilog.
2. Array declaration, array handling in System Verilog.
3. Exercise using procedural statements in System Verilog.
4. Exercise using task and functions in System Verilog.
5. Design and Implementation of various combinational circuits using System Verilog.
6. Design and Implementation of various sequential circuits using System Verilog.
7. Design and Implementation FSM using System Verilog.
8. Developing test benches for basic digital circuits using system Verilog.
9. Write assertions to verify digital circuits using system Verilog.

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	System Verilog for Verification.	Chris spear and Greg Tumbush.	Springer.	3rd Edition.	All.
2	System Verilog Assertions and Functional coverage.	Ashok Mehta.	Springer.	3rd Edition.	1,2,3,4

Reference Books:

1. System Verilog for design by Stuart Sutherland, Simon David Mann, Peter flake.2nd edition. Springer Publications.

Course Name: Satellite Communication

Course Code: ET24T

Category: Professional Elective – 5 (Communication Engineering track)

Preamble:

This course aims to provide the learner fundamental principal concepts used in the working operation of Satellites and associated systems.

Pre-requisites:

- Analog Communication
- Digital Communication

Course Objectives:

- To understand the basics of satellite communications and different satellite orbits.
- Provide an in-depth understanding of satellite communication system operation, launching techniques, and earth station technology.
- To Analyze and evaluate satellite link design.
- To review structure design, payload and space segment related to Nano satellite.

Course Outcomes:

Student will be able to:

CO1: Understand the basic concepts of satellite communication system and orbital parameters.
CO2: Explain various satellite sub-systems, earth station technologies and launching mechanisms.
CO3: Analyse and evaluate link budget and various performance parameters of satellite signal for proper communication.
CO4: Understand Nano Satellite Structure design, payloads, thermal control system and space Segment.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Head	**ISA**	**MSA**	**ESE**	**Total (Passing @40% of total)**
Theory	15	20	40	75
Lab	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment

methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Overview of Satellite Systems	Classification of satellites, Satellite orbital geometry elements, Kepler's Laws, Orbital Perturbations and mitigation, Effects of atmospheric drag and nonspherical earth shape, Satellite position, look angles, visibility limits, satellite eclipses, satellite launching mechanism, types of launchers	6
2	Space Segment and Earth Station	Satellite configuration, transponder sub-system, antenna sub- system, AOC sub- system, TT&C sub-system, power sub-system, thermal sub-system, Reliability and quality assurance, earth station design considerations, block diagram, receive only type earth, transmit-receive type earth station, antenna system, feed system, tracking system, LNA and HPA.	6
3	Satellite Link Analysis	Atmospheric losses, ionospheric losses, transmission losses, feeder losses, antenna misalignment losses, rain attenuation, other impairments, antenna polarization, polarization of satellite signals, cross polarization discrimination, ionospheric depolarization, rain depolarization and ice depolarization, Isotropic radiated power and link budget, Effects of rain, uplink rain-fade margin, downlink rain-fade margin, combined uplink and downlink C/N ratio and intermodulation noise.	6
4	Nano Satellites	Introduction: Important transformation, Review of nano satellite, Global economics related to it, Evolution of nano satellite, ISRO's small satellite program and future Scenario, Payloads for nano satellite: Types of payloads: Earth observation payload, communication payload and scientific payload. Design considerations for payloads.	6
5	Space Segment for Nano Satellites	Thermal control system (TCS) implementation in nano satellite and it's testing for verification of TCS. Power system design for nano satellite, Function and design consideration of Deployment mechanisms, Critical elements in deployment mechanisms, Overview of types of deployment mechanisms.	6
Total			**30**

Textbooks:

1. Dennis Roddy, —Satellite Communications||, 4th Ed., Mc. Graw-Hill International Ed. 2009.
2. M. Richharia, —Satellite Communication Systems Design Principles||, Macmillan Press Ltd. Second Edition 2003.
3. R. N. Mutangi, — Satellite Communication||, Oxford university press, 2016.

Reference Books:

1. Gerard Maral and Michel Bousquet, —Satellite Communication Systems||, 4th Edition Wiley Publication
2. Gerard Maral, —VSAT Networks||, John Willy & Sons
3. Space technology Veterans, Quintessence of Nano satellite technology (small is big), Planet aerospace India, 2020.
4. Timothy Pratt, Charles Bostian, and Jeremy Allmuti, —Satellite Communications||, John Willy & Sons (Asia) Pvt. Ltd. 2004
5. Wilbur L. Pritchard, Henri G. Suyderehoud, and Robert A. Nelson, —Satellite Communication systems Engineering||, Pearson Publication

Course Name: Satellite Communication Laboratory

Course Code: ET24P

Category: Professional Elective – 5 (Communication Engineering track)

Preamble:

This lab course work will enable students to develop analytical solutions to the link design problems in the satellite communication, elaborate the working mechanism of wireless communication with prototype satellite trainer.

Pre-requisites:

- Analog Communication
- Digital Communication

Course Objectives:

- Elaborate the conceptual working of satellite systems
- Analyze the link budget in the satellite communication in various conditions of the losses
- Study the modulation and demodulation of audio, voice signal with satellite trainer board.

Course Outcomes:

Student will be able to:

CO1: Study the working model of wireless satellite communication
CO2: To establish wireless communication with audio video signals using satellite prototype and link design
CO3: To study different modulation and demodulation techniques using satellite prototype.
CO4: To study radiation patterns of different antennas used by the satellite system.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

No	Experiment Title	Mapped CO
1	To set up a satellite communication link and study the changes made in the uplink and downlink frequency operations	CO1
2	To establish audio video link between the satellite transmitter and receiver	CO2
3	To study minimum shift keying modulation using satellite transmitter	CO3

	and receiver	
4	To study the GPS data longitude, latitude	CO1
5	To study data PN sequence generation	CO1
6	To study generation and demodulation of Direct sequence spread spectrum signal	CO3
7	To study the design parameters of the satellite	CO1
8	To study the radiation patterns of the different antennas used in satellite transmitter and receiver	CO4
9	Analysis of Link Budget equation under different conditions and losses	CO2
10	To study the antenna look angles	CO1

Textbooks:

1. Dennis Roddy, —Satellite Communications||, 4th Ed., Mc. Graw-Hill International Ed. 2009.
2. M. Richharia, —Satellite Communication Systems Design Principles||, Macmillan Press Ltd. Second Edition 2003.
3. R. N. Mutangi, — Satellite Communication||, Oxford university press, 2016.

Reference Books:

1. Gerard Maral and Michel Bousquet, —Satellite Communication Systems||, 4th Edition Wiley Publication
2. Gerard Maral, —VSAT Networks||, John Willy & Sons
3. Space technology Veterans, Quintessence of Nano satellite technology (small is big), Planet aerospace India, 2020.
4. Timothy Pratt, Charles Bostian, and Jeremy Allmuti, —Satellite Communications||, John Willy
5. Wilbur L. Pritchard, Henri G. Suyderehoud, and Robert A. Nelson, —Satellite Communication systems Engineering||, Pearson Publication

Course Name: Big Data Analytics

Course Code: ET30T

Category: Professional Elective-5 (Data Analytics & ML Track)

Preamble:

This course aims to provide an overview of big data platforms, its use cases and Hadoop ecosystem. The course introduces programming skills to build simple solutions using big data technologies like MapReduce, NoSQL. The course will provide students fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Introduction to Data Analytics (ET27T Sem-6 EXTC)
- Machine Learning (ET28T Sem-6 EXTC)

Course Objectives:

- To provide an overview of big data platforms, it use-cases and Hadoop ecosystem
- To introduce programming skills to build solutions using big data technologies like MapReduce, NoSQL.
- To learn achieving scalability and streaming capability in big data analytics

Course Outcomes:

Student will be able to:
CO1: Understand the key issues in big data management and its associated applications.
CO2: Apply enabling techniques and algorithms Hadoop, MapReduce, NoSQL in big data analysis.
CO3: Analyse business models and apply software tools for big data analytics.
CO4: Evaluate the perspectives of big data analytics in applications.
CO5: Develop applications for big data analysis using Hadoop and NoSQL.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Head	**ISA**	**MSA**	**ESE**	**Total (Passing @40% of total)**
Theory	15	20	40	75
Lab	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall

be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Introduction	Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional versus Big Data business approach, Technologies available for Big Data, Infrastructure, Big Data Challenges, case studies of Big data solutions	03
2	Hadoop	Introduction to Hadoop, Core Hadoop Components, Hadoop Ecosystem- Apache HBase, Hive, Pig, Mahout, Oozie, Zookeeper, Sqoop, Physical architecture, Overview of Apache Spark	05
3	NoSQL	Introduction to NoSQL, NoSQL data architecture: Key value stores, Column family stores, Document stores. Using NoSQL to manage big data: Big data problems, NoSQL database case studies	06
4	MapReduce	MapReduce Paradigm: MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping with Node Failures. Algorithms Using MapReduce**:** Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce, Computing Natural Join by MapReduce, Grouping and Aggregation by MapReduce, Matrix Multiplication, Matrix Multiplication with One MapReduce Step, Illustrating use of MapReduce with use of real life databases and applications.	08
5	Techniques and applications	Mining Big Data Streams: Flajolet-Martin Algorithm, The Datar-Gionis-Indyk- Motwani Algorithm, Query Answering in the DGIM Algorithm. Big Data Mining Algorithms: Frequent Pattern Mining, Handling Larger Datasets in Main Memory, Basic Algorithm of Park, Chen, and Yu**.** Mining Social- Network Graphs: Social Networks as Graphs, Clustering of Social Network Graphs. Recommendation Engines: A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering.	08
Total			**30**

Textbooks:

1. Big Data Analytics- Radha Shankarmani and M Vijaylakshmi, Wiley
2. Hadoop in Practice – Alex Holmes, Manning Press, Dreametch
3. Making Sense of NoSQL A guide for managers and the rest of us– Dan McCreary, Ann Kelly, Manning Press

Reference Books:

1. Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics – Bill Franks, Wiley
2. Hadoop in Action – Chuck Lam, Dreamtech Press
3. Big Data Analytics – Raj Kamal – PHI India

Course Name: Big Data Analytics Laboratory

Course Code: ET30P

Category: Professional Elective-5 (Data Analytics & ML Track)

Preamble:

This lab course will enable students to learn the technologies used to process big data with tools like Hadoop, MapReduce, Hive and build data mining applications on the large scale.

Pre-requisites:

- Skill Based Lab (Python Programming ET-17 Sem-3 EXTC)
- Introduction to Data Analytics (ET27T Sem-6 EXTC)
- Machine Learning (ET28T Sem-6 EXTC)

Course Objectives:

- To apply Big Data Tools for revealing the data pattern and insights.
- To develop MapReduce program to implement data mining tasks for the big data
- To develop problem solving skills in enabling techniques.

Course Outcomes:

Student will be able to:
CO1: To describe key issues in big data management and experiment with Hadoop framework.
CO2: To explain structured and unstructured data using NoSQL commands.
CO3: To apply scientific computing algorithms for finding similar items and clustering.
CO4: To test fundamental enabling techniques and scalable algorithms for data stream mining.
CO5: To develop problem solving skills in enabling techniques Hadoop and MapReduce.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	--	25

Suggested List of Practical:

No	Experiment Title	Mapped CO
1	Installation of Hadoop Framework and its components and study of ecosystem	CO1
2	Implement word count program using MapReduce	CO3
3	Implement Matrix multiplication on Hadoop MapReduce	CO1
4	Install and configure MongoDB for execution of NoSQL commands	CO2
5	Implement K means clustering algorithm using MapReduce	CO5

6	Hadoop Implementation of file management tasks such as file adding, directory, file retrieval and file deletion	CO4
7	Installation of Hive with practice examples.	CO4
8	Practice of importing and exporting data from various databases	CO2
9	Implement MapReduce Program to implement mining of weather data	CO5
10	Implement Friends-of-friends algorithm in MapReduce	CO5

Textbooks:

1. Big Data Analytics- Radha Shankarmani and M Vijaylakshmi, Wiley
2. Hadoop in Practice – Alex Holmes, Manning Press, Dreametch
3. Making Sense of NoSQL A guide for managers and the rest of us– Dan McCreary, Ann Kelly, Manning Press

Reference Books:

1. Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics – Bill Franks, Wiley
2. Hadoop in Action – Chuck Lam, Dreamtech Press
3. Big Data Analytics – Raj Kamal – PHI India

Course Name: Internet of Things Security and Trust

Course Code: ET36T

Category: Professional elective - 5 (IoT Track)

Preamble:

The modern world is becoming increasingly interconnected through a technology called Internet of Things (IoT). IoT is rapidly evolving field that is transforming the way we live, work, and interact with the real world. This course is useful for learning security aspects of IoT applications. Security is a major requirement for IoT applications since variety of devices and networks are involved in IoT application. This course teaches fundamental aspects of security and different techniques for providing security to IoT application.

