MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belagavi)

Autonomous Programmes

Bachelor of Engineering

SCHEME AND SYLLABUS

(2023 Admitted Batch)

Dr. RAJANNA S. M.Tech., Ph.D., (IITR)
Professor & Head
Dept of E&E Engineering
Malnad College of Engineering
HASSAN 573202

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING
Academic Year: 2026 – 2027

VISION of the Department

To become a department of excellence in the domain of Electrical and Electronics Engineeringproducing 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

PEO1: Pursue a diverse range of career as engineers and researchers.
PEO2: Design and develop innovative systems to provide best solutions to electrical engineering problems.
PEO3: Learn and adapt in a world of constantly evolving technology.

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: Acquire core competency in analyzing, designing and controlling electrical and electronic systems to meet industrial and societal needs.

PSO2: Adopt technology by leveraging state-of-the-art and AI tools to develop innovative solutions in emerging areas like renewable energy, electric vehicles and embedded 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**

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Regulations governing the award of B.E. (2023) Scheme

Credit Breakup for a Programme			
Sl. No	Category	Credits(AICTE Breakup)	MCE – Department of EEE
1.	Humanities and Social Sciences including Management courses, including AE	16	18
2.	Basic Science Courses	22	20
3.	Engineering Science course including workshop, drawing,basics of electrical / mechanical / computer / PL / ET etc.	24	17
4.	Professional Core courses relevant to chosen specialization/branch	59	62
5.	Professional Elective courses relevant to chosen specialization/branch	12	13
6.	Open subjects - Electives from other technical and/or emerging subjects	12	12
7.	Project work and internship in industry or elsewhere	15	18
8.	Mandatory Courses	(non-Credit)	-
Total		**160**	**160**

Semester-wise Allocation of Credits

Year	Semester	Credits	Total Credits
I Year	1	20	40
	2	20	
II Year	3	23	45
	4	22	
III Year	5	22	43
	6	21	
IV Year	7	19	32
	8	13	
Total		160	**160**

- Lecture (L): one hour/week : 1 credit
- Tutorial (T): Two hours/week : 1 credit
- Practical/Lab/Drawing(P): Twohours/week : 1 credit

The duration for courses: Integrated courses and courses with tutorial can have more teaching hours:

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

Scheme of Teaching for the 2023-24 Admitted Batch

THIRD SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
BSC	23MA301	Linear Algebra and Integral Transforms	3-1-0	3	4
PCC	23EE302	Electrical Network Analysis	4-1-0	4	5
IPCC	23EE303	Analog Electronic Circuits (Integrated Laboratory)	3-0-2	4	5
PCC	23EE304	Electric Power Generation &Transmission	4-0-0	4	4
PCC	23EE305	Transformers & Induction Machines	3-0-0	3	3
ESC	23ESEE3X	Engineering Science Course - II	3-0-0	3	3
HSMC	23SCR3X	Social Connect and Responsibility	0-0-2	1	2
AEC	23AEEE3X	Ability Enhancement Course - III	0-0-2	1	2
BSC	23BCM3XX	Bridge Mathematics-1 (Mandate Audit course for Diploma entry students)	3(A)-0-0	Audit	3
MC	23NYP3X	NSS/Yoga/PE	0-0-2(A)	Audit	2
Total				**23**	**33**

Engineering Science Courses – II			
23ESEE31	Electrical and Electronics Measurements	23ESEE33	Sensors and Transducers
23ESEE32	Introduction to PLC	23ESEE34	IoT and its Applications
Ability Enhancement Courses – III			
23AEEE31	Electric Circuits Laboratory	23AEEE33	Electrical Measurements Laboratory
23AEEE32	Electrical Engineering Practices Laboratory	23AEEE34	Renewable Energy Laboratory

FOURTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
IPCC	23EE401	Digital Electronic Circuits (Integrated Laboratory)	3-0-2	4	5
PCC	23EE402	Power Electronics	3-0-0	3	3
IPCC	23EE403	Synchronous and Special Electrical Machines (Integrated Laboratory)	3-0-2	4	5
IPCC	23EE404	Microcontrollers (Integrated Laboratory)	3-0-2	4	5
PCC	23EE405	Transformers & Induction Machines Laboratory	0-0-2	1	2
ETC	23ETC42X	Emerging Technology Course - II	3-0-0	3	3
HSMC	23UHV4X	Universal Human Values	0-0-2	1	1
BSC	23BE4X	Biology for Engineers	1-0-0	1	2
AEC	23AEEE4X	Ability Enhancement Course - IV	0-0-2	1	2
MC	23NYP4X	NSS/Yoga/PE	0-0-2	Audit	2
Total				**22**	**30**

Emerging Technology Courses - II			
23ETEE41	Fuzzy Logic Control	23ETEE43	Python for Electrical Engineers
23ETEE42	Battery Energy Storage Systems	23ETEE44	Object Oriented Programming with C++
Ability Enhancement Course - IV			
23AEEE41	Statistics with R	23AEEE43	Integrated Circuit Laboratory
23AEEE42	Simulation of Digital Electronic Circuits	23AEEE44	IoT Laboratory

FIFTH SEMESTER					
Course Category and Course Code		Course Title	L-T-P	Credits	Contact Hours
HSMC	23EE501	Industrial Management and Professional Engineering Practice	4-0-0	4	4
IPCC	23EE502	Linear Control Systems (Integrated Laboratory)	3-0-2	4	5
PCC	23EE503	Power System Analysis and Stability	3-0-0	3	3
PCC	23EE504	Electromagnetic Fields	3-0-0	3	3
PCC	23EE505	Power Electronics Laboratory	0-0-2	1	2
AEC	23RIP5X	Research Methodology & Intellectual Property Rights	3-0-0	3	3
PEC	23EE51X	Professional Elective Course - I	3-0-0	3	3
HSMC	23EVS5X	Environmental Studies	0-2-0	1	2
MC	23NYP5X	NSS/Yoga/PE	0-0-2	Audit	2
Total				**22**	**27**
The course analytical ability and soft skills 23ASK will be conducted by the TAP coordinator during the vacation period of fifth semester for one credit. The marks for the same will be entered in sixth semester grade card.					

Professional Elective Course – I			
23EE511	Renewable Energy Systems	23EE513	AI in Electrical Engineering
23EE512	Testing and commissioning of Electrical equipment	23EE514	Operational Amplifiers and Linear ICs

SIXTH SEMESTER					
Course Category and Course Code		Course Title	L-T-P	Credits	Contact Hours
PCC	23EE601	Electrical Machine Design	3-0-0	3	3
PCC	23EE602	Modern Control Theory	3-0-0	3	3
PCC	23EE603	Switchgear and Protection	3-0-0	3	3
PEC	23EE62X	Professional Elective Course - II	3-0-0	3	3
OEC	23OEX6X	Open Elective – I	3-0-0	3	3
PI	23PROJ61	Project Work Phase - I	0-0-4	2	4
PEC	23SW01	SWAYAM - I	0-1(A)-0	Audit	--
AEC	23ASK6X	Analytical Ability and Soft Skills	0-0-2	1	2
MC	23NYP6X	NSS/Yoga/PE	0-0-2	Audit	2
Total				**18**	**23**

Professional Elective Course – II			
23EE621	Flexible AC Transmission Systems	23EE623	Smart Grid Technologies
23EE622	Power System Operation and Control	23EE624	Signals and Digital Signal Processing
Open Elective – I			
23OEEE61	Basic Power Electronics	23OEEE62	Alternate Energy Sources

