CURRICULUM
&
SYLLABUS
2023 Scheme
(Autonomous)
Version 1.0

B.TECH
ELECTRICAL AND COMPUTER ENGINEERING

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695015

CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND COMPUTER ENGINEERING

SEMESTERS V & VI

2023 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND COMPUTER ENGINEERING

THIRD YEAR SYLLABUS

2023 SCHEME

Items	Board of Studies (BOS)	Academic Council (AC)
Date of Approval	09.05.2025	28.05.2025

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Electrical & Electronics Engineering Education, Research and Application of knowledge to benefit the society at large.

Mission:

To mould quality Electrical Engineers, fostering creativity and innovation to address global issues.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will succeed as Engineering Professionals in Industry or as Entrepreneurs in Electrical and Computer Engineering and the related disciplines and exhibit an urge for innovation.

PEO2: Graduates will be able to adapt to the advances in Technology by acquiring knowledge and skills manifested through continuous learning and higher qualifications.

PEO3: Graduates will be serving community as socially committed individuals, exhibiting professional ethics in addressing the technical and engineering challenges.

PROGRAMME OUTCOMES (POs)

Engineering graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development testing and operation of Power and Energy Systems in the areas of Generation, Transmission, Conversion, Distribution and Utilization systems.

PSO2: To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development and operation of Industrial systems in the areas of Automation, Control, Energy Management and Economic operation.

CURRICULUM

SEMESTER V										
Slot	**Cate-gory**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	PCC	23ELL30A	Database Management Systems	3	1	0	0	5	4	4
B	PCC	23ELB30B	Microprocessors and Embedded Systems	3	1	2	0	6	6	5
C	PCC	23ELL30C	Electrical Machines	3	1	0	0	5	4	4
D	HSC	23HSL30A	Business Economics and Accountancy	3	0	0	0	4.5	3	3
E	PEC	23ELL31X	Program Elective I	3	0	0	0	4.5	3	3
S	PCC	23ELP30A	Electrical Machines Lab	0	0	2	0	1	2	1
T	PCC	23ELP30B	Database Management System Lab	0	0	2	0	1	2	1
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
TOTAL								**27/ 31.5**	**24/27**	**21/24**

PROGRAMME ELECTIVE I

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
E	PEC	23ELL31A	Renewable Energy Conversions	3-0-0-0	3	3	PES
		23ELL31B	Electromagnetic Theory and Compatibility	3-0-0-0	3	3	PES
		23ELL31C	Signals and Systems	2-1-0-0	3	3	CAI
		23ELL31D	Biomedical Instrumentation	3-0-0-0	3	3	CAI
		23ELL31E	Introduction to Security in Computing	3-0-0-0	3	3	SAN
		23ELL31F	Operating Systems	3-0-0-0	3	3	SAN
		23ELL31G	Introduction to Machine Learning	3-0-0-0	3	3	AML

SEMESTER VI										
Slot	**Cate-gory**	**Course Code**	**Courses**	**Credit Structure**				**SS**	**Hours**	**Credit**
				L	**T**	**P**	**J**			
A	PCC	23ELL30D	Power Electronics	3	1	0	0	5	4	4
B	PCC	23ELL30E	Algorithm Analysis and Design	3	1	0	0	5	4	4
C	PCC	23ELL30F	Computer Communication and Network Security	3	0	0	0	4.5	3	3
D	PEC	23ELL32X	Program Elective II	3	0	0	0	4.5	3	3
E	IEC	23IEL31X	Institute Elective I	3	0	0	0	4.5	3	3
S	PCC	23ELP30C	Networking Lab	0	0	2	0	1	2	1
T	PWS	23ELS38A	Seminar	0	0	4	0	2	4	2
U	PWS	23ELJ38B	Mini Project	0	0	4	0	4	4	2
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**30.5/ 35/34**	**27/30**	**22/25**

PROGRAMME ELECTIVE II

Slot	**Cate-gory Code**	**Course Code**	**Courses**	**L-T-P-J**	**Hours**	**Credit**	**Stream Code**
D	PEC	23ELL32A	Energy Storage Systems	3-0-0-0	3	3	PES
		23ELL32B	Modern Illumination Control	3-0-0-0	3	3	PES
		23ELL32C	Advanced Microcontrollers	3-0-0-0	3	3	CAI
		23ELL32D	Introduction to Signal Processing	3-0-0-0	3	3	CAI
		23ELL32E	Wireless Sensor Networks	3-0-0-0	3	3	SAN
		23ELL32F	Introduction to Artificial Intelligence	3-0-0-0	3	3	AML
		23ELL32G	Soft Computing Techniques	3-0-0-0	3	3	AML

INSTITUTE ELECTIVE I (Common for EEE Department)

Slot	**Category Code**	**Course Code**	**Courses**	**L-T-P-J**	**Hours**	**Credit**
E	IEC	23IEL31A	Introduction to Flight Dynamics and Control	3-0-0-0	3	3
		23IEL31B	Introduction to Power Processing	3-0-0-0	3	3
		23IEL31C	Electrical Drives and Control for Automation	3-0-0-0	3	3
		23IEL31D	Artificial Intelligence in Power Systems	3-0-0-0	3	3

S6 MINORS (Common for EEE Department)

Slot	Cate-gory	Course Code	Courses	L-T-P-J	Credit
R/M/H	VAC	23EEL3MB	Cloud Computing for Internet of Things	3-0-0-0	3
		23EEL3MD	Electrical System Design and Building services	2-1-0-0	3
		23EEL3MF	Smart Grid and Energy Storage Systems	3-0-0-0	3
		23EEL3MH	Introduction to Automotive Electrical & Electronic systems	3-0-0-0	3

S6 HONOURS

Slot	Cate-gory	Course Code	Courses	L-T-P-J	Credit
R/M/H	VAC	23ELL3HB	Introduction to Navigation and Trajectory planning	2-1-0-0	3
		23ELL3HD	Machine Learning Programming	2-1-0-0	3
		23ELL3HF	Distributed Generation and Smart Grid	2-1-0-0	3

SEMESTER V

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL30A	DATABASE MANAGEMENT SYSTEMS	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW:

This course provides students with a thorough understanding of the fundamental principles of Database Management Systems (DBMS), with a strong focus on relational databases. Key topics include DBMS basics, the Entity-Relationship (ER) model, relational database concepts, relational algebra, Structured Query Language (SQL), physical data organization, normalization, and transaction processing. Additionally, the course introduces learners to alternative data management models, including NoSQL. By the end of the course, students will be equipped to efficiently manage data by selecting appropriate structures for organizational data assets and developing applications that leverage database technologies.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Summarize and illustrate fundamental nature and characteristics of database systems	Understand
CO2	Model real-world scenarios using Entity-Relationship diagrams and design efficient solutions for querying and managing data using relational model and SQL.	Apply
CO3	Apply the features of indexing and hashing in database applications	Apply
CO4	Apply normalization algorithms to transform relational schemas into 1NF, 2NF, 3NF, and BCNF, and verify lossless join and dependency preservation properties.	Apply
CO5	Identify and compare the aspects of Concurrency Control and Recovery in Database systems	Apply
CO6	Make use of Redis, MongoDB, Cassandra, ArangoDB to explain the various NoSQL databases	Apply

iii) SYLLABUS

Concept & Overview of Database Management Systems (DBMS), Database Languages, Database architectures and classification.

ER models. Structure of Relational Databases, Synthesizing ER diagram to relational Schema, Introduction to Relational Algebra, introduction to Structured Query Language (SQL), formation of SQL queries using SQL DML (Data Manipulation Language), Physical Data organization, Heap files, Indexing, Singe level and multi-level indices.

B trees, Hashing and indexing, Different anomalies in designing a database and different types of normalization applied to Databases.

Transaction Processing Concepts, concurrency control and recovery, Introduction to noSQL Databases.

Explanation of main characteristics using Redis, MongoDB, Arrango DB, Cassandra.

iv) (a) TEXT BOOKS

1) Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
2) Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.

(b) REFERENCES

1) Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015.
2) NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases and Big Data), Wiley, 2018.
3) Web Resource: https://www.w3resource.com/redis/
4) Web Resource: https://www.tutoria1spoint.com/cassandra/cassandra_introduction.htm
5) web Resource: https://www.w3schoo1s.in/category/mongodb/
6) Web Resource https://www.tutoria1spoint.com/arangodb/index.htm

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction & Entity Relationship (ER) Model: Concept & Overview of Database Management Systems (DBMS) - Characteristics of Database system, Database Users, structured, semi-structured and unstructured data. Data Models and Schema - Three Schema architecture. Database Languages, Database architectures and classification. ER model - Basic concepts, entity set & attributes, notations, Relationships and constraints, cardinality, participation, notations, weak entities, relationships of degree 3.	**12**
II	Relational Model: Structure of relational databases; Integrity constraints; Conversion of ER diagrams to relational schemas. Introduction to Relational Algebra: Selection, projection, Cartesian product operations; Joins – equi-join and natural join; Query examples. Introduction to Structured Query Language (SQL): Data Definition Language (DDL); Table definitions and operations — CREATE, DROP, ALTER, INSERT, DELETE, UPDATE.	**12**
III	SQL DML (Data Manipulation Language), Physical Data Organization: SQL DML (Data Manipulation Language) - SQL queries on single and multiple tables, Nested queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, Triggers, SQL data types. Physical Data Organization - Review of terms: physical and logical records, blocking factor, pinned and unpinned organization. Heap files, Indexing, Single level indices, numerical examples, Multi-level-indices, numerical examples, B- Trees & B+-Trees (structure only, algorithms not required), Extendible Hashing, Indexing on multiple keys — grid files.	**12**

IV	Normalization: Different anomalies in designing a database, the idea of normalization, Functional dependency, Armstrong's Axioms (proofs not required), Closures and their computation, Equivalence of Functional Dependencies (FD), Minimal Cover (proofs not required). First Normal Form (INF), Second Normal Form (2NF), Third Normal Form (3NF), Boyce Codd Normal Form (BCNF), Lossless join and dependency preserving decomposition, Algorithms for checking Lossless Join (LJ) and Dependency Preserving (DP) properties.	**12**
V	Transactions, Concurrency and Recovery, Recent Topics: Transaction Processing Concepts - overview of concurrency control, Transaction Model, Significance of concurrency Control & Recovery, Transaction States, System Log, Desirable Properties of transactions. Serial schedules, Concurrent and Serializable Schedules, Conflict equivalence and conflict serializability, Recoverable and cascade-less schedules, Locking, Two- phase locking and its variations. Log-based recovery, Deferred database modification, check-pointing. Introduction to NoSQL Databases, Main characteristics of Key-value DB (examples Redis), Document DB (examples from MongoDB) Main characteristics of Column- Family DB (examples from Cassandra) and Graph DB (examples from ArangoDB)	**12**
	Total hours	**60**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELB30B	MICROPROCESSORS AND EMBEDDED SYSTEMS	PCC	3	1	2	0	5	2023

i) COURSE OVERVIEW: This course is designed to introduce microprocessor & microcontroller assembly language programming. Students will be taught the basic use of an assembly as well as embedded C programming environment to control peripheral devices. Students will also understand the interfacing of various peripheral elements with microcontrollers to design an automated system. The course prepares the student with a set of concepts common to many different embedded systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the architecture of a microprocessor and microcontroller-based system	Understand
CO2	Develop Assembly language program for 8085 microprocessors and 8051microcontrollers.	Apply
CO3	Develop embedded C programs for I/O ports, Logic operations, serial port communication and timers/counters of 8051.	Apply
CO4	Develop embedded C program to handle interrupts and to interface various peripheral devices with 8051 microcontrollers.	Apply
CO5	Explain the general characteristics and life cycle development of an embedded system.	Understand

iii) SYLLABUS

Internal architecture of 8085 microprocessor, Machine cycles and T states — Fetch and execute cycles- Timing diagram for instruction and data flow. Assembly language programs for 8085 microprocessors.

Architecture of 8051 Microcontrollers, Assembly programming for 8051 microcontrollers, Embedded C programs for I/O port, serial port communication, timer/counter, interfacing external peripherals.

Overview of embedded systems, Current trends and challenges, Product development life cycle.

iv) (a) TEXT BOOKS

1) Douglas V. Hall, *Microprocessors and Interfacing,* Tata McGraw Hill, Education Pvt. Ltd, 2012 Edition.
2) Mathur A., *Introduction to Microprocessors,* Tata McGraw Hill, New Delhi, 2015 Edition.
3) Ramesh Gaonkar, *Microprocessor, Architecture, Programming and Applications,* Pen ram, Fifth Edition, 2000.
4) Muhammad Ali Maidu and Janice Gillespie, *The 8051 Microcontroller and Embedded Systems — using assembly and C,* Pearson, Second Edition 2007.
5) Kenneth J. Ayala, *The 8051 Microcontroller,* 3rd Edition, Thomson/Cengage Learning, 2nd Edition 2007.

(b) REFERENCES

1) Ramesh Gaonkar, *Fundamentals of Microcontrollers and Applications in Embedded Systems (with the PIC18 Microcontroller Family),* January 2010.
2) Manish K Patel, *The 8051 Microcontroller Based Embedded Systems,* McGraw Hill, July 2017, ISBN: 978-93-329-0125-4.
3) Raj Kamal, *Microcontrollers: Architecture, Programming, Interfacing and System Design,* Pearson Education, January 2011.
4) K.Uma Rao & Andhe Pallavi, *The 8051 microcontrollers, architecture and programming and applications,* Pearson, January 2010.
5) Ajay V. Deshmukh, *Microcontrollers and application,* Tata McGraw-Hill Publishing Company Limited, New Delhi,2005.

v) COURSE PLAN

Module	Contents	No. of hours
I	Internal architecture of 8085 microprocessor—Functional block diagram. Instruction set-Addressing modes - Classification of instructions - Status flags. Machine cycles and T states. Assembly language program (ALP) in 8085 microprocessor- Arithmetic operations, Code conversion- BCD to Binary - Binary to BCD, Bubble sort.	**9**
	Laboratory Experiments- 8085 ALP for Data transfer, Arithmetic operations, logical group of instructions & code conversions.	**8**
II	Architecture of Intel 8051 microcontroller: 8051 Register Banks and Stack, Internal Memory Organization of 8051, SFRs. Introduction to 8051 assembly programming: Instruction sets, Data types and Assembler directives, 8051 Addressing Modes, simple Assembly programs.	**9**
	Laboratory Experiments: 8051 ALP for Data transfer: Block data movement, exchanging data, Arithmetic and Logic Operations, sorting, finding the largest element in an array.	**4**
III	Embedded C Programming: Data types and time delay in 8051C, I/O programming, Logic operations, Data conversion. Programming 8051 timers in 8051 C: Timer programming in mode 1 and 2, Counter programming in mode 1 and 2.	**10**
	8051 Embedded C Program for Data Conversions, Bit manipulation, Arithmetic and Logical Operations, Embedded C Timer/Counter implementation in Kei1 software,	**6**
IV	Serial Communication: Basics of communication, serial port programming in 8051 C. Interrupt Programming: Interrupt enable, Timer interrupt, serial communication interrupt, External hardware interrupt programming in 8051 C	**10**

	Interfacing LCD, ADC, DAC, Stepper motor, DC motor.	
	Laboratory Experiments-, Serial Port Programming, Interfacing LCD, ADC, DAC, stepper motor and dc motor.	**12**
V	Overview of Embedded Systems - Application domain of embedded systems, features and characteristics, overview of embedded system architecture; recent trends in embedded systems, Categories of embedded systems-Hard and soft, Design and Development life cycle model, Challenges in Embedded system design	**7**
	Total hours	**75**

Sl. No.	Laboratory Program/Experiment	No. of hours
1	8085 ALP for Data transfer	2
2	8085 ALP for Arithmetic operations	2
3	8085 ALP for Logical operations group of instructions	2
4	8085 ALP for code conversions.	2
5	8051 ALP for Data transfer: Block data movement, exchanging data	2
6	8051 ALP for Arithmetic and Logic Operations, sorting, finding the largest element in an array.	2
7	8051 Embedded C Program for Data Conversions and bit manipulation.	2
8	8051 Embedded C Program for Arithmetic and Logical Operations.	2
9	Embedded C Timer/Counter implementation in Kei1 software	2
10	8051 Embedded C programs for serial port programming in Keil software.	2
11	8051 Embedded C Programs for stepper motor control.	2
12	8051 Embedded C Programs for DC motor direction and speed control using PWM.	2
13	8051 Embedded C Programs for Alphanumerical LCD panel/ keyboard interface.	2
14	8051 Embedded C programs for Interfacing DAC.	2
15	8051 Embedded C programs for Interfacing ADC	2
	Total hours	**30**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 60 : 40

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Assessment of Lab Work	:	10 marks
Lab Exam*	:	10 marks
Total Continuous Assessment	:	**60 marks**
End Semester Examination	:	**40 marks**
TOTAL	:	**100 marks**

*Lab Exam – 2 hours Internal exam for 40 marks.

