MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belagavi)

Autonomous Programmes

Bachelor of Engineering

Scheme for

III - VIII Semesters

Academic Year: 2024-25

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

Admitted Batch: 2021-25

VISION of the Department

To become a department of excellence in the domain of Electrical and Electronics Engineering producing competent engineers with research acumen having moral and social values.

MISSION of the Department

- Enhance industry and alumni interaction.
- Promote continuous quality up gradation of faculty and technical staff.
- Time to time modernization of departmental infrastructure to provide state of the art laboratories.
- Create research-oriented culture to invoke the desire and ability of lifelong learning among the students for pursuing successful career.
- Create and sustain environment of learning in which students acquire knowledge and learn to apply it professionally with due consideration of social and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the program will be able to

1. Design, analyze, operate and maintain equipment related to electrical and electronic industries with continuous integration with core and allied industries.

2. Use state of art laboratories and modern computer based tools to pursue a diverse range of career as engineers and researchers.

3. Bring out innovations to provide best solutions to electrical engineering problems.

4. Fulfill the needs of society in solving technical problems using engineering principles, tools and practices, in an ethical and responsible manner.

PROGRAM 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 modelling 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 teamwork**: 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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Develop models, design, analyze and assess the performance of different types of electrical machines, control systems and generation, transmission, distribution, protection mechanisms in power systems.
PSO2: Demonstrate knowledge and hands-on competence in the application of circuit analysis and design, associated software and applications, analog and digital electronics and microcontrollers to build, test, operate and maintain electrical and electronic systems

Scheme of Evaluation (Theory Courses)

Assessment	Marks
CIE 1	**10**
CIE 2	**10**
CIE 3	**10**
Activities (Minimum 2)	**20**
SEE	**50**
Total	**100**

Scheme of Evaluation (Laboratory Courses)

Assessment	Marks
Continuous internal Evaluation in every lab session by the Course coordinator	**30**
Laboratory CIE conducted by the Course coordinator	**20**
SEE	**50**
Total	**100**

MALNAD COLLEGE OF ENGINEERING, HASSAN

Scheme Structure for B. E. Program with 160 credits

Sl.No.	Category	Description	AICTE Breakup of Credits	MCE Breakup of Credits
1	**HSMC**	**Humanities , Social Sciences and Management courses, UHV**	**12***	**8**
2	**BS**	**Basic Science courses**	**25***	**24**
3	**ES**	**Engineering Science courses including workshop, drawing, basics of electrical/mechanical/computer etc**	**24***	**20**
4	**PCC**	**Professional Core Courses**	**48***	**60**
5	**PEC**	**Professional Elective courses relevant to chosen specialization/branch/**	**18***	**16**
6	**OEC**	**Open subjects – Electives from other technical, emerging, arts, commerce; Ability Enhancement Courses**	**18***	**9**
7	**PI**	**Mini and Major Project work /seminar/ Summer Internship and Research /Industrial Internship**	**15***	**23**
8	**AUDIT**	**Mandatory Non-Credit Courses (Environmental Sciences, Induction training, Indian Constitution, Universal Human Values, Kannada)**	**No credits**	**-**
Total			**160**	**160**

*Minor variation is allowed as per need of the respective discipline

The duration for courses:

1. 4-credits – 50 Hrs
2. 3-credits – 40 Hrs
3. 2-credits – 25 Hrs
4. 1-credit – 15 Hrs

Scheme of Teaching for the 2021-22 Admitted Batch

THIRD SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
BSC	21MA301	Linear Algebra and Integral Transforms	3-1-0	3	4
PCC	21EE302	Analog and Digital Electronic Circuits	4-0-0	4	4
PCC	21EE303	Transformers & Induction Machines	3-0-0	3	3
PCC	21EE304	Electric Power Generation, Transmission & Distribution	4-0-0	4	4
PCC	21EE305	Electrical and Electronics Measurements	3-0-0	3	3
PCC	21EE306	Transformers & Induction Machines Laboratory	0-0-2	1	2
PCC	21EE307	Analog and Digital Electronics Laboratory	0-0-2	1	2
HSMC	21UHV	Universal Human Values	2-0-0	1	2
BS	21BCM301	Bridge Mathematics-1 (Mandate Audit course for Diploma entry students)	0-0-0	0	3
Total				**20**	**27**
PCC: Professional Core; PI: Mini and Major Project work /seminar/ Summer Internship and Research /Industrial Internship; BS: Basic Sciences; HSMC: Humanities and Social Science, Management Courses, UHV; AE: Ability Enhancement Course					

FOURTH SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
BSC	21MA401	Statistics and Complex Analysis	2-0-2	3	4
PCC	21EE402	Electrical Network Analysis	3-0-2	4	5
PCC	21EE403	Synchronous and Special Electrical Machines (Laboratory Integrated)	3-0-2	4	5
PCC	21EE404	Microcontrollers (Laboratory Integrated)	3-0-2	4	5
PCC	21EE405	Electric Networks and Measurements Laboratory	0-0-2	1	2
AEC	21BE	Biology for Engineers	2-0-0	1	2
HSMC	21KNS*/ 21KNB*	Samskrutika Kannada/ Balake Kannada (Group A)	2-0-0	1	2
PI	21INT1	Summer Internship –I	0-0-2	1	--
BS	21BCM401	Bridge Mathematics-II (Mandate Audit course for Diploma entry students)	0-0-0	0	3
Total				**19**	**28**
PCC: Professional Core; PI: Mini and Major Project work /seminar/ Summer Internship and Research /Industrial Internship; BS: Basic Sciences; HSMC: Humanities and Social Science, Management Courses; UHV, AE: Ability Enhancement Course					

Summer Internship-II: At the end of fourth Semester **four weeks** Summer Internship shall be carried out – Based On industrial/ Govt./ NGO/ MSME/ Rural Internship/ Innovation/ Entrepreneurship. Credited In fifth Semester. All the students admitted shall have to undergo mandatory internship of 04 weeks during the vacation of IV semesters. A University Viva-Voce examination shall be conducted during V semester and the prescribed credit shall be included in V semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirement

FIFTH SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PCC	21EE501	Linear Control Systems (Integrated Laboratory)	3-0-2	4	5
PCC	21EE502	Power Electronics	4-0-0	4	4
PCC	21EE503	Electromagnetic Fields	4-0-0	4	4
PCC	21EE504	Electrical Machine Design (Integrated Laboratory)	3-0-2	4	5
HSMC	21EE505	Industrial Management and Professional Engineering Practice	4-0-0	4	4
PCC	21EE506	Power Electronics Laboratory	0-0-2	1	2
UHV	21SCR	Social Connect & Responsibility	0-0-2	1	2
HSMC	21CIP	Constitution of India and Professional Ethics	0-2-0	Audit	2
Total				**22**	**28**
PC: Professional Core; AE: Ability Enhancement Course; HS: Humanities and Social Science					

SIXTH SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PCC	21EE601	Power System Analysis and Stability	4-0-0	4	4
PCC	21EE602	High Voltage Engineering and Switchgear	4-0-0	4	4
PCC	21EE603	Relay and High Voltage Laboratory	0-0-2	1	2
PI	21EE604	Mini Project	0-0-2	2	4
PEC	21EE61X	Professional Elective Course - I	3-0-0	3	3
PEC	21EE62X	Professional Elective Course - II	3-0-0	3	3
PEC	21SW01	SWAYAM	0-1-0	Audit	--
OEC	21OEXX6X	Open Elective –I	3-0-0	3	3
AEC	21ASK	Analytical Ability and Soft Skills	0-2-0	1	2
HSMC	21EVS	Environmental Studies	--	0	2
PI	21INT2	Summer Internship -II	0-0-4	2	4
Total				**23**	**31**
PC: Professional Core; AE: Ability Enhancement Course; HS: Humanities and Social Science					

Professional Elective Course - I			
21EE611	Testing & commissioning of Electrical equipment	21EE613	Advanced Power Electronics
21EE612	Special Electrical Machines	21EE614	Operational Amplifiers and Linear ICs
Professional Elective Course - II			
21EE621	Object Oriented Programming with C++	21EE623	Programmable Logic Controllers
21EE622	Signals and Systems	21EE624	Electric Vehicle Technologies
Open Elective - I			
21OEEE61	Basic Power Electronics	21OEEE62	Alternate Energy Sources

SEVENTH SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
IPCC	21EE701	Computer Methods in Power Systems (Integrated Laboratory)	3-0-2	4	5
PCC	21EE702	Modern Control Theory	4-0-0	4	4
PEC	21EE73X	Professional Elective Course - III	3-0-0	3	3
PEC	21EE74X	Professional Elective Course - IV	3-0-0	3	3
PEC	21EE75X	Elective – V (Industry Elective)	0-0-2	1	2
OEC	21OEX7X	Open Elective -II	3-0-0	3	3
PI	21PROJ7X	Project Work Phase - I	0-0-4	2	4
AEC	21RIP01	Research Methodology & Intellectual Property rights (Mandatory non-credit)	0-2-0	Audit	2
Total				**20**	**26**
AE: Ability Enhancement Course; OE: Open Elective					

Professional Elective Course - III			
21EE731	Digital Signal Processing	21EE733	Electrical Engineering Materials
21EE732	Introduction to Smart Grid	21EE734	Power System Operation and Control
Professional Elective Course - IV			
21EE741	Industrial Drives and Applications	21EE743	Flexible AC Transmission Systems
21EE742	Electrical Power Quality	21EE744	Solar Power Conversion Systems
Open Elective - II			
21OEEE71	Smart Grid Technologies	21OEEE72	Utilization of Electric Power

EIGHTH SEMESTER					
Course Category	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PI	21PROJ8X	Project Work Phase - II	0-0-8	4	8
PI	21INT3	Internship (Research / Industry)	0-0-24	12	24
Total				**16**	**32**

SEVENTH SEMESTER

Course Title	COMPUTER METHODS IN POWER SYSTEMS		
Course Code	21EE701	(L-T-P) C	(3-0-2) 4
CIE	50	Hours/Week	5
SEE	50	Total Hours	64 (40L+24P)

Course Objective: To design generalized computer algorithms for computer aided Power System Analysis, involving networks under various frames of reference.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Form the incidence matrices, network matrices by singular and non-singular transformation.	2	1
2	Explain the various methods of load flow procedures for various power system problems.	1	1
3	Solve load flow numerical problems using various methods.	2	1
4	Develop computer aided algorithms for various power system problems that are based on contemporary and modern industry-based methods.	5	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		3											3	
CO2	2												3	
CO3		2											3	
CO4					2									2

MODULE-1 — 10 Hrs

Network Topology and Network Matrices: **(a)** Introduction, Elementary graph theory, Basic definitions, Oriented graph, Tree, Co-tree, Basic cut sets, Basic loops, Rank of a matrix, Singular and nonsingular matrices, **(b)** Incidence matrices – Element-node, Bus incidence, Tree-branch path, Basic cut-set, Augmented cut-set, Basic loop and Augmented loop matrices, Relation between different matrices **(c)** Primitive network matrices, Impedance form and Admittance form, illustrative examples.

MODULE-2 — 10 Hrs

Formation of Network Matrices: (a) Formation of network matrices by singular transformations in bus, branch and loop frames of reference (Y_{BUS}, Y_{BR} and Z_{LOOP}), and Illustrative examples. Formation of interconnected network matrices by non-singular transformations using augmented interconnected network matrices in both the branch and loop frames of reference and hence arriving at a procedure of formation of network matrices in bus, branch and loop frames of reference, illustrative examples. **(b) Node Elimination by Matrix Algebra:** Derivation of generalized algorithms for a given electric power system for node elimination by matrix manipulation of performance equations, node elimination by considering; (i) the eligible nodes simultaneously and (ii) one node at a time, Illustrative examples. **(c) Algorithms for formation of network matrices:** Introduction, Partial network, Performance equation, algorithms for formation of bus impedance matrix- Z_{BUS} by building algorithms, General cases of Addition of Branch, Addition of Link, illustrative examples.

MODULE-3 — 10 Hrs

Review of Solution of equations: Introduction, Methods of solving linear, Nonlinear and differential equations, iterative methods, Generalized algorithms for solution of linear equations by Gauss elimination and LU factorization methods, Algorithms for solution of nonlinear equations by Gauss-Siedel and Newton-Raphson methods, examples. Load Flow Studies: Introduction, Power flow equations, Classification of buses, Operating constraints, Data for load flow, importance of slack bus and YBUS in load flow analysis, Gauss-Siedel Method, algorithm and flow chart for PQ and PV buses, acceleration of convergence, illustrative examples (numerical problems for maximum of two iterations only).