Pre-requisites:

C Programming
Object Oriented Programming
Microprocessor and Microcontroller

Course Objectives:

- To understand the core concepts of the IoT security.
- To explore different types of vulnerabilities and threats.
- To gain a foundational knowledge of testing.
- To gain foundation knowledge of tools and framework.
- To get understanding of firmware security aspects.
- To gain knowledge of common attack vectors.

Course Outcomes:

Student will be able to:
CO1: Understand the concepts of security in IoT system.
CO2: Implement mechanism to handle IoT Vulnerabilities and Threats.
CO3: Perform testing of IoT systems.
CO4: Use monitoring tools for providing IoT security.
CO5: Use techniques for efficient firmware design of IoT application.
CO6: Identify different attacks.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction	Overview of industrial control systems (ICS), ICS operation & components, Perdue model, SCADA systems, Cyber-physical systems (CPS) & IoT	4
2	IoT Vulnerabilities and Threats	STRIDE methodology, OWASP Iot vulnerabilities, Privacy & trust, Insufficient authentication/authorization, Insufficient access control, Attacks on IoT data, Attacks on IoT layered architecture, Security concerns in IoT applications, Security concerns in SCADA	6
3	IoT Pen Testing	Active vulnerability analysis tools, Port scanning, Operating system fingerprinting and version scanning, Penetration testing, Attack surface mapping	6
4	Monitoring Tools	Exploitation using I2C & SPI, JTAG debugging and exploitation, Boundary scan, Test access ports	6
5	Firmware Implementation	Understanding firmware, Extracting firmware, Manual firmware extraction, Automated file system extraction, Firmware internals, Backdooring a firmware, Static & dynamic analysis	4
6	Attack Surfaces	Software defined radio, Exploiting ZIGBEE & BLE, Power analysis attack, Invasive attack, Perturbation -attacks, Electromagnetic side channel attack, fault injection attack, timing attack, covert channel attacks	4
Total			**30**

Text Books:

1. "Securing the Internet of Things", Shancang Li, Li Da Xu, Syngress, Elsevier, 2017.
2. "Security and Privacy in Internet of Things (IoTs) Models, Algorithms, and Implementations", Edited by Fei Hu, CRC Press, 2016.
3. "IoT Security Guide", DSCI, August 2022.

Reference Books:

1. "Practical Internet of Things Security", Brian Russell Drew Van Duren, Packt Publishing, 2016

Course Name: Internet of Things (IoT) Security and Trust Laboratory

Course Code: ET36P

Category: Professional Elective- 5 (IoT Track)

Preamble:

The modern world is becoming increasingly interconnected through a technology called Internet of Things (IoT). IoT is rapidly evolving field that is transforming the way we live, work, and interact with the real world. This course is useful for learning security aspects of IoT applications. Security is a major requirement for IoT applications since variety of devices and networks are involved in IoT application. This course teaches implementation of different security techniques for IoT application. It also enables learner to use standard tools and frameworks for developing efficient security solutions.

Pre-requisites:

- C Programming
- Object Oriented Programming
- Microprocessor and microcontroller

Course Objectives:

- To understand the core concepts of the IoT security.
- To explore different types of vulnerabilities and threats.
- To gain a foundational knowledge of testing.
- To gain foundation knowledge of tools and framework.
- To get understanding of firmware security aspects.
- To gain knowledge of common attack vectors.

Course Outcomes:

Student will be able to:
CO1: Identify metrics for providing security in IoT system.
CO2: Implement techniques for handling IoT Vulnerabilities and Threats.
CO3: Perform testing of IoT systems.
CO4: Use tools and frameworks for providing security to IoT applications.
CO5: Design efficient secure firmware for IoT applications.
CO6: Implement mechanism to handle different types of attacks in IoT application.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	25	25

Suggested List of Practical:

All practical will be project based with focus on following concepts

1. Identification and implementation of standard metrics for providing security.
2. Handle different types of threats and vulnerabilities in IoT application.
3. Perform security testing of IoT application.
4. Identify and explore different tools for monitoring and providing security to IoT applications.
5. Design secure firmware for IoT application.
6. Handle different types of attacks in IoT application.

Text Books:

1. "Securing the Internet of Things", Shancang Li, Li Da Xu, Syngress, Elsevier, 2017.
2. "Security and Privacy in Internet of Things (IoTs) Models, Algorithms, and Implementations", Edited by Fei Hu, CRC Press, 2016.
3. "IoT Security Guide", DSCI, August 2022.

Reference Books:

1. "Practical Internet of Things Security", Brian Russell Drew Van Duren, Packt Publishing, 2016

Assessment: In-Semester-Assessment (25 Marks)

1. *All the students are required (mandatory) to be present in person during the laboratory conduction session.* The ISA will consist of awarding marks for the complete, successful and in time submission of minimum 10 dually graded experiments (project based).
2. Project prototype to be developed and demonstrated.
3. Graded marks for 10 experiments will be converted to ISA marks of 25. Only one repeat session is allowed to cover up the missed lab session.
4. Students will be awarded grade / or marks on each experiment based on his / her own contribution, showcasing the knowledge application skills, demonstrating measurement work, developing code / solution to the given problem and peer interaction. Student will lose the marks if he or she remains absent for the Laboratory Practical Session.

Course Name: System on Chip

Course Code: EC40T

Category: Professional track – 5 (VLSI track)

Preamble:
This course provides a comprehensive introduction to the design and architecture of System on Chip (SoC), covering fundamental concepts such as processor architectures, memory design, and interconnect systems. Students will explore tradeoffs in performance, power, and area, along with techniques for minimizing delays and costs. The curriculum includes detailed discussions on customization, configuration, and reconfigurable concepts tailored for modern SoC applications. Through a blend of theoretical and practical insights, learners will gain expertise in designing robust and efficient SoC solutions. The course is structured into six modules, totalling 30 hours, to ensure a thorough understanding of each critical component. Ideal for aspiring engineers, this course equips participants with the skills needed to tackle real-world challenges in SoC development.

Pre-requisites:

- Microprocessors & Microcontrollers
- Computer Organization & Architecture
- Digital Electronics
- VLSI Design (Optional but beneficial)

Course Objectives:

After completing this course, students will be able to:

1. To know the basic concepts of System on Chip
2. To understand SoC design with respect to Processor Architecture, Memory, Interconnect and Trade-offs
3. To be familiar with basics of SoC Customization and Configuration.

Course Outcomes:

Learners will be able to:
CO1: Understand overview of SoC System Architecture
CO2: Select Processor for a SoC
CO3: Develop knowledge of memory and interconnect design for SoC
CO4: Apply the knowledge of design tradeoffs for optimized SoC performance
CO5: Describe SoC Customization and Configuration

Course Scheme:

Contact Hours			**Credits Assigned**	
Theory	Practical		Theory	Practical
2	-		2	-

Assessment Guidelines:

Head of Learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to SoC and System Approach	1.1 Overview of System Architecture: Components of a System: Processor, Memory and Interconnects, Basic SoC Model, Hardware and Software: Programmability versus Performance 1.2 Processor Architectures: Functional view approach, Architectural view approach 1.3 Memory and Addressing: Architecture of Memory and Memory for SoC operating Systems 1.4 System Interconnects: Bus based and NoC based interconnect Approach An Approach for SOC Design	7
2	Processor Architecture for SoC	2.1 Processor Selection: Overview and Processor Core Selection 2.2 Basic concepts in Processor Microarchitecture; Basic elements in Instruction Handling: Decoding, Bypassing and Execution unit 2.3 Introduction to Robust Architectures	4
3	Design Trade off and minimizing delays and cost	3.1 Design Tradeoff: Time, Area and Power, reliability and Configurability, 3.2 Buffers: Minimizing Pipeline Delays 3.3 Branches: Reducing Branch Cost	4
4	Memory Design	4.1 Overview: Outline for Memory Design, SoC external Flash Memory And internal memory placement, Size tradeoff 4.2 Scratch pad and Cache Organization: Write Policies, Strategies for Line Replacement at miss time, Multilevel Caches, L1-Icache L1-Dcache 4.3 Memory Address Translation: Translation of Virtual to Real, TLB	6
5	Interconnect Design	5.1 Overview of Interconnect Architectures 5.2 Bus Architectures: Arbitration, Bridge and Bus Structure 5.3 Standard Buses: AMBA and Core Connect Bus	5
6	Customization and Configuration	6.1 Introduction: Estimating Effectiveness of Customization 6.2 Overview of SoC Customization 6.3 Customizing Instruction Processors 6.4 Introduction to Reconfigurable concept	4
Total			**30**

Textbooks:

1. Michael J. Flynn and Wayne Luk, Computer System Design System-on-Chip, Wiley India Pvt. Ltd.
2. Steve Furber, ARM System on Chip Architecture, 2ndEdition, 2000, Addison Wesley Professional

Reference books:

1. Ricardo Ries, Design of System on a Chip: Devices and Components, 1stEdition, 2004, Springer
2. Jason Andrews, Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology), Newnes, BK and CDROM.
3. Prakash Rashinkar, Peter Paterson and Leena Singh L, System on Chip Verification Methodologies and Techniques, 2001,

Course Name: System on Chip Laboratory

Course Code: EC40P

Category: Professional Elective -5 (VLSI track)

Preamble:

This hands-on lab course complements the theoretical foundations of SoC design by providing practical exposure to key tools, methodologies, and workflows used in industry and academia. Through 10 structured lab sessions, students will explore processor simulation, memory hierarchy optimization, interconnect design, FPGA prototyping, and verification techniques. The course emphasizes open-source tools (e.g., gem5, QEMU, RISC-V) alongside industry-standard platforms (e.g., Cadence, Synopsys) to bridge the gap between theory and real-world SoC development. By the end of the course, students will be proficient in designing, analyzing, and optimizing SoC components while adhering to power, performance, and area (PPA) constraints.

Pre-requisites:

- Digital Electronics (mandatory)
- Computer Architecture (mandatory)
- FPGA/VLSI basics (recommended)
- Programming (C/Python/Verilog)

Course Objectives:

By the end of this course, students will be able to:

1. Simulate and analyze processor architectures using tools like QEMU and gem5.
2. Design and evaluate memory subsystems (caches, scratchpads) using trace-driven tools (Dinero IV).
3. Model on-chip interconnects (AMBA buses, NoCs) and analyze their performance.
4. Prototype SoC components on FPGAs using open-source (Litex) or licensed (Vivado) toolchains.
5. Optimize PPA tradeoffs through RTL synthesis and static timing analysis (OpenSTA/Design Compiler).
6. Extend processor ISAs (e.g., RISC-V) and verify custom instructions.
7. Develop verification testbenches using UVM/SystemC for functional validation.
8. Compare open-source and commercial tools for SoC design flows.

Course Outcomes:

Upon completion, learners will be able to:

CO1: Design and simulate processor architectures (RISC-V/ARM) using tools like QEMU/gem5 to analyze performance metrics.
CO2: Optimize memory hierarchies (caches, scratchpads) using trace-driven tools (Dinero IV) and justify design choices.
CO3: Implement on-chip interconnects (AMBA/NoC) and evaluate their latency/throughput in SystemC or BookSim.
CO4: Prototype a minimal SoC (processor + peripherals) on FPGA using open-source (Litex) or

licensed (Vivado) toolchains.
CO5: Synthesize RTL designs (Verilog/VHDL) and analyze power-area-delay tradeoffs using OpenSTA/Synopsys tools.
CO6: Verify SoC modules using UVM testbenches and demonstrate functional correctness.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	25	--	25	50

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Suggested List of Practical's:

Lab Experiments:
1. SoC Design Flow Overview
   Tool: Cadence Innovus (Licensed) / OpenROAD (Open-source)
   Task:
   Explore the end-to-end SoC design flow (RTL to GDSII).
   Set up a basic project in the chosen toolchain.
2. Processor Core Simulation
   Tool: QEMU (Open-source) / *ARM DS-5* (Licensed)
   Task:
   Simulate a RISC-V/ARM core using QEMU.
   Analyze pipeline stages and instruction execution.
3. Cache Memory Performance Analysis
   Tool: gem5 (Open-source)
   Task:
   Model L1/L2 caches in gem5.
   Compare hit/miss rates for different cache configurations.
4. Bus Arbitration & AMBA AHB Simulation
   Tool: *SystemC/TLM-2.0* (Open-source)
   Task:
   Implement a simple AMBA AHB bus with arbitration logic.
   Simulate multi-master contention scenarios.
5. NoC (Network-on-Chip) Design
   Tool: BookSim2 (Open-source) / Noxim (Open-source)
   Task:
   Model a 2D mesh NoC topology.
   Analyze latency and throughput under varying traffic patterns.
6. Memory Hierarchy Optimization
   Tool: Dinero IV (Open-source)

Task:
Trace memory accesses of a benchmark program.
Evaluate performance with scratchpad vs. cache memory.

