CURRICULUM
&
SYLLABUS
2023 Scheme
(Autonomous)

B.TECH
ELECTRICAL AND ELECTRONICS ENGINEERING

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695015

CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTERS VII & VIII

2023 SCHEME

(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
MAR IVANIOS VIDYANAGAR, NALANCHIRA, THIRUVANANTHAPURAM – 695015, KERALA.
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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SYLLABUS

2023 SCHEME

Items	Board of Studies (BOS)	Academic Council (AC)
Date of Approval	25/02/2026	12/03/2026

Head of Department
Chairman, Board of Studies

MAR BASELIOS COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous)
Mar Ivanios Vidyanagar
Nalanchira
Thiruvananthapuram-695015

Chairman, Academic Council

Principal
Mar Baselios College
of Engineering & Technology
Mar Ivanios Vidyanagar, Nalanchira
Thiruvananthapuram-695015

CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTERS VII to VIII

2023 SCHEME

(AUTONOMOUS)

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Vision and Mission of the Institution

Vision:

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

Mission:

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

Vision and Mission of the Department

Vision:

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

Mission:

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

Programme Educational Objectives (PEOs)

1. Graduates will succeed as Professionals in Industry or as Entrepreneurs in Electrical and Electronics Engineering and related disciplines.
2. Graduates will be able to adapt to the advances in Technology by continuously acquiring knowledge and skills, with an urge for innovation.
3. Graduates will be socially committed individuals, exhibiting professional ethics in addressing technical and engineering challenges.

Programme Outcomes (POs)

Engineering Graduates will have the ability to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

Engineering Graduates will have the ability:

1. To apply the knowledge in Electrical and Electronics Engineering for the design of Power Generation, Transmission, Distribution and Utilization systems.
2. To demonstrate the knowledge required to design, develop, test, and implement Electrical & Electronics systems.

CURRICULUM UNDER AUTONOMY STATUS

i) Medium of Instruction: English

ii) Knowledge Segments and Credits

Every course of BTech Programme is placed in one of the nine categories as listed in table below. No semester shall have more than six lecture-based courses and two laboratory courses, and/or drawing/seminar/project courses in the curriculum.

Table 1: Credit distribution and the Knowledge Domains

Sl. No.	Category	Category Code	Proposed 2023 Curriculum
1	Humanities and Social Sciences including Management Courses	HSC	9
2	Basic Science Courses	BSC	26
3	Engineering Science Courses	ESC	24
4	Programme Core Courses,	PCC	69
5	Programme Elective Courses	PEC	18
6	Institute Elective Courses	IEC	6
7	Seminar, Mini Project, Project Work, Internship and Comprehensive Course Viva Voce	PWS	15
8	Mandatory Student Activities (P/F)	MSA	3
Total Mandatory Credits			**170**
	Value Added Courses (Optional) – Honours/Minor	VAC	15

ii) Semester-wise Credit Distribution

Semester	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***Total***
Credits for Courses	***19***	***21***	***22***	***20***	***22***	***24***	***22***	***17***	***167***
Year wise Credit	***40***		***42***		***46***		***39***		***167***
Credits for Activities	***3***								***3***
Total Credits									***170***
Value Added Courses (Optional) – Honours / Minor									***15***
Total Credits									***185***

Humanities and Social Sciences including Management Courses: Universal Human Values, Management for Engineers, Business Economics and Accountancy.

Basic Science Courses: Mathematics, Engineering Physics, Engineering Chemistry, Engineering Physics and Chemistry Labs.

Engineering Science Courses: Basics of Electrical and Electronics Engineering, Engineering Mechanics, Engineering Graphics, Design Engineering, Programming in Python, Problem Solving and programming in C, Manufacturing and Construction Practices B, Electrical and Electronics Workshop.

Mandatory Non-credit Courses: Environmental Science, Professional Communication, Professional Ethics, Industrial Safety Engineering.

General Guidelines

Three hours are kept exclusively for the Remedial / Minor/ Honours courses from third to seventh semester. For the mini project of Minor or Honours in S7/S8, 7 hours are allotted. If a student does not opt for Minor/Honours courses, he/she can be given remedial classes.

SEMESTER I										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL10A	Linear Algebra and Calculus	3	1	0	0	5	4	4
B	BSC	23CYL10A	Engineering Chemistry	3	1	0	0	5	4	4
C	ESC	23ESB10A	Engineering Graphics	2	0	2	0	4	4	3
D	ESC	23ESB10D	Problem Solving and Programming in C	2	1	2	0	4.5	5	4
G	ESC	23ESL1NA	Environmental Science	2	0	0	0	3	2	1*
S	BSC	23CYP10A	Engineering Chemistry Lab	0	0	2	0	1	2	1
T	ESC	23ESB10P	Manufacturing and Construction Practices B	1	0	2	0	2.5	3	2
TOTAL								**25**	**24**	**19**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER II										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL10B	Vector Calculus, Differential Equations and Transforms	3	1	0	0	5	4	4
B	BSC	23PYL10A	Engineering Physics	3	1	0	0	5	4	4
C	ESC	23ESL10C	Engineering Mechanics	2	1	0	0	3.5	3	3
D	ESC	23ESB10G	Python Programming	2	0	2	0	4	4	3
E	ESC	23ESL10J	Basics of Electrical Engineering A	2	0	0	0	3	4	2
		23ESL10L	Basics of Electronics Engineering	2	0	0	0			2
G	HSC	23HSJ1NB	Professional Communication	2	0	0	2	5	4	1*
S	BSC	23PYP10A	Engineering Physics Lab	0	0	2	0	1	2	1
T	ESC	23ESP10B	Electrical and Electronics Workshop	0	0	2	0	1	2	1
TOTAL								**27.5**	**27**	**21**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER III										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL20A	Partial Differential Equation and Complex Analysis	3	1	0	0	5	4	4
B	PCC	23EEB20A	Logic System Design	3	1	2	0	6	6	5
C	PCC	23EEL20B	Measurements and Instrumentation	3	1	0	0	5	4	4
D	PCC	23EEL20C	Electric Circuit Analysis	3	1	0	0	5	4	4
E	ESC	23ESL00A	Design Engineering	2	0	0	0	3	2	2
G	HSC	23HSL2NA	Professional Ethics	2	0	0	0	3	2	1*
S	PCC	23EEP20A	Electrical Network Lab	0	0	2	0	1	2	1
T	PCC	23EEP20B	Simulation Lab	0	0	2	0	1	2	1
M	VAC		Minor Course	3	0	0	0	4.5	3	3
TOTAL								**29/ 33.5**	**26/29**	**22/25**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER IV										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	BSC	23MAL20D	Probability, Statistics and Numerical Methods	3	1	0	0	5	4	4
B	PCC	23EEL20D	Electronic Devices and Circuits	3	1	0	0	5	4	4
C	PCC	23EEL20E	DC Machines and Transformers	2	1	0	0	3.5	3	3
D	PCC	23EEB20F	Microcontroller and Applications	3	1	2	0	6	6	5
E	HSC	23HSL2NB	Universal Human Values - II	2	1	0	0	3.5	3	1*
G	ESC	23ESL2NC	Industrial Safety Engineering	2	1	0	0	3.5	3	1*
S	PCC	23EEP20C	Measurements Lab	0	0	2	0	1	2	1
T	PCC	23EEP20D	Electronic Devices and Circuits Lab	0	0	2	0	1	2	1
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
				2	1	0	0	3.5		
TOTAL								**28.5/ 33/32**	**27/30**	**20/23**

**Not to be considered for Grade/GPA/CGPA. Pass or Fail Only*

SEMESTER V										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PCC	23EEL30A	Power Electronics and Drives	3	1	0	0	5	4	4
B	PCC	23EEL30B	Signals and System Analysis	3	1	0	0	5	4	4
C	PCC	23EEL30C	Synchronous and Induction Machines	3	1	0	0	5	4	4
D	PEC	23EEL31X	Program Elective I	3	0	0	0	4.5	3	3
E	HSC	23HSL30A	Business Economics and Accountancy	3	0	0	0	4.5	3	3
S	PCC	23EEP30A	Electrical Machines Lab	0	0	3	0	1.5	3	2
T	PCC	23EEP30B	Power Electronics Lab	0	0	3	0	1.5	3	2
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
TOTAL								**27/ 31.5**	**24/27**	**22/25**

SEMESTER VI										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PCC	23EEL30D	Linear Control Systems	3	1	0	0	5	4	4
B	PCC	23EEL30E	Power Systems I	3	1	0	0	5	4	4
C	PCC	23EEL30F	Electromagnetic Theory and Compatibility	3	1	0	0	5	4	4
D	PEC	23EEL32X	Program Elective II	3	0	0	0	4.5	3	3
E	IEC	23IEL31X	Institute Elective I	3	0	0	0	4.5	3	3
S	PCC	23EEP30C	Control Systems Lab	0	0	3	0	1.5	3	2
T	PWS	23EES38A	Seminar	0	0	4	0	2	4	2
U	PWS	23EEJ38B	Mini Project	0	0	4	0	4	4	2
M/H	VAC		Minor/Honours Course	3	0	0	0	4.5	3	3
TOTAL								**31.5/ 36**	**29/32**	**24/27**

SEMESTER VII										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PCC	23EEL40A	Power Systems II	3	1	0	0	5	4	4
B	PCC	23EEJ40B	Computer Aided Electrical System Design for Domestic Dwellings	2	1	0	1	4.5	4	4
C	PEC	23EEL43X	Program Elective III	3	0	0	0	4.5	3	3
E	IEC	23IEL42X	Institute Elective II	3	0	0	0	4.5	3	3
S	PCC	23EEP40A	Power Systems Lab	0	0	3	0	1.5	3	2
T	PWS	23EEV48A	Comprehensive Viva Voce	0	0	2	0	1	2	1
U	PWS	23EEJ48A	Project	0	0	10	0	10	10	5
		23EEI48A	Internship*							
M/H	VAC		Minor/Honours Course	0	0	6	0	6	5/3	3
				3	0	0	0	4.5		
TOTAL								**31/37/ 35.5**	**29/34/ 32**	**22/25**

**Students can opt for Internship either in S7 or S8. However, in S7, the internship can be permitted only if there are no pending Programme/Course requirements in the semester, that need to be completed in College in the offline mode, such as laboratory sessions.*

SEMESTER VIII										
Slot	Cate-gory	Course Code	Courses	Credit Structure				SS	Hours	Credit
				L	T	P	J			
A	PEC	23EEL44X	Program Elective IV	3	0	0	0	4.5	3	3
B	PEC	23EEL45X	Program Elective V	3	0	0	0	4.5	3	3
C	PEC	23EEL46X	Program Elective VI	3	0	0	0	4.5	3	3
D	HSC	23HSL00A	Management for Engineers	3	0	0	0	4.5	3	3
U	PWS	23EEJ48B	Project	0	0	10	0	10	10	5
		23EEI48A	Internship*							
M/H	VAC		Minor/Honours Course	0	0	6	0	6	5	3
TOTAL								**28/34**	**22/27**	**17/20**

**Students can opt for Internship either in S7 or S8.*

MICRO SPECIALIZATION STREAM		
No.	**STREAM**	**CODE**
1.	Power and Energy Systems	PES
2.	Power Electronics and Drives	PED
3.	Control Systems and Automation	CSA
4.	Electronics and Instrumentation	EIN
5.	Artificial Intelligence and Machine Learning	AML

PROGRAM ELECTIVE I

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
D	PEC	23EEL31A	Renewable Energy Systems	3-0-0-0	3	3	PES
		23EEL31B	Material Science	3-0-0-0	3	3	PED
		23EEL31C	Embedded Systems	3-0-0-0	3	3	CSA
		23EEL31D	Sensors and Sensing Techniques	3-0-0-0	3	3	EIN
		23EEL31E	Biomedical Instrumentation	3-0-0-0	3	3	EIN
		23EEL31F	Object Oriented Programming	3-0-0-0	3	3	AML
		23EEL31G	Data Structures	2-1-0-0	3	3	AML

PROGRAM ELECTIVE II

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
D	PEC	23EEL32A	Illumination Engineering	2-1-0-0	3	3	PES
		23EEL32B	Electrical Drawing with CAD	2-1-0-0	3	3	PED
		23EEL32C	Electric Drives	3-0-0-0	3	3	PED
		23EEL32D	Industrial Instrumentation and Automation	3-0-0-0	3	3	CSA
		23EEL32E	Digital System Design Using Verilog	2-1-0-0	3	3	CSA
		23EEL32F	Introduction to Nanotechnology	3-0-0-0	3	3	EIN
		23EEL32G	Introduction to Soft Computing	3-0-0-0	3	3	AML
		23EEL32H	Internet of Things	3-0-0-0	3	3	AML

PROGRAM ELECTIVE III

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
C	PEC	23EEL43A	Energy Management and Auditing	3-0-0-0	3	3	PES
		23EEL43B	Power Quality	3-0-0-0	3	3	PES
		23EEL43C	Electrical Machine Design	2-1-0-0	3	3	PED
		23EEL43D	Switch Mode Power Converters	3-0-0-0	3	3	PED
		23EEL43E	Introduction to Robotics	2-1-0-0	3	3	CSA
		23EEL43F	Advanced Control Systems	3-0-0-0	3	3	CSA
		23EEL43G	Digital Signal Processing	2-1-0-0	3	3	EIN
		23EEL43H	Introduction to Machine Learning	3-0-0-0	3	3	AML
		23EEL43I	Introduction to Computer Networks	3-0-0-0	3	3	AML

PROGAM ELECTIVE IV

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
A	PEC	23EEL44A	Smart Grids	3-0-0-0	3	3	PES
		23EEL44B	HVDC and FACTS	3-0-0-0	3	3	PES
		23EEL44C	Energy Storage Systems	3-0-0-0	3	3	PED
		23EEL44D	Digital Control Systems	2-1-0-0	3	3	CSA
		23EEL44E	Communication Engineering	3-0-0-0	3	3	EIN
		23EEL44F	Data Analytics for Electrical Engineers	3-0-0-0	3	3	AML

PROGRAM ELECTVE V

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
B	PEC	23EEL45A	Solar PV Systems	3-0-0-0	3	3	PES
		23EEL45B	Power System Protection	3-0-0-0	3	3	PES
		23EEL45C	Electric and Hybrid Vehicles	3-0-0-0	3	3	PED
		23EEL45D	Modern Control Techniques	3-0-0-0	3	3	CSA
		23EEL45E	Digital Image Processing	3-0-0-0	3	3	EIN
		23EEL45F	VR and AR for Assistive Technology	3-0-0-0	3	3	AML

PROGRAM ELECTIVE VI

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit	Stream Code
C	PEC	23EEL46A	Electrical System Design for Industry and Infrastructure	2-1-0-0	3	3	PES
		23EEL46B	High Voltage Engineering	3-0-0-0	3	3	PES
		23EEL46C	Computer Aided Power System Analysis	2-1-0-0	3	3	PES
		23EEL46D	Special Electric Machines	3-0-0-0	3	3	PED
		23EEL46E	Automotive Electronic Systems	3-0-0-0	3	3	EIN
		23EEL46F	Introduction to Artificial Neural Networks	3-0-0-0	3	3	AML

INSTITUTE ELECTIVE I

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit
E	IEC	23IEL31M	Introduction to Flight Dynamics and Control	3-0-0-0	3	3
		23IEL31N	Introduction to Power Processing	3-0-0-0	3	3
		23IEL31O	Electrical Drives and Control for Automation	3-0-0-0	3	3
		23IEL31P	Artificial Intelligence in Power Systems	3-0-0-0	3	3

INSTITUTE ELECTIVE II

Slot	Category Code	Course Code	Courses	L-T-P-J	Hours	Credit
E	IEC	23IEL42M	Architectural Lighting Design and Control	2-1-0-0	3	3
		23IEL42N	Electric Vehicles	3-0-0-0	3	3
		23IEL42O	Process Control and Automation	3-0-0-0	3	3
		23IEL42P	Sustainable Energy Management	3-0-0-0	3	3

LIST OF ELECTIVE COURSES BASED ON MICRO SPECIALIZATION STREAM

POWER AND ENERGY SYSTEMS						
Category	**No.**	**Course**	**Semester**	**L-T-P-J**	**Hours**	**Credit**
PEC	1	Renewable Energy Systems	S5	3-0-0-0	3	3
	2	Illumination Engineering	S6	3-0-0-0	3	3
	3	Power Quality	S7	3-0-0-0	3	3
	4	Energy Management and Auditing	S7	3-0-0-0	3	3
	5	Smart Grids	S8	3-0-0-0	3	3
	6	Power System Protection	S8	3-0-0-0	3	3
	7	Computer Aided Power System Analysis	S8	2-1-0-0	3	3
	8	Electrical System Design for Industry and Infrastructure	S8	2-1-0-0	3	3
	9	HVDC and FACTS	S8	3-0-0-0	3	3
	10	High Voltage Engineering	S8	3-0-0-0	3	3
	11	Solar PV Systems	S8	3-0-0-0	3	3
POWER ELECTRONICS AND DRIVES						
Category	**No.**	**Course**	**Semester**	**L-T-P-J**	**Hours**	**Credit**
PEC	1	Material Science	S5	3-0-0-0	3	3
	2	Electrical Drawing with CAD	S6	2-1-0-0	3	3
	3	Advanced Electric Drives	S6	3-0-0-0	3	3
	4	Electrical Machine Design	S6	3-0-0-0	3	3
	5	Switch Mode Power Converters	S7	3-0-0-0	3	3
	6	Special Electric Machines	S7	3-0-0-0	3	3
	7	Energy Storage Systems	S8	3-0-0-0	3	3
	8	Electric and Hybrid Vehicles	S8	3-0-0-0	3	3
CONTROL SYSTEMS AND AUTOMATION						
Category	**No.**	**Course**	**Semester**	**L-T-P-J**	**Hours**	**Credit**
PEC	1	Embedded Systems	S5	3-0-0-0	3	3
	2	Industrial Instrumentation and Automation	S6	3-0-0-0	3	3
	3	Digital System Design Using Verilog	S6	2-1-0-0	3	3
	4	Introduction to Robotics	S7	2-1-0-0	3	3
	5	Advanced Control Systems	S7	3-0-0-0	3	3
	6	Digital Control Systems	S8	3-0-0-0	3	3
	7	Modern Control Techniques	S8	2-1-0-0	3	3
ELECTRONICS AND INSTRUMENTATION						
Category	**No.**	**Course**	**Semester**	**L-T-P-J**	**Hours**	**Credit**
PEC	1	Sensors and Sensing Techniques	S5	3-0-0-0	3	3
	2	Biomedical Instrumentation	S5	3-0-0-0	3	3
	3	Introduction to Nanotechnology	S6	3-0-0-0	3	3
	4	Digital Signal Processing	S7	2-1-0-0	3	3
	5	Communication Engineering	S8	3-0-0-0	3	3
	6	Automotive Electronic Systems	S8	3-0-0-0	3	3
	7	Digital Image Processing	S8	3-0-0-0	3	3

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING						
Category	**No.**	**Course**	**Semester**	**L-T-P-J**	**Hours**	**Credit**
PEC	1	Object Oriented Programming	S5	3-0-0-0	3	3
	2	Data Structures	S5	2-1-0-0	3	3
	3	Introduction to Soft Computing	S6	3-0-0-0	3	3
	4	Internet of Things	S6	3-0-0-0	3	3
	5	Introduction to Machine Learning	S7	3-0-0-0	3	3
	6	Introduction to Computer Networks	S7	3-0-0-0	3	3
	7	VR and AR for Assistive Technology	S8	3-0-0-0	3	3
	8	Data Analytics for Electrical Engineers	S8	3-0-0-0	3	3
	9	Introduction to Artificial Neural Networks	S8	3-0-0-0	3	3

B.Tech (MINOR)

Semester	BASKET I				BASKET II				BASKET III				BASKET IV			
	Embedded Systems for Industrial Applications				Architectural Lighting and Electrical System Design				Clean and Sustainable Energy				Electric Vehicle Systems			
	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit
S3	23EEL2MA	Microcontrollers and Embedded Systems	3-0-0	3	23EEL2MC	Basics of Illumination Science and Lighting Design	3-0-0	3	23EEL2ME	Sustainable Energy Systems	3-0-0	3	23EEL2MG	Electric Machinery	3-0-0	3
S4	23EEL2MB	Hardware Interfacing using Arduino-C Platform	3-0-0	3	23EEL2MD	Electric Power Supply and Distribution Systems	3-0-0	3	23EEL2MF	Renewable Energy in Power Grids	3-0-0	3	23EEL2MH	Power Electronics and Energy Storage Devices	3-0-0	3
S5	23EEL3MA	Raspberry Pi - Python Interface for Electrical Engineering	3-0-0	3	23EEL3MC	Energy efficiency in Buildings	3-0-0	3	23EEL3ME	Solar and Wind Energy Conversion Systems	2-1-0	3	23EEL3MG	Hybrid and Electric Vehicles	3-0-0	3
S6	23EEL3MB	Cloud Computing for Internet of Things	3-0-0	3	23EEL3MD	Electrical System Design and Building services	2-1-0	3	23EEL3MF	Smart Grid and Energy Storage Systems	3-0-0	3	23EEL3MH	Introduction to Automotive Electrical and Electronic systems	3-0-0	3
S7/S8	23EEJ4MA	Mini Project	0-0-6-0	3	23EEJ4MC	Mini Project	0-0-6-0	3	23EEJ4ME	Mini Project	0-0-6-0	3	23EEJ4MG	Mini Project	0-0-6-0	3

B.Tech (HONOURS)

Semester	GROUP I: Power Systems				GROUP II: Power Electronics and Drives				GROUP III: Microgrid				GROUP IV: Electric Vehicle Systems[1]			
	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit	Course Code	Course	L-T-P	Credit
S4	23EEL2HB	Network Analysis and Synthesis	2-1-0-0	3	23EEL2HD	Network Analysis and Synthesis	2-1-0-0	3	23EEL2HF	Network Analysis and Synthesis	2-1-0-0	3	23EEL2HH	Modelling and Analysis of Electrical Machines	2-1-0-0	3
S5	23EEL3HA	Renewable Energy Resources and Distributed Generation	3-0-0-0	3	23EEL3HC	Elements of Solar Energy Conversion	3-0-0-0	3	23EEL3HE	Solar Photovoltaics Fundamentals	3-0-0-0	3	23EEL3HG	Electric Vehicle Technology	3-0-0-0	3
S6	23EEL3HB	Analysis of Electrical Machines	2-1-0-0	3	23EEL3HD	Analysis of Power Electronic Circuits	2-1-0-0	3	23EEL3HF	Operation and Control of Power Systems	3-0-0-0	3	23EEL3HH	Automotive Electrical and Electronic Systems	3-0-0-0	3
S7	23EEL4HA	Operation and Control of Generators	3-0-0-0	3	23EEL4HC	Dynamics of Power Converters	2-1-0-0	3	23EEL4HE	Control and Dynamics of Microgrids	3-0-0-0	3	23EEL4HG	Smart Grid and Interfacing	3-0-0-0	3
S8	23EEJ4HB	Mini Project	0-0-6-0	3	23EEJ4HD	Mini Project	0-0-6-0	3	23EEJ4HF	Mini Project	0-0-6-0	3	23EEJ4HH	Mini Project	0-0-6-0	3

[1]Honours Group IV can be opted by the students of Electrical and Electronics Engineering, and Electrical and Computer Engineering.

SYLLABUS

SEMESTER VII

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL40A	POWER SYSTEMS II	PCC	3	1	0	0	4	2023

i) COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of Per unit systems, Fault calculations and Load flow analysis of electric power system. The course also intends to deliver the basic concepts of power system stability and Optimal scheduling of electric Power Generation.

ii) COURSE OUTCOMES

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

CO1	Apply the per unit scheme for any power system network and compute the fault levels.	Apply
CO2	Solve load flow problems of any given power system network using iterative methods.	Apply
CO3	Develop the block diagram representations of Automatic Generation Control scheme of power systems.	Apply
CO4	Solve for the steady state limit and transient stability of power system networks.	Apply
CO5	Solve economic despatch problems of power system networks.	Apply

iii) SYLLABUS

Per unit quantities- Symmetrical components- sequence networks- Fault calculations- symmetrical fault- Unsymmetrical faults - Contingency ranking.

Load flow studies -network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson and Fast Decoupled method (Qualitative analysis only)- principle of DC load flow

Automatic Generation Control: Load frequency control, single area and two area systems - Automatic Voltage Regulation - Exciter Control - SCADA systems

Power system stability - steady state, dynamic and transient stability-power angle curve- steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Equal area criterion application - methods of improving stability.