MODULE-4 — 10 Hrs

NR and FDLF Methods of Load Flow Studies:(a) Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates, importance of Jacobian matrix, Sparsity considerations, solution procedure for systems involving PQ and PV buses, illustrative examples (numerical problems for one iteration only). **(b)** Newton's Decoupled method and its advantages, FDLF Analysis: Algorithm and flow chart for Fast Decoupled load flow method, assumptions made, Comparison of Load Flow Methods.

Laboratory Component	**24 Hrs**

1. Optimal generator scheduling for various power plants (max. four units) without and with the transmission losses.
2. To conduct load flow analysis using Newton Raphson method for at least 3 iterations for a 3 to 4 Bus system (Load flow data to be supplied).
3. Load flow analysis of a given power system using Gauss Siedel method for at least 3 iterations for a 3 to 4 Bus system (Load flow data to be supplied).
4. To determine fault currents & voltages in power systems at a specified location for SLGF, DLGF, LLF and 3LG Fault, without and with fault impedance.
5. Y_{BUS} formation for power systems by the rule of inspection method (without mutual coupling).
6. $_{BUS}$ formation for power systems without & with mutual coupling, by singular transformation method.
7. ABCD parameters: Formation for symmetric configurations, verification of AD-BC=1 and determination of efficiency & regulation for short, medium and long transmission lines.

Text books:

1. Stagg, GW, and EI-Abiad AH, Computer Methods in Power System Analysis McGraw Hill International Student Edition. 1988.
2. Pai, M. A., Computer Techniques in Power System Analysis, TMH, 2nd Edition, 2006.
3. K. Uma Rao, Computer Modeling of Power Systems, Interline publ., Bangalore, 2008.

Reference Books:

1. K. Uma Rao, Computer Modeling of Power Systems, Interline publ., Bangalore, 2008.

Course Title	**MODERN CONTROL THEORY**		
Course Code	**21EE702**	**(L-T-P) C**	**(4-0-0) 4**
CIE	**50**	**Hours/Week**	**4**
SEE	**50**	**Total Hours**	**52**

Course Objective: To demonstrate skills to conduct state space analysis.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Represent a given system using state model by choosing appropriate state variables and obtain the solution of the state equation.	1, 2	1
2	Solve state space models from its classical mathematical model to different applications.	1, 2	1
3	Test controllability and observability of the system and design system using pole placement techniques.	1, 2, 3	1
4	Analyze the stability of linear systems using Liapunov's criteria.	1, 2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1										2	
CO2	2	3	1										2	
CO3	2	3	3										2	
CO4	2	3	1										2	

MODULE-1	**13 Hrs**

Introduction to State variable analysis: Limitations of classical control theory, Concept of state, State variables, state space model for physical systems – electrical and mechanical systems.

State Space Model: State model of linear systems from differential equations and transfer function, direct (CCF and OCF), series and parallel decomposition.

SLC: State Space model of Electro mechanical system.

MODULE-2	13 Hrs

Canonical Models: Similarity transformation of state model, Invariant property, Diagonal canonical model, Jordan canonical model. Transfer function matrix from state model.

Time Domain Analysis in State Space: Solution of time invariant state equation, State Transition matrix (STM).

SLC: Properties of State Transition matrix.

MODULE-3	13 Hrs

Computation of STM using Power series, Laplace transformation and Canonical transformation method.

Controllability and Observability: Concept of controllability and observability, Criterion for controllability and observability - Kalman's test and Gilbert's method. Linear transformation of state model into CCF and OCF.

SLC: Computation of STM using Cayley Hamilton method.

MODULE-4	13 Hrs

Pole placement Techniques: Stability improvements by State feedback, necessary and sufficient conditions for arbitrary pole placement, Design of state feedback controllers, Ackerman's formula. Design of state observers- full order observer.

Stability Analysis: Concept of stability, Equilibrium points, Liapunov's stability definitions, Sign definiteness of scalar functions, Liapunov's function, Liapunov's method for Linear time invariant systems.

SLC: design of reduced order observer.

Text books:

1. K.P. Mohandas, *Modern Control Engineering,* Sanguine Technical publishers, 2006.

Reference Books:

1. M. Gopal, Digital Control & State Variable Methods, 2nd Edition, Tata McGraw Hill, 2003.
2. Katsuhiko Ogata, Modern Control Engineering, 4th Edition, Pearson Education.
3. Benjamin C Kuo, Automatic Control Engineering, Prentice Hall India, 2002.

PROFESSIONAL ELECTIVE COURSE – III

Course Title	DIGITAL SIGNAL PROCESSING		
Course Code	21EE731	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To design and implement digital filter for signal processing applications.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Transform signals using discrete Fourier and Fast Fourier transforms.	1, 2	2
2	Realize IIR and FIR digital systems in various forms.	1, 2	2
3	Design IIR filters as per required specifications.	1, 2, 3	2
4	Design FIR filters as per required specifications.	1, 2, 3	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1											2
CO2	1	2	1											2
CO3	1	2	3											2
CO4	1	2	3											2

MODULE-1 **10 Hrs**

Discrete Fourier Transforms: Definitions, Circular shift, Properties of DFTs, Circular convolution, Stockham's method, Linear convolution of two finite duration sequences, Filtering of long sequences.

SLC: Proofs of different Properties of DFTs.

MODULE-2 **10 Hrs**

Fast Fourier transforms algorithms: Introduction, decimation in time algorithm, decimation in frequency algorithm, decomposition for 'N' a composite number, computation of DFTs and IDFTs. **Realization of digital systems:** Introduction, block diagrams, Realization of IIR systems-direct form and Parallel form.

SLC: Realization of IIR system in Cascade form.

MODULE-3 **10 Hrs**

Realization of FIR systems: Introduction, Direct form, cascade form, linear phase realizations. **Design of IIR Digital filters:** Introduction, Types of filters, Analog Butterworth and Chebyshev filters, frequency transformations.

SLC: Lattice structure realization of FIR Filter.

MODULE-4 **10 Hrs**

Methods of Designing Digital Filters, Impulse Invariant and Bilinear Transformations, Design of digital Butterworth and Chebyshev filters, Frequency transformations. **Design of FIR Digital filters:** Introduction, Windowing, Design of Linear phase FIR filter using rectangular and Hamming windows. Design of Linear phase FIR filter using Frequency sampling technique.

SLC: Design of Linear phase FIR filter using Kaiser Window.

