SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution | Approved by AICTE | Affiliated to Anna University | Accredited by NAAC with A++ Grade
Kuniamuthur, Coimbatore – 641008
Phone : (0422)-2678001 (7 Lines) | Email : info@skcet.ac.in | Website : www.skcet.ac.in

Curriculum & Syllabi

Regulation 2022

2023-2027 Batch

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
(Batch 2023-2027)

VISION OF THE INSTITUTION

- To Produce Globally Competitive Engineers with High Ethical Values and Social Responsibilities.

MISSION OF THE INSTITUTION

- To impart the highest quality state-of-the-art technical education by providing impetus to innovation, research, and development and empowering students with entrepreneurship skills.
- To instill ethical values, imbibe a sense of social responsibility, and strive for societal well-being.
- To identify the needs of society and offer sustainable solutions through outreach programs.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

- To provide the students with high quality technical education in the field of Electrical and Electronics Engineering enabling them to become competent and responsible engineers with employability and entrepreneurial skills.

MISSION OF THE DEPARTMENT

- To equip the students with adequate knowledge in the field of Electrical and Electronics Engineering and professional skills necessary to face the future challenges with confidence and courage.
- To enrich them to engage in research activities leading to innovative applications of technology.
- To enable them to become responsible citizens of the country with a willingness to serve the society.

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)	
PEO 1	Graduates will have successful career in industry that meets the needs of Indian and Multinational companies.
PEO 2	Graduates will have the ability to synthesize data and develop technical concepts for application to product design and to solve contemporary problems.
PEO 3	Graduates will work as part of teams on multidisciplinary projects with good technical, communication and interpersonal skills.
PEO 4	Graduates will fulfill the roles and responsibilities of professional electrical engineers in their chosen career with an attitude to serve the industry and society.
PEO 5	Graduates will undertake research, pursuing higher studies, thereby adopting extended learning, keeping pace with the technological developments and codes of professional practice.

II. PROGRAMME OUTCOMS (POs)	
PO 1	**Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO 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
PO 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
PO 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
PO 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
PO 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
PO 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
PO 8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO 9	**Individual and Team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
PO 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

PO 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
PO 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

III. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The Graduates of B.E – Electrical and Electronics Engineering programme will be able to:

PSO 1	Analyze basic scientific concepts and provide solutions to Electrical and Electronics Engineering problems with a specific focus on emerging energy challenges.
PSO 2	Use relevant software, apply current techniques for data processing problems in the field of modern electronic systems for sustainable development.
PSO 3	Develop products/software to cater to the societal & Industrial needs and adapt ethical values so as to become successful electrical engineering professionals.

IV.MAPPING OF PEOs WITH POs and PSOs

PEO	POs												PSO		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	1	2	3
1	3	3	3	2	2	2	1	2	2	3	3	2	3	3	3
2	3	3	3	2	2	2	1	2	2	3	3	2	3	3	3
3	3	3	3	2	2	2	1	3	3	3	3	2	2	2	2
4	3	3	3	2	2	2	1	3	3	3	3	2	3	3	3
		1- low, 2 - medium, 3 - high, '-' - no correlation													

V. MAPPING OF PEOs WITH PSOs

	PSO 1	PSO 2	PSO 3
PEO 1	3	3	3
PEO 2	3	3	3
PEO 3	2	2	2
PEO 4	3	3	3

AUTONOMOUS CURRICULA AND SYLLABI

Regulations 2022

SEMESTER I							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23SB102	Biology for Engineers	3/0/0	3	3	60/40	BSC
2	23EE101	Basics of Electrical Circuits	3/1/0	4	4	60/40	ESC
3	23MA101	Mathematics I	3/1/0	4	4	60/40	BSC
4	23AS101	Applied Science	4/0/0	4	4	60/40	BSC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23IT101	Application Development Practices	1/0/4	5	3	50/50	ESC
6	23CS101	Problem Solving using C++	1/0/4	5	3	50/50	ESC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EE102	Basics of Electrical Circuits Laboratory	0/0/2	2	1	40/60	ESC
8	23AS102	Applied Science Laboratory	0/0/4	2	2	40/60	BSC
Indian Knowledge System - Blended Learning (Internal 100 Marks)							
9	23TA101	Heritage of Tamils	1/0/0	1	1	0/100	HSMC
Mandatory Course (Internal 100 Marks)							
10	23MC101	Induction Programme	3 weeks				MC
TOTAL				**30**	**25**		

SEMESTER II							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23EE201	Measuring Instruments and Smart Sensors	3/0/0	3	3	60/40	PCC
2	23EE202	Electronic Devices and Integrated Circuits	3/0/0	3	3	60/40	PCC

3	23MA201	Mathematics II	3/1/0	4	4	60/40	BSC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
4	23EN101	Oral and Written Communication Skills	2/0/2	4	3	50/50	HSMC
5	23CD201	Database Management Systems	1/0/4	5	3	50/50	ESC
6	23CY201	Java Programming	1/0/4	5	3	50/50	ESC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EE203	Electronic Devices and Integrated Circuits Laboratory	0/0/2	2	1	40/60	PCC
Indian Knowledge System - Blended Learning (Internal 100 Marks)							
8	23TA201	Tamils and Technology	1/0/0	1	1	0/100	HSMC
Mandatory Course (Internal 100 Marks)							
9	23MC102	Environmental Sciences	1/0/0	1	0	0/100	MC
TOTAL				**28**	**21**		

SEMESTER III							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23MA302	Mathematics III	3/1/0	4	4	60/40	BSC
2	23EE301	Electrical Machines – I	3/0/0	3	3	60/40	PCC
3	23EC202	Digital System Design	3/0/0	3	3	60/40	PCC
4	23GE301	Universal Human Values	3/0/0	3	3	60/40	HSMC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23EC302	Operating Systems for Electronic Devices	3/0/2	5	4	50/50	PCC
6	23CS301	Advanced Java Programming	1/0/4	5	3	50/50	ESC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EE303	Electrical Machines - I Laboratory	0/0/2	2	1	40/60	PCC
8	23EC204	Digital System Design Laboratory	0/0/2	2	1	40/60	PCC

Mandatory Course (Internal 100 Marks)							
9	23MCXX	Mandatory Course III	1/0/0	1	0	0/100	MC
TOTAL				**28**	**22**		

SEMESTER IV							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23EE403	Transmission and Distribution	3/0/0	3	3	60/40	PCC
2	23EE401	Electrical Machines - II	3/0/0	3	3	60/40	PCC
3	23EE402	Control Systems	3/0/0	3	3	60/40	PCC
4	23EE404	Renewable Energy and Storage Systems	3/0/0	3	3	60/40	PCC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23IT211	Introduction to Python Programming	1/0/4	5	3	50/50	ESC
6	23EC403	Embedded C++	3/0/2	5	4	50/50	PCC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EE405	Electrical Machines - II Laboratory	0/0/2	2	1	40/60	PCC
8	23EE406	Control Systems Laboratory	0/0/2	2	1	40/60	PCC
9	23EC303	Idea Laboratory	0/0/2	2	1	40/60	ESC
TOTAL				**28**	**22**		

SEMESTER V							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23EE501	Electric Vehicle Technology	3/0/0	3	3	60/40	PCC
2	23EE9XX	Professional Elective - I	3/0/0	3	3	60/40	PEC
3	23EE0XX	Open / Emerging /Industrial Elective - I	2/0/2	4	3	50/50	OEC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
4	23EE502	Power Electronics	3/0/2	5	4	50/50	PCC
5	23EE503	Principles of Digital Signal Processing	3/1/2	6	5	50/50	PCC

Capstone Project (Internal 100 Marks)							
6	23EE505	Capstone Project - I - Mern Stack	0/0/4	4	2	0/100	PROJ
Mandatory Course (Internal 100 Marks)							
7	23MC108	Mandatory Course-IV - Indian Constitution	1/0/0	1	0	0/100	MC
TOTAL				**26**	**20**		

SEMESTER VI							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory - Blended Learning (Internal 100 Marks)							
1	23GEC01	Entrepreneurship and Startups	3/0/0	3	3	0/100	HSMC
Theory (Internal 40 Marks & External 60 Marks)							
2	23EE601	Internet of Things for Electrical Systems	3/0/0	3	3	60/40	PCC
3	23EE602	Power System Protection and Switchgear	3/0/0	3	3	60/40	PCC
4	23EE9XX	Professional Elective - II	3/0/0	3	3	60/40	PEC
Theory with Practical (Internal 50 Marks & External 50 Marks)							
5	23EE603	Power System Analysis	3/0/2	5	4	50/50	PCC
6	23EE604	Virtual Instrumentation	2/0/2	4	3	50/50	PCC
Practical (Internal 60 Marks & External 40 Marks)							
7	23EE605	Prototype Lab	0/0/2	2	1	40/60	PROJ
Capstone Project (Internal 100 Marks)							
8	23EE606	Capstone Project - II	0/0/4	4	2	0/100	PROJ
TOTAL				**27**	**22**		

SEMESTER VII							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Theory (Internal 40 Marks & External 60 Marks)							
1	23EE0XX	Open / Emerging/ Industrial Elective - II	3/0/0	3	3	60/40	OEC
2	23EE0XX	Open / Emerging/ Industrial Elective - III	3/0/0	3	3	60/40	OEC
3	23EE9XX	Professional Elective - III	3/0/0	3	3	60/40	PEC
4	23EE9XX	Professional Elective - IV	3/0/0	3	3	60/40	PEC
5	23EE9XX	Professional Elective - V	3/0/0	3	3	60/40	PEC
Project (Internal 60 Marks & External 40 Marks)							
6	23EE702	Project - I	0/0/6	6	3	40/60	PRJ
Internship (Internal 100 Marks)							
7	23EES01	Internship	28 days		2	0/100	INT
TOTAL				**21**	**20**		

SEMESTER VIII							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact Hrs/Wk**	**Credits**	**Ext/Int**	**Cat.**
Project							
1	23EE801	Project - II	0/0/24	24	12	40/60	PRJ
TOTAL				**24**	**12**		

SCHEME OF CREDIT DISTRIBUTION – SUMMARY											
S. No.	**Stream**	**Credits/Semester**								**C**	%
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**		
1	Humanities & Social Sciences Including Management (HSMC)	1	4	3	-	3	-	-	-	11	6.7
2	Basic Sciences (BSC)	13	4	4	-	-	-	-	-	21	12.8
3	Engineering Sciences (ESC)	11	6	3	4	-	-	-	-	24	14.6
4	Professional Core (PCC)	-	7	12	18	12	13	-	-	62	37.8
5	Professional Electives (PEC)	-	-	-	-	3	3	9	-	15	9.14
6	Open Electives (OEC) / Emerging Elective Courses (EEC)	-	-	-	-	3	-	6	-	9	5.4
7	Project Work (PROJ)	-	-	-	-	2	3	5	12	22	13.4
8.	Mandatory Course (MC)	0	0	0	-	0	-	-	-	0	0
Total		25	21	22	22	23	19	20	12	164	

STRUCTURE FOR UNDERGRADUATE ENGINEERING PROGRAM			
S. No.	**Course Work - Subject Area**	**AICTE Suggested Credits**	**SKCET Credits (164)**
1.	Humanities and Social Sciences (HS), including Management;	12*	11
2.	Basic Sciences (BS) including Mathematics, Physics, Chemistry, Biology;	32*	21
3.	Engineering Sciences (ES), including Materials, Workshop, Drawing, Basics of Electrical/Electronics/Mechanical/Computer Engineering, Instrumentation;	29*	24
4.	Professional Subjects-Core (PC), relevant to the chosen specialization/branch; (May be split into Hard (no choice) and Soft (with choice), if required	64*	62
5.	Professional Subjects – Electives (PE), relevant to the chosen specialization/ branch;	15*	15
6.	Open Subjects- Electives (OE), from other technical and/or emerging subject areas;	9*	9
7.	Project Work, Seminar and/or Internship in Industry or elsewhere.	15*	22
8.	Mandatory Courses (MC)	Non-credit	**0**
Total		176*	164
Minor Variations is allowed as per need of the respective disciplines			

HUMANITIES & SOCIAL SCIENCES INCLUDING MANAGEMENT (11Credits)							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23TA101	Heritage of Tamils	1/0/0	1	1	0/100	HSMC
2.	23TA201	Tamils and Technology	1/0/0	1	1	0/100	HSMC
3.	23EN101	Oral and Written Communication Skills	2/0/2	4	3	50/50	HSMC
4.	23GE301	Universal Human Values	3/0/0	3	3	60/40	HSMC
5.	23GEC01	Entrepreneurship and Startups	3/0/0	3	3	0/100	HSMC

BASIC SCIENCE COURSES (21 Credits)							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23SB102	Biology for Engineers	3/0/0	3	3	60/40	BSC
2.	23MA101	Mathematics I	3/1/0	4	4	60/40	BSC
3.	23AS101	Applied Science	4/0/0	4	4	60/40	BSC
4.	23AS103	Applied Science Laboratory	0/0/4	4	2	40/60	BSC
5.	23MA201	Mathematics II	3/1/0	4	4	60/40	BSC
6.	23MA302	Mathematics III	3/1/0	4	4	60/40	BSC

ENGINEERING SCIENCE COURSES (24 Credits)							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23EE101	Basics of Electrical Circuits	3/1/0	4	4	60/40	ESC
2.	23EE102	Basics of Electrical Circuits Laboratory	0/0/2	2	1	40/60	ESC
3.	23IT101	Application Development Practices	1/0/4	5	3	50/50	ESC
4.	23CS101	Problem Solving using C++	1/0/4	5	3	50/50	ESC
5.	23CD201	Database Management Systems	1/0/4	5	3	50/50	ESC
6.	23CY201	Java Programming	1/0/4	5	3	50/50	ESC

7.	23CS301	Advanced Java Programming	1/0/4	3	3	50/50	ESC
8.	23IT211	Introduction to Python Programming	1/0/4	5	3	50/50	ESC
9.	23EC303	Idea Laboratory	0/0/2	2	1	40/60	ESC

PROFESSIONAL CORE COURSES (62 Credits)							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23EE201	Measuring Instruments and Smart Sensors	3/0/0	3	3	60/40	PCC
2.	23EE202	Electronics Devices and Integrated Circuits	3/0/0	3	3	60/40	PCC
3.	23EE203	Electronics Devices and Integrated Circuits Laboratory	0/0/2	2	1	40/60	PCC
4.	23EE301	Electrical Machines - I	3/0/0	3	3	60/40	PCC
5.	23EC202	Digital System Design	3/0/0	3	3	60/40	PCC
6.	23EC302	Operating Systems for Electronic Devices	3/0/2	5	4	50/50	PCC
7.	23EE303	Electrical Machines- I Laboratory	0/0/2	2	1	40/60	PCC
8.	23EC204	Digital System Design Laboratory	0/0/2	2	1	40/60	PCC
9.	23EE401	Electrical Machines-II	3/0/0	3	3	60/40	PCC
10.	23EE402	Control Systems	3/0/0	3	3	60/40	PCC
11.	23EE403	Transmission and Distribution	3/0/0	3	3	60/40	PCC
12.	23EE404	Renewable Energy and Storage Systems	3/0/0	3	3	60/40	PCC
13.	23EC403	Embedded C++	3/0/2	5	4	50/50	PCC
14.	23EE405	Electrical Machines-II Laboratory	0/0/2	2	1	40/60	PCC
15.	23EE406	Control Systems Laboratory	0/0/2	2	1	40/60	PCC
16.	23EE501	Electric Vehicle Technology	3/0/0	3	3	60/40	PCC
17.	23EE502	Power Electronics	3/0/2	5	4	50/50	PCC

18.	23EC611	Principles of Digital Signal Processing	3/1/2	6	5	50/50	PCC
19.	23EE601	Internet of Things for Electrical Systems	3/0/0	3	3	60/40	PCC
20.	23EE602	Power System Protection and Switchgear	3/0/0	3	3	60/40	PCC
21.	23EE603	Power System Analysis	3/0/2	5	4	50/50	PCC
22.	23EE604	Virtual Instrumentation	2/0/2	4	3	50/50	PCC

PROFESSIONAL ELECTIVE COURSES (15 Credits)							
S. No	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
ELECTIVE STREAM I – POWER ENGINEERING							
1.	23EE901	Power System Management and Monitoring	3/0/0	3	3	60/40	PEC
2.	23EE902	Power System Operation and Economics	3/0/0	3	3	60/40	PEC
3.	23EE903	Power Quality	3/0/0	3	3	60/40	PEC
4.	23EE904	High Voltage Engineering	3/0/0	3	3	60/40	PEC
5.	23EE905	Power System Automation	3/0/0	3	3	60/40	PEC
6.	23EE906	Residential Electrical Systems	3/0/0	3	3	60/40	PEC
ELECTIVE STREAM II - APPLIED ELECTRONICS							
1.	23EE907	Process Control and Instrumentation	3/0/0	4	3	60/40	PEC
2.	23EE908	Avionics Technology	3/0/0	3	3	60/40	PEC
3.	23EE909	MEMS and Nano electronics	3/0/0	3	3	60/40	PEC
4.	23EE910	VLSI Technology	3/0/0	3	3	60/40	PEC
5.	23EE911	Wireless Communication	3/0/0	3	3	60/40	PEC
6.	23EE941	Green Electronics and Sustainable Design	3/0/0	3	3	60/40	PEC
ELECTIVE STREAM III - INTEGRATED ELECTRONIC SYSTEMS							
1.	23EE912	Embedded System Design using ARM	3/0/0	3	3	60/40	PEC
2.	23EE913	Machine Learning for Embedded Applications	3/0/0	3	3	60/40	PEC
3.	23EE914	Embedded System Programming	3/0/0	3	3	60/40	PEC
4.	23EE915	Embedded Systems for Automotive Applications	3/0/0	3	3	60/40	PEC
5.	23EE916	Embedded Systems in Smart Grid	3/0/0	3	3	60/40	PEC
6.	23EE917	Embedded Control for Electrical Drives	3/0/0	3	3	60/40	PEC

ELECTIVE STREAM IV – CONVERTER AND DRIVES							
1.	23EE918	Design of Electrical Machines	3/0/0	3	3	60/40	PEC
2.	23EE919	Special Electrical Machines	3/0/0	3	3	60/40	PEC
3.	23EE920	PLC, SCADA and Automation	3/0/0	3	3	60/40	PEC
4.	23EE921	Servo Drives in Robotics	3/0/0	3	3	60/40	PEC
5.	23EE922	Modern Power Converters	3/0/0	3	3	60/40	PEC
6.	23EE923	Intelligent Controllers for Drone Technology	3/0/0	3	3	60/40	PEC
ELECTIVE STREAM V – RENEWABLE ENERGY SYSTEMS							
1.	23EE924	Optimal Energy Controllers	3/0/0	3	3	60/40	PEC
2.	23EE925	Industrial Electrification using Renewable Energy System	3/0/0	3	3	60/40	PEC
3.	23EE926	Power Electronics for Renewable Energy System	3/0/0	3	3	60/40	PEC
4.	23EE927	Hybrid Smart grid Technology	3/0/0	3	3	60/40	PEC
5.	23EE928	Fuel Cell and Biogas System	3/0/0	3	3	60/40	PEC
6.	23EE929	Hybrid Wind and Solar Electric Systems	3/0/0	3	3	60/40	PEC
7.	23EE930	Rural Electrification Technologies and Economics	3/0/0	3	3	60/40	PEC
ELECTIVE STREAM VI – E-MOBILITY							
1.	23EE931	Vehicle Charging Infrastructure	3/0/0	3	3	60/40	PEC
2.	23EE932	Vehicle Design and Fabrication	3/0/0	3	3	60/40	PEC
3.	23EE933	Autonomous Electric Vehicle	3/0/0	3	3	60/40	PEC
4.	23EE934	Vehicle-to-Grid Integration	3/0/0	3	3	60/40	PEC
5.	23EE935	Renewable Energy Integration with EV Charging	3/0/0	3	3	60/40	PEC
6.	23EE936	Plug-in Hybrid Electric Vehicles (PHEV)	3/0/0	3	3	60/40	PEC
7.	23EE937	Electric Power Train	3/0/0	3	3	60/40	PEC

OPEN/ EMERGING/ INDUSTRY (9 Credits)							
S. No	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23EE001	Residential and Commercial Electrical Systems	3/0/0	3	3	60/40	OEC
2.	23EE002	Autonomous Vehicles	3/0/0	3	3	60/40	OEC
3.	23EE003	Special Purpose Machines	3/0/0	3	3	60/40	OEC
4.	23EE004	Renewable Energy Sources	3/0/0	3	3	60/40	OEC
5.	23EE005	Servo and Robot Drives	3/0/0	3	3	60/40	OEC
6.	23EE006	Industrial Safety Management	3/0/0	3	3	60/40	OEC

7	23EE007	Machine Learning Applications in Energy Systems	3/0/0	3	3	60/40	OEC
8	23EE008	Big Data Analytics for Smart Grid	3/0/0	3	3	60/40	OEC
9	23EE009	Real Time Systems	3/0/0	3	3	60/40	OEC
10	23EE010	Flexible and Stretchable Electronics	3/0/0	3	3	60/40	OEC
11	23EE011	Rapid System Prototyping with FPGAs	3/0/0	3	3	60/40	OEC
12	23EE012	Augmented and Virtual Reality	3/0/0	3	3	60/40	OEC

PROJECT WORK (22 Credits)

S. No.	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	Ext/ Int	Cat.
1.	23EE505	Capstone Project - I - Mern Stack	0/0/4	4	2	0/100	PRJ
2.	23EE606	Capstone Project - II	0/0/4	4	2	0/100	PRJ
3.	23EE605	Prototype Lab	0/0/2	2	1	40/60	PRJ
4.	23EE702	Project - I	0/0/6	6	3	40/60	PRJ
5.	23EE801	Project - II	0/0/24	24	12	40/60	PRJ

PROFESSIONAL ELECTIVE COURSES: VERTICALS					
Vertical I	**Vertical II**	**Vertical III**	**Vertical IV**	**Vertical V**	**Vertical VI**
Power System Management and Monitoring	Process Control and Instrumentation	Embedded System Design using ARM	Design of Electrical Machines	Optimal Energy Controllers	Vehicle Charging Infrastructure
Power System Operation and Economics	Avionics Technology	Machine Learning for Embedded Applications	Special Electrical Machines	Industrial Electrification using Renewable Energy System	Vehicle Design and Fabrication
Power Quality	MEMS and Nano electronics	Embedded System Programming	PLC, SCADA and Automation	Power Electronics for Renewable Energy System	Autonomous Electric Vehicles
High Voltage Engineering	VLSI Technology	Embedded Systems for Automotive Applications	Servo Drives in Robotics	Hybrid Smart grid Technology	Vehicle-to-Grid Integration
Power System Automation	Wireless Communication	Embedded Systems in Smart Grid	Modern Power Converters	Fuel Cell and Biogas System	Renewable Energy Integration with EV Charging
Residential Electrical Systems	Green Electronics and Sustainable Design	Embedded Control for Electrical Drives	Intelligent Controllers for Drone Technology	Hybrid Wind and Solar Electric Systems	Plug-in Hybrid Electric Vehicles (PHEV)
				Rural Electrification Technologies and Economics	Electric Power Train

INTERN (3 Credits)							
S. No	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	Ext/ Int	Cat.
1.	23EES01	Employability Enhancement Skills (Internship)	28 days		2	0/100	INT

VALUE ADDED COURSES (Based on student's interest)			
S. No	Course Code	Course Title	Sem
1	23VA301	Solar Energy Technology	III / IV
2	23VA302	Industry 5.0 using Industrial Internet of Things	V/VI
3	23VA303	Microgrid Technology	V/VI
4	23VA304	FPGA-based Switched Mode Power Converters	V/VI
5	23VA305	Phase-Locked Loop Circuit Design	V/VI
6	23VA306	Substation Designing	V/VI
7	23VA307	Contemporary Digital Techniques	V/VI
8	23VA308	Recent Power Electronics and Control	V/VI
9	23VA309	Neuro-Instrumentation	III / IV
10	23VA504	Massive Open Online Courses (MOOC) / NPTEL	I-VIII

MANDATORY COURSES (Non-Credits) (Courses conducted either by internal faculty or through MOOCs)							
S. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**Ext/ Int**	**Cat.**
1.	23MC101	Induction Program	3 weeks		0	0/100	MC
2.	23MC102	Environmental Sciences	1/0/0	1	0	0/100	MC
3.	23MC103	Soft Skills	1/0/0	1	0	0/100	MC
4.	23MC104	Management Organizational Behaviour	1/0/0	1	0	0/100	MC
5.	23MC105	General Aptitude	1/0/0	1	0	0/100	MC
6.	23MC106	Life Skills and Ethics	1/0/0	1	0	0/100	MC
7.	23MC107	Stress Management	1/0/0	1	0	0/100	MC
8.	23MC109	Essence of Indian Traditional Knowledge	1/0/0	1	0	0/100	MC
9.	23MCC01	Indian Constitution	1/0/0	1	0	0/100	MC

L: Lecture **T:** Tutorial **P:** Practical **C:** Credit **O:** Outside Class hours **Cat.:** Category

HSMC : Humanities and Social Sciences including Management
BSC : Basic Science Courses
ESC : Engineering Science Courses
PCC : Professional Core Courses
PEC : Professional Elective Courses
OEC : Open and Emerging Elective Courses
PRJ : Project Work
INT : Internship
MC : Mandatory Course

Definition of Credit:

L – Lecture	1 Hr. Lecture (L) per week	1 credit
T – Tutorial	1 Hr. Tutorial (T) per week	1 credit
P - Practical/Practice (Project and Industry based Courses)	1 Hr. Practical (P) per week	0.5 credit

SEMESTER – V

23EE501	Electric Vehicle Technology	3/0/0/3
Nature of Course	C (Theory Concept)	
Pre-requisites	Electrical Machines, Power Electronics	

Course Objectives:

1	To understand the basics of Electric Vehicles and its components.
2	To introduce the fuel cells and electrification challenges.
3	To understand the Battery-operated electric vehicle and BMS.

Course Outcomes:
Upon completion of the course, students shall have ability to

C501.1	Assess the basic concepts of EV and its types in modern scenario.	[AP]
C501.2	Compare BEV, FCEV, PHEV and its challenges.	[AN]
C501.3	Examine the components of Battery electric vehicles and power converters.	[AN]
C501.4	Interpret the Modern power electronics converters, ICE and regenerative braking systems.	[AP]
C501.5	Illustrate Hybrid electric vehicles, FCEVs architecture and its market level utilization.	[AP]

Course Contents:

Electric Vehicle and their Challenges **15**

Introduction to Electric Vehicle: Need of EV, economic considerations and environmental impacts. Basics of vehicle performance - Vehicle power source characterization - Mathematical models to describe vehicle performance -Types of electric vehicles, Compare : battery electric vehicle, Fuel cell based electric vehicle, plug-in hybrid electric vehicle. E-Mobility-electrification challenges, business connected mobility.

Battery Electric Vehicle **15**

Basic components of Battery Electric Vehicle drive train - Electric propulsion subsystem: Drive shaft, mechanical transmission, Power Converters, suspension systems - Modern Power Electronic Converters (DC-AC / DC-DC) - Electronic Control Unit (ECU) - Energy Storage Requirements in Electric Vehicle - Battery management system (BMS) - Differences and modifications of Internal Combustion Engine and BEV - Regenerative braking system in BEV.

Hybrid and Fuel Cell Electric Vehicle **15**

Architecture and components of Hybrid Electric Vehicle and drive train, Power flow control in hybrid drive train topologies - Classification: Mild Hybrid, Strong Hybrid, series, and series-parallel, complex hybrid - Fuel efficiency - Concept of Plug-in Hybrid Electric Vehicle - Architecture and components of Fuel cell Electric Vehicle FCEV drive train system. Commercial and Market analysis of FCEV utilization.

Total	**45 Periods**

Text Books:	
1	Babu A.K “Electric & Hybrid Vehicles”, 2^{nd} edition,Khanna Publisher, New Delhi, 2022.
2	Mehrdad Ehsani, Yimin Gao, Ali Emadi “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals”, 2^{nd} edition ,CRC Press, 2010.
3	Husain, I. “Electric and Hybrid Vehicles” ,2^{nd} edition,Boca Raton, CRC Press, 2010.

Reference Books:

1	Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles”, 1^{st} edition,Springer, 2013.
2	Tariq Muneer and Irene Illescas García, “The automobile, In Electric Vehicles: Prospects and Challenges”,1^{st} edition, Elsevier, 2017.
3	Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” ,2^{nd} edition John Wiley and Sons, 2012.
Web References:	
1	https://archive.nptel.ac.in/courses/108/106/108106170/
2	https://onlinecourses.nptel.ac.in/noc24_ee30/preview
3	https://onlinecourses.nptel.ac.in/noc22_ee53/preview
4	https://www.udemy.com/course/electric-and-hybrid-vehicle-engineering

23EE918	**Design of Electrical Machines**	**3/0/0/3**
Nature of Course	G (Theory Analytical)	
Pre-requisites:	Electrical Machines - I and Electrical Machines – II	

Course Objectives:

1	To understand the basic design concepts.
2	To analyze the design of electrical static and dynamic machines.
3	To implement the design optimization procedures of electrical machines.

Course Outcomes:
Upon completion of the course, students shall have ability to

C918.1	Analyze the basic parameters and design considerations of electrical machines.	[AN]
C918.2	Investigate the design of DC machines.	[AN]
C918.3	Analyze the design of core and shell type Transformers.	[AN]
C918.4	Apply the design procedures of electrical machines using computational approach.	[AP]
C918.5	Examine the design of Induction and Synchronous machines.	[AN]

Course Contents:

Basic Design Concepts and Design of DC Machines **15**
Considerations and Limitations in design; Choice of specific electric and magnetic loadings; Magnetic circuit calculations - Smooth and Slotted armature surface, Ventilating ducts, Total gap contraction factor, MMF for airgap and Teeth; Real and apparent flux density of rotating machines. Design of DC machines: Output Equation - Main Dimensions; Choice of number of poles; Armature core design; Design of commutator and brushes.

Design of Transformers and Computational Approach **15**
Output rating of single phase and three phase transformers; Optimum design of transformers; Design of cores - Square core and cruciform core for core-type transformer; Design of tanks and cooling tubes of transformers. Introduction to Computer Aided Design of Electrical Machines - Different approaches of CAD, Design of optimization methods; Introduction to FEM based design.

Design of AC Machines **15**
Design of Induction Machines: Output Equation - Main dimensions; Design of stator; Design of squirrel cage rotor - Design of slip ring rotor. Design of Synchronous Machines: Output Equation - Main dimensions - Short circuit ratio; Design of stator and rotor of cylindrical pole and salient pole machines; Design of damper winding.

Total	**45 Periods**

Text Books:	
1	Sawhney A K, “A Course in Electrical Machine Design”, Dhanpat Rai and Sons, 4^{th} edition, New Delhi, Reprint 2022.
2	Sen S K, “Principles of Electrical Machine Design with Computer Programmes”, 2^{nd} edition,Oxford and IBH Publishing, 2006.
3	Deshpande M V “Design and Testing of Electrical Machine Design” ,3^{rd} edition Wheeler Publications, 2011.
Reference Books:	
1	Agarwal R K, “Principles of Electrical Machine Design”, 5^{th} edition S.K.Kataria and Sons, Delhi, 2014.
2	Say M G, “Theory & Performance and Design of AC Machines”, 3^{rd} edition, ELBS London, 2005.
3	Murthy K.M.V , “Computer Aided Design of Electrical Machines”, 1^{st} edition ,B.S. Publications, 2008.
Web References:	
1	https://cusp.umn.edu/electric-machine-design-videos
2	https://motorsolver.com/workshops/electric-machine-design-lectures/
3	http://www.ppi-engineering.com/design/
4	https://www.youtube.com/watch?v=PIl4pz7ohpA
5	https://nptel.ac.in/courses/108105131/

23EE906	Residential Electrical Systems		3/0/0/3
Nature of Course	G (Theory and Analytical)		
Pre-requisites	Transmission and Distribution		
Course Objectives:			
1	To give a basic knowledge on residential and wiring systems.		
2	To understand the different applications like heating and illumination.		
3	To familiarize with the Electrical system components.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C906.1	Assess the electrical wiring systems for residential consumers, representing the systems with standard symbols and drawings, SLD.		[AP]
C906.2	Analyze the various components of residential electrical systems.		[AN]
C906.3	Evaluate the size, rating and cost of electrical installations for residential applications.		[AN]
C906.4	Appraise the electrical Illumination systems and its various components.		[AN]
C906.5	Analyze the energy saving in illumination systems, designing scheme for a residential premises.		[AN]
Course Contents:			

Electrical System Components **15**

LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components - Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system - Contactor, Isolator, Relays, MPCB - Electric shock and Electrical safety practices. Introduction to Home Automation - HUB, Sensors, and Actuators - Room-by-Room design concept - Various communication protocols.

Electrical Wiring Systems **15**

Types of residential wiring systems - general rules and guidelines for installation - load calculation and sizing of wire - rating of main switch - distribution board and protection devices, - earthing system calculations - requirements of residential installation, deciding lighting scheme and number of lamps - earthing of residential installation - selection and sizing of components.

Illumination Systems **15**

Terms used in illumination Engineering - Classification of light sources. Incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps - Design of illumination systems - Indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting - Energy saving lamps.

Total	**45 Periods**

Text Books:	
1	Uppal S.L and Garg G.C , "Electrical Wiring, Estimating &Costing", 6th edition, Khanna publishers, 2020.
2	Wadhwa, C.L. "Generation Distribution And Utilization Of Electrical Energy", 4th edition, New Age International Publishers, 2012.
3	DipankarSaha "Smart Home Automation with IoT" ,1st edition,BPB Publications, 2024.
Reference Books:	
1	Joshi H, "Residential Commercial and Industrial Systems", 1st edition, McGraw Hill Education, 2008.
2	Open Shaw Taylor E, "Utilization of Electric Energy", Orient Longman, 5th Edition, 2007
3	Phil Simmons and Ray C Mullin" Electrical Wiring Residential", Delmar Cengage Learning, 20th Edition ,2020
Web References:	
1	https://www.udemy.com/course/practical-home-electrical-installation/
2	https://www.coursera.org/courses?query=electrica
3	https://southcentral.edu/Workforce/residential-electrician-training-onlinecourse.
4	https://www.udemy.com/course/learn-the-basics-of-household-wiring/
5	https://onlinecourses.swayam2.ac.in/nou25_ec07/preview

23EE907	Process Control and Instrumentation	3/0/0/3
Nature of Course	G (Theory and Analytical)	
Pre-requisites	Control Systems, Measuring Instruments and Smart Sensors	
Course Objectives:		
1	To study the basic concepts of Process Control and Measuring Instruments.	
2	To understand the characteristics of various systems and control techniques.	
3	To familiarize with the advanced control methods in process industries.	
Course Outcomes: **Upon completion of the course, students shall have ability to**		
C907.1	Interpret the industrial process control variables and measuring instruments.	[AP]
C907.2	Analyze the concepts of final control elements and actuators.	[AN]
C907.3	Construct the mathematical model of different process control.	[AP]
C907.4	Evaluate the performance of control system with controllers and control strategies along with instrumentation.	[AP]
C907.5	Analyze the concepts of different advanced process control systems.	[AN]

Course Contents:

Module 1: Process Control Variables and Controlling Elements **15**

Introduction to process control, process variables, degree of freedom, Industrial measurement systems – different types of industrial variables and measurement systems elements – sensors and transducers for different industrial variables like pressure, torque, speed, temperature – sensor principles – examples of sensors – sensor scaling – Industrial signal conditioning systems – Amplifiers – Filters – A/D converters for industrial measurements systems – review of general Industrial instruments – I/P and P/I converters, pneumatic and electric actuators, valve positioned, control valves – characteristics of control valves, inherent and installed characteristics, valve body, globe, butterfly, diaphragm, ball valves, control valve sizing, cavitations and flashing, selection criterion, Servo drives, Stepper motor drives.

Module 2: Process Modelling and Control Actions **15**

Process modeling, characteristics of liquid systems, gas systems, thermal systems, mathematical model of first order level, pressure and thermal process – higher order process, interacting non-interacting systems.Basic control actions, characteristics of ON-OFF, P, I and D control, PI, PD and PID control modes, Response of controllers for different types of test inputs, pneumatic and electronic controllers to realize various control actions, selection of control mode for different processes, optimum controller settings, tuning of controllers – process reaction curve method, continuous cycling method, damped oscillation method, Ziegler Nichols methods.1/4 decay ratio, feed forward control, ratio control, cascade control, averaging control, multivariable control, hybrid control, expert systems. Distillation column, control of top and bottom product compositions, reflux ratios, control of chemical reactors, control of heat exchanger, steam boiler, drum level control and combustion control, P&I diagrams.

Module 3: Advanced Control Systems **15**

Model predictive control – Batch Process control – Plant-wide control & monitoring – Plant-wide control design – Instrumentation for process monitoring – Statistical process control –

Introduction to Fuzzy Logic in Process Control – Introduction to OPC – Introduction to environmental issues and sustainable development relating to process industries. Process Automation – Role of digital computer system in process control, Distributed instrumentation and control system – PLC, DCS, SCADA.		
	Total	**45 Periods**

Text Books:	
1.	Stephanopoulos. G, "Chemical Process Control: An introduction to theory and process", Pearson Education, india, 2015
2.	Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, "Process Dynamics and Control", Wiley, 4th Edition, 2016.
3	Ernest O. Doebelin "Measurement systems application and design", McGraw Hill Education, 6th Edition, 2017
Reference Books:	
1	B. Wayne Bequette, "Process control, modeling, Design and simulation", Prentice Hall of India (P) Ltd., 2003
2	Franklyn W. Kirk, Thomas A. Weedon, Phillip Kirk, "Instrumentation and Process Control", American Technical Publishers, 2019.
3.	Jason L. Speyer,Walter H.Chung,"Stochastic Processes,Estimation, and Control",PHI Ltd (2013)
Web References:	
1	https://archive.nptel.ac.in/courses/103/105/103105064/
2	https://www.youtube.com/watch?v=hinLrnoBWnI
3	https://archive.nptel.ac.in/courses/103/101/103101003/

23CS001	**Programming with Data Structures**	**2/0/2/3**
Nature of Course	J (Programming)	
Prerequisites		

Course Objectives:

1	Introduce fundamental data structures and algorithmic techniques essential for solving computational problems efficiently.
2	Apply data structure concepts to design and analyze algorithms for real-world applications.
3	Teach students how to evaluate the efficiency of different data structures and algorithms using Asymptotic notations.
4	Gain insights into linear and non-linear data structures like stacks, queues, trees, and graphs.
5	Apply Sorting and searching techniques in Real world applications.

Course Outcomes:

Upon completion of the course, students shall have ability to:

C004.1	Analyze fundamental data structures such as arrays and linked lists	[AN]
C004.2	Utilize stacks and queues to develop solutions for real-world computational challenges.	[AP]
C004.3	Examine binary trees, binary search trees (BST), traversal methods, and searching algorithms, while assessing their efficiency using complexity analysis.	[AP]
C004.4	Evaluate the effectiveness of various graph algorithms and hashing techniques in solving computational problems.	[AN]
C004.5	Design efficient solutions using sorting and searching techniques to optimize problem-solving in real-world applications.	[AP]

MODULE I - INTRODUCTION TO LINEAR DATA STRUCTURES **12**

Data Structures Introduction & Linked Lists - Understanding Data Structures and their importance, Comparison: Arrays vs Linked Lists, Types of Linked Lists: Singly Linked List: Creation, Insertion, Deletion, and Traversal, Doubly Linked List: Creation, Insertion, Deletion, and Traversal, Circular Linked List: Creation and Applications, Stack Implementations: Stack Model and Concept, Array and Linked List Implementations of Stacks. Applications of Stacks-Infix, Prefix, and Postfix Expressions: Conversion and Evaluation, Balancing Parentheses using Stacks. Queue Implementations - Array and Linked List Implementations of Queues, Priority Queue and Applications

MODULE II – NONLINEAR DATA STRUCTURES **8**

Trees: Creation, Traversal, and Searching - Binary Tree: Structure, Creation, Insertion, and Deletion, Binary Search Tree (BST): Concept and Operations, Tree Traversals: Inorder, Preorder, Postorder and Level Order Traversals. Graph Implementations - Weighted and Directed Graphs, Adjacency Matrix and Adjacency List Implementations. Graph Traversal Techniques: Breadth-First Search (BFS) and Depth-First Search (DFS)

MODULE III - HASH FUNCTIONS, SORTING AND SEARCHING TECHNIQUES **10**

Hashing and Techniques: Direct Address Table, Hash Functions, Collision Resolution Techniques: Linear Probing, Quadratic Probing, Double Hashing. Sorting Algorithms - Basic

Sorting Techniques: Bubble Sort, Insertion Sort, Selection Sort: Implementation and Time Complexity Analysis. Advanced Sorting Techniques: Merge Sort and Quick Sort: Implementation and Time Complexity Analysis. Searching Algorithms - Linear Search and Binary Search, Applications, Time Complexity Analysis of Searching.

List of Lab Experiments:

1. Implement Singly Linked List operations (Creation, Insertion, Deletion & Traversal)
2. Implement Doubly Linked List operations (Creation, Insertion, Deletion & Traversal)
3. Implement Circular Linked List operations and explore its applications
4. Implement Stack operations using Array and Linked List
5. Evaluate Infix, Prefix, and Postfix Expressions using Stacks
6. Implement Queue operations using Array and Linked List
7. Implement Binary Tree operations (Creation, Insertion, Deletion) and Tree Traversals
8. Implement Breadth-First Search (BFS) and Depth-First Search (DFS) on Graphs
9. Implement Hashing with Collision Resolution Techniques (Linear and Quadratic Probing)
10. Implement Sorting Algorithms and evaluate their time complexities.
11. Implement Linear Searching Techniques evaluate their time complexities.
12. Implement Binary Searching Techniques evaluate their time complexities.

Total Theory	**30 periods**
Total Lab	**30 periods**
Total	**60 periods**

Text Books:

1	Narasimha Karumanchi, "Data Structures and Algorithms Made Easy", 6th Edition, CareerMonk Publications, 2022.
2	Seymour Lipschutz, "Data Structures (Schaum's Outline Series)", Revised First Edition, McGraw Hill Education, 2019.
3	Debasis Samanta, "Classic Data Structures", Second Edition, PHI Learning, 2009.

Reference Books:

1	Reema Thareja, "Data Structures Using C", 3rd Edition, Oxford University Press, 2022.
2	Jean-Paul Tremblay and Paul G. Sorenson, "An Introduction to Data Structures with Applications", 2nd Edition, McGraw-Hill Education, 1984.
3	Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", 3rd Edition, MIT Press, 2009.

Web References:

1	https://www.khanacademy.org/computing/computer-science/algorithms
2	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-006-introduction-to-algorithms-spring-2011/
3	https://www.w3schools.com/dsa/dsa_intro.php
4	https://techdevguide.withgoogle.com/paths/data-structures-and-algorithms/

23EE502	Power Electronics	3/0/2/4
Nature of Course	E (Skill based)	
Course Pre-requisites	Electronic Devices and Integrated Circuits	

Course Objectives:

1	To facilitate the knowledge about the characteristics of Power semiconductor devices.
2	To provide adequate knowledge of Converters and DC choppers
3	To impart the concepts of PWM inverters.
4	To illustrate the operation of AC-AC converters.

Course Outcomes:
Upon completion of the course, students shall have ability to

C502.1	Analyze the static and dynamic characteristics of power semiconductor devices.	[AN]
C502.2	Analyze the various types of controlled converters with R, RL, RLE loads and the effects of source impedance.	[AN]
C502.3	Examine the operation of DC-DC converters and resonant converters.	[AN]
C502.4	Examine the operation of single phase and three phase inverters with various PWM techniques.	[AN]
C502.5	Assess the working principle of AC-AC converters and the role of various power electronic converters in clean energy.	[AP]

Course Contents:

Power Semiconductor Devices and Converters **15**

Power Semiconductor Switches- SCR, TRIAC, MOSFET, IGBT and its static and dynamic characteristics, Introduction to Silicon carbide and Gallium nitride (GaN) power devices, protection gate drive circuits and heat sink. Single phase half and full wave converters with R, RL, and RLE load. Three phase half and full wave converters with R, RL load. Dual converter. Power factor improvement, effect of source impedance

DC to DC Converters **15**

DC to DC Chopper – Principle of step-up and step-down chopper- chopper configurations. Buck, boost, buck - boost converter, Cuk and SEPIC converter. SMPS. Introduction to resonant converters-classification, ZVS and ZCS.

Inverters and AC Voltage Controllers **15**

Single phase half bridge and full bridge inverter, Three phase inverters - Constant voltage source and constant current source inverters - PWM control of inverters - Sinusoidal, Space vector modulation techniques - AC to AC voltage controller - Cycloconverters - Role of power electronic converters in renewable energy and electric vehicles.

Total Theory	**45 Periods**

Course Contents:			
S.No	List of Experiments	CO Mapping	BT
1.	Analyze the voltage and current characteristics on SCR and TRIAC.	C502.1	[AN]
2.	Analyze the dynamic characteristics of MOSFET and IGBT.	C502.1	[AN]
3.	Analyze latching and holding currents, turn-on/turn-off behaviour of SCR using a static circuit.	C502.1	[AN]
4.	Performance Comparison of Single-Phase Half and Fully Controlled Rectifiers under Varying Load Conditions.	C502.2	[AP]
5.	Analyze the performance of Three phase fully controlled rectifier.	C502.2	[AN]
6.	Analyze the performance of a close loop speed control system for DC Shunt motor using 3 phase rectifier using a suitable simulation tool.	C502.2	[AN]
7.	Analyze the buck converter and boost converter circuit using power MOSFET.	C502.3	[AN]
8.	Compare the performance of ZVS and ZCS converter.	C502.3	[AN]
9.	Performance Verification of Single-Phase IGBT Inverters with Different Modulation Strategies.	C502.4	[AP]
10.	Examine the operation of three phase voltage source Inverter with 120° and 180° conduction mode using Virtual lab	C502.4	[AP]
11.	Analyze the performance of AC-AC Voltage controller.	C502.5	[AN]
12.	Simulate a Buck Converter for Solar PV Battery Charging Application.	C502.5	[AP]
	Total Lab	**30 Periods**	
	Total	**75 Periods**	

Text Books:	
1	Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics Converters, Applications and Design", 3rd edition,John Wiley &Sons edition 2011.
2	Muhammad H. Rashid, "Power Electronics: Devices, Circuits and Applications", 4th edition, Pearson Education, 2017.
3	Bhimbra P S, "Power Electronics", 7th edition, Khanna Publishers , 2018.

Reference Books:	
1	Vedam Subramanian, "Power Electronics" ,2nd edition,New age international , 2018.
2	Singh M D, "Power Electronics", Tata McGraw-Hill, 2nd Edition 2014.
3	Bimal K. Bose, "Modern Power Electronics and amp; AC Drives", 1st edition,Pearson, 2015.

Web References:	
1	https://nptel.ac.in/courses/108101038/
2	https://www.tutorialspoint.com/power_electronics/index.htm
3	https://in.mathworks.com/help/sps/power-converters.html
4	https://www.coursera.org/learn/power-electronics

23EE503	Principles of Digital Signal Processing		3/1/2/5
Nature of Course	E (Skill Based)		
Course Pre-requisites	Differential Equations and Transforms		
Course Objectives:			
1	To study and analyse various signals and systems and their mathematical operations		
2	To study various transformation techniques in signal processing.		
3	To design analog and digital filters for signal processing applications.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C503.1	Illustrate various types of signals and systems.		[AP]
C503.2	Analyse the mathematical operations on signals and systems.		[AN]
C503.3	Analyse various transformation techniques.		[AN]
C503.4	Illustrate various types of digital filters using IIR and FIR filter design.		[AP]
C503.5	Interpret the programmable digital signal processor.		[AP]
Course Contents:			

Signals and Systems **20**

Standard signals - Classification of signals - Discrete Time (DT) signals: Deterministic and Random signals, Periodic and Aperiodic signals, Energy and Power signals, Odd and Even signals - Classification of systems - Discrete Time systems: Static and Dynamic, Causal and Non-causal, Linear and Nonlinear, Time - variant and Time - invariant, Stable and Unstable. LTI System - Convolution and Correlation - Applications in filtering, image processing, and system analysis.

Transformation Techniques **20**

Z Transform: properties, ROC - Inverse Z transforms - Stability analysis - Discrete Fourier Transforms - Properties - Circular Convolution - Fast Fourier Transform algorithms - Decimation in Time Algorithm and Decimation in Frequency Algorithm. Discrete time Fourier Transform - Relation between DFT and DTFT - Applications in audio processing.

Design of Digital Filters and Architecture of DSP **20**

FIR filter: design of linear phase FIR filters - design of FIR filters using windowing technique - Rectangular, Hamming, Hanning windows. IIR filter: Analog low pass filter design - Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation. Architecture of DSP - Von Neumann and Harvard architecture - Architecture and features of TMS 320C55xx DSP processor. Architecture of one DSP processor for motor control. Case study- Digital signal Processing in Industrial automation.

Total Theory	**60 Periods**

Lab Component			
S.No	**List of Experiments**	**CO Mapping**	**BT**
1	Simulate a digital signal processing application using basic signals using suitable simulation tools and Virtual lab.	C503.1	[AN]
2	Sampling and Reconstruction of signals for audio recording, speech recognition, and data transmission using suitable simulation tools and virtual lab.	C503.2	[AN]
3	Computation of linear convolution in filtering, image processing, and system analysis.	C503.2	[AN]
4	Computation of circular convolution in signal processing and image processing.	C503.2	[AN]
5	Frequency response of LTI system for System Analysis.	C503.2	[AN]
6	Implementation of FFT in digital recording.	C503.3	[AN]
7	Design and analysis of FIR filter using windowing technique for applications requiring linear phase response.	C503.4	[AP]
8	Design of IIR Butter worth filter.	C503.4	[AP]
9	Design of IIR Chebyshev filter.	C503.4	[AP]
10	Manipulate digital signals using mathematical algorithms, finding applications in audio/speech processing, image/video processing, radar/sonar using DSP processor	C503.5	[AN]
11	Convolution using DSP processor for audio recording.	C503.5	[AN]
12	Implement any one DSP concept using a mini project	C503.5	[AN]
	Total Lab	**30 Periods**	
	Total	**90 Periods**	
Text Books:			
1.	Proakis J G and Manolakis D G , “Digital Signal Processing Principles, Algorithms and Applications”, 5th edition ,Pearson Education, New Delhi, 2022.		
2.	Nagoorkani A, “Digital Signal Processing”, 2^{nd} edition ,Tata McGraw Hill, New Delhi, 2012.		
3.	Mitra S K , “Digital Signal Processing: A computer based approach”, 4^{th} edition,McGraw Hill, 2011.		
Reference Books:			
1.	Oppenheim A V and Schafer R W, “Discrete Time Signal Processing”, 3^{rd} edition, Prentice Hall, 2011.		
2.	Salivahanan, A. Vallavaraj, C. Gnanapriya, “Digital Signal Processing”, 2^{nd} edition,Tata McGraw Hill,New Delhi, 2011.		
3.	Vinay K. Ingle and Proakis J G , “Digital Signal Processing Using MATLAB”, 3rd Edition', Pearson Education, 2010.		

Web References:	
1	https://www.tutorialspoint.com/digital_signal_processing/
2	https://www.allaboutcircuits.com/projects/category/embedded/digital-signal-processing/

3	https://www.dspguide.com/ch28/3.htm
4	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-341-discrete-time-signal-processing-fall-2005/
5	http://nptel.ac.in/courses/117102060/
6	http://www.ictacademy.in/Pages/Digital-Signal-Processing.aspx

23EE505	Capstone Project - I	0/0/4/2
Nature of Course	Practical	
Pre Requisites	Basics of Electrical Circuits and Analog Electronics	
Course Objectives:		
1	To demonstrate the interpersonal skills and technical abilities.	
2	To apply suitable tools and techniques to solve the practical problems.	
3	To develop a working model	
Course Outcomes: **Upon completion of the course, students shall have ability to**		
C505.1	Design and develop a working model.	[C]
C505.2	Develop technical skill, presentation skill and interpersonal behavior.	[AP]
C505.3	Demonstrate interdisciplinary skill, ethical values and team work.	[AP]
C505.4	Examine market trends in terms of economics and finance.	[AP]
Course Guidelines:		

Introduction: Identifying an Innovation Challenge, Needs Finding, Observation Techniques, Techniques for Organizing Data. **Ideate:** Rules of Brainstorming, Brainstorm Facilitation. **Prototype:** Role of DT in your work, Prototyping Techniques, Testing Prototypes. **Experiments:** Introduction to Experimental Design, Types of Experiments, Business model canvass. Introduction and need for intellectual property rights.

1. Each student is expected to do a project and form a team of 3 members.
2. Every team shall have a guide who is the member of the faculty of the institution. Identification of faculty guide has to be completed within a week from the day of beginning of sixth semester.
3. The student has to identify and fabricate his/her idea into the project-working model by conducting literature survey and finalize it.
4. A project report (of the Capstone project-I) to this effect has to be submitted by the team. Also, the complete design project report has to be submitted by team.
5. Three mid semester reviews and one end semester review of the progress of the project work have to be conducted by a team of faculty (minimum 3 and a maximum of 5) along with their faculty guide as a member of the faculty team.
6. During the end semester exam, one internal examiner and one external examiner, appointed by the COE will examine the Capstone project-I done by the students.

Summative assessment based on Continuous Examination

Activity	Month	Continuous Assessment [100 marks]
Project Evaluation	August	30
Project Evaluation	September	30
Project Evaluation + Presenting in International Conference/Journal	October	40

23MCC01	**Indian Constitution**	**1/0/0/0**
Nature of Course	Theory	
Pre Requisites	NIL	
Course Objectives:		
1	To familiarize with basic information about Indian constitution	
2	To understand the fundamental rights and duties as citizens of India.	
3	To make use of legal directions in developing solutions to societal issues	
Course Outcomes: **Upon completion of the course, students shall have ability to**		
C01.1	Explain the objectives of the Constitution of India and its formation	
C01.2	Understand the state and central policies (Union and State Executive), fundamental rights and their duties.	
C01.3	Make use of legal directions in developing solutions to societal issues	
C01.4	Utilized for competitive exams that requires knowledge of Indian Constitution	
Course Contents:		
Module **5** Historical perspective, The making of the Constitution, The Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India. Fundamental Rights, Directive Principles of State Policy, Fundamental Duties, Citizenship Article 5-11. **Module** **5** Federal structure, Powers of the Union and the states, Centre-State Relations, Union Executive - President, Prime Minister, Union Cabinet, Parliament, Supreme Court of India, State Executives - Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Elections, Electoral Process, and Election Commission of India, Election Laws. Powers and Functions of Municipalities and Panchayat **Module 3** **5** Amendments - Methods, Emergency Provisions, National Emergency, President Rule, Financial Emergency, Provisions for SC and ST, OBC, women, children and backward classes, Right to Property, Freedom of Trade and Commerce. Agricultural Law.		
	Total:	**15 Periods**

Text Books:	
1	Basu D D, “Introduction to the Constitution of India”, LexisNexis, New Delhi, 22nd Edition, 2016.
2	“Bare act-constitution of India”, The universal Publications, LexisNexis 2020, New Delhi, India.
3	Bakshi, P.M.**,** The Constitution of India, Universal Law Publishing, New Delhi, 19th Edition, 2023**.**
Reference Books:	
1	Subhash.C.Kashyap, “Our Constitution: An Introduction to India’s Constitution and Constitutional Law”, National Book Trust, India, 5th edition, 2019.
2	Laxmikanth M, “Constitution of India”, Cengage Learning India. 1st edition 2018.
3	Jain, M.P.**,** Indian Constitutional Law, LexisNexis, New Delhi, 8th Edition, 2023
Web References:	
1	https://unacademy.com/course/the-indian-constitution/NSKQ8XXQ
2	https://unacademy.com/goal/upsc-civil-services-examination-ias-preparation/KSCGY
3	https://legislative.gov.in/constitution-of-india
4	https://www.indiacode.nic.in
5	https://www.clearias.com/indian-constitution/
6	https://www.mea.gov.in/constitution-of-india.htm

SEMESTER VI

23GEC01	Entrepreneurship and Startups		3/0/0/3
Nature of Course	G (Theory Analytical)		
Pre-requisites	Power System Analysis		
Course Objectives:			
1	To provide a comprehensive understanding of the entrepreneurial process, from idea generation to start up growth.		
2	To familiarize students with different startup funding mechanisms and legal frameworks.		
3	To equip students with problem solving, innovation, and business decision-making skills.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C01.1	Apply the knowledge of entrepreneurship and startup ecosystem concepts to identify potential business opportunities and suitable startup types.		[AP]
C01.2	Apply lean startup methodology and create a Business Model Canvas for a selected startup idea using brainstorming tools like Miro or Google Jamboard.		[AP]
C01.3	Analyze various startup financing options, legal compliance requirements, and value chain positioning to construct a feasible financial and go-to-market strategy.		[AN]
C01.4	Analyze real-world startup failures and crisis scenarios to identify root causes and recommend corrective strategies for future ventures.		[AN]
C01.5	Apply the principles of sustainable business practices and strategic scaling to design a socially impactful startup model and simulate a realistic exit strategy.		[AP]

Course Contents:

Introduction to entrepreneurship & startup ecosystem **12**

Overview of Entrepreneurship & Startups - Characteristics of Successful Entrepreneurs - Identifying Business Opportunities and Idea Generation - Types of Startups: Lifestyle, Scalable, Small Business, Social, etc. - Lean Startup Methodology & Business Model Canvas - The Role of Incubators, Accelerators, and Startup Ecosystems - Government Initiatives & Policies for Startups in India and Globally.

Blended Learning Components: Online Resources: TED Talks, YouTube case studies, startup success/failure analysis. Interactive Tools: Google Jamboard, Miro for brainstorming ideas. Peer Collaboration: Discussion forums, peer feedback on ideas.

Blended Learning Activities: Online Case Study & Discussion: Analyze Airbnb's startup journey and discuss key success factors, Post reflections in an LMS discussion forum. Business Idea Brainstorming & Validation: Use Google Jamboard/Miro for real-time ideation, Peer feedback & faculty guidance on feasibility Live Expert Q&A Session: Industry expert session (Incubator/Founder/Startup Mentor), Pre-session task: Students prepare 3-5 key questions. Mini Startup Pitch Challenge: Each student delivers a 2-minute elevator pitch to the class.

Startup finance, Legal framework & Business strategy **15**

Startup Financial Planning: Bootstrapping, Angel Investors, Venture Capital, Crowdfunding - Developing a Financial Model & Revenue Strategy - Legal Aspects of Startups: Business

Registration, IP & Patent Protection, Taxation & Compliance Risk Analysis and Mitigation Strategies - Go-to-Market Strategy and Product-Market Fit - Digital Marketing & Branding Strategies for Startups - Growth Hacking & Scaling Strategies.

Blended Learning Components: Simulation-based Learning: Crowdfunding campaign simulation, Workshop-based Learning: Hands-on experience with legal forms, compliance, Industry Collaboration: Investor/VC guest lecture.

Blended Learning Activities: Crowdfunding Simulation: Develop a Kickstarter campaign for a startup idea, Create a video pitch, funding goal, and reward structure. Startup Legal Workshop: Draft a business contract or IP filing document in teams, Present the drafted document for peer review. Digital Marketing Challenge: Design a Google Ads or Social Media campaign for a startup, Run a dummy ad campaign and analyze engagement. Shark Tank-Style Investment Pitch: Teams pitch ideas to a panel of faculty/industry investors, Evaluation based on Business Model, Financial Viability, Market Potential.

Startup Sustainability, Scaling, and Exit Strategies **18**

Startup Growth Stages: Expansion, Scaling, Diversification - Sustainable Business Models and Social Entrepreneurship - Leadership and Team Building in Startups - Fail Fast, Learn Faster: Case Studies on Startup Failures - Mergers, Acquisitions, and IPOs - Ethical & Social Responsibilities of Entrepreneurs - Future Trends in Entrepreneurship & Startups (AI-driven Startups, Blockchain, Green Startups)

Blended Learning Components: Project-Based Learning: Startup failure analysis report, Role-Playing & Gamification: Crisis management simulation, Hackathons & Competitions: Sustainability-focused startup challenge.

Blended Learning Activities**:** Startup Failure Analysis Report: Study 3 failed startups (e.g., Quibi, Theranos, Juicero), Submit a failure report identifying key reasons & lessons learned. Crisis Management Role-Playing: Teams are given a real-world startup crisis (financial loss, leadership change, PR crisis), Create a crisis response plan & present solutions. Sustainability Hackathon: Design a social impact startup model, Pitch with impact assessment & business viability. Startup Exit Strategy Simulation: Teams simulate an IPO, merger, or acquisition, Prepare a strategic exit report & investor pitch.

Total	**45 Periods**

Text Books:

1	Steven Fisher, Ja-nae Duane, “The Startup Equation -A Visual Guidebook for Building Your Startup”, Indian Edition, Mc Graw Hill Education India Pvt. Ltd, 2016.
2	Donald F Kuratko, Jeffrey S. Hornsby, New Venture Management: The Entrepreneur’s Road Map, 2nd edition, Routledge 2017.
3	David H. Hott, “Entrepreneurship New Venture Creation”, 1st edition, Pearson Education India, 2018.

Reference Books:	
1	Greco, F. “Startup Ecosystems: Components for an Interpretative Model and International Benchmarks”. 1st edition, Springer Nature, Switzerland 2023.
2	Aulet, B.” Disciplined Entrepreneurship: 24 Steps to a Successful Startup” 1st edition,Wiley,2013
3	Harris, T. “Start-up: A Practical Guide to Starting and Running a New Business” ,1st edition, Springer International Publishing,2018
Web References:	
1	https://onlinecourses.nptel.ac.in/noc20_mg35/preview
2	https://cloud.google.com/startup
3	https://startup.google.com/
4	https://www.startupindia.gov.in/

23EE601	Internet of Things for Electrical Systems		3/0/0/3
Nature of Course	C (Theory Concept)		
Course Objectives:			
1	To explore the concepts of internet technology and need of IoT.		
2	To discuss about IoT network layer and various protocols.		
3	To train the students to build IoT systems using sensors, single bard computers and open source IoT platforms.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C601.1	Analyze the IoT concepts integrated to electrical systems.	[AN]	
C601.2	Design and develop IoT based network connectivity and sensor systems.	[AP]	
C601.3	Analyze the wireless technologies for IoT and interfacing technologies.	[AN]	
C601.4	Appraise IoT applications in industrial and real world.	[AP]	
C601.5	Analyze the cloud computing, data analytics and applications to electrical systems.	[AN]	

Course Contents:

Concepts of IoT and Electrical Systems **15**

Exploring concepts of IoT - Sensing - Actuation - Basics of IoT Networking - Connectivity Technologies - Sensor Networks - UAV Networks - Machine to Machine Communication - Interoperability in Internet of Things

IoT Networking, Protocols, and Sensor Interfacing to Smart grid **15**

IP addressing for IoT, IPv6, Protocols - MQTT, HTTP, CoAP Wireless Protocols - LoRa, Wi-Fi. Real-time data transfer, Security and Encryption. Interfacing techniques - Analog/Digital Inputs, ADCs, Interrupts. Integration of Sensors and Actuators with Arduino - Sensor-Cloud - Fog Computing - Smart Cities and Smart Homes - Connected Vehicles - Smart Grid

IoT for Smart Grid **15**

Driving factors of smart grid in generation, transmission, distribution level applications, Metering using smart grid. IoT-based Load Monitoring and Control. Internet on Energy (IoE),Internet on Vehicles(IoV) and its applications. Case studies: IoT for smart cities - Health care - Agriculture - Smart meters.

Total	**45 Periods**

Text Books:

1	Vijay Madisetti , Arshdeep Bahga, “Internet of Things A Hands-on-Approach” 1st edition,,Universities Press,2014.
2	Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, “From Machine to Machine to Internet of Things”, 1st edition,Elsevier Publications, 2014.
3	Barrie Sosinsky, “Cloud Computing Bible”, 1st edition,Wiley-India, 2010.

Reference Books:	
1	LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning," The Internet of Things: From RFID to the Next-Generation Pervasive Network", 1st edition,Aurbach publications, March, 2008.
2	Asoke K Talukder and Roopa R Yavagal, "Mobile Computing," 1st edition,Tata McGraw Hill, 2010.
3	Ronald, Krutz, Russell Dean Vines, "Cloud Security: A Comprehensive Guide to Secure Cloud Computing",1st edition, Wiley-India, 2010.
Web References:	
1	https://onlinecourses.nptel.ac.in/noc19_cs65/preview
2	https://nptel.ac.in/courses/106105195
3	https://archive.nptel.ac.in/courses/108/108/108108098/
4	https://www.youtube.com/watch?v=OlEF6GSeaKg-nptel

23EE602	Power System Protection and Switchgear	3/0/0/3
Nature of Course	D (Theory Application)	
Course Pre-requisites	Transmission and Distribution, Power System Analysis	
Course Objectives:		
1	To learn the fundamentals of protective relays used in power systems.	
2	To give a broad coverage on types of protective schemes and lighting arresters	
3	To study about the theory of arching and types of circuit breakers.	
Course Outcomes: **Upon completion of the course, students shall have ability to**		
C602.1	Interpret the importance of protective devices in power systems.	[AP]
C602.2	Examine the working of various protective relays.	[AN]
C602.3	Apply suitable protection schemes for different apparatus, feeders and bus bar faults.	[AP]
C602.4	Illustrate the causes of overvoltage, overcurrent and its protection methods.	[AP]
C602.5	Examine the operation of various circuit breakers with arcing concepts.	[AN]
Course Contents:		

Protective Relays **15**

Fundamentals of Protection and Switchgear in Power Systems - Types of Relays - Classification of Electromechanical and Induction relays - Operating principle - Applications - Types of Overcurrent Relays - Definite Time, Inverse Time & IDMT Relays - Static Relays and Numerical Relays - Operating principle - Applications - Modern Protective Relays - Digital - Numeric Relays.

Apparatus Protection **15**

Generator protection - Motor protection - Transformer Protection - Transmission Line Protection - Distance - Differential and Carrier current protection - Feeder - Bus bar protection - Overcurrent protection - Ground Fault protection - Digital Protection of Electrical Apparatus; Wide Area Measurements - Synchronous Phase Measurement Units - Fault location, Identification and Protection.

Circuit Breakers **15**

Fault clearing process - Theory of Arcing and Arc quenching - Circuit breakers - Classification - Minimum oil - Air blast - SF6 and Vacuum Circuit Breakers - Case studies on SF6 and Vacuum Circuit Breaker - Recovery Voltage - Current Chopping - Interruption of Capacitive Current - Resistor Switching - Introduction of Miniature Circuit Breakers - Molded Circuit Breakers - Solid state and Hybrid Circuit Breakers.

Total	**45 Periods**

Text Books:

1	Paul M. Anderson, Charles Henville, Rasheek Rifaat, Brian Johnson and Sakis Meliopoulos, "Power System Protection", 2nd edition, IEEE Press, Wiley, 2022.
2	Wadhwa C L, "Electrical Power Systems", 8th edition ,New Age International (P) Ltd, 2022.
3	Badri Ram, Vishwakarma "Power System Protection and Switchgear" 2nd edition, Tata McGraw Hill, 2016

Reference Books:	
1	Omar Salah Elsayed Atwa, Practical Power System and Protective Relays Commissioning, 1st edition,Academic Press, Elsevier, 2019.
2	Ramesh Bansal, “Power System Protection in Smart Grid Environment”,1st edition, Taylor andFrancis, CRC Press, 2019.
3	Paithangar Y.G , “Fundamentals of Power System Protection” 2nd edition,PHI learning Pvt Ltd, 2010.
Web References:	
1	https://archive.nptel.ac.in/courses/108/107/108107167/
2	https://www.youtube.com/playlist?list=PLLy_2iUCG87BIJ6ZliVIRCx2Crf9_fJMB
3	https://www.coursera.org/lecture/mv-substation-part-b/need-and-application-of-surge-arresters-sdefb
4	https://www.coursera.org/lecture/advanced-study-of-protection-schemes-and-switchgear/bus-protection-schemes-FOlGM
5	https://www.youtube.com/watch?v=Zx27WM20vhw

23EE903	Power Quality		3/0/0/3
Nature of Course	G (Theory Analytical)		
Pre-requisites	Power System Analysis		
Course Objectives:			
1	To introduce the power quality problem and educate on production of voltages sags, over voltages, harmonics and methods of control.		
2	To study overvoltage problems, sources and effect of harmonics in power system networks.		
3	To impart knowledge on various methods of power quality monitoring.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C903.1	Illustrate the importance of various power quality issues.		[AP]
C903.2	Analyze the impact of voltage sags and interruptions in the power system.		[AN]
C903.3	Analyze the problems on over voltages in the power system network.		[AN]
C903.4	Analyze the effect of harmonics in the power system.		[AN]
C903.5	Apply the various methods of power quality monitoring and techniques.		[AP]
Course Contents:			

Introduction to Power Quality **15**

Overloading - Under Voltage - Over voltage - Concepts of transients: Long and short duration interruption - Sags and Swells - Voltage sag - Voltage swell - Voltage imbalance - Voltage fluctuation - Power Frequency variations - International standards of power quality: Limits and regulations. Computer Business Equipment Manufacturers Associations curve - ITI curve.

Voltage Sags, Interruptions and Over Voltages **15**

Sources of sags and interruptions - Voltage sag performance - Analysis and calculation of various faulted conditions - Analysis of voltage sag - Induction motor starting - Sag severity - Mitigation of voltage sags - Active series compensators - Static transfer switches and fast transfer switches - Sources of over voltages - Capacitor Switching - Ferro Resonance - Mitigation of voltage swells - Surge arresters - Low pass filters - Lightning protection - Shielding – Line arresters - An introduction to computer analysis tools for transients - ETAP, Dig silent Power Factory and EMTP.

Harmonics and Power Quality Monitoring **15**

Harmonic sources from commercial and industrial loads - Harmonic sources - Power system response characteristics - Harmonics Vs transients. Effect of harmonics - Harmonic distortion - Voltage and current distortion - Harmonic indices - Inter harmonics – Infraction harmonics - Harmonics with distortion factor and true power factor. IEEE 519-2014 and IEEE 3002.8-2018 standards - Monitoring and diagnostic techniques for various power quality problems - Power line disturbance analyzer - Harmonic / spectrum analyzer - Flicker meters - Disturbance analyzer - Applications of expert systems for power quality monitoring.

Total	**45 Periods**

Text Books:	
1	Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality" ,3rd edition,McGraw Hill,2017.
2	Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," 1st edition,Elsevier Academic Press, 2015.
3	Arrillaga P J., Watson N.R., Chen S., "Power System Quality Assessment", 1st edition,Wiley, 2011.
Reference Books:	
1	Bollen M.H.J, "Understanding Power Quality Problems: Voltage Sags and Interruptions", 1st edition,New York: IEEE Press, 2013.
2	Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, "Power Quality: Problems and mitigation Techniques", 1st edition,Wiley 2015.
3	Heydt G.T., "Electric Power Quality", 2nd Edition. West Lafayette, IN, Starsin a circle publication, 2009.
Web References:	
1	https://electrical-engineering-portal.com/
2	https://nptel.ac.in/courses/108107157
3	https://electricityforum.com/electrical-training/power-quality-training
4	https://studypowerquality.com/

23EE910	VLSI Technology		3/0/0/3
Nature of Course	D (Theory Application)		
Course Pre-requisites	NIL		
Course Objectives:			
1	To understand the VLSI design problems, design methodologies and manufacturing technology.		
2	To design the MOS circuits based on design rules and analyse the circuit as inverters and logic gates.		
3	To expose the layouts of application specific devices and to become familiar with digital circuits programming.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C910.1	Illustrate the VLSI design problems, design domains and CMOS fabrication Technology.	[AP]	
C910.2	Analyze the characteristics of MOS transistors and the design concepts of MOS circuits.	[AN]	
C910.3	Analyze the CMOS circuits as inverters and transmission gates.	[AN]	
C910.4	Interpret the device layouts of specific applications.	[AP]	
C910.5	Apply modeling concepts of HDL programming for the design of digital circuits.	[AP]	

Course Contents:

Introduction to VLSI design methodologies **15**

Moore's law, VLSI design problem, design domains, design methods and technologies. VLSI Fabrication Technology & MOS transistors: Fabrication - NMOS, PMOS, CMOS, Twin tub process and Silicon on insulator Technology - MOS transistors - Enhancement mode & Depletion mode, NMOS transistor Current Equation - Second order effects. MOSFET as a Switch, Nano MOSFET - MOS Layers - Stick Diagrams - Design rules and Layout, Sheet Resistance, Area Capacitance of layers, Transistor sizing, Power Dissipation.

CMOS Circuit **15**

NMOS Inverter - CMOS inverter - Switching characteristics. Pass Transistor and Transmission gates - NMOS and CMOS Logic gates - Stick Diagram, Layout Design Rules. ASICS: Types of ASICS - Physical Design flow - Programming Technology - Anti fuse - PREP Benchmarks - Actel ACT - Xilinx LCA – Altera FLEX - Altera MAX - Xilinx I/O blocks.

VLSI Programming **15**

Review of VLSI Design automation tools - Fundamental VHDL units - Design of 2 bit Adders and Multipliers using VHDL. Verilog HDL - Module and ports - Gate level, Behavioural and Dataflow modeling for 2 bit Adders and Multipliers.

Total	**45 Periods**

Text Books:	
1	Pucknell D.A,Eshraghian K, “Basic VLSI Design”, Prentice Hall of India, New Delhi, 3rd Edition,2013.
2	Smith M.J.S ., “Application Specific Integrated Circuits”, 1st edition,Addison -Wesley Longman Inc., 2013.
3	Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, 2nd edition, Pearson 2013.
Reference Books:	
1	Weste N.H, Eshraghian K, “Principles of CMOS VLSI Design: a system Perspective” ,1st edition,Pearson Education, India, 2013.
2	Volnei A. Pedroni, “Circuit Design and Simulation with VHDL”, MIT Press,2nd edition 2010.
3	Gerez S.H,”Algorithms for VLSI Design Automation”, John Wiley &Sons, 2011.

Web References:	
1	https://nptel.ac.in/courses/117101058
2	https://www.coursera.org/learn/fundamentals-of-digital-design-for-vlsi-chip-design
3	https://www.coursera.org/learn/vlsi-chip-design-and-simulation-with-electric-vlsi-eda-tool
4	https://www.tutorialspoint.com/vlsi_design/index.htm
5	https://www.edaplayground.com/
6	https://elearn.maven-silicon.com/

23EE603	Power System Analysis		3/0/2/4
Nature of Course	G (Theory and Analytical)		
Course Pre-requisites	Transmission and Distribution		
Course Objectives:			
1	To understand the concepts of power systems and its components.		
2	To apply various numerical methods to analyze fault conditions in a power system.		
3	To study the various stability methods for analyzing power system network.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C603.1	Interpret the various power system components, compute the per unit quantities, and construct the bus admittance and impedance matrices.		[AP]
C603.2	Analyze various load flow conditions in a power system network.		[AN]
C603.3	Analyze short circuit conditions in generator and transmission lines.		[AN]
C603.4	Analyze different types of faults in the power system network.		[AN]
C603.5	Examine the various stability issues in the power system network.		[AP]
Course Contents:			

Modeling of Power System and Load Flow Analysis **20**

Modeling of power system components - Single line diagram, Per unit analysis, Formation of admittance matrix with and without mutual admittance, Zbus building algorithm without mutual impedances. Phase shifting transformers. **Load flow analysis:** Classification of buses - Formation of load flow equations. Load flow solution using Gauss-Seidel, Newton - Raphson and Fast decoupled method. AI and ML algorithms for power flow analysis. IEEE standard 3002 series (IEEE 3002.2, 3002.3 & 3002.9) and IEC standard 60909.

Short Circuit Analysis **15**

Importance of short circuit study - Types of faults in power system - Short circuit transients in generator and transmission line - Symmetrical fault analysis using Z_{bus} algorithm - Positive, negative and zero sequence impedances, Sequence networks, Unsymmetrical fault analysis - Line to Ground, Line to Line, Double Line to Ground faults. Advanced AI-driven techniques for fault analysis.

Power System Stability **10**

Concepts of stability in power system - Steady state, Dynamic and Transient stability. Single machine infinite bus system - Swing equation, Power angle equation and Power angle curve. Equal area criterion - Critical clearing angle and time. Multi machine stability. Solution of swing equation using Modified Euler's and Runge - Kutta method. Optimal control approach for enhancing transient stability.

Total Theory	**45 Periods**

Lab Component			
S.No	**List of Experiments**	**CO Mapping**	**BT**
1	Computation of transmission line parameters.	C603.1	[AP]
2	Modeling of transmission lines using the nominal T and nominal π methods.	C603.1	[AP]
3	Formulating the bus admittance matrix: effects of including and excluding mutual elements.	C603.1	[AP]
4	Approaches to creating the Z bus matrix for power flow studies using V lab.	C603.1	[AP]
5	Implementation of Gauss-Seidel algorithm for power system load flow analysis using simulation software.	C603.2	[AN]
6	Load flow analysis by Newton - Raphson iterative technique using simulation software.	C603.2	[AN]
7	Thevenin-based method for assessing symmetrical faults in power engineering.	C603.3	[AN]
8	Comparative analysis of line-to-ground, line-to-line, and double line-to-ground faults using suitable simulation tool.	C603.4	[AN]
9	Demand analysis per day of any specific area.	C603.5	[AN]
10	Simulation and optimization of micro grid operations using suitable simulation tool.	C603.5	[AP]
11	Steady state stability evaluation of electrical power networks using suitable simulation tool.	C603.5	[AP]
12	Transient stability evaluation using the point-by-point method for electrical power networks.	C603.5	[AP]
	Total Lab	**30 Periods**	
	Total	**75 Periods**	

Text Books:

1	John J. Grainger and William. D. Stevenson, Jr, “Power System Analysis”, 2nd edition, McGraw-Hill International, 2017.
2	Hadi Saadat, “Power System Analysis”, 3rd edition, Tata McGraw Hill, 2015.
3	Kothari D. P and Nagrath I. J, “Modern Power System Analysis”, 3rd Edition., Tata McGraw Hill Publishing Company Limited, 2011.

Reference Books:

1	Murthy P S R, “Power System Analysis”, 3rd Edition, BS Publications, 2023.
2	Pai M. A, “Computer Techniques in Power System Analysis”, 3rd Edition, Tata McGraw-Hill Publishing Company Limited. 2014.
3	Duncan Glover J, Sarma M S and Thomas. J. Overbye, “Power System Analysis and Design” , 5th Edition, Cengage Learning, 2011.

Online Resources:

1	https://nptel.ac.in/courses/108104051
2	https://www.coursera.org/learn/industrial-power-system-analysis-and-stability
3	https://www.youtube.com/watch?v=HcMh7ahJxfo
4	https://www.youtube.com/watch?v=oVh472Etiw0

23EE604	Virtual Instrumentation		2/0/2/4
Nature of Course	C (Theory Concept), K (Problem Programming)		
Course Pre-requisites	NIL		
Course Objectives:			
1	To understand the architecture of VI and basic programming concepts in software tool.		
2	To learn different Data Acquisition system concepts		
3	To develop real time applications using software tool.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C604.1	Infer the architecture and features of Virtual Instrument.		[AN]
C604.2	Build the graphical programming in LabVIEW software		[AP]
C604.3	Illustrate the basic concepts of PC based data acquisition		[AP]
C604.4	Analyze the Control system design and PID Controller toolkits in LabVIEW		[AN]
C604.5	Demonstrate the LabVIEW Toolkit usage in Image Processing and Machine vision applications		[AP]

Course Contents:

VI Programming Techniques **10**

Block diagram and Architecture of VI - Graphical System Design (GSD) model - Comparison with conventional programming - LabVIEW Software environment VI‟s and sub -VI‟s - Loops - Arrays - Clusters - Graphs and charts - Case and sequence structures - Formula nodes - Local and global variable - String and File I/O.

DAQ and Analysis Tools **10**

Concept of PC based data acquisition - DAQ Software Architecture-DAQ Assistant - Analog Input and Analog Output - Digital Input and Digital Output - Timers-Counters - Grounding: Differential and Single Ended - Increasing Measurement Quality of DAQ - Temperature based data acquisition system.

LABVIEW tools and applications of VI **10**

Control Design and Simulation Tools – PID Control Toolkit- IMAQ: Image processing and analysis - Machine Vision- Motion Control- Web Publishing Tools -Simple programming with Arduino Uno-LabVIEW interface

Total Theory	**30 Periods**

Lab Component

S.No	List of Experiments	CO Mapping	BT
1	Development of a virtual voltmeter for analog Signal monitoring.	C604.1	[AP]
2	Design a line counter system using loop structures using simulation software.	C604.1	[AP]
3	Create a student marks processing and result generation Using Array Functions.	C604.2	[AP]
4	Create a Student Information Management System (SIMS) using Clusters with a simulation software.	C604.2	[AP]
5	Develop a patient information management system using Cluster based programming using simulation software.	C604.2	[AP]

6	Automated traffic light control system using case and sequence structures using simulation software.	C604.3	[AP]
7	Create a text based report generator using strings and file I/O in using simulation software	C604.3	[AP]
8	Design a real time temperature monitoring and data acquisition system.	C604.4	[AP]
9	Modelling and control of a water level system using control design toolbox.	C604.4	[AP]
10	Automated defect inspection system using IMAQ toolbox.	C604.5	[AP]
11	Apply IMAQ toolbox for Edge Detection.	C604.5	[AP]
12	Perform pattern matching using IMAQ Match toolbox	C604.5	[AP]
	Total Lab	**30 Periods**	
	Total	**60 Periods**	

Text Books:

1	Jovitha Jerome, “Virtual Instrumentation using LabVIEW”, 1st edition,Prentice Hall, 2010.
2	Gary W. Johnson, Richard Jennings, “Lab-view Graphical Programming”, 4th edition,TataMcGraw Hill Professional Publishing, 2011.
3	Essick, John, “Hands-On Introduction to LabVIEW for Scientists and Engineers”, 4th edition,Oxford University Press,2013.

Reference Books:

1	P.Surekha, S.Sumathi, “LabVIEW based Advance Instrumentation”, 1st edition,Springer,2007.
2	Sanjay Gupta and Joseph John, “Virtual Instrumentation using LabVIEW“, 1st edition,TataMcGraw-Hill Inc, 2017.
3	Thomas Klinger,”Image Processing with LabVIEW and IMAQ Vision”, 1st edition,Pearson Publishing,2003.

Web References:

1	http://www.ni.com/academic/students/learn-labview/
2	http://www.ni.com/academic/students/learn-daq/
3	https://www.electronicshub.org/labview-projects/
4	http://www.ni.com/webcast/2898/en/

23EE605	Prototype Lab		0/0/2/1
Nature of Course	Practical / Project		
Pre Requisites	Basics of Electrical Circuits and Analog Electronics		
Course Objectives:			
1	To apply theoretical knowledge to practical problems.		
2	To demonstrate the ability to work effectively in teams.		
3	To develop technical skill, presentation skill and interpersonal behaviour		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C605.1	Analyze system requirements to identify suitable components and subsystems for prototype development.		[AN]
C605.2	Apply appropriate tools and techniques for simulation, hardware integration, and prototyping.		[AP]
C605.3	Develop technical skill, presentation skill and interpersonal behaviour.		[AP]
C605.4	Demonstrate interdisciplinary skill, ethical values and team work.		[AP]
C605.5	Analyze the performance of the prototype through testing and debugging		[AN]

Course Guidelines:

Introduction: Identifying an Innovation Challenge, Needs Finding, Observation Techniques, Techniques for Organizing Data. **Ideate:** Rules of Brainstorming, Brainstorm Facilitation. **Prototype:** Role of DT in your work, Prototyping Techniques, Testing Prototypes. **Experiments:** Introduction to Experimental Design, Types of Experiments, Business model canvass. Introduction and need for intellectual property rights.

1. Each student is expected to do a prototype and form a team of 3 members.
2. Every team shall have a guide who is the member of the faculty of the institution. Identification of faculty guide has to be completed within a week from the day of beginning of sixth semester.
3. The student has to identify and fabricate his/her idea into the project working model by conducting literature survey and finalize it.
4. A project report to this effect has to be submitted by the team. Also, the complete design project report has to be submitted by team.
5. Three mid semester reviews and one end semester review of the progress of the prototype have to be conducted by a team of faculty (minimum 3 and a maximum of 5) along with their faculty guide as a member of the faculty team.
6. During the end semester exam, one internal examiner and one external examiner, appointed by the COE will examine the prototype done by the students.

Summative assessment based on Continuous and End Semester Examination

Activity	Continuous Assessment [60 marks]	End Semester Examination [40 marks]
Prototype Evaluation -I	30	100
Prototype Evaluation-II	30	
Prototype Evaluation-III	40	

23EE606	Capstone Project - II		0/0/4/2
Nature of Course	Practical		
Pre Requisites	Basics of Electrical Circuits and Analog Electronics		
Course Objectives:			
1	To demonstrate the interpersonal skills and technical abilities.		
2	To apply suitable tools and techniques to solve the practical problems.		
3	To design and develop a working model		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C606.1	Design and develop a working model.		[C]
C606.2	Develop technical skill, presentation skill and interpersonal behavior.		[AP]
C606.3	Demonstrate interdisciplinary skill, ethical values and team work.		[AP]
C606.4	Examine market trends in terms of economics and finance.		[AP]

Course Guidelines:

Introduction: Identifying an Innovation Challenge, Needs Finding, Observation Techniques, Techniques for Organizing Data. **Ideate:** Rules of Brainstorming, Brainstorm Facilitation. **Prototype:** Role of DT in your work, Prototyping Techniques, Testing Prototypes. **Experiments:** Introduction to Experimental Design, Types of Experiments, Business model canvass. Introduction and need for intellectual property rights.

1. Each student is expected to do a project and form a team of 3 members.
2. Every team shall have a guide who is the member of the faculty of the institution. Identification of faculty guide has to be completed within a week from the day of beginning of sixth semester.
3. The student has to identify and fabricate his/her idea into the project working model by conducting literature survey and finalize it.
4. A project report (Capstone project-II) to this effect has to be submitted by the team. Also, the complete design project report has to be submitted by team.
5. Three mid semester reviews and one end semester review of the progress of the project work have to be conducted by a team of faculty (minimum 3 and a maximum of 5) along with their faculty guide as a member of the faculty team.
6. During the end semester exam, one internal examiner and one external examiner, appointed by the COE will examine the Capstone project-II done by the students.

Summative assessment based on Continuous Examination

Activity	Month	Continuous Assessment [100 marks]
Project Evaluation	February	30
Project Evaluation	March	30
Project Evaluation + Presenting in International Conference/Journal	April	40

23EE924	Optimal Energy Controllers	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	

Course Objectives:

1	To provide an exposure to different type of optimal control problems such as time- optimal, fuel optimal, energy optimal control problems.
2	To impart knowledge and skills needed to design Linear Quadratic Regulator for Time invariant and Time-varying Linear system (Continuous time and Discrete-time systems).
3	To introduce concepts needed to design optimal controller in the presence of state constraints and time optimal controller.

Course Outcomes:

Upon completion of the course, students shall have ability to

C924.1	Explain different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems.	[AP]
C924.2	Design optimal controller using Dynamic Programming Approach and H-J-B equation.	[AP]
C924.3	Design Linear Quadratic Regulator for Time-invariant and Time-varying Linear system (Continuous time and Discrete-time systems)	[AP]
C924.4	Analyze optimization methods based on the behaviour of biological and swarm of insects	[AP]
C924.5	Analyze the concepts of Genetic programming.	[AN]

Course Contents:

Module 1: Calculus of Variations and Optimal Control **15**

Introduction – Performance Index- Constraints – Formal statement of optimal control system – Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variation problem Extrema of functions and functional with conditions – variational approach to optimal control system

Module 2: Linear Quadratic and Discrete Time Optimal Control System **15**

Linear Quadratic: Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case

Discrete Time: Variational calculus for Discrete time systems – Discrete time optimal control systems:- Fixedfinal state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system – Steady state regulator system.

Module 3: Intelligent Optimization Techniques **15**

Introduction to Intelligent Optimization, Genetic Algorithm: Types of reproduction operators, crossover & mutation, Simulated Annealing Algorithm, Particle Swarm

Optimization (PSO), Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.		
	Total Hours	**45**
Text Books:		
1	Donald E. Kirk, Optimal Control Theory – An Introduction, Dover Publications, Inc. Mineola, New York, 2012, 10th Edition.	
2	An Introduction to Optimization by E. K. P. Chong and S. H. Żak (4th edition), published by Wiley & Sons, Inc., New York 2013.	
3	William S Levine, “Control System Fundamentals,” The Control Handbook, CRC Press, Tayler and Francies Group, 2011, 2nd Edition.	
Reference Books:		
1	D. Subbaram Naidu, Optimal Control Systems, CRC Press, New York, 2003, 1st Edition	
2	Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012, 3rd Edition	
3	Yan Wang, Cheng-Lin Liu, Zhi-Cheng Ji, Quantitative Analysis and Optimal Control of Energy Efficiency in Discrete Manufacturing System, Springer, 2020, 1st Edition.	
Web References:		
1	https://in.mathworks.com/discovery/optimal-control.html#lqrlqg	
2	https://www.codeproject.com/Articles/863257/Simple-Software-for-Optimal-Control 3	
3	https://joss.theoj.org/papers/10.21105/joss.02809	

23EE925	Industrial Electrification using Renewable Energy System		3/0/0/3
Nature of Course	D (Theory Application)		
Pre-requisites	Nil		
Course Objectives:			
1	To provide the knowledge regarding the energy consumption pattern in agro based industries and quantification techniques		
2	To provide the knowledge regarding the identification of opportunities for renewable energy sources in industrial Electrification.		
CourseOutcomes: **Upon completion of the course, students shall have ability to**			
C925.1	Infer the need of industrial electrification and the energy conversion		[AP]
C925.2	Interpret the working of Solar energy system in industrial electrification		[AN]
C925.3	Analyze the technologies in Solar energy system in industrial electrification		[AN]
C925.4	Infer suitable applications for wind energy system in industrial electrification		[AP]
C925.5	Infer suitable applications for bio energy system in industrial electrification		[AP]
Course Contents:			

Module 1: Industrial Electrification **15**

Elucidation of unit operations in industry. Energy quantification techniques, system boundary, estimation of productivity, plant capacity utilization, energy density ratio and energy consumption pattern. Energy flow diagram and conservation opportunities identification.

Module 2: Solar Energy System in Industrial Electrification **15**

Solar energy for industrial application: Solar water heating, steam solar cooking system, industrial solar dryer and solar process heat, solar cooling system (refrigeration, air conditioning and solar architecture technology), solar furnace and solar greenhouse technology for high-tech cultivation. Solar photovoltaic technology for industrial power.

Module 3: Wind and Bio Energy System in Industrial Electrification **15**

Wind energy: Aero generator of new era and national and international state of art in wind power generation. Other renewable energy sources: Magneto hydro dynamics, fuel cells technology and micro-hydro energy technology.

Bio energy: Bio energy for industrial application: Quantification of industrial bio-waste, characterization, power generation through bio-methanation, gasification and dendro thermal power plant.

Total Hours	**45**

Text Books:	
1	Duffie JA and Beakman WA. 2006. Solar Energy Thermal Process. John Wiley and Sons, New York
2	Kumar S. 2011. Energy Conservation Building User Code Guide. Bureau of Energy Efficiency, New Delhi.
3	Rathore NS, Kurchania AK and Panwar NL. 2007. Non-Conventional Energy Sources Himanshu Publications, Udaipur, Rajasthan.
Reference Books:	
1	Sayigh AAM. 2012. Solar Energy Engineering. Academic Press, New York.
2	Singh P, Kurchania AK, Rathore NS and Mathur AN. 2005. Sustainable Development through Renewable Energy Sources. Yash Publications, Bikaner, Rajasthan
Web References:	
1	https://onlinecourses.swayam2.ac.in/nou23_es03/preview
2	https://www.coursera.org/learn/wind-energy
3	https://www.edx.org/course/solar-energy-delftx-et3034x-0

23EE926	Power Electronics for Renewable Energy Systems	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	
Course Objectives:		
1	To study different non-conventional energy systems and its applications.	
2	To enhance student's knowledge and interpret new technologies in energy storage system.	
3	To learn techno-economical storage methods of renewable energy systems.	

Course Outcomes:

Upon completion of the course, students shall have ability to

C926.1	Infer the need of power converters, different renewable energy system and the energy conversion systems	[AP]
C926.2	Analyze the working of power converters for Solar energy system	[AN]
C926.3	Analyze the working of power converters for Wind energy system	[AN]
C926.4	Apply suitable power for converters for wind and solar energy system	[AP]
C926.5	Interpret hybrid renewable energy system with case studies.	[AP]

Course Contents:

Module 1: Renewable Energy System **15**

Potential of renewable energies in India's future Power generation, Need of power electronics for power generation from renewable energies. Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy - Solar Photovoltaic (PV), Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area. Electric Machines for Renewable Energy conversion: Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) – Permanent Magnet Synchronous Generator (PMSG).

Module 2: Power Converters for Solar and Wind Energy System **15**

Solar PV Systems: Solar PV characteristics, Grid requirement for PV, Power electronic converters used for solar PV, Control techniques, MPPT, Grid connected and Islanding mode, Grid synchronization, PLLs, battery charging in PV systems. **Wind Energy Conversion*:*** Wind Turbine characteristics, Grid requirement for Wind, PMSM and DFIG for wind generators, Power electronic converters for PMSM and DFIG, Control techniques, MPPT, Grid connected and Islanding mode.

Module 3: Converters Hybrid Renewable Energy System		**15**
Need for Hybrid Systems- Range and type of hybrid systems- Power converters for hybrid renewable energy system - Case studies on power converters of Diesel-PV, Wind-PV, Micro hydel - PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).		
	Total Hours	**45**

Text Books:	
1	JohnT widwell and Tony Weir,"Renewable EnergyResources",4th Edition, Routledge, 2021.
2	Md. Rabuil Islam, "Emerging Power Converters for Renewable Energy and Electric Vehicles", CRC Press, 2020
3	Haitham Abu-Rub , "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications (Wiley - IEEE)", IEE Press, Wiley, 2014
Reference Books:	
1	Jorge Garcia, "Analysis and Design of Hybrid Energy Storage Systems", Energies, MDPI, 2020
2	Sukhatme,"SolarEnergy",TataMcGrawHillPublishingCompanyLtd.,NewDelhi, 2017.
3	G.Masters, "Renewable and Efficient Electric Power Systems", IEEE-WileyPublishers, 2013.
Web References:	
1	https://onlinecourses.swayam2.ac.in/nou23_es03/preview
2	https://www.coursera.org/learn/wind-energy
3	https://www.edx.org/course/solar-energy-delftx-et3034x-0

23EE927	Hybrid Smart Grid Technology	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	

Course Objectives:

1	To understand the basics and control algorithms of smart grid
2	To identify the issues and challenges of renewable energy integration in smart grid
3	To understand the operation and control of smart grid environment

Course Outcomes:
Upon completion of the course, students shall have ability to

C927.1	Understand the operation and control concepts of smart grid distribution.	[AN]
C927.2	Interpret the RES integration and planning strategies of smart grids.	[AP]
C927.3	Analyze the concept and developments of smart grid.	[AN]
C927.4	Acquire knowledge on smart grid components and process	[AN]
C927.5	Analyze the concept of micro grid architecture	[AN]

Course Contents:

Module 1: Operation and Control of Smart Grids **15**

Introduction to Smart grid, Operation and Control of Smart Grids Operational aspects of smart grid system, active and reactive power response, control concepts in smart distribution system, Demand side management of smart grid, Demand response analysis of smart grid- Data management in smart grid-Protection and control in substations-Smart grid operation and planning.

Module 2: Smart Grid Technologies **15**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers

Module 3: **Hybrid AC/DC Microgrid** **15**

Definition; Drivers; Benefits and integration standards; Types of microgrids- AC, DC and Hybrid microgrids. Architectures: AC-coupled, DC-coupled and AC-DC-coupled hybrid microgrid; Power management; interlinking converter control strategies.

	Total Hours	**45**
Text Books:		
1	Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, River Publishers; first edition, 2009.	
2	Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, first edition, 2012.	
3	J. Momoh, “Smart Grid: Fundamentals of Design and Analysis,” Wiley-IEEE Press, first edition, 2012.	
Reference Books:		
1	S. K. Salman, “Introduction to the Smart Grid: Concepts, Technologies and Evolution,” IET Energy Engineering Series, first edition, 2017.	
2	J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, “Smart Grid: Technology and Applications,” John Wiley and Sons, first edition, 2015.	
3	Radian Belu, “Energy Storage, Grid Integration, Energy Economics, and the Environment”, CRC Press, first edition, 2019.	
Web References:		
1	https://onlinecourses.nptel.ac.in/noc23_ee60	
2	https://www.udemy.com/course/smart-grid-a-complete-guide-on-smart-grid-technology	
3	https://www.udemy.com/course/smart-grid-technologies/	

23EE928	Fuel Cell and Biogas System		3/0/0/3
Nature of Course	D (Theory Application)		
Pre-requisites	Nil		
Course Objectives:			
1	To study different types of energy Fuel cell systems and their applications.		
2	To learn about the cost-effectiveness and eco-friendliness of Fuel Cells and Bio-Energy.		
3	To enhance student's knowledge and interpret new technologies in energy storage systems.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C928.1	Interpret the working of fuel cell and analyze different types of fuel cell performance.	[AP]	
C928.2	Infer the importance of fuel cell energy production methodologies and its applications.	[AP]	
C928.3	Analyze the fundamental knowledge about various Bio Energy generation technologies.	[AN]	
C928.4	Illustrate the operation and importance of different Bio Energy applications and storage systems.	[AP]	
C928.5	Analyze the cost effectiveness and eco-friendliness of Fuel Cells and Bio-Energy system	[AN]	
Course Contents:			

Module 1: Fundamentals of Fuel Cell Technology 15

Fuel Cell system: Principle - Working - Thermodynamics and kinetics of fuel cell process - Performance evaluation of fuel cell - comparison on battery Vs fuel cell. Types of fuel cells - Alkaline fuel cell (AFC), Phosphoric acid fuel cell (PAFC) , Solid oxide fuel cell (SOFC), Molten carbonate fuel cell (MCFC), Direct methanol fuel cell (DMFC), Proton exchange membrane fuel cell (PEMFC) - relative merits and demerits.

Module 2: Bio-Energy System 15

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical - conversion - anaerobic digestion - Biogas Systems: Technology of Bio-gas production, Biogas Plants, Digester types, Digester design, Chemical kinetics and mathematical modeling of bio-methanation process, Dung, Vegetable Waste and Night Soil and Municipal Waste based Bio -gas plants, Lighting, Electricity generation, Bio gas Bottling Plant Technology.

Module 3: Application of Fuel Cell and Bio-Energy System 15

Fuel cell usage for domestic power systems - Large scale power generation - Automobile, Space - Economic and environmental analysis on usage of Fuel cell - Future trends in fuel cells - Application of Biogas slurry in agriculture - Design of Biogas for cold climates - Biomass energy programme in India.

Total Hours	**45**

Text Books:	
1	John T widwell and Tony Weir, “Renewable Energy Resources”,4th Edition, Routledge, 2021.
2	B.H.Khan, “Non-Conventional Energy Resources”,3rd Edition, Tata McGraw Hill New Delhi, 2017.
3	Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.
Reference Books:	
1	Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009
2	Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Press.
3	A.J. Bard & L.R. Faulkner, Electrochemical Methods Fundamentals and Applications, John Wiley & Sons,2000.
Web References:	
1	https://archive.nptel.ac.in/courses/103/102/103102015/
2	https://archive.nptel.ac.in/courses/103/103/103103207/
3	https://archive.nptel.ac.in/courses/103/103/103103206/

23EE929	Hybrid Wind and Solar Electric System	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	

Course Objectives:

1	To study various Solar PV systems designs and their applications.
2	To learn about the different conversion mechanisms of wind and solar energy technologies
3	To enhance student's knowledge and interpret new technologies in Hybrid energy systems.

Course Outcomes:
Upon completion of the course, students shall have ability to

C929.1	Infer various SPV systems designs and their applications	[AP]
C929.2	Identify various solar energy technologies and their applications	[AP]
C929.3	Analyze the fundamental knowledge about wind energy generation technologies.	[AN]
C929.4	Illustrate the importance of grid integration techniques, and power quality issues.	[AN]
C929.5	Analyze the grid connected and stand alone renewable energy management system	[AN]

Course Contents:

Module 1: Solar PV System Design and Applications **15**

Basic photo voltaic system for power generation - Components of PV systems- Design of PV systems- Power conditioning and storage arrangement – Maximum power point tracking (MPPT) - Introduction to string inverters. Solar cell array system analysis and performance prediction - Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design-storage autonomy - voltage regulation - centralized and decentralized SPV systems - System installation - Operation and maintenance - PV market analysis and economics of SPV systems.

Module 2: Wind Energy Conversion Systems **15**

Types of wind generator system based on Electrical machines-Induction Generator and Permanent Magnet Synchronous Generator (PMSG), Grid Connected-Single and Double output system, Self-excited operation of Induction Generator and Variable Speed PMSG. Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations.

Module 3: Recent Advancements and Hybrid Energy System **15**

Need for Hybrid Systems – Grid related problems on absorption of wind – Grid interfacing arrangement – Operation, control and technical issues of wind generated electrical energy – Interconnected operation – Hybrid systems. Recent Advances in PV Applications: Building Integrated PV systems, Solar energy storage system and their economic aspects. - Grid Connection Issues. Case studies of Wind-PV systems.

Total Hours	**45**

Text Books:	
1	John T widwell and Tony Weir, “Renewable Energy Resources”,4th Edition, Routledge, 2021.
2	B.H.Khan, “Non-Conventional Energy Resources”,3rd Edition, Tata McGraw Hill New Delhi, 2017.
3	Chetan Singh Solanki, Solar Photo voltatics – Fundamentals, Technologies and Applications, PHI Learning Private limited, 2011.
Reference Books:	
1	John A.Duffie, William A.Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 2013.
2	Rai. G.D, “Non-conventional energy sources”, Khanna publishers, 6th Edition, 2017
3	Kaldellis. J.K, Stand–alone and Hybrid Wind Energy Systems, CRC Press, 2010
Web References:	
1	https://archive.nptel.ac.in/courses/115/103/115103123/
2	https://archive.nptel.ac.in/courses/103/103/103103206/
3	https://archive.nptel.ac.in/courses/108/108/108108078/

23EE930	Rural Electrification: Technologies and Economics	3/0/0/3
Nature of Course	Theory	
Course Pre-requisites	Nil	

Course Objectives:

1.	To understand the importance and challenges of rural electrification.
2.	To study the technologies and systems used for rural power generation, including renewable energy sources.
3.	To explore the planning, implementation, and sustainability of rural electrification projects.

Course Outcomes:
Upon completion of the course, students shall have ability to

C930.1	Explain the key components of the power grid, including DG-grid interconnection, mini/microgrid economics, and regulatory challenges.	[AP]
C930.2	Describe the basic concepts of various power generation technologies, such as gas turbines, solar thermal, USPV, wind, and biomass.	[AP]
C930.3	**I**nterpret the evaluation of DG costs, covering historical, current, and future perspectives, along with basic cost analysis and demand scheduling.	[AN]
C930.4	Discuss the role of rural electrification in improving economic development, healthcare, education, and overall quality of life in rural areas.	[AN]
C930.5	Apply cost-benefit calculations, economic/financial analysis, and load curve analysis to stand-alone electrification projects.	[AP]

Course Contents:

Module1: Generation Technologies **15**

Decentralized generation technologies; Costs and choice of technology, Demand and benefits forecasting and program development. The power grid; DG-Grid interconnection issues, Mini and Micro Grids – Economics – Environmental Factors –Transmission and Regulations.

Module 2 : Gas Turbine and Biomass Based Generation **15**

Basic gas turbine generator concepts; Utility system turbine generators; Mini and micro gas turbine generators; Solar thermal power generation, utility scale photovoltaic (USPV) generation; Wind powered generation. Biomass based generation; DG Evaluation: Cost from past, present, and future, basic DG cost analysis, cost Evaluation and schedule of demand.

Module 3 :Economics and Cost Analysis **15**

Principles of cost-benefit calculations, Economic and financial analysis of stand-alone electrification projects, Decentralized versus central station generation, Traditional power systems, Load curves and load curve analysis**.** Electricity Reforms,Tariff-National Tariff Policy, Tariff Applications.

Total Hours	**45**

Text Books:	
1	Rural Electrification: A Guide to Developing and Implementing Rural Electrification Programs by G. G. Chase, published by Greenleaf Publishing ,2021.
2	Rural Electrification through Decentralized Off-Grid Systems in Developing Countries" by USAID, published by Routledge in 2020.
3	Energy Systems and Sustainability: Power for a Sustainable Future" by Bob Everett, Roger M. O'Connell, and Colin R. O'Connell, published by Oxford University Press in 2021.
Reference Books:	
1	Rural Energy and Development: Improving Energy Access for the Poor by Ravi Prakash Singh, published by Routledge in 2023.
2	The Renewable Energy Home Handbook: A Guide to Rural Energy Independence, Off-Grid and Sustainable Living by Ariane M. Davis, published by New Society Publishers in 2022.
Web References:	
1	https://www.nrel.gov/docs/fy16osti/66597.pdf?
2	https://etn.global/wp-content/uploads/2018/02/MGT-Technology-Summary-final-for-the-website.pdf?
3	https://www.researchgate.net/publication/335227775_Sustainable_microgrids_Economic_environmental_and_social_costs_and_benefits_of_microgrid_deployment

23EE932	Vehicle Design and Fabrication		3/0/0/3
Nature of Course	C (Theory Concept)		
Course Pre-requisites	Electrical Machines – I		
Course Objectives:			
1	To know the concepts of Electric Vehicle mechanics and Battery modeling.		
2	To impart the knowledge of Testing Electric Motor and Controllers.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C932.1	Illustrate the Electric Vehicle Standardization.		[AP]
C932.2	Examine the Performance of Electric Vehicle Mechanics		[AN]
C932.3	Interpret the Battery Modelling, Types and Charging for Electric Vehicle.		[AP]
C932.4	Analyze the Performance of Electric motors and controllers by various Testing Methods.		[AN]
C932.5	Infer the different testing procedure of Electric Vehicle.		[AP]

Course Contents:

Module 1: EV Standardization 10

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.

Module 2: Electric Vehicle Mechanics and Battery Modeling, Types and Charging 20

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings-Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics. Batteries in Electric and Hybrid Vehicles - Battery Basics - Battery Parameters. Types- Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (NiMH) Battery - Li-Ion Battery - Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride, Research and Development for Advanced Batteries. Battery Modelling, Electric Circuit Models. Battery Pack Management, Battery Charging.

Module 3: Testing of Electric Motors And Controllers For Electric And Hybrid Electric Vehicles 15

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

Total Hours 45

Text Books:	
1.	Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition
2.	Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition
3	Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
Reference Books:	
1	Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
2	Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition
Web References:	
1	https://trimis.ec.europa.eu/roadmaps/vehicle-design-and-manufacturing-vdm
2	https://www.jimcoracing.com/pages/vehicle-design-fabrication?srsltid=AfmBOorJ9iQTb_4YdElqLK4uSz9yjfBD7HQ1AzZs8REcTlQhnVBPBD06
3	https://autoprotoway.com/automotive-design-process/

23EE933	Autonomous Electric Vehicle		3/0/0/3
Nature of Course	C (Theory Concept)		
Course Pre-requisites	Nil		
Course Objectives:			
1	To know the concepts of Autonomous Vehicles and Electric Mobility.		
2	To impart the knowledge of Autonomous Vehicle Sensors and Perception Systems.		
3	To apply driving algorithms and control systems for autonomous vehicles.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C933.1	Illustrate the autonomous vehicle technology and express the environmental and economic benefits of electric mobility.		[AP]
C933.2	Examine the autonomous vehicle sensor types and choose the applications of sensors..		[AN]
C933.3	Interpret the perception algorithm for object detection and tracking of vehicle.		[AP]
C933.4	Analyze the Performance of Autonomous vehicle with different Driving Algorithms.		[AN]
C933.5	Investigate the operation of various of autonomous vehicle with Machine Learning and Artificial Intelligence.		[AN]

Course Contents:

Module 1: Introduction to Autonomous Vehicles and Electric Mobility 15

Overview of autonomous vehicle technology; Evolution and current state of autonomous driving; Introduction to electric vehicles (EVs) and their significance in autonomous driving; Comparison between conventional vehicles and electric vehicles; Environmental and economic benefits of electric mobility

Module 2: Autonomous Vehicle Sensors and Perception Systems 15

Sensors used in autonomous vehicles (LiDAR, radar, cameras, ultrasonic sensors) - Principles of operation and applications of each sensor type - Sensor fusion techniques for combining data from multiple sensors - Perception algorithms for object detection, classification, and tracking in electric autonomous vehicles - Challenges and solutions in sensor integration for electric vehicles.

Module 3: Autonomous Driving Algorithms and Control Systems 15

Overview of autonomous driving algorithms (path planning, decision-making, localization) - Control systems for autonomous electric vehicles - adaptive cruise control - lane-keeping and automated parking - Integration of machine learning and artificial intelligence in autonomous electric vehicle control - Safety considerations and fail-safe mechanisms in autonomous electric vehicle systems.

Total Hours	**45**

Text Books:	
1.	Husain, I., Electric and hybrid vehicles: design fundamentals. CRC press (2021).
2.	Sciarretta, A., & Vahidi, A., Energy-efficient driving of road vehicles. Cham, Switzerland: Springer International Publishing (2020).
3.	Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A., Autonomous vehicle technology: A guide for policymakers. Rand Corporation (2014).
Reference Books:	
1	Qu, Z., Cooperative control of dynamical systems: applications to autonomous vehicles. Springer Science & Business Media (2009).
2	Gillespie, T. (Ed.)., Fundamentals of vehicle dynamics. SAE international (2021).
Web References:	
1	https://ocw.tudelft.nl/course-readings/4-1-2-lecture-notes-autonomous-electric-vehicles/
2	https://www.cliffsnotes.com/study-notes/1373539
3	https://skill-lync.com/blogs/what-are-autonomous-electric-vehicles

23EE934	Vehicle to Grid Integration		3/0/0/3
Nature of Course	D (Theory Application)		
Pre-requisites	Nil		
Course Objectives:			
1	Understanding the fundamentals of V2G technology in modern energy systems.		
2	Focusing on Electric Vehicle integration into the Power grid.		
3	To understand the grid stability on EV integration.		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C934.1	Infer the benefits and V2G in electricity market.		[AP]
C934.2	Analyze the smart grid infrastructure, challenges and opportunities.		[AN]
C934.3	Determine the communication architectures and its compatibility.		[AN]
C934.4	Analyze the bi-directional charging mechanism and integration controllers.		[AN]
C934.5	Interpret the control strategies and integration technologies		[AN]
Course Contents:			

Module 1: Introduction and Challenges of V2G **15**

History and Development of (Vehicle-to-Grid) V2G. Suitability of V2G in electricity market. Economic potential benefits of V2G and grid efficiency. Evolution of Electric Vehicle integration to grid. Infrastructure and concepts of Smart Grid Challenges and opportunities of integrating EVs into the grid.

Module 2:V2G System Components and Technologies **15**

V2G communication protocols and standards. V2G communication architectures, interoperability and compatibility considerations. V2G system architecture and components, Power electronics and bidirectional charging mechanism; Vehicle-grid integration controllers (VGICs) and software platforms.

Module 3: V2G, V2V Control strategies and Grid Integration **15**

Grid services by V2G systems – frequency regulation, peak hour handling and saving, ancillary services. Control algorithms and optimization of technologies. Cybersecurity considerations in V2G systems. V2G's role in urban energy management and Smart cities. Integration with other smart grid technologies using IoT and AI. Case studies on realtime applications.

Total Hours	**45**

Text Books	
1	Junwei Lu and Jahangir Hossain, Vehicle-to-Grid: Linking electric vehicles to the smart grid (Energy Engineering), IET (2015).
2	Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
3	ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor 1; Jesus Fraile-Ardanuy, IET 2020, 1st Edition.
Reference Books:	
1	Kevin A. Wilson, The Electric Vehicle Revolution: The Past, Present, and Future of EVs, Motorbooks (2023).
2	Sekyung Han and Moses Amoasi Acquah, Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) Technologies, MDPI (2021).
3	Lou Shrinkle, Modular Battery Swap: How We Can Get Everybody Driving an Electric Car Paperback, Waterside Productions (2022).
Web References:	
1	https://archive.nptel.ac.in/courses/108/102/108102121/
2	https://content.e-bookshelf.de/media/reading/L-12068737-edcb0d794c.pdf

23EE935	Renewable Energy Integration with EV Charging		3/0/0/3
Nature of Course	D (Theory Application)		
Pre-requisites	Nil		
Course Objectives:			
1	To impart knowledge on EV Charging systems.		
2	To familiarize the concept of Battery Management and Battery parameters.		
3	To provide knowledge on renewable energy powered EV charging systems		
Course Outcomes: **Upon completion of the course, students shall have ability to**			
C935.1	Interpret the basic concepts of EV charging methods.	[AP]	
C935.2	Illustrate the National and International standards on charging technology.	[AP]	
C935.3	Analyze the Battery management and charging technologies.	[AN]	
C935.4	Analyze the charging topology of hybrid renewable energy system.	[AN]	
C935.5	Prioritize the concepts with case studies.	[AN]	
Course Contents:			

Module 1:Introduction to EV Charging methods and Its standards **15**

Basic concepts of different types of EV chargers. Electric Vehicle charging station design, installations - different modes of charging infrastructure. Battery chargers – slow, rapid and DC fast chargers. Wireless charging technologies. Conductive and Inductive charging methods. International standards and regulations, Indian standard IS 17017-part-1,2,23-25

Module 2:Battery Management and Charging Technology **15**

Function and Significance of Battery Management Systems. - Characteristic Parameters: State of Charge (SoC), Depth of Discharge (DoD) and State of Health (SoH) – Estimation methods of SoC and SoH - Ampere-hour integral. Topology of the BMS - Introduction to IoT based Battery Monitoring System.

Module 3:Electrical Vehicle Charging using Renewable Energy Systems **15**

Introduction to EV charging systems for residential and commercial buildings - solar PV system – wind energy conversion systems - charging infrastructure with hybrid solar PV, wind and battery. - Wireless charging- Smart Charging and V2G, Study the vehicle wireless charger using software simulation. Power quality of renewable energy integration with charging stations. Case study - Electrical Vehicle Charging and batteries.

Total Hours	**45**

Text Books	
1	Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, “The Role of Energy Storage with Renewable Electricity Generation”, National Renewable Energy Laboratory (NREL) – A National Laboratory of the U.S. Department of Energy – Technical Report NREL/ TP6A2-47187, January 2010.
2	Viral, R., Tomar, A., Asija, D., Rao, U.M., & Sarwar, A. (Eds.). (2022). Smart Grids for Renewable Energy Systems, Electric Vehicles and Energy Storage Systems (1st ed.). CRC Press.
3	Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration”, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021.
Reference Books:	
1	F. A. Silva and M. P. Kazmierkowski, "Energy Storage Systems for Electric Vehicles [Book News]," in IEEE Industrial Electronics Magazine, vol. 15, no. 4, pp. 93-94, Dec. 2021.
2	Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban,Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 2020.
3	Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016.
Web References:	
1	https://archive.nptel.ac.in/courses/108/106/108106182/
2	https://ieeexplore.ieee.org/document/10245693
3	https://ieeexplore.ieee.org/document/10110228

23EE936	Plug-in Hybrid Electric Vehicles (PHEV)	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	
Course Objectives:		
1	To understand the concepts of Plug-in Electric Vehicles and its importance.	
2	To analyze the design and optimizing performance of PHEV.	
3	To impart the knowledge of Electric drive trains, and charging infrastructure.	
Course Outcomes: Upon completion of the course, students shall have ability to		
C936.1	Analyze basic concepts of Electric Hybrid Vehicles.	[AN]
C936.2	Analyze the charging protocols in Electric Vehicles.	[AN]
C936.3	Illustrate the energy management in EVs.	[AP]
C936.4	Analyze the performance and dynamics in PHEV.	[AN]
C936.5	Apply the renewable energy technology in PHEVs.	[AP]

CourseContents:

Module 1: Introduction to Plug-in Electric Hybrid Vehicles **15**

Evolution of Hybrid and Electric Vehicles. Types of Electric Hybrid Vehicles (EHVs) and Plug-in Hybrid Electric Vehicles (PEVs). Electric Power Train components-Motors, Inverters, Converters. Charging Infrastructure and protocols. On-board chargers and power distribution, Vehicle control systems, Advances and challenges of PHEVs

Module 2: Architecture and Development of PHEVs **15**

Design consideration of PHEV Technologies, Vehicle dynamics and control, Energy management in Hybrid systems, optimization of fuel efficiency and emissions. Cooling system for batteries and electric motors. Impacts of temperature on performance. Modelling of vehicle dynamics and power trains. Smart Charging Infra-structure, Integration of PEVs to Electric Grid.

Module 3: Future Trends and Applications of PHEVs **15**

Conversions of ICE vehicles to PHEV. Advances in Battery Technology and Energy Storage. Integration with Renewable Energy Storage. Cyber Security Challenges, Data Attacks and Intrusions in PEV Communications. Testing protocols and Standards for PHEVs. Case studies on popular models of PHEVs.

Total Hours	**45**

Text Books:	
1	"Plug-in Hybrid Electric Vehicle (PHEV): Fundamentals, Technology, and Design", Ali Emadi, Mehrdad Ehsani, John M. Miller, CRC Press, 2024, ISBN-13: 978-1138196631.
2	"Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach" (2nd Edition), Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, Wiley Publication, 2021, ISBN: 978-1118403105.
3	"Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives"**by** Chris Mi, M. Abul Masrur, and David Wenzhong Gao, Wiley Publication, 2018, ISBN-13: 978-1118970560.
Reference Books:	
1	"Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles" edited by Sheldon S. Williamson. Pringer Publication, 2019.
2	"Thermal Management of Electric Vehicle Battery Systems" by Ibrahim Dincer and Halil S. Hamut.Wiley Publication, 2021.
3	"The Electric Vehicle Conversion Handbook"by Mark Warner, HP Books publication, 2011.

WebReferences:	
1	https://archive.nptel.ac.in/courses/108/103/108103009/
2	https://e-amrit.niti.gov.in/types-of-electric-vehicles
3	https://afdc.energy.gov/vehicles/how-do-plug-in-hybrid-electric-cars-work

23EE937	Electric Power Train	3/0/0/3
Nature of Course	D (Theory Application)	
Pre-requisites	Nil	
Course Objectives:		
1	To acquire knowledge on electric drive train and motor traction	
2	To provide knowledge on various power converters and regenerative braking.	
3	To impart knowledge on drive efficiency of various motors and its steady state analysis.	
Course Outcomes: **Upon completion of the course, students shall have ability to**		
C937.1	Illustrate electric drive trains architecture.	[AP]
C937.2	Illustrate the electric power converters technology and its switching modes.	[AP]
C937.3	Interpret various controllers used in AC, DC drives and drive train characteristics.	[AP]
C937.4	Acquire knowledge on speed control of various drives.	[AN]
C937.5	Explain the steady state analysis in PMSM.	[AN]

Course Contents:

Module 1: Introduction to Electric Vehicles **15**

Introduction to Electric Vehicles: Electric Drive-train, Tractive effort in normal driving, Energy consumption concept of Electric Drive Trains and its Architecture-Electric Propulsion unit. Si, SiC, GaN devices based power converters - Distribution of electric power in DCDC, AC-DC, DC-AC converters used in EV drives. Various switched mode DC/DC converters for EV drive. Construction and operation of speed control using acceleration

Module 2: Power Converters in Drive **15**

Role of power converters in Drives. DC-DC Converters, buck-boost, bidirectional DC-DC Converters, effect of parasitic elements, performance analysis, controllers design for DC-DC converters, Single Phase and Three Phase Inverter, VSI and CSI topologies, PWM Techniques- Space Vector PWM Hysteresis Control, Comparison of PWM techniques and closed loop control of drives. Transmission and Drive Train Characteristics-Regenerative Braking Characteristics.

Module 3: Efficient Motors for power Train **15**

Drive efficiency: impact of altitude, ambient temperature, gradient and motors. Different type of motors used and its comparative study. BLDC drives-various speed control strategies – closed loop control – Autonomous control. Control strategies of regenerative braking in drives. Speed control of AC drives. Permanent magnet

synchronous machine for EV power train, Non-Salient & Salient Drives, Generic Model, Steady State Analysis, Field Oriented Control. Switched Reluctance Machine for EV power train. Operating principles, Analysis of SRM drives and speed control.		
	Total Hours	**45**
Text Books:		
1	Ali Emadi's "Handbook of Automotive Power Electronics and Drives", Taylor & Francis, First Edition, USA, 2018.	
2	David Crolla, Behrooz Mashadi, “Vehicle Power train Systems”, January 2012, Wiley	
3	Bimal K Bose; Modern Power Electronics and AC Drives " Pearson Education, second Edition, 2003.	
Reference Books:		
1	Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications, 2017.	
2	R Krishnan , Electric motor drives: Modelling, Analysis, and Control, 2013	
Web References:		
1	https://onlinecourses.nptel.ac.in/noc24_ee30/preview	
2	https://evreporter.com/ev-powertrain-components/	