Economic Operation - Distribution of load between units within a plant - penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

iv) (a) TEXT BOOKS

1) Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2) D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3) Kundur P., *Power system Stability and Control*, McGraw Hill, 2006.
4) Allen J. Wood and Bruce F. Wollenberg., *Power Generation, Operation, and Control,* Wiley, 2nd Edition, 1996.

5) Cotton H. and H. Barbera, Transmission & Distribution of Electrical Energy, 3/e, Hodder and Stoughton, 1978.
6) Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
7) Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria & Sons, 2009.
8) Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai & Sons, New Delhi, 1984.

(b) REFERENCES

1) John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
2) Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
3) Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
4) Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

v) COURSE PLAN

Module	Contents	No. of hours
I	Per unit quantities-single phase and three phase-Symmetrical components- Sequence networks- Fault Calculations-Symmetrical faults- Unsymmetrical faults - single line to ground, line to line, double line to ground faults.	**13**
II	Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson and Fast Decoupled method (Qualitative analysis only) - principle of DC load flow.	**12**
III	Automatic Generation Control: Load frequency control: single area and two area systems-Droop Characteristics-Automatic Voltage Regulation - SCADA systems.	**11**
IV	Power system stability - steady state, dynamic and transient stability-power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method, RK method - Equal area criterion and its applications - methods of improving stability limits - Phasor Measurement Units - Wide Area Monitoring Systems.	**13**
V	Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.	**11**
	Total hours	**60**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEJ40B	Computer Aided Electrical System Design for Domestic Dwellings	PCC	2	1	0	1	4	2023

i) COURSE OVERVIEW: This course provides a comprehensive understanding of electrical system design for residential buildings, covering fundamental concepts, standards, and practical applications. The course emphasizes safe, efficient, and code-compliant electrical installations while integrating modern energy-efficient and smart home technologies.

ii) COURSE OUTCOMES

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

CO1	Explain the standards and regulations used in the design of components for medium and high voltage installations.	Understand
CO2	Develop lighting scheme for indoor applications.	Apply
CO3	Illustrate the need for protective devices and earthing associated with domestic electrical installations.	Understand
CO4	Develop electrical schematic for low/medium voltage domestic electrical installations and select suitable protective devices.	Apply
CO5	Select suitable components for PV system for residential building.	Apply
CO6	Demonstrate the design aspects of high-rise buildings and various smart energy conservation aspects.	Understand

iii) SYLLABUS

General awareness of IS Codes: IS 732 - IS 3043 IS 2026- IS 3646- IS 5216 - NEC - The Electricity Act 2003 - Classification of voltages-standards and specifications, tolerances for voltage and frequency.

Indoor Lighting design - Illumination calculations, - Light Loss Factor -Lighting schemes - Types of lamps and luminaries – Lighting calculations- Average lumen method-DIALUX

Domestic Installation- Types of domestic wiring systems- selection of number of sub circuits. Principle of operation of MCB, RCCB and RCBO. Importance of earthing

Design of electrical system for domestic dwellings for single phase supply (LV) and three phase supply (MV) – Calculation of connected load and sub circuits - Selection of DB, Circuit Breakers and wires. Pre-commissioning tests of domestic installations

Electrical installations of high-rise buildings - Introduction to Solar PV Systems – Components of PV system - Solar panel efficiencies - PV modules - Design of a PV system for domestic application - selection of equipments- Smart Energy Conservation Techniques in domestic installations

iv) (a) TEXT BOOKS

1) K. B. Raina, S. K. Bhattacharya, "Electrical Design Estimating Costing", New Age Publishers, Reprint edition, 2010.
2) S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating and Costing", Khanna Publishers, 9th Edition, 2014.
3) J. B. Gupta, "A Course in Electrical Installation Estimating and Costing", S.K. Kataria & Sons; Reprint 2013 edition.
4) M. K. Giridharan, "Electrical Systems Design", I K International Publishers, New Delhi, 2nd edition, 2016
5) AutoDesk Inc., "AutoCAD Electrical User Guide", Autodesk Publications, Latest Edition.

(b) REFERENCES

1) National Electric Code, Bureau of Indian Standards publications, 2011.
2) Relevant Indian Standard – specifications (IS – 732, IS – 746, IS – 3043, IS – 900)
3) Theodore R Bosela, "Electrical Systems Design", Prentice Hall; 1st edition, 2002
4) U.A.Bakshi, V.U.Bakshi, Electrical Technology, Technical publications, Pune, 1st Edition, 2020.

Data Book (Approved for use in the examination):

1) M K Giridharan, Electrical Systems Design Data Hand book, I K International Publishers

v) COURSE PLAN

Module	Contents	No. of hours
I	**General awareness of IS Codes:** IS 732 - IS 3043 IS 2026- IS 3646 - The Electricity Act 2003- General introduction- Distribution of Electricity (Part VI)- Central Electricity Authority (Part IX)- Regulatory Commissions (Part IX). National Electric Code (NEC 2011) – Scope. Graphical symbols and signs as per NEC for electrical installations. Classification of voltages-standards and specifications, tolerances for voltage and frequency- Pre-commissioning tests of domestic installations	**10**
II	**Indoor Lighting design:** Definitions of luminous flux, Lumen, Luminous intensity, illuminance - Coefficients of Utilization (CoU) - factors affecting CoU - Light Loss Factor (LLF). Lighting schemes - Types of luminaries for indoor lighting. DLOR and ULOR, Selection of lamp and luminance. Lighting calculations- Average lumen method - Space to mounting height ratio - Design of lighting systems for a medium area seminar hall using LED luminaires. Lighting system design using software (eg: DIALux /Relux).- case studies	**13**

III	**Domestic Installation:** Types of domestic wiring systems - Connected load-diversity factor. Selection of number of sub circuits. Selection of distribution boards to provide over load, short circuit and earth leakage protection. Principle of operation of MCB, RCCB and RCBO. Selection and coordination of protective devices. Circuit wiring layout and phase balancing. Safety aspects applicable to low and medium voltage installations. Cable sizing based on current capacity, voltage drop and short-circuit considerations. Earthing systems for domestic dwellings – TT, TN and IT systems. - step potential and touch potential - safety aspects and first aid.	**11**
IV	**Design of electrical system for domestic dwellings** for single phase supply (LV) and three phase supply (MV) – Calculation of connected load and sub circuits - Selection of DB, Circuit Breakers and wires- Estimation of electrification in domestic buildings- preparation of layout, wiring, diagram and estimates - house, office buildings. **Familiarization of AutoCAD toolset-** Preparation of wiring layout drawings using CAD	**13**
V	**Electrical installations of high-rise buildings:** Distribution systems – rising main, cable system - Installation of lifts, standby generators, fire pumps - electric schematic drawing. **Introduction to Solar PV Systems:** off-grid and on-grid systems – Components of PV system - PV modules - types, selection criteria - Design of a PV system for domestic application - selection of equipments. **Smart Energy Conservation Techniques in domestic installations-** Smart home electrical systems (IoT-based automation, wireless control, and sensors) - Home energy management systems (HEMS) and smart metering	**13**
	Total hours	**60**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 marks
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEP40A	POWER SYSTEMS LAB	PCC	0	0	3	0	2	2023

i) COURSE OVERVIEW:

Objective of the course is to train the students to perform load flow studies, short circuit studies, stability studies and automatic generation control using software. This course also imparts practical knowledge in testing Ferranti effect in transmission line, testing various power system components as per the standards, plotting relay characteristics, improving power factor of induction motor and measuring earth electrode resistance.

ii) COURSE OUTCOMES

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

CO 1	Make use of MiPower software to conduct load flow studies, short circuit studies and stability studies on a given power system network	Apply
CO 2	Make use of MATLAB Simulink to perform AGC of single area and two area systems	Apply
CO 3	Apply Ferranti effect test on a transmission line	Apply
CO 4	Experiment with power system switchgear, cables, dielectric materials and relays as per standards	Apply
CO 5	Select suitable capacitor bank to improve the power factor of an induction motor to a desired value	Apply
CO 6	Utilise Earth megger to measure Earth electrode resistance of an earthing system	Apply

iii) SYLLABUS

• Software Experiments: Load flow studies, short circuit studies, transient stability studies, AGC.

• Hardware Experiments: High voltage testing, Ferranti effect, relay testing, insulation testing of cables, Measurement of Earth electrode resistance, testing of dielectric strength of different materials, power factor improvement of induction motor.

iv) REFERENCES

1) Hadi Saadat, Power System Analysis, 2/e, McGraw Hill, 2002.
2) Kothari D. P. and I. J. Nagrath, Modern Power System Analysis, 4/e, TMH, 2011.
3) M. S. Naidu, V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill Education, 2004.
4) Wadhwa C. L., Electrical Power Systems, 4/e, New Age International, 2017.
5) IEEE 1547 and 2030 Standards.
6) IS Codes for Testing of Power System components.

At least 12 experiments (6 hardware experiments are mandatory)

v) COURSE PLAN

Expt No.	List of exercises/experiments	No. of hours
Part A: POWER SYSTEM SIMULATION EXPERIMENTS		
I	Load Flow Studies – Gauss-Siedel Method, Newton – Raphson Method, Fast Decoupled Method – Effect of change in load/generation schedule	**3**
II	Load Flow Studies – Gauss-Siedel Method, Newton – Raphson Method, Fast Decoupled Method – Effect of change in real power/reactive power limits	**3**
III	Short Circuit Studies – Symmetrical Faults	**3**
IV	Short Circuit Studies – Unsymmetrical Faults	**3**
V	Transient Stability Studies	**3**
VI	Automatic Generation Control – Single Area System	**3**
VII	Automatic Generation Control – Two Area System	**4**
Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)		
I	Ferranti Effect and Reactive Power Compensation	**3**
II	High Voltage Testing – Power Frequency & Impulse	**3**
III	Relay Testing – Over Current Relay (Electromechanical & Static)	**3**
IV	Relay Testing – Under Voltage Relay (Electromechanical & Static)	**3**
V	Insulation Testing – LT & HT Cable	**3**
VI	Power Factor improvement of Induction Motor	**3**
VII	Measurement of Earth Electrode Resistance	**3**
VIII	Testing of Dielectric Strength of Transformer Oil	**3**
IX	Testing of Dielectric Strength of Solid Insulating Materials	**3**
X	Testing of Dielectric Strength of Air	**3**
	Total hours	**36**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

(a) Attendance	:	5 marks
(b) Continuous Assessment	:	55 marks
(c) End Semester Lab Examination	:	40 marks
Total	**:**	**100 marks**

vii) END SEMESTER LAB EXAMINATION PATTERN

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

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEV48A	Comprehensive Viva Voce	PWS	0	0	2	0	1	2023

i) COURSE OVERVIEW:

The objective of this course is to evaluate the students' basic understanding and application capability in the core domains of their respective engineering branch.

ii) COURSE OUTCOMES

CO1	Apply fundamental concepts from core engineering courses to analyze and solve basic engineering problems relevant to the branch of study.	Apply
CO2	Demonstrate comprehensive technical understanding by articulating engineering concepts, reasoning, and solutions effectively during viva voce examination.	Understand

iii) SYLLABUS

Electronic Devices and Circuits: Transistor characteristics, Amplifiers, Power amplifiers, Oscillators, Operational amplifier circuits, multivibrators.

Logic System Design: Logic Gates Boolean Algebra, De Morgan's Theorem Karnaugh Map. Combinational Logic Design, Sequential Logic Design , Counters- Asynchronous and synchronous, Ring and Johnson counters. Programmable Logic Devices

Measurements and Instrumentation: Measurement of voltage, Current, power and energy, Potential and current transformers, Measurement of resistance, self-inductance, capacitance and frequency, Magnetic Measurements, Oscilloscopes, Digital Measurement of Electrical Quantities., Transducers

Electric Circuit Analysis: Network theorems, Time domain analysis of dynamic circuits - steady state and transient response analysis, Laplace Transform, Coupled circuits, Resonance, Two port networks.

Electrical Machines: Transformers, losses and efficiency, Autotransformers, DC motor and generator, AC motors - Induction Motor, Synchronous motor, Single-phase induction motor. principle, types, emf equation, characteristics, methods of speed control,

Microcontroller and Applications: Architecture of Intel 8051 Microcontrollers, Assembly programming for 8051 microcontrollers, Embedded C programs for I/O port, serial port communication, timer/counter, Interrupt programming, interfacing external peripherals. Advanced Processors and Concepts, Vega Board Processors

Signals and Systems: Classification of signals and systems, Fourier analysis, Laplace transform, Z transform, Differential and difference equations, sampling, DTFS and DTFT

Power Electronics: Power semiconductor devices, characteristics, Drive circuits, Single phase and three phase rectifiers, Inverters, DC-DC converters, AC voltage regulators.

Power systems: Electric power generation, Power factor improvement, transmission line parameters, modelling of transmission lines, Overhead and underground transmission schemes,

Power distribution systems, power system protection schemes, Per unit quantities, Symmetrical components, fault analysis, load flow analysis, automatic voltage regulation, Economic dispatch, power system stability.

Control Systems: Mathematical modelling of electrical and mechanical system, Transfer function, step response of first order and second order, time domain and frequency domain analysis, stability analysis, state space analysis

iv) a) TEXTBOOKS

1. Thomas L. Floyd, Digital Fundamentals, Pearson Education, 10th Edition, 2011.
2. Boylestad R. L. and Nashelsky L., "Electronic Devices and Circuit Theory", Pearson Education, 10th Edition, 2009.
3. Sawhney A. K., "A course in Electrical and Electronic Measurements and instrumentation", Dhanpat Rai & Co. (P), 10th Edition, 2015.
4. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013.
5. Simon Haykin and Barry Van Veen, Signals and Systems, Wiley India, New Delhi, 2nd Edition, 2007.
6. Kenneth J. Ayala, The 8051 Microcontroller Architecture, Programming and Application, Cengage Learning, 3rd Edition,2012.
7. Rashid M H, Power Electronics – Circuits, Devices and Applications, Prentice Hall of India, New Delhi, 4th edition, 2014
8. Bimbra P. S., "Electric Machines", Khanna Publishers, 2nd Edition, 2017
9. Masters, Gilbert M., Renewable and Efficient Electric Power Systems, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
10. I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, 6th Edition, 2018.

b) REFERENCES

1. Donald P. Leach, Albert Paul Malvino, Digital Principles and Applications, Tata Mc Graw Hill, 8th Edition, 2014.
2. Bernard Etkin, Dyn Floyd T. L., "Fundamentals of Analog Circuits", Pearson Education, 2nd Edition, 2012.
3. Gupta J. B., "A course in Electronic and Electrical Measurement and Instrumentation", S K Kataria & Sons, 13th Edition, 2007
4. Joseph A. Edminister and Mahmood Nahvi, "Electric Circuits", McGraw Hill, 7th Edition, 2017.
5. Gupta J. B., "Theory and Performance of Electrical Machines", S K Kataria & Sons, 14th Edition, 2013.
6. Michael J. Roberts, Fundamentals of Signals and Systems, Tata McGraw-Hill, New Delhi, 2nd Edition, 2010.
7. Shibu K. V., "Introduction to Embedded Systems", 2nd Edition, McGraw Hill Education India, 2016.
8. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications, and Design, Wiley India, 3rd Edition, 2018
9. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, Electric Power System, John Wiley & Sons, 2012.
10. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson, 13th Edition, 2016.

v) Course Plan

Module	Contents	No. of hours
I	**Electronic Devices and Circuits**	3
	Logic System Design	3
II	**Measurements and Instrumentation**	3
	Electric Circuit Analysis	3
III	**Electrical Machines**	3
	Microcontroller	3
IV	**Signals and Systems**	3
	Power Electronics	3
V	**Power system**	3
	Control Systems	3
	Total	**30 hours**

vi) COURSE GUIDELINES AND EVALUATION

i) The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum. Mock tests, mock viva voce sessions, technical discussions may be conducted by the faculty in charge during the hours assigned for the course.

ii) **Total marks: 50**

Continuous internal evaluation-25 marks

Attendance – 5 marks

Multiple choice questions test and comprehensive viva (minimum 2 each) - 20 marks

Final viva voce examination-25 marks

The mark will be treated as internal and should be uploaded along with internal marks of other courses.

The final viva voce examination shall be conducted by a panel of two evaluators. The panel shall consist of one senior faculty member from the Department and an expert from Industry/research institute/academia **or** two senior faculty members from the Department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEJ48A	PROJECT	PWS	0	0	10	0	5	2023

i) COURSE OVERVIEW:

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.

Desirable: The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii) Evaluation Guidelines

Total: 100 marks (Minimum required to pass: **50** Marks).

● Project progress evaluation by guide: **20** Marks.

● Two interim evaluations by the Evaluation Committee: **30** Marks (15 marks for each evaluation).

● Final evaluation by the Final Evaluation committee: **30** Marks

● Quality of the report evaluated by the evaluation committee: **20** Marks

Interim Evaluation:

The Evaluation committee comprises of HoD or a senior faculty member, Project coordinator and Project supervisor.

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i) COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.
- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii) COURSE OVERVIEW

Students can undertake an internship at an industry, research organization, or a reputed academic institution with prior approval of the respective Head of the Department.

The internship is designed to promote meaningful skill development through structured, outcome-driven experiential learning. It shall focus on clearly defined technical competencies, such as domain-specific skills, software proficiency, exposure to industry-standard tools, and structured engineering problem-solving tasks. The learning objectives of the internship, along with the expectations of the host organization and the academic requirements of the institution, shall be clearly defined in consultation with the host organization and mutually agreed upon prior to the approval of the internship.

Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months.**

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

iii) COURSE OUTCOMES

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

CO1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze
CO4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv) GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.

- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
  - ✓ Internship report detailing the work carried out and learning outcomes
  - ✓ Internship Completion Certificate issued by the host organisation
  - ✓ Feedback from the employer
  - ✓ Proof of stipend received, if applicable

v) ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

(i) Evaluation done by the industry,
(ii) Student's diary,
(iii) Internship report, and
(iv) Internship viva voce.

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	:	**50 marks**
Final Assessment		
Internship Report	:	25 Marks
Internship Viva Voce	:	25 marks
Total Final Assessment	:	**50 marks**
TOTAL	:	**100 marks**

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to

the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organisation. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation
- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

PROGRAMME ELECTIVE III

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43A	ENERGY MANAGEMENT AND AUDITING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The goal of this course is to enable the students to understand the concept of energy management and energy management opportunities. The course helps the students to understand the energy auditing procedure and the different methods used for the economic analysis of energy projects.

ii) COURSE OUTCOMES

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

CO1	Explain the significance of energy management and auditing.	Understand
CO2	Summarize energy efficiency improvement opportunities for electrical loads.	Understand
CO3	Explain various Demand Side Management techniques.	Understand
CO4	Explain the process of energy audit and the method of cogeneration.	Understand
CO5	Make use of various methods for economic energy analysis.	Apply

iii) SYLLABUS

Energy Management - General Principles and Planning. Energy management opportunities in Lighting and Motors.

Energy management in industries and commercial establishments-Energy conservation in boiler, steam and furnace. Heat recovery schemes.

Demand side Management- techniques of DSM. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Energy Audit- need, types and methodologies. Energy Economics: Economic analysis: methods. Computer aided Energy Management Systems.

iv) (a) TEXT BOOKS

1) Albert Thumann, William J. Younger, Handbook of Energy Audits, 9th edition, Fairmont Press, 2012.
2) Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.
3) Craig B. Smith, Kelly E Parmenter, Energy management principles: Applications, Benefits, Savings, 2nd edition, Pergamon Press, 2001.
4) D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook,2nd edition, CRC Press, 2007.
5) G.G. Rajan, Optimizing energy efficiencies in industry, Illustrated edition, Tata McGraw Hill, Pub. Co., 2001.

6) Energy Conservation and Sustainable Building Code (Commercial and Office Buildings) 2024, Ministry of Power, Government of India.

(b) REFERENCES

1) IEEE recommended practice for energy management in industrial and facilities. IEEE std 739 - 1995 (Bronze book).
2) M Jayaraju and Premlet, Introduction to Energy Conservation and Management, 3rd edition, Phasor Books, 2008.
3) Paul O'Callaghan, Energy management, 1st edition, McGraw Hill Book Co., 1993.
4) Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.
5) Reference for ENS: https://beeindia.gov.in/eco-niwas-samhita-ens

v) COURSE PLAN

Module	Contents	No. of hours
I	**Energy Management**: General principles of Energy management and Energy management planning. Peak Demand controls, Methodologies, Types of Industrial Loads, Optimal Load scheduling -Case studies. Energy management opportunities in Lighting and Motors. Electrolytic Process and Electric heating, Case studies.	**8**
II	**Energy Management in Industries and Commercial Establishments**: Boiler - working principle - blow down, energy conservation opportunities in boiler. Steam: Properties of steam, distribution losses, steam trapping - opportunities for energy savings in steam distribution. Heat Recovery Systems: Waste heat recovery system - Energy saving opportunities. Energy Conservation and Sustainable Building Code (ECSBC)- Eco Niwas Samhita (ENS) -Overview.	**10**
III	**Demand Side Management (DSM)**: Introduction to DSM, benefits of DSM, Different techniques of DSM- time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority techniques - peak clipping, peak shifting, valley filling. Strategic conservation, energy efficient equipment. Ancillary services- Introduction of ancillary services, Types of Ancillary services.	**9**
IV	**Energy audit**: Definition, Need, Types of energy audit. Pre-audit, audit and post audit phases-purpose and results. Energy audit Instruments – Energy audit report - format. Cogeneration-Types and Schemes, Optimal operation of cogeneration plants- Case study.	**9**
V	**Energy Economics**: Economic analysis methods, cash flow model, time value of money, evaluation of proposals, pay-back period,	**9**

	average rate of return method, internal rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS) – Block diagram.	
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43B	Power Quality	PEC	3	0	0	0	3	2023

i) **COURSE OVERVIEW**: This course offers an introduction to the key concepts of power quality in electrical systems. This course covers different power quality issues and its mitigation methods. It also gives insights about techniques and technologies used for monitoring and mitigating these problems.

ii) **COURSE OUTCOMES**

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

CO1	Classify the sources and effects of power quality problems.	Understand
CO2	Summarize the mechanism of harmonic generation and analysis	Understand
CO3	Explain the important aspects of power quality monitoring.	Understand
CO4	Illustrate power quality mitigation techniques.	Understand
CO5	Explain power quality issues in grid connected renewable energy systems and the need for grounding and wiring.	Understand

iii) **SYLLABUS**

Power quality phenomenon, Sources and effects of power quality problems, classification and origin of power quality disturbances. Harmonics mechanism of harmonic generation, Harmonic sources, Harmonic analysis using Fourier series and Fourier transforms, Harmonic indices, Power quality Monitoring Mitigation of Power quality problems, passive filters, active filters, hybrid filters, DVR, DSTATCOM and UPQC. Power factor correction, Single phase active power factor converter, Power Quality issues of Grid connected Renewable Energy Systems, Introduction Grounding and wiring.

iv) **(a) TEXT BOOKS**

1) R. C. Dugan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill, 2012.
2) C. Sankaran, “Power Quality”, CRC Press, 2002.
3) G. T. Heydt, “Power Quality”, Stars in circle publication, Indiana, 1991.
4) Jose Arillaga, Neville R. Watson, “Power System Harmonics”, Wiley, 1997.
5) Math H. Bollen, ‘Understanding Power Quality Problems’ Wiley-IEEE Press, 1999.
6) Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality problems and Mitigation Techniques”, John Wiley and Sons Ltd, 2015.