Text books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principle, Algorithms and Applications, Fourth Edition, PHI, 2007.

Reference Books:

1. Johnny R. Johnson, Introduction to Digital Signal Processing, PHI, 2003.
2. B. Somanathan Nair, Digital Signal Processing, PHI, 2003.
3. P. Ramesh Babu, Digital Signal Processing, Fourth Edition, SciTech Publications, 2011.
4. A. Nagoor Kani, Digital Signal Processing, Second Edition, McGraw Hill Education (India) Private Ltd., 2012.

Course Title	INTRODUCTION TO SMART GRID		
Course Code	21EE732	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To demonstrate the modernization of Electrical Power Systems and to address Issues in Smart Grid Implementation.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Interpret different components of smart grid	1	1
2	Identify various avenues of Smart grid in context to real time power system operations.	1	1
3	Explain and analyze operational features of Smart grid.	1	1
4	Assess role of Smart grid to address real life challenges in power system operation and control	1,6	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3												3	
CO3	3												3	
CO4	3					2							3	

MODULE-1	10 Hrs

Introduction to Smart Grid: Evolution of Electric Grid, Evolution of Indian National Grid, Regulatory authorities in Indian Power sector, Concept of Smart Grid, Why implement the Smart Grid now? Early Smart Grid initiatives, Overview of the technologies required for the Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid.

Information and communication technologies: Data communication- Introduction, switching techniques and communication channels. Layered architecture and protocols-ISO/OSI model and TCP/IP

SLC: Smart grid initiatives in India

MODULE-2	10 Hrs

Sensing, Measurement, Control and Automation Technologies: Smart metering: Key components of smart metering, overview of the hardware used, Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication. Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations.

SLC: Cyber Security for Smart Grid

MODULE-3	10 Hrs

Distribution automation equipment: Introduction, Substation automation equipment, Current transformers, Voltage transformers, Intelligent electronic devices, Bay controller, Remote terminal units. Faults in the distribution system: Components for fault isolation and restoration, Fault location, isolation and restoration , Voltage regulation.

Distribution Management System: Data sources and associated external systems-structure and main components, modelling and analysis tools, Applications.

SLC: Computational tools to Smart Grid

MODULE-4	10 Hrs

Transmission system operation: Introduction, Data sources, IEDs and SCADA, Phasor measurement units, Energy management systems, Wide area applications, On-line transient stability controller, Pole-slipping preventive controller. **Energy storage**- Introduction, various energy storage technologies. Case study- Agent based control of EV battery charging.

SLC: Microgrid and renewable energy.

Text books:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", wiley India.

Reference Books:

1. Bharat Modi, Anu prakash and Yogesh Kumar "Fundamentals of Smart Grid Technology"
2. James Momoh "*SMART GRID Fundamentals of Design and Analysis*", IEEE press, A John Wiley & Sons, Inc., Publication

Course Title	**ELECTRICAL ENGINEERING MATERIALS**		
Course Code	**21EE733**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To enhance the knowledge on electrical engineering materials.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Classify the different electrical engineering materials.	1	-
2	Use the knowledge for different devices and machines	1	-
3	Explain the various electrical materials used in various electrical applications.	1,2	-
4	Classify the different electrical engineering materials.	1	-

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2													
CO2	2													
CO3	2	3												
CO4	2													

MODULE-1	**8 Hrs**

Conducting Materials: Classification of materials based on Atomic structure for conductor, insulator, semiconductor, Types of conducting materials, materials of high and low resistivity, Materials used for Lamp, Transmission lines, concept of stranded conductors, bimetals, contact materials, carbon materials, Thermo-couple materials, skin effect, proximity effect, cryotron, Fuse material (Preece's Law)

MODULE-2	**12 Hrs**

Insulation and dielectric materials: Introduction, electric dipole, dipole moment, dielectric materials, polar & non-polar dielectrics**,** static dielectric constant, electrical polarization mechanisms, temperature dependence of dielectric constant, internal fields in liquids and solids, dielectric losses. Characteristics of a good insulating materials, Gaseous insulating material -properties and composition of gases, Liquid insulating material, solid insulating material, insulating varnishes, insulating materials for transformers, machines, instrument & magnet wires, capacitors, overhead transmission lines.

MODULE-3	**10 Hrs**

Magnetic Materials: Introduction, magnetic parameters, classification of magnetic materials, principal ferromagnetic elements, Ferromagnetism, magnetic domains. Magnetic Anisotropy, magnetostriction, paramagnetism, diamagnetism, magnetically soft materials, magnetically hard materials, B-H curves of soft and hard magnetic materials, special purpose materials, feebly magnetic materials and its application.

MODULE-4	**10 Hrs**

Materials for electrical components: Resistors – carbon composition resistor, insulated moulded resistor**,** film type resistor , cracked carbon resistor, alloy resistor, wire wound resistor , thermistor Capacitor – ceramic dielectric capacitor , glass-dielectric capacitor, plastic dielectric capacitor, Inductor**s**, Relays and its types and Problems.

Text books:

1. A.J Dekker, Prentice Hall India Learning Private Limited.
2. Electrical engineering Materials, R.K Rajput, Laxmi Publications.
3. An Introduction to Electrical Engineering Materials by Dr.C.S Indulkar, Dr.S.Thiruvengadam

Course Title	POWER SYSTEM OPERATION AND CONTROL		
Course Code	21EE734	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To create practical insight about Power System Operation and Control, hence study several intricate issues involved

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the fundamental principles of power system operation and control, including the various operating states and control objectives	1	1
2	Develop various mathematical models for control mechanisms.	2	1
3	Analyse the economic and operational aspects of power systems with different methods	2	1
4	Solve various real life problems with respect to modern methods used in power system operation and control	2	-

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2												1	
CO2		2											1	
CO3		2											1	
CO4		1												

MODULE-1	10 Hrs

Introduction to Power system operation and control: Introduction, operating states of Power system, objectives of Power system control, key concepts of reliable operation, major threats to system security- case study.

Introduction to SCADA, components of SCADA system. Digital computer configuration. Introduction to voltage and reactive power control-production and absorption of reactive power, methods of voltage control by reactive power injection.