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 40
- Exam Duration : 2 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL30C	ELECTRICAL MACHINES	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW:

This course enables students to gain familiarity with the operational principles, performance and applications of DC, induction, synchronous machines and transformers as well as with the fundamentals of special electric machines.

ii) COURSE OUTCOMES:

After the completion of the course, the student will be able to:

CO1	Illustrate the principle and characteristics of DC generators and motors.	Understand
CO2	Develop the equivalent circuit of single-phase transformers and explain the principle of transformers and auto-transformers.	Apply
CO3	Outline the construction, principle and types of three-phase and single-phase induction machines.	Understand
CO4	Summarize the principle of alternators and synchronous motors and evaluate alternator regulation.	Understand
CO5	Outline the principle, features and applications of stepper motors, universal motors, SRMs and BLDC Motors.	Understand
CO6	Select suitable machines for specific applications based on their performance characteristics.	Apply

iii) SYLLABUS

DC machines-construction, DC generators: principle of operation -emf equation-types of excitations- armature reaction, OCC.
DC motors-Principle of operation- torque and speed equations- characteristics- starters - losses and efficiency – load test.
Transformers – construction - principle of operation – emf equation- phasor diagram- losses and efficiency – OC and SC tests - equivalent circuits - maximum efficiency – all day efficiency – auto transformers.
Three phase induction motors- types - principle of operation – torque slip characteristics- - methods of starting, Single-phase motors- principle of operation - resistance split phase motor – capacitor start motors.
Synchronous machines: construction– emf equation of alternator – regulation of alternator by emf method.
Synchronous motors- methods of starting- applications.
Stepper motors, universal motors, SRMs, BLDC motors - principle - emf equation, torque equation.

iv) (a) TEXT BOOKS

1) Bimbhra P. S., “Electric Machines”, Khanna Publishers, 2nd Edition, 2017.

2) Fitzgerald A. E., Kingsley C. and Umans S., “Electric Machinery”, McGraw Hill, 6th Edition, 2003.
3) Theodore Wildi, “Electrical Machines, Drives and Power Systems”, Pearson Education. Asia, 6th Edition, 2013.
4) Kothari D. P., Nagrath I. J., “Electric Machines”, Tata McGraw Hill, 5th Edition,2017.

(b) REFERENCES

1) Gupta J. B., “Theory and Performance of Electrical Machines”, S K Kataria & Sons, 14th Edition, 2013.
2) Deshpande M. V., “Electrical Machines”, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.
3) S.K. Bhattacharya, “Electrical Machines”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 4th Edition, 2017.
4) Say M. G., “The Performance and Design of AC Machines”, CBS Publishers, New Delhi, 3rd Edition, 2002.
5) Ashfaq Husain, Haroon Ashfaq, “Electric Machines” Dhanpat Rai and Co., 3rd Edition, 2005.
6) Clayton A. E. and Hancock N. N., “The Performance and Design of Direct Current Machines”, CBS Publishers & Distributors, New Delhi, 3rd Edition, 2004.

v) COURSE PLAN

Module	Contents	No. of hours
I	**DC Machines**: Principles of electromechanical energy conversion, Construction of DC Machines. **DC generators:** Principle of operation, EMF equation, types of generators based on excitations, concept of armature reaction, characteristics, OCC, losses and efficiency- numerical problems.	**12**
II	**DC motors:** Principle of operation, torque and speed equations, types-shunt, series and compound motors, Back EMF, necessity of starters, characteristics of DC motors, applications, losses and efficiency, load test on DC motors, numerical problems.	**12**
III	**Transformers** – Construction, principle of operation, emf equation, phasor diagram on load, OC and SC tests - equivalent circuits, losses and efficiency- maximum efficiency, all day efficiency- simple numerical problems; Auto transformers.	**12**
IV	**Three phase induction motors** - Slip ring and Squirrel cage motors, principle of operation, torque-slip characteristics, star-delta starting, auto transformer starting. Single phase induction motors- resistance split-phase motors, capacitor-start induction motors. **Synchronous machines**: Construction-types-principle of operation-emf equation of alternator-concept of regulation of alternators-regulation by EMF method.	**12**

V	**Synchronous motors:** Principles of operation of synchronous motors, methods of starting, applications-synchronous condenser**.** **Special electric motors:** Stepper motors, Universal motors, SRMs, BLDC Motors- Principle of operation, features, torque equation (concept only), applications.	**12**
	Total hours	**60**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELP30A	ELECTRICAL MACHINES LAB	PCC	0	0	2	0	1	2023

i) COURSE OVERVIEW:

The course objective is to equip students with hands-on experience in testing AC and DC machines, enabling them to verify results and analyze performance using suitable tests.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply suitable tests on the given DC machine to determine its performance characteristics.	Apply
CO2	Apply suitable tests on the given single-phase transformer to determine its efficiency and losses and to pre-determine its equivalent circuit.	Apply
CO3	Experiment with the given induction motor to obtain its performance characteristics.	Apply
CO4	Develop the equivalent circuit of the given induction motor by conducting no-load and blocked rotor tests.	Apply
CO5	Apply direct loading and EMF methods to calculate the regulation of the given three-phase alternator.	Apply

iii) SYLLABUS

- Familiarization of meters, instruments and safety measures adopted in the laboratory; Study of starters of three-phase Induction Motors
- Load Test on a DC Series Motor
- Load Test on a DC Shunt Motor
- OCC of a DC Shunt Generator
- Load Characteristics of a DC Shunt Generator
- Load Characteristics of a DC Compound Generator
- OC and SC tests on a single-phase transformer
- Load Test on a Single-Phase Transformer
- Separation of constant losses of a Single-Phase Transformer
- Load Test on a three-phase Slip ring Induction Motor
- Starting of a three phase Squirrel Cage Induction Motor using Y-Δ Starter
- Load Test on a single-phase Capacitor Start Run Induction Motor
- No Load and Blocked Rotor tests on a a single-phase Capacitor-Start Induction Motor
- Regulation of a three-phase Alternator by direct loading
- Regulation of a three-phase Alternator by EMF method

iv) REFERENCES

1) Bimbhra P. S., “Electric Machines”, Khanna Publishers, 2nd Edition, 2017.

2) D. P. Kothari, I. J. Nagrath, “Electric Machines”, Tata McGraw Hill, 5th Edition,2010.

3) Say M. G., “The Performance and Design of AC Machines”, CBS Publishers, New Delhi, 3rd Edition, 2002.

4) Langsdorf M. N., "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised Edition, 2001.

v) COURSE PLAN

Module	Contents	No. of hours
I	a. Familiarization of meters and instruments used in Electrical Machines Lab b. Study of safety measures to be taken while performing experiments in the lab c. Study of starters of three phase Induction Motors	2
II	**Load Test on a DC Series Motor** a. Plot the performance characteristics b. Plot the electrical and mechanical characteristics	2
III	**Load Test on a DC Shunt Motor** a. Plot the performance characteristics b. Plot the electrical and mechanical characteristics	2
IV	**OCC of a DC Shunt Generator** a. Plot the OCC at rated speed b. Plot the OCC at a speed other than the rated speed c. Determine the critical resistance and critical speed d. Determine the additional resistance to be added in the field circuit to just excite the machine at rated speed.	2
V	**Load Characteristics of a DC Shunt Generator** Plot the internal and external characteristics.	2
VI	**Load Characteristics of a DC Compound Generator** a. Plot the load characteristics of the given DC Compound generator when cumulatively compounded. b. Plot the load characteristics of the given DC Compound generator when differentially compounded.	2
VII	**OC and SC Tests on a single-phase transformer** a. Predetermination of efficiency b. Develop the equivalent circuit of the given single-phase transformer.	2
VIII	**Load Test on a single-phase transformer** Calculate the regulation and efficiency at different loads and upf.	2
IX	**Separation of Constant losses of a Single-Phase Transformer** Determine the components of constant losses of a single-phase transformer.	2
X	**Load test on a three-phase slip ring Induction Motor** a. Start the motor using an autotransformer starter and perform load test. b. Plot the performance characteristics.	2
XI	**Starting of a three-phase squirrel cage Induction Motor using Y-△ Starter** a. Start the motor using Y-△ Starter and perform load test. b. Plot the performance characteristics.	2

XII	**Load Test on a single-phase capacitor start run Induction Motor** a. Perform load test on the motor b. Plot the performance characteristics of the motor	**2**
XIII	**No Load and Blocked Rotor tests on a single-phase capacitor start Induction Motor** a. Conduct no load and blocked rotor test on the given single-phase induction motor. b. Predetermine the equivalent circuit.	**2**
XIV	**Regulation of a three-phase Alternator by direct loading** a. Determine the regulation of three-phase alternator by direct loading. b. Plot the regulation curve.	**2**
XV	**Regulation of a three phase Alternator by EMF method** Predetermine the regulation of the given three-phase alternator by EMF method at 0.8pf lag, upf and 0.8pf lead.	**2**
	Total Hours	**30**

vi) ASSESSMENT PATTERN

Continuous Assessment		
Attendance	:	5 marks
Assessment of Lab Work	:	55 marks
Continuous Assessment in Lab (Lab work + Record + Viva - voce) -35 marks and Internal Lab test -20 marks		
Final Lab Assessment	:	40 marks
TOTAL	**:**	**100 marks**

vii) FINAL LAB ASSESSMENT

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

(a)	Preliminary work	:	15 marks
(b)	Implementing the work/Conducting the experiment	:	10 marks
(c)	Result and inference	:	10 marks
(d)	Viva voce	:	5 marks
	Total	**:**	**40 marks**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELP30B	DATABASE MANAGEMENT SYSTEM LAB	PCC	0	0	2	0	1	2023

i) COURSE OVERVIEW:

The Database Management Systems course is designed to equip students with a strong foundation in database management concepts. It enables them to design and implement database applications based on these principles. The course provides practical experience in key areas such as database creation, SQL query development, transaction management, and working with NoSQL databases like MongoDB. Students will develop the skills needed to independently create, manage, and administer databases, along with building essential tools for database design and deployment. Additionally, the course enhances students' understanding of emerging technologies focused on managing Big Data.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Develop database schema for a given real-world problem-domain using Apply standard design and modelling approaches.	Apply
CO2	Construct queries using SQL for database creation, interaction, modification, and updation.	Apply
CO3	Model and implement triggers and cursors.	Apply
CO4	Develop procedures, functions, and control structures using PL/SQL.	Apply
CO5	Experiment with CRUD operations in NoSQL Databases.	Apply
CO6	Develop database applications using front-end tools and back-end DBMS.	Apply

iii) SYLLABUS

- Design a database schema for an application with ER diagram from a problem description
- Creation, modification, configuration, and deletion of databases using UI and SQL Commands
- Creation of database schema - DDL (create tables, set constraints, enforce relationships, create indices, delete and modify tables). Export ER diagram from the database and verify relationships (with the ER diagram designed in step 1).
- Database initialization - Data insert, Data import to a database (bulk import using UI and SQL Commands).
- Practice SQL commands for DML (insertion, updating, altering, deletion of data, and viewing/querying records based on condition in databases)
- Implementation of built-in functions in RDBMS.
- Implementation of various aggregate functions in SQL
- Implementation of Order By, Group By & Having clause
- Implementation of set operators nested queries, and join queries

- Implementation of queries using temp tables
- Practice of SQL TCL commands like Rollback, Commit, Savepoint
- Practice of SQL DCL commands for granting and revoking user privileges
- Practice of SQL commands for creation of views and assertions
- Implementation of various control structures like IF-THEN, IF-THEN-ELSE, IF- THENELSEIF, CASE, WHILE using PL/SQL
- Creation of Procedures, Triggers and Functions
- Creation of Packages
- Creation of Cursors
- Familiarization of NoSQL Databases and CRUD operations
- Design a database application using any front-end tool for any problem selected. The application constructed should have five or more tables

iv) REFERENCES

1) Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
2) Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.
3) Ramakrishnan R. and Johannes Gehrke, Database Management Systems, 3/e, McGraw-Hill Education, 2002.
4) Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015
5) Dan Sullivan, NoSQL for Mere Mortals, Addison-Wesley, 2015.
6) NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases and Big Data), Wiley, 2018.
7) Feuerstein S., Oracle PL/SQL Programming, 6th Edition, O'Reilly Media, 2014.
8) Kristina Chodorow, MongoDB: The Definitive Guide, 3rd Edition, O'Reilly Media, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	Creation, modification, configuration, and deletion of databases using UI and SQL Commands	**2**
II	Design a database schema for an application with ER diagram from a problem description	**2**
III	Creation of database schema - DDL (create tables, set constraints, enforce relationships, create indices, delete and modify tables). Export ER diagram from the database and verify relationships (with the ER diagram designed in step 1).	**2**
IV	• Database initialization - Data insert, Data import to a database (bulk import using UI and SQL Commands) • Practice SQL commands for DML (insertion, updating, altering, deletion of data, and viewing/querying records based on condition in databases)	**4**
V	• Implementation of built-in functions in RDBMS • Implementation of various aggregate functions in SQL	**2**
VI	• Implementation of Order By, Group By & Having clause. • Implementation of set operators nested queries, and join queries.	**2**

VII	• Implementation of queries using temp tables. • Practice of SQL TCL commands like Rollback, Commit, Savepoint.	**2**
VIII	• Practice of SQL DCL commands for granting and revoking user privileges • Practice of SQL commands for creation of views and assertions	**2**
IX	Implementation of various control structures like IF-THEN, IF THEN-ELSE, IF-THEN ELSIF, CASE	**2**
X	Implementation of loops using PL/SQL (for loop, while loop)	**2**
XI	Creation of Procedures, Triggers and Functions	**2**
XII	• Creation of Packages • Creation of Cursors	**2**
XIII	Familiarization of NoSQL Databases and CRUD operations.	**2**
XIV	Design a database application using any front-end tool for any problem selected. The application constructed should have five or more tables.	**2**
	Total hours	**30**

vi) ASSESSMENT PATTERN

Continuous Assessment		
Attendance	:	5 marks
Assessment of Lab Work	:	55 marks
Continuous Assessment in Lab (Lab work + Record + Viva - voce) -35 marks and Internal Lab test -20 marks		
Final Lab Assessment	:	40 marks
TOTAL	**:**	**100 marks**

vii) FINAL LAB ASSESSMENT

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

Preliminary work	:	15 marks
Implementing the work/Conducting the experiment	:	10 marks
Result and inference	:	10 marks
Viva voce	:	5 marks
Total	**:**	**40 marks**

PROGRAMME ELECTIVE I

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL31A	RENEWABLE ENERGY CONVERSIONS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The goal of this course is to expose the students to learn the concepts of solar thermal and solar electric systems. It illustrates the operating principles of wind, and ocean energy conversion systems and the features of biomass and small hydro energy resources. The course describes the concepts of fuel cell and hydrogen energy technologies.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the concepts of solar thermal and solar electric systems.	Understand
CO2	Explain the concepts of ocean thermal energy conversion systems and tidal power plants.	Understand
CO3	Illustrate the operating principles of wind energy conversion systems.	Understand
CO4	Outline the features of biomass energy and small hydro power.	Understand
CO5	Illustrate the concepts of fuel cell, hydrogen energy and different energy storage methods.	Understand

iii) SYLLABUS

Introduction, Classification of Energy Resources, Principle of Conversion of Solar Radiation into Heat, Solar Thermal Electric Power Generation, Solar Photovoltaic, Solar PV Systems. Ocean Thermal Energy Conversion, Tidal power plants. Wind Energy Conversion Systems -Betz limit. Biomass conversion technologies. Small Hydro Power, Fuel Cell-principle of operation, Hydrogen energy, Energy storage –necessity and different methods.

iv) (a) TEXT BOOKS

1) G. D. Rai, “Non-Conventional Energy Sources”, Khanna Publishers, 2010.
2) Rao S. and B. B. Parulekar, “Energy Technology”, Khanna Publishers, 1999.

(b) REFERENCES

1) G.N. Tiwari, “Solar Energy-Fundamentals, Design, Modelling and Applications”, Narosa Publishers, 2002.
2) Earnest J. and T. Wizelius, “Wind Power Plants and Project Development”, PHI Learning, 2011.
3) Sab S. L., “Renewable and Novel Energy Sources”, MI. Publications, 1995.
4) Sawhney G. S., “Non-Conventional Energy Resources”, PHI Learning, 2012.
5) Tiwari G. N., “Solar Energy- Fundamentals, Design, Modelling and Applications”, CRC Press, 2002.