SEVENTH SEMESTER					
Course Category and Course Code		Course Title	L-T-P	Credits	Contact Hours
IPCC	23EE701	Computer Methods in Power Systems (Integrated Laboratory)	3-0-2	4	5
PCC	23EE702	High Voltage Engineering	3-0-0	3	3
PCC	23EE703	Relay and High Voltage Laboratory	0-0-2	1	2
PEC	23EE73X	Professional Elective Course - III	3-0-0	3	3
PEC	23EE74X	Elective -IV (Industry Elective)	1-0-0	1	1
OEC	23OEX7X	Open Elective -II	3-0-0	3	3
PI	23PROJ71	Project Work Phase - II	0-0-8	4	8
Total				**19**	**25**

Professional Elective Course – III			
23EE731	Energy Auditing & Demand-Side Management	23EE733	Solar Power Conversion Systems
23EE732	Automation in Industry 4.0	23EE734	Electrical Power Quality
Open Elective – II			
23OEEE71	Smart Grid Technologies	23OEEE72	Utilization of Electric Power
23OEEE73	Electric Vehicle Technology		

EIGHTH SEMESTER					
Course Category and Course Code		Course Title	L-T-P	Credits	Contact Hours
PEC	23SW02	Professional Elective (Online Courses) Only through NPTEL - SWAYAM - II		3	12 (weeks)
OEC	23SW03	Professional Elective (Online Courses) Only through NPTEL - SWAYAM - III		3	12 (weeks)
PI	23INT	Internship (Research / Industry)	0-0-20	10	20
Total				**16**	**20**

SEVENTH SEMESTER

Course Title	COMPUTER METHODS IN POWER SYSTEMS		
Course Code	23EE701	(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	HIGH VOLTAGE ENGINEERING		
Course Code	23EE702	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To learn the technology associated in high voltage generation, measurement and testing.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the classification, need to generate high voltages and applications of high voltages.	1	1
2	Demonstrate fundamental knowledge of gaseous insulation and theoretically analyze criterion for electrical breakdown of gaseous insulating media.	1,2	1
3	Describe the techniques of generating HVAC, HVDC, Lightning & Switching impulse voltage and current.	1,2	1
4	Explain measurement of high voltages, high currents and high voltage surges.	1,2	1

MODULE-1 — 10 Hrs

Introduction: Introduction to HV technology, Advantages of electric power transmission at high voltages. Need for generating high voltages in a laboratory. Important applications of high voltages. Types of HV insulators, cables and bushings. Breakdown phenomena: Classification of HV insulating media. Gaseous dielectrics: Ionization: Primary and secondary ionization processes. Criterion for gaseous insulation breakdown based on Townsend's theory. Limitations of Townsend theory, Streamer theory, Corona discharges. Breakdown in electronegative gases. Paschen's law and its significance. Time lags of breakdown.

SLC: Solid insulating media.

MODULE-2 — 10 Hrs

Generation of High voltage AC and DC: HVAC - HV transformer; Need for cascade connection and working of transformers units connected in cascade. Series resonant circuit - Principle of operation and advantages. Tesla coil. HVDC - Voltage doubler circuit. Cockcroft-Walton type high voltage DC set. Calculation of Voltage regulation, Ripple and Optimum number of stages for minimum voltage drop.

SLC: Potential dividers - Resistance dividers, Capacitance divider.

MODULE-3 — 10 Hrs

Generation of Lightning Impulse voltages: Introduction to standard Lightning Impulse (LI) voltages and necessity of generating them in a laboratory. Analysis of single stage impulse generator – Deriving impulse voltage expression representing a double exponential wave. Multistage IG and Generation of LI & SI voltages: Multistage impulse generator working on Marx principle. Rating of a Multistage impulse generator. Components of Multistage impulse generator.

SLC: Types and working of Lightning arrestors.