(b) REFERENCES

1) Surajit Chattopadhyay, ‘Electric power quality’ – Springer, 2011
2) Angelo Baggini (Ed.) Handbook of Power Quality, Wiley, 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Power quality** - Sources and effects of power quality problems, Need for concern of Power quality, types of power quality disturbances – Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker.	9
II	**Harmonics** - mechanism of harmonic generation, Triplen harmonics, Harmonic sources – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages. Case study of harmonic analysis - diode bridge rectifier load on AC system	9
III	**Harmonic indices**: CF, DF, THD, TDD, TIF, DIN, C – message weights, Displacement and total power factor. **Standards**: Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000. **Power quality Monitoring**: Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters. Case study using power quality analyser	9
IV	**Mitigation of Power quality problems** – Power Quality mitigation in Transmission and Distribution system. Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters –description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR. **Power quality conditioners** - DSTATCOM and UPQC - Configuration and working.	9
V	**Power factor correction** – Single phase active power factor converter – circuit schematic and control block diagram. Power Quality issues of Grid connected Renewable Energy Systems – operating conflicts. Electromagnetic Interference (EMI -introduction - **Grounding and wiring**– reasons for grounding – wiring and grounding problems - solutions to these problems.	9
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43C	ELECTRICAL MACHINE DESIGN	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW

The main goal of this course is to expose the students to the fundamental design principles of both static and rotating electrical machines. Students will explore the design of single phase and three-phase transformers as well as DC, induction, and synchronous machines. It gives an insight into the general idea to the computer aided design of electrical machines.

ii) COURSE OUTCOMES

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

CO1	Illustrate the fundamental factors and constraints involved in the design of electrical machines.	Understand
CO2	Develop the detailed design specifications for the armature and field systems of DC machinery.	Apply
CO3	Develop the design calculations for the transformer's magnetic framework, conductor arrangements and cooling mechanisms to ensure optimal efficiency and thermal stability.	Apply
CO4	Develop the electromagnetic design for the stator and rotor assemblies of the induction machine.	Apply
CO5	Develop the design specifications for the stator and rotor assemblies of a synchronous machine.	Apply
CO6	Apply software tools (ANSYS) to model and optimize electrical machine performance.	Apply

iii) SYLLABUS

Magnetic circuit calculations, Magnetic Leakage Calculation, Unbalanced Magnetic Pull-Practical aspects of unbalanced magnetic pull.

Design of transformers - single phase and three phase transformers - distribution and power transformers, overall dimensions of core.

Design of DC machines - output equation, design of field winding, conductor cross section, design of inter pole, design of compensating winding.

Design of synchronous machines, Design of three phase induction motors, design of rotor bar, design of end ring, design of slip ring rotor winding.

iv) (a) TEXT BOOKS

1) Sawhney A.K., *A Course in Electrical Machine Design*, Dhanpat Rai & Co. (P) Limited, New Delhi,2016.
2) William T. Ryan, *Design of Electrical Machinery*, Creative Media Partners, LLC, 4th Edition, 2015.
3) Upadhay K.G., *Design of Electrical Machines*, New Age International, 2011.
Agarwal R.K., *Principles of Electrical Machine Design*, S. K. Kataria & Sons, 5th Edition 2014.

4) Say M.G., *The Performance and Design of AC Machines,* CBS Publishers, New Delhi, 3rd Edition, 2002.
5) Albert E Clayton & Hancock N.N., *Performance and Design of DC Machines*, Oxford and IBH Publishing Co & PVT Ltd, New Delhi, 3rd Edition,1971.

(b) REFERENCES

1) Rajani V., Nagarajan V.S., *Electrical Machine Design*, Pearson Publications, 3rd Edition, 2018.
2) Thomas A. Lipo, *Introduction to AC machine design*, Wiley-IEEE Press, 2017.
3) Deshpande M.V., *Design and Testing of Electrical Machines*, PHI Learning Pvt. Ltd., 2010.
4) Juha Pyrhonen, Valeria Hrabovcova, Tapani Jokinen, *Design of Rotating Electrical Machines,* John Wiley and Sons Inc., 2nd Edition, 2013.
5) Ramamoorthy M, "*Computer Aided Design of Electrical Equipment*", East-West Press, 2nd Edition, January 2008.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Principles of electrical machine design:** General design considerations, types of enclosures - types of ventilation. Heating - cooling and temperature rise calculation – numerical problems. Continuous, short time and intermittent ratings. Insulation classes – Introduction to modern insulating materials, such as Nomex, Polyamide films and Silicone. Types of cooling in transformers and rotating electrical machines. **Magnetic system** - Carter's coefficient – real and apparent flux density. Unbalanced magnetic pull and its practical aspects.	**9**
II	**DC Machines**: Output equation - main dimensions - choice of specific electric and magnetic loadings, magnetic material and type of cooling considered - choice of speed and number of poles - design of armature conductors, slots and winding - design problems. Design of air-gap - design of field system – design problems. Fundamental design aspects of interpoles, compensating winding, commutator and brushes.	**8**
III	**Transformers**: Design of transformers - single phase and three phase transformers - distribution and power transformers - output equation - core design with due consideration to percentage impedance required - window area - window space factor - overall dimensions of core – design problems. Windings - no. of turns - current density in consideration to the insulation scheme - conductor section. Design of cooling tank with tubes – design problems.	**9**

	Essential design features of cast resin dry type transformers. Fundamentals of K-factor rated transformer, ECBC standards for transformers, BEE Star rating of transformers.	
IV	**Induction machines**: Output equation - main dimensions - choice of specific electric and magnetic loadings, magnetic material and type of cooling considered - design of stator and rotor windings - design of stator and rotor slots, air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor - design of slip ring rotor winding - design problems. Design aspects of induction motor for drive applications (basic principles only).	**9**
V	**Synchronous Machines:** Output equation - salient pole and turbo alternators - main dimensions - choice of specific electric and magnetic loadings, magnetic material and type of cooling considered - significance of short circuit ratio - choice of speed and number of poles - design of armature conductors, slots and winding - round conductor or rectangular conductor - design of air-gap - design problems. **Introduction to Computer Aided Design:** Analysis and synthesis methods - hybrid techniques. Introduction to machine design software using Finite Element Method. Design, simulation and optimization using electromagnetic field ANSYS simulation software (Demo or assignment-based tasks).	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43D	SWITCH MODE POWER CONVERTERS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The goal of this course is to expose the students to the analysis of different non-isolated, isolated DC-DC converters. It gives an insight to the design of DC-DC converters. It also includes the different PWM techniques of DC- AC converters and the concepts of Resonant converters.

ii) COURSE OUTCOMES

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

CO1	Compare the different non-isolated and isolated DC-DC converter topologies.	Understand
CO2	Model the different non-isolated and isolated DC-DC converter topologies.	Apply
CO3	Explain the operation of Switched mode inverters and rectifiers.	Understand
CO4	Summarize the different inverter modulation strategies an power factor correction techniques.	Understand
CO5	Explain the operation of Soft switching resonant converters.	Understand

iii) SYLLABUS

Linear power supply, Switched mode power supply, DC-DC convertors without isolation – buck, boost, buck boost.
Discontinuous conduction mode of dc-dc converter , Cuk converter , Full bridge dc-dc converter.
DC-DC converters with isolation – Flyback converter, Forward converter, Push Pull-Half Bridge, Full Bridge converter, current source converter.
Switched mode DC-AC converter – single phase inverter, three phase inverter, Sine Pulse width modulation – unipolar and bipolar switching.
Resonant converters – Series resonant converter, parallel resonant converter, load resonant converter , Zero Voltage Switching , Zero current switching..

iv) (a) TEXT BOOKS

1. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design, 3rd Edition, Wiley India Pvt Ltd, 2018.

2 Rashid M H, Power Electronics – Circuits, Devices and Applications, Prentice Hall of India, New Delhi, 4th edition, 2014.

3. Taylor Morey , Abraham Pressman , Keith Billings , Switching Power Supply Design, McGraw Hill,3rd Edition, ,2009.

(b) REFERENCES

1. Daniel W Hart, *Power Electronics*, Tata McGraw Hill, 2011.
2. Umanand L , *Power Electronics- Essentials and Applications*, Wiley 2011

3. Christophe P. Basso, *Switch-Mode Power Supplies Spice Simulations and Practical Designs* BPB Publication, 2010.
4. Muhammad Rashid, *Digital Power Electronics and Applications*, first edition, Elsevier, 2005.
5. Christophe Basso, *Switch-Mode Power Supplies, SPICE Simulations and Practical Designs*, Second Edition 2014

v) COURSE PLAN

Module	Contents	No. of hours
I	**Linear Vs Switching Power Electronics. -**Linear Power Supply, disadvantages of linear power supply – switched mode power supply. Buck, Boost, Buck-boost and Ćuk converters: Principles of steady state analysis, Inductor volt-seconds balance and capacitor amp-seconds balance. Operation in Continuous Conduction Mode (CCM)- Voltage Gain, design of filter inductance & capacitance - boundary between continuous and discontinuous conduction – critical values of inductance/load resistance - Examples for buck and boost converters. Discontinuous Conduction Mode (DCM) of buck converter with constant output voltage – Output voltage ripple in DCM. Voltage Gain in DCM for buck converters. Synchronous Buck Converter.	9
II	**DC-DC converters with electrical isolation:** High-frequency transformers for DC-DC converters: unidirectional magnetic core excitation & bidirectional core excitation. Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain. CCM operation of double ended fly-back converter. Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter. Push-Pull, Half-Bridge and Full-Bridge converters: Operation in Continuous Conduction Mode (CCM), Flux-walking in isolated converters. Current-source DC-DC converter.	9
III	**Switched Mode DC to AC converters:** Review of single-phase bridge inverters - 3-phase Sine-PWM inverter, Linear Modulation, RMS, fundamental line to line voltage, Overmodulation - Square wave operation in three-phase inverters - Switch utilisation ratio of 1-phase & 3-phase full-bridge inverters. Single-Phase Power-Factor Correction, Problems due to harmonics in the current drawn by equipment. Basic concept of active power factor correction (PFC) techniques	9
IV	**Modulation Schemes:** Space Vector Modulation: Concept of space vector, space vector modulation, reference vector & switching (dwell) times, space vector sequence, comparison of sine PWM & space vector PWM. Programmed (selective) harmonic elimination switching in single phase inverters (Formulation example with elimination of two harmonics at a time) – current controlled voltage source inverter -	9

	Hysteresis current control. Matlab Simulation of SVPWM fed Two level inverter.	
V	**Soft switching and resonant converters:** Hard-switched Vs Soft-switched converters -Principles of resonant converters, Classical series resonant and parallel resonant converters, Quasi-Resonant Converters, Multi resonant Converters, Zero-Voltage Transition (ZVT) Converters, Zero-voltage and Zero-current switching, Resonant converter design techniques based on frequency response	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43E	INTRODUCTION TO ROBOTICS	PEC	2	1	0	0	3	2023

i)COURSE OVERVIEW: This course introduces students to the foundational principles and technologies that enable robotic systems. It provides a multidisciplinary approach to explore the modeling, control, and application of robots.

ii) COURSE OUTCOMES

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

CO1	Identify the anatomy and specifications of robots for typical application.	Understand
CO2	Select the appropriate sensors and actuators for robots.	Apply
CO3	Identify robotic configuration and gripper for a particular application.	Apply
CO4	Solve forward and inverse kinematics of robotic manipulators.	Apply
CO5	Develop trajectories in joint space and Cartesian space.	Apply
CO6	Develop the dynamic model of a given robotic manipulator and its control strategy.	Apply

iii) SYLLABUS

Definitions, Types of Robots, Anatomy of a robotic manipulator, open kinematic vs closed kinematic chain, degrees of freedom, Robot considerations for an application, Robot Applications.

Sensors and Actuators Sensor classification, Internal sensors, External sensors, Selection of sensors. Actuators for robots, Electric actuators, Linear actuators, selection of motors; Hydraulic actuators, Pneumatic Actuators.

Robot configurations, features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies

Classification of End effectors. Kinematics and Motion Planning - Robot Coordinate Systems, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward and inverse Kinematics of typical robots upto 3 DOF, Motion Planning.

Dynamics and Control of Robots - Dynamic model of a robot using Lagrange's equation, dynamic modeling of 1 DOF robot, PID control of a single link manipulator- Computed torque control.

iv) (a) TEXT BOOKS

1. S K Saha, *Introduction to Robotics*, Tata McGraw Hill, 2nd edition, 2017.
2. Robert. J. Schilling, *Fundamentals of robotics – Analysis and control*, Prentice Hall of India, 1st edition, 1990.

3. R K Mittal and I J Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi, 1st edition, 2003.
4. John. J. Craig., *Introduction to Robotics* (*Mechanics and control*), Pearson Education Asia, 3rd edition, 2004.
5. Saeed B. Nikku, *Introduction to Robotics*, Pearson Education, 2nd edition, 2010.
6. Rachid Manseur, *Robot Modeling and Kinematics*, Lakshmi publications, 2nd edition, 2008.

(b) REFERENCES

1. Ashitava Ghosal, *Robotics-Fundamental concepts and analysis*, Oxford University press, 2006.
2. S. R. Deb, *Robotics Technology and Flexible Automation*, 2nd edition, 2017.
3. Boltans W., *Mechatronics*, Pearson Education, 6th edition, 2016.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Definitions - Robots, Robotics; Types of Robots- Manipulators, Mobile Robots - wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator - links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom. **Robot specifications for an application** - number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control. **Robotic Applications:** Industrial Applications - Material handling, welding, Spray painting, Machining. Non-industrial - medical, mining, space, defense, security, domestic, entertainment.	**8**
II	**Sensor for robots** - classification - touch, force, proximity, vision sensors. Internal sensors - Position sensors, velocity sensors, acceleration sensors, Force sensors. Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors. **Actuators for robots -** classification - Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors Hydraulic actuators - Components and typical circuit, advantages and disadvantages; Pneumatic Actuators - Components and typical circuit, advantages and disadvantages.	**10**
III	**Grippers for Robots-** Classification - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers. **Robot classification** Classification based on Robot configurations - PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots.	**9**

	Classification of robots based on motion control methods and drive Technologies.	
IV	**Robot Coordinate System s-** Fundamental and composite rotations, homogeneous coordinates and transformations. **Robot Kinematics** - Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF. Inverse Kinematics of a typical 3 DOF robot. **Motion Planning** - joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	**9**
V	**Dynamics and Control of Robots** Dynamics - Dynamic model of a robot using Lagrange's equation, dynamic modeling of 1 DOF robot **Control Techniques -** Transfer function and state space representation, Performance and stability of feedback control. PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control, Gravity control.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43F	ADVANCED CONTROL SYSTEMS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces selected advanced control techniques suitable for an elective course. Emphasis is given to application-oriented understanding of state-space methods, state feedback control, optimal control concepts, nonlinear system behavior, and digital control, with minimal mathematical complexity.

ii) COURSE OUTCOMES

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

CO1	Apply state-space concepts to analyze linear control systems.	Apply
CO2	Apply state feedback and observer techniques for control system design.	Apply
CO3	Apply optimal control concepts to improve system performance.	Apply
CO4	Apply nonlinear system analysis techniques for stability assessment.	Apply
CO5	Apply digital control techniques for discrete-time systems.	Apply

iii) SYLLABUS

Review of state-space modelling, solution of state equations, state transition matrix, controllability and observability, Kalman's criteria, system realization.

State feedback control, pole placement, Ackermann's formula, full-order and reduced-order observers, separation principle.

Performance indices, formulation of optimal control problems, Linear Quadratic Regulator (LQR), Algebraic Riccati Equation, introduction to LQG control.

Classification of nonlinear systems, phase plane analysis, equilibrium points, stability concepts, Lyapunov stability analysis, describing function method.

Sampling and discretization, discrete-time state-space models, z-transform review, stability analysis in z-domain, digital controller design.

iv) (a) TEXT BOOKS

1) Ogata, K., Modern Control Engineering, 5th Edition, Pearson Education, 2010.
2) Dorf, R. C. and Bishop, R. H., Modern Control Systems, 12th Edition, Pearson Education, 2011.
3) Nise, N. S., Control Systems Engineering, 6th Edition, Wiley India, 2011.
4) Gopal, M., Control Systems: Principles and Design, 4th Edition, McGraw-Hill Education, 2016.

5) Kuo, B. C. and Golnaraghi, F., Automatic Control Systems, 9th Edition, Wiley India, 2014.

(b) REFERENCES

7) Chen, C. T., Linear System Theory and Design, 4th Edition, Oxford University Press, 2013.

8) Astrom, K. J. and Murray, R. M., Feedback Systems: An Introduction for Scientists and Engineers, 1st Edition, Princeton University Press, 2008.

9) Phillips, C. L. and Harbor, R. D., Feedback Control Systems, 5th Edition, Pearson Education, 2015.

v) COURSE PLAN

Module	Contents	No. of hours
I	**State Space Review and System Properties** Review of state-space representation of linear systems, solution of state equations, state transition matrix (conceptual treatment), controllability and observability, Kalman's controllability and observability criteria, realization of simple state models.	9
II	**State Feedback and Observer Techniques** Concept of state feedback control, pole placement approach, design using Ackermann's formula, practical limitations of pole placement, concept of state observers, full-order observer design, observer-based control systems, separation principle.	9
III	**Introduction to Optimal Control** Need for optimal control, performance indices, formulation of optimal control problems, Linear Quadratic Regulator (LQR), qualitative understanding of Algebraic Riccati Equation, advantages and applications of LQR, brief introduction to Linear Quadratic Gaussian (LQG) control.	9
IV	**Basics of Nonlinear Control Systems** Introduction to nonlinear systems, common nonlinearities in control systems, equilibrium points, linearization concept, phase plane analysis, stability concepts, introduction to Lyapunov stability (conceptual), describing function method and limit cycle analysis.	9
V	Sampling and reconstruction, discretization of continuous-time systems, pulse transfer function, discrete-time state-space models, stability analysis of discrete systems, Jury stability criterion (basic application), digital controller design using pole placement, introduction to digital PID controllers.	9
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of 30 **marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43G	DIGITAL SIGNAL PROCESSING	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW: This course covers the fundamentals of Discrete Fourier Transform (DFT) and its computation using both the direct method and the Fast Fourier Transform (FFT). It also introduces techniques for designing Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filters based on given specifications. In addition, the course provides a detailed analysis of finite word-length effects in fixed-point digital signal processing systems and discusses the architecture of a digital signal processor.

ii) COURSE OUTCOMES

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

CO1	Apply Discrete Fourier and Fast Fourier transforms on discrete time signals.	Apply
CO2	Model various structures for realization of IIR and FIR discrete time systems.	Apply
CO3	Develop IIR filters using impulse invariant and bilinear transformation methods.	Apply
CO4	Develop FIR filters using frequency sampling method and window function method.	Apply
CO5	Explain the finite word length effects and multirate digital signal processing.	Understand

iii) SYLLABUS

Discrete-Fourier Transform - Frequency domain sampling - Discrete Fourier transform (DFT), inverse DFT (IDFT -Filtering of long data sequences – Fast Fourier transform (FFT). Realization of IIR and FIR Systems - conversion of lattice to direct form and vice versa- signal flow graphs and transposed structures. IIR Filter Design - frequency transformation in analog domain - design of LP,

HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation. FIR Filter Design and Representation of Numbers - IEEE 754 32-bit single precision floating point representation. Finite Word Length Effects and Multi rate digital signal processing: Concepts only, design of practical sampling rate converters, Decimators and Interpolators (Concept only).

iv) (a) TEXT BOOKS

1. John G. Proakis & Dimitris G. Manolakis, Digital Signal Processing Principles, Algorithms & Applications, Fourth edition, Pearson Education / Prentice Hall, 2007.
2. P. Ramesh Babu, Digital Signal Processing, Fourth Edition Scitech Publications (India) Pvt Ltd, 2011.
3. Emmanuel C. Ifeachor, & Barrie W. Jervis, Digital Signal Processing, Pearson Education / Prentice Hall, 13th Edition, 2013.

4. Alan V. Oppenheim, Ronald W. Schafer & Hohn. R. Back, Discrete Time Signal Processing, Pearson Education, 2nd edition, 2005.
5. Sanjit K. Mitra, "Digital Signal Processing, A Computer based Approach", Tata McGraw-Hill, 4 th Edition, 2017.

(b) REFERENCES

1) Li Tan, *Digital Signal Processing, Fundamentals & Applications*, Academic Press,1st Edition, 2008.
2) D.Ganesh Rao&Vineeta P Gejji, *Digital Signal Processing, A simplified Approach*, Sanguine Technical Publishers, 2nd Edition, 2008.
3) Johny R. Johnson, *Introduction to Digital Signal Processing*, PHI, 2006.
4) S. K. Mitra, *Digital Signal Processing, A Computer Based Approach*, Tata McGraw-Hill, 1998.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Discrete-Fourier Transform**- - Review of Discrete Fourier transform (DFT),inverse DFT (IDFT) - Frequency domain sampling -properties of DFT -Filtering of long data sequences - over-lap save method, over-lap add method -Fast Fourier transform (FFT)- radix -2 decimation-in-time FFT (DIT-FFT) algorithm, Radix-2 decimation-in-frequency FFT (DIF-FFT) algorithm.	**9**
II	**Realization of IIR and FIR Systems**-Introduction to FIR and IIR systems - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole system, lattice ladder structure – conversion of lattice to direct form and vice- versa - signal flow graphs and transposed structures – Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization.	**9**
III	**IIR Filter Design** -Conversion of analog transfer function to digital transfer function – impulse invariant transformation and bilinear transformation – warping effect. Design of IIR filters – low-pass, high pass, band-pass, band-stop filters – Butterworth and Chebyshev filter – frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.	**9**
IV	**FIR Filter Design** -Impulse response of ideal low pass filter-Design of FIR filter (LP, HP filters) using window functions Rectangular, Hanning, Hamming -FIR filter (LP, HP, BP, BS filters) design based on frequency sampling approach **Representation of numbers-fixed point representation -** floating point representation – IEEE 754 32-bit single precision floating point representation.	**9**

	Introduction to FDA Toolbox in MATLAB: Design of filters using FDA toolbox (Demonstration/Assignment only)	
V	**Finite Word Length Effects** -Finite word length effects in digital Filters: input quantization - quantization overflow- techniques to prevent overflow - product quantization error-rounding and truncation, round-off noise power, limit cycle oscillations, zero input limit cycle oscillations, overflow limit cycle oscillations, signal scaling. **Multi rate digital signal processing:** Concepts only, design of practical sampling rate converters, Decimators and Interpolators (Concept only).	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions. Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43H	INTRODUCTION TO MACHINE LEARNING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The goal of this course is to introduce the fundamental concepts of Machine Learning and types of Machine learning algorithms.

ii) COURSE OUTCOMES After the completion of the course, the student will be able to:

CO1	Apply Python programming, data handling tools and visualization techniques to perform exploratory data analysis on real-world datasets.	Apply
CO2	Apply supervised learning algorithms to solve classification and regression problems.	Apply
CO3	Apply discriminative and probabilistic classifiers and evaluate their performance using standard metrics.	Apply
CO4	Apply unsupervised learning and dimensionality reduction techniques for data exploration and pattern discovery.	Apply
CO5	Apply ensemble methods and density estimation techniques to develop machine learning solutions for practical applications in Electrical and Electronics Engineering domains.	Apply

iii) SYLLABUS

Introduction to python and machine learning: Supervised and Unsupervised, Generative and Discriminative models, Classification and Regression problems; Discriminative classifiers: Perceptrons, Multi-layer perceptron, RBF Networks, Decision Trees, Support Vector Machines; Bayesian Classification, Performance Analysis, Unsupervised Learning & Density Estimation: Clustering Concept & K-Mean Clustering, Gaussian Mixture Models, EM. PCA for dimensionality reduction, Density Estimation, Ensemble methods: Ensemble strategies, boosting and bagging; Applications and Case studies.

iv) (a) TEXT BOOKS

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

(b) REFERENCES

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

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Python and Machine Learning:** Introduction to Python: Data Types in Python, NumPy, Pandas, Matplotlib, and Seaborn, Exploratory Data Analysis (EDA): Descriptive statistics (mean, median, variance, standard deviation), Data visualization techniques: histograms, boxplots, scatter plots. Introduction to Machine Learning and Machine Learning Algorithms (Supervised, Unsupervised and Reinforcement learning), Generative models vs. Discriminative models, Classification (categorical output) vs. Regression (continuous output) problems.	9
II	**Supervised Learning & Linear Models:** Introduction to Supervised Learning Algorithm: Linear Regression - Linear relationship, Assumptions of Linear regressions, Errors, Logistic Regression: Logistic function & Sigmoid Curve, Confusion matrix, Linear Discriminative Classifiers: The Perceptron, Multi-layer Perceptron (MLP): Feed forward networks, activation functions, and Backpropagation and RBF Networks: Radial Basis Function networks and localized learning.	10
III	**Discriminative Models & Performance Analysis:** Advanced Discriminative-classifiers: Decision-trees, Support-vector Machines (SVM), Probabilistic-classification: Bayesian Classification, KNN Classifier, Performance Analysis: Evaluation metrics: Confusion Matrix, Precision, Recall, F1-Score, Graphical analysis: ROC Curves and AUC (Area Under Curve).	8
IV	**Unsupervised Learning:** Introduction to Unsupervised Learning: Clustering Concept & K-Mean Clustering - Distance measures, Types of clustering: Hierarchical Clustering: Distance calculation between data points, Cluster and dendrograms formation, Cophenetic correlation, Gaussian Mixture Models, EM.	9
V	**Density Estimation, Ensemble Methods & Case Studies:** Principal Component Analysis (PCA): Principal component Co variance matrix, PCA for dimensionality reduction, Density Estimation: Parametric vs. Non-parametric density estimation in learning. Ensemble Techniques: Bagging, Boosting, Random Forest, Applications and Case Studies: Applications of Machine learning in various domains, Implementation of Machine Learning Algorithms using Python (Supervised and Unsupervised Learning-Can be given as a project).	9

	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL43I	INTRODUCTION TO COMPUTER NETWORKS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course offers learners a comprehensive understanding of how computer networks are constructed, ranging from local area networks (LANs) to the vast, global Internet. It explores how these networks enable computers to share information and communicate effectively. The curriculum covers the physical components of computer networks, the layers of the OSI Reference Model, and principles of inter-networking. Additionally, learners will develop the skills to compare and evaluate existing network technologies, enabling them to select an optimal network design for specific systems.

ii) COURSE OUTCOMES

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

CO1	Explain the features of computer networks, network design models and the fundamental characteristics of the physical layer	Understand
CO2	Explain the design issues of data link layer, link layer protocols, bridges and switches	Understand
CO3	Illustrate wired LAN protocols (IEEE 802.3) and wireless LAN protocols (IEEE 802.11)	Understand
CO4	Select appropriate routing algorithms, congestion control techniques, and Quality of Service requirements for a network	Apply
CO5	Illustrate the functions and protocols of the network layer, transport layer, and application layer in inter-networking	Understand

iii) SYLLABUS

Introduction - Reference Models - Physical Layer - Data link layer - Medium Access Control (MAC) sublayer - Wireless LANs - 802.11 -Network layer - Routing Algorithms- Congestion Control Algorithms - Quality of Service (QoS) - Network Layer in Internet - Transport Layer – User Datagram Protocol (UDP) - Transmission Control Protocol (TCP) – Application Layer protocols.

iv) (a) TEXT BOOKS

1. Andrew S. Tanenbaum, *Computer Networks*, 4/e, PHI (Prentice Hall India).
2. Behrouz A Forouzan, *Data Communication and Networking*, 4/e, Tata McGraw Hill
3. Keshav, *An Engineering Approach to Computer Networks*, Addison Wesley, 1998.
4. Larry L Peterson and Bruce S Dave, *Computer Networks – A Systems Approach*, 5/e, Morgan Kaufmann.