6) A.A.M. Saigh (Ed), "Solar Energy Engineering", Academic Press, 1977.
7) Abbasi S. A. and N. Abbasi, "Renewable Energy Sources and Their Environmental Impact", Prentice Hall of India, 2001.
8) Boyle G. (ed.), "Renewable Energy - Power for Sustainable Future", Oxford University Press, 1996.
9) Earnest J. and T. Wizelius, "Wind Power Plants and Project Development", PHI Learning, 2011.
10) F. Kreith and J.F. Kreider: "Principles of Solar Engineering", McGraw Hill, 1978.
11) Khan B.H, "Non-Conventional Energy resources", Tata McGraw Hill, 2009.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Classification of Energy Resources- Conventional and Non-Conventional Energy Resources- Classification, Availability and their limitations-– Advantages, Comparison. SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors, Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector). SOLAR ELECTRIC SYSTEMS - Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems – stand alone and grid connected.	**11**
II	ENERGY FROM OCEAN - Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system - Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling - Advantages & Limitations of OTEC. TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin - double basin types Limitations - Environmental impacts.	**8**
III	WIND ENERGY – Introduction - Basic principles of Wind Energy Conversion Systems (WECS), -site selection criteria. Wind speed measurement- Classification of WECS - types of rotors. wind power equation - Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS.	**9**
IV	BIOMASS ENERGY – Introduction - Biomass fuels - Biomass conversion technologies – Energy through fermentation –pyrolysis, Gasification and Combustion - Factors affecting biogas generation- TYPES OF BIOGAS PLANTS – KVIC and Janata model - Biomass program in India. SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts- selection considerations.	**10**

V	EMERGING TECHNOLOGIES: Fuel Cell-principle of operation-classification- applications. Hydrogen energy - hydrogen production - hydrogen storage and utilization. ENERGY STORAGE: Need of energy storage; Different modes of energy storage, Flywheel storage, Pumped Hydroelectric energy storage, Compressed Air Energy Storage.	**7**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL31B	ELECTROMAGNETIC THEORY AND COMPATIBILITY	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The objective of the course is to familiarize the students with the concepts of electrostatics, magnetostatics and electromagnetic fields. It also aims to provide the students with Maxwell's equations, the fundamental concepts of electromagnetic wave propagation, transmission lines and electromagnetic compatibility.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply principles of vector analysis and coordinate systems to determine solutions for static electric and magnetic field scenarios	Apply
CO2	Apply Gauss's and Coulomb's laws to solve for electric fields and potentials in problems involving various charge distributions and capacitors.	Apply
CO3	Make use of Biot-Savart's and Ampere's Circuital Laws to determine magnetic fields due to various current distributions.	Apply
CO4	Outline wave equations from Maxwell Equations for time-varying fields and explain wave propagation through different media.	Understand
CO5	Summarize the properties of uniform plane wave propagation in different media.	Understand

iii) SYLLABUS

Introduction to Co-ordinate Systems; Del, Curl, Gradient operations; Divergence Theorem; Stokes' Theorem.

Coulomb's law; Electric field intensity; Flux Density; Gauss's law; Potential-Potential Gradient; Poisson's and Laplace's equations.

Biot-Savart's law; Magnetic Field intensity; Magnetic Flux Density; Ampere's circuital law; Force between current carrying conductors; Magnetic Potential.

Conductors and dielectrics; Continuity equation; Boundary conditions; Maxwell's Equations; Polarization.

Electromagnetic Wave Equations; Uniform Plane Waves; Poynting Theorem; Transmission Lines. Electromagnetic compatibility.

iv) (a) TEXT BOOKS

1) Matthew N.O. Sadiku, *Principles of Electromagnetics*, Oxford university Press, 6th Edition, 2015.
2) Bakshi A.V. and Bakshi U.A., *Electromagnetic Theory*, Technical Publications, 2020.
3) John Kraus and Daniel Fleisch, *Electromagnetics with Applications*, McGraw-Hill Education, 5th Edition, 2015.

(b) REFERENCES

1) William, H. Hayt. and John A. Buck, *Engineering Electromagnetics*, McGraw-Hill Education, 8th Edition, 2017.
2) William, H. Hayt and John A. Buck, *Problems and Solutions in Electromagnetics,* McGraw- Hill Education, 2017.
3) Joseph A. Edminister, *Electromagnetics, Schaum's Outline Series*, McGraw-Hill Education, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Co-ordinate Systems:** Introduction to vector calculus and different co-ordinate systems- Rectangular, Cylindrical and Spherical co-ordinate systems; Representation of a point, base vectors, vector representation, Transformation of points and vectors among the three coordinate systems - Transformation matrices. Del operator - Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field in different co-ordinate systems, Divergence Theorem, Stokes' Theorem.	9
II	**Electrostatics:** Coulomb's Law, Electric field intensity, Electric field due to a line charge, Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite sheet charge; Electric Potential, Conservative property of electric field, Equipotential surfaces; concept of Electric Dipole; Poisson's and Laplace's equations; Capacitance of a two-wire transmission line.	9
III	**Magnetostatics:** Biot-Savart's Law, Magnetic Field intensity due to finite and infinite current carrying conductors; Magnetic field intensity on the axis of a rectangular current carrying loop; Magnetic flux Density; Ampere's circuital Law and its application to find the magnetic field due to an infinite current carrying conductor; Force between current carrying conductors.	9
IV	**Electric and Magnetic fields in materials:** Conduction current and displacement current; Equation of continuity; Relationship between current density and charge density; Dielectric polarization; Expressions for energy and energy density; Maxwell's Equations in Differential and Integral form for time-varying fields. **Electromagnetic Waves:** Wave Equations from Maxwell's Equations in point form and Phasor form.	9
V	**Uniform Plane Waves** -Properties of uniform plane waves, propagation of Uniform Plane waves in free space; Propagation of Uniform Plane waves in loss-less and lossy dielectric medium, good conductors; Properties of uniform plane waves in different medium-attenuation constant, phase constant, propagation constant, intrinsic impedance; Skin effect and Skin depth; Poynting Vector and Poynting Theorem; Basic concepts of Transmission Lines–VSWR, Impedance matching; Electromagnetic compatibility.	9
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL31C	SIGNALS AND SYSTEMS	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces fundamental concepts in the analysis of signals and systems, which are foundational in electrical, electronics, and computer engineering applications. It covers both continuous-time and discrete-time signals and systems, focusing on classification, transformations, and system properties. The course develops analytical tools such as convolution, Fourier analysis, Laplace transforms, Z-transforms, and discrete-time Fourier transforms (DTFT), enabling students to understand and analyze the time and frequency domain behavior of systems. Applications are emphasized in areas such as control, communications, and digital signal processing.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Classify different types of signals and systems, and perform basic signal transformations.	Understand
CO2	Model Linear Time-Invariant (LTI) systems using differential and difference equations.	Apply
CO3	Apply Fourier transform to study system behavior in the frequency domain.	Apply
CO4	Make use of Laplace transform to determine system behavior and assess causality and stability.	Apply
CO5	Make use of Z-transform to analyze discrete-time systems.	Apply
CO6	Make use of DTFT for analysis of discrete time system.	Apply

iii) SYLLABUS

Introduction to signals and systems – Classification of signals, basic signals, signal operations, system classification, impulse response and convolution.

LTI system properties and response, differential equation and block diagram representation of CT systems, discrete-time system modeling using difference equations, initial condition analysis, convolution-based solutions.

Fourier Series for periodic signals, CT Fourier Transform (CTFT, key properties, frequency response of LTI systems.

Laplace Transform: definition, ROC, properties, inverse techniques, system analysis via transfer functions and pole-zero plots, system properties: causality, stability, inverse systems.

Sampling process and theorem, signal reconstruction (ZOH, FOH), Z-transform, ROC, properties, inverse methods, system analysis using Z-transfer function, discrete-time convolution, and DTFT properties.

.

iv) (a) TEXT BOOKS

1) A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*, 2nd Edition, Pearson Education, 2015.
2) P. Ramakrishna Rao, *Signals and Systems*, 2nd Edition, McGraw Hill Education, 2013.
3) Simon Haykin and Barry Van Veen, *Signals and Systems*, 2nd Edition, Wiley India, 2007.
4) S. Salivahanan, A. Vallavaraj, C. Gnanapriya, *Signals and Systems, McGraw Hill Education, 2011.*
5) A. Anand Kumar, *Signals and Systems, 3rd Edition, PHI Learning, 2018.*

(b) REFERENCES

1) Michael J. Roberts, *Fundamentals of Signals and Systems*, 1st Edition, McGraw Hill, 2007.
2) B. P. Lathi, *Linear Systems and Signals*, 2nd Edition, Oxford University Press, 2009.
3) S. Salivahanan, A. Vallavaraj, C. Gnanapriya, *Signals and Systems*, McGraw Hill Education, 2011.
4) Ramesh Babu & Rama Devi, *Signals and Systems*, Scitech Publications, 2020.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Signals and Systems:** Classification of signals: Continuous-time, Discrete-time. Elementary signals: Step, impulse, ramp, exponential, sinusoidal. Signal operations: Time shifting, scaling, folding. Classification of systems: Linear/nonlinear, time-invariant/time-variant, causal/non-causal, stable/unstable. Impulse response and convolution: Continuous and discrete time.	**9**
II	**LTI Systems and Differential Equations:** LTI system properties and response, Differential equation representation of continuous-time LTI systems, Block diagram representation, Discrete-time system modeling using difference equations, Initial condition analysis and convolution-based solution.	**9**
III	**Fourier Analysis of Continuous-Time Signals:** Fourier Series: Periodic signal representation, Harmonic analysis of common signals, Continuous-Time Fourier Transform (CTFT): Definition, existence, Properties of CTFT: Linearity, scaling, time/frequency shifting, convolution, Frequency response of LTI systems.	**9**
IV	**Laplace Transform and System Behaviour:** Laplace Transform: Definition, ROC, properties, Inverse Laplace Transform techniques, Transfer function and relation to system differential equations, Pole-zero analysis, System properties: Causality, stability, inverse systems, Time and frequency response from pole-zero plots.	**9**

V	**Discrete-Time Analysis & Z-Transform:** Sampling process and Sampling theorem, Signal reconstruction: Zero-order hold, First-order hold, Z-transform: Definition, ROC, properties, Inverse Z-transform methods, Z-transfer function and system stability/causality, Convolution in discrete time, Discrete-Time Fourier Transform: Definition, properties.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL31D	BIOMEDICAL INSTRUMENTATION	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

Goal of this course is to provide an overview of instrumentation systems used in clinical medicine and biomedical research. The course is designed to give the basic concepts of Instrumentation involved in the medical field and human physiology.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Interpret the basics concepts of anatomy and physiology.	Understand
CO2	Explain different techniques for the measurement of various physiological parameters.	Understand
CO3	Illustrate modern imaging techniques for medical diagnosis.	Understand
CO4	Summarize the various therapeutic equipment used in the biomedical field.	Understand
CO5	Outline the patient safety measures and recent advancements in the medical field.	Understand

iii) SYLLABUS

Introduction to biomedical instrumentation, Physiology and Anatomy of human body, Bioelectric potential, Bio potential Electrodes, Transducers for biomedical applications. Measurement of blood pressure, blood flow, cardiac output, Plethysmography, heart sounds. ECG, ECG and EMG block diagram, electrodes, waveforms and features, Measurements of respiratory parameters. Modern Imaging System, Therapeutic equipment, Test on blood cells. Physiological effects of electric current, Introduction to Tele- medicine - Introduction to medical robotics.

iv) (a) TEXT BOOKS

1) Leslie Cromwell and F.J. Weibell, E.A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall India, 2nd edition, 1990.
2) Carr & Brown, Biomedical Equipment Technology, 4th edition, Pearson, 2002.
3) R.S. Khandpur, HandBook of Biomedical instrumentation, 3rd edition, Tata McGraw Hill Publishing Co Ltd., 2014.

(b) REFERENCES

1) John G Webster, Medical Instrumentation - Application and Design, 4th edition, John Wiley and Sons, 2007.
2) L.A. Geddes and L.E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley & Sons, 1975.
3) Andrew G Webb, Principles of Biomedical Instrumentation, Cambridge university press, 2018.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Biomedical Instrumentation:** Overview of Biomedical Instrumentation - Basic concepts of biomedical instrumentation. Man-Instrumentation System: Challenges in measuring living systems. Human Physiological Systems (Brief Overview) - Cardiovascular system: Heart and circulation. Respiratory system: Basic physiology. Nervous and muscular systems. Bioelectric Potentials - Generation and propagation of bioelectric potentials, Resting potential and action potential. Bio-potential electrodes: Surface electrodes, microelectrodes, and needle electrodes. Transducers for Biomedical Applications - Overview of transducers used in biomedical instrumentation. Pressure, temperature, and respiration rate measurement systems.	9
II	**Measurement of Blood Pressure and Cardiac Measurements:** Blood Pressure Measurement - Direct vs. indirect measurement methods. Oscillometric method for blood pressure measurement. Ultrasonic method for non-invasive blood pressure measurement. Cardiac Measurements - Electrocardiography (ECG): Working principles, electrodes, and leads. Einthoven's Triangle: Understanding ECG lead configuration. ECG machine and ECG read-out devices. ECG Block diagram. Measurement of blood flow and cardiac output. Plethysmography: Photoelectric and impedance methods. Phonocardiography: Measurement of heart sounds	9
III	**Measurement of Nervous System and Respiratory Parameters**: Electroencephalography (EEG) - EEG: Basic waveforms and features. 10-20 electrode placement system for EEG measurement. Block diagram of EEG system. Electromyography (EMG) - Measurement of muscle electrical activity. Block diagram of EMG system. Nerve conduction velocity (NCV) measurement techniques. Respiratory Parameters - Spirometry: Measuring lung volumes and capacities. Pneumography: Respiratory rate and volume measurement. Finger-tip oximeter: Principle and working.	9
IV	**Modern Imaging Systems and Therapeutic Equipment:** Modern Imaging Systems - Basic X-ray machines: Working principle and components. Computed Tomography (CT) Scanner: Principles and components. Ultrasonic Imaging: Working principle and types of ultrasound imaging. Magnetic Resonance Imaging (MRI) - Basic	10

	principles. Positron Emission Tomography (PET) - Introduction to imaging principles. Therapeutic Equipment - Cardiac pacemakers, Defibrillators, Haemodialysis machines and Artificial kidney. Lithotripsy, Shortwave and Microwave Diathermy, Ventilators, Heart-Lung Machine, and Infant Incubators	
V	**Clinical Laboratory Instruments, Electrical Safety, and Emerging Technologies:** Clinical Laboratory Instruments - Instruments for blood tests. Chemical testing in clinical laboratories- Basic principles and applications. Electrical Safety in Biomedical Equipment - Physiological effects of electric current on the human body. Shock hazards from electrical equipment in medical environments. Methods for preventing electrical accidents in healthcare settings. Emerging Technologies: Introduction to telemedicine- Applications and technologies. Medical robotics - Introduction to robotic surgery and rehabilitation. Nano-robots - Principles and future applications in healthcare. Orthopaedic prosthesis fixation - Modern techniques in biomedical instrumentation	**8**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL31E	INTRODUCTION TO SECURITY IN COMPUTING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course provides a foundational understanding of security in computing, integrating essential mathematical concepts with core cybersecurity principles. Students will explore integer and modular arithmetic, prime numbers, and cryptographic fundamentals that form the basis of secure systems. The course also covers real-world security threats, vulnerabilities, and countermeasures in web applications, email, and browser security. Additionally, it introduces program security concepts, malware analysis, operating system security mechanisms, and database security principles. By the end of the course, students will have the analytical skills and technical knowledge needed to understand and mitigate security risks in computing environments.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply number theory concepts such as modular arithmetic, prime numbers, and factorization in cryptographic applications.	Apply
CO2	Solve congruences using techniques like the Chinese Remainder Theorem and discrete logarithms for secure computations.	Apply
CO3	Explain the security threats and vulnerabilities in web applications, browsers, and email systems.	Understand
CO4	Explain the basic security mechanisms to protect programs, operating systems, and databases from attacks.	Understand
CO5	Explain the malware and other security risks while applying best practices for system and data protection.	Understand

iii) SYLLABUS

Integer Arithmetic: Integer division, Divisibility, GCD, Euclid's algorithm, Extended Euclid’s algorithm, Linear Diophantine Equations. Modular Arithmetic: Operations, Properties, Algebraic Structures. Prime Numbers & Factorization: Prime-power factorization, Fermat & Mersenne primes, Fermat’s theorem, Euler’s theorem, Euler’s totient function, Primality testing, Fermat’s factorization. Congruences & Chinese Remainder Theorem: Simultaneous linear congruence, Power modulus, Pseudoprimes, Carmichael numbers, Solving congruences, Primitive roots, Discrete logarithms. Computer Security Basics: Threats, Vulnerabilities, Controls, Web attacks, Email attacks, Browser security. Program Security: Non-malicious programming errors, Malware analysis. Operating System Security: Security in OS design, Access control mechanisms. Database Security: Security requirements, Integrity, Database disclosure risks.

v) (a) TEXT BOOKS

1) Behrouz A Forouzan, Cryptography and Network Security, 3/e, Tata McGraw-Hill.