7. FPGA-Based SoC Prototyping
   Tool: Xilinx Vivado (Licensed) / Litex (Open-source)
   Task:
   Implement a soft-core (e.g., RISC-V) on an FPGA.
   Interface with peripherals (UART, GPIO).
8. Power & Area Tradeoff Analysis
   Tool: Synopsys Design Compiler (Licensed) / OpenSTA (Open-source)
   Task:
   Synthesize a small RTL design.
   Compare power/area metrics for different constraints.
9. Custom Instruction Set Extension
   Tool: RISC-V GCC Toolchain (Open-source)
   Task:
   Add a custom instruction to a RISC-V core.
   Verify using spike simulator.
10. SoC Verification with UVM
    Tool: Verilator + UVM (Open-source) / Cadence Xcelium (Licensed)
    Task:
    Develop a UVM testbench for a simple SoC module.
    Run functional coverage checks.

Lab Setup Recommendations:
Open-source stack: gem5 + QEMU + RISC-V tools + Verilator.
Licensed tools (if available): Cadence/Synopsys for industry-grade flows.
FPGA boards: Xilinx Artix-7 or Lattice ECP5 for hands-on prototyping.

These labs balance theory and hands-on practice, preparing students for both academic and industry challenges in SoC design.

Tools/Platforms:

Category	Open-Source	Licensed
Simulation	QEMU, gem5, Spike	ARM DS-5, Synopsys VCS
Synthesis	Yosys + OpenSTA	Synopsys Design Compiler
FPGA Prototyping	Litex, Verilator	Xilinx Vivado, Intel Quartus
Verification	Verilator + UVM	Cadence Xcelium

Textbooks:

1. Michael J. Flynn and Wayne Luk, Computer System Design System-on-Chip, Wiley India Pvt. Ltd.
2. Steve Furber, ARM System on Chip Architecture, 2ndEdition, 2000, Addison Wesley Professional

Reference books:

1. Ricardo Ries, Design of System on a Chip: Devices and Components, 1stEdition, 2004, Springer
2. Jason Andrews, Co-Verification of Hardware and Software for ARM System on Chip Design (Embedded Technology), Newnes, BK and CDROM.
3. Prakash Rashinkar, Peter Paterson and Leena Singh L, System on Chip Verification Methodologies and Techniques, 2001, Kluwer Academic Publishers

Course Name: Wireless Sensor Network

Course Code: ET25T

Category: Professional Elective – 6 (Communication Engineering track)

Preamble:

Wireless Sensor Networks (WSNs) have emerged as a transformative technology enabling real-time monitoring and data collection in diverse domains such as environmental monitoring, industrial automation, healthcare, military surveillance, and smart infrastructure. This course introduces the fundamental principles, design challenges, and technological aspects associated with the development and deployment of WSNs. It aims to provide students with a solid understanding of sensor node architecture, communication protocols, network topologies, data aggregation techniques, localization, synchronization, and power management strategies. The course also explores recent advancements such as mobile and cognitive sensor networks, and their integration into the Internet of Things (IoT). Through theoretical learning and practical simulations, students will gain the skills required to design, implement, and evaluate efficient and robust WSN solutions for real-world applications.

Pre-requisites:

Analog Communications, Digital Communications, Computer communication Networks

Course Objectives:

- To provide a solid foundation in the fundamental concepts, architecture, and characteristics of wireless sensor networks (WSNs).
- To familiarize students with the various hardware and software components used in sensor nodes and their interactions.
- To analyze and design protocols used in WSNs for efficient communication, including MAC, routing, and data dissemination techniques.
- To enable students to explore localization, synchronization, and deployment strategies that ensures network coverage and connectivity.
- To examine power management techniques, fault tolerance strategies, and security mechanisms critical to the operation of energy-constrained and mission-critical WSN applications.

Course Outcomes:

Learner will be able to:

CO1: Explain the fundamental concepts, Types of WSN and components of WSN networks.
CO2: Analyze various communication protocols used in WSN.
CO3: Assess power management techniques, security threats and fault tolerant mechanisms for WSN.
CO4: Design and evaluate node deployment strategies and time sync methods for effective WSN operation.
CO5: Demonstrate the ability to model and simulate WSN using relevant tools.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Wireless Sensor Networks	History, Definition, Components of Wireless Sensor Networks, Comparison with ad hoc and traditional networks, applications, Types, Challenges and requirements, Sensor node architecture	8
2	Network structure and Protocols	Network Topologies: star, mesh, tree, cluster-based topology. Protocols: Overview of OSI Layer, MAC Layer and Link layer protocols. Routing protocols (LEACH, PEGASIS, TEEN), Data centric routing, aggregation and fusion techniques.	8
3	Power management and security in WSN	Power design considerations, Reliability and fault tolerance, Security issues in WSN: security requirements and threats, Attacks (Sybil, Sinkhole, Wormhole), Security mechanisms.	5
4	Node deployment, localization and synchronization	Sensor deployment strategies: Random vs. Deterministic, Coverage and connectivity's issues. Localization techniques: range based and range free. Time synchronization in WSN	6
5	Applications of WSN	Cognitive sensor networks: Spectrum awareness and dynamic spectrum access. IOT and integration with WSN. WSN Simulation tools (NS-2, NS-3, OMNet++), Case studies in smart cities	3
Total			**30**

Textbooks:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, Wireless Sensor Networks: Technology, Protocols and Applications, Wiley, ISBN: 978-0471743002
2. Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufman, ISBN: 978-1558609143

Reference Books:

1. Handbook of Sensor Networks: Algorithms and Architectures" – Edited by Ivan Stojmenovic
2. "Introduction to Wireless and Mobile Systems" – Dharma Prakash Agarwal, Qing-An Zeng

Course Name: Wireless Sensor Networks - Laboratory

Course Code: ET25P

Category: Professional Elective – 6 (Communication Engineering track)

Preamble:

Wireless Sensor Networks (WSNs) have emerged as a transformative technology enabling real-time monitoring and data collection in diverse domains such as environmental monitoring, industrial automation, healthcare, military surveillance, and smart infrastructure. This course introduces the fundamental principles, design challenges, and technological aspects associated with the development and deployment of WSNs. It aims to provide students with a solid understanding of sensor node architecture, communication protocols, network topologies, data aggregation techniques, localization, synchronization, and power management strategies. The course also explores recent advancements such as mobile and cognitive sensor networks, and their integration into the Internet of Things (IoT). Through theoretical learning and practical simulations, students will gain the skills required to design, implement, and evaluate efficient and robust WSN solutions for real-world applications.

Pre-requisites:

Analog Communication, Digital Communication, Computer Communication Networks

Course Objectives:

- To provide hands-on experience in configuring and simulating wireless sensor networks using standard simulation tools.
- To develop the ability to implement and evaluate communication protocols such as MAC and routing specific to WSN environments.
- To familiarize students with programming sensor nodes and interfacing with protocols.
- To enable students to design, simulate, and test WSN features like node deployment, localization, time synchronization, and data aggregation.
- To cultivate the ability to apply WSN concepts to develop basic real-time monitoring applications with potential real-world impact.

Course Outcomes:

Learner will be able to:

CO1: Demonstrate the ability to configure and simulate WSN topologies.
CO2: Evaluate performance of MAC and routing protocols.
CO3: Develop and test sensor node code for deployment and coverage simulation.
CO4: Design and analyze localization techniques.
CO5: Create a functional WSN application prototype for real time data acquisition and monitoring

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Practical:

Learners are expected to perform practical based on the following suggested topics.

Sr No	Suggested Topic(s)
1	Create and visualize a basic WSN with sensor nodes, sink node, and communication links.
2	Implementation and Analysis of MAC Protocols (e.g., B-MAC, S-MAC).
3	Simulation of Routing Protocols (e.g., LEACH, PEGASIS, AODV)
4	Node Deployment and Coverage Simulation.
5	Localization Algorithm Simulation
6	Time Synchronization in WSN
7	Data Aggregation and Fusion
8	Security in WSN
9	Introduction to WSN Hardware Platforms
10	Sensor Node Programming
11	Wireless Communication Between Sensor Nodes

Textbooks:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, Wireless Sensor Networks: Technology, Protocols and Applications, Wiley, ISBN: 978-0471743002
2. Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufman, ISBN: 978-1558609143

Reference Books:

1. "Handbook of Sensor Networks: Algorithms and Architectures" – Edited by Ivan Stojmenovic
2. "Introduction to Wireless and Mobile Systems" – Dharma Prakash Agarwal, Qing-An Zeng

Course Name: Deep Learning

Course Code: ET 31T

Category: Professional Track – 6 (Data Analytics and Machine Learning track)

Preamble:

The course is designed to provide a conceptual and practical understanding of deep neural networks, including feedforward networks, convolutional neural networks (CNNs), recurrent neural networks (RNNs), and advanced architectures such as Transformers and Generative Adversarial Networks (GANs). It emphasizes the mathematical underpinnings of back propagation, optimization techniques, and regularization strategies to develop robust models.

Pre-requisites:

Basic mathematics and Statistical concepts, Linear algebra, Machine Learning

Course Objectives:

- To learn the fundamentals of Neural Network.
- To gain an in-depth understanding of training Deep Neural Networks.
- To acquire knowledge of advanced concepts of Convolution Neural Networks, Auto encoders and Recurrent Neural Networks.
- Students should be familiar with the recent trends in Deep Learning.

Course Outcomes:

Student will be able to:
CO1: Gain basic knowledge of Neural Networks.
CO2: Acquire in depth understanding of training Deep Neural Networks.
CO3: Design appropriate DNN model for supervised, unsupervised and sequence learning applications.
CO4: Gain familiarity with recent trends and applications of Deep Learning.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head	**ISA**	**MSA**	**ESE**	**Total (Passing @40% of total)**
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No	Module name	Content	No of Hours
1	Fundamentals of Neural Network	Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes. Deep Networks: Fundamentals, Brief History, Three Classes of Deep Learning Basic Terminologies of Deep Learning	4
2	Training, Optimization and Regularization of Deep Neural Network	Training Feedforward DNN Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, And Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function. Optimization Learning with back propagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp. Regularization Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output	10
3	Auto encoders: Unsupervised Learning	Introduction, Linear Auto encoder, Undercomplete Auto encoder, Over complete Auto encoders, Regularization in Auto encoders, Denoising Auto encoders, Sparse Auto encoders, Contractive Auto encoders, Application of Auto encoders: Image Compression	6
4	Convolutional Neural Networks (CNN): Supervised Learning	Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs. CNN, Variants of basic Convolution function 4.2 Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture	7
5	Recurrent Neural Networks (RNN)	Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Back propagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT 5.2 Long Short Term Memory : Selective Read, Selective write, Selective Forget, Gated Recurrent Unit	9
6	Recent Trends and Applications	Generative Adversarial Network (GAN): Architecture 6.2 Applications: Image Generation, DeepFake	4
Total			**30**

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville. —Deep Learning, MIT Press Ltd, 2016
2. Li Deng and Dong Yu, —Deep Learning Methods and Applications, Publishers Inc.
3. Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.

4. JM Zurada —Introduction to Artificial Neural Systems, Jaico Publishing House
5. M. J. Kochenderfer, Tim A. Wheeler. —Algorithms for Optimization, MIt Press.

Reference Books:

1. Buduma, N. and Locascio, N., —Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc.".
2. François Chollet. —Deep learning with Python — (Vol. 361). 2018 New York: Manning.
3. Douwe Osinga. —Deep Learning Cookbook||, O'REILLY, SPD Publishers, Delhi.
4. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
5. S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India

Course Name: Deep Learning Lab

Course Code: ET 31P

Category: Professional Track – 6 (Data Analytics and Machine Learning track)

Preamble:

The Deep Learning Laboratory is designed to provide students with hands-on experience in building, training, and evaluating neural networks using modern tools and real-world datasets. This lab acts as a practical companion to theoretical deep learning concepts, offering a structured environment where students experiment with convolutional neural networks (CNNs), recurrent neural networks (RNNs), transfer learning, and generative models. It emphasizes understanding the inner workings of deep learning architectures and applying them to complex problems.

Pre-requisites:

Basic mathematics and Statistical concepts, Linear algebra, Machine Learning

Course Objectives:

1. To implement basic neural network models for simulating logic gates.
2. To implement various training algorithms for feedforward neural networks.
3. To design deep learning models for supervised, unsupervised and sequence learning.