MODULE-4 — 10 Hrs

Measurement of high voltages, currents and surges: Electrostatic voltmeter - Principle, construction and limitations. Chubb and Fortes cue method for HVAC measurement. Generating voltmeter - Principle and construction. Standard sphere gap for measurement of various types of high voltages; Factors affecting the measurements. Potential dividers - Resistance dividers, Capacitance divider, Mixed RC potential divider. Surge measurement - Klydanograph and magnetic links, Introduction to Partial discharges (PD), PD measurement.

SLC: Testing of insulators under various sources.

Prescribed Text Books

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	High Voltage Engineering	M. S. Naidu and V. Kamaraju	4th	Tata McGraw Hill	1995
2	High Voltage Engineering	C. L. Wadhwa	-	New Age International Private Limited	1995

Reference Text Books:

Sl. No	Book Title	Authors	Edition	Publisher	Year
1	High Voltage Engineering Fundamentals	E. Kufell and W.S. Zaengl	2nd	Pergamon Press	1984

E Books and online course materials:

1. https://psr.edu.in/wp-content/uploads/2023/06/High-Voltage-Engineering.pdf
2. https://www.udemy.com/course/high-voltage-and-insulators-for-electrical-power-engineering/?srsltid=AfmBOoplACr-6MRi1NrK1zoKTXF0ilsMiE9fzqyg81rCyLKRgpjeT4-a&coupo

Online Courses and Video Lectures:

1. https://www.udemy.com/course/high-voltage-and-insulators-for-electrical-power-engineering/?utm_campaign=Search_DSA_Beta_Prof_la.EN_cc.India_Subs&utm_source=google&
2. https://nescacademy.nasa.gov/playlist/c8a0c94a732a4385a383ae64e9a6aabc54.

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Three CIEs conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted Activity1: Substation visit and build a mini smart substation model.	10
	Activity 2: Students analyze and select suitable breakers for different real world systems.	10
Total		**50**

Course Articulation Matrix

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

Course Title	RELAY AND HIGH VOLTAGE LABORATORY		
Course Code	23EE703	L-T-P	(0-0-2) 1
CIE	50	Hours/Week	2
SEE	50	Total Hours	28

Course Objective: To demonstrate behaviour of switchgear devices subjected to high voltage application.

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

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Assess the operating characteristics of an Electromechanical type over current relay, Static over-voltage relay and Static under-voltage relay.	1, 2, 9, 10	1
2	Conduct experiment for inferring spark over behaviour of air insulation subjected for HVAC, HVDC applications under Uniform/Non-uniform field conditions.	1, 2, 9, 10	1
3	Perform the experiment on given fuse wire sample to examine its fusing current versus melting time characteristic and Assess the quality of transformer oil sample and its dielectric strength.	1, 2, 9, 10	1
4	Experimentally map field lines for co-axial cable model using electrolytic tank.	1, 2, 9, 10	1

LIST OF EXPERIMENTS

1. Operating characteristics and calculation of error in operating time for over-current electromechanical relay.
2. Operating characteristics of static over-voltage relay.
3. Operating characteristics of static under-voltage relay.
4. Breakdown strength of transformer oil, using oil testing unit.
5. Current-time characteristics of fuse.
6. Spark over characteristics of air insulation subjected to high voltage AC-with Spark over voltage corrected to STP.
7. Spark over characteristics of air insulation subjected to high voltage DC under uniform field condition.
8. Spark over characteristics of air insulation subjected to high voltage DC under non-uniform field condition.
9. Measurement of HVAC using standard spheres.
10. Field mapping using electrolytic tank for Co-axial cable model.

Course Articulation Matrix

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

Course Title	ENERGY AUDITING AND DEMAND SIDE MANAGEMEMT		
Course Code	23EE731	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To perform energy auditing using various techniques to meet effective energy consumptions.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Enhance the knowledge relating to energy, situation of energy and its consumption.	1,12	-
2	Analyse the elements of energy auditing and electrical system optimization.	1,2	-
3	Explain the concept of demand side management and apply its techniques.	1,2,7	-
4	Explain about the energy efficient motors, electrical tariff, lighting basics and load priority techniques	1,	

Course Articulation Matrix

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

MODULE-1 **10 Hrs**

Introduction: Energy Sources, Different types and its applications. Energy situation – world and India, energy consumption, conservation. Payback analysis, Depreciation (Problems)

SLC : Electrical codes and Standards.