2) Charles P Pfleeger, Shari Lawrence Pfleeger, Jonathan Margulies, Security in Computing, 5/e, Prentice Hall.
3) G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007

(b) REFERENCES

1) William Stallings, Cryptography and Network Security Principles and Practices, 4/e, Pearson Ed.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Integer arithmetic - Integer division, Divisibility, Greatest Common Divisor (GCD), Euclid's algorithm for GCD, Extended Euclid's algorithm, Linear Diophantine Equations. Modular arithmetic - Operations, Properties. Algebraic structures.	**8**
II	Prime numbers - Prime numbers and prime-power factorization, Fermat and Mersenne primes, Fermat's theorem, Applications, Euler's theorem, Euler's totient function, Applications. Primality testing – Deterministic algorithms and Probabilistic algorithms. Factorization - Fermat's factorization.	**10**
III	Linear congruence - Simultaneous linear congruence, Chinese Remainder Theorem (CRT). Congruence with a prime - Power modulus, Arithmetic modulo p, Pseudoprimes and Carmichael numbers, Solving congruence, modulo prime powers. Primitive roots - Existence of primitive roots for primes, Discrete logarithms.	**10**
IV	Introduction to computer security – Threats, Vulnerabilities, Controls. Browser attack types, Web attacks targeting users, Email attack types. Introduction to program security - non-malicious programming oversights, Malware.	**9**
V	Operating system security – Security in operating system, Security in design of operating system. Database security – Security requirements of databases, Reliability and integrity, Database disclosure.	**8**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL31F	OPERATING SYSTEMS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The goal of this course is to introduce the concepts of memory management, device management, process management, file management, security and protection mechanisms available in an operating system. The course helps the learner to understand the fundamentals about any operating system design so that they can extend the features of the operating system to detect and solve many problems occurring in the operating system and to manage the computer resources appropriately.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the fundamental concepts, structure, and functions of operating systems, including system calls, process management, and virtualization.	Understand
CO2	Explain process scheduling techniques, inter-process communication mechanisms, and their role in multitasking environments.	Understand
CO3	Demonstrate process synchronization techniques, deadlock handling strategies, and their applications in concurrent execution.	Understand
CO4	Illustrate memory management strategies such as paging, segmentation, and virtual memory concepts for efficient resource utilization.	Understand
CO5	Summarize file system structures, storage management techniques, and disk scheduling algorithms for effective data storage and retrieval.	Understand

iii) SYLLABUS

Operating system overview – Operations, Functions, Service – System calls, Types – Operating System structure. Processes - Process states, Process control block, threads, scheduling, Operations on processes. Process Scheduling. Process synchronization- Race conditions. Synchronization problems. Memory Management: Concept of address spaces. Segmentation, Paging. Virtual memory. File System: File concept, File-system implementation, Directory implementation. Allocation methods.

iv) (a) TEXT BOOKS

1) Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, ' Operating System Concepts', 9th Edition, Wiley India 2013.
2) Andrew S Tanenbaum, Herbert Bos “Modern Operating Systems”, 4th Edition, Pearson India, 2016.
3) William Stallings, “Operating systems: Internals and Design Principles”, 7th Edition, Pearson Education India, 2013.

(b) REFERENCES

1) Garry Nutt, Nabendu Chaki, Sarmistha Neogy, "Operating Systems", 3rd Edition Pearson Education, 2016.
2) D.M.Dhamdhere, "Operating Systems", 2nd Edition, Tata McGraw Hill, 2011.
3) Sibsankar Haldar, Alex A Aravind, "Operating Systems", Pearson Education, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Operating Systems: Overview, Functions, Services, System Calls, Types of System Calls, OS Structure – Simple, Layered, Microkernel, Modular, Hybrid Systems, Virtualization, System Boot Process. Basics of Process Management: Process States, Process Control Block, Threads, and Process Operations – Creation and Termination.	**8**
II	Process Scheduling and Inter-Process Communication: IPC Mechanisms – Shared Memory and Message Passing. Process Scheduling: Concepts, Scheduling Criteria, Scheduling Algorithms – First Come First Served, Shortest Job First, Priority Scheduling, Round Robin, Multilevel Queue Scheduling, Real-time Scheduling.	**10**
III	Process Synchronization and Deadlocks: Race Conditions, Critical Section Problem, Peterson's Solution, Synchronization Hardware, Mutex Locks, Semaphores, Monitors. Classical Synchronization Problems – Producer-Consumer, Dining Philosophers, Readers-Writers. Deadlocks: Necessary Conditions, Resource Allocation Graphs, Deadlock Prevention, Deadlock Avoidance – Banker's Algorithm, Deadlock Detection, Recovery from Deadlock. Introduction to Concurrency and Multithreading.	**10**
IV	Memory Management: Address Spaces, Swapping, Contiguous Memory Allocation, Fixed and Variable Partitions, Segmentation, Paging, Virtual Memory, Demand Paging, Page Replacement Algorithms, Thrashing, Memory Allocation Strategies – First Fit, Best Fit, Worst Fit.	**9**
V	File and Storage Management: File Concept – Attributes, Operations, Types, Structure, Access Methods, Protection, File-System Implementation, Directory Implementation, Allocation Methods. Storage Management: Magnetic Disks, Solid-State Disks, Disk Structure, Disk Scheduling, Disk Formatting, RAID, File System Performance, I/O System Overview.	**8**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL31G	INTRODUCTION TO MACHINE LEARNING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course introduces Python programming and essential machine learning concepts with a focus on Electrical and Computer Engineering applications. It covers data handling, visualization, core ML algorithms, and model evaluation techniques. Key topics include supervised and unsupervised learning, model optimization, and ethical aspects of ML, along with practical case studies and a brief on deployment.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the fundamental concepts of machine learning and Python-based data analysis.	Understand
CO2	Apply supervised learning algorithms and evaluate models using appropriate metrics.	Apply
CO3	Apply unsupervised learning techniques and dimensionality reduction methods.	Apply
CO4	Explain the impact of ensemble learning and model tuning on performance.	Understand
CO5	Apply machine learning models to real-world problems and interpret results effectively and ethically.	Apply

iii) SYLLABUS

Machine Learning and Python – EDA and Data Preprocessing, Data Visualization, Basics of Statistics and Types of Machine Learning Algorithms.
Supervised, Unsupervised and Reinforcement learning, Principal Component Analysis. Advanced Techniques in Machine Learning: Ensemble Methods and Model Optimization, Applications of Machine Learning.

iv) (a) TEXT BOOKS

1) McKinney, W. (2012). Python for Data Analysis. O'Reilly Media: Sebastopol.
2) Bishop C. M., "Pattern Recognition and Machine Learning", Springer, 2010.
3) Mueller A. C. & Guido S., "Introduction to Machine Learning with Python", O'REILLY' Publishers, 2016.
4) Géron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media: Sebastopol.
5) Buduma N. & Locascio N., "Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms", O'REILLY' Publishers, 2017.

(b) REFERENCES

1) Shai Shalev-Shwartz and Shai Ben-David, "Understanding Machine Learning", Cambridge University Press, 2017.
2) Simon Haykin, "Neural networks and learning machines", 3rd Edition. Pearson Education India, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Python and Machine Learning Fundamentals:** Basics of Python Programming: Data Types, Control Structures NumPy and Pandas for Data Handling. Data Visualization using Matplotlib, Seaborn, Plotly. Exploratory Data Analysis (EDA) and Preprocessing. Overview of Machine Learning: ML Types (Supervised, Unsupervised, Reinforcement). Applications of ML in Electrical and Computer Engineering	**9**
II	**Supervised Learning Fundamentals – Regression & Classification:** Linear Regression: Assumptions, Model Fitting, Residuals, Logistic Regression: Sigmoid Function, Decision Boundaries. Evaluation Metrics: Confusion Matrix, Accuracy, Precision, Recall, F1-Score. Bias-Variance Trade-off, Overfitting, Underfitting. Case Studies using Supervised Learning.	**9**
III	**Supervised Learning: Advanced Models & Unsupervised Learning:** Naïve Bayes Classifier, K-Nearest Neighbours (KNN), Support Vector Machines (SVM) – Kernel Trick (Conceptual). Decision Trees – Entropy, Gini Index, Pruning. Clustering Techniques: K-Means, Hierarchical Clustering, DBSCAN. Principal Component Analysis (PCA) for Dimensionality Reduction. Distance Metrics and Cluster Evaluation.	**10**
IV	**Ensemble Learning & Model Optimization:** Ensemble Techniques: Bagging, Boosting, Random Forest, Cross-Validation: K-Fold, Stratified K-Fold, Feature Selection, Scaling, Handling Missing Data, Model Performance Optimization – Grid Search, Random Search, ROC Curve, AUC Score.	**8**
V	**Applications of ML** in Signal Processing like noise reduction and speech recognition, Power Systems applications like Fault detection and load forecasting, Anomaly Detection in industrial systems (any relevant areas). Introduction to Model Interpretability: SHAP, LIME (Concepts Only). Ethics in ML – Fairness, Bias, Explainability. Introduction to Deployment: Pickle, Joblib (Conceptual Overview). Case Studies in Electrical & Computer Engineering Domains.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

HONOURS

Course Code	Course Name	Category	L-T-P-J	Credit	Year of Introduction
23ELL3HA	PROCESS AUTOMATION	VAC	3-0-0-0	3	2023

i) COURSE OVERVIEW

The course aims to familiarise students with the concepts of process control. It presents basic control system concepts to enable students to model and analyse physical systems in time domain. Students will be introduced to classical controllers and advanced control strategies used in process control. The different components like actuators, control valves, PLCs and industrial robots used for process automation will also be introduced.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the basic concepts of control systems	Understand
CO2	Apply time domain techniques for response analysis of physical systems	Apply
CO3	Explain the concepts of system stability, types of classical controllers and advanced control strategies in process control.	Understand
CO4	Explain the architecture of Industrial Automation Systems and its components	Understand
CO5	Build simple ladder programs for operation of PLC	Apply
CO6	Summarize the use of industrial robots	Understand

iii) SYLLABUS

Basic concepts of control systems - Process control block diagram – Control system evaluation – Transfer function - Modeling of physical systems – Response analysis of first order and second order systems - Linearisation - Time domain and frequency domain specifications – Transportation lag – Concept of stability – On-off, P, PI and PID Controllers – Ziegler Nichol's tuning method - Advanced control strategies – Process Identification -Automation architecture - Actuators - Control Valves- Discrete state process control - Programmable Logic Controllers - Ladder programming – Industrial robots – Robot subsystems, classification and Applications.

iv) a) TEXTBOOKS

1) Coughanowr, D. R., LeBlanc S., *Process Systems Analysis and Control*, 3rd edition, McGraw-Hill (2008).
2) C. D. Johnson, *Process control Instrumentation Technology*, Pearson Education, Eighth Edition, 2006, PHI, 8th Edition, 2013.
3) William L. Luyben, *Process Modelling, Simulation and Control for Chemical Engineers*, Mc- Graw Hill, 2nd edition.
4) Surekha Bhanot, *Process Control - Principles & Applications*, Oxford University Press, 2008

5) S. K. Saha, *Introduction to Robotics*, McGraw Hill Education Pvt. Ltd., 2nd edition, 2014
6) Norman S. Nice, *Control Systems Engineering*, 6th edition

b) REFERENCES

1) Stephanopoulos G., *Chemical Process Control: An Introduction to Theory and Practice*, Pearson Education (1984), PHI, 2006.
2) B. Wayne Bequette, *Process control: Modeling, Design and simulation*, Prentice Hall of India (P) Ltd., 2003
3) Huges T, *Programmable Controllers*, ISA press, 4th Edition Illustrated, 2005.
4) Considine D.M., *Process Instruments and Controls Handbook*, Second Edition, McGraw, 1999.
5) G. Liptak, *Handbook of Process Control*, 1996
6) K. Krishnaswamy, *Process Control*, New Age International, 2007.
7) Patranabis D., *Principles of Process Control*, Tata McGraw Hill, New Delhi.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Process Control Systems** Process Control principles – self regulated system, Human aided control, Automatic control, Servomechanisms, Discrete state control systems, Open loop and closed loop systems, Process Control block diagram, Control System evaluation – objective, stability, steady state and transient regulations, Evaluation criteria. Concept of transfer function, Poles and zeros, Type and order, Standard test signals.	9
II	**Linear System Analysis** Time domain specifications – Delay time, Rise time, Peak time, Peak Overshoot, Settling time. Linear open loop systems: Response of first order systems: Step response, impulse response. Physical examples of first order systems: Modelling of liquid level control, mixing process and heating process as first order systems, Concept of linearization of system model. Response of first order systems in series – Non-interacting and interacting systems for liquid level control. Response analysis of second order systems – Undamped, underdamped, critically damped and overdamped systems. Frequency response – Frequency domain specifications – Resonant Peak, Resonant Frequency, Bandwidth, Gain margin and Phase margin. Modelling of transportation lag	9
III	**Closed-Loop Control Systems & PID Controllers** Linear Closed loop systems: Closed loop system - Characteristic equation, Concept of stability, Location of poles and stability, Routh's stability test. Study of ON-OFF control, P, PI and PID controllers, Ziegler Nichol's method for PID tuning. Advanced Control strategies: Cascade control, Feedforward control, Ratio Control, Smith Predictor control, Selective control, Model Reference Adaptive Control.	9

IV	**Industrial Automation & Actuators** Process Identification and automation: Direct methods – Time domain eyeball fitting of Step test data, Direct sine wave testing. Architecture of Industrial Automation Systems: Final control operation – Actuators and Control elements. Actuators – Construction, Principle, Advantages and disadvantages of Hydraulic, Pneumatic and Electrical actuators. Control elements – Control Valves construction and principle, Types –quick opening, linear, equal percentage, Classification	**9**
V	**Discrete State Control & Robotics** Programmable Logic Controllers – architecture and operation, Comparison of PLC & PC, Relays and Ladder Logic, Ladder Programming – Basic symbols used, Realization of AND, OR logic, Concept of latching. Introduction to Timer/Counters- Simple ladder programs Industrial Robots: Robot Subsystems – Motion, Recognition and Control subsystems, Classification of Robots – Based on work envelope, actuation and motion control methods, Industrial Applications – Material handling, welding, spray painting, machining, assembling.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL3HC	MATHEMATICS FOR MACHINE LEARNING	VAC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The goal of this course is to introduce students to make use of the concepts, rules and results about linear equations, matrix algebra, vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems. This course will enable students to perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients. It also aims to expose students to train Machine Learning Models using unconstrained and constrained optimization methods.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply the concepts of systems of linear equations, matrix operations, linear mappings, and vector spaces to solve computational and data-oriented problems.	Apply
CO2	Apply matrix decompositions to analyse and approximate high-dimensional data in machine learning applications.	Apply
CO3	Apply vector calculus operations including gradients and higher-order derivatives in multivariable functions.	Apply
CO4	Explain the principles of probability theory to model uncertainty and estimate outcomes in data-driven systems.	Understand
CO5	Apply gradient-based and constrained optimization techniques to train and tune machine learning models.	Apply

iii) SYLLABUS

Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank. Matrix Representation of Linear Mappings, Image and Kernel. Norms, Inner Products, Orthonormal Basis, Orthogonal Complement, Projection into One Dimensional Subspaces, Eigenvalues and Eigenvectors, Matrix Approximation.
Differentiation of Univariate Functions - Gradients of Vector Valued Functions, Gradients of Matrices, Back propagation and Automatic Differentiation.
Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem.
Summary Statistics and Independence – Gaussian distribution - Conjugacy and the Exponential Family. Gradients in Deep Network, Automatic Differentiation.
Higher Order Derivatives - Linearization and Multivariate Taylor Series. Constrained Optimization and Lagrange Multipliers. Linear Programming - Quadratic Programming.

iv) (a) TEXT BOOKS

1) Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
2) K.B. Datta, *Matrix and Linear Algebra*, PHI Learning, 2009.
3) T. Veerarajan, *Probability, Statistics and Random Processes*, McGraw-Hill Education, 4th Edition, 2016.

(b) REFERENCES

1) Stephen Boyd and Lieven Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004.
2) Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006. U. Dinesh Kumar and Manaranjan Pradhan,
3) *Machine Learning Using Python*, Wiley India, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Linear algebra**: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces –Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.	**9**
II	**Analytic geometry, matrix decompositions:** Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization. Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.	**9**
III	**Vector calculus:** Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives-Linearization and Multivariate Taylor Series.	**9**
IV	**Probability and Distributions:** Construction of a Probability Space - Discrete and Continuous Probabilities, Random variables and probability distributions, Sum Rule, Product Rule, and Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family – Change of Variables/Inverse Transform.	**9**
V	**Optimizatio**n: Optimization Using Gradient Descent - Gradient Descent with Momentum, Stochastic Gradient Descent. Constrained Optimization and Lagrange Multipliers – Convex Optimization - Newton's and Quasi-Newton method. Linear Programming - Quadratic Programming. Applications in parameter estimation and model fitting	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL3HE	MICROGRIDS	VAC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The goal of this course is to introduce the fundamental concepts of dynamics and control of microgrid. This course covers different control strategies for microgrid and their analysis.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Illustrate the basic concept of a microgrid and its components	Understand
CO2	Compare different storage systems for microgrid applications	Understand
CO3	Outline the operating modes, interconnection standards and issues in microgrids	Understand
CO4	Explain the various control strategies for microgrids	Understand
CO5	Model various components of microgrids	Apply

iii) SYLLABUS

Microgrid Concept –Components — Technical and Economic advantage of microgrids- Challenges and disadvantages of microgrid development.
Microgrids and Energy storage systems (ESS)- Application of energy storage systems in microgrids. PE interface design for energy storage systems.
Operation of microgrid in grid connected and islanded mode, Interconnection standards IEEE 1547 series, Integration issues of distributed generation – Power management in microgrids– Fault ride through capability of microgrid.
Control architectures in microgrid, Basic control strategies, Coordinated control schemes in multi-microgrids, frequency, voltage regulations and volt-VAR support.
Dynamic modelling of individual components in AC and DC microgrids, brief concept on the design of microgrid stabilizers to improve stability, Stability of hybrid AC/DC microgrid.

iv) (a) TEXT BOOKS

1) H. Bevrani, B. François, T. Ise, “Microgrid Dynamics and Control”, John Wiley & Sons, 1st Edition, 2017.
2) N. D. Hatziargyriou, “Microgrids Architecture and control”, IEEE Press Series, John Wiley & Sons Inc, 1st Edition, 2013.