(b) REFERENCES

1) Fred Halsall, *Computer Networking and the Internet*, 5/e.
2) James F. Kurose, Keith W. Ross, *Computer Networking: A Top-Down Approach*, 6/e.
3) W. Richard Stevens. *TCP/IP Illustrated* Volume 1, Addison-Wesley, 2005.
4) William Stallings, *Computer Networking with Internet Protocols*, Prentice-Hall,

2004.

5) *Request for Comments (RFC) Pages* - IETF -https://www.ietf.org/rfc.html.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction – Uses of computer networks, Network hardware, Network software. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models. Physical Layer – Modes of communication, Physical topologies, Signal encoding, Repeaters and hub, Transmission media overview. Performance indicators – Bandwidth, Throughput, Latency, Queuing time, Bandwidth–Delay product.	**9**
II	Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols, High-Level Data Link Control(HDLC)protocol. Medium Access Control (MAC) sublayer – Channel allocation problem, Multiple access protocols Ethernet, Ethernet cabling, Manchester encoding, Ethernet MAC sublayer protocol, Binary Exponential Backoff algorithm. Switched Ethernet, Fast Ethernet, Gigabit Ethernet, IEEE 802.2: Logical Link Control. Wireless LANs -802.11, Bridges & switches, Repeaters, Hubs, Bridges, Switches, Routers and Gateways. (Basic concept only)	**10**
III	Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Multicast routing. General principles of congestion control, Congestion prevention policies, Congestion control algorithms. Load shedding, Jitter control. Quality of Service (QoS) - requirements, Techniques for achieving good QoS.	**8**
IV	IP protocol, IP addresses, Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP), Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First(OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting, IPv6	**9**
V	Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). Transmission Control Protocol (TCP) – Overview of TCP, Application Layer –File Transfer Protocol (FTP), Domain Name System (DNS), Electronic mail, Multipurpose Internet Mail Extension (MIME), Simple Network Management Protocol (SNMP), World Wide Web (www) – Architectural overview.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

INSTITUTE ELECTIVE II

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42M	ARCHITECTURAL LIGHTING DESIGN AND CONTROL	IEC	2	1	0	0	3	2023

i) COURSE OVERVIEW: This course explores the principles of architectural lighting design and control, covering fundamental lighting concepts, lamp technologies, and luminaire types. It includes interior, exterior, and specialized lighting designs, emphasizing energy efficiency, daylight integration, and automation using smart control systems. Students will gain insights into modern lighting techniques, sustainable solutions, and real-world applications in buildings, streets, and urban environments.

ii) COURSE OUTCOMES

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

CO1	Explain the fundamental principles of light, illumination, and various lamp technologies used in architectural lighting.	Understand
CO2	Illustrate the various types of luminaires and their structural features	Understand
CO3	Develop the lighting scheme for efficient indoor lighting system	Apply
CO4	Develop the lighting scheme for efficient outdoor and specialized lighting system	Apply
CO6	Demonstrate smart and sustainable lighting practices and lighting controls for modern architecture.	Understand

iii) SYLLABUS

Role of lighting in architecture, Fundamentals of Lighting and Lamps –Quality of lighting-lamp types- Fluorescent, LED, Sodium vapour, Mercury vapour lamps

Luminous flux, Luminous intensity, Lumen, Candle power, Illumination - Luminaire types – Reflectors, refractors, mounting types, Fixture selection.

Interior Lighting Design – Illumination calculations, Average lumen method, Space-to-mounting height ratio, Lighting design for seminar halls, offices, residences, Staircase, corridor, and entrance lighting, Human-centric lighting.

Outdoor and Specialized Lighting – Road and street lighting, Spacing-to-mounting height ratio, Flood lighting, Façade lighting, Landscape and garden lighting, S

Smart Lighting Systems – Lighting control methods, Dimmers, Motion and occupancy sensors, Photo sensors, Timers, IoT-based lighting, Smart city lighting automation.

DALI, DMX, Sustainable lighting strategies.

iv) (a) TEXT BOOKS

1) G. Steffy, *Architectural Lighting Design*, John Wiley & Sons, 2nd Edition, 2013.

2) M. David Egan and Victor Olgyay, *Architectural Lighting*, McGraw-Hill Education, 3rd Edition, 2002.
3) Claude Engle, *Lighting: Basics, Concepts and Applications*, Fairmont Press, 1st Edition, 2010
4) Craig DiLouie, *Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications*, Fairmont Press, 1st Edition, 2006.
5) Robert Simpson, *Lighting Control: Technology and Applications*, Taylor and Francis, 2003.
6) M K Giridharan, *Electrical System Design*, I K International Publishing House Pvt. Ltd, 2015.
7) M.S. Rea, *The IESNA Lighting Handbook*, Illuminating Engineering Society of North America (IESNA), 10th Edition, 2011.
8) R. G. Hopkinson, *Lighting for Architecture*, Elsevier, 2013.

(b) REFERENCES

1) D.C. Pritchard, *Lighting*, 6th edition, Routledge, 2014
2) Jack L. Lindsey, *Applied Illumination Engineering*, The Fairmont Press Inc.
3) M.A. Cayless, *Lamps and Lighting*, Routledge, 1996.
4) Mohamed Boubekri, *Daylighting, Architecture and Health: Building Design Strategies* Architectural Press, UK.
5) Mark Karlen, James Benya, *Lighting Design Basics*, Wiley, 3rd Edition, 2017.
6) Peter Tregenza, David Loe, *The Design of Lighting*, Routledge, 2013.
7) Gary Gordon, *Interior Lighting for Designers*, Wiley, 5th Edition, 2015.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Lighting in Architecture:** Role of lighting in architecture – visual comfort, aesthetics, safety, productivity. Quality of Lighting: Brightness balance, uniformity, shadow and modelling. Color rendering index (CRI), Glare - Lighting systems- direct, indirect, semi direct, semi indirect, Types of lamps – Fluorescent, LED, High & Low-pressure sodium vapour lamps, Metal halide - Solid state lighting – LEDs and OLEDs- Comparative analysis of lamp technologies – Energy efficiency, lifespan, color rendering	9
II	Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, Lamp efficiency, Illuminance, Laws of illumination, Inverse square law and Lambert's Cosine law. **Types of luminaires:** recessed, surface-mounted, pendant, track, wall-mounted- Fixture selection based on applications - Luminaire selection criteria **Optical systems –** reflectors, lenses, diffusers. Ingress protection (IP) ratings. Thermal management in luminaires.	8

III	**Interior Lighting Design:** Maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization-LLF- factors affecting-Illumination calculations – Average lumen method, Space to mounting height ratio, Design of Seminar halls, offices, residential spaces – Lighting for staircases, corridors, and entrances – Auditorium lighting.	**10**
IV	**Outdoor and Specialized Lighting:** Road lighting design – Spacing to mounting height ratio, Street lighting arrangements – Pole placements and fixture types Flood lighting design – Selection of lamps and projectors. Façade lighting techniques – floodlighting, grazing, wall washing, Landscape and garden lighting.	**9**
V	**Lighting Controls and Smart Systems:** Need for Lighting Controls-Types: switches, dimmers, Automatic controls – occupancy sensors, daylight sensors, timers. DALI, DMX protocols -Wireless lighting controls. **Smart Lighting Systems:** Human Centric Lighting (HCL) – Introduction to IoT-based lighting -Case studies on energy-efficient lighting in urban environments **Sustainable lighting:** Daylight harvesting- lighting in green buildings	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of 30 marks each (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42N	ELECTRIC VEHICLES	IEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The main goal of this course is to expose the students to the fundamental concepts and trends in electric and hybrid vehicles. It gives an insight into the drive system, battery management system and energy sources used in electric vehicles.

ii) COURSE OUTCOMES

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

CO1	Apply hybrid electric vehicle architecture principles to determine the overall vehicle performance metrics.	Apply
CO2	Illustrate the fundamental principles and provide a comparative study of diverse Electric Vehicle and Hybrid Electric Vehicle powertrain architectures.	Understand
CO3	Outline the architecture and operational characteristics of propulsion systems utilized in electric and hybrid-electric transport.	Understand
CO4	Explain mathematical battery modelling techniques, examine various battery chemistries and illustrate their respective charging methods.	Understand
CO5	Summarize various communication protocols and technologies used in vehicle networks and high efficiency battery charging infrastructures for automotive applications.	Understand

iii) SYLLABUS

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Electric Drive Drain, Power flow control.
Electric Propulsion unit: Configuration and control of DC motor drives and Induction Motor drives.
Energy Storage Requirements in Hybrid and Electric Vehicles, Battery modelling.
Communication Systems, Overview of EV battery chargers, Energy Management Strategies.

iv) (a) TEXT BOOKS

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3rd Edition 2021.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier,2010.

4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

(b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd, 2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.
5) Dishore S.V, Electric Vehicle Architecture, Lakshmi Publications,2023.

(c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM,IITD) – Electric and Hybrid vehicles
https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
Electric Vehicle Conductive AC Charging System

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles. **Basics of vehicle performance**, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. **Autonomous Vehicles:** Levels of automation, significance & effects of automation in vehicles.	**9**
II	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.	**8**

	Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies. Comparative insights into BEV, HEV, PHEV and Fuel Cell EV architectures.	
III	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles. Four quadrant operation. Configuration and control of separately excited DC motors, Induction Motors (block diagram representation of FOC), voltage and frequency control.	**8**
IV	**Battery Modeling, Types and Charging**: Batteries in Electric and Hybrid Vehicles-Battery Basics -Battery Parameters. Battery Modelling, Electric Circuit Models. Types-Lead Acid Battery-Nickel-Cadmium Battery-Nickel-Metal-Hydride (NiMH) Battery-Li-Ion Battery -Li-Polymer Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride, Battery Charging methods.	**10**
V	**Communications**, supporting subsystems: In vehicle networks-Communication Protocols - CAN, LIN, FLEXRAY (Basics only). **Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to vehicle power flow block schematic diagrams. Types of charging stations - AC Level 1 & 2, DC - Level 3. **Introduction to energy management strategies**: Classification of different energy management strategies, comparison of different energy management strategies.	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42O	Process Control and Automation	IEC	3	0	0	0	3	2023

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

ii) COURSE OUTCOMES

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

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

iii) SYLLABUS

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

iv) (a) TEXT BOOKS

1) Coughanowr, D. R., LeBlanc S., *Process Systems Analysis and Control*, 3rd edition, McGraw-Hill, 2008.
2) C. D. Johnson, *Process control Instrumentation Technology*, Pearson Education, Eighth Edition, 2006, PHI, 8th Edition, 2013.
3) William L. Luyben, *Process Modelling, Simulation and Control for Chemical Engineers*, Mc- Graw Hill, 2nd edition, 1996.

4) Surekha Bhanot, *Process Control - Principles & Applications*, Oxford University Press, 2008.
5) S. K. Saha, *Introduction to Robotics*, McGraw Hill Education Pvt. Ltd., 2nd edition, 2014.
6) Norman S. Nice, *Control Systems Engineering*, 6th edition, 2011.

(b) REFERENCES

1) Stephanopoulos G., *Chemical Process Control: An Introduction to Theory and Practice*, Pearson Education (1984), PHI, 2006.
2) B. Wayne Bequette, *Process control: Modeling, Design and simulation*, Prentice Hall of India (P) Ltd., 2003.
3) Huges T, *Programmable Controllers*, ISA press, 4th Edition Illustrated, 2005.
4) Considine D.M., *Process Instruments and Controls Handbook*, Second Edition, McGraw, 1999.
5) G. Liptak, *Handbook of Process Control*, 1996.
6) K. Krishnaswamy, *Process Control*, New Age International, 2007.
7) Patranabis D., *Principles of Process Control*, Tata McGraw Hill, New Delhi, 3rd edition, 2017.

v) COURSE PLAN

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

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

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23IEL42P	SUSTAINABLE ENERGY MANAGEMENT	IEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The main goal of this course is to enable the students to understand the concept of sustainable energy management. The course helps the students to understand the different methods used for energy management and economic analysis of energy.

ii) COURSE OUTCOMES

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

CO1	Explain the significance of energy management and planning.	Understand
CO2	Summarize energy management opportunities in electric lighting, transformers and motor loads.	Understand
CO3	Identify energy management strategies in industries and commercial establishments.	Apply
CO4	Explain Demand Side Management techniques.	Understand
CO5	Make use of various methods for economic energy analysis.	Apply

iii) SYLLABUS

Energy Management - General Principles and Planning. Energy management opportunities in Lighting, Transformers and Motors.

Energy management in industries and commercial establishments-Energy conservation in boiler and steam. Heat recovery systems- cogeneration.

Demand Side Management- techniques of DSM. Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Energy Economics: Economic analysis: methods. Computer aided Energy Management Systems.

iv) (a) TEXT BOOKS

1) Mirjana Radovanović, Sustainable Energy Management: Planning, Implementation, Control and Strategy, 2nd edition, Academic Press (Elsevier), 2022.
2) Akilu Yunusa-Kaltungo (Ed.), Key Themes in Energy Management, Springer Nature, 2024.
3) Vinay Kandpal, Rakesh Kumar, Ashok Kumar (Eds.), Sustainable Energy Transition: Circular Economy and ESG Practices, Springer, 2024.

4) Craig B. Smith, Kelly E Parmenter, Energy management principles: Applications, Benefits, Savings, 2nd edition, Pergamon Press, 2001.
5) Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.
6) D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook,2nd edition, CRC Press, 2016.
7) G.G. Rajan, optimizing energy efficiencies in industry, Illustrated edition, Tata McGraw Hill, Pub. Co., 2001.

(b) REFERENCES

1) IEEE recommended practice for energy management in industrial and facilities.
2) IEEE std 739 - 1995 (Bronze book).
3) M Jayaraju and Premlet, Introduction to Energy Conservation and Management, 3rd edition, Phasor Books, 2008.
4) Paul O'Callaghan, Energy management, 1st edition, McGraw Hill Book Co., 1993.
5) Wayne C. Turner, Steve Doty, Stephen A. Roosa**,** ***Energy Management Handbook*****,** 10th edition**, River Publishers,** 2025..

v) COURSE PLAN

Module	Contents	No. of hours
I	Review of Sustainable Development Goals. **Energy Management**: General principles of Energy management and Energy management planning. Peak demand control-methodologies. **Energy Efficiency in Lighting**: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.	**9**
II	**Energy Efficiency in Motors:** Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching. **Energy efficiency in Transformers:** Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.	**9**
III	**Energy Management in Industries and Commercial Establishments**: Boiler - working principle - blow down, energy conservation opportunities in boilers. Identifying opportunities for energy savings in steam distribution. General fuel economy measures, energy conservation opportunities in furnaces - Case study. **Heat Recovery Systems**: Waste heat recovery system - Energy saving opportunities. Cogeneration-Types and Schemes, Optimal operation of cogeneration plants - Case study. Assessment of carbon foot-print, life cycle analysis (LCA), sustainable building codes and basics of energy auditing.	**11**
IV	**Demand Side Management (DSM):** Introduction to DSM, benefits of DSM, Different techniques of DSM - time of day pricing, multi-utility power exchange model, time of day models for planning. Load management, load priority technique, strategic conservation, energy	**9**

	efficient equipment.	
V	**Energy Economics**: Economic analysis methods, cash flow model, time value of money, pay-back period, average rate of return method, present value method, life cycle costing approach. Digital Energy Management Systems (EMS) – Basic Concepts.	**7**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

MINORS/HONOURS

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEJ4MA/23EEJ4MC/ 23EEJ4ME/23EEJ4MG	MINIPROJECT	VAC	0	0	6	0	3	2023

i) COURSE OVERVIEW

The course encourages students to **apply the concepts, methods, and tools** learned to solve **real-world or socially relevant problems**. The course also emphasizes **innovation, and critical thinking**, encouraging students to explore new ideas and technologies. The mini project topic selected will be assigned to a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. It helps students develop skills in teamwork, project planning, technical documentation, and communication.

ii) COURSE OUTCOMES

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

CO 1	Identify real life engineering problems that are socially relevant, technically feasible and economically viable.	Apply
CO 2	Design proper scientific methodology to successfully complete the project	Apply
CO 3	Develop solutions to socially relevant practical problems by applying suitable scientific tools	Apply
CO 4	Evaluate the performance of the developed solution using suitable data analysis, validation techniques, and engineering judgement.	Evaluate
CO 5	Prepare a technical report and present the project outcomes effectively using appropriate engineering and communication tools	Apply
CO6	Build the culture of working effectively in a team, upholding professional and ethical responsibilities	Apply

iii) COURSE PLAN

In this course, each group consisting of a maximum of four members is expected to identify a topic of interest in consultation with Faculty-in-charge of mini project, review the literature and gather information pertaining to the chosen topic, state the objectives and develop a methodology to achieve the objectives. Execute experimental procedure, design/fabrication or develop codes/programs or conduct case studies to achieve the objectives. Demonstrate the novelty of the project through the results and outcomes.

The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A project report is submitted by each student at the end of the semester.

iv) ASSESSMENT PATTERN

The final evaluation will be conducted as an internal evaluation based on the level of objectives achieved, the report and a viva-voce examination, conducted by a 3-member committee appointed by Head of the Department offering minor. The committee members shall be HoD or a senior faculty member, Mini project coordinator and project supervisor. The Committee will evaluate the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement. The progress of the mini project is evaluated through a minimum of TWO reviews. At the time of the 1st review, students are expected to propose a methodology to achieve the objectives after completing a thorough literature study of the existing systems under their chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution.

v) Mark Distribution

Total: 100 marks (Minimum required to pass: 50 Marks).

- Project progress evaluation by guide : 20 Marks.
- Two interim evaluations by the Evaluation Committee : 30 Marks (15 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 30 Marks
- Quality of the report evaluated by the evaluation committee: 20 Marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL4HA	OPERATION AND CONTROL OF GENERATORS	VAC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

The goal of this course is to impart knowledge to the students about the broad classification of various electric generator topologies and types of excitation systems. The course also intends to deliver the operation and control strategies of Induction Generators, Synchronous Generators and Permanent Magnet Synchronous generators.

ii) COURSE OUTCOMES

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

CO1	Compare different excitation systems and explain the various methods used for controlling active and reactive power.	Understand
CO2	Identify the various control schemes for active and reactive power compensation of synchronous generators.	Apply
CO3	Develop a synchronous machine model that incorporates the effect of saliency and stability.	Apply
CO4	Illustrate the operational principles and performance characteristics of both Wound Rotor Induction Generators and Self-Excited Induction Generators.	Understand
CO5	Develop the model of Permanent Magnet Synchronous Generators.	Apply

iii) SYLLABUS

Electric generators-types, applications, review.
Excitation systems-block diagram, components, classification, compensation of excitation systems.
Control of active and reactive power-active power and frequency control, automatic generation control, reactive power and voltage control.
Synchronous machine dynamics-stability, swing equation.
Induction generators-operation at power grid, Self-excited induction generators.
Permanent magnet synchronous generators-field distribution, emf and torque, autonomous PMSG.

iv) (a) TEXT BOOKS

1) Kimbark E. W., *Power System Stability*, Vol. III, Wiley Publications, 2017.
2) Allen J. Wood., Bruce F. Wollenberg, Gerald B. Sheble, *Power Generation, Operation and Control*, Wiley Publications, New York ,3rd Edition 2013.
3) Kundur P., *Power system stability and control*, McGraw-Hill, 1994.
4) Stevenson W. D., *Elements of Power system analysis*, 1995.

5) Concordia C., *Synchronous Machines*, Wiley Publications, 1958.

(b) REFERENCES

10) Hadi Saddat, *Power System Analysis*, McGraw-Hill, 2002.
11) Fitzgerald A. E., Charles Kingsley Jr., Stephen D. Umans, *Electric Machinery*, McGraw-Hill Higher Education,6th Edition, 2003.
12) Bhag Singh Guru, Huseyin R. Hiziroglu, *Electric Machinery and Transformers*, Oxford University Press Inc, 3rd Edition,2000.
13) Bhimbra P. S., *Generalized Theory of Electrical Machines*, Khanna Publishers, 7th Revised Edition 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Electric Generators**- Types of electric generators, generator applications. **Excitation Systems**- Classification-DC, AC and static systems, voltage regulator, power system stabilizer. Compensation of excitation systems-IEEE type excitation systems, instability problem of exciter, solution to the instability of exciter, need for power system stabilizer. Co-ordinated AVR, PSS and speed governor control, FACTS aided control of synchronous generators.	9
II	**Control of Active power and Reactive power**: Active power and frequency control-fundamentals of speed governing, control of generating unit power output. Fundamentals of automatic generation control. Reactive power and voltage control-production and absorption of reactive power, methods of voltage control, shunt reactors, shunt capacitors, series capacitors, synchronous condensers, static VAR systems.	9
III	**Synchronous Machine Dynamics:** Dynamics of synchronous generators in transient situations, factors affecting transient stability, swing equation, models for stability studies, Synchronous machine model including saliency, steady-state stability-small disturbances, transient stability-equal area criterion-application to sudden increase in power output.	9
IV	**Wound rotor Induction Generators**- Construction, steady state equations, equivalent circuit, phasor diagrams, operation at the power grid- stator power versus power angle, rotor power versus power angle and operation at zero slip. **Self-excited Induction Generators**: Cage rotor Induction machine-principle, self-excitation, steady state performance of Three-phase	9

	Self-excited Induction generators.	
V	**Permanent Magnet Synchronous Generator Systems:** Configuration and characteristics- air-gap field distribution, emf and torque, stator core loss modelling, circuit model, autonomous PMSGs with controlled constant speed and AC load.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL4HC	Dynamics of Power Converters	VAC	2	1	0	0	3	2023

i) COURSE OVERVIEW: The goal of the course is to analyse the steady state equivalent modelling and AC circuit modelling of power electronic converters. It also includes the canonical modelling of converters. The course also imparts knowledge about the transfer function of the converter and controller design.

ii) COURSE OUTCOMES

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

CO1	Model the DC-DC converters under steady state condition.	Apply
CO2	Develop dynamic model of switch mode power converters using state space averaging and circuit averaging techniques.	Apply
CO3	Develop the transfer function of DC-DC converters.	Apply
CO4	Illustrate the closed-loop control of DC-DC converters.	Understand
CO5	Explain the discontinuous conduction mode of dc-dc converters	Understand

iii) SYLLABUS

Steady State Converter Analysis -Small-Ripple Approximation, Analysis of buck, boost and buck-boost converter in continuous & discontinuous conduction mode, inclusion of semiconductor Conduction Losses in converters.
AC Equivalent Circuit Modelling Small signal AC modelling of Buck, Boost converter, Perturbation and Linearization, Modelling the pulse width modulator
State Space Averaging. State space averaging of non-ideal buck boost converter, Canonical Circuit Model of DC-DC converters.
Converter Transfer Functions. Frequency response analysis, Transfer Functions of the Buck-Boost Converter, graphical construction of converter transfer functions, Controller Design. Converters in Discontinuous Conduction Mode AC and DC equivalent circuit modelling of the discontinuous conduction mode

iv) (a) TEXT BOOKS

1. Robert W Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer,3rd edition,2001.
2. Taylor Morey , Abraham Pressman , Keith Billings , *Switching Power Supply Design*, McGraw Hill,3rd Edition, ,2009.
3. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 3rdedition, Prentice Hall India, New Delhi, 2014.