SLC - *Indian power sectors*

MODULE-2	10 Hrs

Automatic Generation control and interconnected Power systems:

Introduction, basic generator control loops, commonly used terms in AGC, functions of AGC, speed governors, mathematical model of ALFC, Automatic generation controller, proportional integral controller, Tie-line control with primary speed control, Tie-line bias control (frequency bias Tie-line control)

SLC - *Practical implementation of AGC in India.*

MODULE-3	10 Hrs

Economic Operation of Power Systems: Introduction to Economic and Operational aspects of Power Systems, Optimal system operation with thermal plants, constraints in economic operation, Spinning reserve, Performance Curves, Incremental production costs for steam power plants, Problems of Economic Load Scheduling - solution through Equal Incremental cost criterion for operation of power plants, EqualIncremental cost criterion for operation of power plants with generation capacity limits and transmissionlosses considered, transmission loss as a function of plant generation, the B-coefficients, expression for incremental transmission loss in terms of B-coefficients, Numerical Examples comprising of all the casesincluded above.

SLC- *Algorithm for economic dispatch problem including losses*

MODULE-4	10 Hrs

Unit commitment: Introduction, Constraints in unit commitment, Priority list method, dynamicprogramming, Alternative approaches to unit commitment

SLC-*Security of power system*

Text books:

1. Power System Operation and Control, Dr. K Uma Rao, Wiley India.

Reference Books:

1. George L. Kusic; Computer Aided Power System Analysis, PHI, New Delhi, II Edition Reprint, 2003. Calculus by Thomas Finney, 9th edition, Pearson education, 2002.
2. B.M. Weedy , B.J. Cory; Electric Power systems, John Wiley and sons, 4th edition.

PROFESSIONAL ELECTIVE COURSE – IV

Course Title	**INDUSTRIAL DRIVES AND APPLICATIONS**		
Course Code	**21EE741**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To analyze the working of various electrical machines fed from power converters

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Describe the dynamics of electric drives.	1	1
2	Analyse the operation of DC, Induction and Synchronous motor drives.	1,2	1
3	Solve numerical problems on control of motor drives.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2												2	2
CO2	2	3											2	2
CO3	2	3											2	2

MODULE-1	**12 Hrs**

An Introduction to Electrical Drives and Its Dynamics: Electrical drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, fundamental torque equation, speed torque conventions and Multiquadrant operation, equivalent value of drive parameters , components of load torques, nature & classification of load torques, load equalization.

SLC: Status of AC&DC drives

MODULE-2	**10 Hrs**

DC Motor Drives: Introduction to DC motors, starting, braking, Transient Analysis-(a) Transient analysis of separately excited motor with armature control (b) Transient analysis of separately excited motor with field control., **Controlled Rectifier Fed DC drives**-(a) Single phase fully controlled rectifier control of DC separately excited motor (b) Single phase half-controlled rectifier control of DC separately excited motor (c) Dual converter control of DC separately excited motor (d) Control of fractional HP motors.

SLC: Speed control, Methods of Armature Voltage control

MODULE-3	**10 Hrs**

Induction Motor Drives: Introduction to IM, Operation with unbalanced source voltages and single phasing, operation with unbalanced rotor impedances, starting, braking, variable frequency control from voltage sources, Voltage source inverter control, slip power recovery, linear induction motor and its control.

SLC: Cycloconverter converter

MODULE-4	**8 Hrs**

Synchronous Motor Drives: Introduction to synchronous motors, Operation from fixed frequency supply, synchronous motor variable speed drives, Sinusoidal PMAC Motor drives

SLC: Brushless DC motor Drives

Text books:

1. K.Dubey, Fundamentals of electric drives, 2nd Edition, Naroso Publishing House, 5th Reprint, Chennai-2002

Reference Books:

1. N.K.De & P.K.Sen, Electrical Drives, PHI-2007.
2. S.K. Pillai, A First Course on Electric Drives, Wiley Eastern Ltd.

Course Title	**ELECTRICAL POWER QUALITY**		
Course Code	**21EE742**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To interpret the power quality phenomenon and estimate the harmonics in electrical systems.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Recognize the different terminologies of power quality.	1,2	1
2	Interpret the various power quality variations.	1,2	1
3	Apply suitable solutions for transients and harmonics.	1,2	1
4	Describe the interconnection standards associated with power quality.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											2	
CO2	2	2											2	
CO3	3	2											2	
CO4	2	2											2	

MODULE-1 **10 Hrs**

Introduction: Power Quality-voltage quality, power quality evaluation procedures, general classes of power quality problems, transients-long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuations, power quality terms.

MODULE-2 **10 Hrs**

Voltage sags and Interruptions: Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, Motor sags.

Transients over voltages: Sources of transients over voltages, principles of over voltages protection, utility capacitor switching transients.

MODULE-3 **10 Hrs**

Fundamentals of harmonics: Harmonic distortion, harmonic indexes, harmonic sources from commercial loads, harmonic sources from industrial loads, effects of harmonics distortion.

Applied Harmonics: Harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters.

MODULE-4 **10 Hrs**

Power quality benchmark: Introduction, benchmark in process, power quality contract, power quality state estimation, including power quality in distribution planning, interface to utility system, power quality issues, interconnection standards.

Text books:

1. Dugan, Roger C, Santoso, Surya, McGranaghan, Mark F/Beaty and H.Wayne, Electric power qulity, McGraw-Hill Professional Publication 2003.

Reference Books:

1. G.T. Heydt, Electric Power Quality, stars in a circle publications 1991.
2. M.H. Rashid, Modern Power Electronics Tata McGraw Hill 2002.
3. Math H.J. Bollen, understanding Power quality problems voltages sags and interruptions IEEE Press, 2000.

Course Title	FLEXIBLE AC TRANSMISSION SYSTEMS		
Course Code	21EE743	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To understand importance of FACTS controller in transmission system.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain basics of Flexible AC Transmission Systems.	1	1
2	Apply the concepts of Static Var Compensator and STATCOM.	1,2	1
3	Describe the operation of TCSC, GCSC, TSSC, SSSC.	1,2	1
4	Apply the concepts of voltage regulators, phase angle regulators, UPFC and IPFC.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3	3											3	
CO3	2	3											2	
CO4	2	3											2	

MODULE-1 — 10 Hrs

FACTS Concepts & General System Considerations: Flow of power in an AC system, limits of the loading capability, Power flow and dynamic stability considerations of a transmission interconnection, relative importance of controllable parameters, Basic types of FACTS controllers, Brief description and definitions of FACTS controllers, Benefits from FACTS.

Voltage Sourced Converters: Basic concept, Single-phase full-wave bridge converter operation, Single phase-leg operation, square wave voltage harmonics for a single-phase bridge, three phase full wave bridge converter, sequence of valve conduction process in each phase-leg.