(b) REFERENCES

1) S. Chowdhury, S P Chowdhury and P Crossely, “Microgrids and active distribution networks”, IET Renewable energy series 6.
2) Suleiman M. Sharkh, Mohammad A. Abusara, “Power electronic converters for microgrid”, IEEE Wiley
3) Amirnaser Yezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, IEEE John Wiley Publications, 2009.
4) Magdi S. Mahmoud, Microgrid: Advanced Control Methods and Renewable Energy System Integration, Elsevier, 2017.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Microgrids**- Microgrid Concept –Components – Micro sources, loads, power electronic interfaces - Architecture of microgrids (AC/DC/Hybrid AC/DC) – Technical and Economic advantage of microgrids- Challenges and disadvantages of microgrid development.	8
II	**Microgrids and Energy storage systems (ESS)**- Different types of Batteries- Advanced lead acid battery, Flow battery, battery performance, storage density, Fuel cell, Flywheel, Supercapacitor, Pumped hydro storage, Superconducting magnetic energy storage, Compressed air energy storage system, Thermal energy storage — Application of energy storage systems in microgrids. PE interface design for energy storage system.	9
III	**Operation of microgrid in grid connected and islanded mode** – AC microgrid, DC microgrid, Hybrid AC/DC microgrid – Interconnection standards IEEE 1547 series, Integration issues of distributed generation. **Power management in microgrids**– Fault ride through capability of microgrid.	8
IV	**Control architectures in microgrid** – Master slave with power-based control, Hierarchical control with centralized and distributed control - Basic control strategies – PQ control, V/f control, Droop control – Advanced control techniques- Coordinated control schemes in multi-microgrids, frequency, voltage regulations and volt-VAR support.	9
V	**Dynamic modelling of individual components in AC and DC microgrids** – Voltage source converter model, DC/DC converter model, line model, load model - state space model analysis and influence of system parameters on the microgrid dynamics - brief concept on the design of microgrid stabilizers to improve stability, Stability of hybrid AC/DC microgrid.	11
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

SEMESTER VI

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL30D	POWER ELECTRONICS	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW: This course provides an in-depth understanding of power electronic converters and their role in modern electrical and electronic systems. Course combines theoretical foundations with practical insights, applications, simulations and case studies to enhance industry readiness.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the operation and characteristics of power semiconductor devices used in power electronics circuits.	Understand
CO2	Illustrate the working of various controlled rectifiers in power electronic systems.	Understand
CO3	Apply the principles of DC-DC converters in designing power electronic systems.	Apply
CO4	Explain the operation and control of inverters and AC voltage controllers.	Understand
CO5	Apply power electronic circuits for real-world applications and to simulate various power converter circuits.	Apply

iii) SYLLABUS

Power electronics scope and applications, power vs signal electronics, characteristics and comparison of power diodes, MOSFETs, IGBTs, and wide bandgap devices like SiC and GaN, SCR characteristics, two-transistor model, protection techniques, gate drive and isolation circuits, single-phase and three-phase controlled rectifiers with R, RL, and RLE loads, , voltage source and current source inverters with PWM techniques, modulation indices and harmonic analysis, DC-DC converters including buck, boost, buck-boost, single/two/four-quadrant choppers, switching regulators and component selection, AC voltage controllers, MATLAB Simscape simulations of converters, applications of power electronics in electric drives, renewable energy systems, electric vehicles.

iv) (a) TEXT BOOKS

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd Edition, 2018.
2) Dubey G K, *Fundamentals of Electrical Drives*, Narosa Publishing House, New Delhi, 2nd Edition, 2012.
3) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 3rd Edition, 2001.

(b) REFERENCES

1) Rashid M H, *Power Electronics – Circuits, Devices and Applications*, Prentice Hall of India, New Delhi, 4th edition, 2014.
2) Robert Bausiere, Francis Labrique, Guy Seguier, *Power Electronic Converters: DC-DC Conversion*, Springer, 2013.

3) P.S.Bimbhra, *Power Electronics*, Khanna Publishers, New Delhi, 6th edition, 2010.
4) Joseph Vithayathil, *Power Electronics*, Tata McGraw-Hill, New Delhi, 2010.
5) M.D.Singh and K.B.Khanchandani, *Power Electronics*, Tata McGraw Hills Publishing Company Limited, 2006.
6) MATLAB Documentation – *Simscape Electrical Toolbox* and online resources.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Power Electronic Devices:** Introduction to Power Electronics-Importance, Applications. Characteristics and operation of power semiconductor devices: Diodes, SCR, TRIAC, GTO. Power Transistors, BJT, Power MOSFET, IGBT, Wide band gap devices- SiC and GaN. SCR– Switching characteristics. Triggering methods for SCR, Two transistor analogy, di/dt and dv/dt protection-snubber circuit, Opto-coupler and pulse transformer-based isolation, Gate Drive Circuit.	**12**
II	**Phase Controlled Rectifiers:** Single-phase half-wave, full-wave controlled rectifiers, half controlled rectifiers with R, RL, RLE loads (continuous & discontinuous conduction) – Output voltage equations – Three-phase half-wave and bridge converters – Fully controlled and half-controlled configurations with RLE load in continuous conduction mode– Waveforms for various firing angles. MATLAB Simscape simulation of single and three-phase rectifiers.	**13**
III	**Inverters and PWM Techniques:** Voltage Source Inverters – Single-phase half-bridge & full-bridge with R and RL loads – THD analysis – Three-phase bridge inverter – 120° and 180° conduction – Current Source Inverter (1-φ) with capacitor commutation **PWM strategies:** Single-pulse, multiple-pulse, and sinusoidal PWM – Modulation index and frequency modulation ratio. Introduction to SVPWM. MATLAB Simscape modeling of VSI, THD analysis using FFT tool.	**12**
IV	**DC-DC Converters and Switching Regulators:** Step-down, step-up choppers – Single, two, and four-quadrant operations – PWM and current-limit control – Buck, Boost, Buck-Boost converters in continuous conduction – Design of power circuits- switch selection, inductor, and capacitor sizing. MATLAB Simscape implementation of DC-DC converters.	**12**
V	**AC Voltage Controllers:** Single phase AC Voltage Controller with R, RL load – RMS output voltage, input power factor. **Applications of Power Electronics:** Power Electronics in Renewable Energy Systems, Electric Drives and Motor Control using Power Converters, DC-DC converter in EV powertrains and power system applications. Smart Grids. HVDC, and traction systems Application of inverters in UPS, Induction Heating, Embedded system and IoT, wireless power transfer.	**11**
	Total hours	**60**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL30E	ALGORITHM ANALYSIS AND DESIGN	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW:

The course is designed to introduce students to the principles of computer algorithm design and analysis. These concepts form the core foundation of computer science and are crucial for the effective work of any programmer. The main objective of the course is to equip students with a solid understanding of designing and analyzing fundamental classes of algorithms. By the end of the course, students will be able to develop their own variations of algorithms for specific computational problems and effectively evaluate and compare their efficiency and performance.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply algorithm analysis techniques to evaluate and express the time and space complexities using asymptotic notations.	Apply
CO2	Solve recurrence relations and compute the time complexity of recursive algorithms.	Apply
CO3	Illustrate graph traversal algorithms and the structure of AVL trees and disjoint sets with relevant applications.	Understand
CO4	Make use of Divide-and-Conquer, Greedy Strategy, Dynamic Programming, Branch-and-Bound, and Backtracking algorithm design techniques to solve problems.	Apply
CO5	Apply strategies to identify computationally tractable and intractable problems, and implement solutions to address intractability.	Apply

iii) SYLLABUS

Introduction to Algorithm Analysis, Time and Space Complexity, Analysis of Recursive Algorithms, Advanced Data Structures and Graph Algorithms, Self-Balancing Tree - AVL Trees, DFS and BFS traversals, Topological Sorting, Divide & Conquer and Greedy Strategy, Dynamic Programming, Back Tracking and Branch & Bound, Control Abstraction, Branch and Bound Algorithm for Travelling Salesman Problem, Introduction to Complexity Theory, Tractable and Intractable Problems, Complexity Classes, Approximation algorithms

iv) (a) TEXT BOOKS

1) T.H.Cormen, C.E.Leiserson, R.L.Rivest, C. Stein, Introduction to Algorithms, 2nd Edition, Prentice-Hall India (2001).
2) Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, “Fundamentals of Computer Algorithms”, 2nd Edition, Orient Longman Universities Press (2008).
3) Sara Baase and Allen Van Gelder —Computer Algorithms, Introduction to Design and Analysis, 3rd Edition, Pearson Education (2009).
4) Jon Kleinberg, Eva Tardos, “Algorithm Design”, First Edition, Pearson (2005).

(b) REFERENCES

1) Richard Neapolitan and Kumarss Naimipour, "Foundations of Algorithms", 5th Edition, Jones & Bartlett Learning (2015).
2) Robert Sedgewick, Kevin Wayne, "Algorithms",4th Edition Pearson (2011).
3) Gilles Brassard, Paul Brately, "Fundamentals of Algorithmics", Pearson (1996).
4) Steven S. Skiena, "The Algorithm Design Manual", 2nd Edition, Springer (2008).

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Algorithm Analysis- Characteristics of Algorithms, Time and Space Complexity - Best, Worst and Average Case Complexities, Asymptotic Notations - Big-Oh (O), Big- Omega (Ω), Big-Theta (Θ), Little-oh (o) and Little- Omega (ω) and their properties. Classifying functions by their asymptotic growth rate, Time and Space Complexity Calculation of simple algorithms. Analysis of Recursive Algorithms: Recurrence Equations, Solving Recurrence Equations – Iteration Method, Recursion Tree Method, and Master's Theorem (Proof not required).	**13**
II	Self-Balancing Tree - AVL Trees (Insertion and deletion operations with all rotations in detail, algorithms not expected); Disjoint Sets- Disjoint set operations, Simple Union and find algorithms- weighted union, collapsing find algorithms. DFS and BFS traversals - Analysis, Strongly Connected Components of a Directed graph, Topological Sorting.	**11**
III	Control Abstraction of Divide and Conquer- 2-way Merge sort, Strassen's Algorithm for Matrix Multiplication-Analysis. The Control Abstraction of Greedy Strategy- Fractional Knapsack Problem. Minimum Cost Spanning Tree Computation- Kruskal's Algorithms – Analysis. Single Source Shortest Path Algorithm - Dijkstra's Algorithm-Analysis.	**12**
IV	Dynamic programming -The Control Abstraction- The Optimality Principle- Matrix Chain Multiplication-Analysis. All Pairs Shortest Path Algorithm - Floyd-Warshall Algorithm-Analysis. The Control Abstraction of Back Tracking – The N Queen's Problem. Branch and Bound Algorithm for Travelling Salesman Problem.	**12**
V	Tractable and Intractable Problems, Complexity Classes – P, NP, NP-Hard and NP-Complete Classes- NP Completeness proof of Clique Problem and Vertex Cover Problem- Approximation algorithms- Bin Packing, Graph Coloring. Randomized Algorithms (Definitions of Monte Carlo and Las Vegas algorithms), Randomized version of Quick Sort algorithm with analysis.	**12**
	Total hours	**60**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL30F	COMPUTER COMMUNICATION AND NETWORK SECURITY	PCC	3	0	0	0	3	2023

i) COURSE OVERVIEW

This course provides a comprehensive understanding of computer networks and security, covering foundational principles, protocols, and real-world applications. It begins with networking fundamentals, exploring the network edge, core, and packet-switched architectures, followed by a deep dive into transport and network layer mechanisms such as TCP, UDP, IPv4, IPv6, and routing protocols like OSPF and BGP.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain networking fundamentals by explaining network architectures, protocol layers, and key performance metrics.	Understand
CO2	Explain the transport and network layer concepts to configure, manage, and troubleshoot TCP/IP, IPv4/IPv6, routing algorithms, and SDN-based networks.	Understand
CO3	Demonstrate proficiency in link-layer technologies by analysing MAC protocols, VLANs, firewalls, and network troubleshooting tools.	Understand
CO4	Apply cryptographic techniques and security threats to design secure communication systems using encryption methods.	Apply
CO5	Utilize secure networking solutions using protocols like SSL/TLS, IPSec, VPNs, and wireless security standards to protect network infrastructure.	Apply

iii) SYLLABUS

Networking Fundamentals: Network edge, core, packet switching, delay, loss, throughput. Protocol Architectures: TCP/IP, OSI model, protocol layers and services. Application Layer Protocols: HTTP, HTTPS, DNS, SMTP, IMAP, POP3, Content Delivery Networks (CDNs), Video streaming. Transport Layer: TCP, UDP, multiplexing, congestion control, reliable data transfer. Network Layer: IPv4, IPv6, subnetting, NAT, OSPF, BGP, SDN, ICMP, SNMP, NetFlow. Link Layer: Error detection & correction, MAC protocols (CSMA/CD, CSMA/CA), Ethernet, VLANs, MPLS, VPNs, DHCP, ARP, NAT, Firewalls. Network Troubleshooting & Monitoring: Wireshark, Traceroute, Ping, Netstat, Nmap. Network Security: Threats & attacks (MITM, DDoS, SQL Injection), Cryptographic techniques (Symmetric & Asymmetric encryption), Digital signatures, MACs, PKI. Encryption Methods: Caesar Cipher, Playfair Cipher, Hill Cipher, One-Time Pad. Secure Protocols: SSL/TLS, IPSec (AH, ESP), VPNs, IKE, Wireless Security (WPA2, WPA3, EAP). Network Protection Strategies: Firewalls, IDS, IPS, Securing emails and network services.

iv) (a) TEXT BOOKS

1) Andrew S. Tanenbaum, Computer Networks, 4/e, PHI (Prentice Hall India).
2) Behrouz A Forouzan, Data Communication and Networking, 4/e, Tata McGraw Hill.
3) William Stallings, Cryptography and Network Security Principles and Practice, Pearson Edu, 6e.

(b) REFERENCES

1) Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e, Morgan Kaufmann.
2) Fred Halsall, Computer Networking and the Internet, 5/e.
3) James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4) Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5) Behrouz A. Forouzan, Cryptography and Network Security, McGraw Hill, 2e.
6) Johannes A. Buchmann, Introduction to Cryptography, Springer, 2e.
7) Douglas R. Stinson, Cryptography Theory and Practice, 3e, Chapman & Hall/CRC, 2006.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Foundations of Networking:** Network edge, core, and packet switching. Delay, loss, and throughput in networks. Protocol layers & service models (TCP/IP, OSI). Application Layer: Principles of network applications (client-server model). Web technologies: HTTP, HTTPS, DNS, and Content Delivery Networks (CDNs). E-mail protocols: SMTP, IMAP, POP3. Video streaming & peer-to-peer networks. Socket programming introduction (Python/Java examples).	8
II	**Transport & Network Layer** Transport Layer: Multiplexing & demultiplexing. Connectionless Transport (UDP) vs. Connection-oriented (TCP). Reliable data transfer & congestion control (TCP congestion control). Network Layer. IPv4 & IPv6 addressing, Subnetting, NAT. Routing Algorithms: Link-state, distance vector. Internet Routing: OSPF (intra-AS), BGP (inter-AS).	9
III	**Link Layer & Network Management** Error Control & Medium Access Control. Error detection & correction (CRC, Parity, Hamming codes). MAC protocols (CSMA/CD, CSMA/CA). Ethernet, VLANs, and switching concepts. Network Virtualization & Data Center Networking. Virtual LANs (VLANs), MPLS, and VPNs. DHCP, ARP, NAT, and role of firewalls. Web Client-Server Interaction: TCP, HTTP, and DNS resolution.	10

IV	**Network Security & Cryptography** Introduction to Network Security: Threats & attacks: MITM, DDoS, SQL Injection. Principles of Cryptography: Symmetric & Asymmetric encryption. Cryptanalysis Techniques & Secure Communication. Caesar Cipher, Playfair Cipher, Hill Cipher, One-Time Pad. Digital signatures, Message Authentication Codes (MACs). Public Key Infrastructure (PKI) & Certificates.	**9**
V	**Secure Protocols & Wireless Security** Securing Network Services: Transport Layer Security (TLS/SSL). IPSec (AH, ESP) & VPN Technologies. IKE (Internet Key Exchange). Wireless Network Security & Authentication. Wi-Fi Security: WPA2, WPA3, EAP. Securing E-mail Communication. Firewalls, IDS, IPS.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELP30C	NETWORKING LAB	PCC	0	0	2	0	1	2023

i) COURSE OVERVIEW:

This course provides learners with hands-on experience in network programming using Linux system calls and network monitoring tools. It includes the implementation of network protocols and algorithms, configuration of network services, and an introduction to network simulators. Through this, learners gain the skills to develop and implement protocols and assess their performance in real-world networks.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Make use of network related commands and configuration files in Linux Operating System.	Apply
CO2	Develop network application programs and protocols.	Apply
CO3	Make use of network monitoring tools to analyse network traffic.	Apply
CO4	Design and configure a network with multiple subnets with wired and wireless LANs using a network simulator.	Apply
CO5	Develop simulation of fundamental network concepts using a network simulator.	Apply

iii) SYLLABUS

- Getting started with the basics of network configuration files and networking commands in Linux.
- To familiarize and understand the use and functioning of system calls used for network programming in Linux.
- Implement client-server communication using socket programming and TCP as transport layer protocol.
- Implement client-server communication using socket programming and UDP as transport layer protocol.
- Simulate flow control protocols. (Stop and Wait, Go back N, Selective Repeat ARQ protocols)
- Implement and simulate algorithms for Distance Vector Routing protocol or Link State Routing protocol.
- Implement Simple Mail Transfer Protocol.
- Implement File Transfer Protocol.
- Implement congestion control using a leaky bucket algorithm.
- Understanding the Wireshark tool.
- Design and configure a network with multiple subnets with wired and wireless LANs using required network devices. Configure commonly used services in the network.
- Study of NS2 simulator.

iv) REFERENCES

1) W. Richard Stevens, Bill Fenner, Andy Rudoff, UNIX Network Programming: Volume 1, The Sockets Networking API, 3rd Edition, Pearson, 2015.
2) Andrew S. Tanenbaum and David J. Wetherall, Computer Networks, 5th Edition, Pearson Education (Prentice Hall), 2010
3) Lisa Bock, Learn Wireshark: Confidently navigate the Wireshark interface and solve real-world networking problems, Packt Publishing, 2019.
4) Teerawat Issariyakul, Ekram Hossain, Introduction to Network Simulator NS2,2nd Edition, Springer, 2019.

v) COURSE PLAN

Module	Contents	No. of hours
I	Getting started with the basics of network configuration files and networking commands in Linux.	**2**
II	To familiarize and understand the use and functioning of system calls used for network programming in Linux.	**2**
III	Implement client-server communication using socket programming and TCP as transport layer protocol.	**2**
IV	Implement client-server communication using socket programming and UDP as transport layer protocol.	**2**
V	Simulate Stop and Wait protocol	**2**
VI	Simulate sliding window flow control protocols. (Go back N or Selective Repeat ARQ protocols)	**2**
VII	Implement and simulate algorithms for Distance Vector Routing protocol or Link State Routing protocol.	**2**
VIII	Implement Simple Mail Transfer Protocol.	**4**
IX	Implement File Transfer Protocol.	**2**
X	Implement congestion control using a leaky bucket algorithm.	**2**
XI	Understanding the Wireshark tool. Installation, Analysing Data packets, Threeway handshaking, Filters, Flow graphs, Statistics and protocol hierarchies.	**2**
XII	Design and configure a network with multiple subnets with wired LANs using required network devices. Configure commonly used services in the network.	**2**
XIII	Design and configure a network with multiple subnets with wireless LANs using required network devices. Configure commonly used services in the network.	**2**
XIV	Study of NS2 simulator	**2**
	Total hours	**30**

vi) ASSESSMENT PATTERN

Continuous Assessment		
Attendance	:	5 marks
Assessment of Lab Work	:	55 marks
Continuous Assessment in Lab (Lab work + Record + Viva - voce) -35 marks and Internal Lab test -20 marks		
Final Lab Assessment	:	40 marks
TOTAL	**:**	**100 marks**

vii) FINAL LAB ASSESSMENT

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

(a)	Preliminary work	:	15 marks
(b)	Implementing the work/Conducting the experiment	:	10 marks
(c)	Result and inference	:	10 marks
(d)	Viva voce	:	5 marks
	Total	**:**	**40 marks**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELS38A	SEMINAR	PWS	0	0	4	0	2	2023

i) COURSE OVERVIEW

The course will equip graduates with skills in reading, understanding, presenting, and preparing reports on academic documents. The course involves exploring academic literature to select a relevant document in the student's area of interest and, under a seminar guide's supervision, develop skills in presenting and preparing technical reports. The course aims to enhance the ability of students to engage critically with scholarly work and communicate technical information effectively.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Outline topic based on recent advancements and emerging trends	Understand
CO2	Identify academic documents from the literature which are related to her/his areas of interest.	Apply
CO3	Plan, study, and deliver a presentation on a selected topic.	Apply
CO4	Develop a technical report on the topic identified.	Apply

iii) GENERAL GUIDELINES

- An Internal Evaluation Committee (IEC) shall be constituted by the department, comprising the program's HOD/Senior Faculty as Chairperson, along with the seminar coordinator and the student's seminar guide as members. All IEC members must be present during each student's seminar presentation.
- Formation of IEC and guide allotment shall be completed within a week after the End Semester Examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- A topic/paper relevant to the discipline shall be selected by the student during the semester break.
- The seminar topic should be current and broad-based, rather than narrowly focused on specific research. Ideally, it should be closely related to the student's final year project area. Team members may select or be assigned seminar topics that cover different aspects of their common project theme.
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

iv) EVALUATION PATTERN

Total Marks	CIE Marks
100	100

CONTINOUS ASSESSMENT EVALUATION PATTERN

Seminar Guide (20 Marks):

Background Knowledge – 10 marks (based on the student's understanding of the selected topic).
Relevance of Topic – 10 marks (based on the suitability and significance of the selected paper/topic).

Seminar Coordinator (15 Marks):

Seminar Diary – 10 marks (weekly progress tracked and approved by the guide).

Attendance – 5 marks.

Presentation by IEC (45 Marks):

Clarity of Presentation – 10 marks.
Interaction – 10 marks (ability to answer questions).
Overall Participation – 10 marks (engagement during others' presentations).
Quality of the content – 15 marks.

Marks awarded by IEC for report (20 Marks)

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELJ38B	MINI PROJECT	PWS	0	0	4	0	2	2023

i) COURSE OVERVIEW:

The objective of this course is to enable students to apply the fundamental principles of Electrical Engineering in the effective development of an application or research-oriented project. It guides learners through the essential phases of the problem identification, literature review, determination of methodology and its implementation for design and development of appropriate solution.

ii) COURSE OUTCOMES:

After the completion of the course the student will be able to

CO1	Identify problems that are socially relevant, technically feasible and economically viable.	Apply
CO2	Make use of relevant literature to explore existing solutions and established processes.	Apply
CO3	Identify appropriate design approaches, using modern tools with a strong commitment to professional ethics.	Apply
CO4	Deduce innovative interpretation of the study outcomes, using engineering and management principles to generate novel insights or improvements.	Evaluate
CO5	Apply appropriate communication techniques to prepare presentations and reports that convey project outcomes effectively	Apply
CO6	Develop the ability to manage tasks independently and engage collaboratively in team environments to achieve shared goals	Apply

iii) GUIDELINES:

Student groups consisting of three to four members are required to select a topic of interest in consultation with their Project Supervisor. They should conduct a thorough literature review and identify a problem to address the gaps identified, related to the chosen topic. Clear objectives must be defined, and a suitable methodology should be developed to achieve them. The project should incorporate innovative design concepts, while considering important factors such as performance, scalability, reliability, aesthetics, ergonomics, user experience, and security.

The progress of the mini project is evaluated based on three reviews. The first review is to check the feasibility in implementation of the project. The second review is to evaluate the progress of the work. The third review will evaluate the completed work. The review committee will be constituted by the Head of the Department comprising of HoD or a senior faculty member, Mini Project coordinator and project supervisor. The evaluation shall be made based on the progress/outcome of the project, reports and a viva-voce examination, conducted internally by the review committee. A project report is required at the end of the semester. The project has to be demonstrated for its full design specifications.

iv) MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks
100	60	40

v) CONTINOUS ASSESSMENT EVALUATION PATTERN

First Review and Second Review **60 marks**

Attendance	5 marks
Marks awarded by Project Supervisor	10 marks
Marks awarded by Review Committee	45 marks

Final Review **40 marks**

Project Report	10 marks
Marks awarded by Review Committee	30 marks

<table>
<tr><th colspan="20">Marks awarded by review committee - First and Second Review</th></tr>
<tr><td colspan="4">Problem identification considering social relevance, feasibility and economics.
CO 1</td><td colspan="4">Review of relevant literature, identification of gaps in existing literature, framing objectives.
CO 2</td><td colspan="4">Framing of methodology, usage of modern tools and display of professional ethics.
CO 3</td><td colspan="4">Quality of results, conclusions, solutions including innovation and novelty
CO 4</td><td colspan="4">Preparation of technical presentation.
CO 5</td><td colspan="4">Individual contribution to the project
CO 6</td><td>Total Marks</td></tr>
<tr><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(5)</td><td colspan="4">(10)</td><td>(45)</td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td></td></tr>
<tr><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td></td></tr>
<tr><th colspan="20">Marks awarded by Project Supervisor - First and Second Review</th></tr>
<tr><td colspan="16" rowspan="3"></td><td colspan="4">Display of sound knowledge at individual level in various phases of the project
CO 6</td><td>Total Marks</td></tr>
<tr><td colspan="4">(10)</td><td>(10)</td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td></td></tr>
<tr><td colspan="16"></td><td>P</td><td>F</td><td>VG</td><td>O</td><td></td></tr>
<tr><th colspan="20">Marks awarded by Review Committee - Final Review</th></tr>
<tr><td colspan="4">Quality of Technical Report
CO5</td><td colspan="4">Framing of methodology, usage of modern tools and display of professional ethics.
CO 3</td><td colspan="4">Preparation of technical presentation.
CO 5</td><td colspan="4">Quality of results, conclusions, solutions displaying innovation and creativity
CO 4</td><td colspan="4">Individual contribution displaying ability to work in team
CO 6</td><td colspan="4">Total Marks</td><td></td></tr>
<tr><td colspan="4">(10)</td><td colspan="4">(10)</td><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(5)</td><td colspan="4">(40)</td><td></td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td colspan="4"></td><td></td></tr>
<tr><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td colspan="4"></td><td></td></tr>
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P-Poor F-Fair VG-Very Good O-Outstanding

PROGRAMME ELECTIVE II

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL32A	ENERGY STORAGE SYSTEMS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course is to expose the students to the fundamental concepts of energy storage systems used in different applications.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Interpret the role of energy storage in power systems.	Understand
CO2	Classify thermal, kinetic and potential storage technologies and their applications.	Understand
CO3	Compare Electrochemical, Electrostatic and Electromagnetic storage technologies.	Understand
CO4	Apply energy storage technology in renewable energy integration.	Apply
CO5	Illustrate energy storage technology applications for smart grids.	Understand

iii) SYLLABUS

Introduction to energy storage in power systems- General considerations
Overview on Energy storage technologies - Thermal energy, Potential energy: Pumped hydro-Compressed Air, Kinetic energy: Mechanical- Flywheel, Power to Gas
Overview on Energy storage technologies- Batteries- Parameters, Fuel cells, Electrostatic energy Electromagnetic energy, Comparative analysis, Environmental impacts.
Energy storage and renewable power sources- Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated and integrated power systems with renewable power sources.
Energy storage Applications - Smart grid, Smart house, Mobile storage system- Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Hybrid energy storage systems.

iv) (a) TEXT BOOKS

1) Osaka T., Datta M., “Energy Storage Systems in Electronics-New Trends in Electrochemical Technology”, CRC Press 2000.
2) Rand D.A.J., Moseley P.T., Garche J. and Parker C.D., “Valve regulated Lead–Acid Batteries”, Elsevier 2004.

(b) REFERENCES

1) Broussely M. and Pistoia G., “Industrial Applications of Batteries from Cars to Aerospace and Energy Storage”, Elsevier, 2007
2) Nazri G. A. and Pistoia G., “Lithium Batteries – Science and Technology”, Kluwer Academic Publishers, 2004.
3) Larminie J., Dicks A. and Wiley-Blackwell, “Fuel Cell Systems Explained”, 2nd Edition, Wiley Publications, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to energy storage in power systems:** Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage, comparison of storages and applications, Energy storage in the power and transportation sectors. Energy storage systems in electric vehicles, Electric vehicle market scenario. Need and role of energy storage systems in power systems, General considerations, Energy and power balance in a storage unit.	**9**
II	**Overview on Energy storage technologies:** Thermal energy: General considerations - Storage media- Containment- Thermal energy storage in a power plant, Potential energy: Pumped Hydro-Compressed Air, Kinetic energy: Mechanical - Flywheel, Power to Gas - Hydrogen - Synthetic methane	**9**
III	**Electrochemical and Electromagnetic Energy storage technologies:** Electrochemical energy -Batteries- Battery parameters: C-rating -SoC-DoD- Specific Energy-Specific power (numerical examples), Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.	**9**
IV	**Energy storage and renewable power sources:** Types of renewable energy sources: Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated power systems with renewable power sources, Storage role in an integrated power system with grid-connected renewable power sources.	**8**
V	**Energy storage Applications:** Smart grid, Smart microgrid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems - Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Hybrid energy storage systems: configurations and applications.	**10**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL32B	MODERN ILLUMINATION CONTROL	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: Goal of this course is to provide an in-depth exploration of modern lighting techniques, technologies, and control systems used in architectural, commercial, and residential settings. Students will learn principles of lighting design, energy-efficient lighting solutions, and advanced control methodologies to create dynamic and sustainable illuminated environments.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the types, components and working of artificial lighting system.	Understand
CO2	Develop lighting schemes for indoor applications.	Apply
CO3	Develop lighting schemes for outdoor applications.	Apply
CO4	Explain the various control strategies and circuits for lighting applications.	Understand
CO5	Explain the various Energy-Efficient Lighting Sources.	Understand

iii) SYLLABUS

Lamp materials - glass, filament, phosphor coating, ceramics, electrodes, gases, capping cement - Types of luminaire, Design consideration, Indian standard recommendation.

Interior Lighting design: Average lumen method - Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires Special features of entrance, staircase, Corridor lighting.

Exterior lighting design- Point to point method – Design of Street Lighting/road lighting – Spacing to mounting height ratio. Selection of lamp and projector, recommended method for aiming of lamp.

Illumination Control circuits: Purpose of lighting control - Lighting control by transformer and ballasts - Electromagnetic & Electronic ballast - Operation & comparison in light control. Ignitors and starters

Lighting Control Technologies & Protocols: Selection of Lighting Control systems - Types of control systems.

Smart Lighting Systems & IoT Integration: IoT in lighting: architecture, data flow, and cloud connectivity.

iv) (a) TEXT BOOKS

1) Robert Simpson, Lighting Control: Technology and Applications, Taylor and Francis, 2003
2) Craig DiLouie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, CRC Press, 2005

3) M K Giridharan, Electrical System Design, I K International Publishing House Pvt. Ltd, 2015

(b) REFERENCES

1) D.C. Pritchard, Lighting, 6th edition, Routledge, 2014
2) Jack L. Lindsey, Applied Illumination Engineering, The Fairmont Press Inc.
3) M.A. Cayless, Lamps and Lighting, Routledge, 1996.
4) J.B.Murdoch, Illumination Engineering from Edison's lamp to the laser Macmillan Publishing company
5) Mohamed Boubekri, Daylighting, Architecture and Health: Building Design Strategies Architectural Press, UK

v) COURSE PLAN

Module	Contents	No. of hours
I	**Lamps & Accessories:** Lamp materials - glass, filament, phosphor coating, ceramics, electrodes, gases, capping cement etc. Theory of operation, Life, Characteristics and Application of Fluorescent tube, High & Low pressure sodium vapour, mercury vapour lamp, Metal halide, fluorescent lamp, LED. **Luminaire:** Types of luminaire - Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lighting fixtures according to installation.	**8**
II	**Lighting terms and definitions:** luminous flux, Luminous intensity, illuminance, efficacy- CRI- Glare-effects - Coefficients of Utilisation (CoU) - factors affecting CoU - Light Loss Factor (LLF) – Laws of Illumination. **Interior Lighting design**: Average lumen method - Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires. Benefits of LED lamps over the yesteryear luminaires. Special features of entrance, staircase, Corridor lighting.	**10**
III	**Exterior lighting design:** Point to point method – Design of Street Lighting/road lighting – Spacing to mounting height ratio- Various arrangements in road lighting –Requirements of good road lighting. **Flood Lighting:** Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, recommended method for aiming of lamp- Calculation of their wattage and number and their arrangement.	**10**
IV	**Lighting Control circuits:** Purpose of lighting control - Lighting control by transformer and ballasts - Electromagnetic & Electronic ballast - Operation & comparison in light control. Ignitors and starters. **Sensors and actuators for lighting control:** Motion and occupancy sensors, photo sensors and timers – Actuators: dimmers, relays, smart drivers. Introduction to adaptive lighting and AI-based control	**8**

V	**Lighting Control Technologies & Protocols:** Selection of Lighting Control systems - Types of control systems (analog, digital, networked)- Lighting control protocols - Wired control protocols: DALI, DMX, KNX - Wireless control: Zigbee, Z-Wave, Wi-Fi **Smart Lighting Systems & IoT Integration:** IoT in lighting: architecture, data flow, and cloud connectivity- Smart home/office lighting systems - Security, scalability, and data privacy	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL32C	ADVANCED MICROCONTROLLERS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course introduces students to advanced microcontroller architectures, with a focus on the ARM and RISC-V (VEGA THEJAS32) platforms. It covers the ARM processor design philosophy, system-level features like AMBA bus protocols, memory, and peripherals, and explores the ARM and THUMB instruction sets. Students will also learn about embedded software components including boot code and operating systems. The course further examines the RISC-V instruction set, exception handling, and the architecture of the THEJAS32 microcontroller, supported by practical exposure to demonstration boards like ARIES V2.0.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply the knowledge of Embedded C to program dsPIC30F microcontroller and its peripherals.	Apply
CO2	Summarize the ARM architecture, core dataflow, and system-level features.	Understand
CO3	Explain the ARM instruction set architecture and the function of key instruction types and extensions.	Understand
CO4	Summarize the RISC-V instruction set architecture, register model, and exception handling in the VEGA THEJAS32 microcontroller.	Understand
CO5	Apply the knowledge of VEGA THEJAS 32 microcontroller to program ARIES development boards.	Apply

iii) SYLLABUS

Introduction to dsPIC30F: Programming in C, Interrupt structure, Peripherals of dsPIC30F: GPIO, Timers, Input Capture, Output Compare, UART, CAN. ARM Processor: RISC Vs ARM architecture, ARM processor architecture, AMBA bus protocol, core data flow model, registers, current program status register, Pipeline, Exceptions, Interrupts and Vector Table, Core extensions. ARM Instruction sets: Data processing, software interrupt, ARMv5e extensions, VEGA THEJAS 32 microcontroller

iv) (a) TEXT BOOKS

1) Steve Furber, ARM system-on-chip architecture, Addison Wesley, Second Edition, 2000
2) Andrew N Sloss, Dominic System and Chris Wright, ARM System Developers Guide, Elsevier, Morgan Kaufman publisher, 1st Edition, 2008.
3) Lusio Di Jasio, Programming 16-bit PIC microcontrollers in C, Newnes – Elsevier 2nd edition, 2012

(b) REFERENCES

1) dsPIC 30F Programmer's Reference Manual, Microchip.
2) THEJAS32 Programmer's Manual, C-DAC.