(b) REFERENCES

1. Ned Mohan, Undeland, Robbins, *Power Electronics: Converters, Applications and Design*, 3rd ed., John Wiley, 2018
2. Umanand L, Bhatt , *Design of Magnetic Components for Switched Mode Power Converters,* S R New Age International, New Delhi, 2001
3. John. G.Kassakian, George.C.Verghese, *Principles of Power Electronics* Addison-Wesley Publications ,1991.
4. Muhammad H.Rashid, "Power Electronics, Devices, Circuits and Applications", Pearson, 3rd edition, 2014
5. Dishore SV, "SMPS and UPS"-Lakshmi Publications,Chennai,2020.

v) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of Steady state converter modelling and analysis applied to basic DC-DC converters: Buck, boost and buck-boost converter - Principle of volt-sec balance, amp-sec balance, and small-ripple approximation - Steady-state (dc) equivalent circuits, losses and efficiency. Inclusion of semiconductor conduction losses in converter model.	**9**
II	Small-signal AC modelling (Buck & Boost Converter)- Averaging of inductor/capacitor waveforms - perturbation and linearisation. State-Space Averaging-Circuit Averaging and averaged switch modelling-Canonical Circuit Model - Manipulation of dc-dc converters circuit model into Canonical Form-Modelling the pulse width modulator.	**9**
III	Converter Transfer Functions: - Review of frequency response analysis techniques - Bode plots - Converter transfer functions - graphical construction. Converter transfer functions of ideal buck, boost and buck-boost converters - Measurement of ac transfer functions and impedances.	**9**
IV	Controller Design: Effect of negative feedback on the network transfer functions - loop transfer function-Controller design specifications- PD, PI and PID compensators - applications to the basic dc-dc topologies - Practical methods to measure loop gains: Voltage and current injection.	**9**
V	Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the DCM switch network. Transfer functions of ideal buck and boost converters in DCM.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance : 5 marks

CA Exams (2 numbers) : 20 marks

Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL4HE	CONTROL & DYNAMICS OF MICROGRIDS	VAC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The main goal of this course is to expose the students to the concept of microgrids, power electronic converter circuits, control and protection schemes of microgrids. It also intends to develop a conceptual introduction to the various power quality issues and mitigation techniques in microgrids.

ii) COURSE OUTCOMES

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

CO1	Explain microgrid architecture, types, advantages, disadvantages and dynamic interactions of microgrid with the main grid.	Understand
CO2	Classify the various types of Power Electronic Converters in AC and DC microgrids.	Understand
CO3	Illustrate the various control and protection schemes of microgrids.	Understand
CO4	Summarise the various Power Quality Issues and Mitigation Techniques in microgrids.	Understand

iii) SYLLABUS

Distributed Generation and Active Distribution Network, Distributed Energy Resources in Microgrid, The Microgrid Architecture, Dynamic interactions of Microgrid with main grid. DC Microgrid System, Power Electronic Topologies-AC/DC Converters (Rectifiers), DC/DC Converters, DC/AC Inverters. Power Electronic Converters in AC Microgrid. Control of Power Electronic Converters in AC Microgrid, DC Microgrid Control, Hierarchical Control in Microgrid. AC Microgrid Protection Schemes**.** Islanding Protection of Microgrid. Protective Systems in DC Microgrids. Power Quality Issues and Mitigation Techniques in Microgrid.

iv) (a) TEXT BOOKS

1) Ali Keyhani, Design of Smart Power Grid Renewable Energy, John Wiley & Sons, 2011.
2) James Momoh, SMART GRID Fundamentals of Design and Analysis, John Wiley & Sons, 2012.
3) Naser Mahdavi Tabatabaei, Ersan Kabalci, Nicu Bizon, Microgrids Architectures, Control and Protection Methods, Power Systems, Springer, 2019.
4) Papia Ray, Monalisa Biswal, Microgrid: Operation, Control, Monitoring and Protection, Lecture Notes in Electrical Engineering, Springer, 2020.
5) S. Chowdhury, S. P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks, IET, 2009.

(b) REFERENCES

1) R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, "Electrical Power System Quality", McGraw-Hill, 2nd edition, 2005.
2) Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley, 2011.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Overview of Microgrids-**Distributed Generation and Active Distribution Network, Distributed Energy Resources in Microgrid, The Microgrid Architecture, Types, Technical and Economical advantages of Microgrid, Challenges and disadvantages of Microgrid development, Dynamic interactions of Microgrid with main grid.	**8**
II	**Power Electronic Converters in DC Microgrid**- DC Microgrid System, Power Electronic Topologies-AC/DC Converters (Rectifiers), DC/DC Converters, DC/AC Inverters. **Power Electronic Converters in AC Microgrid-**Classification of Power Converters for RES, Topologies of the Power Inverters (DC-AC Power Conversion)	**9**
III	**Microgrid Control Systems**-Control of Power Electronic Converters in AC Microgrid, DC Microgrid Control, Hierarchical Control in Microgrid, Distributed Control of Microgrids, Intelligent and Adaptive Control, Load Shedding, Emergency and Local Control, Various Droop Control Strategies in Microgrids, Fuzzy PID Control of Microgrids, Adaptive and Online Control of Microgrids Using Multi-agent Reinforcement Learning.	**9**
IV	**Microgrid Protection -** AC Microgrid Protection Schemes-Overcurrent Protection, Protection of Radial Distribution Lines using Fuses, Protection of Radial Feeders using Over-Current Relays, Protection of Distribution Lines having Bi-Directional Power Flow, Adaptive Protection of Active Distribution Networks, Integrated Bus-Bar and Line Protection of Microgrids, Islanding Protection of Microgrid, Under/Over Voltage Protection, Under/Over Frequency Protection.	**10**
V	**Protective Systems in DC Microgrids-** HVDC microgrids, key control parameters, ratings**.** Challenges in DC Microgrid Protection, Fault Detection Methods in DC Microgrid, Protection Schemes in LVDC Microgrids, Protection Schemes in MVDC and HVDC Microgrids. **Power Quality Issues and Mitigation Techniques in Microgrid**-Harmonics and its Impact in Microgrid, Mitigation of Current Related Issues.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 marks
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL4HG	SMART GRID AND INTERFACING	VAC	3	0	0	0	3	2023

i) COURSE OVERVIEW

The course aims to provide students with a conceptual introduction to smart grids, its architecture, components and communication technologies. It also aims to provide an insight about the need for energy storage, application of IoT and various communication technologies in smart grid.

ii) COURSE OUTCOMES

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

CO1	Explain the need, benefits and functions of smart grid and its various components	Understand
CO2	Explain the various smart grid technologies	Understand
CO3	Explain various energy storages technologies in smart grid	Understand
CO4	Apply IoT concepts to design and implement solutions for smart grid applications	Apply
CO5	Explain the various communication technologies used in smart grid	Understand

iii) SYLLABUS

Introduction to Smart Grids and Smart Grid Components Reference architecture – Smart meters – Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).
Smart Grid Technologies Smart Substations – IEC 61850 Substation Architecture, Smart Appliances.
Energy Storage Technologies Role of Energy Storage Systems – Applications – Overview of energy storage technologies.
Electrical energy storage Types – Characteristics and Specifications of Battery Storage – Mobile Energy Storage Systems – V2G and G2V operation, Hybrid Storage.
IoT applications in Smart Grid– IoT based home automation- Automobile IoT
Communication and Cloud Computing HAN, NAN, SANET – Communication Protocols – Cloud architecture of smart grid.

iv) (a) TEXT BOOKS

1) Ali Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley-IEEE Press, 2011.
2) James Momoh, Smart *Grid: Fundamentals of Design and Analysi*s, Wiley-IEEE Press, 2015.
3) Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt, Energy Storage in Power Systems. Wiley Publication, 2016.

(b) REFERENCES

1) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals*", Theory and Design, CRC Press, 2004.
2) Faisal M., Hannan M. A., Ker P. J., Hussain A., Mansor M. B., Blaabjerg F., "*Review of Energy Storage System Technologies in Microgrid Applications: Issues and Challenge*s," in *IEEE Access*, vol. 6, pp. 35143-35164, 2018. doi: 10.1109/ACCESS.2018.2841407.
3) Yilmaz M., Krein P. T., "Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles," *IEEE Transactions on Power Electronics,* vol. 28, no. 5, pp. 2151-2169, May 2013, doi: 10.1109/TPEL.2012.2212917.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Smart Grid**: Evolution of Electric Grid- Comparison of Smart Grid with Conventional Grid - Need and Definitions of Smart Grid - Benefits, Challenges and Key Application Areas of Smart Grid. **Smart Grid Components:** Smart Grid Reference Architecture- Introduction to Smart Meters, Real Time Pricing - Intelligent Electronic Devices (IED) and their Application for Monitoring and Protection, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).	**9**
II	**Smart Grid Technologies:** Smart Substations, Substation Automation, IEC 61850 Substation Architecture, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home and Building Automation.	**9**
III	**Energy Storage Technologies**: Role of Energy Storage Systems - Applications - Overview of Energy Storage Technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical - Comparison of Various Storage Technologies - Criteria for Selection of Storage Systems. **Mobile Storage Systems**: Electric Vehicle, G2V, V2G. Basic concepts of Hybrid Energy Storage Systems. Case Study on EV charging and V2G.	**9**
IV	**IoT Applications in Smart Grid**: Definition and Characteristics of IoT, Applications of IoT in Smart Grid - Energy Management, Demand Response and Grid Control, IoT based Home Automation, Smart Metering for Electricity Consumers.	**9**
V	**Communication Networks for Smart Grid**: Interoperability and Connectivity - Home Area Network (HAN), Neighborhood - Area Networks (NANs), Sensor and Actuator Networks (SANETs) -	**9**

	Communication Protocols. **Cloud computing in Smart Grid**: Private, Public and Hybrid Cloud. Cloud Architecture of Smart Grid. Case Study on Cloud-based Energy Monitoring using IoT Sensors with AI Integration.	
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

SYLLABUS

SEMESTER VIII

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23HSL00A	Management for Engineers	HSC	3	0	0	0	3	2023

i. COURSE OVERVIEW

The objective of the course is to introduce the basic concepts and functions of management, highlight its role in organizational performance, and explore decision-making approaches that help managers achieve excellence.

ii. COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the characteristics of management in the contemporary context.	Understand
CO 2	Summarize the functions of management.	Understand
CO 3	Apply the concepts of decision-making models and productivity measurement to enhance organizational effectiveness.	Apply
CO 4	Apply the project management techniques to determine project schedules and completion probabilities.	Apply
CO 5	Explain the functional areas of management and the concept of entrepreneurship.	Understand

iii. SYLLABUS:

Introduction to management theory - Characteristics of Management, Introduction to management theory, System approaches to Management, Levels of Manager and Skill required.

Management and organization - Functions of Management, Planning types, Principles of organisation, Organisation Structures. Staffing, Leading and Controlling.

Productivity and decision making - Concept of productivity and its measurement. Decision making process, Decision trees;

Project management- Network construction, CPM and PERT
Networks, Scheduling computations, PERT time estimates, Probability of completion of project.

Functional areas of management- Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility.

iv (a) TEXT BOOKS

1. H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 10th ed., McGraw-Hill, 2015
2. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 15th ed., Pearson, 2016.
3. R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 11th ed., McGraw-Hill Education, 2020.
4. M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2020.

(b) REFERENCES

1. R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 15th ed. McGraw Hill Education (India), 2018.
2. P C Tripathi and P N Reddy, Principles of management, TMH, 5th edition, 2012
3. K. Ashwathappa, 'Human Resources and Personnel Management', TMH, 7th edition, 2011.
4. D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 2019

v. COURSE PLAN

Module	Contents	Hours
I	Management Definition, Characteristics of Management, Importance of Management, Management - Art or Science perspective, Evolution of Management - Introduction to Management Theories-Taylor's Scientific Management, Gilbreth's Motion Study, McGregor's Theory X and Theory Y, System Approach and Contingency Approach to Management, Henry Mintzberg's Managerial Roles, Levels of Management – Top, Middle, and Operational, Skills Required for Managers – Technical, Human, and Conceptual skills.	**8**
II	Functions of Management - Planning, Organizing, Staffing, Leading, Controlling. Planning- Planning types- strategic, tactical and operational plans, Mission, Goals, Strategy, Programmes, Procedures, Steps in Planning. Organising- Principles of Organisation, Delegation, Span of Control, Organisation Structures. Staffing- Selection process and employee training, Employee retention- Maslow's Hierarchy of Needs. Directing and Leadership -Traits of a leader, Leader vs Manager, Managerial grid model for leadership styles. Controlling-Types of control: Preventive, Concurrent, and Feedback.	**8**
III	Concept of productivity and its measurement; Competitiveness- Cost Advantage and Differential advantage, Quality, Speed, Innovation. Decision making process; Steps, types - Programmed and Non-	**10**

	Programmed decisions. Decision making under uncertainty- Maximum Criterion, Minimax Criterion, Maximin Criterion, Laplace Criterion, Hurwicz Alpha Criterion, Decision making under risk – Expected Monetary Value, Expected Opportunity Loss, Decision trees.	
IV	Project Management, Network construction, Arrow diagram, CPM and PERT to find critical paths, Critical Path Method -Determining Start and Finish Times: Earliest Start Time (ES), Earliest Finish Time (EF), Latest Start Time (LS), Latest Finish Time (LF), Float. Project Evaluation Review Technique PERT, PERT Time Estimates – Optimistic, Pessimistic, and Most Likely Time Calculations, Probability of completion of project.	**10**
V	Introduction to functional areas of management, Operations management, Human resources management, Marketing management, financial management, Entrepreneurship-Characteristics and mindset of successful entrepreneurs Types of entrepreneurships- Small Business Entrepreneurship, Scalable Start up Entrepreneurship, Social Entrepreneurship, Corporate social responsibility.	**9**
	Total Hours	**45**

vi. ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40: 60

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

vii. CONTINUOUS ASSESSMENT TEST

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

viii END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEJ48B	PROJECT	PWS	0	0	10	0	5	2023

i) COURSE OVERVIEW:

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems. The course is mainly intended to evoke the innovation and invention skills of a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.

Desirable: The project outcome should be published in a peer-reviewed journal or presented at a conference, or a patent application should be filed.

It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Apply multidisciplinary knowledge to model and solve real world problems.	Apply
CO 2	Apply innovative and creative problem-solving to develop sustainable and socially relevant products, processes, or technologies.	Create
CO 3	Exhibit effective teamwork and leadership skills in diverse environments, with the ability to comprehend and carry out designated responsibilities.	Apply
CO 4	Execute tasks by planning effectively and utilizing available resources to meet deadlines, while adhering to ethical and professional standards.	Apply
CO 5	Effectively document, present, and communicate technical and scientific outcomes in professional written and verbal formats.	Apply

iii) Evaluation Guidelines

Total: 100 marks (Minimum required to pass: **50** Marks).

- Project progress evaluation by guide: **20** Marks.

● Two interim evaluations by the Evaluation Committee: **30** Marks (15 marks for each evaluation).

● Final evaluation by the Final Evaluation committee: **30** Marks

● Quality of the report evaluated by the evaluation committee: **20** Marks

Interim Evaluation:

The Evaluation committee comprises of HoD or a senior faculty member, Project coordinator and Project supervisor.

Final Evaluation:

The final evaluation committee comprises of Project coordinator, domain expert from the Department and expert from Industry/research/academic Institute / senior faculty from a sister department.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEI48A	INTERNSHIP	PWS	0	0	-	0	5	2023

i) COURSE OBJECTIVES

The internship is an integral component of the undergraduate programme aimed at providing students with immersive learning through practical exposure in industry, research organizations, or academic institutions.

BENEFITS OF INTERNSHIP

Benefits to Students

- Provides practical exposure to real-world industrial and organizational environments, enabling the application of theoretical knowledge gained in classrooms.
- Enhances professional competencies such as communication, teamwork, time management, interpersonal skills, and workplace ethics.
- Facilitates the development of technical and domain-specific skills, thereby strengthening overall professional readiness.
- Assists students in assessing their career interests and determining the suitability of a particular industry or profession.
- Improves employability by strengthening profiles for placements, higher education, and potential recruitment by the host organization.
- Encourages professional networking and relationship - building with industry experts and peers.
- Offers an opportunity to evaluate the organization and work culture before committing to full-time employment.

Benefits to the Institute

- Strengthens industry - academia collaboration.
- Facilitates smoother and more effective placement processes.
- Enhances institutional credibility and brand value.
- Supports student engagement and retention.
- Enables curriculum updates based on industry and student feedback.
- Improves the overall teaching - learning process through industry relevance.

Benefits to the Industry

- Provides access to a pool of motivated, job-ready students who can contribute immediately.
- Offers a cost-effective mechanism to evaluate and recruit potential employees.
- Enables the availability of a flexible workforce for temporary, project-based, or seasonal requirements.
- Brings fresh perspectives and innovative approaches to problem-solving.
- Enhances organizational visibility and employer branding within academic institutions.
- Strengthens corporate image by contributing to education and skill development.

TYPES OF INTERNSHIPS

- Industry Internship with/without Stipend
- Government / PSU Internship (BARC/Railway/ISRO etc.)
- Internship with prominent education/ Research Institutes
- Internship with Incubation centres /Start-ups

ii) COURSE OVERVIEW

Students can undertake an internship at an industry, research organization, or a reputed academic institution with prior approval of the respective Head of the Department.

The internship is designed to promote meaningful skill development through structured, outcome-driven experiential learning. It shall focus on clearly defined technical competencies, such as domain-specific skills, software proficiency, exposure to industry-standard tools, and structured engineering problem-solving tasks. The learning objectives of the internship, along with the expectations of the host organization and the academic requirements of the institution, shall be clearly defined in consultation with the host organization and mutually agreed upon prior to the approval of the internship.

Each student shall be assigned a faculty guide/supervisor for monitoring and evaluation. The internship shall be relevant to the student's stream of study and can be carried out in Semester **VII** or Semester **VIII**, as specified by the Department, for a minimum duration of **three months.**

A student shall be permitted to undertake the internship only after the respective semester registration. During the internship period, any other courses or academic activities shall be pursued in online mode or as specified by the Department, to ensure timely fulfillment of all academic requirements.

iii) COURSE OUTCOMES

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

CO1	Apply theoretical knowledge and engineering principles to practical problems encountered in professional practice.	Apply
CO2	Demonstrate technical competence and understanding of tools, techniques, and processes relevant to the chosen field of specialization.	Apply
CO3	Analyse social, environmental, economic, safety, and administrative factors influencing industrial operations and decision-making processes.	Analyze
CO4	Communicate effectively through technical reports, presentations, and professional interactions in an industrial or research environment.	Apply
CO5	Apply professional ethics, teamwork, and adaptability while performing assigned tasks in a multidisciplinary work setting.	Apply

iv) GUIDELINES FOR STUDENTS

- Duration of internship is three to six months (One semester).
- Students may undertake mini projects, case studies, or related technical tasks during the internship with the prior approval of the competent authority at the host organisation.
- Students shall strictly adhere to the rules, regulations, code of conduct, and working hours prescribed by the host organisation.

- Prior permission shall be obtained from the host organisation before using or reproducing any data, documents, drawings, photographs, or proprietary information for academic purposes.
- Students shall follow all ethical practices, confidentiality requirements, and Standard Operating Procedures (SOPs) of the host organisation.
- Students shall comply with all health, safety, and environmental guidelines prescribed by the host organisation during the internship period.
- Students shall maintain regular contact with the assigned faculty guide/supervisor and submit weekly progress updates on the work carried out.
- Each student shall maintain a diary/logbook recording daily activities, learning outcomes, and progress throughout the internship period.
- On completion of the internship, students shall submit the following documents to the Department:
  - ✓ Internship report detailing the work carried out and learning outcomes
  - ✓ Internship Completion Certificate issued by the host organisation
  - ✓ Feedback from the employer
  - ✓ Proof of stipend received, if applicable

v) ASSESSMENT PATTERN

The marks awarded for the Internship will be based on the following:

(i) Evaluation done by the industry,
(ii) Student's diary,
(iii) Internship report, and
(iv) Internship viva voce.

Continuous Assessment		
Student's diary/ Daily Log	:	25 marks
Evaluation done by the industry	:	25 marks
Total Continuous Assessment	:	**50 marks**
Final Assessment		
Internship Report	:	25 Marks
Internship Viva Voce	:	25 marks
Total Final Assessment	:	**50 marks**
TOTAL	:	**100 marks**

Student's Diary/ Daily Log

The purpose of maintaining a daily diary is to cultivate systematic documentation habits and to encourage students to record observations, impressions, information gathered and suggestions, if any, during the internship period. The diary shall contain a day-to-day record of activities, learning experiences, technical details, and relevant sketches or drawings related to

the work carried out. The daily diary shall be signed regularly by the industry supervisor and shall be verified and ratified by the faculty guide during the interim review.

The interim review shall be conducted midway through the internship by the Internship Review Committee, comprising the internship coordinator, faculty supervisor, and a senior faculty member of the Department. The review may be conducted in online or offline mode, based on the feasibility of the student's physical presence on campus.

Internship Report

On completion of the internship, each student shall prepare and submit a comprehensive internship report to the faculty supervisor. The report shall present a systematic account of the activities undertaken, observations made and knowledge gained during the training period. Students may consult the industry supervisor during the preparation of the final report, subject to compliance with the confidentiality policies and norms of the host organization. The completed report shall be duly certified and signed by the Industry Supervisor, Faculty guide and the Head of the Department.

The internship report shall be evaluated based on the following criteria:

- Originality and technical content
- Adequacy, clarity and relevance of the written presentation
- Organization, format, use of drawings, sketches, language and overall style
- Variety and relevance of learning experiences documented
- Demonstration of practical applications and linkage with theoretical concepts covered in the curriculum

Evaluation done by the industry

The performance of the student during the internship shall be evaluated by the industry supervisor or the person-in-charge using a prescribed evaluation format provided by the institution. The evaluation shall cover key parameters such as professional behaviour, technical competence, learning ability, initiative, quality of work, communication skills, teamwork, discipline, time management, and overall professional attitude.

The faculty guide shall share the evaluation format with the host organisation and coordinate the assessment process. The completed evaluation form shall be duly signed and sealed by the industry supervisor and submitted to the Department as part of the internship assessment records.

Internship Viva Voce

The viva voce examination shall be conducted by the Internship Review Committee. The committee shall assess the student's understanding of the internship work, technical competence, learning outcomes, and professional orientation.

PROGRAMME ELECTIVE IV

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44A	SMART GRIDS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW

The course aims to provide students with a conceptual introduction to smart grids, its architecture, components and smart grid technologies. It also aims to provide an insight about smart meters and power quality issues and different network layers in smart grid communication.

ii) COURSE OUTCOMES

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

CO1	Outline the need, benefits and functions of smart grid and its various components.	Understand
CO2	Explain the various smart grid technologies.	Understand
CO3	Explain the concepts and functions of smart meters.	Understand
CO4	Identify the power quality issues in the smart grid.	Apply
CO5	Explain various networks used in smart grid communication.	Understand

iii) SYLLABUS

Introduction to Smart Grids and Smart Grid Components.
Smart Grid Technologies: Wide Area Monitoring, Protection and Control, Fault Detection, Isolation and Service Restoration, Outage Management.
Introduction to Smart Meters, Advanced Metering infrastructure (AMI), Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) and their Application for Monitoring and Protection.
Power Quality in Smart Grid, Power Quality Issues of Grid Connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid.
Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), CLOUD Computing to make Smart Grids Smarter,

iv) (a) TEXT BOOKS

1) Ali Keyhani, *Design of Smart Power Grid Renewable Energy Systems*, Wiley-IEEE Press, 2011.
2) James Momoh, Smart *Grid: Fundamentals of Design and Analysi*s, Wiley-IEEE Press, 2015.
3) Stuart Borlase, *Smart Grid Infrastructure Technology and Solutions*, CRC Press; 2nd Edition, 2017.