Course Outcomes:

Students will be able to:

CO1: Implement basic neural network models to learn logic functions.
CO2: Design and train feedforward neural networks using various learning algorithms.
CO3: Build and train deep learning models such as Auto encoders, CNNs, RNN, LSTM etc.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	25	50

Suggested List of Practical:

No	Experiment Title	Mapped CO
1	Implement Perceptron algorithm to simulate any logic gate.	CO1
2	Implement Multilayer Perceptron algorithm to simulate XOR gate.	CO1
3	To explore python libraries for deep learning e.g. Theano, Tensor Flow etc.	CO1
4	Implement a back propagation algorithm to train a DNN with at least 2	CO2

	hidden layers.	
5	Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function.	CO2
6	Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function.	CO2
7	Design the architecture and implement the auto encoder model for Image denoising.	CO3
8	Design and implement a CNN model for digit recognition application.	CO3
9	Design and implement a CNN model for image classification.	CO3
10	Design and implement LSTM for Sentiment Analysis.	CO3
11	Design and implement RNN for classification of temporal data.	CO3

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville. —Deep Learning, MIT Press Ltd, 2016
2. Li Deng and Dong Yu, —Deep Learning Methods and Applications, Publishers Inc.
3. Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4. JM Zurada —Introduction to Artificial Neural Systems, Jaico Publishing House
5. M. J. Kochenderfer, Tim A. Wheeler. —Algorithms for Optimization, MIt Press.

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1. Buduma, N. and Locascio, N., —Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc.".
2. François Chollet. —Deep learning with Python — (Vol. 361). 2018 New York: Manning.
3. Douwe Osinga. —Deep Learning Cookbook||, O'REILLY, SPD Publishers, Delhi.
4. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
5. S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India

Course Name: Industrial Internet of Things (IIoT)

Course Code: ET37T

Category: Professional elective – 6 (IoT Track)

Preamble:

This course introduces students to IIoT complexity on a scale previously unseen in the software industry. Software architecture must accommodate these heterogeneous domains and competencies and handle the increasing levels of complexity. The IIoT generates large amounts of data that is subsequently stored, analysed, archived and eventually fed back into the product life cycle.

Pre-requisites:

- Modern Sensor Technology for IoT
- Principles of IoT

Course Objectives:

- To understand the concepts of Industry 4.0 and IIoT.
- To learn the reference architecture of IIoT
- To learn industrial data acquisition and transmission
- To learn the IIoT key technologies.
- To learn securities in IIoT.
- To learn application areas in IIoT.

Course Outcomes:

Student will be able to:
CO1: Understand the fundamentals of Industry 4.0 and IIoT.
CO2: Understand different types of architectures required in the IIoT applications.
CO3: Apply knowledge of data acquisition and transmission techniques required in IIoT.
CO4: Understand Key technologies required in the implementation of IIoT model.
CO5: Create a security system for IIoT application.
CO6: Design prototype model of IIoT system.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	2	2	1

Assessment Guidelines:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
2	2	2	1

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall

be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no.	Module name	Content	No of Hours
1	Introduction	Overview of Industry 4.0 and Industrial Internet of Things, Industrial Internet, Design requirements of Industry 4.0, Drivers of Industry 4.0, Sustainability Assessment of Industries, Smart Business Perspective, Basics, IIOT and Industry 4.0, Industrial Internet Systems, Industrial Sensing, Industrial Processes, IIOT Challenges – Identifying Things within the internet, Discovering Things and the Data they possess, Managing massive amount of data, Navigating Connectivity Outages, IIOT Edge - Leveraging the Power of Cloud Computing, Communicating with Devices on the Edge, Determining a Request/Response Model	4
2	IIOT Reference Architecture	The IIC Industrial Internet Reference Architecture - Industrial Internet Architecture Framework (IIAF), Industrial Internet Viewpoints. The Three-Tier Topology, Key Functional Characteristics of Connectivity. Software Architectural Style for the Industrial Internet of Things. Challenges of Software Engineering in IIoT, Principles for Software Architecture design in IIoT, The Principled Decomposition, and The Architectural Style.	5
3	IIoT data acquisition and transmission	Introduction, Features and Components of - Foundation Field bus, Profibus, HART, Interbus, Bitbus, CC-Link, Modbus, Batibus, DigitalSTROM, Controller Area Network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa and Lora WAN) NB-IoT, IEEE 802.11AH, Distributed Control System, PLC, SCADA	6
4	Key Technologies in IIoT	Off-Site Technologies: Cloud Computing in IIOT Fog Computing: Principles, Architectures, and Applications. On-Site Technologies: Big Data and Advanced Analytics	5
5	IIoT securities	Securing the Industrial Internet- Security in Manufacturing, PLCs and DCS, Securing the OT (Operation Technology), Network, System Level: Potential Security Issues, Identity Access Management. Internet of Things (IoT) Cyber security Improvement Act of 2017, Other governmental bodies, IoT security best practices, Holistic security. The IoT Security Lifecycle	6
6	IIoT Applications	Develop New Business Models: Adopt Smart	4

		Architectures and Technologies, Sensor-Driven Computing, Industrial Analytics, Intelligent Machine Applications, Transform the Workforce. Inventory Management and Quality Control: Introduction, Inventory Management and IIOT, Quality Control Case Studies: Manufacturing Industry, Automotive Industry and Mining Industry, Healthcare Applications in Industries, Challenges associated with Healthcare	
Total			**30**

Textbooks:

1. "Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress)
2. "Introduction to Industrial Internet of Things and Industry 4.0", by Sudip Misra, Chandana Roy And Anandarup Mukherjee, CRC Press (Taylor & Francis Group)
3. "Internet of Things Principles and Paradigms", by Rajkumar Buyya, Amir Vahid Dastjerdi, ELSEVIER Inc.
4. Internet of things For Architects, Perry Lea Packt Publication, 2018

Reference Books:

1. "Practical Internet of Things Security", by Brian Russell, Drew Van Duren (Packt Publishing)
2. "Industrial Internet of Things and Communications at the Edge", by Tony Paine, CEO, Kepware Technologies
3. "Architectural Design Principles For Industrial Internet of Things", Hasan Derhamy, Luleå University of Technology, Graphic Production

Course Name: Industrial Internet of Things (IIoT) Laboratory

Course Code: ET37P

Category: Professional elective – 6 (IoT Track)

Preamble:

The IIoT Lab is a hands-on learning environment where you will gain practical experience in designing, developing, and deploying IIoT solutions. By the end of this lab, students will have a strong foundation in IIoT concepts and be prepared to apply your knowledge to real-world industrial applications.

Pre-requisites:

- Modern Sensor Technology for IoT
- Principles of IoT

Course Objectives:

- Familiarize students with the fundamentals of Industrial IoT (IIoT).
- Understand the core concepts of IIoT, including sensors, actuators, communication protocols, and data analytics.
- Gain insights into the applications of IIoT in various industries.
- Develop the skills necessary to design and implement IIoT solutions.

Course Outcomes:

Student will be able to:
CO1: Learn IIoT and its key components
CO2: Study and interface the different types of sensors and actuators used in IIoT applications
CO3: Analyze the various communication protocols used in IIoT
CO4: Analyze and interpret data collected from IIoT devices
CO5: Design and implement simple IIoT solutions

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Scheme:

Head	ISA	MSA	ESA	Total
Practical	25	-	25	050

Suggested List of Practical:

1. Familiarization with Development Boards: This experiment will get students familiar with popular development boards like Arduino Uno or Raspberry Pi. Students will learn how to set up the board, install the necessary software, and write simple programs to control LEDs, read sensor data, and control actuators.
2. Sensor Interfacing: This experiment will introduce students to various sensors used in IIoT applications, such as temperature sensors, humidity sensors, light sensors, and pressure sensors. Students will learn how to interface these sensors with the development board and read the sensor data.
3. Actuator Control: This experiment will introduce students to actuators used in IIoT applications, such as relays, motors, and solenoids. Students will learn how to control these actuators using the development board based on sensor readings or user input.
4. Data Visualization: This experiment will teach students how to visualize the data collected from sensors. Students will use software tools to plot the data on graphs and charts, allowing for easier monitoring and analysis.
5. Communication Protocols: This experiment will cover various communication protocols used in IIoT, such as Modbus, Profibus, and MQTT. Students will learn how to configure these protocols for communication between devices and the cloud platform.
6. Cloud Integration: This experiment will introduce students to cloud platforms for IIoT applications. Students will learn how to connect their IIoT devices to the cloud platform, send sensor data to the cloud, and receive commands from the cloud.
7. Remote Monitoring and Control: This experiment will build on the previous experiments by creating a system where students can remotely monitor sensor data and control actuators over the internet.
8. Data Analytics: This experiment will introduce students to basic data analytics techniques used in IIoT applications. Students will learn how to analyze sensor data to identify trends, patterns, and anomalies.
9. Robotics arms and Industry 4.0 Setup

Textbooks:

1. Industrial Automation with the Internet of Things by Andreas Georgakopoulos and Peter Slyepen
2. Designing the Industrial Internet of Things by Adrian McEwen and Hakim El-Darwich

Reference Books:

1. Internet of Things (IoT) Prototyping with Arduino and Raspberry Piby Colin Wong
2. Hands-On Industrial Internet of Things by Richard Radoczki

Course Name: Mixed Signal VLSI Design

Course Code: EC43T

Category: Professional elective – 6 (VLSI Track)

Preamble:
In the era of highly integrated electronic systems, the convergence of analog and digital circuitry on a single chip, commonly referred to as Mixed Signal VLSI Design, plays a critical role in enabling advanced functionalities across a range of applications, from communication systems to biomedical devices. This subject introduces students to the principles, methodologies, and design techniques essential for developing integrated circuits that process both analog and digital signals. It emphasizes the challenges of noise, signal integrity, power consumption, and layout intricacies, while also addressing current trends such as data converters (ADC/DAC), PLLs, and mixed-signal SoCs. Through a combination of theoretical learning and practical design experience, students will be equipped to tackle real-world mixed-signal VLSI design challenges and contribute effectively to the semiconductor industry.

Pre-requisite:

- Basics of VLSI Design
- Digital System Design
- Advanced VLSI Design
- Analog IC Design

Course Objectives:

- Introduce the fundamentals of mixed signal VLSI design flow, CMOS technology, and layout challenges in integrated analog-digital systems.
- Understand and evaluate key performance specifications and error sources in DAC and ADC systems.
- Analyze and compare various DAC and ADC architectures and their practical implementation aspects.
- Explore the design and operation of switched capacitor circuits, including sampling techniques and amplifier configurations.
- Study the principles, types, and applications of oscillators and PLLs in mixed-signal integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:
CO1: Explain the mixed-signal VLSI design flow and identify key layout challenges specific to analog-digital integration.
CO2: Evaluate performance specifications of DACs and ADCs and assess their impact on signal integrity.
CO3: Compare different data converter architectures and determine their suitability for various applications.
CO4: Design and simulate switched capacitor circuits for amplification and integration tasks.
CO5: Analyze oscillator and PLL designs and their applications in modern communication and clock systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	15	20	40	075

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Mixed Signal VLSI**	06
	1.1	Overview of Mixed Signal VLSI Design Flow, CMOS Technology Overview (Analog & Digital), Need for Mixed Signal ICs	
	1.2	Mixed Signal Layout issues like, floor planning, power supply and ground issues, fully differential design, guard rings, shielding, interconnect considerations	
2		**Data Converter Fundamentals**	06
	2.1	**DAC Specifications:** Differential Non-linearity, Integral Non-linearity, Offset, Gain Error, Latency, Signal to Noise Ratio (SNR), Dynamic Range	
	2.3	**ADC Specifications:** Quantization Error, Differential Non-linearity, missing codes, Integral Non-linearity, Offset, Gain Error, aliasing, Signal to Noise aperture error	
3		**Data Converter Architectures**	06
	3.1	**DAC architectures:** Digital input code, Resistor String and mismatch errors, R-2R ladder network, Current steering DAC, Charge scaling DACs, Cyclic DAC, Pipeline DAC	
	3.2	**ADC architectures:** Flash ADC, two step Flash ADC, Pipeline ADC, Integrating ADC, and Successive approximation ADC	
4		**Switched Capacitor Circuits**	06
	4.1	General Considerations **Sampling Switches:** MOSFETs as switches, Speed considerations, Precision Considerations, Charge injection cancellation.	
	4.2	**Switched Capacitor Amplifier:** Unity gain buffer, non-inverting amplifier and precision multiply by two circuits. Switched Capacitor Integrator & Switched Capacitor Common Mode	

		Feedback	
5		**Oscillators and Phase Locked Loops**	06
	5.1	**Oscillators:** General considerations, Ring oscillators, LC oscillators, VCO	
	5.2	**Phase locked loops:** Simple PLL, Charge pump PLL, Non-ideal effects in PLL, Delay locked loops and applications of PLL in integrated circuits	
		Total	**30**

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Design of Analog CMOS Integrated Circuits	Behzad Razavi	Tata McGraw Hill	2nd	1,2,3,4,5
2	CMOS Circuit Design, Layout, and Simulation	R. Jacaob Baker, Harry W. Li, David E. Boyce	Wiley	2nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	CMOS Circuit Design, Layout and Simulation	Baker Li Boyce	Wiley	3rd	1,2,3,4,5
2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4th Edition	3,4,5
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4th Edition	1,2,3,4,5
5	Basics of CMOS Cell Design	Etienne Sicard and Sonia Delmas Bendhia	Tata McGraw Hill	4th	1,2,3,4,5
6	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan	Pearson Education	5th	1,2,3,4,5

		Banerjee,			
7	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3rd	1,2,3,4,5

Course Name: Mixed Signal VLSI Design Laboratory

Course Code: EC43P

Category: Professional elective – 6 (VLSI Track)

Preamble:
The Mixed Signal VLSI Design Lab provides hands-on experience in designing, simulating, and analyzing circuits that integrate both analog and digital components on a single chip. This lab complements theoretical learning by enabling students to implement and verify key mixed-signal building blocks such as data converters, switched capacitor circuits, oscillators, and PLLs using industry-standard EDA tools. Through practical exposure to circuit-level design, layout, and verification, students will develop the skills necessary to address real-world design challenges in the semiconductor industry. The lab also fosters problem-solving, critical thinking, and design optimization techniques, preparing students for advanced work in mixed-signal integrated circuit design.