3) Tammy Noergaard, Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers, Newnes – Elsevier 2nd edition, 2012.
4) Tim Wilshurst, Designing Embedded Systems with PIC Microcontrollers, Newnes – Elsevier 2nd edition, 2010.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to 16-bit microcontrollers** – dsPIC30F CPU, Data memory, Program Memory. Programming in C, Peripherals of dsPIC 30F**:** I/O Ports, Timers, Input Capture, Output Compare, Motor Control PWM, 10-bit A/D Converter, UART.	**9**
II	**ARM Processor**: RISC design and ARM design philosophy, AMBA bus protocol, ARM bus technology, Memory, Peripherals, Embedded system software – Initialization (BOOT) code, Operating System, Applications. ARM Processor Fundamentals, ARM core dataflow model, registers, current program status register, Pipeline, Exceptions, Interrupts and Vector Table, Core extensions.	**9**
III	**Introduction to the ARM Instruction set:** Introduction, Data processing instructions, Load - Store instruction, Software interrupt instructions, Program status register instructions, Loading constants, ARMv5E extensions, Conditional Execution	**10**
IV	**VEGA THEJAS32 Microcontroller**: RISC-V Instruction Set Architecture, Registers – General Purpose Registers, Control and Status Registers, Operating Modes, Programmers' Model for Base Integer ISA, Base Instruction Formats, Exceptions, Traps, and Interrupts.	**9**
V	THEJAS32 Microcontroller: Functional Bock diagram, CPU, Memory Mapped input output and Interrupts, Demonstration Boards-ARIES V2.0	**8**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL32D	INTRODUCTION TO SIGNAL PROCESSING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces fundamental concepts and techniques of signal processing, focusing on both theory and practical applications. Students will learn the principles of signals and systems, frequency domain analysis, digital filter design, finite word length effects, and modern DSP architectures. The course emphasizes both classical techniques like DFT, FFT, and FIR/IIR filters and recent advancements including adaptive filtering, DSP implementation challenges, and emerging topics such as signal modeling and real-time processing.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Apply discrete-time signal and system analysis techniques using transforms to solve practical problems.	Apply
CO2	Explain the structure and realization methods of FIR and IIR systems using various forms.	Understand
CO3	Develop IIR (Butterworth and Chebyshev) digital filters using impulse invariant and bilinear transformation methods.	Apply
CO4	Construct FIR filters using frequency sampling method and window function method.	Apply
CO5	Explain the architectural features of digital signal processors, the effects of finite word length and summarize basic machine learning concepts in signal processing.	Understand

iii) SYLLABUS

Signals and systems; frequency domain sampling; Discrete Fourier Transform (DFT), Inverse DFT (IDFT) and key properties; filtering long data sequences using overlap-save and overlap-add methods; Fast Fourier Transform (FFT), Radix-2 Decimation-in-Time (DITFFT) and Decimation-in-Frequency (DIFFFT) algorithms; introduction to Short-Time Fourier Transform (STFT). FIR and IIR systems; realization of FIR (direct, cascade, lattice, linear phase) and IIR systems (direct form 1 and 2, cascade, parallel, lattice, lattice-ladder structures); signal flow graphs; polyphase structures. Analog to digital transfer function conversion using impulse invariant and bilinear transformation; warping effect; design of Butterworth, Chebyshev, and Elliptic IIR filters; frequency transformation. FIR filter design using frequency sampling and window methods (rectangular, Hamming, Hanning, Blackman, Kaiser); introduction to Kaiser window. Finite word length effects: quantization, overflow, rounding, truncation, round-off noise, limit cycle oscillations; signal scaling techniques. Digital signal processor architectures: Harvard architecture, pipelining, dedicated hardware units, parallelism, on-chip memory; basics of machine learning applications in signal processing.

iv) (a) TEXT BOOKS

1) John G. Proakis & Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms & Applications, Pearson.
2) Alan V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, Signals and Systems, Pearson.
3) Saeed V. Vaseghi, Advanced Digital Signal Processing and Noise Reduction, Wiley.
4) Monson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley.
5) I. J. Nagrath, Signals and Systems, McGraw Hill Education, 2009.

(b) REFERENCES

1) U. Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays, Springer.
2) Emmanuel Ifeachor & Barrie W Jervis, "Digital Signal Processing", Pearson, 13th edition, 2013.
3) P. Ramesh Babu, R. Anandanadarajan, "Signals and Systems", SCITECH Publications Pvt. Ltd, 2008.
4) Li Tan, "Digital Signal Processing, Fundamentals & Applications", Academic Press, 1st edition, 2008.
5) D. Ganesh Rao & Vineeta P Gejji, "Digital Signal Processing, A Simplified Approach", Sanguine Technical Publishers, 2nd edition, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	Review of signals and systems – Frequency domain sampling – Discrete Fourier Transform (DFT) – Inverse DFT (IDFT) – Properties of DFT- Filtering of long data sequences: overlap-save and overlap-add methods – Fast Fourier Transform (FFT) – Radix-2 Decimation-in-Time FFT (DITFFT) algorithm – Radix-2 Decimation-in-Frequency FFT (DIFFFT) algorithm – Introduction to Short-Time Fourier Transform (STFT).	**9**
II	Introduction to FIR and IIR systems – Realization of FIR systems: direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole systems, lattice-ladder structure – Conversion between lattice and direct forms – Signal flow graphs and transposed structures – Realization of FIR systems: direct form, cascade form, lattice structure, linear phase realization – Introduction to Polyphase Structures for FIR Filters.	**9**
III	Conversion of analog transfer function to digital transfer function: impulse invariant and bilinear transformation – Warping effect – Design of IIR filters: low-pass, high-pass, band-pass, band-stop filters – Butterworth and Chebyshev filters – Frequency transformation in analog domain – Design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation – Introduction to Elliptic Filters.	**9**

IV	Impulse response of ideal low-pass filter – Linear phase FIR filter – Frequency response of linear phase FIR filter – Design of FIR filters using window functions (LP, HP, BP, BS) – Rectangular, Bartlett, Hanning, Hamming, Blackman windows – Introduction to Kaiser Window– FIR filter design based on frequency sampling approach.	**8**
V	Finite word length effects in digital filters: input quantization, quantization noise power, steady-state output noise power, coefficient quantization, overflow – Techniques to prevent overflow – Product quantization error – Rounding and truncation – Round-off noise power – Limit cycle oscillations: zero input limit cycle oscillations, overflow limit cycle oscillations – Signal scaling. Digital signal processor architecture: Harvard architecture (block diagram) – Pipelining – Dedicated hardware multiplier/accumulator – Special instructions dedicated to DSP – Replication – On-chip memory cache – Extended parallelism –Introduction to Basic Concepts of Machine Learning for Signal Processing Applications (overview only).	**10**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL32E	WIRELESS SENSOR NETWORKS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course provides a comprehensive introduction to Wireless Sensor Networks (WSN), covering their architecture, communication protocols, data management, energy efficiency, and security challenges. Students will explore sensor node design, network protocols, localization techniques, and database management specific to WSN environments.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the fundamentals of wireless sensor networks and its application to critical real time scenarios.	Understand
CO2	Explain the unique constraints, challenges, and advantages associated with ad-hoc and sensor networks.	Understand
CO3	Classify MAC protocols for ad-hoc and sensor networks and explain their applications in wireless sensor networks.	Understand
CO4	Classify routing protocols and describe the challenges and requirements in designing routing protocols for wireless sensor networks.	Understand
CO5	Classify different energy management schemes.	Understand

iii) SYLLABUS

Fundamentals of wireless communication technology – Electromagnetic spectrum radio propagation, characteristics, modulation of wireless channels.

Introduction to adhoc/sensor networks – Key definitions of adhoc/ sensor networks.

MAC Protocols – Issues in designing MAC protocols for adhoc wireless networks – design goals, classification of MAC protocols – MAC protocols for sensor networks.

Routing Protocols – Issues in designing a routing protocol – classification of routing protocols. QoS and Energy Management – Issues and Challenges in providing QoS.

iv) (a) TEXT BOOKS

1) Siva Ram Murthy, and B. S. Manoj, AdHoc Wireless networks, Pearson Education, 2008.
2) Mohammad Ilyas and Imad Mahgoub, “Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems” CRC Press, 2009.
3) William Stallings, "Wireless Communications and Networks ", Pearson Education, 2004.

(b) REFERENCES

1) Shuang-Hua Yang, “Wireless Sensor Networks: Principles, Design and Applications”, Springer-Verlag London, 2014.

2) Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2003.
3) Förster, Anna, Introduction to wireless sensor networks, Wiley-IEEE Press; John Wiley & Sons, 2016.
4) Pratyay Kuila, Prasanta K. Jana, “Clustering and Routing Algorithms for Wireless Sensor Networks: Energy Efficiency Approaches”, Chapman and Hall/CRC, 2018.
5) Feng Zhao, Leonidas J. Guibas, “Wireless Sensor Networks: An Information Processing Approach” Morgan Kaufmann Publishers, 2004.
6) Michel Banatre, Pedro Jose Marron, AnibalOllero and Adam Wolisz, “Cooperating Embedded Systems and Wireless Sensor Networks”, ISTE Ltd, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of wireless communication technology, the electromagnetic spectrum, radio wave propagation, characteristics of wireless channels, digital modulation techniques, multiple access methods (FDMA, TDMA, CDMA), wireless LANs, PANs, WANs, and MANs, introduction to Wireless Internet and emerging technologies.	**8**
II	Introduction to adhoc/sensor networks: Key definitions of adhoc and sensor networks, unique constraints and challenges, advantages of adhoc/sensor networks, application areas, issues in adhoc wireless networks, design issues of sensor networks, sensor network architecture, data dissemination and data gathering techniques.	**10**
III	MAC Protocols: Design issues in MAC protocols for adhoc wireless networks, design goals and requirements, classification of MAC protocols, MAC protocols for sensor networks, location discovery, quality-of-service considerations, energy efficiency, other related issues, S-MAC protocol, IEEE 802.15.4 standard.	**8**
IV	Routing Protocols: Design issues in routing protocols for wireless networks, classification of routing protocols: table-driven, on-demand, hybrid, flooding-based, hierarchical, and power-aware routing techniques.	**9**
V	QoS and Energy Management: Challenges in providing Quality of Service (QoS), classification of QoS approaches, MAC and network layer solutions, QoS support frameworks, the importance of energy management, classification of energy management schemes: battery management, transmission power control, and system-level power optimization.	**10**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL32F	INTRODUCTION TO ARTIFICIAL INTELLIGENCE	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces students to the fundamentals of Artificial Intelligence, covering intelligent agents, core Machine Learning paradigms, and ethical considerations. It builds the mathematical foundation needed for AI and explores practical applications through Neural Networks, Computer Vision, and Natural Language Processing. Students will gain both theoretical insights and hands-on experience using industry-standard tools.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Summarize the foundations of Artificial Intelligence and ethical implications related to responsible AI.	Understand
CO2	Apply essential mathematical concepts, tools and optimization techniques fundamental to AI and Deep Learning.	Apply
CO3	Explain the structure and functioning of neural networks and the impact of hyperparameters on learning performance.	Understand
CO4	Outline the working principles of convolutional neural networks and their application	Understand
CO5	Explain natural language processing techniques and sequential models in NLP applications	Understand

iii) SYLLABUS

Introduction to AI, Scope and Applications of AI, Intelligent Agents, Supervised Learning, Unsupervised Learning, Reinforcement Learning, AI vs ML vs DL, AI Ethics, Linear Algebra, Probability and Statistics, Calculus, Optimization Techniques, Information Theory, Tools for Math in AI, Neural Networks, Perceptron, MLP, Activation and Loss Functions, Backpropagation, Hyperparameter Tuning, Deep Neural Networks, CNN Building Blocks, CNN Architectures, Transfer Learning, Object Detection, Semantic Segmentation, Siamese Networks, Applications of CV, Statistical NLP, Word Embeddings, Sequential Models (RNN, LSTM, GRU), NLP Applications.

iv) (a) TEXT BOOKS

1) Patrick Henry Winston, *Artificial Intelligence*, Third Edition, Addison-Wesley Publishing Company, 2004.
2) Nils J. Nilsson, *Principles of Artificial Intelligence*, Illustrated Reprint Edition, Springer Heidelberg, 2014.
3) Stuart Russell and Peter Norvig. *Artificial Intelligence: A Modern Approach*, 3rd Edition, PHI, 2009.
4) Nils J. Nilsson, *Quest for Artificial Intelligence*, First Edition, Cambridge University Press, 2010.

(b) REFERENCES

1) G.F. Luger & W.A. Stubblefield, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, 3rd edition, Addison Wesley, 1998.
2) E. Rich, K. Knight, *Artificial Intelligence*, 2nd edition, McGraw Hill, 1991.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to AI:** Definition and Scope of AI, Historical Evolution and Applications, Intelligent Agents: Structure, Types, Environment Interaction. ML Overview: Supervised, Unsupervised, Reinforcement Learning. AI vs. ML vs DL: Differences and Relationships. Ethics in AI: Bias, Fairness, Privacy, and Responsible AI.	**9**
II	**Mathematics for AI:** Linear Algebra: Vectors, Matrices, Eigenvalues, and Singular Value Decomposition. Probability and Statistics: Bayes' Theorem, Distributions, Expectation. Calculus: Derivatives, Partial Derivatives, Chain Rule. Optimization: Gradient Descent, Cost Functions. Information Theory Basics (Entropy, KL Divergence). Tools and Packages used for Math in AI.	**10**
III	**Neural Networks and Deep Learning:** Introduction to Neural Networks, Building Blocks of Neural Networks (Neurons, Layers, Activations, Weights), Perceptron and Multi-layer Perceptron, Activation Functions, Loss Functions, Backpropagation and Weight Updates, Hyperparameter Tuning (Learning Rate, Epochs, Batch Size, Optimizers), Deep Neural Networks: Architectures and Training.	**9**
IV	**Computer Vision:** Working with Images and CNN Building Blocks (Convolution, Pooling, ReLU), CNN Architecture and Transfer Learning, Object Detection (YOLO, SSD, RCNNs), Semantic Segmentation (U-Net, FCN), CNNs at Work: Siamese Network for Metric Learning, Applications in Smart Vehicles, Medical Imaging, and Surveillance.	**9**
V	**Natural Language Processing:** Introduction to Statistical NLP Techniques, Word Embeddings (Word2Vec, GloVe, FastText), Introduction to Sequential Models (RNNs, LSTMs, GRUs), NLP Applications: Text Classification, Sentiment Analysis, Chatbots.	**8**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL32G	SOFT COMPUTING TECHNIQUES	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces students to the foundational and application-oriented aspects of Soft Computing, a multidisciplinary field combining fuzzy logic, neural networks, and evolutionary algorithms. The course emphasizes intelligent computation, approximate reasoning, and adaptive learning, which are crucial for modern systems that handle uncertainty, non-linearity, and imprecise data. The course equips students with both conceptual clarity and applied problem-solving skills relevant to fields such as control systems, pattern recognition, optimization, and artificial intelligence.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the principles of soft computing, its components and the differences from hard computing.	Understand
CO2	Develop fuzzy logic systems using fuzzy sets, membership functions, and inference mechanisms for decision-making and control applications.	Apply
CO3	Develop artificial neural networks for solving classification and regression problems in engineering domains.	Apply
CO4	Explain the structure and operation of competitive neural networks and hybrid soft computing models used in pattern recognition and clustering.	Understand
CO5	Outline evolutionary algorithms such as genetic algorithms and simulated annealing to solve engineering optimization problems.	Understand

iii) SYLLABUS

Introduction to soft computing and its components: fuzzy logic, neural networks, and evolutionary algorithms. Basics of artificial intelligence and machine learning; supervised and unsupervised learning.