MODULE-2 — 10 Hrs

Static Shunt Compensator - SVC: Objective of shunt compensation, Methods of controllable VAR generation (Variable Impedance type, Switching converter type, Hybrid Var generators), Types and V-I Characteristics of - TCR, TSR, FC-TCR.

STATCOM: Comparison between SVC and STATCOM, The Principle of STATCOM Operation, The V-I Characteristic, The regulation slope, Transfer function and dynamic performance, transient stability enhancement and power oscillation damping, Var reserve control.

MODULE-3 — 10 Hrs

Static Series Compensators- TCSC, GCSC, TSSC: Objectives of series compensation, Variable impedance type of series compensators: Fixed-Series Compensation, Thyristor-Controlled Series Capacitor (TCSC), Advantages of the TCSC, Operation of the TCSC, Modes of TCSC Operation- Bypassed-Thyristor Mode, Blocked-Thyristor Mode, Partially Conducting Thyristor and Vernier Mode, V-I characteristics of TCSC. Operation and V-I characteristics of GCSC and TSSC.

Switching converter type series compensators- SSSC: The Principle of Operation, V-I characteristics, capability to provide real power compensation, immunity to sub-synchronous resonance.

MODULE-4 — 10 Hrs

Static Voltage and phase angle regulators: Objectives of Voltage and Phase Angle Regulation, Power Flow Control by Phase Angle Regulators, Real and Reactive Loop Power Flow Control, Improvement of Transient Stability with phase Angle Regulators , Power Oscillation Damping with phase Angle Regulators, Approaches to Thyristor-Controlled Voltage and phase Angle Regulators (TCVRs and TCPARs) , Continuously Controllable Thyristor Tap Changers, Continuously Controllable Thyristor Tap Changers, Thyistor Tap Changer with Discrete Level Control, switching converter based voltage and phase angle regulators, Hybrid Phase Angle Regulators.

Unified Power Flow Controller –UPFC: Introduction, The Unified Power Flow Controller, Basic Operating Principles, Conventional Transmission Control Capabilities, Interline **Power Flow Controller** -**IPFC**: Basic Operating Principles and Characteristics.

Text books:

1. Narain G. Hingorani and Laszlo Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, Standard Publishers Distributors, Delhi, First Edition, 2001.
2. R. R. Mohan Mathur and Rajiv K. Varma, THYRISTOR-BASED FACTS CONTROLLERS FOR ELECTRICAL TRANSMISSION SYSTEMS, IEEE Press, John Wiley and Sons, First Edition, 2002.

Reference Books:

1. K. R. Padiyar, FACTS, Controllers in Power Transmission and Distribution, New Age International Publishers, First Edition, 2007.

Course Title	**SOLAR POWER CONVERSION SYSTEMS**		
Course Code	**21EE744**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To design solar PV system for real time applications.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the structure of solar PV cells, connection diagrams of modules and array for real time applications.	1,2	1
2	Apply concepts of solar thermal and PV systems.	1,2	1
3	Analyze sizing of solar modules, battery and inverter systems for standalone applications.	1,2	1
4	Estimate real time cost of solar PV system.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											3	
CO2	3	2											2	
CO3	3	2											3	
CO4	3	1											2	

MODULE-1	**10 Hrs**

Basic of Solar PV Cells: Structure of solar cell, types of solar cell, equivalent circuit of a PV cell, I-V and P-V characteristics solar cell, solar cell efficiency, fill factor, Effects of temperature, irradiance, series and shunt resistance on characteristics of solar cell.

Solar Photovoltaic Modules: Solar PV modules & arrays from solar cells - Series and parallel connection of modules, mismatch in cell/module. Mismatch in series connection - Hot spots in the module & bypass diode, mismatching in parallel connection - blocking Diode.

SLC: MPPT Technology

MODULE-2	**10 Hrs**

Solar Thermal Systems Design & Applications: Solar thermal systems-concentrating & non- concentrating types of collectors with examples. Liquid Flat plate collectors –working principle, Performance analysis, Energy gain and thermal efficiency, numerical examples.

Applications – Solar water heater-working principle, types of heating system, components &specifications, design & costing of solar water heater. Solar cooking systems-Box type & dish type solar cookers-materials used, payback period calculations. Solar based power generation.

SLC: Space heating systems

MODULE-3	**10 Hrs**

Photovoltaic Systems Design & Applications: Basic components of SPV system, stand-alone PV system configurations. Design methodology of PV systems-PV –powered DC Fan without battery system, PV powered

DC pump. Design of stand-alone PV system with battery & inverter for AC - DC load- Design of sizing of PV module, inverter, Battery bank for a given AC load and numerical examples. Hybrid PV systems-, types of hybrid systems, issues with hybrid system. Grid connected PV systems –two stage grid connected systems.
SLC: Battery storage system

MODULE-4	**10 Hrs**

Economic analysis: Lifecycle costing (LCC), time value of money**,** present worth of future one –time investments, present worth of future worth of future recurring investments, Life cycle cost, Annualized LCC (ALCC), unit cost of generation and numerical examples. Initial and annual costs, definitions, Repayment of loan in equal annual installments costs, Annual solar savings, Cumulative solar saving (CSS) and lifecycle savings, payback period and numerical examples.
SLC: ADD-ON solar systems.

Text books:

1. Chetan Singh Solanki, Solar Photovoltaic - Fundamentals, Technologies and Applications. 3rd edition, PHI Learning Pvt. Ltd.
2. S.P. Sukhatme, Solar Energy: Principles of thermal collection and storage. McGraw-Hill Education, 1996.

Reference Books:

1. ChenmingHu,R. M. White, Solar cells-From Basic to Advanced Systems, McGraw-Hill, 1983.
2. G.D. Rai, Non-conventional Energy Sources
3. D.Yogi Goswami, F.Kreith andJ.F.Kreider: Principles of Solar Engineering, McGraw Hill, 1978.

ELECTIVE – VI (INDUSTRY ELECTIVE)

Course Title	PLC FOR INDUSTRIAL APPLICATIONS		
Course Code	21EE751	(L-T-P) C	(0-0-1) 1
CIE	50	Hours/Week	2
SEE	50	Total Hours	26

Course Objective: To develop PLC programs for industrial applications.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Describe architecture and hardware of PLC.	1,5	2
2	Discuss input, output devices used with PLCs.	1,5	2
3	Apply ladder programming using basic and advanced ladder logic to solve control problems.	1,2,3,5	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3									2
CO2	3				3									2
CO3	3	2	2	2	3									2

MODULE-1	6 Hrs

Introduction to PLC: Programmable logic controller hardware and internal architecture, CPU, buses, memory, input/output unit, sourcing & sinking, PLC programming.