MODULE-2 **10 Hrs**

Energy Auditing: Introduction, Elements of energy audits, energy use profiles, measurements in energy audits, presentation of energy audit results.

Electrical System Optimization: The power triangle, Motor horsepower, Power flow concept. Electrical Equipment and power factor –correction.

SLC: Location of capacitors.

MODULE-3 **10 Hrs**

Demand Side Management: Introduction to DSM, concept of DSM, benefits of DSM, different techniquesof DSM – time of day pricing, multi-utility power exchange model, time of day models for planning.

SLC: DSM based on season

MODULE-4 **10 Hrs**

Energy efficient motors: Lighting basics, Electrical rate tariff. Load management, Load priority technique, Peak clipping, Peak shifting, Valley filling, Strategic conservation, energy efficient equipment.

SLC: Seasonal pricing of Tariff

Text books:

1. Larry C. White, Philip S. Schmidt, David R. Brown, Industrial Energy Management Systems, Hemisphere Publishing Corporation, New York.
2. Albert Thumann, Fundamentals of Energy Engineering, Prentice Hall Inc, Englewood Cliffs, New Jersey.

Reference Books:

1. D.P.Sen, K.R.Padiyar, Indrane Sen, M.A.Pai, Recent Advances in Control and Management of Energy Systems, Interline Publisher, Bangalore, 1993.
2. Jyothi Prakash, Demand Side Management, TMH Publishers
3. Hand book on energy auditing - TERI (Tata Energy Research Institute).

Course Title	AUTOMATION IN INDUSTRY 4.0		
Course Code	23EE732	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To explore Industry 4.0 technologies and their impact on intelligent manufacturing and automation.

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

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1	Explain Industry 4.0 technologies and Cyber-Physical Systems.	1, 2, 12	1,2
2	Analyze smart industrial and healthcare applications.	1, 2, 3, 4,12	1,2
3	Evaluate smart energy systems and energy storage technologies.	1, 2, 4, 12	1,2
4	Apply Industry 4.0 concepts in smart automation and intelligent applications.	1, 3, 12	1,2

MODULE – 1	10 Hrs.

INTRODUCTION TO INDUSTRY 4.0: Introduction, Historical Context, General framework, Application areas, Dissemination of Industry 4.0 and the disciplines that contribute to its development, Artificial intelligence, The Internet of Things and Industrial Internet of Things, Additive manufacturing, Robotization and automation, Current situation of Industry 4.0. comparison of Industry 4.0 to Industry 5.0

MODULE - 2	11 Hrs.

INDUSTRY 4.0 AND CYBER PHYSICAL SYSTEM: Introduction to Cyber Physical Systems (CPS), Architecture of CPS- Components, Data science and technology for CPS, Emerging applications in CPS in different fields. Case study: Application of CPS in health care domain.

MODULE - 3	11 Hrs.

SMART ENERGY SOURCES: Energy Storage for Mitigating the Variability of Renewable Electricity Sources-Types of electric energy storage, Potential of Sodium-Sulfur Battery Energy Storage to Enable Integration of Wind-Case study. Electric Vehicles as Energy Storage: V2G Capacity Estimation.

MODULE - 4	10 Hrs.

SMART APPLICATIONS: Understanding Smart Appliances -Smart Operation-Smart Monitoring-Smart Energy Savings-Smart Maintenance, Case study-Smart Cars, Self-Driving Cars, Introducing Google's Self-Driving Car, Intellectual Property Rights.