99

(b) REFERENCES

1) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals*", Theory and Design, CRC Press, 2004.
2) Faisal M., Hannan M. A., Ker P. J., Hussain A., Mansor M. B., Blaabjerg F., "*Review of Energy Storage System Technologies in Microgrid Applications: Issues and Challenge*s," in *IEEE Access*, vol. 6, pp. 35143-35164, 2018. doi: 10.1109/ACCESS.2018.2841407.
3) Yilmaz M., Krein P. T., "Review of Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles," *IEEE Transactions on Power Electronics,* vol. 28, no. 5, pp. 2151-2169, May 2013, doi: 10.1109/TPEL.2012.2212917.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Smart Grid**: Introduction to DERs and Micro Grid, Concept, Definitions and Need for Smart Grid, Smart Grid Functions, Components of Smart Grid, Opportunities, Challenges and Benefits, Difference between Conventional & Smart Grid, Concept of Resilient and Self-Healing Grid, Present development and International Policies in Smart Grid, National Smart Grid Mission.	**9**
II	**Smart Grid Technologies:** Smart Substations, Substation Automation, IEC 61850 for substations, Feeder Automation, Transmission Systems: EMS, FACTS and HVDC, Wide Area Monitoring, Protection and Control, Distribution Systems: DMS, Volt/VAr Control, Fault Detection, Isolation and Service Restoration, Outage Management, High Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).	**9**
III	**Smart Meters:** Introduction to Smart Meters, Advanced Metering infrastructure (AMI), benefits, AMI Protocols, Standards and Initiatives, AMI Needs in the Smart Grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) and their Application for Monitoring and Protection.	**9**
IV	**Power Quality Management in Smart Grid**: Power Quality & EMC in Smart Grid, Power Quality Issues of Grid Connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality Monitoring, Power Quality Audit.	**9**
V	**High Performance Computing**: Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power-line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids Smarter, Cyber Security for Smart Grid.	**9**

	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of 30 **marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44B	HVDC AND FACTS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course introduces the fundamentals of HVDC transmission and FACTS technologies. It covers comparison of AC and DC transmission systems, applications, planning aspects, and modern trends in HVDC. Basic FACTS concepts, objectives, classification, benefits, and applications are discussed. The course explains the operation and analysis of HVDC converters, including rectifier and inverter characteristics. Basic HVDC control strategies are introduced to understand system operation. The course also covers static shunt and series compensation, focusing on the types, working principles, and applications.

ii) COURSE OUTCOMES

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

CO1	Explain the basic concepts related to HVDC transmission and FACTS devices	Understand
CO2	Illustrate the working of Graetz circuit in HVDC transmission	Understand
CO3	Explain various HVDC control schemes	Understand
CO4	Summarize the operation of various Static Shunt Compensators	Understand
CO5	Summarize the operation of various Static Series Compensators	Understand

iii) SYLLABUS

BASIC HVDC CONCEPTS: Comparison of AC-DC transmission systems, application of DC transmission, types of DC links, Benefits from FACTS controllers.

HVDC CONVERTERS: Graetz circuit.

HVDC SYSTEM CONTROL: Basic control-desired features of control-actual control Characteristics.

STATIC SHUNT COMPENSATION: Objectives of Shunt Compensation, Working of various Static Shunt Compensators.

STATIC SERIES COMPENSATORS: Concept of series capacitive compensation, GCSC, TSSC and TCSC.

iv) (a) TEXT BOOKS

1) K. R. Padiyar, “HVDC Transmission Systems”, 2nd edition, New Age International publishers, 2012.
2) N. G. Hingorani and L. Gyugui, “Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems”, B.S. Publications, Indian Reprint 2000.

(b) REFERENCES

1) E. Uhlmann, “Power Transmission by Direct Current”, Springer 1st edition, 2012.
2) Vijay K. Sood, “HVDC and FACTS Controller: Application of Static Converters in power systems”, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, First edition January 2004.
3) E.W. Kimbark, “Direct Current Transmission”, Wiley Inter Science-NewYork, 1971.

4) R. Mohan Mathur, Rajiv K Varma, "Thyristor based FACTS Controller for Electrical Power Systems", John Wiley Sons, 2011.
5) X. P. Zhang, C. Rehtanz, B.Pal, "Flexible AC Transmission System Modeling and Control", Springer, 2006.
6) Padiyar K.R., 'FACTS controllers for Transmission and Distribution Systems' New Age International Publishers, 1st Edition, 2007.
7) Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS –Modeling and simulation in Power Networks' John Wiley & Sons, 1st Edition, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	**BASIC HVDC CONCEPTS**: Introduction, Comparison of AC and DC Transmission (Economics of power transmission, technical performance and Reliability), Application of DC transmission, Description of DC transmission system (Types of DC links and Converter Station), Planning for HVDC transmission, Modern trends in HVDC technology. **FACTS CONCEPTS:** Definition and evolution of FACTS, objectives of FACTS controllers. Classification of FACTS Controllers-shunt, series, and combined shunt–series controllers with suitable examples (conceptual understanding only), Benefits and Applications of FACTS.	**9**
II	**HVDC CONVERTERS:** Introduction, Graetz circuit –with grid control but no overlap-with grid control and overlap less than 60^0 - relationship between AC and DC quantities-equivalent circuit of rectifier, Inversion- equation of average direct current and voltage in terms of β and γ– equivalent circuit of inverter.	**9**
III	**HVDC SYSTEM CONTROL:** Basic means of control-desired features of control-actual control characteristics-constant minimum ignition angle control-constant current control-constant extinction angle control-tap changer control-power control and current limits, System control hierarchy, firing angle control.	**9**
IV	**STATIC SHUNT COMPENSATION:** Introduction to shunt compensation and its role in reactive power control. Types of static shunt compensators – Static VAR Compensator (SVC) and STATCOM. Working principle of SVC using thyristor-controlled reactors and capacitors. Working principle of STATCOM based on voltage source converters. Comparison of SVC and STATCOM in terms of response and performance. Applications of static shunt compensators in power systems.	**9**
V	**STATIC SERIES COMPENSATION:** Concept of series capacitive compensation, Types of static series compensators – GCSC, TSSC and TCSC. Working principle of GCSC. Working principle of TSSC and TCSC for controllable series reactance. Comparison of series	**9**

	compensators based on controllability and response. Applications of static series compensators in improving power transfer capability and system stability.	
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	25 marks
Assignment/Project/Case study etc.	:	10 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44C	ENERGY STORAGE SYSTEMS	PEC	3	0	0	0	3	2023

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

ii) COURSE OUTCOMES

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

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

iii) SYLLABUS

Introduction to energy storage in power systems- General considerations

Overview on Energy storage technologies - Thermal energy, Potential energy: Pumped hydro-Compressed Air, Kinetic energy: Mechanical- Flywheel, Power to Gas

Overview on Energy storage technologies- Batteries- Parameters, Fuel cells, Electrostatic energy Electromagnetic energy, Comparative analysis, Environmental impacts.

Energy storage and renewable power sources- Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated and integrated power systems with renewable power sources.

Energy storage Applications - Smart grid, Smart house, Mobile storage system- Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Hybrid energy storage systems.

iv) (a) TEXT BOOKS

1) Osaka T., Datta M., “Energy Storage Systems in Electronics-New Trends in Electrochemical Technology”, CRC Press 2000.
2) Rand D.A.J., Moseley P.T., Garche J. and Parker C.D., “Valve regulated Lead–Acid Batteries”, Elesevier 2004.
3) Sterner, M., & Stadler, I. (Eds.). Handbook of energy storage: Demand, technologies, integration. Springer. (2019).
4) Jain, Pramod. Energy storage in grids with high penetration of variable generation. Asian Development Bank .11710. 2017.
5) Díaz-González, Francisco, Andreas Sumper, and Oriol Gomis-Bellmunt. Energy storage in power systems. John Wiley & Sons, 2016.

(b) REFERENCES

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

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to energy storage in power systems:** Energy storage systems overview - Scope of energy storage, needs and opportunities in energy storage, comparison of storages and applications, Energy and power balance in a storage unit. Introduction to global energy storage landscape, cost trends, and deployment growth. Need for long-duration energy storage (LDES) in high renewable penetration systems.	9
II	**Overview on Energy storage technologies:** Thermal energy: General considerations - Storage media- Containment- Thermal energy storage in a power plant, Molten salts, phase-change materials (PCMs), thermochemical storage. Potential energy: Pumped Hydro- Compressed Air- Advanced CAES technologies: Adiabatic CAES, underwater CAES concepts. Kinetic energy: Mechanical - Flywheel, Power to Gas - Hydrogen - Synthetic methane, ammonia.	9
III	**Electrochemical and Electromagnetic Energy storage technologies:** Electrochemical energy -Batteries- Battery parameters: C-rating -SoC- DoD- Specific Energy-Specific power (numerical examples), Emerging battery chemistries: Solid-state batteries (high safety, fast charging, EV relevance), Sodium-ion batteries (low-cost, stationary grid storage), Redox flow batteries (long duration, scalable) Zinc-air, magnesium-ion, and advanced lithium chemistries - Sustainability in storage: battery recycling, circular economy, life cycle analysis. Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.	9
IV	**Energy storage and renewable power sources:** Integration of storage with large-scale solar, wind, offshore wind, and hybrid renewable systems. Storage role in isolated power systems with renewable power sources, Storage role in an integrated power system with grid-	8

	connected renewable power sources. Seasonal storage concepts: hydrogen, thermal, and flow-based solutions	
V	**Energy storage Applications:** Smart grid, Smart microgrid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems - Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Hybrid energy storage systems: configurations and applications. Residential energy storage, smart homes, and demand-side energy management. - Overview of grid services provided by storage (frequency regulation, peak shaving).	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44D	DIGITAL CONTROL SYSTEMS	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW: This course aims to provide a strong foundation in discrete domain modelling, analysis and design of digital controllers to meet performance requirements.

ii) COURSE OUTCOMES

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

CO1	Explain the various control blocks and components of digital control systems. Mathematical modelling of ZOH and FOH	Apply
CO2	Make use of z-domain techniques to analyse sampled data systems	Apply
CO3	Design a digital controller/ compensator in the frequency domain.	Apply
CO4	Design a digital controller/ compensator in the time domain.	Apply
CO5	Develop controllers for linear discrete time systems using state variable concepts.	Apply

iii) SYLLABUS

Basic digital control system - Mathematical modelling - sampling and reconstruction -Zero order and First order hold circuits - realization of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain. Pulse transfer function of different configurations of systems - Modified z-transform –Time Response of discrete time system. Design of controller/Compensator in frequency domain - Bilinear transformation and sketching of frequency response. Introduction to design and simulation using MATLAB. Design of controller/Compensator based on time response, Design of controllers and compensators by the method of Ragazzini - Introduction to Dead beat response and deadbeat controller design. Modern control approach to digital control - Introduction to state space - Computation of solution of state equation and state transition matrix. Controllability, observability and stability of discrete time systems. Digital controller and observer design.

iv) (a) TEXT BOOKS

1) C. L. Philips, H. T. Nagle, "Digital Control Systems", Prentice-Hall, 3rd edition, 1995
2) M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill, 4th edition, 2017.
3) Ogata K., Discrete-Time Control Systems, Pearson Education, 2nd edition, 2015.
4) Gene F. Franklin, J. David Powell, Michael Workman, Digital Control of Dynamic Systems, 3rd edition, Pearson, 1997.

(b) REFERENCES

1) Benjamin C. Kuo, Digital Control Systems, Oxford University Press, 2nd edition, 2007
2) Liegh J. R., Applied Digital Control, Dover Publications Inc., 2nd edition, 2006
3) C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw-Hill Inc.,US, 2nd edition, 1992
4) V. I. George, C.P. Kurian, Digital Control Systems, Cengage Learning, 1st edition, 2012
5) Kavita Singh, Rashmi Vashisth, Digital Control System, Galgotia Publications, 2012

v) COURSE PLAN

Module	Contents	No. of hours
I	Basic digital control system- Mathematical modeling - sampling and reconstruction - Zero order and First order hold circuits - realization of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain.	**9**
II	Pulse transfer function of different configurations of systems- Modified z-transform-Time Response of discrete time system. Order and Type of a system Steady state error and Static error constants. Matlab Simulation of simple digital control systems for time domain analysis.	**8**
III	Bilinear transformation and sketching of frequency response - Digital P/PI/PID controller design based on frequency response – Digital compensator based on frequency response. Introduction to design and simulation using MATLAB (for demo/ assignment only and not to be included for examination).	**10**
IV	Design of lag and lead compensator using root locus – Design of controllers and compensators by the method of Ragazzini- Dead beat response controller introduction only. Matlab Simulation.	**8**
V	Introduction to state space - state space modeling of discrete time SISO system - Computation of solution of state equation and state transition matrix. Controllability, observability and stabilizability of discrete time systems- Loss of controllability and observability due to sampling	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44E	COMMUNICATION ENGINEERING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course provides a comprehensive introduction to the principles and techniques used in modern communication systems. It covers the fundamental concepts of analog and digital communication, including signal representation, modulation and demodulation techniques, noise analysis, and bandwidth considerations.

ii) COURSE OUTCOMES

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

CO1	Explain modulation and the fundamentals of amplitude and frequency modulation techniques.	Understand
CO2	Summarize the principle of operation of AM and FM transmitters and receivers.	Understand
CO3	Explain the fundamentals of digital modulation techniques.	Understand
CO4	Outline the principles of cellular, optic fibre and advanced wireless communication systems.	Understand
CO5	Make use of multiple access techniques for the design of satellite communication systems.	Apply

iii) SYLLABUS

AM and FM fundamentals – Generation of AM-AM and FM transmitters and receivers -Digital communication systems – Pulse Modulation Techniques-Cellular Communication-Satellite communication – Wireless Technologies-Future Wireless Network Requirements.

iv) (a) TEXT BOOKS

1. Kennedy G., Electronic Communication Systems, McGraw-Hill, New York, 2008.
2. Roody and Coolen, Electronic Communication, Prentice Hall of India LTD., New Delhi, 2007.
3. Wayne Tomasi, Electronic communication system fundamentals, Pearson Education, 2003.
4. Behrouz A. Forouzan, Data Communication and Networking (Fourth Edition), Tata McGraw Hill, 2017.
5. Sunilkumar S. Manvi, Mahabaleshwar S. Kakkasageri, Wireless and Mobile Networks, Concepts and Protocols, Second Edition, Wiley India, 2016.

(b) REFERENCES

1. William Scheweber, *Electronic Communication Systems*, Prentice Hall of India LTD, New Delhi, 2004.
2. Wayne Tomasi, *Electronic Communication Systems*, Prentice Hall of India LTD, New Delhi, 2004.

3. Frank R. Dungan, *Electronic Communication Systems*, 3/e, Vikas Publishing House, 2002.
4. Bruce Carlson, *Communication Systems*, Tata McGraw Hill, New Delhi, 2001
5. Taub and Schilling, *Principles of Communication Systems*, McGraw-Hill, New York,2008.
6. Anokh Singh, *Principles of Communication Engineering*, S. Chand and Company Ltd., Delhi.
7. Pei Zheng, Larry L Peterson, Bruce S Davie, Adrian Farrel, Wireless Networking Complete, Morgan Kaufmann Publications, 2009.

v) COURSE PLAN

Module	Contents	No. of hours
I	Modulation -Definition, Types of modulation, Need for modulation-AM and FM fundamentals-AM – Frequency spectrum – vector representation – power relations – generation of AM – DSB, DSB/SC, SSB, VSB. FM – frequency spectrum – power relations.	**9**
II	AM and FM transmitters and receivers-Block diagrams of low power and high-power AM transmission - AM receivers: straight receivers super heterodyne receiver - choice of intermediate frequency - simple AVC circuit -Block diagrams of direct FM transmitter and Armstrong transmitter -FM receivers (balanced -slope detector and Foster-Seely discriminator only).	**9**
III	Digital communication: -Principles of digital communication – Need of digital modulation in modern communication-sampling process-pulse modulation Techniques- sampling process-PAM, PWM and PPM concepts - PCM encoder and decoder Applications of data communication.	**9**
IV	Cellular Communication- Basic concepts, frequency reuse, interference cell splitting, sectoring, cell system layout, cell processing. Optical Fibers – types: sources, detectors used, digital filters, optical link. Satellite communication Multiple access (MA) techniques-FDMA, TDMA, CDMA, SDMA applications in satellite communication. Design of Downlinks Ku-Band GEO Satellite Systems, Uplink Design.	**9**
V	Introduction to current wireless technologies-Concepts of Bluetooth, Zigbee, WIFI technologies-future wireless network requirements, IEEE 802.11 (Wi-Fi) standards and applications (IEEE 802.11a/b/g/n/ac/ax), HiperLAN technology, WPAN (IEEE 802.15.1, IEEE 802.15.3 & IEEE 802.15.4) and WMAN (IEEE 802.16a - WiMAX), 6G Networks – Use Cases and Technologies.	**9**

	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL44F	DATA ANALYTICS FOR ELECTRICAL ENGINEERS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course provides foundational and data analytics concepts with a specific focus on applications in Electrical and Electronics Engineering. It covers statistical analysis, machine learning algorithms, and real-world applications in Electrical Engineering.

ii) COURSE OUTCOMES

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

CO1	Explain basic concepts of data types, Python programming, and exploratory data analysis.	Understand
CO2	Explain probability, statistical inference, and hypothesis testing concepts used in data analytics.	Understand
CO3	Explain the principles of supervised learning algorithms and their performance evaluation metrics.	Understand
CO4	Explain the concepts of unsupervised learning, clustering, dimensionality reduction, and feature analysis.	Understand
CO5	Apply data analytics techniques using Python to analyze real-world datasets for forecasting and decision making.	Apply

iii) SYLLABUS

Introduction to Data Analytics: Overview and role of data analytics, Descriptive statistics and data visualization, Introduction to Python libraries: NumPy, Pandas, Matplotlib.

Probability and Statistical Inference: Probability theory, random variables, distributions, Hypothesis testing, confidence intervals, Correlation and regression analysis.

Supervised Learning: Linear and logistic regression, Decision trees, random forests, Support vector machines (SVMs). Unsupervised Learning & Dimensionality Reduction: K-means and hierarchical clustering, Principal Component Analysis (PCA), t-SNE, Feature selection methods. Applications of Data Analytics.

iv) (a) TEXT BOOKS

1) Aurelien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow*, 3rd Edition, O'Reilly, 2023.
2) Wes McKinney, *Python for Data Analysis*, 3rd Edition, O'Reilly, 2022.
3) Montgomery, D. C., & Runger, G. C., *Applied Statistics and Probability for Engineers*, 7th Edition, Wiley, 2018.

(b) REFERENCES

1) James, G., Witten, D., Hastie, T., & Tibshirani, R.*An Introduction to Statistical Learning with Applications in Python*, 2nd Edition, Springer, 2023.

2) Kuhn, M., & Johnson, K., *Applied Predictive Modeling*, Springer, 2013.
3) Jake VanderPlas, *Python Data Science Handbook*, O'Reilly, 2022.
4) Chollet, F., *Deep Learning with Python*, 2nd Edition, Manning, 2021.
5) Bishop, C. M., *Pattern Recognition and Machine Learning*, Springer, 2006.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Data Analytics & Python** - Types of data: structured, unstructured, time-series, categorical. Basics of data collection in engineering systems and sensors. Introduction to Python programming for data analytics. Python packages: NumPy, Pandas. Basic data handling and tabular data analysis. Introduction to Exploratory Data Analysis (EDA). Descriptive statistics: mean, median, variance, standard deviation. Basic data visualization: histograms, boxplots, scatter plots.	**9**
II	**Probability and Statistical Analysis** - Basic probability concepts: conditional probability and Bayes' theorem. Random variables: discrete and continuous. Common probability distributions. Central Limit Theorem and Law of Large Numbers (conceptual). Estimation techniques and confidence intervals. Hypothesis testing: z-test, t-test, chi-square test. Correlation, covariance, and simple linear regression.	**9**
III	**Supervised Learning Basics -** Introduction to supervised learning concepts. Regression vs classification problems. Linear regression and logistic regression. Model evaluation metrics: accuracy, precision, recall, confusion matrix. Decision trees and ensemble methods: Bagging and Random Forests (conceptual). Overview of Support Vector Machines (SVM) and k-Nearest Neighbors (kNN).	**9**
IV	**Unsupervised Learning & Feature Analysis** - Introduction to unsupervised learning. Clustering techniques: K-Means and hierarchical clustering. Dimensionality reduction using Principal Component Analysis (PCA). Feature selection concepts. Data transformation and scaling methods.	**8**
V	**Applications of Data Analytics -** Applications of data analytics in electrical and engineering systems. Analysis of time-series, sensor, and IoT data. Basic forecasting, trend analysis, and anomaly detection concepts. Data-driven decision making in real-world systems. Case studies using Python from domains such as energy systems, industrial monitoring, and smart applications.	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

PROGRAM ELECTIVE V

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL45A	SOLAR PV SYSTEMS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course offers an in-depth introduction to the principles, components, and design of Solar Photovoltaic (PV) systems. It covers the fundamental concepts of solar energy, including solar radiation measurements and solar spectrum analysis, and gradually builds up to system design and grid integration. The course also introduces simulation tools for PV system design, life cycle cost analysis, and economic viability assessment.

ii) COURSE OUTCOMES

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

CO1	Explain the basics of solar energy conversion systems.	Understand
CO2	Explain the concepts and applications of solar thermal systems.	Understand
CO3	Outline the key parameters of PV modules and explain the various Maximum Power Point Tracking methods.	Understand
CO4	Model the components of solar photovoltaic systems using the advanced PV technologies.	Apply
CO5	Demonstrate the overcurrent protection methods and economics of PV Systems.	Understand

iii) SYLLABUS

Source of Solar Energy- Solar Constant - Solar Radiation on a Horizontal Surface - Solar Radiation on an Inclined Surface - Monthly Average Daily Solar Radiation on Inclined Surfaces. Solar Thermal System - Solar thermal collectors, Solar concentrators - Solar cooker, Solar Furnace, Solar Greenhouse, Solar Water Heater, Heric topology. Solar PV Systems - Solar Cell (Photovoltaic) Materials - Photovoltaic (PV) Module and PV Array, Packing Factor of the PV Module - Effect of shadowing - MPPT Techniques.

Solar PV Systems- Design of Standalone System, Grid Interactive PV System, Bifacial solar modules and floating solar farms, Building-Integrated Photovoltaics (BIPV), Solar PV in electric vehicles and charging stations, Agri-voltaic and solar desalination. Protection Against Islanding and Reverse Power Flow –EMI Filters.