Pre-requisite:

- Basics of VLSI Design
- Digital System Design
- Advanced VLSI Design
- Analog IC Design

Course Objectives:

- Introduce the fundamentals of mixed signal VLSI design flow, CMOS technology, and layout challenges in integrated analog-digital systems.
- Understand and evaluate key performance specifications and error sources in DAC and ADC systems.
- Analyze and compare various DAC and ADC architectures and their practical implementation aspects.
- Explore the design and operation of switched capacitor circuits, including sampling techniques and amplifier configurations.
- Study the principles, types, and applications of oscillators and PLLs in mixed-signal integrated circuits.

Course Outcomes:

After successful completion of the course students will be able to:
CO1: Explain the mixed-signal VLSI design flow and identify key layout challenges specific to analog-digital integration.
CO2: Evaluate performance specifications of DACs and ADCs and assess their impact on signal integrity.
CO3: Compare different data converter architectures and determine their suitability for various applications.
CO4: Design and simulate switched capacitor circuits for amplification and integration tasks.
CO5: Analyze oscillator and PLL designs and their applications in modern communication and clock systems.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment Guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	50

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested list of Practical:

Practical No.	Module No.	Suggested list of Experiments	Topics to be highlighted	CO Map
1	1	Design Flow Demonstration	Implement a simple mixed-signal design using a standard EDA tool (e.g., Cadence). Demonstrate the steps: schematic, simulation, layout, and verification	CO1
2	1	CMOS Inverter Analysis	Simulate analog and digital characteristics (rise/fall time, noise margin) of a CMOS inverter.	CO1
3	1	Layout of Differential Pair with Guard Ring	Design and layout of differential pair circuits, incorporating guard rings and proper floor planning practices.	CO1
4	2	DAC Linearity Analysis	Simulate a simple R-2R ladder DAC and measure parameters like DNL and INL using a testbench.	CO2
5	2	ADC Quantization Noise Study	Implement a basic SAR ADC model and analyze quantization noise and SNR with different input signals.	CO2
6	2	Error Analysis in Converters	Simulate the effect of offset and gain errors in DAC and compare with theoretical expectations.	CO2
7	3	Design of 4-bit Flash ADC	Implement and simulate a Flash ADC using comparators and resistor ladders; test speed	CO3

			and accuracy.	
8	3	SAR ADC Design and Timing Simulation	Design a SAR logic and capacitor array for a SAR ADC and simulate conversion timing.	CO3
9	3	Pipeline DAC Simulation	Create a simple pipeline DAC architecture in SPICE or Verilog-A	CO3
10	4	MOSFET Switch Behavior	Simulate a MOSFET as a sampling switch under different frequencies and analyze charge injection.	CO4
11	4	Switched Capacitor Integrator	Design and simulate an SC integrator and measure output for sinusoidal and step inputs.	CO4
12	4	Switched Capacitor Amplifier	Implement a non-inverting SC amplifier and observe gain stability and precision behavior.	CO4
13	5	Ring Oscillator Design	Design a 3-stage ring oscillator and observe frequency behavior with varying supply voltages and transistor sizes.	CO5
14	5	VCO Design and Simulation	Create a Voltage-Controlled Oscillator (VCO) and simulate its frequency tuning range.	CO5
15	5	PLL Modeling	Simulate a basic Charge Pump PLL in MATLAB or Verilog-A; study lock-in behavior and phase noise.	CO5

Textbooks:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
1	Design of Analog CMOS Integrated Circuits	Behzad Razavi	Tata McGraw Hill	2nd	1,2,3,4,5
2	CMOS Circuit Design, Layout, and Simulation	R. Jacaob Baker, Harry W. Li, David E. Boyce	Wiley	2nd	1,2,3,4,5
3	CMOS Analog Circuit Design	P. E. Allen and D. R. Holberg	Oxford University Press	3rd	1,2,3,4,5
4	Analysis and design of Analog Integrated Circuits	Gray, Meyer, Lewis, Hurst	Wiley	5th	1,2,3,4,5

Reference Books:

Sr. No	Textbook Titles	Author/s	Publisher	Edition	Module Nos.
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2	Digital Integrated Circuits: A Design Perspective	Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic	Pearson Education	2nd	2,3,4,5
3	Introduction to VLSI Circuits and Systems	John P. Uyemura	Wiley India Pvt. Ltd.	Revised 4th Edition	3,4,5
4	CMOS Digital Integrated Circuits Analysis and Design	Sung-Mo Kang and Yusuf Leblebici,	Tata McGraw Hill	Revised 4th Edition	1,2,3,4,5
5	CMOS VLSI Design: A Circuits and Systems Perspective	Neil H. E. Weste, David Harris and Ayan Banerjee,	Pearson Education	5th	1,2,3,4,5
6	Analysis and Design of Digital Integrated Circuits	David Hodges, Horace Jackson, Resve Saleh.	McGraw-Hill, Inc.	3rd	1,2,3,4,5
8	Basic VLSI Design	Douglas A Pucknell, Kamran Eshraghian,	Prentice Hall of India Private Ltd.	3rd	1,2,3,4,5

Course Name: **PROJECT 1(Synopsis)**

Course Code: ET48

Category: Project and Internship

Preamble:

The Project work enables student to develop the requires skills and knowledge gained during the programme by applying them for the analysis of specific problem or issue, via a substantial piece of work which is carried out over an extended period.

Pre-requisites:

- Mini-Project.
- Knowledge of Core subject of Project domain.
- Knowledge of tools required as per project domain.
- Knowledge of Hardware development board as per project domain.

Course Objectives:

The aim of this course is.

- Enables the students to acquire required skill set for analysis of specific problem or issue.
- Enables the students to demonstrate the proficiency in the design of research project.
- Enables the students to learn appropriate methods of collection and analysis of data presentation of results.

Course Outcomes:

CO1: The students can use this opportunity to experiment with different computational techniques and modern tools and use it to make proper selection of project work.
CO2: Student should be able to understand and apply the behavioural science by working in a team
CO3: Students can analyse, design and implement the problem and lead to its accomplishment with proper planning.
CO4: Students should be able to effectively communicate their ideas and about their project concepts either verbally or through demonstration and creating the report for further references.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head of learning	**ISA**	**MSE**	**ESE**	**Total**
Theory	50	-	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Project Guidelines:

- To precede the project work it is very important to select a right topic. Project can be undertaken on any of the following domain.
  - Embedded system.
  - IOT
  - Wireless and Mobile communication.
  - Microwave communication.
  - Electronic system design.
  - VLSI.
  - Digital and Image processing.
  - Instrumentation and Automation.
  - Bio-Medical.
  - Networking.
  - Cloud Computing.
  - Software.
  - Data Science
  - AI/ML
  - Any other domain as per Students and guide choice.

- Project work must be carried out by the group of at least 2 students and maximum 4 students and must be original.
- Students are encouraged to take live projects from industry and make sure that they should evolve them in the unique way as per the guidelines given by industry and internal project guide.
- The project work can be undertaken in research institute or organization/company/any business establishment.
- Students must consult internal guide along with the external guide (if any) in selection of topic.
- Head of the Department and senior staff in the department will take the decision regarding selection of project topic. However internal guide will have all the rights of selecting the final year project topic of their individual group.
- Students has to submit weekly report to the internal guide and whereas internal guide has to keep track on the progress of the project and also has to maintain attendance report.The progress report can used for awarding the ISA Marks.
- In case of Industry projects, visit by internal guide will be proffered.

Project Synopsis format:

At the end of SEM7 each project group have to submit the Project synopsis report should be preferably contain at least following details.

- Abstract.
- Introduction.
- Literature survey.
  1. Survey of existing system.
  2. Limitation of the existing system or research gap.
  3. Problem statement and objective.
  4. Scope.

- Proposed system.
    1. Analysis/Framework/Algorithm.
    2. Details of hardware and software system.
    3. Design details.
    4. Methodology (Your approach to solve the problem).
- Implementation plan for next semester.
- Conclusions.
- References.
-

In semester assessment (ISA)

Distribution of ISA Marks should be as follow.

- Weekly attendance on project day.
- Contribution in the project work.
- Synopsis report.
- Term end presentation (Internal).
  The final certification and acceptance of ISA ensures the satisfactory performance on the above aspects.

Oral and practical examination

The oral and practical examination of Project 1(Synopsis) should be conducted by Internal and External examiners approved by Mumbai University and college. Students have to Present and Demonstrate Project 1(Synopsis) topic.

Detailed syllabus of Final Year
Semester - VIII

Course Name: Optical Communication

Course Code: ET13T

Category: Core

Preamble:

The Optical Communication course is designed to provide students with a comprehensive understanding of the principles and technologies involved in the transmission of information using optical fibers. The course aims to equip students with foundational knowledge of light propagation in optical media, including the behavior of optical fibers, modes of transmission, and dispersion effects. It emphasizes the analysis and design of optical sources such as LEDs and laser diodes, as well as photo detectors like PIN and avalanche photodiodes. Students will explore key components of optical communication systems, including multiplexing techniques, optical amplifiers, and modulation formats. The course also introduces modern advancements such as wavelength-division multiplexing (WDM), coherent detection, and the architecture of high-capacity fiber optic networks. Through theoretical concepts and practical insights, the course prepares students to understand system design considerations and performance analysis, thereby enabling them to contribute effectively to the development and deployment of modern optical communication systems.

Pre-requisites:

Digital Communications, Analog Communications

Course Objectives:

- To introduce the fundamental concepts and principles of optical fiber communication systems.
- To explain the structure, types, and transmission characteristics of optical fibers.
- To study the working and characteristics of optical sources, detectors, and other essential components.
- To analyze the effects of attenuation, dispersion, and nonlinearities on signal transmission.
- To familiarize students with modern optical communication technologies such as WDM, optical amplifiers, and coherent detection.

Course Outcomes:

Learner will be able to:

CO1: Recall and describe the fundamental principles of optical fiber communication, including light propagation, types of fibers, and the concept of total internal reflection.

CO2: Explain the working principles and characteristics of optical sources (LEDs and lasers), detectors (PIN and APDs), and other key components used in optical communication systems.

CO3: Apply theoretical concepts to calculate losses, dispersion, and power budgets in simple optical links using appropriate models and equations.

CO4: Analyse the performance of optical communication systems by evaluating key parameters such as

attenuation, dispersion, noise, and bandwidth to determine system efficiency.

CO5: Design and propose an optical communication link or network that meets specific requirements by selecting suitable components and optimizing for performance metrics such as BER, SNR, and bandwidth.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
2	-	2	-

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Theory	15	20	40	75

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction and Basics of Optical fiber communication	Historical Development, Electromagnetic Spectrum, Optical Bands and Windows, Need for optical fiber communication, Fiber optic cable types and color codes, Block diagram, advantages and disadvantages of optical fiber cables, loss and bandwidth, applications, and deployment. Basics of Optical Fiber: Review of Ray theory; Wave theory, Light propagation in optical fiber Classification of optical fibers, Propagation modes, MFD in SMF, Fiber material, Fabrication techniques for high quality fiber: MCVD, fiber joints, fiber connectors, splices.	8
2	Transmission Characteristic of Optical Fiber	Dispersion in Optical fiber, types of dispersion, Dispersion compensation techniques and dispersion measurements, Time domain and Frequency Domain measurements. Dispersion management, Need for dispersion management and Post compensation techniques. Transmission losses in the optical fiber, Attenuation, Absorption losses, radiation losses and linear scattering losses, Comparison of optical fibers,	8

		Measurement of attenuation: Insertion loss, Return loss, OTDR.	
3	Optical Communication Systems	Working principle and characteristics of sources Edge emitting LED, Edge emitting LASER, VCEL, Spectrum, Noise, and Optical amplifiers. Working principle and characteristics of detectors (PIN, APD), optical receivers, receiver performance: Bit error rate, Q function and Eye diagram, Point to point links system considerations, link power budget, and rise time budget	5
4	Optical Network System Components and Optical Networks	Couplers, isolators, circulators, multiplexers, Optical filters - fiber gratings, Fabry, switches and wavelength converters, Add drop multiplexers, Optical amplifiers, Optical cross connects, modulators.	6
5	Packet Switching and Access Networks	OTDM, multiplexing and de-multiplexing, synchronization and broadcast OTDM networks. Network architecture overview, optical access networks. FTTH Network, Optical Burst switching Networks, Radio over fiber, Passive optical networks.	3
		Total	**30**

Textbooks:

1. G. Keiser, *Optical Fiber Communications*, 5th ed., New York, NY, USA: McGraw-Hill, 2021.
2. J. M. Senior and M. Y. Jamro, *Optical Fiber Communications: Principles and Practice*, 3rd ed., Harlow, U.K.: Pearson Education, 2009.
3. G. P. Agrawal, *Fiber-Optic Communication Systems*, 4th ed., Hoboken, NJ, USA: Wiley, 2010.

Reference Books:

1. R. Ramaswami, K. Sivarajan, and G. Sasaki, *Optical Networks: A Practical Perspective*, 3rd ed., San Francisco, CA, USA: Morgan Kaufmann, 2009.
2. B. Mukherjee, *Optical WDM Networks*, 1st ed., New York, NY, USA: Springer, 2006.
3. J. Gower, *Optical Communication Systems*, 2nd ed., Englewood Cliffs, NJ, USA: Prentice Hall, 1993.

Course Name: Optical Communication - Laboratory

Course Code: ET13P

Category: Core

Preamble:

The Optical Communication course is designed to provide students with a comprehensive understanding of the principles and technologies involved in the transmission of information using optical fibers. The course aims to equip students with foundational knowledge of light propagation in optical media, including the behavior of optical fibers, modes of transmission, and dispersion effects. It emphasizes the analysis and design of optical sources such as LEDs and laser diodes, as well as photo detectors like PIN and avalanche photodiodes. Students will explore key components of optical communication systems, including multiplexing techniques, optical amplifiers, and modulation formats. The course also introduces modern advancements such as wavelength-division multiplexing (WDM), coherent detection, and the architecture of high-capacity fiber optic networks. Through theoretical concepts and practical insights, the course prepares students to understand system design considerations and performance analysis, thereby enabling them to contribute effectively to the development and deployment of modern optical communication systems.

Pre-requisites:

Nil

Course Objectives:

- To familiarize students with the software for designing and simulating optical communication systems.
- To enable students to model key optical components such as transmitters, fibers, amplifiers, and receivers using simulation tools.
- To simulate and analyze the performance of optical links under various conditions, including attenuation, dispersion, and noise.
- To provide experience in evaluating system-level parameters such as BER, Q-factor, and eye diagrams through software-based analysis.
- To encourage students to explore advanced optical communication techniques like WDM, DWDM, using virtual experiments.

Course Outcomes:

Learner will be able to:

CO1: Identify and describe the various simulation tools and optical components available
CO2: Explain the behavior of optical systems and components based on simulation results, including the impact of attenuation, dispersion, and noise.
CO3: Use software to model and simulate basic optical communication systems, including transmitters, optical fibers, and receivers.
CO4: Analyse system performance by interpreting output parameters such as bit error rate (BER), Q-factor, and eye diagrams under different configurations.
CO5: Design and optimize advanced optical communication systems (e.g., WDM links) using simulation tools to meet specific performance requirements.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	2	-	1

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Practical	25	-	25	050

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Suggested List of Practical:

Learners are expected to perform practical based on the following suggested topics.

Sr No	Suggested Topic(s)
1	Understand the function of lasers (CW and modulated), modulators, and photodiodes.
2	Simulate and plot optical power loss over distance using single-mode/multimode fibers.
3	Analyze the effects of chromatic dispersion on pulse broadening.
4	Compare NRZ and RZ modulation formats using BER and eye diagram analysis.
5	Compare direct modulation vs. external Mach-Zehnder modulator (MZM).
6	Study an IM-DD system using laser and PIN/APD photo detector.
7	Simulate DSB-FC systems and analyze bandwidth and signal quality.
8	Implement SSB using MZM and compare with DSB systems.
9	Simulate transmission of RF signals over optical links and analyze system performance.
10	Simulate WDM with multiple laser sources and evaluate channel spacing and crosstalk.
11	Design a high-capacity DWDM system with narrow channel spacing and analyze spectral efficiency.
12	Use OADM to add/drop specific WDM channels and evaluate system routing.
13	Study gain, noise figure, and saturation effects of EDFAs in long-haul systems.
14	Evaluate system performance under varying input power, distance, and dispersion.
15	Perform parameter sweeps (fiber length, power, dispersion) to optimize system BER.

Textbooks:

1. G. Keiser, *Optical Fiber Communications*, 5th ed., New York, NY, USA: McGraw-Hill, 2021.
2. J. M. Senior and M. Y. Jamro, *Optical Fiber Communications: Principles and Practice*, 3rd ed., Harlow, U.K.: Pearson Education, 2009.
3. G. P. Agrawal, *Fiber-Optic Communication Systems*, 4th ed., Hoboken, NJ, USA: Wiley, 2010.

Reference Books:

1. R. Ramaswami, K. Sivarajan, and G. Sasaki, *Optical Networks: A Practical Perspective*, 3rd ed., San Francisco, CA, USA: Morgan Kaufmann, 2009.
2. B. Mukherjee, *Optical WDM Networks*, 1st ed., New York, NY, USA: Springer, 2006.
3. J. Gower, *Optical Communication Systems*, 2nd ed., Englewood Cliffs, NJ, USA: Prentice Hall, 1993.

Course Name: **PROJECT 2(Final)**

Course Code: ET49

Category: Project and Internship

Course Objectives:

The primary objective is to meet the milestones formed in the overall project plan decided in Project-1.The idea presented in Project-1 should be implemented in Project-2 with results, conclusion and future work. The project will culminate in the production of thesis by each individual students.

Course Outcomes:

CO1: Identify various technologies and fields for making project.
CO2: Understand the process to make reports and presentations.
CO3: Apply engineering knowledge to solve various industrial problems.
CO4: Analyse ethical practices and tools used for different technologies.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
-	8	-	4

Assessment Guidelines:

Head of learning	ISA	MSE	ESE	Total
Lab	75	-	50	125

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Project Guidelines:

- Each project group have to submit.
  - Working hardware model of their final project.
  - Working software model of final year project along with design and simulation results.
  - Write the scholarly paper on their project topic in IEEE format and published it in any of the repute Conference or Journal.
  - Prepare the short video on working of project and upload it on YOUTUBE and also submit it to department.

Project Report format:

At the end of semester 8, each project group have to submit the Project s report (Black-Book) should be preferably contain at least following details.

- Abstract.
- Introduction.
- Literature survey.
    1. Survey of existing system.
    2. Limitation of the existing system or research gap.
    3. Problem statement and objective.
    4. Scope.
- Proposed system.
    1. Analysis/Framework/Algorithm.
    2. Details of hardware and software system.
    3. Design details.
    4. Methodology (Your approach to solve the problem).
- Hardware circuit diagram(if any)
- Software algorithm along with programme (If internal guide permits).
- Specification of hardware components (Data Sheet).
- Cost of project.
- Conclusions.
- References.
-

In semester assessment (ISA)

Distribution of ISA Marks should be as follow.

- Weekly attendance on project day.
- Contribution in the project work.
- Final Project report (Black-Book).
- Term end presentation (Internal).
- Working or Non-working project.

The final certification and acceptance of ISA ensures the satisfactory performance on the above aspects.

Oral and practical examination

The oral and practical examination of Project 2(Final) should be conducted by Internal and External examiners approved by Mumbai University and college. Students have to Present and Demonstrate Project 2(Final) topic.

Detailed syllabus of Final Year Semester – VII and VIII
Open Elective Courses

Open Elective Courses

Open Elective bucket offers no courses at Institute level for all branches. The Learner is expected to complete the requirement of 15 credits by taking 5 courses as suggested in their program structure.

The following is the list of courses offered by Institute.

Sr. No.	Course Code	Course Title	Hours Per Week			Credits
			Theory	Practical	Tutorial	
1	OE21	Cyber Law	3	-	-	3
2	OE22	Project Management	3	-	-	3
3	OE23	Product Lifecycle Management	3	-	-	3
4	OE24	Sustainability Management	3	-	-	3
5	OE25	Operation Research	3	-	-	3
6	OE26	IPR and Patenting	3	-	-	3
7	OE27	Research Methodology	3	-	-	3
8	OE28	Renewable Energy Management	3	-	-	3
9	OE29	Energy Audit and Management	3	-	-	3
10	OE30	Bioinformatics	3	-	-	3
11	OE31	Nanotechnology	3	-	-	3

Course Name: Cyber Law

Course Code: OE21

Category: Open Elective

Preamble:
This course explores the evolving landscape of cyber law and security, equipping students with legal frameworks and technology insights necessary to navigate the challenges posed by digital crimes. It emphasizes both technical and legal aspects of cybersecurity, with a focus on Information Technology Act, 2000 (ITA 2000) and the amendments in the Information Technology Amendment Act, 2008 (ITAA 2008).

Pre-requisites: Nil

Course Objectives:

- To introduce students to the legal framework governing cyber activities, with a focus on ITA 2000 and ITAA 2008.
- To understand the technical foundations of cybersecurity and the role of various security mechanisms in preventing cyber threats.
- To explore different types of cybercrimes and the processes involved in investigating and addressing them.
- To examine the legal aspects of e-commerce, e-governance, and the use of electronic signatures in Indian law.
- To analyze the importance of privacy, data protection, and how international laws influence Indian regulations.
- To provide a global perspective on cyber law and international conventions, addressing challenges like intellectual property and cyber warfare.

Course Outcomes:

Student will be able to:
CO1: Explain the key provisions of ITA 2000 and ITAA 2008 and their impact on various legal domains.
CO2: Gain practical knowledge of cybersecurity tools and techniques such as encryption, firewalls, and digital signatures.
CO3: Identify different types of cybercrimes and apply forensic techniques to investigate digital crimes.
CO4: Assess the legal implications of e-commerce, e-governance, and electronic contracts in India.
CO5: Analyze privacy and data protection laws in India and evaluate them from an international perspective.
CO6: Understand global cyber law frameworks and how international treaties impact the regulation of cyberspace in India.

Course Scheme:

Contact Hours		**Credits Assigned**	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Introduction to Cyber Law and IT Act	Evolution and necessity of ITA 2000 Overview of ITA 2000 and ITAA 2008: Key provisions, authorities, and penalties Amendments to Indian Penal Code, Evidence Act, and other laws Case studies on jurisdiction under cyber law	6
2	Cyber Security Framework	Definition and importance of cybersecurity Overview of threats: hacking, malware, phishing, and cyberterrorism Basic security mechanisms: firewalls, encryption, PKI, and digital signatures Role of CERT-IN and other agencies in India	7
3	Cyber Crimes and Investigation	Types of cybercrimes: data theft, identity theft, cyberstalking, cyberbullying, and online fraud Investigation procedures for cybercrimes Seizure of digital evidence and forensic procedures Digital forensics: tools and anti-forensics measures	8
4	E-Commerce, E-Governance, and Cyber Law	E-commerce regulations under ITA 2000 and ITAA 2008 Validity of electronic signatures and contracts in Indian law E-Governance and issues in e-taxation Cyber Tribunal and appellate processes	8
5	Privacy, Data Protection, and Emerging Trends	Sensitive Personal Data or Information (SPDI) under Indian law International perspectives on data protection and privacy (GDPR, HIPAA) Impact of cloud computing and data localization Case studies on privacy violations and legal recourse	8
6	International Cyber Law and Legal Framework	UNCITRAL model law and international conventions on cybercrime Intellectual property rights in cyberspace: trademarks, patents, and copyright Cyber warfare, digital sovereignty, and human rights Cyber law practices in other jurisdictions (US, EU, China)	8
Total			**45**

Textbooks:

1. "Cyber Law & Cyber Crimes" by Advocate Prashant Mali, Snow White Publications, Mumbai.
2. "Information Technology Law and Practice" by Vakul Sharma, Universal Law Publishing Co. Pvt. Ltd.
3. "The Indian Cyber Law" by Suresh T. Vishwanathan, Bharat Law House, New Delhi.

Reference Books:

1. "Digital Evidence and Computer Crime" by Eoghan Casey, Academic Press.
2. "Cyber Law in India" by Farooq Ahmad, Pioneer Books.
3. "Computer Forensics: Principles and Practices" by Linda Volonino et al., Pearson Prentice-Hall, 2007.

Course Name: Project Management

Course Code: OE22

Category: Open Elective

Preamble:
This course discusses tools that any organization can use to improve its ability to plan, implement, and control its activities as well as the ways in which it utilizes its people and resources.

Pre-requisites: Nil

Course Objectives:

1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Course Outcomes:
Student will be able to:
CO1. Apply selection criteria and select an appropriate project from different options.
CO2. Write work break down structure for a project and develop a schedule based on it.
CO3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
CO4. Use Earned value technique, determine & predict status of the project.
CO5. Capture lessons learned during project phases and document them for future reference

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Project Management Foundation	Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	6
2	Initiating Projects	How to get a project started, selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter, Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	8
3	Project Planning and Scheduling	Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS)	8
4	Planning Projects	Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	8
5	Executing Projects, Monitoring and Controlling Projects and Project Contracting	Executing Projects: Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. Project Contracting: Project procurement management, contracting and outsourcing	8
6	Project Leadership and Ethics Closing the Project	Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects. Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final	7

		report; doing a lesson learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study	
Total			**45**

Reference Books:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7 th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Course Name: Product Life Cycle Management

Course Code: OE23

Category: Open Elective

Preamble:

This course aims to give students an overview of product Life Cycle Management (PLM) which is a strategic approach to managing the entire lifecycle of a product, from its inception through design, manufacturing, deployment, and disposal. This course gives student insights on various aspects such as PLM Strategies, Product design, Product Data Management, Virtual Product Development Tools, Integration of Environmental Aspects in Product Design, Life Cycle Assessment and Life Cycle Cost Analysis

Pre-requisites:

Nil

Course Objective:

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Course Outcomes:

Students will be able to:

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Product Lifecycle Management and PLM Strategies	**Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM	10
2	Product Design	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering. and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	10
3	Product Data Management (PDM)	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	06
4	Virtual Product Development Tools	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case Studies	07
5	Integration of Environmental Aspects in Product Design	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of- Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental	06

		Strategies and Considerations for Product Design	
6	Life Cycle Assessment and Life Cycle Cost Analysis	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	06
Total			**45**

Textbooks:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229

Reference Books:

1. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
2. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Name: Sustainability Management

Course Code: OE24

Category: Open Elective

Preamble:

To provide learners with a comprehensive understanding of sustainability principles, strategies, and management practices that enable organizations to operate responsibly while achieving long-term success.

Pre-requisites:

NIL

Course Objectives:

- To provide a comprehensive understanding of sustainability concepts and their importance in global and organizational contexts.
- To equip participants with the tools and frameworks to develop and implement effective sustainability strategies.
- To foster the ability to analyze environmental, social, and economic impacts and propose practical solutions.
- To empower learners to lead and manage sustainable practices through innovation, technology, and ethical decision-making.

Course Outcomes:

Learner will be able to:

CO1: Understand the Core Principles of Sustainability: Comprehend the key environmental, social, and economic dimensions of sustainability

CO2: Analyze Environmental Impacts: Evaluate organizational and societal environmental footprints and recommend sustainable practices.

CO3: Develop Strategies for Social and Economic Sustainability: Formulate strategies that address social equity, community engagement, and economic resilience.

CO4: Implement Sustainability Practices: Design and implement sustainability strategies within an organizational context, including reporting and stakeholder management.

CO5: Leverage Technology and Innovation: Utilize emerging technologies to enhance sustainability outcomes.

CO6: Lead and Manage Change: Apply leadership and change management principles to foster a sustainability-focused culture.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Sustainability	Overview of Sustainability: Definition, history, and importance. Sustainable Development Goals (SDGs): UN's 2030 Agenda and its impact on global development. Three Pillars of Sustainability: Environmental, social, and economic dimensions. Current Challenges: Climate change, resource depletion, inequality, and global initiatives.	5
2	Environmental Sustainability	Understanding Environmental Impact: Carbon footprint, waste management, and biodiversity. Energy Management: Renewable energy sources, energy efficiency, and innovations in energy systems. Circular Economy: Concepts, examples, and transitioning to closed-loop systems. Sustainable Resource Management: Water, minerals, and sustainable agriculture.	8
3	Social Sustainability	Social Equity and Inclusion: Addressing diversity, equity, and inclusion in organizations. Community Engagement: Building partnerships and contributing to societal development. Labor Practices: Ethical employment practices, health, and safety. Corporate Social Responsibility (CSR): Importance, frameworks, and success stories.	7
4	Economic Sustainability	Sustainable Business Practices: Triple bottom line approach. Green Finance: ESG investing, green bonds, and carbon pricing. Sustainable Innovation: Developing products and services that align with sustainability goals.	5

		Regulatory Frameworks: Policies and standards for sustainable business operations.	
5	Sustainability Strategy & Implementation	Developing a Sustainability Strategy: Key steps and tools. Stakeholder Engagement: Identifying and collaborating with key stakeholders. Sustainability Reporting: Standards (GRI, SASB), metrics, and case studies. Measuring Impact: Life cycle assessment (LCA), carbon accounting, and sustainability indicators.	8
6	Technology and Innovation for Sustainability	Digital Transformation: Role of AI, IoT, and big data in achieving sustainability. Green Technologies: Innovations in clean energy, transportation, and waste management. Smart Cities: Integration of sustainable technologies in urban planning. Role of Blockchain: Transparency and traceability in sustainability practices.	6
7	Leadership and Change Management in Sustainability	Sustainability Leadership: Characteristics and examples of successful leaders. Driving Organizational Change: Overcoming resistance and fostering a sustainability culture. Ethical Decision Making: Frameworks for responsible leadership. Global Case Studies: Examining successful implementations of sustainability initiatives.	6
		Total	**45**

Textbooks:

1. "Sustainability Principles and Practice" by Margaret Robertson.
2. "The Triple Bottom Line" by Andrew Savitz.
3. "The Business Guide to Sustainability" by Darcy Hitchcock and Marsha Willard.

Reference Books:

1. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
2. "Sustainability: A Systems Approach" by Tony Clayton and Nicholas Radcliffe.

Course Name: Operations Research

Course Code: OE25

Category: Open Elective

Preamble: This course discusses various tools in scientific management.

Course Objectives:

1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

Course Outcomes:

Learner will be able to…

CO1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
CO2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
CO3. Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
CO4. Understand the applications of integer programming and a queuing model and compute important performance measures

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Operations Research	**Introduction to Operations Research**: Introduction, Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem:** Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the steppingstone method and MODI method. **Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem:** Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	15
2	Queuing models	Queuing models: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	6
3	Simulation	Simulation: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	6
4	Dynamic programming	Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stagecoach/Shortest Path, cargo loading and	6

		Reliability problems.	
5	Game Theory	Game Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	6
6	Inventory Models	Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	6
Total			**45**

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Name: IPR and Patenting

Course Code: OE26

Category: Open Elective

Preamble:

This course discusses legal rights that can be registered with a legal authority in some presentable or tangible form which can be sold or bought or licensed, like physical property given to creator or innovator to harvest the economic benefits on their invention or creation.

Course Objectives:

1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as international treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

Course Outcomes:

Learner will be able to…

1. Understand Intellectual Property assets
2. Assist individuals and organizations in capacity building
3. Work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Intellectual Property Rights (IPR):	Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. Importance of IPR in Modern Global Economic Environment: Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	6
2	Enforcement of Intellectual Property Rights:	Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, international agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement Indian Scenario of IPR: Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	8
3	Emerging Issues in IPR:	Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc	6
4	Basics of Patents:	Definition of Patents, Conditions of patentability, Patentable and nonpatentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	8
5	Patent Rules:	Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	9
6	Procedure for Filing a Patent (National and International):	Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement Patent databases: Important websites, Searching international databases	8

Total	**45**

REFERENCE BOOKS:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting, Interpretation of Patent Specifications and Claims, New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Course Name: Research Methodology

Course Code: OE27

Category: Open Elective

Preamble: This course offers "An overview of research methodology including basic concepts employed in quantitative and qualitative research methods. Includes computer applications for research.

Pre-requisites: Nil

Course Objectives:

1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

Course Outcomes:

Students will be able to:
CO1: Demonstrate the ability to choose methods appropriate to research aims and objectives
CO2: Understand the limitations of particular research methods
CO3: Develop skills in qualitative and quantitative data analysis and presentation
CO4: Develop advanced critical thinking skills
CO5: Demonstrate enhanced writing skills

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment/evaluation guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose a revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction and Basic Research Concepts	Introduction and Basic Research Concepts 1.1 Research – Definition: Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology 1.2 Need of Research in Business and Social Sciences	10

		1.3 Objectives of Research 1.4 Issues and Problems in Research 1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	
2	Types of Research	Types of Research 2.1. Basic Research 2.2. Applied Research 2.3. Descriptive Research 2.4. Analytical Research 2.5. Empirical Research 2.6 Qualitative and Quantitative Approaches	8
3	Research Design and Sample Design	Research Design and Sample Design 3.1 Research Design – Meaning, Types and Significance 3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	9
4	Research Methodology	Research Methodology 4.1 Meaning of Research Methodology 4.2. Stages in Scientific Research Process: a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report	8
5	Ethics in Research	Ethics in Research Plagiarism - Definition, different forms, consequences, unintentional plagiarism, copyright infringement, collaborative work. Qualities of good Researcher.	5
6	ICT Tools for Research	ICT Tools for Research: Role of computers in research, maintenance of data using software such as Mendeley, Endnote, Tabulation and graphical presentation of research data and software tools. Web search: Introduction to Internet, use of Internet and www, using search engines and advanced search tools.	5
Total			**45**

Textbooks:

1 Donald Cooper and PS Schindler (2009) Business Research Methods, 9th edition, Tata McGraw Hill.
2 Kothari C. R Research Methodology

3 Uma Sekaran (2010) Research Methods for Business, 4th edition, Wiley.
4 Ranjit Kumar (2009) Research Methodology, 2nd edition, Pearson Education
5 Naresh Malhotra and S Dash (2009) Marketing Research, 5th edition, Pearson Prentice Hall.
6 Michael V. P Research Methodology.
7 Fred N. Kerlinger: Foundations of Behavioral Research.

Reference books

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course: Renewable Energy Management

Category: Open Elective

Course Code: OE28

Preamble:

Renewable Energy Management focuses on the development, implementation, and management of renewable energy projects. This course aims to equip students with the knowledge and skills required to effectively manage renewable energy resources, assess their impact, and implement sustainable energy solutions. The curriculum covers various renewable energy technologies, their applications, and the economic, environmental, and policy aspects of renewable energy systems.

Pre-requisites:

Nil

Course Outcomes:

CO1: Understand the principles and technologies of various renewable energy sources.

CO2: Analyse the economic, environmental, and social impacts of renewable energy projects.

CO3: Evaluate and design renewable energy systems for specific applications.

CO4: Develop strategies for the integration and management of renewable energy in the energy mix.

CO5: Understand the policies, regulations, and incentives related to renewable energy.