Prescribed Text Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Industry 4.0‖, Wiley- ISTE,	Jean-Claude André	2019	Wiley- ISTE	JULY 2019
2	Handbook of Industry 4.0 and SMART Systems	Diego Galar Pascual, Pasquale Daponte, Uday Kumar	2020	Taylor and Francis	2020
3	Industry 4.0: Managing the Digital Transformation	Alp Ustundag, Emre Cevikcan	-	Springer	2017

Reference Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Cybersecurity for Industry 4.0: Analysis for Design and Manufacturing	Lane Thames, Dirk Schaefe	-	Springer	201

E Books and online course materials:

1. https://nielibrary.com/stream_pdf/publication/701/663b3174f2408.pdf

Online Courses and Video Lectures:

1. https://nptel.ac.in/courses/106105195
2. https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_mg92

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Three CIEs conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted Activity 1: Industry visit by group of students to analyse the technology using in the small scale industry.	10
	Activity 2: Seminar by students of any international journal paper based on present automation in industries at present situation.	10
Total		**50**

Course Articulation Matrix

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

Course Title	SOLAR POWER CONVERSION SYSTEMS		
Course Code	23EE733	(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.

Course Title	ELECTRICAL POWER QUALITY		
Course Code	23EE734	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To understand power quality issues, including voltage disturbances and harmonic distortion, and methods for mitigating in commercial and industrial systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1.	Identify various power quality issues including voltage variations, transients and waveform distortions.	1, 7, 12	1
2.	Explain the sources and effects of voltage sags, interruptions and transient overvoltage in power systems.	1, 6, 12	1
3.	Discuss the sources and effects of harmonic distortion in commercial and industrial systems.	1, 6, 12	1
4.	Describe power quality benchmarking practices and standards for utility and customer interface.	1, 6, 12	1

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.

Prescribed Textbooks:

Sl.No	Book title	Authors	Edition	Publisher	Year
1.	Electric power quality	Dugan, Roger C, Santoso, Surya, McGranaghan, Mark F/Beaty and H.Wayne	3rd	McGraw-Hill Professional Publication	2003.

Reference Books:

Sl.No	Book title	Authors	Edition	Publisher	Year
1.	Electric Power Quality	G.T. Heydt	3rd	Stars in a circle publications	1991
2.	Modern Power Electronics	M.H. Rashid	5th	Tata McGraw Hill	2002
3.	Understanding Power quality problems voltages sags and interruptions	Math H.J. Bollen	3rd	IEEE Press	2000

E-books and online course materials:

1. https://ebooks.iospress.nl/book electric -power-quality people
2. https://link.springer.com/book/10.1007/978-981-99-7333-0
3. https://nptel.ac.in/courses/115103123

Proposed Assessment Plan (for 50 marks of CIE)

Tool	Remarks	Marks
CIE	Three CIE's conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted 1. Case study on power quality issues in different commercial and industrial sectors 2. Report and presentation	 10 10
Total		50

Course Articulation Matrix

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

OPEN ELECTIVE – II

Course Title	SMART GRID TECHNOLOGIES		
Course Code	23OEEE71	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To apply control and automation to modern electrical Power systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the concepts, architecture, and enabling technologies of Smart Grid systems.	1	1
2	Analyze the role of communication networks, protocols, and information security in Smart Grid applications.	1	1
3	Illustrate the operation of smart substations, intelligent electronic devices (IEDs), and automation technologies used in modern power systems.	1	1
4	Evaluate different energy storage technologies and their applications in Smart Grid systems.	1	1

MODULE-1 **10 Hrs**

Introduction to Smart Grid: Evolution of Electric Grid, Evolution of Indian National Grid, Concept of Smart Grid, why implement the Smart Grid now? Overview of the technologies required for the Smart Grid, Difference between conventional & smart grid.

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

MODULE-2 **10 Hrs**

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

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

MODULE-3 **10 Hrs**

Information Security for the Smart Grid - Introduction, Encryption and decryption, Symmetric key encryption, Public key encryption, Cyber security standards.

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

MODULE-4 **10 Hrs**

Energy Storage Technologies: Introduction, Classification of electrical energy storage systems, Energy storage technologies - compressed air energy storage systems, Pumped hydro energy storage, flywheel energy storage, Li-ion Batteries, Flow battery, electrochemical capacitors/supercapacitors. Energy storage applications. SWOT analysis of battery energy storage systems in smart grids.

Prescribed Text Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Smart Grid: Technology and Applications	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama	1st	Wiley India	2012
2	Fundamentals of smart grid systems	Muhammad Kamran	-	Academic Press	2022

Reference Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Fundamentals of Smart Grid Technology	Bharat Modi, Anu prakash and Yogesh Kumar	1st	S.K. Kataria & Sons	2015
2	SMART GRID Fundamentals of Design and Analysis	James Momoh	1st	IEEE press, A John Wiley & Sons, Inc	2012

E Books and online course materials:

1. https://content.e-bookshelf.de/media/reading/L-596321-3608238b29.pdf
2. https://unglueit-files.s3.amazonaws.com/ebf/d4fa5732b34f4a23a0630d366eaf2f28.pdf

Online Courses and Video Lectures:

1. https://onlinecourses.nptel.ac.in/noc23_ee60/preview

Proposed Assessment Plan (for 50 marks of CIE):

Tool	Remarks	Marks
CIE	Three CIEs conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted 1) activity 1 2) activity 2	20
Total		**50**

Course Articulation Matrix

Course Outcomes	Program Outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												2	
CO2	3												2	
CO3	3												2	
CO4	3												2	

Course Title	UTILIZATION OF ELECTRICAL POWER		
Course Code	23OEEE72	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

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

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

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1	Apply the concepts of electrical power for heating and welding systems	1	1
2	Apply the principle of illumination	1, 2	1
3	Discuss the various drives used in industrial application	1, 2	1
4	Illustrate locomotives using electrical motor	1, 2	1

MODULE-1	10 Hrs

ELECTRIC HEATING AND WELDING: Introduction, Advantages and methods of electric heating-resistance heating, induction heating and dielectric heating. **Electric welding**- resistance and arc welding, electric welding equipment, comparison between AC and DC Welding.

MODULE-2	10 Hrs

ILLUMINATION FUNDAMENTALS AND ILLUMINATION METHODS: Introduction, terms used in illumination, laws of illumination, Types of lamps (Incandescent lamp, florescent lamp, CFL, LED)-comparison of LED with others lamps, sources of light. Discharge lamps-(Mercury vapor and Sodium vapor lamps), Basic principles of light control, Types of lighting schemes and flood lighting.

MODULE-3	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-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.

Prescribed Text Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Utilization of electrical energy	E.O.Taylor	2nd	Orient Blackswan	2000
2	Electrical Drives: Concept and applications	Vedam Subrahmanyam	2nd	McGraw Hill education	2017

Reference Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Art and Science of Utilisation of Electrical Energy	H.Pratab, DhanpatRai	2nd	-	-

E Books and online course materials:

1. https://backbencher.club/utilization-of-electrical-power/
2. https://vtupulse.com/cbcs-eee-notes/17ee742-utilization-of-electrical-power-uep-vtu-notes/

Online Courses and Video Lectures:

1. https://www.youtube.com/watch?v=7xqe8HhlZ04
2. https://www.youtube.com/watch?v=NVqDMLkhlq4

Proposed Assessment Plan (for 50 marks of CIE):

Tool	Remarks	Marks
CIE	Three CIEs conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted 1) Presentation on IEEE Conference/Journal papers-With report 2) Quiz	20
Total		**50**

Course Articulation Matrix

Course Outcomes	Program Outcomes													
	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	
CO4	3	3											2	

Course Title	ELECTRIC VEHICLE TECHNOLOGY		
Course Code	23OEEE73	(L-T-P) C	(3-0-0)3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To acquire basic knowledge of electrical vehicle engineering.

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

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1	Identify EV concepts, EV configurations and various EV parameters for better understanding of the EV technology	1, 2	1
2	Analyze transmission control module shift schedules to assess the impact of Powertrain changes.	1, 2	1
3	Analysis of different type of energy sources	1, 2	1
4	Apply the knowledge of electric circuits and mathematics to model lithium batteries and to estimate the state of charge and state of health of lithium batteries	1, 2	1

MODULE – 1 **10 Hrs.**

INTRODUCTION TO HYBRID ELECTRIC VEHICLES: Background of Electric vehicle technology, Block diagram of EV, Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, Drive controllers of EV.

MODULE – 2 **10 Hrs.**

ELECTRIC TRAINS: Electric Drive-trains: Basic concept of electric traction. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

MODULE – 3 **10 Hrs.**

ENERGY STORAGE: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis.

MODULE - 4 **10 Hrs**

BATTERY MANAGEMENT SYSTEM (Lithium-ion Battery): Battery parameters. Construction, operation, chemistry, safety, performance and integration of Lithium-ion batteries, Balance of plant. System description and architectures of battery management system, Thevenin equivalent circuit of a battery. Definitions of SoC and SoH, Challenges in estimation of SoC. OCV measurement. Coulomb counting for SoC estimation. Predictive SoH models.

Prescribed Text Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, Yimin Gao, Sebastien E Gay, Ali Emadi,	2nd	CRC Press	2009
2	A Systems Approach to Lithium Battery Management	Phillip Weicker	4th	Artech House	2014

Reference Books:

Sl.No	Book Title	Authors	Edition	Publisher	Year
1	Modern Electric Vehicle Technology	C.C Chan, K.T Chau	2	Oxford University Press Inc., New York	2001
2	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Hussein	4	CRC Press	2003
3	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi	5	CRC Press	2004
4	Electric Vehicle Technology Explained, , 2003	James Larminie, John Lowry	6	Wiley	2003

E Books and online course materials:

1. https://www.nielit.gov.in/content/online-course-ev-technology-public-charging-station-0
2. https://www.classcentral.com/subject/electric-vehicles
3. https://course.cutm.ac.in/wp-content/uploads/2020/06/Notes-on-Electric-Vehicles.pdf

Online Courses and Video Lectures:

1. https://onlinecourses.nptel.ac.in/noc22_ee53/preview
2. https://www.dqindia.com/iit-madras-offers-free-online-course-electric-vehicles-can-Completed-12-weeks/

Teaching - Learning – Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours / Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Integrated Lab Component	-	-	-
3	Activity Based Learning (ABL1 & ABL2)	-	-	44
4	Evaluation of Learning Process	-	-	04
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (for 50 marks of CIE)

Tool	Remarks	Marks

CIE	Three CIEs conducted for 20 marks each and reduced to 10 marks	30
Activity Details	Details of activities to be conducted 1) Details of activity 1(International journal based seminar presentation by students) (10 Marks) 2) Details of activity 2 (Industrial visit or Electrical vehicle workshop visit by students)(10 Marks)	20
Total		**50**

Activity Based learning (27 hours)

ABL 1 : EV manufacturing plant visit OR Electrical vehicle workshop visit	**14 hours**
ABL 2: International journal based seminar presentation by students	**13 hours**
ABL 1+ ABL 2 (total hours)	**27 hours**

Evaluation of learning process (07 hours)

Type of Evaluvation	**Hours**
CIE(1,2 and 3)	03
Activity 1 and 2	01
Semester End exam	03
Total	**07**

Course Articulation Matrix

Course Outcomes	**Program Outcomes**													
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2											1	
CO2	3	2											1	
CO3	2	2											1	
CO4	3	2											1	