Input devices: Common terms to define performance of sensors, mechanical switches, proximity sensors, photoelectric sensors and switches, encoders, temperature sensors.

SLC: IEC 61131 Standard for PLCs.

MODULE-2	6 Hrs

Input devices: Position/displacement sensors, strain gauge, pressure sensors, liquid level sensor, fluid flow sensor, smart sensor.

Output devices: Relay, solenoids and directional valves, dc motor control, stepper motor drives.

SLC: single and double acting cylinders

MODULE-3	6 Hrs

PLC Ladder programming: Ladder diagrams, PLC ladder programming, logic functions, multiple outputs, latching, interlocking, entering programs, ladder programs for simple applications.

Advanced Ladder Logic: Jump, jumps within jumps, subroutines, master control.

SLC: function blocks

MODULE-4	7 Hrs

Advanced Ladder Logic: Types of timers, on-delay timer, off-delay timer, pulse timer, retentive timer, forms of counters, up-counter, down-counter, ladder programs for industrial applications

SLC: Timers with counters.

Text books:

1. W. Bolton, **"Programmable Logic Controllers"**, Elsevier Publication, Oxford UK.

Reference Books:

1. E.A Paar, "Programmable Controllers-An Engineers Guide", Newness publication.
2. Johnson Curties, "Process Control Instrumentation Technology", 8th edition, Prentice Hall of India.
3. John W Webb, Ronald Reis, "Programmable logic controller: principle and application", Pearson publication.

OPEN ELECTIVE – II

Course Title	SMART GRID TECHNOLOGIES		
Course Code	21OEEE71	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To demonstrate the modernization of Electrical Power Systems and to address Issues in Smart Grid Implementation.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Interpret different components of smart grid	1	1
2	Identify various avenues of Smart grid in context to real time power system operations.	1	1
3	Explain and analyze operational features of Smart grid.	1	1
4	Assess role of Smart grid to address real life challenges in power system operation and control	1,6	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3												3	
CO3	3												3	
CO4	3					2							3	

MODULE-1	10 Hrs

Introduction to Smart Grid: Evolution of Electric Grid, Evolution of Indian National Grid, Regulatory authorities in Indian Power sector, Concept of Smart Grid, Why implement the Smart Grid now? Early Smart Grid initiatives, Overview of the technologies required for the Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid.

Information and communication technologies: Data communication- Introduction, switching techniques and communication channels. Layered architecture and protocols-ISO/OSI model and TCP/IP

SLC: Smart grid initiatives in India

MODULE-2	10 Hrs

Smart Grid Enabling Technologies: Smart metering: Key components of smart metering, overview of the hardware used, Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication.

Communications infrastructure*:* Home-area network, Neighborhood area network, Data concentrator, Meter data management system, Protocols for communications.

SLC: Cyber Security for Smart Grid

MODULE-3	10 Hrs

Demand-side integration: Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations

Smart Measurement and Monitoring Technologies: Smart Substations, Substation Automation equipment's. Intelligent Electronic Devices (IED) & their application for monitoring & protection.

SLC: Computational tools to Smart Grid

MODULE-4	10 Hrs

Distribution management systems: Introduction , Data sources and associated external systems , SCADA , Modelling and analysis tools : Topology analysis , Load forecasting , Power flow analysis , Fault calculations , Other analysis tools.

Energy Storage Technologies: introduction, various energy storage technologies. Case study- Agent based control of EV battery charging.

SLC: Microgrid and renewable energy.

Text books:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", wiley India.

Reference Books:

1. Bharat Modi, Anu prakash and Yogesh Kumar "Fundamentals of Smart Grid Technology"
2. James Momoh "*SMART GRID Fundamentals of Design and Analysis*", IEEE press, A John Wiley & Sons, Inc., Publication

Course Title	**UTILIZATION OF ELECTRICAL POWER**		
Course Code	**21OEEE72**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To understand usage of power in various electrical applications.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Discuss the operation of electric drives	1	1
2	Describe different methods of electrical heating and electric welding.	1,2	1
3	Explain various techniques for designing indoor &outdoor lighting schemes	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												2	
CO2	3	3											2	
CO3	3	3											2	

MODULE-1 **10 Hrs**

ELECTRIC DRIVES: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, particular applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization.

MODULE-2 **10 Hrs**

ELECTRIC HEATING AND WELDING: Advantages and methods of electric heating, resistance heating induction heating and dielectric heating. Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding.

MODULE-3 **10 Hrs**

ILLUMINATION FUNDAMENTALS AND ILLUMINATION METHODS: Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere, sources of light. Discharge lamps, MV and SV lamps – comparison between tungsten filament lamps and fluorescent tubes, Basic principles of light control, Types and design of lighting and flood lighting.

MODULE-4 **10 Hrs**

ELECTRIC TRACTION: System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking-plugging rheostatic braking and regenerative braking.

Text books:

1. "Utilization of electrical energy" by E.O.Taylor.
2. "Electrical Drives: Concept and applications" by Vedam Subrahmanyam" THM.

Reference Books:

1. "Art and Science of Utilisation of Electrical Energy" by H.Pratab, DhanpatRai& Co.

Course Title	RESEARCH METHODOLOGY & INTELLECTUAL PROPERTY RIGHTS		
Course Code	21RIP01	(L-T-P) C	(0-2-0) Audit
CIE	100	Hours/Week	2
SEE	-	Total Hours	28

Course Objective: Understand research methodology, design, data collection, and analysis techniques and gain knowledge of Intellectual Property Rights (IPR) with a focus on patents, designs, trademarks, and copyrights, including their registration and protection procedures.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Acquire research skills and conduct comprehensive literature reviews	8,10, 12	-
2	Apply research design knowledge to create prototype	3,4, 8, 10,12	-
3	Evaluate methods for data collection, analysis, and sampling design	4, 8, 10, 12	-
4	Understand global and Indian patent scenarios, as well as registration requirements, infringements and protections related to trademarks, copyrights, and designs	6,8, 10, 12	-

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1								3		2		3		
CO2			3	3				3		2		3		
CO3				3				3		2		3		
CO4						3		3		2		3		

MODULE-1	7 Hrs

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Types of Research, Ethics in Research, Types of Research Misconduct. Literature Review and Technical Reading. Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge flow through Citations, Acknowledgments.