Overcurrent protection of solar PV power system, Life cycle costing, Growth models. Introduction to simulation software for solar PV system design.

iv) a.TEXT BOOKS

1. Chetan Singh Solanki, Renewable Energy Technologies: A practical guide for beginners, 3rd Edition, PHI.
2. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, 3rd Edition, PHI.
3. D.P. Kothari, M Jamil, Grid Integration of Solar Photovoltaic Systems, CRC Press, 2018.
4. G. N. Tiwari: Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002.
5. John A. Duffie and William A. Beckman, *Solar Engineering of Thermal Processes*, 5th

ed., John Wiley & Sons, 2020

6. A.A.M. Saigh (Ed), Solar Energy Engineering, Academic Press, 1977.

b. REFERENCES

1. Masters, Gilbert M., *Renewable and Efficient Electric Power Systems*, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
2. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, *Renewable Energy Systems*, Pearson, 2017.
3. G. N. Tiwari, Arvind Tiwari, Shyam, *Handbook of Solar Energy: Theory, Analysis and Applications*, Springer, 2016.
4. Khan B. H., *Non-Conventional Energy Resources*, Tata McGraw Hill, 2009.
5. D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
6. S. Rao and B. B. Parulekar, *Energy Technology: Nonconventional, Renewable and Conventional*, 3rd ed., Khanna Publishers, 2013.
7. Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
8. Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
9. Godfrey Boyle (Ed.), *Renewable Energy: Power for a Sustainable Future*, 3rd ed., Oxford University Press, 2012.
10. Tara Chandra Kandpal, Hari Prakash Garg, *Financial evaluation of Renewable Energy Technologies*, Mac Millam India Limited, 2003.
11. IEEE Application Guide for IEEE Std 1547(TM), *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*, in IEEE Std 1547.2-2008, pp.1217, 15 April 2009.

v)COURSE PLAN

Module	Contents	No. of hours
I	Introduction - Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Extra-terrestrial Region - Terrestrial Region, Solar radiation at a given location - Daily Radiation Pattern, Annual Variation in Solar Radiation, Optimal Tilt for Solar Equipment, Monthly Averaged Global Radiation at Optimal Tilt.	**10**
II	Solar Thermal system - Principle of Conversion of Solar Radiation into Heat, – Solar thermal collectors – Flat plate collectors and its types – Heat transfer processes – Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) Applications - Solar Cooking Systems- Principle of cooking. Speed of cooking- Energy required for cooking, Types of Solar cooker-Box type solar cooker-Dish type solar cooker- Heat Transfer type solar cooker, Solar Furnace, Solar Greenhouse, Solar Water Heater (flat plate). Fresnal lens, Heric topology, Design of solar pond, Solar desalination plant, Solar butane plant.	**9**

III	Solar PV Systems-Introduction - Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect - Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell, Photovoltaic (PV) Module and PV Array – Single - Crystal Solar Cell Module, Thin-Film PV Modules, Emerging and New PV Systems - Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-MPPT Techniques - P&O, incremental conductance method. Peroxide solar cell, Study of lead acid battery, design of battery building integrated pv system, solar PV material.	**9**
IV	Solar PV Systems – Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems. Cost estimation of a PV system, Solar PV Lantern -Design and Costing, Grid Interactive PV System-Advanced PV Applications: Bifacial solar modules and floating solar farms, Building-Integrated Photovoltaics (BIPV), Solar PV in electric vehicles and charging stations, Agri-voltaic and solar desalination.	**8**
V	Protection Against Islanding and Reverse Power Flow – EMI Filters. Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications. Life cycle costing, Growth models, Annual payment and present worth factor, payback period, LCC with examples. Introduction to simulation software for solar PV system design.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 **marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
23EEL45B	POWER SYSTEM PROTECTION	PEC	3	0	0	3	2023

i)COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of generation, transmission and distribution of electric power. The course also intends to deliver the basic concepts of power system protection including the different types of relays and circuit breakers.

ii)COURSE OUTCOMES

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

CO1	Explain the need for protective schemes and classify different types of electrical faults and their effects on power systems.	Understand
CO2	Illustrate the operating principles and characteristics of electromechanical, static, numerical relays, and microprocessor-based relay used in protection systems.	Understand
CO3	Interpret the principles and settings of overcurrent protection schemes and compare different types of overcurrent relays.	Understand
CO4	Summarize the working and characteristics of distance protection relays and assess their performance under different fault conditions.	Understand
CO5	Illustrate the concepts and components of differential protection, pilot relaying schemes, and circuit breaker operation with reference to power system protection.	Understand

iii)SYLLABUS

Introduction to Power System Protection.

Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays, Microprocessor relay and Numerical Relays. Overcurrent Protection, Distance Protection. Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection. Differential Protection, Rotating Machines Protection

Transformer and Bus zone Protection: Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection. Circuit Breakers: Operating Principle and Types.

iv)(a) TEXT BOOKS

1. Bhuvanesh Oza, Nirmal Kumar Nair, Rashesh Mehta, *Power System Protection and Switchgear*, Tata McGraw Hill, 1st edition, 2017.

2. Badri Ram and D. N. Vishwakarma, *Power System Protection and Switchgear*, 3rd ed., McGraw Hill, 2022.

3. J. B. Gupta, *A Course in Electrical Power*, S. K. Kataria & Sons, 11th ed., 2025.

REFERENCES

4. B. Bhalja, R. P. Maheshwari, and N. G. Chothani, *Protection and Switchgear*, 2nd ed. New Delhi, India: Oxford Univ. Press, 2018.
5. Sunil S. Rao, *Switchgear and Protection*, Khanna Publishers, 2nd edition, 2012.
6. N. Veerappan S.R. Krishnamurthy, *Power System Switchgear and Protection*, S. Chand, 1st edition, 2009.
7. Y. G. Paithankar and S. R. Bhide, *Fundamentals of Power System Protection*, 2nd ed., PHI Learning, 2010 .

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Power System Protection:** Need for protective schemes, Nature and Cause of Faults, Types of Faults, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers and Voltage Transformers for Protection.	9
II	**Relay Construction and Operating Principles:** Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Microprocessor based relay. **Overcurrent Protection:** Introduction, Time–current Characteristics, Current and Time Setting, Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.	9
III	**Distance Protection:** Introduction, Impedance Relay, Reactance Relay, Mho Relay, Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Introduction to Microgrid- MicroGrid Protection- Communication Aided Protection, AI and Advanced Sensing, Hybrid AC-DC Protection.	9
IV	**Pilot Relaying Schemes:** Introduction, Wire Pilot Protection, Carrier Current Protection, Merz price, circulating current scheme, carrier current scheme **Differential Protection:** Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection. **Rotating Machines Protection:** Introduction, Generator Protection- (Numerical problems). **Transformer and Bus zone Protection:**	9

	Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection.	
V	**Circuit Breakers:** Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Rate of rise of recovery voltage-natural frequency of oscillating, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 **marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL45C	ELECTRIC AND HYBRID VEHICLES	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: The primary objective of this course is to familiarize students with the fundamental principles and emerging trends in electric, hybrid, and autonomous vehicles. It will cover the electric machines employed, their control strategies for EV applications, diverse charging infrastructure, and relevant communication protocols.

ii) COURSE OUTCOMES

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

CO1	Apply hybrid electric vehicle architecture principles to determine the overall vehicle performance metrics.	Apply
CO2	Illustrate the fundamental principles and provide a comparative study of diverse Electric Vehicle and Hybrid Electric Vehicle powertrain architectures.	Understand
CO3	Explain the architecture and operational characteristics of propulsion systems utilized in electric and hybrid-electric transport.	Understand
CO4	Outline the most effective energy storage solutions and high-performance battery chargers for vehicle applications.	Understand
CO 5	Summarize various communication protocols and technologies used in vehicle networks and high efficiency battery charging infrastructures for automotive applications.	Understand

iii) SYLLABUS

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Electric Drive train, Power flow control.
Electric Propulsion unit, Configuration and control of DC motor drives, Induction Motor drives, PM and SRM motor drives.
Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell and supercapacitor-based energy storage.
Communication Systems, Energy Management Strategies, EV charging technologies and policies.

iv) (a) TEXT BOOKS

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3rd Edition 2003.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier,2010.
4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

(b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd,2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.
5) Dishore S.V, *Electric Vehicle Architecture*, Lakshmi Publications,2023.

(c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM,IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
   Electric Vehicle Conductive AC Charging System

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. **Conventional Vehicles**: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. **Autonomous Vehicles:** Levels of automation, significance & effects of automation in vehicles	**10**
II	**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies. **Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.	**8**

	Comparative insights into BEV, HEV, PHEV and FCEV architectures.	
III	**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles **DC Drives**: Review of Separately excited DC Motor control – Speed and torque equations -Closed loop control of speed and torque. **Induction motor Drives**: Voltage and frequency control- Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC).	**9**
IV	**Energy Storage**: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Modelling, Battery Management System. Fuel Cell based energy storage systems-Hybridization of different energy storage devices **Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to vehicle power flow block schematic diagrams.	**9**
V	**Types of charging stations** - AC Level 1 & 2, DC - Level 3 –V2G concept- Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences. **Vehicle Communication protocols**: Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 **marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL45D	MODERN CONTROL TECHNIQUES	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces advanced and modern control techniques for linear, nonlinear, and multivariable systems. Emphasis is given to application-oriented understanding of multivariable systems, robust and adaptive control strategies, digital and discrete-time controllers, and nonlinear system analysis using Lyapunov methods. Mathematical complexity is minimized while focusing on practical control system design and simulation using MATLAB/Simulink.

ii) COURSE OUTCOMES

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

CO1	Apply advanced state-space methods to model and analyze multivariable control systems.	Apply
CO2	Apply optimal and robust control techniques to improve system performance.	Apply
CO3	Apply adaptive control strategies to systems with uncertain or varying parameters.	Apply
CO4	Apply nonlinear system analysis techniques to assess stability.	Apply
CO5	Apply digital and discrete-time controllers for practical system implementation.	Apply

iii) SYLLABUS

State-space representation of SISO and MIMO systems, controllability, observability, modal decomposition, Jordan canonical form, system realization.

Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, H∞ control introduction, robust controller design, performance evaluation.

Model Reference Adaptive Control (MRAC), Self-Tuning Regulators (STR), parameter estimation, practical implementation examples.

Nonlinear system classification, phase-plane analysis, equilibrium points, Lyapunov stability, describing function method, limit cycle analysis.

Sampling and discretization, discrete-time state-space modeling, stability analysis in z-domain, digital PID and pole-placement controllers.

iv) (a) TEXT BOOKS

3) Ogata, K., Modern Control Engineering, 5th Edition, Pearson, 2010

4) Dorf, R. C., Bishop, R. H., Modern Control Systems, 12th Edition, Pearson, 2011

5) Chen, C.-T., Linear System Theory and Design, 4th Edition, Oxford University Press, 2013

6) Franklin, G. F., Powell, J. D., Emami-Naeini, A., Feedback Control of Dynamic Systems, 8th Edition, Pearson, 2019Kuo, B. C. and Golnaraghi, F., Automatic Control Systems, 9th Edition, Wiley India, 2014.

(b) REFERENCES

8) Skogestad, S., Postlethwaite, I., Multivariable Feedback Control, 2nd Edition, Wiley, 2005

9) Åström, K. J., Adaptive Control, 2nd Edition, Dover, 2008

10) Zhou, K., Doyle, J., Essentials of Robust Control, Prentice Hall, 1998.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Advanced State-Space and MIMO Systems** Review of state-space representation for SISO and MIMO systems, controllability and observability for multivariable systems, modal decomposition, Jordan canonical form, system realization, MATLAB simulation examples.	**9**
II	**Optimal and Robust Control** Linear Quadratic Regulator (LQR), Linear Quadratic Gaussian (LQG) control, introduction to H∞ control, robust controller design for uncertain systems, performance evaluation, sensitivity analysis, MATLAB/Simulink implementation.	**9**
III	**Adaptive Control Techniques** Model Reference Adaptive Control (MRAC), Self-Tuning Regulators (STR), parameter estimation methods, practical implementation using simulation, case studies from robotics and process control.	**9**
IV	**Nonlinear and Multivariable System Analysis** Classification of nonlinear systems, phase-plane analysis, equilibrium points, Lyapunov stability assessment, describing function method, limit cycle analysis, stability analysis of multivariable systems.	**9**
V	**Digital and Discrete-Time Control** Sampling and discretization of continuous-time systems, discrete-time state-space modeling for MIMO systems, stability analysis in z-domain, Jury criterion, digital PID and pole-placement controllers, MATLAB implementation of digital controllers.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL45E	DIGITAL IMAGE PROCESSING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course is designed impart the knowledge of image fundamentals and the mathematical transformations essential for various image-processing operations. It introduces students to key techniques such as image segmentation, image enhancement, and image compression.

ii)COURSE OUTCOMES

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

CO1	Explain the various aspects of digital image representation.	Understand
CO2	Make use of matrix theory and mathematical transforms for image processing.	Apply
CO3	Interpret various image segmentation techniques.	Understand
CO4	Apply the image enhancement techniques in spatial and frequency domain	Apply
CO5	Explain the techniques for compression and restoration of images.	Understand

iii) SYLLABUS

Digital Image Fundamentals: Image Representation- simple image formation model. Color image fundamentals- 2D sampling, quantization. Review of matrix theory - Toelpitz, Circulant and Block matrix. Review of Fourier transform and DFT – FFT. Image segmentation: Segmentation and threshold function, Matching, Colour segmentation. Image Enhancement in Spatial domain: Basic Gret level transforms, Histogram, Histogram processing: Smoothening and sharpening filters, Laplacian Filters. Image Enhancement in Frequency domain. Image compression: Need for image compression, Basics of image compression standards- JPEG, MPEG. Image restoration- Blind image Restoration. MATLAB implementation

iv) (a) TEXT BOOKS

a. Rafael C. Gonzales, Richard E. Woods, “Digital Image Processing”, 4th edition, Pearson Education India, 2019.

b. S Jayaraman, S Esakkirajan, T Veerakumar, “Digital image processing” ,5th edition, Tata Mc Graw Hill, 2015.

c. S. Jayaraman, S. Esakkirajan, T. Veerakumar, Tata McGraw Hill 2014.

d. Malay K. Pakhira, “Digital Image Processing and Pattern Recognition”, 1st edition, PHI Learning Pvt. Ltd., 2011.

b)REFERENCES

1) Anil Jain K, “Fundamentals of Digital Image Processing”, 3rd edition, PHI Learning Pvt. Ltd., 2011.
2) Kenneth R Castleman, “Digital Image Processing”, 2nd edition, Pearson Education, 2003.

3) Pratt William K, "Digital Image Processing", 4th edition, John Wiley Publications, 2007.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Digital Image Fundamentals:** Image Representation, basic relationship between pixels, elements of DIP system, elements of visual perception- simple image formation model. Vidicon and Digital Camera working principles Brightness, contrast, hue, saturation, Mach band effect **Color image fundamentals-** RGB, CMY, HIS model. 2D sampling, quantization, Grayscale resolution.	**9**
II	**Review of matrix theory:** row and column ordering- Toeplitz, Circulant and Block matrix. **Review of Fourier transform and DFT**- properties of 2D Fourier Transform- FFT- Separable image transforms- Walsh - Discrete Cosine Transform, Haar Transform.	**9**
III	**Image segmentation:** Segmentation and threshold function, Algorithms in thresholding, line detection, edge detection, edge linking by Graph Search Method, Region based segmentation, Matching, Color segmentation. **Implementation of image segmentation in real world applications (Demonstration/Assignment only)**	**9**
IV	**Image Enhancement in Spatial domain:** Basic Grey level transforms, Histogram, Histogram processing: equalization, Image subtraction, Image averaging. Smoothening and sharpening filters, Laplacian Filters. **Image Enhancement in Frequency domain:** Smoothing frequency domain filtering, Sharpening frequency domain filtering, Homomorphic filtering.	**9**
V	**Image compression:** Need for image compression, Lossless compression: Variable length coding – LZW coding – Bitplane coding, predictive coding-DPCM. Lossy Compression: Transform coding – Wavelet coding – Basics of Image compression standards: JPEG, MPEG. Model of Image Degradation/restoration process – Noise models Inverse filtering –Least mean square filtering – Constrained least mean square filtering – Blind image restoration –Familiarization of Image Processing with MATLAB (Image Compression and Image Restoration, Image smoothening)	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – **1.5 hours**

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL45F	VR AND AR FOR ASSISTIVE TECHNOLOGY	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course explores the intersection of Virtual Reality (VR), Augmented Reality (AR), and assistive technologies to empower individuals with disabilities and enhance their quality of life. Students will gain hands-on experience and theoretical knowledge to develop innovative solutions leveraging immersive technologies to overcome physical, cognitive, and sensory challenges.

ii) COURSE OUTCOMES

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

CO 1	Explain the fundamental concepts of AR and VR, including key components of AR/VR systems.	Understand
CO 2	Describe AR/VR development tools, platforms, and basic software technologies used for creating immersive applications.	Understand
CO 3	Explain the principles of human-centered design and accessibility in AR/VR applications.	Understand
CO 4	Explain the applications of AR and VR in assistive technology, including navigation assistance, rehabilitation, and cognitive support.	Understand
CO 5	Develop a simple AR/VR-based application addressing an engineering problem using appropriate tools and platforms.	Apply

iii) SYLLABUS

Introduction to AR and VR: Definitions, Concepts, and History. Hardware and Software, Basics of 3D Graphics and Visualization - Overview of AR/VR Applications in Various Domains. Introduction to Development Platforms, Basic Programming for AR and VR Applications. Applications of AR and VR in Assistive Technology. Ethical and Privacy Considerations in AR/VR, Legal and Regulatory Frameworks for AR/VR, AR and VR in Industry and Healthcare.

iv) (a) TEXTBOOKS

1) Schmalstieg and T. Hollerer, Augmented Reality: Principles and Practice, Addison-Wesley, 2016.
2) T. Parisi, Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, O'Reilly Media, 2015.
3) J. Jerald, The VR Book: Human-Centered Design for Virtual Reality, ACM Books, 2015.
4) R. Riener and M. Harders, Virtual Reality in Medicine, Springer, 2012.
5) W. R. Sherman and A. B. Craig, Understanding Virtual Reality: Interface, Application, and Design, Morgan Kaufmann, 2018.

(b) REFERENCES

1) S. Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Addison-Wesley, 2017.
2) J. Linowes, Unity Virtual Reality Projects, Packt Publishing, 2018.
3) J. Donally, The Immersive Classroom: Create Customized Learning Experiences with AR/VR Technology, ISTE, 2021.
4) M. Augstein and W. Ortner, Augmented Reality: Reflections on Its Contribution to Knowledge Formation, Springer, 2023.
5) A. B. Craig, Understanding Augmented Reality: Concepts and Applications, Morgan Kaufmann, 2013.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of AR and VR** - Introduction to Augmented Reality (AR) and Virtual Reality (VR): definitions, concepts, and historical evolution. Differences between AR, VR, and Mixed Reality (MR). Components of AR and VR systems. Hardware elements: sensors, cameras, displays, controllers, and haptic devices. Software components and system architecture. Basics of 3D graphics and visualization. Tracking and registration concepts in AR/VR systems. Performance parameters such as latency, frame rate, and realism. Overview of AR/VR applications in various domains.	8
II	**Tools and Technologies for AR and VR Development** - Introduction to AR/VR development platforms. Unity: basics of scene creation and AR/VR integration. Overview of Unreal Engine for VR applications. AR SDKs such as ARCore and ARKit. Understanding Head-Mounted Displays (HMDs) and mobile-based AR/VR systems. Introduction to basic programming concepts for AR/VR applications using C# (Unity scripting) with exposure to Python. Introduction to 3D modeling and asset creation using tools such as Blender.	10
III	**Human-Centered Design and Assistive Technology** - Principles of human-centered design for AR and VR systems. Accessibility and usability considerations in immersive applications. Usability evaluation parameters: comfort, cognitive load, interaction efficiency, and task performance. AR/VR applications for physical disabilities with case studies. AR/VR applications for cognitive disabilities, including immersive learning and therapy. Ethical considerations in the design of assistive AR/VR technologies.	9
IV	**Applications of AR and VR in Assistive Technology** - AR-based navigation assistance for visually impaired users in indoor and outdoor environments. VR-based rehabilitation and therapy: fundamentals of motor skill recovery and cognitive rehabilitation. Psychological and cognitive benefits of VR-based therapy. Integration of haptic feedback devices with AR/VR systems.	10

	Cognitive and learning support using immersive technologies. System limitations, validation approaches, and practical deployment challenges. Case studies in assistive AR/VR applications.	
V	**Ethical, Social, and Industrial Aspects of AR and VR -** Ethical and privacy considerations in AR/VR systems. Safety, data security, and responsible use of immersive technologies. Legal and regulatory frameworks governing AR/VR applications. Role of AR and VR in industry, healthcare, and assistive domains. Human–Computer Interaction (HCI) and user experience considerations in AR/VR. Emerging trends, societal impact, and future challenges of AR and VR technologies.	**8**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

PROGRAM ELECTIVE VI

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46A	Electrical System Design for Industry and Infrastructure	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW:

This course focuses on the principles and practices involved in the design of electrical systems for industrial plants and infrastructure projects. It covers the planning, analysis and design of power distribution systems, lighting systems, substations and protection schemes in compliance with relevant standards and codes

ii) COURSE OUTCOMES

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

CO1	Develop lighting scheme for industrial installations and select suitable luminaires based on applications.	Apply
CO2	Demonstrate the purpose of various protective devices and cables for industrial loads and its selection criteria.	Understand
CO3	Develop the single line diagram of 11kV indoor transformer substation with light and power loads in an industry.	Apply
CO4	Make use of short circuit calculations to design the earthing system for a 11kV substation.	Apply
CO5	Explain the significance of backup power supply and energy saving techniques in industrial installations.	Understand

iii) SYLLABUS

Industrial Lighting systems: Importance of proper lighting in industrial installations- design considerations - Industrial lighting design- emergency lighting.

Classification of Industrial installations- selection of transformer, cables

Design of electrical distribution systems with main switch board, sub switch boards and distribution boards -selection of bus bars and switchgears. Selection of 11kV indoor transformer substations up to 500kVA.

Short circuit calculations and earthing design for the HV and LV sides of an 11 kV substation. Lightning protection system for industrial building.

Selection of standby Diesel Generator set (DG set), Automatic Mains failure (AMF) systems. Automatic Power Factor Correction (APFC) panel - Energy Conservation Techniques in electrical power distribution.

iv) (a) TEXT BOOKS

1) S. K. Bhattacharya, K. B. Raina, *Electrical Design Estimating and Costing*, New Age International Publishers 1st edition.
2) Theodore R Bosela, *Electrical Systems Design*, Prentice Hall, 1st edition, 2002.

3) J.B. Gupta, *Course in Electrical Installation Estimating & Costing*, S. K. Kataria & Sons. 9th edition, 2012.
4) M. K. Giridharan, *Electrical Systems Design*, I K International Publishers, New Delhi, 2nd edition, 2016.
5) Steven J. Marrano, *Electrical System Design and Specification Handbook for Industrial Facilities*, Fairmont Press, 1998

(b) REFERENCES

1) *Electrical Installation Design Guide: Calculations for Electricians and Designers*, The Institution of Engineering and Technology (IET), 5th edition, 2022
2) U.A.Bakshi, V.U.Bakshi, *Electrical Technology*, Technical publications, Pune, 1st Edition, 2020.
3) IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.
4) V. K. Jain & Amitabh Bajaj, *Design of Electrical Installations*, Lakshmi Publications Pvt. Ltd., 2nd edition 2012.

Data Book (Approved for use in the examination):

1) M K Giridharan, *Electrical Systems Design Data Hand book*, I K International Publishers.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Industrial Lighting system:** Illumination level as per standards – Lighting Design Considerations - mounting height, spacing, glare control, uniformity and maintenance factor. Shadow control and Color rendering for accurate task performance. Selection of luminaires in industry. Ingress protection (IP) and impact resistance (IK) ratings. Design of lighting in industrial plants, warehouses and outdoor areas. Emergency and safety lighting systems	**8**
II	**Industrial installations:** Industrial buildings classification - Overview of IEC, IEEE standards in industrial systems Selection of transformers – rating, impedance and cooling. Busbar systems and cable distribution. Selection of armoured power cables (AYFY, A2XFY, YWY) – calculation of ampacity, cable voltage drop calculation. Industrial loads - motors, starting of motors - Introduction to PCC, MCC panels. Specifications of LT Breakers - Motor wiring diagram. Selection of switchgears – circuit breakers, contactors and relays.	**8**
III	**Design of Industrial Installation:** Design of distribution systems with light power and motor loads for small and medium industries. Selection of switchgears and protective devices -single line diagram. **Design of Substations:** components of indoor and outdoor substations- single line diagram - Design of indoor 11kV substations up to 500kVA - Case study of an industry installation.	**10**

IV	**Substation earthing:** Earth Mat, Earthing electrode, Grounding conductors, Neutral Grounding system. **Short circuit calculations:** Short circuit calculations and earthing design for the HV and LV sides of a 11kV substation – Pre-commissioning tests of 11kV indoor/outdoor substation Lightning protection system for industrial building - role of grounding in lightning protection systems – safety aspects.	**10**
V	**Standby power supply:** Selection of standby Diesel Generator set (DG set) - Power rating- Continuous, Prime and Standby power ratings- installation and essential Protections-Introduction to Automatic Mains failure (AMF) systems. Automatic Power Factor Correction (APFC) panel. **Energy Conservation Techniques** in industrial power distribution - Lighting automation and controls (DALI, sensors, daylight harvesting)	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 marks
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46B	HIGH VOLTAGE ENGINEERING	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course provides insights into the generation of various types of high-voltage waveforms, along with their measurement and analysis. It also covers insulation coordination of equipment and machinery used in high-voltage applications, and offers a basic understanding of HVDC and FACTS devices and testing methods using different testing circuits.

ii) COURSE OUTCOMES

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

CO1	Develop different high voltage and current waveform generation circuits.	Apply
CO2	Explain different sensing & measurement techniques for high voltage and current measurement.	Understand
CO3	Explain the terms related to insulation coordination and surge arrestors.	Understand
CO4	Outline different HVDC and FACTS devices and their application in HV systems.	Understand
CO5	Explain different testing methods for equipment and applications of HV systems.	Understand

iii) SYLLABUS

Generation of High DC and AC Voltages - Generation of impulse voltages.

High voltage and high current measurements. High voltage testing - Measurement of dielectric constant and loss factor. Partial discharge measuring techniques.

Insulation Coordination and surge arresters - Classification of Voltages and Over voltages - Insulation Coordination Procedure.

HVDC and FACTS - HVDC transmission - - Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC).

Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers, surge diverters, cables - Insulation Systems for AC and DC Voltages- Insulation Systems for impulse voltages.

iv) (a) TEXT BOOKS

1) C.L Wadhwa, High voltage Engineering, New age international (P) Ltd, 3rd edition, 2012.
2) Naidu M.S. and Kamaraju V., High voltage Engineering, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
3) Andreas Kuchler, High Voltage Engineering Fundamentals – Technology – Applications, Springer, 2018.

4) N.G. Hingorani and L.Gyugyi, *Understanding FACTS*, IEEE Press, 2000.

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(b) REFERENCES

1) Farouk A.M. Rizk & Giao N. Trinh, High Voltage Engineering, CRC Press, 2014.
2) Kuffel, E., Zaengl, W.S. and Kuffel J., High Voltage Engineering Fundamentals, Elsvier India P Ltd, 2005.
3) Hugh M. Ryan, High-Voltage Engineering and Testing, IET Power and energy series, 2013.
4) Dieter Kind, Kurt Feser, High voltage test techniques, Elsevier Science, 2nd edition, 2001.
5) Khalil Denno, High Voltage Engineering in Power Systems, CRC Press, Newyork, 1992.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Generation of High Voltage and Currents.** Generation of High DC and AC Voltages- half-wave rectifier circuit – Cockroft - Walton voltage multiplier circuit - Electrostatic generator - Generation of high AC voltages - Cascaded Transformers- Series resonant circuit. Generation of Impulse Voltages and Currents - Impulse voltage- Impulse generator circuits - Multistage impulse generator circuit - Construction of impulse generator - Triggering of impulse generator -Impulse current generation.	8
II	**HV measuring techniques** High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap - Rod-to-rod Spark Gap - Electrostatic Voltmeter- Electro-optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement. Dielectric measurements - Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response. Partial discharge measuring technique-Requirements on a partial discharge measuring system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations	10
III	**Insulation Coordination and surge arresters** Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages - Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages. Determination of Coordination Withstand Voltage- Deterministic Approach, Statistical Approach: Risk of Failure. Surge Arresters- Rated Voltage- Discharge Current - Impulse Current	9

	Tests- Residual Voltages.	
IV	**HVDC:** HVDC transmission –General principles-VSC HVDC-Main components of HVDC links- Thyristor valves, Converter transformer, Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies. **FACTS**: Series and Shunt compensation- Static Shunt compensators: Static var compensators (SVCs), STATCOM, Static Series compensators: TSSC, TCSC, SSSC. Unified power flow controller (UPFC).	**10**
V	**Testing of HV Systems:** High voltage testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables. Insulation Systems for AC Voltages -Cables, bushings and transformers- Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors).	**8**
	Total hours	**45**

ix) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

x) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

xi) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of 60 marks
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – 3 hours

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46C	COMPUTER AIDED POWER SYSTEM ANALYSIS	PEC	2	1	0	0	3	2023

i) COURSE OVERVIEW: The basic objective of this course is to familiarize the efficient computational techniques applied in analyzing the power system

ii) COURSE OUTCOMES

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

CO1	Apply Graph theory, Z_{BUS} and Y_{BUS} methods to model power system networks	Apply
CO2	Make use of Y_{BUS}-based numerical techniques and load flow methods to analyze power system performance.	Apply
CO3	Explain the concepts of optimal power flow, active and reactive power objectives, and security-constrained operation of power systems.	Understand
CO4	Apply Z_{BUS} and Y_{BUS}–based methods, including fault factor tables and systematic algorithms, to analyze balanced and unbalanced power system faults	Apply
CO5	Develop contingency analysis and state estimation models for power systems using Z_{BUS} and Y_{BUS}.	Apply

iii) SYLLABUS

Overview of graph theory: tree, co-tree and bus incidence matrix, development of network matrices from graph theoretic approach.

Inversion of the Y_{BUS} matrix for large systems. Tinney's Optimally Ordered Triangular Factorization

Three-phase Load Flow: load flow equations, solution techniques

Reactive Power Allocation and Scheduling, Sources of reactive power, reactive power capability curve, FACT devices

Network fault calculations using Z bus, Contingency analysis in Power systems: Contingency Calculations using ZBUS and YBUS, Table of Factors.

State estimation – least square and weighted least square methods

iv) (a) TEXT BOOKS

1) George Kusic "Computer-Aided Power Systems Analysis", PHI 2nd edition, 2009
2) D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", Tata McGraw-Hill Education, 2003.

3) Arthur R. Bergen, Vijay Vittal, “Power Systems Analysis”, 2nd Edition, Pearson Higher Education
4) J. J. Grainger and W. D. Stevenson, Jr., "Power System Analysis", McGraw-Hill International Edition, 1994.
5) T.K. Nagsarkar and M.S. Sukhija, "Power System Analysis", Oxford University Press, 2016.
6) Arrillaga J. and Watson N.R. “ Computer Modelling of Electrical Power Systems”, John Wiley & Sons, 2003 Reprint
7) M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005

(b) REFERENCES

1) L. P. Singh, “Advanced Power System Analysis and Dynamics”, 3rd Edition, New Age Intl, 1996.
2) M. A. Pai, “Computer Techniques in Power Systems Analysis”, Tata McGraw-Hill, 2nd Edition 2005.
3) Arthur R. Bergen, Vijay Vittal, “Power Systems Analysis”, 2nd Edition, Pearson Higher Education
4) Wood, Allen J., Bruce F. Wollenberg, and Gerald B. Sheblé. “Power generation, operation”, and control. John Wiley & Sons, 2013

v) COURSE PLAN

Module	Contents	No. of hours
I	**Overview of Graph theory:** Tree, co-tree and incidence matrix, Development of network matrices from Graph theoretic approach. **Bus Reference Frame:** Injections and Loads. Z_{BUS} and Y_{BUS}. Formulation of Bus Impedance matrix for elements without Mutual Coupling	**9**
II	Inversion of the Y_{BUS} matrix for large systems. Tinney’s Optimally Ordered Triangular Factorization- Tinney’s Schemes for Near-Optimal Ordering **Three-phase Load Flow:** load flow equations, solution techniques- Gauss Seidal, Newton Raphson methods and fast decoupled method; Three phase AC-DC load flow	**10**
III	**Reactive Power Allocation and Scheduling:** Sources of reactive power, reactive power capability curve, FACT devices, modeling of reactive power allocation problem, solution techniques. Security constrained optimal power flow.	**8**
IV	Network fault calculations using Z_{BUS} and Y_{BUS} - Table of Factors, Algorithm for calculating system conditions after fault – three phase short circuit, three phase to ground, double line to ground, line to line and single line to ground fault.	**9**

V	**Contingency analysis in Power systems:** Contingencies Using Z_{BUS} in a Superposition Method- Z_{BUS} Line Contingency Method- Y_{BUS} Table of Factors for Contingencies- Double Contingencies Using Y_{BUS} Table of Factors (Balanced Case) State estimation – least square and weighted least square estimation methods for linear systems.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46D	SPECIAL ELECTRIC MACHINES	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course provides an understanding of special electric machines relevant to electric vehicles, robotics, renewable energy systems, and industrial automation, with emphasis on operating principles, characteristics, basic control concepts, and applications.

ii) COURSE OUTCOMES

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

CO1	Illustrate the operating principles and applications of permanent magnet DC motors, brushless DC motors, and permanent magnet synchronous motors.	Understand
CO2	Classify the various types of stepper motors and explain how their excitation methods and characteristics influence their use in motion control applications.	Understand
CO3	Explain the operating principle and control challenges of synchronous and switched reluctance motors in modern drive applications.	Understand
CO4	Illustrate the difference in operation and performance between AC and DC servomotors within high-precision motion control systems.	Understand
CO5	Outline the principle and applications of single-phase motors and linear electric machines used in transportation and automated industrial systems.	Understand

iii) SYLLABUS

Permanent Magnet DC Motors and Brushless DC Motors – construction – principle of operation – characteristics – applications – Permanent Magnet Synchronous Motor: basic construction and principle of operation.

Stepper Motors – basic principle – classification – excitation methods – static and dynamic characteristics – micro stepping– applications.

Reluctance Motors – Synchronous Reluctance Motor: principle of operation – torque production – characteristics – applications; Switched Reluctance Motor: principle of operation – torque-speed characteristics – power converter circuits – applications.

Servomotors – AC servomotors and DC servomotors: principle of operation – types – characteristics – comparison – applications.

Single Phase and Linear Special Machines –principle of operation – applications.

Linear induction motor – principle – thrust production – thrust-speed characteristics – applications.

iv) (a) TEXT BOOKS

1) E. G. Janardanan, "Special Electrical Machines", PHI Learning Private Limited, 2014.
2) T. J. E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
3) Theodore Wildi, "Electric Machines, Drives and Power Systems", Pearson Education, 5th Edition, 2013.

(b) REFERENCES

11) Irving L. Kosow, "Electrical Machinery and Transformers", Pearson, 2nd Edition 2007.
12) Paul Acamley, "Stepping Motor – A Guide to Theory and Practice", IEE London, 2002.
13) B. K. Bose, "Modern power electronics and AC drives", Prentice Hall of India, N J, 2002.
14) Cyril George Veinott, Joseph E. Martin, "Fractional and Sub fractional Horsepower Electric Motors: Available Types, Basic Operating Principles, Selection, and Maintenance", McGraw-Hill, 4th Edition, 2007.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Permanent Magnet DC Motors:** PMDC motors – construction, principle of operation, characteristics, applications. **Brushless DC motors** – construction, principle of operation, electronic commutation using Hall sensors, square-wave and sinusoidal excitation. **Permanent Magnet Synchronous Motor** (PMSM): basic construction and principle of operation, comparison of BLDC and PMSM, applications, overview of drive circuits.	9
II	**Stepper motors:** Basic principle, classification – variable reluctance, permanent magnet and hybrid stepper motors, excitation modes, static and dynamic characteristics, micro stepping, open-loop and closed-loop operation, drive circuits (unipolar and bipolar), applications in positioning and motion control systems.	9
III	**Reluctance Motors:** Synchronous Reluctance Motor – construction, working principle, torque production, characteristics, applications. Switched Reluctance Motor – construction, principle of operation, torque-speed characteristics, power converter circuits (overview), rotor position sensing, advantages and limitations, basic control concepts, applications.	10
IV	**Servomotors:** AC servomotors – construction, principle of operation, features, performance characteristics, damping, applications. DC servomotors – field-controlled and armature-controlled servomotors, characteristics, comparison with AC servomotors, applications in	8

	robotics and industrial automation.	
V	**Single-Phase Special Electric Machines:** Universal motor, Hysteresis Motor and AC series motor – construction, principle of operation, characteristics, applications. **Linear Induction Motors:** principle of operation, thrust production (qualitative), thrust-speed characteristics, end effects, transverse edge effect, applications.	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46E	AUTOMOTIVE ELECTRONIC SYSTEMS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW: This course provides a foundational understanding of modern automotive electronic systems including sensors, actuators, communication networks, control systems, and emerging trends in hybrid, electric, and autonomous vehicles.

ii) COURSE OUTCOMES

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

CO1	Explain the concepts of electric and hybrid vehicles and automotive electronic systems.	Understand
CO2	Explain the automotive sensors and actuators used for monitoring and control in vehicle systems.	Understand
CO3	Interpret in-vehicle networking concepts and automotive communication protocols used for interfacing electronic control units and subsystems.	Understand
CO4	Explain the automotive control systems such as engine management, cruise control, braking, traction, and steering systems.	Understand
CO5	Summarize the working of major automotive control systems.	Understand

iii) SYLLABUS

Classification of Electric vehicles. Introduction to the role and evolution of electronics in modern vehicles; Electronic Control Unit (ECU) architecture and development process. Study of key automotive sensors used for monitoring vehicle and engine parameters. Overview of actuators used in vehicles for executing control actions. Communication Protocols & Infotainment, ECU communication methods and networking with TCP/IP; overview of automotive infotainment, telematics, and GPS-based navigation systems. Analysis of major automobile control systems, introduction to hybrid and electric vehicle electronics.

iv) (a) TEXT BOOKS

1) William B. Ribbens, *Understanding Automotive Electronics*, 8th Edition, Elsevier, 2017.
2) Robert Bosch GmbH, *Automotive Handbook*, 10th Edition**,** Wiley, 2018.
3) Konrad Reif (Ed.), *Automotive Electronics Handbook*, 2nd Edition, McGraw-Hill, 2014.
4) Ronald K. Jurgen, *Automotive Electronics Handbook*, McGraw-Hill Professional, 1999.

(b) REFERENCES

1) James D. Halderman, *Automotive Electricity and Electronics*, 6th Edition, Pearson, 2018
2) Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003
3) Mehrdad Ehsani et al., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, 2nd Edition, CRC Press, 2018
4) Nicolas Navet, *Automotive Embedded Systems Handbook*, CRC Press, 2009.
5) G. Meyer & J. Valldorf, *Advanced Microsystems for Automotive Applications*, Springer, 2009.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Electric and Hybrid Vehicles:** Classification of vehicles: ICE, HEV, PHEV, BEV, FCEV**,** Comparison of conventional vehicles and EVs**,** Advantages and challenges of electric vehicles **Introduction to Automotive Electronics** Introduction to Modern Automotive Systems. Evolution of Automotive Electronics. Need for electronics in automobiles. Application areas of electronic systems in modern automobiles: Electronics Engines Control, Electronics Fuel Control, Electronics Ignition, Automotive transmissions, Electronic Control Unit (ECU) design cycle: V-Model development cycle. Components of ECU. Examples of ECUs in automotive. Future Trends in Automotive Hybrid and Electric Automotive: Autonomous Vehicles and Driving Challenges, V2X Technology.	**8**
II	**Automotive Sensors** Airflow rate sensor (MAS), Engine Crankshaft Angular Position Sensor, Hall effect Position Sensor, Optical Crankshaft Position Sensor, Manifold Absolute Pressure (MAP), Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Air Bag Sensors	**9**
III	**Automotive Actuators** Automotive Ignition Control Actuators, Fuel Injector Actuator, Solenoids, Various types of electric motors and piezoelectric force generators, Relays (Solid State relays and Electromechanical relays). Electro-Pneumatic: Pneumatic Motors, Electro Hydraulic Valves.	**8**
IV	**Communication Protocols and Infotainment systems** Overview of automotive communication protocols: CAN, LIN, Flex Ray and Ethernet. Communication interface with ECUs, TCP/IP for automotive applications, Infotainment Systems: Application of telematics in automotive domain, Global positioning systems (GPS).	**10**

V	**Automotive Control Systems** Digital Engine Control System, Vehicle Motion Control System: Typical Cruise Control System, Stepper Motor-Based Actuator for Cruise Control, Antilock Braking Systems, Traction Control System, Electronically controlled power steering systems. Introduction to ADAS, Sensors Used in ADAS, ADAS Features / Functions, Perception Algorithms, Localization & Mapping and Planning & Control.	**10**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEL46F	INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS	PEC	3	0	0	0	3	2023

i) COURSE OVERVIEW:

This course introduces the basic principles and models of Artificial Neural Networks. It covers learning algorithms, network architectures, and training techniques for solving engineering problems. Applications of neural networks in electrical and computer engineering are highlighted, along with an overview of emerging deep learning models.

ii) COURSE OUTCOMES

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

CO1	Explain the fundamentals of artificial neural networks, including biological motivation, neuron models, learning paradigms, and basic network architectures.	Understand
CO2	Apply perceptron and feedforward neural network models to solve simple classification and regression problems.	Apply
CO3	Apply the working of the backpropagation learning algorithm and evaluate neural network training performance.	Apply
CO4	Implement and train multilayer neural networks using appropriate learning parameters and performance metrics.	Apply
CO5	Explain advanced neural network architectures and their applications in electrical and computer engineering domains.	Understand

iii) SYLLABUS

Biological and artificial neurons, history of neural networks, neuron models, activation functions, learning paradigms, network architectures, perceptron model, perceptron learning algorithm, limitations of single-layer networks, multilayer feedforward neural networks, loss functions, gradient descent, backpropagation learning algorithm, training parameters, overfitting and regularization, radial basis function networks, self-organizing maps, recurrent neural networks, applications in electrical engineering, applications in computer engineering, introduction to deep learning, convolutional neural networks, long short-term memory networks.

iv) (a) TEXT BOOKS

1) Simon Haykin, Neural Networks and Learning Machines, Pearson, 3rd Edition, 2009
2) D. E. Rumelhart, J. L. McClelland, PDP Research Group, Parallel Distributed Processing: Explorations in the Microstructure of Cognition, MIT Press, 1986
3) Jacek M. Zurada, Introduction to Artificial Neural Systems, West Publishing Company, 1992
4) S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing, Wiley-India, 2nd Edition, 2011
5) B. Yegnanarayana, Artificial Neural Networks, PHI Learning, 2009.

(b) REFERENCES

1) Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.
2) Kumar, S. (2004). *Neural Networks: A Classroom Approach*. Tata McGraw-Hill.
3) Aggarwal, T. (2013). *Neural Networks*. Khanna Publishing House.
4) LeCun, Y., Bengio, Y., & Hinton, G. (2015). *Deep Learning*. Nature, 521(7553), 436–444.
5) Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* (2nd ed.). O'Reilly Media.
6) Raschka, S., & Mirjalili, V. (2019). *Python Machine Learning: Machine Learning and Deep Learning with Python, Scikit-Learn, and TensorFlow 2*. Packt Publishing.
7) Chollet, F. (2018). *Deep Learning with Python*. Manning Publications.
8) Murphy, K. P. (2012). *Machine Learning: A Probabilistic Perspective*. MIT Press.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Fundamentals of Artificial Neural Networks:** Biological motivation for neural networks; structure and function of biological neurons; comparison between biological and artificial neurons. Historical development of neural networks. McCulloch–Pitts neuron model. Artificial neuron model: inputs, weights, bias, activation function, and output. Types of activation functions: step, linear, sigmoid, tanh, ReLU. Network architectures: single-layer and multi-layer networks. Learning paradigms: supervised, unsupervised, and reinforcement learning. Basic neural network terminologies and performance measures.	**9**
II	**Perceptron and Feedforward Neural Networks:** Perceptron learning algorithm; convergence theorem and limitations of single-layer perceptron. Linearly separable and non-separable problems. Multilayer Feedforward Neural Networks (MLP). Role of hidden layers. Forward propagation mechanism. Cost / loss functions. Gradient descent learning. Weight initialization and normalization. Introduction to universal approximation capability of neural networks. Practical implementation of simple feedforward networks using Python (TensorFlow/Keras).	**10**
III	**Backpropagation Learning Algorithm:** Error correction learning. Backpropagation algorithm: derivation and working principle. Chain rule application in neural networks. Training process of multilayer networks. Learning rate, momentum term, batch and online learning. Stopping criteria. Issues in backpropagation: vanishing gradient, overfitting, underfitting, local minima. Techniques to improve training: regularization, early stopping, data normalization, cross-validation. Performance evaluation metrics.	**8**

IV	**Advanced Neural Network Models:** Radial Basis Function (RBF) Networks: structure, training, and applications. Competitive learning. Kohonen Self-Organizing Maps (SOM): architecture, learning algorithm, feature mapping, clustering. Recurrent Neural Networks (RNN): basic concept, feedback connections, dynamic behavior. Simple RNN models and applications in time-series prediction. Comparison of feedforward and recurrent networks. Applications of advanced neural models in engineering problems.	**9**
V	**Applications and Emerging Trends in Neural Networks:** Neural network applications in electrical engineering: load forecasting, fault diagnosis, power system stability, control systems, signal processing. Applications in computer engineering: pattern recognition, image classification, speech processing, and data analytics. Introduction to deep neural networks. Overview of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks. Challenges, limitations, and ethical considerations in neural network deployment. Case studies and real-world implementation examples. (Students can be encouraged to do hands-on projects and case studies on the topics learned as a part of their Assessments)	**9**
	Total hours	**45**

vi) CONTINUOUS ASSESSMENT EVALUATION PATTERN

Attendance	:	5 marks
CA Exams (2 numbers)	:	20 marks
Assignment/Project/Case study etc.	:	15 marks
Total	:	**40 marks**

vii) CONTINUOUS ASSESSMENT EXAMINATION PATTERN

- Two tests of **30 marks each** (2 ½ modules to be covered in each exam)
- Duration – 1.5 hours

viii) END SEMESTER EXAMINATION PATTERN

- Two parts - Part A and Part B – with a total of **60 marks**
- Part A contains compulsory questions. Part B contains choice questions.
- Duration – **3 hours**

MINORS/HONOURS

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
23EEJ4HB/23EEJ4HD/ 23EEJ4HF/23EEJ4HH	MINI PROJECT	VAC	0	0	6	0	3	2023

i) COURSE OVERVIEW

The main objective of this course is to apply fundamental concepts learned in the respective Honour streams of Engineering through practical implementation. The course provides students with exposure to the development of application-oriented software, hardware solutions, or software simulations in their chosen field. Working in small teams under faculty supervision, students identify a relevant problem, perform literature review, plan and execute the project, and present the outcomes through a working model or prototype. The mini project enhances problem-solving ability, teamwork, project planning, and technical communication skills, and serves as a foundation for future research or major project work

ii)COURSE OUTCOMES

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

CO1	Identify engineering problems that are socially relevant, technically feasible, and economically viable.	Apply
CO2	Make use of relevant literature and existing engineering principles to explore and analyze potential solutions.	Apply
CO3	Develop a suitable design or methodology using modern tools while adhering to professional ethics.	Apply
CO4	Evaluate the performance or feasibility of the proposed solution using theoretical or experimental validation.	Evaluate
CO5	Apply effective communication techniques to prepare technical reports, presentations, and demonstrations.	Apply
CO6	Plan and execute project activities and coordinate effectively within a team to meet objectives and deadlines.	Apply

iii) COURSE PLAN / GUIDELINES:

In this course, each group consisting of a maximum of 4 members is expected to design and develop a moderately complex software/hardware system relevant to their domain with practical applications. The basic concept of product design may be taken into consideration. Students should identify a topic of interest in consultation with the Project guide assigned and Project coordinator in charge of the course. They should review the literature from latest
journals, relevant conferences and gather information pertaining to the chosen topic. Later the group should state the objectives and develop a methodology to achieve the objectives and then carry out the design/fabrication or develop codes/programs to achieve the objectives. Finally, the team should demonstrate the novelty of the project

through the working results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department/Project Coordinator in charge. A project report is required at the end of the semester which will be evaluated and approved by the department. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due considerations. A zeroth review may be conducted to finalize the topic and plan in the beginning. Two continuous reviews will assess progress and implementation.

iv)(a) EVALUATION SCHEME

The Mini Project shall be evaluated through a comprehensive assessment framework designed to monitor continuous progress, technical competence, and quality of documentation. The evaluation carries a total of 100 marks, with a minimum pass requirement of 50 marks, and is conducted through multiple stages involving the project guide and an evaluation committee. Continuous assessment includes project progress evaluation by the guide, two interim evaluations by the Evaluation Committee to assess problem formulation, design, and implementation progress, and a final evaluation to judge the level of completion, functionality, demonstration, technical understanding, and viva-voce performance. In addition, the quality of the project report is assessed for technical depth, clarity, organization, and adherence to prescribed standards. The Evaluation Committee comprises the Head of the Department or a senior faculty member, the Mini Project Coordinator, and the Project Supervisor, ensuring a fair and holistic evaluation of the mini project

v) END SEMESTER EXAMINATION PATTERN

- Project progress evaluation by Guide: 20 marks
- Interim Evaluation – I: 15 marks
- Interim Evaluation – II: 15 marks
- Final Evaluation by Evaluation Committee: 30 marks
- Quality of Project Report: 20 marks

Total: **100 marks**