CO6: Gain practical skills in renewable energy project planning, implementation, and management.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head of Learning	ISA	MSE	Project	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Mod No.	Module Name	Content	No. of hrs.
1	Introduction to Renewable Energy	• Overview of global and national energy scenarios • Importance and benefits of renewable energy • Types of renewable energy sources: solar, wind, biomass, hydro, and geothermal • Comparison between renewable and non-renewable energy • Current trends and future prospects in renewable energy	7
2	Solar Thermal Energy	• Principles of solar thermal energy conversion • Solar collectors: flat plate, evacuated tube, and concentrating collectors • Solar thermal applications: water heating, space heating,	6

		and industrial processes • Solar thermal power plants: parabolic troughs, solar towers, and dish Stirling systems • Economic and environmental aspects of solar thermal energy	
3	Solar Photovoltaics	• Principles of photovoltaic energy conversion • Types of photovoltaic cells: monocrystalline, polycrystalline, and thin film • Design and components of photovoltaic systems: modules, inverters, and batteries • Performance analysis of PV systems: efficiency, shading, and temperature effects • Grid integration and energy storage for PV systems	6
4	Wind Energy	• Fundamentals of wind energy conversion • Wind turbine types, components, and operation • Wind farm design and site selection • Environmental and social impacts of wind energy projects • Economic analysis and policy considerations for wind energy	6
5	Biomass, Hydro and Geothermal Energy	• Biomass & Bio Energy • Biomass resources and conversion technologies • Bioenergy production: biogas, biofuels, and biomass power generation • Waste-to-energy systems • Environmental and economic aspects of bioenergy • Policies and incentives for bioenergy development • Hydro Energy • Principles of hydro power generation • Small-scale and large-scale hydro power plants • Geothermal Energy • Geothermal energy resources and extraction methods • Applications and challenges of geothermal energy • Environmental and economic considerations for hydro and geothermal energy	9
6	Renewable Energy and Management Policy	• Energy management principles and practices • Renewable energy project planning and management • Integration of renewable energy into the grid • Policies, regulations, and incentives for renewable energy • Case studies of successful renewable energy projects	11
		Total	45

Textbooks:

1. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
2. "Renewable Energy Systems: The Earthscan Expert Guide to Renewable Energy Technologies for Home and Business" by David Thorpe
3. "Energy Management Handbook" by Wayne C. Turner and Steve Doty

Reference Books:

1. "Solar Engineering of Thermal Processes" by John A. Duffie and William A. Beckman

2. "Wind Energy Explained: Theory, Design and Application" by James F. Manwell, Jon G. McGowan, and Anthony L. Rogers
3. "Biomass to Renewable Energy Processes" by Jay Cheng
4. "Hydropower: Renewable Energy for a Sustainable Future" by Dirk Aschenbach
5. "Geothermal Energy: Renewable Energy and the Environment" by William E. Glassley
6. "Renewable Energy Policy and Politics: A Handbook for Decision-Making" by Volker M. Quaschning

Course Name: Energy Audit and Management

Course Code: OE29

Category: Open Elective

Preamble:
Energy Audit is a systematic approach for decision-making in energy management to balance the total energy inputs with its use. The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization to minimize energy costs/waste without affecting production & quality with minimum environmental effects.

Pre-requisites: Nil

Course Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Course Outcomes:
Student will be able to:
CO1. To identify and describe present state of energy security and its importance.
CO2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
CO3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
CO4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
CO5. To analyze the data collected during performance evaluation and recommend energy saving measures

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment Guidelines:

Head	ISA	MSA	ESA	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned in the above table. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module no	Module name	Content	No of Hours
1	Energy Scenario	Present Energy Scenario, Energy Pricing, Energy	5

		Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	
2	Energy Audit Principles	Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	10
3	Energy Management and Energy Conservation in Electrical System	Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipment and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	10
4	Energy Management and Energy Conservation in Thermal Systems	Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
5	Energy Performance Assessment	On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis	5
6	Energy conservation in Buildings:	Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	5
		Total	**45**

Reference Books:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy

Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.
9. http://www.bee-india.nic.in

Course Name: Bioinformatics

Course Code: OE30

Category: Open elective

Preamble:
This course is designed with the objective of equipping students with a robust understanding of the integration between biology and computational science, key bioinformatics concepts, methodologies, and applications. Through a combination of theoretical knowledge and practical applications, students will develop a holistic understanding of how computational methods can enhance the comprehension of biological processes. It also emphasizes real-world biological questions and research challenges, empowering them to make meaningful contributions to the rapidly evolving field of bioinformatics.

Pre-requisites:
Nil

Course Objectives:

- To enable learners to understand the basic principles of bioinformatics.
- To provide a foundational understanding of key bioinformatics concepts, including biological data types and analysis methods.
- To develop the skills necessary for analyzing and interpreting genomic and proteomic datasets using computational techniques.
- To familiarize students with essential bioinformatics tools and databases, enabling effective selection and application in research.
- To encourage the integration of bioinformatics approaches into biological research, fostering the ability to formulate and test hypotheses.

Course Outcomes:

Learner will be able to:
CO1: Understanding of foundational bioinformatics concepts.
CO2: Comprehending and applying knowledge of basic principles of mathematics and statistics.
CO3: Implementing efficient and reliable bioinformatics solutions by optimizing the usage of existing tools. CO4: Apply problem-solving skills to multivariate methods in bioinformatics.
CO5: Search and apply bioinformatics tools to analyze and interpret biological data

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the

commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Bioinformatics	Basics of Biology: Characteristics and Principles of cells, DNA and chromosomes, genes and the genomes. Types of biological data, Sequencing Methods: DNA & Protein, Genomic Sequencing, and Human Genome Project Overview and scope of Bioinformatics, Computers in biology, medicine & different problems in biology, Applications of Bioinformatics	9
2	Biological databases and their classification	Based on storage techniques (Flat, Relational, Object Oriented). Based on data (Primary, Secondary, Specialized and Composite). Search engines: Entrez& SRS Sequence databases: NCBI, EMBL, DDBJ Structural Databases: PDB Protein Databases: PIR, SWISS PROT Other Databases: Chemical and Drug Molecule Databases	9
3	Algorithms in Bioinformatics	Sequence Alignment: Heuristic Method (BLAST, FASTA) Pairwise Sequence Alignment: Local and Global Alignment (Dynamic programming Methods: Needleman Wunch Algorithm, Smith Waterman Algorithm.), Multiple Sequence Alignment: CLUSTAL W, Phylogenetic Analysis.	9
4	Introduction to drug designing	History of drug design, Stages of drug discovery and development; Drug properties, likeness. Preparation of Protein Structure: In silico Structure Prediction - Homology Modeling; Threading; Fold Recognition. Ab initio modeling; Model refinement and validation Molecular Visualization Software: Methods for representing biological data, 3D Structure Viewers Concept of pharmacophore mapping and pharmacophore based Screening	10
5	Computer aided drug designing	High throughput Virtual Screening and Molecular Docking: Rigid and Flexible Docking Analysis of Protein-Ligand interactions Quantitative Structure Activity Relationship (QSAR) (3D-QSAR approaches like COMFA and COMSIA.) Molecular Mechanics and Molecular Dynamics Simulations: Understanding the structural stability of protein and protein-ligand complex ADMET analysis	8
Total			**45**

Suggested list of Assignments:

1. Retrieving sequences, it's structural and functional data from the set of databases.
2. Analyzing sequences through alignment tools - BLAST, FASTA and CLUSTAL s.
3. 3D Protein modelling, validation and visualization
4. Protein ligand interaction by docking techniques

5. Designing a potential drug candidate.

Suggested List of Value-Added Home Assignments:

1. Mapping genes to biological pathways and analyze their interactions.
2. Construct and interpret a phylogenetic tree.

Suggested Online Courses:

1. Bioinformatics: Algorithms and Applications, offered by NPTEL Swayam, https://onlinecourses.nptel.ac.in/noc21_bt06/preview
2. Bioinformatics: Introduction and Methods, offered by Peking University through Coursera, https://coursesity.com/r/site/bioinformatics-introduction-and-methods-

Reference Books:

1. Bioinformatics and Functional genomics, Jonathan Pevsner, Wiley Blackwell, 2015, Third edition.
2. Bioinformatics: Sequence and genome analysis, David mount, Cold Spring Harbor, N.Y press, 2004, Second edition.
3. Strategies for Organic Drug Discovery Synthesis and Design, Daniel Lednicer, Wiley International Publishers, 1998, Second Edition.
4. Essential Bioinformatics, Jin Xiong, Cambridge University Press, 2006, First Edition.

Course Name: Nanotechnology

Course Code: OE31

Category: Open elective

Preamble:
The course aims to provide a comprehensive understanding of nanotechnology fundamentals, its scientific principles, fabrication techniques, applications in engineering, and the ethical considerations associated with its usage. Students will explore how nanotechnology can be applied to different fields of engineering, including electronics, materials science, biomedical applications, and energy.

Pre-requisites:
Nil

Course Objectives:

- To enable learners to understand the basic principles and concepts of nanotechnology.
- To enable learners to explain the properties and behavior of materials at the nanoscale.
- To enable learners to describe the fabrication and characterization techniques used in nanotechnology.
- To enable learners to explore the applications of nanotechnology in various engineering fields.
- To enable learners to analyze the societal and ethical implications of nanotechnology advancements.

Course Outcomes:

Learner will be able to:

CO1: Understand nanotechnology fundamentals.
CO2: Analyze nanoscale phenomena
CO3: Understand and apply key nanofabrication methods for creating nanoscale structures and devices. CO4: Understand the principles behind various characterization techniques for nanoscale materials.
CO5: Explore engineering applications of nanotechnology.
CO6: Evaluate ethical, environmental, and societal Impacts.

Course Scheme:

Contact Hours		Credits Assigned	
Theory	Practical	Theory	Practical
3	-	3	-

Assessment guidelines:

Head of Learning	ISA	MSE	ESE	Total
Theory	20	30	50	100

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction to Nanotechnology	Definition, scope, and multidisciplinary nature of nanotechnology. Historical development of nanotechnology and key breakthroughs. Types of nanomaterials: nanoparticles, nanotubes, nanowires, quantum dots, and nanocomposites. Nanoscale dimensions: importance of size, surface area, and quantum effects. Exploration of nanotechnology's role in various industries (electronics, medicine, energy, etc.).	9
2	Properties of Nanomaterials	In-depth study of the physical, chemical, electrical, optical, and mechanical properties of nanomaterials. Surface energy, surface-to-volume ratio, and its impact on material properties. Detailed study of quantum confinement and its influence on electrical and optical properties. Toxicity and environmental concerns of nanomaterials: impact on living organisms and ecosystems.	9
3	Nanofabrication Techniques	Comprehensive overview of top-down and bottom-up nanofabrication methods. In-depth study of lithographic techniques: photolithography, electron-beam lithography. Advanced deposition techniques: Chemical Vapor Deposition (CVD), Atomic Layer Deposition (ALD), Physical Vapor Deposition (PVD). Molecular self-assembly, nanoimprint lithography, and soft lithography techniques.	9
4	Characterization of Nanomaterials	Detailed study of key characterization tools: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM), Scanning Tunneling	6

		Microscopy (STM), X-ray diffraction (XRD). Optical spectroscopy and Raman spectroscopy techniques. Importance of precision and resolution in nanomaterial characterization.	
5	Applications of Nanotechnology in Engineering	Nanotechnology in Electronics: nanoscale transistors, quantum dots, and nanomaterials for next-gen electronics. Energy Applications: nanomaterials for solar cells, energy storage, supercapacitors, and batteries. Biomedical Applications: drug delivery, diagnostic tools, nanomedicine, and tissue engineering. Environmental Applications: nanotechnology in water purification, air filtration, and pollution control. Mechanical and Civil Engineering: nanocomposites, self-cleaning surfaces, and smart materials.	8
6	Societal, Ethical, and Environmental Implications	Ethical issues related to nanotechnology: privacy concerns, nanotoxicology, and regulation. Environmental impacts of nonmaterial's: nanowaste management and recycling. Public perception of nanotechnology and its societal impacts. Responsible innovation and future directions for ethical development of nanotechnology. Regulatory frameworks for nanomaterials in India and worldwide.	4
Total			**45**

Suggested list of Assignments:

1. Explore one specific application of nanotechnology in any engineering field (e.g., electronics, medicine, or energy).
2. Comparative Analysis of Nanoscale vs. Bulk Properties.
3. Design of a Nanofabrication Process for a device.
4. Nanomaterials Characterization Report interpretation.
5. Propose a simple nanotechnology-based solution for an engineering challenge in your chosen field.
6. Ethical and Environmental Implications of Nanotechnology.

Suggested List of Value-Added Home Assignments:

1. Reviewing Nano products and new technologies.
2. Novel technical paper writing based on recent advancements.
3. Problem Based Learning on Nano sensor development.

Suggested Online Courses:

1. Nanotechnology : Introduction, Essentials, and Opportunities
   https://www.udemy.com/course/nanotechnology/?couponCode=IND21PM
2. Nanotechnology: A Maker's Course
   https://www.coursera.org/learn/nanotechnology

Reference Books:

1. Marc Madou, "Fundamentals of Microfabrication", CRC Press, 1997.

2. Charles P. Poole and Frank J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, 2003.
3. Sulabha Kulkarni, "Nanotechnology: Principles and Practices", Springer, 2015.
4. R.S. Tiwari and A. Gosh, "Nanomaterials and Nanotechnology", S. Chand & Company, 2017.
5. Patricia I. Dolez, "Nanoengineering: Global Approaches to Health and Safety Issues", Elsevier, 2015.