MODULE-2	7 Hrs

Research Design: Need for Research Design, Important Concepts Related to Research Design: Dependent and Independent Variables, Extraneous Variable, Variable, Common Control, Confounded Relationship, Research Hypothesis. Experimental Designs: Introduction to Randomized Block Design, Complete Randomized Design, Latin Square Design, and Factorial Design.

MODULE-3	7 Hrs

Method of Data Collection: Primary and Secondary Data Collection. Sampling Design: Sampling fundamentals, Measurement, and Scaling Techniques, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, and Types of Sample Design. Data Analysis: Testing of Hypotheses: Null Hypothesis, Alternative Hypothesis, Type I and Type II Errors. Procedure for Hypothesis Testing: Mean, Variance, and Chi-square Test.

MODULE-4	7 Hrs

Introduction to IPR: Different forms of IPR, Role of IPR in Research and Development. Patents: Principles Underlying Patent Law, Types of Patent Applications in India, Procedure for Obtaining a Patent. Design: What is a Design? Essential Requirements for a Registrable Design, Procedure of Registration of a Design. **Trademarks:** Essentials of a Trademark, Registration, and Protection of Trademarks, Rights Conferred by Registration of Trademarks, Infringements. Copyrights:
Characteristics of Copyrights, Rights Conferred by Registration of Copyrights, Registration of Copyrights, Infringements, Remedies against Infringement of Copyrights.

Activity Components

- Students select a research topic and perform a literature review, identifying existing knowledge, synthesizing prior art, and compiling relevant citations leading to publishing a survey paper.
- Students develop research proposals, including the formulation of research hypotheses.

- Students collect primary or secondary data, design a sampling procedure, and perform data analysis using statistical techniques.
- Students analyze real-world case study/studies for legal issues and propose solution/s to infringement cases.

The rubrics for evaluation will be set suitably as decided by the BOS and will be announced to the students at the beginning of the semester.

Text books:

1. Kothari C R. Research methodology: Methods and techniques. New Age International; 2004.
2. Pandey N, Dharni K. Intellectual property rights. PHI Learning Pvt. Ltd.; 2014 Jul 30.
3. Deb D, Dey R, Balas V E. Engineering research methodology. A Practical Insight for Researchers. 2019;153.

Reference Books:

1. Thiel D V. Research methods for engineers. Cambridge University Press; 2014 Sep 11.

Course Title	Research/Industry Internship III		
Course Code	21INT3	(L-T-P)C	(0-0-24) 12
Exam	3 Hrs.	Weeks	14-16 weeks
CIE	100 Marks	Total Hours	---

Course Objective: It involves a short theoretical or experimental research project supervised by a researcher/ To bridge the gap between the theoretical knowledge obtained in the classrooms and the practical skills required in the actual workplace

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO's
1	Get exposure to real world job environment and gain practical experience	1,2,3,4,5,10,12
2	Generating technical paper/s and publish in refereed journal/s and conferences	1,2,8,9,10,12

Guidelines for Research Internship III	
Purpose	It involves a short theoretical or experimental research project supervised by a researcher.
Skills acquired	• Planning and scheduling. • Documentation. • Critical thinking. • Data collection. • Data analysis. • Appreciating and practicing the ethical values.
Expected Outcomes	• Generating technical paper/s and publish in refereed journal/s. • Possibility of acquiring an intellectual ownership and patent. • Build a prototype for an idea on which the research was carried out. • File patent/s.
Selection	• In consultation with a researcher/ researchers working in MCE research Centre • A research institute • Company's R and D department.
Team Size	Can be carried out either individually or in a team(**Upto 5 students**)
Venue	Laboratory of college A research institute Company's R and D department.
Supervision	Internship shall be carried out under the supervision of a faculty mentor* at the department level For all students attending in-house internship, the attendance should be maintained by the Faculty mentor

Parameters for Assessment	Diary Report presentation skill Technical Paper Recommendation Letter from the guide
Evaluation	**CIE (100 Marks)–**The CIE marks shall be awarded by a committee* consisting of the faculty mentor and two faculty members of the Department, one of whom shall be the Guide (applicable for in-house interns). The schedule for evaluation will be announced by chairman BOE at the end of the semester. The Evaluation can be done in ***phases as decided by the internal BOS*** of the department. The contents of the report and the evaluation Rubrics will be set by the Department based on the assessment parameters **SEE (100 Marks)–** Contribution to the internship and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department. Marks shall be awarded based on the evaluation of the diary, report, presentation skill and viva voce
*For interdisciplinary internship its necessary to involve an expert from each discipline	
Guidelines for Industry Internship III	
Purpose	To bridge the gap between the theoretical knowledge obtained in the classrooms and the practical skills required in the actual workplace
Skills acquired	• Applying the theoretical knowledge in a practical scenario • Build confidence in applying the skills learnt • Documentation • Communication • Appreciating and practicing the ethical values
Expected Outcomes	• Get exposure to a real world job environment and gain practical experience • Build confidence in applying the skills learnt. • Enhances Placement Opportunity
Selection	• Can select individually • Can seek the help from the department
Team Size	Can be carried out either individually or in a team(**not exceeding 5 students**).
Venue	In a domain specific organization

Supervision	Internship shall be carried out under the supervision of a faculty mentor* at the department level. One faculty mentor can supervise a maximum of 20 students.
Parameters for Assessment	Diary Report presentation skill Recommendation Letter from the guide
Evaluation	**CIE (100 Marks) -**The CIE marks shall be awarded by a committee* consisting of the faculty mentor and two faculty members of the Department, one of whom shall be the Guide (applicable for in-house interns). The schedule for evaluation will be announced by chairman BOE at the end of the semester. The Evaluation can be done in ***phases as decided by the internal BOS*** of the department. The contents of the report and the evaluation Rubrics will be set by the Department based on the assessment parameters **SEE (100 Marks)-** Contribution to the internship and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department. Marks shall be awarded based on the evaluation of the diary, report, presentation skill and viva voce
*For interdisciplinary internship its necessary to involve an expert from each discipline	

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	-	-	-	-	3	-	3		
CO2	3	3	-	-	-	-	-	3	2	2	-	3		