Fuzzy sets and membership functions, fuzzy operations and relations, fuzzy inference systems including fuzzification, rule evaluation, aggregation, and defuzzification; fuzzy logic controllers.

Artificial neural networks: biological neuron models, perceptron, activation functions, learning paradigms, single and multilayer feedforward networks, backpropagation algorithm, Hebb nets, ADALINE, MADALINE. Competitive neural networks: Kohonen's self-organizing maps, Adaptive Resonance Theory, pattern associators, Hopfield networks.

Hybrid systems: neuro-fuzzy systems, genetic algorithm-based neural networks, fuzzy-genetic models. Evolutionary search techniques: state space search, heuristic and best-first search, hill climbing, genetic algorithms, multi-objective optimization, and simulated annealing.

iv) (a) TEXT BOOKS

1) Samir Roy, Udit Chakraborty, *Introduction to Soft Computing Neuro-Fuzzy and Genetic Algorithms*, Pearson Publications, 2013.
2) S. Rajasekharan, G. A. Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
3) Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.

(b) REFERENCES

1) S. N. Sivanandan, S. N. Deepa, *Principles of Soft Computing*, Wiley India, 2007.
2) J. S. R. Jang, C. T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
3) Timothy J. Ross, *Fuzzy logic with Engineering Applications*, Wiley Publications, 3rd edition, 2010.
4) Driankov D., Hellendoorn H., Reinfrank M, An *Introduction to Fuzzy Control*, Narosa Publications, 1993.
5) Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002.
6) Zurada J. M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
7) Hassoun Mohammed H., *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.
8) Suran Goonatilake & Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley, 1995.
9) D. E. Goldberg, *Genetic Algorithms in Search Optimization and Machine Learning*, Pearson Education, 1989.
10) Research articles & application papers in AI-ML for ECE.
11) Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Soft Computing and AI**: Soft Computing Paradigm - definition, need, components, comparison. Soft Computing vs Hard Computing, Overview of Artificial Intelligence and Intelligent Systems. Basics of Machine Learning - Supervised vs Unsupervised Learning, Typical ML Workflow and Use Cases. Applications - AI in Control Systems, Diagnostics, Smart Grids.	**6**
II	**Fuzzy Sets and Fuzzy Inference Systems:** Review of Crisp Sets and Boolean Logic. Fuzzy Sets - Membership, Functions, Set Operations, Properties, Fuzzy Relations and Extension Principle. Fuzzy Logic - Linguistic Variables, Fuzzy Rules and Reasoning. Fuzzy Inference Systems (FIS) - Mamdani and Sugeno Models, Fuzzification, Rule Evaluation, Aggregation, Defuzzification, Applications in Control Systems - Fan Speed Control, Room Temperature Control.	**10**

III	**Artificial Neural Networks (ANNs):** Biological Neuron and McCulloch-Pitts Model, Single-Layer and Multi-Layer Feedforward Networks, Activation Functions, Perceptron, Hebb's Rule, ADALINE and MADALINE. Backpropagation Algorithm - Architecture, Training, Convergence, Introduction to Machine Learning Models using ANN - Regression, Classification, Application in Fault Detection and Pattern Recognition.	**10**
IV	**Competitive Neural Networks and Hybrid Systems:** Competitive learning and clustering, Kohonen's Self-Organizing Maps (SOM), Applications of SOM in data clustering and fault pattern recognition, Hybrid systems overview, Need for hybridization, Adaptive Neuro-Fuzzy Inference System (ANFIS) - structure and training, Applications of ANFIS in control and classification. Introduction to other hybrid models - Fuzzy-Genetic Algorithm, Neural Network-Genetic Algorithm (conceptual overview only), Overview of associative memory models, Hopfield networks (brief).	**9**
V	**Evolutionary Algorithms and Search Strategies:** Search Problems in AI - State Space, Heuristic Search, Best-First Search, Hill Climbing, Optimization Problems in Engineering. Genetic Algorithms (GAs) - Chromosomes, Selection, Crossover, Mutation, Fitness Evaluation, Multi-objective Genetic Algorithms (MOGA), Simulated Annealing and Comparison with GAs, Applications - Circuit Optimization, Load Forecasting, Resource Scheduling.	**10**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

HONOURS

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL3HB	INTRODUCTION TO NAVIGATION AND TRAJECTORY PLANNING	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW: This course introduces the fundamental principles and techniques used in navigation and trajectory planning for autonomous systems such as mobile robots, drones, and self-driving vehicles. The course blends theoretical foundations with practical applications, covering localization, mapping, path planning, trajectory generation.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Illustrate key components of a navigation system and explain various navigation algorithms.	Understand
CO2	Explain the various localization and estimation techniques.	Understand
CO3	Apply a suitable method for obstacle avoidance for a specific task.	Apply
CO4	Apply different path planning and trajectory planning techniques.	Apply
CO5	Explain the various Trajectory Generation and Optimization techniques.	Understand
CO6	Apply algorithms in real-world applications using Modern Simulation Tools.	Apply

iii) SYLLABUS

Introduction to Autonomous Navigation and Path Planning-Definition and basic concepts of autonomous navigation and path planning-Introduction to various techniques and algorithms used for navigation and path planning-Navigation Techniques and Algorithms-Obstacle Avoidance Techniques-Workspace Analysis and Trajectory Planning-Work Envelope of different Robots-Applications-Optimal Path Planning Techniques and Trajectory Planning-Introduction to Robot Operating System (ROS), and GAZEBO, Case Studies and Examples

iv) (a) TEXT BOOKS

1) Niku S B, *Introduction to Robotics, Analysis, Control, Applications*, John-Wiley & Sons Inc, 2011.
2) Ashitava Ghosal, *Robotics Fundamental Concepts and Analysis,* Oxford University Press.
3) Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, Sebastian Thrun, *Principles of Robot Motion-Theory, Algorithms, and Implementation*, MIT Press, Cambridge, 2005.
4) Steve LaValle, *Planning Algorithms*, Cambridge Univ. Press, New York, 1st edition 2006.

5) Kevin M. Lynch, Frank C. Park, *Modern Robotics: Mechanics, Planning, and Control,* Cambridge University Press, 1st edition, 2017

(b) REFERENCES

1) Patnaik, Srikanta, *Robot Cognition and Navigation an Experiment with Mobile Robots*, Springer-Verlag Berlin and Heidelberg, 2007.
2) Reza N Jazar, *Theory of Applied Robotics*, Springer, 2010.
3) Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, *Introduction to Autonomous Mobile Robots*, Bradford Company Scituate, USA, 2004.
4) Graig, *Introduction to Robotics – Mechanics and Control*, 2nd edition, Pearson Education, Inc.
5) S.R. Deb, *Robotics Technology and Flexible Automation*, Tata McGraw-Hill, New Delhi, Fourth Edition, 2009.
6) Yoran Kaen, *Robots for Engineering*, Tata McGraw-Hill.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to navigation:** Introduction to navigation - Global vs. local navigation - Coordinate frames and transformations (inertial, body, world) - Sensors for navigation: IMU, GPS, odometry, LiDAR Camera modeling and calibration, structure from motion, visual motion estimation. Navigation Techniques and Algorithms - Dead reckoning -Beacon-based navigation -Landmark-based navigation	9
II	**Localization:** Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems **Obstacle Avoidance Techniques:** Potential field method - Virtual force field method - Artificial potential fields method	9
III	**Introduction to path and trajectory planning:** Workspace Analysis and Trajectory Planning-Work Envelope of different autonomous vehicle – Applications - Continuous Path Motion -Interpolated Motion-Straight Line Motion Optimal Path Planning Techniques and Trajectory Planning - Dijkstra's algorithm-A* algorithm- Trajectory planning for Autonomous Vehicle - Sampling-based algorithms: RRT, PRM -	9
IV	**Trajectory Generation and Optimization:** Polynomial trajectory generation (splines, Bézier curves) - Time-parameterized planning - Constraints: velocity, acceleration, obstacle avoidance - Trajectory optimization: cost functions, convex/non-convex approaches.	9
V	Dynamic environments and real-time replanning - Model Predictive Control (MPC) basics -Multi-robot coordination fundamentals - Introduction to Robot Operating System (ROS), and GAZEBO - Applications: autonomous cars, UAVs, mobile robots-Case Studies and Examples.	9
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Cate-gory	L	T	P	J	Credit	Year of Introduction
23ELL3HD	MACHINE LEARNING PROGRAMMING	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW: This course introduces the fundamentals of Machine Learning (ML) with a practical focus on implementation using Python. It equips students with the knowledge and skills required to build data-driven models for real-world applications. Students will explore supervised and unsupervised learning techniques, model evaluation strategies, and recommendation systems. The course emphasizes understanding the machine learning workflow, from data preprocessing and visualization to model tuning and deployment, while reinforcing hands-on learning through Python tools and libraries relevant to Electrical and Computer Engineering domains.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain Python libraries and data preprocessing techniques essential for building machine learning pipelines.	Understand
CO2	Apply supervised learning techniques for classification and regression problems using Python.	Apply
CO3	Apply unsupervised learning algorithms and dimensionality reduction methods to extract patterns from data.	Apply
CO4	Explain different model evaluation techniques, feature engineering, and hyperparameter tuning for improving ML models.	Understand
CO5	Apply recommendation system techniques and gain insights into deploying ML models and emerging applications like time series and reinforcement learning.	Apply

iii) SYLLABUS

Introduction to Python and Data Handling: Python basics, NumPy, Pandas, DataFrames, data preprocessing, and pipeline creation using Scikit-learn. Data Visualization and Supervised Learning: EDA, Matplotlib, Seaborn, Linear and Logistic Regression, k-NN, Naive Bayes, Decision Trees, SVM, Ensemble Methods (Random Forest, AdaBoost, Gradient Boosting). Unsupervised Learning and Dimensionality Reduction: K-Means, Hierarchical Clustering, PCA, and real-world clustering applications. Model Evaluation and Tuning: Feature engineering, cross-validation techniques (K-Fold, Stratified, Bootstrap), performance metrics (Precision, Recall, F1-score, ROC-AUC), hyperparameter tuning, and interpretability basics (SHAP, LIME). Recommendation Systems and Deployment: Popularity-based and content-based filtering, collaborative filtering, matrix factorization, SVD, introduction to time series forecasting and reinforcement learning, and basics of ML model deployment using Pickle, Joblib, and Flask/Streamlit (concept only).

iv) (a) TEXT BOOKS

1) Andreas C. Müller, Sarah Guido, *Introduction to Machine Learning with Python*, First Edition, O'Reilly Media, 2016.

2) Sebastian Raschka, Vahid Mirjalili, *Python Machine Learning*, Second Edition, Ingram Short Title, 2017.
3) Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, Third Edition, O'Reilly Media, 2022.

(b) REFERENCES

1) Abhishek Vijayvargia, *Machine Learning with Python*, BPB Publications, 2018.
2) Manaranjan Pradhan, U. Dinesh Kumar, *Machine Learning Using Python*, Wiley Publications, 2019.
3) Dr. Manish H. Attal, *Machine Learning and Python*, BlueRose Publishers, 2022.
4) Tariq Rashid, *Make Your Own Neural Network*, CreateSpace Independent Publishing, 2016.
5) V.K. Jain, *Data Science and Machine Learning Using Python*, Khanna Book Publishing, 2021.
6) Nikhil Buduma, Nicholas Locascio, *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms*, O'Reilly Media, 2017.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Python and Data Handling:** Python basics and essentials: Series and DataFrames, Accessing and modifying data, Combining DataFrames, Functions, Saving and Loading CSV files, Data preprocessing: Handling missing values, outliers, scaling, Data pipeline creation using Scikit-learn.	**9**
II	**Data Visualization and Supervised Learning:** Exploratory Data Analysis (EDA), Data visualization using Matplotlib and Seaborn, Supervised Learning: Classification and Regression, Linear and Logistic Regression, k-Nearest Neighbors, Naive Bayes, Decision Trees, Kernelized SVM. Ensemble Methods: Random Forest, AdaBoost, Gradient Boosting. Case studies and applications using Python.	**9**
III	**Unsupervised learning and Dimensionality Reduction:** Clustering- K-means clustering, Dynamic clustering, comparison and evaluation of clustering algorithms. Hierarchical Clustering & Principal Component Analysis (PCA) for dimensionality reduction. Case studies and Application of Unsupervised learning Algorithms using Python Programming.	**9**
IV	**Model Evaluation and Tuning:** Featurization and Feature Engineering, Cross-validation techniques: K-Fold, Stratified K-Fold, Bootstrap, Model performance measures: Accuracy, Precision, Recall, F1-score, ROC-AUC, Confusion Matrix, Error Analysis, Hyperparameter Tuning: Grid Search, Randomized Search, Overfitting, Bias-Variance Tradeoff, Model interpretability basics: SHAP, LIME (conceptual overview).	**9**

V	**Recommendation Systems and Model Deployment:** Popularity-Based, Content-Based Filtering, Collaborative Filtering, Similarity Measures. Matrix Factorization and SVD. Introduction to Time Series Forecasting and Reinforcement learning. Basics of Model Deployment: Pickle, Joblib, Flask/Streamlit (concept only).	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23ELL3HF	DISTRIBUTED GENERATION AND SMARTGRID	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces the fundamentals of Distributed Generation and Smart Grid technologies, focusing on microgrid configurations, control strategies, and integration of renewable energy resources. It covers smart metering, automation, power quality, and demand-side management for efficient and sustainable energy systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

CO1	Explain the integration of distributed generation with the main grid and the various microgrid configurations with their technical and economic advantages and challenges	Understand
CO2	Summarize the opportunities, benefits, and challenges associated with Smart Grid technologies	Understand
CO3	Summarize the operating principles of key distributed energy systems	Understand
CO4	Explain the functions of central and microsource controllers in microgrid control, and the major protection issues including islanding and grid integration impacts	Understand
CO5	Outline the functionalities of smart meters, sensors, AMI, and substation automation, and their influence on load management, demand-side management, and power quality improvements	Understand

iii) SYLLABUS

Introduction to Distributed Generation and its integration with the grid, concepts and configurations of microgrids (AC/DC), interconnection strategies, advantages, challenges, and economic impacts.

Overview of Smart Grid evolution, its need, opportunities, and benefits. Detailed study of Distributed Energy Resources including solar PV, wind, CHP systems, and small-scale hydro generation.

Microgrid control strategies using central and microsource controllers, focusing on active/reactive power, voltage control, and load sharing.

Protection issues including islanding and the impact of DG on the market and environment. Smart metering technologies, dynamic pricing models, energy-efficient devices, demand-side management, and power quality issues with Smart Grids. Substation automation and communication protocols like IEC 61850.

iv) (a) TEXT BOOKS

1) Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-47062761-7, John Wiley & Sons, 2016.

2) James Momoh, Smart Grid: Fundamentals of Design and Analysis, ISBN: 978-0-470-889398, Wiley-IEEE Press, 2016.
3) R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, "Electrical Power System Quality", McGraw-Hill, 2012.

(b) REFERENCES

1) Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley, 2011.
2) S. Chowdhury, S.P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks, ISBN 978-1-84919-014-5, IET, 2009.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Distributed Generation:** Introduction - Integration of distributed generation to Grid – Concepts of Micro Grid - Typical Microgrid configurations - AC and DC micro grids - Interconnection of Microgrids - Technical and economic advantages of Microgrid-Challenges and disadvantages of Microgrid development. **Smart Grid:** Evolution of Electric Grid - Definitions and Need for Smart Grid, Opportunities, challenges and benefits of Smart Grids.	9
II	**Distributed Energy Resources:** Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation. **Control of Microgrids:** Introduction to Central Controller (CC) and Microsource Controllers (MCs) - Control functions of microsource controllers, Active and reactive power control, Voltage control, Storage requirement for fast load tracking, Load sharing through power-frequency control.	9
III	**Protection issues for Smart grids:** Introduction, Islanding, Different islanding scenarios, Major protection issues of standalone Microgrid - Impact of DG integration on electricity market, environment, distribution system. Introduction to Smart Meters, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). Electricity tariff – one-part tariff, two tariff and maximum demand tariff - Dynamic pricing: time-of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time Pricing. Automatic Meter Reading (AMR), Smart Sensors, Energy efficient devices- Home & Building Automation.	9
IV	**Smart distributed energy resources and their grid integration:** Load Curves-Load Shaping Objectives-Methodologies - Peak load shaving Energy Management-Role of technology in demand response-Demand Side Management. Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs).	9

V	Smart Substations, Substation Automation, IEC 61850 Substation Architecture, Feeder Automation. **Power quality**: Introduction - Types of power quality disturbances - Voltage sag (or dip), transients, short duration voltage variation, long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker - Harmonic sources: SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps, harmonic indices (THD, TIF, DIN, C – message weights)-Power quality aspects of smart grids.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

Continuous Assessment		
Attendance	:	5 marks
Assignments	:	15 marks
Assessment through Tests	:	20 marks
Total Continuous Assessment	:	**40 marks**
End Semester Examination	:	**60 marks**
TOTAL	:	**100 marks**

vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours