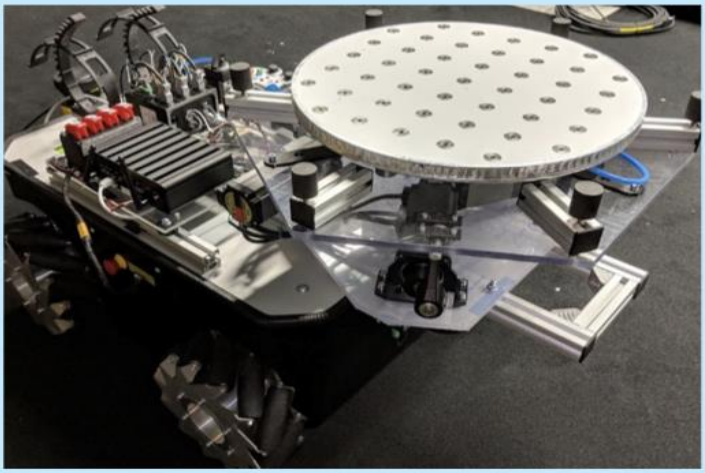
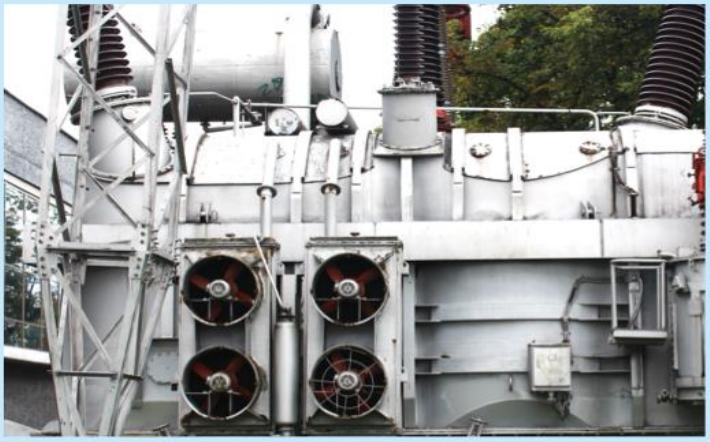
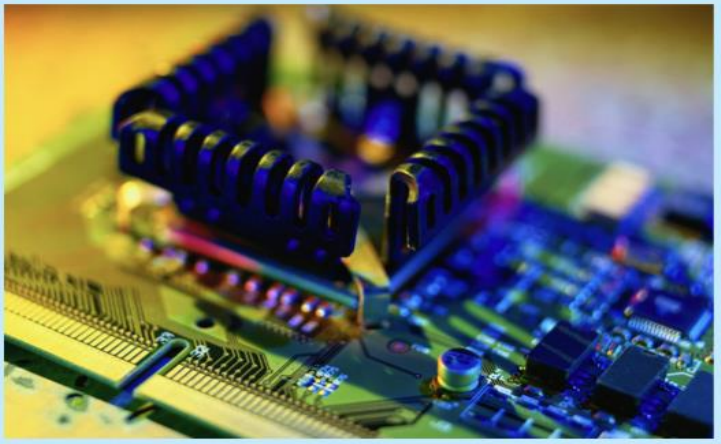
DEPARTMENT OF ELECTRICAL ENGINEERING

SCHOOL OF ENGINEERING AND TECHNOLOGY

Courses of Study 2023-2024







B.TECH

ELECTRICAL ENGINEERING

with

Honors/Minor Specilization

in

Energy Systems Engineering

Electric Vehicle Technology

Courses of Study

(Approved for Batches 2023 and Onwards)

B.Tech Electrical Engineering
with
Minor Specialization/Honors

Approved in 5th Board of Studies (BoS 2023) held on 24 November, 2023

Department of Electrical Engineering
Islamic University of Science and Technology, Kashmir

Preface

It is with great enthusiasm that we introduce the carefully constructed Courses of Study booklet for the **Bachelor of Technology (B.Tech.) program in Electrical Engineering.** The curriculum in consideration demonstrates a progressive approach by adhering to the principles set forth in the National Education Policy 2020 (NEP2020) and the Model Curriculum 2023 of the All-India Council for Technical Education (AICTE). This represents a notable progression in the field of engineering education. Recognizing the profound impact of education, the Department of Electrical Engineering, IUST embarked on a thorough process of self-assessment. A collective vision for the future of electrical engineering technology was developed through extensive departmental meetings, valuable feedback from alumni, insights from student representatives, collaborative discussions with industry experts, and diverse perspectives from faculty members across multiple disciplines.

As a catalyst for change, the department head facilitated the formation of specialized groups among faculty members, each dedicated to specific domains within the field of electrical engineering. These domains encompass power systems, power electronics converters and their control, control theory and optimization, as well as renewable energy systems. The utilization of a collaborative method facilitated the emergence of innovative deliberations, leading to the formulation of novel courses within syllabi and the enhancement of course outlines. The department effectively included skill development, entrepreneurship, and data analytics into the fundamental aspects of electrical engineering education to adapt to the ever-changing trends in the industrial world.

A notable characteristic of this curriculum is the incorporation of the **Minor Specialization/Honors in Energy Systems and Electric Vehicle Technologies.** These specializations would provide students with the opportunity to customize their education, fostering interdisciplinary learning and the development of a comprehensive range of skills. The objective is to provide students with the necessary tools and knowledge to pursue their interests within the wider domain of electrical engineering, thereby augmenting their ability to compete in a constantly changing employment landscape.

The department holds a strong conviction that the adoption of technology is vital in equipping students for the era of digitalization. This rigorous procedure highlights our dedication to delivering an education that is pertinent, groundbreaking, and adaptable to the constantly evolving demands of the engineering field.

As we introduce this all-encompassing curriculum, we want it to function as a fundamental basis for the educational and vocational trajectory of our students, equipping them with the necessary skills and knowledge to achieve substantial advancements in the realm of electrical engineering. Our sincerest wishes are extended to all students commencing this educational endeavor. Wishing them a fruitful journey in their quest for knowledge, and hope that they emerge from this program as engineers who are empowered, innovative, and socially conscious.

Department of Electrical Engineering
Islamic University of Science and Technology

About the Department

Vision

The Department of Electrical Engineering, Islamic University of Science and Technology aspires to be a destination for high quality scientific and technological education in electrical sciences and technology, a research and innovation hub with special emphasis on sustainable development in the service of humanity, and a centre where education and research are in full compliance with international standards of quality assurance.

Mission

M1:. Quality education and research: Engage in high quality education and research with an eye on international standards.

M2:. Skills and competence for serving industrial needs: Produce skilled and competent manpower trained in electrical engineering and technology for current and emerging needs of the industry.

M3:. Holistic development: Provide an interdisciplinary learning environment that is student-centric, value-based and promotes holistic student development.

M4:. Societal relevance and sustainable development: Drive research and innovation in electrical sciences and technology to serve societal needs and with emphasis on sustainable development.

The Department of Electrical Engineering at IUST was established in 2012. It currently offers one undergraduate program awarding a Bachelor of Technology (B. Tech) degree in electrical engineering. Ten batches of electrical engineers have graduated since the inception of the department. In 2018, a Ph.D. program was started. The department has state-of-the-art infrastructural facilities to provide its students education and training aligned to its mission. The faculty is well qualified and dedicated, having received training and education at reputed institutions within the country.

Students entering the undergraduate program are provided basic training in analysis and design of electrical energy systems, including, broadly, systems employed for generation, transmission, control and conversion of electrical energy. It is also ensured that students gain sufficient general knowledge in related disciplines of electrical and computer sciences, so that they remain capable of obtaining a specialized degree in their area of interest.

The Department has a well-equipped facility for giving students hands-on training and exposure in all fundamental technologies that are a part of a standard graduate level electrical engineering course, like electromechanical energy conversion, power systems, control systems, computation and simulation etc. All labs are Wi-Fi enabled and have a 24x7 uninterrupted power supply. The

department also has a well-equipped departmental library with a good collection of basic and advanced books in electrical engineering and allied subjects.

About the 5th Board of Studies Meeting

The Department of Electrical Engineering (DoEE), IUST, convened its 5th Board of Studies (BoS) meeting on 24th November 2023. The BoS agenda included revision of curriculum for B. Tech Electrical Engineering, introduction of Minor/Honors, postgraduate programmes and Ph.D course work. The meeting was attended by the following:

Board Members Approved by the Competent Authority

1.	Dr. Rumaan Bashir	I/C Dean, SoE&T, IUST	Chairperson
2.	Mr. Rayes Ahmad Lone	I/C Head, EE, IUST	Member/Convener
3.	Prof. Shameem Ahmad Lone	Professor, EE, NIT Srinagar	Member (AC Nominee)
4.	Prof. Mohmmad Rizwan	Professor, EE, DTU, New Delhi	Member (AC Nominee)
5.	Syed Mohammad Ashraf	Manager (Electrical), NHPC Ltd	Member (Industrial Expert)
6.	Dr. Shahkar Ahmad Nahvi	Assistant Professor, EE, IUST	Member
7.	Mr. Zahoor Ahmad Ganie	Assistant Professor, EE, IUST	Member
8.	Mrs. Baziga Youssuf	Assistant Professor, EE, IUST	Co-Opted Member
9.	Dr. Mubashar Yaqoob Zargar	Assistant Professor, EE, IUST	Co-Opted Member
10.	Dr. Ahmed Sharique Anees	Assistant Professor, EE, IUST	Co-Opted Member
11.	Dr. Salman Ahmad	Assistant Professor, EE, IUST	Co-Opted Member
12.	Dr. Viqar Yousuf	Assistant Professor, EE, IUST	Co-Opted Member
13.	Dr. Zahid Farooq	Assistant Professor, EE, IUST	Co-Opted Member
14.	Dr. Danish Rafiq	NPDF Fellow, SERB	Co-Opted Member
15.	Dr. Peer Bilal Ahmad	I/C HOD, Mathematics	Co-Opted Member
16.	Dr. Mohd Junaid Mir	Assistant Professor, ME, IUST	Co-Opted Member
17.	Dr. Imran ul Amin	Assistant Professor, Management, IUST	Co-Opted Member
18.	Dr. Javid Ahmad Khan	Assistant Professor, Economics, IUST	Co-Opted Member
19.	Dr. Shabir Ahmad Kumar	Assistant Professor, Physics, IUST	Co-Opted Member
20.	Mrs. Shaiqa Nasreen	Assistant Professor, ECE, IUST	Co-Opted Member

Department of Electrical Engineering
Islamic University of Science and Technology

Contents

Definition of Credit

1 Lecture Hour (L) Per Week	1 Credit
1 Tutorial Hour (T) Per Week	1 Credit
1 Practical Hour (T) Per Week	0.5 Credit
1 Social Hour (S) Per Week	1 Credit

Range of Credits

A range of credits from 173 and above shall be required for a student to be eligible to get an undergraduate degree in Electrical Engineering. A student will be eligible to get an undergraduate degree with Honours or an additional Minor Degree, if he/she completes an additional 18 or more credits during the degree.

Course Code and Definition

All courses (except Open Electives) are denoted by a seven-digit alphanumeric code (XXXXXXX), three alphabets followed by three numerals, followed by one alphabet. The first three alphabets designate the department offering the course, e.g., ELE for Electrical Engineering. The first numeral following the three alphabets indicate the level of the course, 1 to 4 for undergraduate 1st to 4th year, 5 to 6 for postgraduate courses. Open electives have a zero in place of the above level numeral and six digits only. The next two numerals are the unique identification numbers for the course. Courses running in odd semesters are labelled from 01 to 49 and courses running in even semesters are labelled from 50 to 99. The last alphabet indicates the nature of the course. It is one amongst six choices, C (Core Course), E (Discipline Centric Elective), G (Generic Elective), B (Bridge Course), A (Audit Course) and S (Specialization Course/Minor Degree). Since, open electives are identified by a zero in place of the level numeral (at fourth digit), therefore the last digit does not have significance in their course code, and hence will not be used for the definition of the same.

Distribution of Credits

S. No.	Category	Credits Breakup
1.	Humanities and Social Science including Management Courses	09
2.	Basic Science Courses	19
3.	Engineering Science Courses	31
4.	Professional Core Courses	75
5.	Discipline Centric Electives	12
6.	Generic Electives (min)	09 (min)
7.	Open Electives (min)	08 (min)
8.	Project	10
9.	Specialization	18 (Optional)
10.	Seminar/ Internship	Audit
	Total	**173 (min)**

Course Structure, Course Outline and Detailed Course Contents from 1st to 8th Semesters of B.Tech (EE)

Part A

COURSE STRUCTURE (SEMESTERS 1st to 8th)

Program Outcomes (POs) (B. Tech Electrical Engineering)

PO1 Ability to apply the knowledge of mathematics, science and engineering principles for modeling, analyzing and solving electrical engineering problems.

PO2 Ability to identify, formulate and analyze real-life electrical engineering problems.

PO3 Ability to design and develop solutions for real-life electrical engineering problems.

PO4 Ability to design and develop sophisticated equipment and experimental systems for carrying out detailed investigation to multifaceted electrical engineering problems.

PO5 Ability to develop and utilize modern tools for modeling, analyzing, and solving electrical engineering problems.

PO6 Dedication to work as an electrical engineer who can identify solutions to various local and global problems faced by the society.

PO7 Ability to design and develop modern systems for the upkeep of pollution free environment.

PO8 Willingness and ability to upkeep professional ethics and social values.

PO9 Willingness and ability to think independently, take initiative and lead a team of engineers or researchers.

PO10 Ability to express ideas clearly and communicate orally as well as in writing with others.

PO11 Willingness and ability to maintain lifelong learning process by way of participating in various professional activities.

PO12 Willingness and ability to take up administrative responsibilities involving both project and financial management confidently.

Complete List of Core Courses

S. No	Course Code	Course Title	Hours Per Week				Credits	Semester	Category
			L	T	P	S			
1	MTH115C	Calculus for Engineers	3	1	0	0	4	I	Professional Core
2	PHY102C	Engineering Physics	3	0	2	0	4	I	Professional Core
3	CHM102C	Engineering Chemistry	3	0	2	0	4	I	Professional Core
4	CIV101A	Introduction to Environmental Science and Engineering	2	0	0	1	0	I	Professional Core
5	MEC102C	Engineering Visualisation	1	0	4	0	3	I	Professional Core
6	ENG107F	Technical Communication	2	0	2	0	3	I	Professional Core
7	MEC104A	Engineering Perspectives	1	0	0	1	0	I	Professional Core
8	MTH155C	Linear Algebra and Differential Equations	3	1	0	0	4	II	Professional Core
9	CIV152C	Engineering Mechanics	3	0	0	0	3	II	Professional Core
10	ELE150C	Basic Electrical Engineering	3	0	2	0	4	II	Professional Core
11	CSE160F	Programming for Problem Solving	3	0	2	0	4	II	Professional Core
12	ECE151C	Basic Electronic Devices	3	0	0	0	3	II	Professional Core
13	MEC152C	Product Realisation through Manufacturing	0	0	2	1	2	II	Professional Core
14	SS01A	Ethics and Social Responsibilities	1	0	0	0	0	II	Professional Core

S. No	Course Code	Course Title	Hours Per Week			Credits	Semester	Category
			L	T	P			
1	ELE202C	Network Analysis	3	1	0	4	III	Professional Core
2	ELE205C	Signals and Systems	3	0	0	3	III	Professional Core

3	PHY202C	Engineering Electromagnetics	3	0	0	3	III	Engineering Science
4	ECE213C	Analog Electronics	3	0	0	3	III	Professional Core
5	PHY201C	Electrical Engineering Materials	3	0	0	3	III	Professional Core
6	ELE208C	Introduction to Matrix Programming	0	0	2	1	III	Professional Core
7	MTH204C	Advanced Engineering Mathematics	3	0	0	3	III	Basic Science
8	ECE214C	Analog Electronics Lab	0	0	2	1	III	Professional Core
9	ELE256C	Electrical Machines-I	3	1	0	4	IV	Professional Core
10	ELE257C	Data Science with Statistical Foundations	2	0	2	3	IV	Engineering Sciences
11	ELE258C	Control System Principles	3	1	0	4	IV	Professional Core
12	ELE259C	Electrical Measurements	3	1	0	4	IV	Professional Core
13	ECE263C	Digital Electronics and Logic Design	3	0	0	3	IV	Professional Core
14	ELE260C	Electrical Machines-I Lab	0	0	2	1	IV	Professional Core
15	ELE261C	Electrical Measurements Lab	0	0	2	1	IV	Professional Core
16	ELE262C	Control System Principles Lab	0	0	2	1	IV	Professional Core
17	ECE264C	Digital Electronics and Logic Design Lab	0	0	2	1	IV	Professional Core
18	ELE302C	Electrical Machines-II	3	1	0	4	V	Professional Core
19	ELE304C	Elements of Power Systems	3	1	0	4	V	Professional Core
20	ELE308C	Numerical Methods Using Scientific Computing	2	0	2	3	V	Engineering Sciences
21	ECE318C	Microprocessors and Microcontrollers	3	0	0	3	V	Professional Core
22	ECO301C	Fundamentals of Economics	3	0	0	3	V	Humanities & Social Sciences

23	ELE310C	Electrical Machines-II Lab	0	0	2	1	V	Professional Core
24	ELE311C	Elements of Power Systems Lab	0	0	2	1	V	Professional Core
25	ECE319C	Microprocessors and Microcontrollers Lab	0	0	2	1	V	Professional Core
26	ELE352C	Power Electronics	3	1	0	4	VI	Professional Core
27	ECE364C	Communication Systems	3	0	0	3	VI	Professional Core
28	ELE357C	Power System Analysis	3	1	0	4	VI	Professional Core
29	ELE358C	Control System Design	2	0	2	3	VI	Professional Core
30	ELE362C	Tinkering Lab	0	0	2	1	VI	Professional Core
31	ELE359C	Power Electronics Lab	0	0	2	1	VI	Professional Core
32	ELE360C	Power System Analysis Lab	0	0	2	1	VI	Professional Core
33	ELE401C	Electric Drives	3	1	0	4	VII	Professional Core
34	ELE407C	Introduction to Machine Learning	2	0	2	3	VII	Professional Core
35	ELE408C	Project (Minor)	0	0	4	2	VII	Professional Core
36	ELE409C	Electric Drives Lab	0	0	2	1	VII	Professional Core
37	ELE410C	Switchgear and Protection	3	1	0	4	VII	Professional Core
38	DMS4EEC	Project Management & Reporting	3	0	0	3	VII	Humanities & Social Sciences
39	ELE411C	Switchgear and Protection Lab	0	0	2	1	VII	Professional Core
40	ELE451C	Project (Major)	0	0	16	8	VIII	Professional Core

Complete List of Elective Courses

S. No	Course Code	Course Title	Hours Per Week			Credits	Semester	Course Category
			L	T	P			
1	ELE354E	Power Station Practice	3	0	0	3	VI	Discipline Centric
2	ELE355E	Special Electrical Machines	3	0	0	3	VI	Discipline Centric
3	ELE356E	Computational Electromagnetics	3	0	0	3	VI	Discipline Centric
4	ELE357E	Electrical Machine Design	3	0	0	3	VI	Discipline Centric
5	ELE358E	Applied Linear Algebra for Electrical Engineering	3	0	0	3	VI	Discipline Centric
6	ELE359E	Power Generation Plants	3	0	0	3	VI	Discipline Centric
7	ELE354G	Renewable Energy Systems	3	0	0	3	VI	Generic
8	ELE355G	Sensors, Transducers & Instrumentation Systems	3	0	0	3	VI	Generic
9	ELE403E	Power System Operation and Control	3	0	0	3	VII	Discipline Centric
10	ELE404E	High Voltage Engineering	3	0	0	3	VII	Discipline Centric
11	ELE405E	Energy Conservation and Auditing	3	0	0	3	VII	Discipline Centric
12	ELE406E	Advanced Power Electronics	3	0	0	3	VII	Discipline Centric
13	ELE407E	Nonlinear Control Systems	3	0	0	3	VII	Discipline Centric
14	ELE404G	Electrical Installations	3	0	0	3	VII	Generic
15	ELE405G	Design of Solar PV Systems	3	0	0	3	VII	Generic
16	ELE455E	Utilization of Electrical Energy	3	0	0	3	VIII	Discipline Centric
17	ELE456E	Electric Vehicle Technology	3	0	0	3	VIII	Discipline Centric

18	ELE452E	Flexible AC Transmission System (FACTS)	3	0	0	3	VIII	Discipline Centric
19	ELE453E	EHV AC &DC Transmission	3	0	0	3	VIII	Discipline Centric
20	ELE457E	Power System Dynamics and Stability	3	0	0	3	VIII	Discipline Centric
21	ELE458E	Power Quality	3	0	0	3	VIII	Discipline Centric
22	ELE459E	Fundamentals of Smart Grids	3	0	0	3	VIII	Discipline Centric
23	ELE460E	Principles of System Identification	3	0	0	3	VIII	Discipline Centric
24	ELE461E	Optimal Control Methods	3	0	0	3	VIII	Discipline Centric
25	ELE450G	Small Hydro Plants	3	0	0	3	VIII	Generic
26	ELE451G	Wind Energy Technology	3	0	0	3	VIII	Generic
27	ELE452G	Optimization for Engineering Design	2	0	2	3	VIII	Generic
28	ELE454G	Carbon Audit and Net Zero Energy Buildings	3	0	0	3	VIII	Generic
29	ELE001	Technology: What, Why and Why not?	2	0	0	2	-	Open
30	ELE002	Green Buildings: An Introduction	2	0	0	2	-	Open
31	ELE003	Electricity in Daily Use	2	0	0	2	-	Open
32	ELE004	Solar Photovoltaic Installation and Maintenance	2	0	0	2	-	Open (Skill)
33	ELE005	Electrical System Installations and Maintenance	2	0	0	2	-	Open (Skill)
34	ELE006	Energy: Environmental Impact and Conservation	3	0	0	3	-	Multidisciplinary (FYUGP)

Complete List of Audit Courses

S. No.	Course Code	Course Title	Hours Per Week			Credits	Semester	Category
			L	T	P			
1	MTH210B*	Bridge course in Mathematics-I	2	0	0	0	III	Engineering Science
2	MTH260B*	Bridge course in Mathematics-II	2	0	0	0	IV	Engineering Science
3	ELE263A	Seminar	-	-	-	0	IV	Professional Core
4	ELE361A	Industrial Training (15 days)	-	-	-	0	VI	Professional Core
5	ELE452A	Internship (30 days/4 weeks)	-	-	-	0	VIII	Professional Core

* *Audit Bridge course for lateral entry students only*

PART - B

COURSE OUTLINE (SEMESTERS 1st TO 8th)

Semester I

S.No	Course Code	Course Title	L	T	P	S	Hours Per Week	Credits
1	MTH115C	Calculus for Engineers	3	1	0	0	4	4
2	PHY102C	Engineering Physics	3	0	2	0	5	4
3	CHM102C	Engineering Chemistry	3	0	2	0	5	4
4	CIV101A	Introduction to Environmental Science and Engineering	2	0	0	1	2	0
5	MEC102C	Engineering Visualisation	1	0	4	0	5	3
6	ENG107F	Technical Communication	2	0	2	0	4	3
7	MEC104A	Engineering Perspectives	1	0	0	1	1	0
Total Credits								**18**

Semester II

S.No	Course Code	Course Title	L	T	P	S	Hours Per Week	Credits
1	MTH155C	Linear Algebra and Differential Equations	3	1	0	0	4	4
2	CIV152C	Engineering Mechanics	3	0	0	0	3	3
3	ELE150C	Basic Electrical Engineering	3	0	2	0	5	4
4	CSE160F	Programming for Problem Solving	3	0	2	0	5	4
5	ECE151C	Basic Electronic Devices	3	0	0	0	3	3
6	MEC152C	Product Realisation through Manufacturing	0	0	2	1	2	2
7	SS01A	Ethics and Social Responsibilities	1	0	0	0	1	0
Total Credits								**20**

Semester III

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE202C	Network Analysis	3	1	0	4
2	ELE205C	Signals and Systems	3	0	0	3
3	PHY201C	Electrical Engineering Materials	3	0	0	3
4	PHY202C	Engineering Electromagnetics	3	0	0	3
5	ECE213C	Analog Electronics	3	0	0	3
6	ELE208C	Introduction to Matrix Programming	0	0	2	1
7	MTH204C	Advanced Engineering Mathematics	3	0	0	3
8	ECE214C	Analog Electronics Lab	0	0	2	1
9	XXX0xx	Open Elective	-	-	-	Y
10	MTH210B	Bridge Course in Mathematics – I*	2	0	0	0
11	XXXxxxS	Specialization Course – I #				S
Total Credits						**21+Y+S**

** Audit course for lateral entry students only*
 # is for those students who opt for specialization (Honors/Minor)

Semester IV

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE256C	Electrical Machines-I	3	1	0	4
2	ELE257C	Data Science with Statistical Foundations	2	0	2	3
3	ELE258C	Control Systems Principles	3	1	0	4
4	ELE259C	Electrical Measurements	3	1	0	4
5	ECE263C	Digital Electronics and Logic Design	3	0	0	3
6	ELE260C	Electrical Machines-I Lab	0	0	2	1
7	ELE261C	Electrical Measurements Lab	0	0	2	1
8	ELE262C	Control System Principles Lab	0	0	2	1
9	ELE263A	Seminar	-	-	-	0
10	ECE264C	Digital Electronics and Logic Design Lab	0	0	2	1
11	XXX0xx	Open Elective	-	-	-	Y
12	MTH260B	Bridge Course in Mathematics – II*	2	0	0	0
13	XXXxxxS	Specialization Course II #				S
Total Credits						**22 + Y +S**

** Audit course for lateral entry students only*
 # is for those students who opt for specialization (Honors/Minor)

Semester V

S. No.	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE302C	Electrical Machines-II	3	1	0	4
2	ELE304C	Elements of Power Systems	3	1	0	4
3	ELE308C	Numerical Methods Using Scientific Computing	2	0	2	3
4	ECE318C	Microprocessors and Microcontrollers	3	0	0	3
5	ECO301C	Fundamentals of Economics	3	0	0	3
6	ELE310C	Electrical Machines II Lab	0	0	2	1
7	ELE311C	Elements of Power Systems Lab	0	0	2	1
8	ECE319C	Microprocessors and Microcontrollers Lab	0	0	2	1
9	XXX0xx	Open Elective	-	-	-	Y
10	XXXxxxS	Specialization Course 3 #				S
					Total Credits	**20+Y+S**

 # is for those students who opt for specialization (Honors/Minor)

Semester VI

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE352C	Power Electronics	3	1	0	4
2	ELE357C	Power System Analysis	3	1	0	4
3	ELE358C	Control System Design	2	0	2	3
4	ECE364C	Communication Systems	3	0	0	3
5	ELE359C	Power Electronics Lab	0	0	2	1
6	ELE362C	Tinkering Lab	0	0	2	1
7	ELE360C	Power System Analysis Lab	0	0	2	1
8	xxx3xxG	Elective (Generic)	X	0	0	X
9	ELE3XXE	Elective (Discipline Centric)	3	0	0	3
10	XXX0xx	Open Elective	-	-	-	Y
11	ELE361A	Industrial Training (15 days)				0
12	XXXxxxS	Specialization Course 4 #				S
Total Credits						**20+X+Y+S**

 # is for those students who opt for specialization (Honors/Minor)

Discipline Centric Elective Courses:

S. No.	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE354E	Power Station Practice	3	0	0	3
2	ELE355E	Special Electrical Machines	3	0	0	3
3	ELE356E	Computational Electromagnetics	3	0	0	3
4	ELE357E	Electrical Machine Design	3	0	0	3
5	ELE358E	Applied Linear Algebra for Electrical Engineering	3	0	0	3
6	ELE359E	Power Generation Plants	3	0	0	3

Generic Elective Courses:

S. No.	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE354G	Renewable Energy Systems	3	0	0	3
2	ELE355G	Sensors, Transducers & Instrumentation Systems	3	0	0	3

Semester VII

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE401C	Electric Drives	3	1	0	4
2	ELE407C	Introduction to Machine Learning for Electrical Engineering	2	0	2	3
3	ELE410C	Switchgear and Protection	3	1	0	4
4	DMS4EEC	Project Management & Reporting	3	0	0	3
5	ELE4xxE	Elective (Discipline Centric)	3	0	0	3
6	XXX4xxG	Elective (Generic)	X	0	0	X
7	XXX0xx	Open Elective	-	-	-	Y
8	ELE409C	Electric Drives Lab	0	0	2	1
9	ELE411C	Switchgear and Protection Lab	0	0	2	1
10	ELE408C	Project (Minor)	0	0	4	2
11	XXXxxxS	Specialization Course 5 #				S
Total Credits						**21+X+Y+S**

 # is for those students who opt for specialization (Honors/Minor)

Discipline Centric Elective Courses:

S. No.	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE403E	Power System Operation and Control	3	0	0	3
2	ELE404E	High Voltage Engineering	3	0	0	3
3	ELE405E	Energy Conservation and Auditing	3	0	0	3
4	ELE406E	Advanced Power Electronics	3	0	0	3
5	ELE407E	Nonlinear Control Systems	3	0	0	3

Generic Elective Courses:

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE404G	Electrical Installations	3	0	0	3
2	ELE405G	Design of Solar PV Systems	3	0	0	3

Semester VIII

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE451C	Project (Major)	0	0	16	8
2	ELE4xxE	Elective (Discipline Centric)	3	0	0	3
3	ELE4xxE	Elective (Discipline Centric)	3	0	0	3
4	XXX4xxG	Elective (Generic)	X	0	0	X
5	XXX0xx	Open Elective	-	-	-	Y
6	XXXxxxS	Specialization Course 6 #				S
7	ELE452A	Internship (30 days/4 weeks)				0
Total Credits						**14+X+Y+S**

 # is for those students who opt for specialization (Honors/Minor)

Discipline Centric Elective Courses:

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE452E	Flexible AC Transmission System (FACTS)	3	0	0	3
2	ELE453E	EHV AC & DC Transmission	3	0	0	3
3	ELE455E	Utilization of Electrical Energy	3	0	0	3
4	ELE456E	Electric Vehicle Technology	3	0	0	3
5	ELE457E	Power System Dynamics and Stability	3	0	0	3
6	ELE458E	Power Quality	3	0	0	3
7	ELE459E	Fundamentals of Smart Grids	3	0	0	3
8	ELE460E	Principles of System Identification	3	0	0	3
9	ELE461E	Optimal Control Methods	3	0	0	3

Generic Elective Courses:

S. No	Course Code	Course Title	Hours Per Week			Credits
			L	T	P	
1	ELE450G	Small Hydro Plants	3	0	0	3
2	ELE451G	Wind Energy Technology	3	0	0	3
3	ELE452G	Optimization for Engineering Design	2	0	2	3
4	ELE454G	Carbon Audit and Net Zero Energy Buildings	3	0	0	3

PART-C

DETAILED COURSE CONTENT

(SEMESTERS 1st TO 8th)

SEMESTERS 1st and 2nd

MTH115C Calculus For Engineers **3-1-0-0**

Course Objectives: The objective of this course is to provide introduction to important topics of applied mathematics, namely Single and Multivariable Calculus and Vector Calculus etc. The course would provide the relevant background and foundations necessary to understand the higher engineering mathematics courses.

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

1. Apply single variable differentiation and integration to solve applied problems in engineering and find the maxima and minima of functions.
2. Understand sequences and various techniques to discuss convergence or divergence of infinite series.
3. Evaluate partial derivatives, limits, total differentials, Jacobians, Taylor series and optimization problems involving several variables with or without constraints.
4. Evaluate multiple integrals in finding the volumes of different solids.
5. Evaluate some complicated integrals by making use of differential under integral sign method.

Module I

Differential Calculus: Review of limit, indeterminate forms and L'Hospital's rule. Continuity and differentiability. Mean value theorems and applications, Taylor's theorem, maxima, and minima.

Module II

Real Sequences and Series: Sequences and series, limsup, liminf, convergence of sequences and series of real numbers, absolute and conditional convergence.

Module III

Integral Calculus: Riemann integral, fundamental theorem of integral calculus, applications of definite integrals, improper integrals, beta and gamma functions.

Module IV

Advanced Calculus: Functions of several variables, limit and continuity, partial derivatives and differentiability, chain rule, homogeneous functions and Euler's Theorem. Taylor's theorem, maxima and minima and the method of Lagrange's multipliers.

Module V

Applications Of Integral Calculus: Double and triple integration, Jacobian and change of variables formula. Parameterization of curves and surfaces. Differential under the sign of integration both with constant and variable limits and applications.

Pre-requisites: NA

Text Books:

1. J. Bird, Higher Engineering Mathematics, , 6th Edition, Elsevier Limited, 2017.
2. J. Stewart,Calculus: Early Transcendentals , 8th Edition, Cengage Learning, 2017.

Reference Books:

1. K. A. Stroud and Dexter J. Booth, Engineering Mathematics,7th Edition, Palgrave Macmillan, 2013.

Online Resources:

1. Basic Calculus for Engineers, Scientists and Economists by Prof. Joydeep Dutta (IIT Kanpur) NPTEL Course (https://nptel.ac.in/courses/111104085).

PHY102C Engineering Physics **3-0-2-0**

Course Objectives: This course will enable students to understand the basics of the latest advancements in Physics viz., Quantum Mechanics, Nanotechnology, Lasers, Electromagnetic Theory and Fiber Optics.

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

1. Explain the dual nature of radiation and matter.
2. Apply Schrodinger's equations to solve finite and infinite potential problems.
3. Apply quantum ideas at the nano-scale and for understanding the operation and working principle of optoelectronic devices.
4. Analyze Maxwell's equations in differential and integral form.
5. Classify the optical fibre for different engineering applications.

Module I

Vector Calculus: Vector Analysis, Transformation of vectors under rotation, Gradient of scalar field, divergence and curl of vector field in Cartesian and Spherical coordinate systems, line, surface & volume integrals, Gauss's divergence theorem, Stoke's theorem.

Module II

Quantum Mechanics: Need for quantum theory, Plank's radiation law, Compton effect, Heisenberg's uncertainty Principle, de-Broglie hypothesis, basic postulates of quantum mechanics, Schrödinger Equation (Time dependent and Independent), wave function and its interpretation, Application of Schrödinger theory to particle in 1D box, superposition principle, Step potential (Qualitative only) and concept of tunnelling.

Module III

Electromagnetic Theory-I: Electric field of continuous charge distribution, Divergence and curl of electric field, Gauss's law (integral and differential form), Electric potential and its relationship with electric field, Biot-Savart law, Divergence and curl of magnetic field, Magnetic vector potential.

Module IV

Electromagnetic Theory-II: Faraday's laws, Ampere's law, Maxwell's modification of Ampere's law, Maxwell Equations in media and vacuum, Continuity equation, EM Wave Equation (Derivation) and boundary conditions, plane wave solutions.

Module V

Fibre Optics: Fiber Optics: optical fiber, Structure and types of optical fibers, Total internal reflection, Light propagation through fibers, Acceptance angle, Numerical Aperture, Brewster's angle, Attenuation, Applications of fiber optics in communication and endoscopy.

List of Experiments

Mechanics

1. To determine the value of Acceleration due to gravity (g) by using Bar Pendulum.

2. To determine the Young's Modulus of elasticity of rectangular Steel Bar by Bending of Beam Method.
3. Determination of Modulus of rigidity of wire by Maxwell's Needle
4. To determine the moment of Inertia of a Flywheel

Electromagnetism

1. To determine the value of e/m of an Electron by Thomson Method
2. To determine the frequency of AC by Melde's Method

Quantum Mechanics

1. To determine Planck's constant.
2. To verify Stefan's Law by Electrical method.

Solid State Physics and Electronics

1. To study the Hall Effect:
    a. Determination of Hall Voltage and RH.
    b. Determination of mobility of charge carriers and carrier concentration in a Semiconductor.
2. To determine the energy band gap of a semiconductor sample by Four Probe method

Optics

1. To determine the refractive index of Crown Glass Prism.
2. To determine the Wavelength of Prominent lines of Mercury Light by Plane Diffraction Grating.
3. To study the slit diffraction pattern and determine the wavelength of laser light.

Pre-requisites: NA

Text Books:

1. D. J. Griffith, Introduction to Electrodynamics, 2014, 4th Edition, Pearson.
2. D. Neamen, Semiconductor Physics and Devices: Basic Principles, McGraw Hill
3. A. Beiser, Concepts of Modern Physics, 2013, Sixth Edition, Tata McGraw Hill.
4. W. Silfvast, Laser Fundamentals, 2008, Cambridge University Press.
5. I. Prakash, A textbook of practical physics Vol 1 & 2, Kitab Mahal, 1987.
6. C. L. Arora, B.Sc. Practical Physics, S. Chand pub.

Reference Books:

1. B. D. Duggal, C. L. Chhabra D. K. Mynbaev and L. L .Scheiner, Fiber Optic Communication Technology, 2011, Pearson
2. R. A. Serway, C. J. Mosses and C. A. Moyer Modern Physics, 2010, 3rd Indian Edition Cengage learning.
3. J. R. Taylor, C D. Zafiratos and M.A. Dubson, Modern Physics for Scientists and Engineers, 2011, PHI Learning Private Ltd.
4. The Feynman Lectures on Physics Vol 1-3.
5. P. R. Sasi Kumar, Practical Physics, PHI.

6. Lab. Manuals.

Online Resources:

1. Engineering Physics II by Prof. D. K. Ghosh (IIT Bombay), NPTEL Course (https://nptel.ac.in/courses/122101002).
2. Electromagnetic Theory by Prof. D. K. Ghosh (IIT Bombay), NPTEL Course (https://nptel.ac.in/courses/115101005).

CHM102C Engineering Chemistry **3-0-2-0**

Course Objectives: The objective of this course is to impart technological aspects of applied chemistry and lay the foundation for practical application of chemistry in engineering applications.

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

1. Evaluate the causes of metallic corrosion and apply the methods for corrosion protection of metals.
2. Evaluate the electrochemical energy storage systems such as lithium batteries, fuel cells and design for usage in electrical and electronic applications.
3. Analyse the properties of different polymers and distinguish the polymers which can be degraded and demonstrate their usefulness.
4. Explain the chemistry and classification of lubricants.
5. Explain the significance of modern automated instruments for performing multiple simultaneous sampling and testing.

Module I

Chemical Thermodynamics: Introduction and Importance of Thermodynamics, Introduction to different laws of Thermodynamics, Qualitative difference between First and Second Laws of thermodynamics, Work done in Isothermal and Adiabatic Conditions, Heat capacities, Relation between Cp and Cv, Carnot engine, Entropy, Helmholtz free energy (A) and Gibbs free energy (G), Relation between A and G. Thermodynamic Criteria for Reversible and Irreversible processes

Module II

Electro-Chemistry and Corrosion: Introduction of electrochemistry and corrosion: a correlation, Difference between metal and electrolytic conductance with the basic applicable terminology, Electrochemical cells, Batteries, Fuel Cells, Lithium ion batteries---General characteristics, electrode materials and electrolytes. Electrochemical theory of Corrosion and Dry Corrosion, mechanisms involved in different types of corrosion, Factors affecting Corrosion, Electrochemical series versus Galvanic series, Corrosion protection - cathodic protection – sacrificial anodic and impressed current protection methods.

Module III

Nanotechnology and Polymers: Introduction to nanomaterials and polymers with special emphasis on the applications in material science, Properties at Nanoscale: Optical, Electrical, and Magnetic. General Methods of Preparation of Nanomaterials viz Top Down (Ball Milling, Lithography), Bottom-up Methods (Sol-Gel, Solution Based Method) and microbial synthesis. Basic terms used in polymer science, Preparation, Properties and Engineering applications of some Important Polymers, Polythene, Polyvinyl Chloride, Polystyrene, Teflon, Phenol Formaldehyde resin.

Module IV

Lubricants: Introduction, Function of Lubricants, Mechanism of Lubrication, Classification of Lubricants (Liquid, Semisolid, Solid), Properties of Lubricants (Flash Point and Fire Point, Viscosity, Aniline Point Acid value).

Module V

Instrumental Techniques: Introduction, Advantages and Disadvantages of Instrumental and Non-Instrumental Methods, Electromagnetic Radiation, Electromagnetic Spectrum, Light Absorption (Beers-Lambert Law), UV-Vis. spectroscopy, Types of Transitions, Chromophores, Auxo-chromes and Applications; Infrared Spectroscopy, Modes of vibration, IR bands corresponding to different functional groups and Applications. Introduction to Thermal Methods of Analysis: Thermo gravimetric analysis (TGA), Principle, Instrumentation, Applications of TGA in analysis of engineering materials.

List of Experiments:

1. Basic Introduction on Solution Preparation, Concentration terms, Handling of Glassware, Chemicals.
2. Determination of strength of NaOH solution by standardisation of sodium hydroxide using Oxalic acid.
3. To determine the acid value of a given mineral oil or vegetable oil.
4. To determine the moisture content of a given sample of coal.
5. To determine the Degree of dissociation of a weak acid by Conductometry.
6. Determination of the strength and pKa value of the weak acid by titration with an alkali.
7. To determine the Aniline point of the given sample of a Lubricating oil.
8. Synthesis of phenol formaldehyde resin.
9. To determine the temporary and permanent hardness of a sample of water by complexometric titration.
10. To determine the Alkalinity of the given sample of water.
11. Determination of the ion exchange capacity of cation exchange resin.
12. Construction and working of an Zn-Cu electrochemical cell.
13. Determination of viscosity-average molecular weight of different natural/ synthetic polymers.
14. Analysis of Iron in carbon steel by potentiometry.
15. Determination of level of TDS in water.
16. Demonstration Experiments:
    a. Determination of pH of different concentrations of acid and bases by pH meter.
    b. Spectrophotometer (concentration determination, wavelength maximum).

Pre-requisites: NA

Text Books:

1. P .C. Jain, Engineering Chemistry, 16th Edition, Dhanpat Rai & Sons, New Delhi.
2. L. A. Munro, Chemistry in Engineering, 1964, Prentice Hall, New York.
3. J. Kuriacose, R. Rajaram, Chemistry in Engineering and Technology Volumes I & II, , 2001, TMH publishing company Limited, New Delhi.
4. R. M. E. Diamant, Applied Chemistry for Engineers, 3rd Revised Edition, Pitman Publishing.
5. P. C. Jain, Engineering Chemistry, 16th Edition, Dhanpat Rai & Sons, New Delhi.
6. L. A. Munro, Chemistry in Engineering, 1964, Prentice Hall, New York.

Reference Books:

1. T. Minami, M. Tatsumisago, M.Wakihara, C. Iwakura, S. Kohijiya, Solid state ionics for batteries, Springer Publication, 2009.
2. S. Dhameja, Electric Vehicle Battery Systems, Newnes publication, 2001.
3. P. Sharma and Pathania, Principles of Physical Chemistry –2017, 4th Edition, Vishal Publishing Co.
4. N. Perez, Electrochemistry and Corrosion Science, 2nd Edition, 2016, Springer.
5. T. Minami, M. Tatsumisago, M. Wakihara, C. Iwakura and S. Kohijiya, Solid state ionics for batteries, Springer Publication, 2009.
6. S. Dhameja, Electric Vehicle Battery Systems, Newnes publication, 2001.

Online Resources:

1. Engineering Chemistry I NPTEL Course (IIT Bombay) (https://archive.nptel.ac.in/courses/122/101/122101001/).
2. Tribology NPTEL Course (IIT Delhi) (https://nptel.ac.in/courses/112102014).

CIV101A Introduction to Environmental Science and Engineering 2-0-0-1

Course Objectives: This course will enable students to understand the basic principles of environmental engineering and to introduce the fundamental concepts of environmental pollution and its sources. The course shall also enable the students to understand the policies vis a vis environmental issues and ethics and will impart the concept of sustainability.

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

1. Explain the principles of environmental sciences and engineering.
2. Identify the issues related to environmental pollution.
3. Explain the concept of sustainable development goals (SDG).
4. Discuss contemporary issues related to the environment.

Module I

Introduction: History of Environmental Science and Engineering, Biography of Renowned Environmental Scientists and Professionals.

Module II

Resources and Pollutions: Natural Resources; Renewable and Nonrenewable Energy Sources; Introduction to Environmental Pollution; Evolution of Pollution Control Strategies and Environmental Infrastructure.

Module III

Environmental Policies and Ethics: Major Environmental Episodes; Evolution of Environmental Acts and Policies; Environmental Ethics.

Module IV

Sustainability: Sustainability Concepts; Recent Research and Future Prospects in the field of Environment.

Module V

From Theory to Practice: Invited Talks from Environment Experts; Recorded Videos and Reference Study Material, Tours to different sites and facilities.

Pre-requisites: NA

Text Books:

1. W. P. Cunningham and M. A. Cunningham , Principles of Environmental Science, Tata McGraw-Hill Publishing Company, New Delhi, 2002.

Reference Books:

1. A. R. W. Jackson and J. M. Jackson, Environmental Sciences: The Environment and Human Impact, Longman Publishers, 1996.
2. G. M. Masters, Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi, 2008.

3. A. Rosencranz, S. Divan and M. L. Noble, Environmental Law and Policy in India: Cases, Materials and Statutes, Tripathi Pvt. Ltd, Bombay, 1992.
4. S. R. Asolekar and R. Gopichandran, Preventive Environmental Management – An Indian Perspective Foundation Books Pvt. Ltd., New Delhi (the Indian association of Cambridge University Press, UK), 2005.

Online Resources:

1. Introduction to Environmental Engineering by Dr. V. C. Srivastava (IIT Roorkee), NPTEL Course (https://nptel.ac.in/courses/103107084).

MEC102C Engineering Visualisation **1-0-4-0**

Course Objectives: This course will enable students to understand the importance of basic concepts and principles of Engineering Drawing (components, sections, views, and graphical representation) and enrich them with the knowledge of dimensioning, conventions and standards related to working drawings in order to become professionally efficient. The students will develop an ability to read and interpret engineering drawings created by others.

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

1. Explain the significance of engineering drawing.
2. Implement the engineering graphics standards for a given drawing.
3. Construct a 3D (Isometric Projection) from a given set of 2D drawings, vice versa.
4. Use Computer aided tools (CAD Software) for better visualisation.
5. Draw various 2D drawings using conventional and CAD tools.

Module I

Introduction to Conventional Drawing: Importance of Engineering Drawing, Drawing instruments and materials, B.I.S. and ISO Conventions, Dimensioning & Tolerances, First angle and third angle projection method. Projection of points in different quadrants.

Module II

Projection of Lines and Planes: Orthographic Projection of Straight Line parallel to one plane and inclined to the other plane–Straight Line inclined to both the planes–True Length and inclination of lines with reference planes–Traces of line–Projection of Planes, projection of planes with its inclination with two reference planes, concept of auxiliary plane method for projection of planes.

Module III

Projection of Solids and Sections of Solids: Classifications of Solids, Projections of right and regular solids, Section plane perpendicular to one plane and parallel to other, Section plane inclined to one plane and perpendicular to other plane.

Module IV

Isometric Projections: Principles of Isometric projection, Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa.

Module V

Introduction to CAD: Introduction to Computer Aided Drafting (CAD), Reasons for implementing CAD, Applications of CAD, Benefits/limitations of CAD, Hardware of CAD system, Types of CAD software, the Menu System, Toolbars, Standard, Object Properties, Dialog boxes and windows, Shortcut menus, Different commands used in CAD.

1. Exercise on CAD software for projection of lines with reference to different planes
2. Exercise on CAD software for projection of planes with its inclination with two reference planes.
3. Exercise on CAD software for projection of solids with reference to different planes.

4. Exercise on CAD software for Section plane perpendicular to one plane and parallel to other.
5. Exercise on CAD software for Section plane inclined to one plane and perpendicular to another plane.

Pre-requisites: NA

Text Books:

1. N. D. Bhatt, V. M. Panchal and P. R. Ingle, Engineering Drawing, Charota Publishing House, 2014.

Reference Books:

1. B. Agrawal and C. M. Agrawal, Engineering Graphics, TMH Publication, 2012.
2. K. L. Narayana, and P Kannaiah, Text book on Engineering Drawing, Scitech Publishers, 2008.

Online Resources:

3. Engineering Graphics and Design by Prof. Naresh Varma Dalta, Prof. S. R. Kale (IIT Delhi), NPTEL Course (https://archive.nptel.ac.in/courses/112/102/112102304/).
4. Engineering Drawing by Prof. P. S. Robi (IIT Guwahati), NPTEL Course (https://nptel.ac.in/courses/112103019).

ENG107F Technical Communication **2-0-2-0**

Course Objectives: This course will enable students to have written and spoken communications skills. The students will have communicative competence through listening and speaking activities in the classroom and language lab. They will acquire proficiency levels in LSRW skills on par with the requirements for placement interviews of high-end companies / competitive exams. They shall be able to evaluate complex arguments and to speak and write on general and technical topics.

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

1. Improve listening skills so as to understand complex business communication in a variety of global English accents.
2. Enrich vocabulary through proper pronunciation and improve speaking skills in academic and social contexts.
3. Interpret texts, diagrams and improve both reading and writing skills which would help him/her in his/her academic as well as professional career.
4. Interpret topics from different perspectives; analyze complex concepts and present them in speech and writing
5. Write clearly and coherently on academic and general topics.

Module I

Fundamentals of verbal, non-verbal Communication: Verbal communication: Role and purpose of communication. Forms of communication. Barriers to effective communication. Non-verbal Communication: Relevance and effective use. Para language: Importance, Elements, Interpretation. Kinesis, Proxemics, Haptics, Chronemics, Occulesics. Cross-cultural non-verbal communication. Global accents.

Module II

Effective Reading, Comprehension and listening skills: Process and types of reading. Reading tactics and strategies. Skimming, Scanning, Intensive reading, Extensive reading. Reading Comprehension. Process and Types of Listening. Effective Listening: Principles and Barriers. Paraphrasing/Summarizing. Activities to enhance listening (Listening to News, Motivational speeches in global English accents). Activity: Note-making and Interpretive exercises.

Module III

Art of Public Speaking: Impromptu, Importance of Non-verbal Communication, Technical Talks, Dynamics of Professional Presentations – Individual & Group. Speaking: Socializing Skills - Introducing Oneself, SWOT analysis, Speeches: Types of speeches like extempore /monologues etc. Group discussion on: Factual, controversial and abstract issues.

Module IV

Writing Skill: Structure of documents, importance of tabs, indents and line spacing, Précis, Report writing, Letter writing (formal, informal), Notices, Summary writing, Parts of a Research paper, Abstract writing, how to avoid plagiarism, Resume Preparation/CV– writing your comprehensive CV including professional achievements in your life, SOP writing, how to write a review, review of Ted-talks: globally famous personalities, motivational speakers – sports celebrities, entrepreneurs. Activity: Classroom discussion and note-making.

Module V

Presentation Skills: Structure of presentations, Persuasive and Content-Specific Presentations Activity: Technical Presentations, Use of visual communication to inform, engage, inspire and persuade your audience, Usage of colors, fonts, pictures and videos to increase the impact of presentation. Use of data through compelling charts and graphs that narrate a story/theme.

Pre-requisites: NA

Text Books:

1. S. Kumar and L. Pushp, English Language and Communication Skills for Engineers, India, Oxford University Press, 2018
2. I. Bhattacharya, An Approach to Communication Skills, Dhanpat Rai Publications Pvt Ltd.
3. O. Clive and C. Latham-Koenig, New English File: Advanced Students Book. Paperback. Oxford University Press, UK, 2017.
4. A. Rizvi, Effective Technical Communication. McGraw-Hill India, 2017.

Reference Books:

1. P. Seargeant and B. Greenwell, From Language to Creative Writing, Bloomsbury Academic, 2013.
2. S. Brown and D. Smith, Active Listening, 3rd Edition, UK: Cambridge University Press, 2011.
3. M. Swan, Practical English Usage (Practical English Usage), 4th edition, UK: Oxford University Press, 2017.
4. W. Peter, Teaching and Developing Reading Skills: Cambridge Handbooks for Language teachers, UK: Cambridge University Press, 2018.
5. E. H. Glendinning and B. Holmstrom, Study Reading, 2nd Edition, UK: Cambridge University Press, 2012.

Online Resources:

1. http://www.eco-ction.org/dt/thinking.html (Leopold, Aldo. “Thinking like a Mountain")
2. https://www.esl-lab.com/
3. http://www.bbc.co.uk/learningenglish/
4. https://learningenglish.voanews.com/a/using-voa-learning-english-to-improve-listeningskills/3815547.html

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MEC104A Engineering Perspectives **1-0-0-1**

Course Objectives: This course will enable students to get exposed to engineering solutions in terms of sustainability, economic, environmental, and social considerations. The course will also highlight the socio-technical and interdisciplinary nature of engineering.

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

1. Explain the significance of research and development in engineering and its enormous impact on our day to day lives.
2. Develop an interest in stem subjects via DIY exercises and experiential learning workshops.

Outline of the Course:
Introduction to Engineering, Exposing students to "Engineering" as a profession that creates wealth for nations, and as a vehicle for economic growth, Exposing students to successful research cases, products and innovations which have reached people/industry/society.

Thought provoking lectures by successful industrialists, entrepreneurs, designers and alumni like Aerospace, Mechatronics, Additive manufacturing, Engineering Material, Software's, Microprocessors, AI/ML, Design, Global warming, Disaster management, Sustainability, SDG etc.

Social Component:
Do It Yourself (DIY) projects in teams: Select from ideas and make quick prototypes (mock-ups) using available material.

1. Visit to at least one local industry
2. Visit to Design Innovation Centre, IUST
3. Visit to one laboratory from each engineering department.
4. Experiential learning workshops: e.g., Simple assemblies, 3D printing, Reverse Engineering etc.

Evaluation: Based on attendance/viva voce/DIY projects/etc.

Textbooks: NA

Reference Books: NA

Online Resources: NA

MTH155C Linear Algebra and Differential Equations **3-1-0-0**

Course Objectives: This course will enable students to understand the elementary notions of Fourier series, which is vital in practical harmonic analysis. The students will be exposed to the concept of eigenvalues and eigenvectors of matrices and the transform techniques to solve linear systems that arise in sciences and engineering. The course will also enrich the skills in solving initial and boundary value problems.

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

1. Explain and apply the concept of vector spaces, subspaces, bases, dimension, and their properties.
2. Relate matrices and linear transformations, compute Eigenvalues and Eigenvectors of linear transformations.
3. Identify and apply the nature, formation, geometry, and solution of differential equations.
4. Apply the techniques to solve differential equations including series solution.
5. Employ the tools of Fourier series to find harmonics of periodic functions from the tabulated values.

Module I

Vector Spaces: Vector spaces over Q, R and C, subspaces, linear independence, linear span of a set of vectors, basis, and dimension of a vector space, sum and direct sum. Systems of linear (homogeneous and non-homogeneous) equations, matrices and Gauss elimination, elementary row operations, row space, column space, null space, and rank of a matrix.

Module II

Linear Mapping and Matrices: Linear transformation, rank-nullity theorem and its applications, matrix representation of a linear transformation, change of basis and similarity. Eigenvalues and eigenvectors, characteristic and minimal polynomials, Cayley-Hamilton theorem (without proof) and applications.

Module III

Ordinary Differential Equations I: Review of first order differential equations, Picard's theorem, linear dependence and Wronskian. Dimensionality of space of solutions, linear ODE with constant coefficients of second and higher order, Cauchy-Euler equations.

Module IV

Differential Equations II: Simultaneous differential equations. System of linear differential equations with constant coefficients, fundamental matrix, matrix methods.

Module V

Power Series and Fourier Analysis: Power Series and its convergence, power series method, Fourier series - Euler's formulae - Dirichlet's conditions - Change of interval - Half range series – RMS value – Parseval's identity – Computation of harmonics.

Pre-requisites: NA

Text Books:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, 2015, John Wiley, India.
2. M. D. Greenberg, Advanced Engineering Mathematics, 2nd Edition, 2006 Pearson.

Reference Books:

1. B. S. Grewal, Higher Engineering Mathematics, 43rd Edition, 2015 Khanna Publishers, India,

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Online Resources:

1. Ordinary Differential Equations and Applications by A. K. Nandakumaran, P. S. Datti & Raju K. George, (IISc Bangalore), NPTEL Course (https://www.digimat.in/nptel/courses/video/111108081/L01.html).
2. Linear Algebra by Dr. K.C. Sivakumar, Department of Mathematics (IIT Madras), NPTEL Course (https://nptel.ac.in/courses/111106051).

CIV152C Engineering Mechanics **3-0-0-0**

Course Objectives: This course will enable students to have the knowledge of fundamental laws and basic concepts of rigid body mechanics to solve problems of bodies under rest or in motion. The students will also be able to apply conditions of static equilibrium to analyze physical systems and compute the properties of areas and bodies.

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

1. Compute the resultant system of forces in plane and space acting on bodies.
2. Predict the support-reactions and the internal forces of the members of various trusses and Frames.
3. Apply transfer theorems to determine properties of various sections.
4. Analyse equilibrium of connected bodies virtual work method.
5. Apply the laws of dynamics to real life problems.

Module I

Statics: Fundamental concepts and laws of mechanics. Equilibrium of bodies: Free-body diagrams, conditions of equilibrium, torque due to a force, statical determinacy. Force systems: principle of moments, resultant of forces, couple systems, equilibrium of rigid bodies, Support reactions.

Module II

Properties of plane surfaces: Centroid of simple figures from first principle, centroid of composite sections; Area moment of Inertia, Moment of Inertia of plane sections from first principles, theorems of moment of inertia, moment of inertia of standard sections and composite sections.

Module III

Concept of stress and strain: Conditions of equilibrium, compatibility and stress strain relations. Stress-strain diagrams, Modulus of elasticity, Poisson's ratio, Bulk modulus, Modulus of rigidity. Shear force and bending moment in beams; Structural analysis**:** Forces in members of a truss by method of joints and method of sections and principle of virtual work.

Module IV

Centre of Gravity and Moment of Inertia: Centre of gravity and its implications; Mass moment of inertia, Moment of inertia of Cylinder, Cone, Sphere, etc.

Module V

Fundamentals of Dynamics: Kinematics and Kinetics of particles in rectilinear and curvilinear motion; Kinematics and Kinetics of Rigid bodies, types of motion, instantaneous centre of rotation in plane motion, D'Alembert's principle and its applications in plane motion and connected bodies, Work Energy principle, Impulse-Momentum principle.

Pre-requisites: N/A

Text Books:

1. F. Beer, E. Johnston, D. Mazurek, P. Cornwell and B. Self. Vector Mechanics for Engineers: Statics and Dynamics, 10th Edition, McGraw-Companies, Inc., New York, 2013
2. Hibbeler, R.C., Engineering Mechanics: Statics and Dynamics, Prentice Hall 2012.

Reference Books:

1. R.C. Hibbeler and A. Gupta, Engineering Mechanics: Statics and Dynamics (11th Edition), Pearson Education Inc., Prentice Hall, 2010.
2. J. L. Meriam and L. G., Kraige Engineering Mechanics, Volume I - Statics, Volume II - Dynamics, 7th Edition, John Wiley & Sons, New York, 2012.

Online Resources:

1. Engineering Mechanics by Prof. K. Rames (IIT Madras), NPTEL Course (https://archive.nptel.ac.in/courses/112/106/112106286/).

ELE150C Basic Electrical Engineering **3-0-2-0**

Course Objectives: The objective of the course is to explain the fundamentals of AC and DC circuits and operative principle of transformer and electric machines with background of magnetic circuits. The course will also expose students to the working principle of electrical installation and protection equipment.

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

1. Define the basic terminology/definitions of electrical engineering.
2. Solve the basic DC and AC electric circuits.
3. Apply the knowledge of theorems/laws to analyse the DC and AC electric networks.
4. Explain the working principles of magnetic circuits, transformers, and electrical machines.
5. Design and implement the common electrical installation and protective equipment for a particular application.

Module I

DC Circuits analysis: Electrical circuit elements (R, L and C), voltage and current sources, Ohm's law, Kirchhoff's current and voltage laws, analysis of simple circuits with dc excitation, Mesh analysis and Nodal analysis, Superposition, Thevenin and Norton Theorems.

Module II

AC Circuit analysis and three phase circuits: Representation of sinusoidal waveforms, peak and RMS values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel). Three phase balanced circuits, voltage and current relations in star and delta connections.

Module III

Magnetism and Transformer operation: Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation, and efficiency. Auto-transformer and three-phase transformer connections.

Module IV

Electrical Machines: Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, concept of slip, construction and working principle of a separately excited DC motor, construction and working of a synchronous generator.

Module V

Electrical Installations and types of batteries: Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries.

List of Experiments

1. Connection of Ammeters, voltmeters, Wattmeter and Multimeter in DC and AC circuits and selection of their ranges, Use of LCRQ meter.
2. Introduction to CRO, Discussion on front panel buttons and their uses.

3. To study the color coding of Resistors (4-band, 5-Band schemes), familiarization with Capacitors (Ceramic and Electrolytic, DC, AC), value calculation of ceramic caps and Inductors and their measurement using LCRQ meter.
4. Introduction to Breadboard and verify the KVL and KCL using discrete components on Breadboard.
5. To verify the Superposition theorem.
6. To measure single phase power by Wattmeter method.
7. Determination of voltage, current, power and power factor of series RLC circuit.
8. Demonstration of cut-out sections of machines: dc machine, three phase induction machine, single-phase induction machine and synchronous machine.
9. Demonstration of various commonly used electrical equipment such as fuses, MCB, Types of Wires and Types of Batteries etc.
10. Study of Light emitting diodes (common cathode/common anode), Monochromic, RGB and their Voltage current relationships.
11. Study of VI characteristics of PN junctions.
12. Study of BJT as a switch to drive a load (e.g LED, small DC Motor etc.)

Pre-requisites: NA

Text Books:

1. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, Basic Electrical Engineering, McGraw Hill, 2009.
3. V. D. Toro, Electrical Engineering Fundamentals, Prentice Hall India, 1989.
4. L. Nashelsky and R Boylestad, Electronic Devices and Circuit Theory: Pearson New International Edition.

Reference Books:

1. E. Hughes, Electrical and Electronics Technology, Pearson, 2010.
2. C. K. Alexender, Mathew N. O. Sadiku, Fundamentals of Electric circuits, McGraw Hill,
3. J. E. Kemmerly William H. Hayt, Engineering Circuit Analysis,McGraw Hill, 2012.
4. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
5. A. Chakrabarti, Circuit Theory, Dhanpat Rai Publications, 6th Edition, 2006.
6. V. N. Mittal and Arvind Mittal, Basic Electrical Engineering, McGraw Hill.

Online Resources:

1. Basic Electrical Technology by Prof. N.K. De, Prof. G. D. Roy, Prof. T. K. Bhattacharya (IIT Kharagpur), NPTEL Course (https://nptel.ac.in/courses/108105053).

CSE160F Programming for Problem Solving **3-0-2-0**

Course Objectives: The objective of this course is to introduce the concept of problem-solving strategies for simple problems with the fundamental syntax and semantics of the C language. The course will also enable students to use various data types and control structures in C programming.

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

1. Design and implement algorithms and flowchart for simple problems.
2. Use syntax and semantics in C programming.
3. Define and describe C programming concepts like data types, control structures.
4. Use modular approach for problem solving using functions
5. Store and retrieve data from complex data types and files.

Module I

Introduction to Problem Solving: Introduction to problem solving, flowcharts, algorithms, the compilation process, features of C language, structure of C program, data types, constants and variables. arithmetic, relational and logical operators, type conversion, increment and decrement operators, bitwise operator, assignment operator and expressions, conditional expressions, precedence and associativity, I/O functions, basic C program examples.

Module II

Control Structures and Arrays: Introduction to conditional branching. iterative loops, arranging things: arrays, 2-D arrays, character arrays and strings.

Module III

Functions: Functions and parameters passing by value, recursion as a different way of solving problems, macros.

Module IV

Pointers: Idea of pointers, defining pointers, pointer and function argument (call by reference), pointer and array, pointer to functions, pointer to pointer, pointer to multi-dimensional array.

Module V

Structures and File Handling: Structures: defining structures and array of structures. unions, Storage classes: scope and extent, storage classes in a single source file: auto, extern, static & register. Use of pointers in self-referential structures, command line arguments, File handling.

List of Experiments

1. Familiarisation with the programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving conditional branching.
4. Iterative problems
5. 1D Array manipulation
6. Matrix problems,
7. String operations
8. Simple functions

9. Passing values in functions
10. Recursive functions
11. Pointers
12. Pointer and array
13. Pointer and function
14. structures
15. File operations

Pre-requisites: NA

Text Books:

1. B. W. Kernighan and D. M. Ritchie, The C Programming Language, Prentice Hall of India.
2. B. Gottfried, Schaum's Outline of Programming with C, McGraw Hill Education India.

Reference Books:

1. A. Shaw, Learn C the hard way: Practical exercises on the computational subjects you keep avoiding (like C), Addison-Wesley Professional.
2. V. D. I. Peter, Expert C programming: deep C secrets. Prentice Hall Professional.

Online Resources:

1. Introduction to Programming in C NPTEL Course (IIT Kanpur) (https://archive.nptel.ac.in/courses/106/104/106104128/).
2. Online Compiler: (https://www.onlinegdb.com).

ECE151C Basic Electronic Devices **3-0-0-0**

Course Objectives: The objective of this course is to provide the student with the fundamental skills to understand the basics of semiconductor electronics and components like diode, LED, transistor, FET etc.

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

1. Define the concepts of the depletion region and minority carrier injection.
2. Explain how a diode works and the applications of diodes.
3. Explain the operation of the Zener diode and its applications.
4. Explain the formation of several devices by joining two different Semi-Conductor materials.
5. Explain the Construction and working of unipolar electronic devices.

Module I

Fundamentals of Semiconductor : Introduction to band theory in solids, Conduction and Valence band, concept of forbidden energy, Germanium and Silicon as semiconductors, Doping in Semiconductors(S.Cs), Types of doping, Conduction in Si and Ge (Extrinsic & Intrinsic), Majority and minority charge carriers in S.Cs, Concept of Energy Levels, Excitation and de-excitation and energy release phenomenon, Luminescence. carrier transport by drift and diffusion, carrier generation and recombination, Poisson and Continuity equation.

Module II

Semiconductor Junctions: Introduction to PN semiconductor junctions, construction, Band diagrams of PN junctions, Depletion region, Barrier potential, P-N junction under zero, Forward and reverse bias, built-in potential barrier, electric field and space charge width, junction capacitance, charge flow in a P-N junction, current-voltage relationship, minority carrier distribution, junction breakdown mechanisms, application of P-N junctions.

Module III

Special Semiconductor Junctions: Zener diode constructions and VI characteristics, LEDs Voltage and current relationships in LEDS, Seven segment display, Introduction to Solar Cell, VI characteristics of solar cell. metal-semiconductor junctions, ohmic contacts, Laser diode, photodiode, PIN diode.

Module IV

Bipolar Junction Devices: Bipolar Junction transistor, Construction, principle of operation, modes of operation, C.B,C.E,C.C configurations of BJT. Static IV characteristics in active and saturation modes, minority carrier distribution, emitter efficiency, Transistor action, BJT as a switch, BJT as current controlled current source, current gain, amplification due to BJT (C.B).

Module V

Unipolar Junction Devices: UJT, Construction and principle of operation. Field effect Transistors, JFET construction and working, p-channel/n-channel FET, VI characteristics. Introduction to MOSFET construction and working, MOSFET as a switch.

Pre-requisites: NA

Text Books:

1. D. Neamen, Semiconductor Physics And Devices: Basic Principles, McGraw Hill Education India.
2. A. P. Malvino, D. J. Bates and P. E. Hoppe, Electronic Principles, McGraw Hills, 9th Edition.

Reference Books:

1. E. D. Gates, Introduction to Electronics, Delmar, Cengage Learning 6th Edition.
2. L. Nashelsky and R. Boylestad, Electronic Devices and Circuit Theory, Pearson New International Edition.

Online Resources:

1. Basic Electronics by Prof. M. B. Patil, Department of Electrical and Electronics Engineering, (IIT Bombay), NPTEL Course (https://nptel.ac.in/Courses/108101091).

MEC152C Product Realisation through Manufacturing **0-0-2-1**

Course Objectives: The objective of the course is to expose students to the role of manufacturing processes in product realisation by endeavouring hands-on activities by undertaking manufacturing exercises and assembly activity in teams.

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

1. Explain and select manufacturing processes for a particular product realisation task
2. Safely use various tools, instruments and machines for a particular product realisation task
3. Practise various trades including fitting, carpentry, machining and welding.
4. Apply skills acquired from C01, C02, and C03 in order to fabricate a prototype with societal applications.

Module I

Overview of Manufacturing Methods and Tools:

Manufacturing as a backbone of a developed economy, Subtractive manufacturing, conventional, CNC, additive manufacturing, forging and forging tools, metal casting, plastic moulding, glass cutting.

Module II

Introduction to workshop practices: Safety precautions, introduction of various shops trades used in engineering and technology viz., machining trade, sheet metal and spray-painting section, fitting and bench work section, welding section, smithy and forging section, carpentry and pattern making section, automobile section, electrical and electronics section, plastic moulding section etc.

Module III

Practicals in machine shop:

1. Demonstration of basic operations on the lathe machine, such as drilling, facing, turning, taper turning, step turning, knurling, chamfering etc.
2. Demonstration of basic measuring instruments.
3. To manufacture a job on the centre lathe as per given drawing
4. To perform additional operations such as grooving, drilling, knurling.
5. To manufacture a job on the CNC lathe and CNC milling trainers as per the given drawing

Module IV

Practicals in fitting shop and carpentry shop:

1. Demonstration of all basic hand tools/ measuring tools and equipment.
2. Demonstration of simple operations such as marking, punching, filing, sawing, scrapping, and drilling.
3. Demonstration and practice of different carpentry operations like planning, sawing and chiselling and joints.
4. Demonstration of pattern making tools and materials
5. To prepare a half lap cross joint.

Module V

Practicals in welding shop:

1. Demonstration of all basic tools and personal protective equipment.
2. To make a single-V butt joint of mild steel 80×50×8 mm.
3. To make a lap joint of mild steel 85×35×6 mm.

Social Component Module:

Fabrication of a prototype: This module includes fabrication of a prototype using the skills, knowledge and the tools and machines available in the workshop. The prototype should be developed by a team of students which has relevance to some societal problems. The developed prototype shall be submitted by the students at the end of the semester for evaluation.

Pre-requisites: NA

Text Books:

1. S. K. H Choudhury, Elements of Workshop Technology, Media promoters and publishers private limited, Mumbai.
2. P. N. Rao, Manufacturing Technology, Vol. I and Vol. II, Tata McGraw Hill House, 2017.

Reference Books:

1. S. Kalpakjian and S. S. Schmid, Manufacturing Engineering and Technology, 4th edition, Pearson Education India Edition, 2002.
2. P. Gowri, Hariharan and A. S. Babu, Manufacturing Technology – I, Pearson Education, 2008.
3. R. A. Lindberg, Processes and Materials of Manufacture, 4th edition, Prentice Hall India, 1998.

Online Resources: NA

SS01A Ethics and Social Responsibilities **1-0-0-0**

Course Objectives: This course aims to foster a holistic understanding of ethics by introducing students to diverse worldviews, ethical theories, and practical applications. Through philosophical, and scientific perspectives, students will develop a nuanced appreciation for ethical dilemmas. They will gain proficiency in major ethical theories and learn to apply them effectively in personal, social, and professional contexts, particularly in the field of engineering. The course will also emphasise the ethical responsibilities of engineers in addressing global issues and emerging technologies, equipping students with critical analytical skills for making ethically sound decisions in an ever-evolving ethical landscape.

Course Outcomes: Upon completing this course, students will have developed a well-rounded ethical perspective by examining philosophical, and scientific worldviews. They will have attained a solid grasp of major ethical theories and the ability to adeptly apply them in personal, social, and professional situations. Additionally, students will be equipped to understand and address the ethical responsibilities inherent in engineering, particularly in the context of global challenges and emerging technologies, enabling them to make sound ethical decisions in diverse, real-world scenarios.

Module I

Worldview: An Introduction, Philosophical Perspective, Scientific Perspective, Science and Scientism

Module-II

Applied Ethics, Meaning and Introduction of Ethics, Overview of Key Ethical Theories (Utilitarianism, Deontology, Virtue Ethics, etc.), Personal & Social Ethics, Professional Ethics

Module-III

Ethical Considerations in Engineering, The Role of Engineers in Society, Environmental Ethics and Sustainable Engineering, Engineering and Global Issues (e.g., Climate Change, Resource Depletion), Ethical Considerations in Emerging Technologies (e.g., AI, Biotechnology)

Evaluation: Presentation cum Viva Voce

Suggested Readings:

1. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
2. India Wins Freedom - Maulana Abdul Kalam Azad.
3. Wings of Fire: Autobiography, A. P. J. Abdul Kalam.
4. Theology, and Ethics, Ted Peters, Science, London: Taylor and Francis, 2017.
5. The Alchemy of Happiness, Al-Ghazali. Translated by Claud Field.

3rd Semester

Course Code	Course Title					Type of Course
ELE202C	Network Analysis					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	1	0	4	4	Professional Core

Course Objectives: Build a solid understanding and ability to analyze linear time-invariant circuits using network theorems, transform methods, and differential equations. Use this ability to synthesize circuits and design filters meeting desired specifications.

Course Outcomes:

1. Recall and explain the basic network theorems, describe the Laplace transformation properties and their application in solving network problems.
2. Demonstrate an understanding of differential equations and their role in analyzing electrical circuits. Interpret the time domain behavior of circuits using pole-zero plots derived from network functions.
3. Apply the knowledge of network theorems and impedance functions to analyze and solve complex electrical circuits.
4. Analyze synthesis problems and formulate strategies using positive real functions and Hurwitz polynomials.
5. Synthesize LC and RC circuits with desired specifications, considering filter design principles. Synthesize constant K & m derived filters to meet specific frequency response requirements.

MODULE I

Differential equation modeling of networks: Review of the basic network theorems. First order differential equation: Differential equations as applied in solving networks, Application of initial conditions, Evaluating initial conditions in networks, Laplace Transformation properties, Solution of Network problems with Laplace transformation, Waveform analysis, and synthesis: The unit step, ramp, and impulse functions and their Laplace transforms, Initial and final value of f(t) from F(s), Convolution integral, convolution as summation.

MODULE II

Network theorems and impedance functions: Complex frequency, transform impedance and transform circuits, series and parallel combinations of elements, Network Functions: poles and zeros: Network functions for one port and two-port networks (ladder and general networks), Poles and zeros of network functions, Restriction on pole and zero locations for driving point and transfer functions, Time domain behavior from pole zero plot.

MODULE III

Two-port parameters: Introduction to two-port parameters - motivating real-world examples, Admittance, impedance, transmission, and hybrid parameters, Relationship between parameter sets, Parallel connection of two port Networks, Characteristics impedance of two-port networks.

MODULE IV

Network synthesis: Synthesis problem formulation - Understanding the essence of network synthesis and its real-world applications, Positive real functions and their significance in network synthesis, properties of positive real functions, Hurwitz polynomials and their role in network synthesis, properties of RC, LC, and RL driving point functions, Analyzing the frequency response and impedance characteristics of different driving point functions, Synthesizing LC and RC circuits with desired specifications using Foster and Cauer methods. Evaluating the trade-offs and advantages of each synthesis approach for different circuit designs.

MODULE V

Filter fundamentals: Introduction to filters and motivating real-world examples, pass and stop band, filter classification based on their frequency characteristics, constant K & m derived filters, the behavior of characteristic impedance overpass & stop bands, design of filters, trade-offs between filter characteristics such as cutoff frequency and selectivity. Introduction to active filters, Practical applications of both passive and active filters in communication systems, audio engineering, and signal processing.

Text Books:	
1.	C. L. Van Valkenberg, "Network Analysis," 3rd ed. Prentice-Hall,1959.
2.	F. Kuo, "Network Analysis & Synthesis," 2nd ed. Wiley, 2006.
Reference Books:	
1.	J. D. Ryder, "Networks, Fields & Lines." Englewood Cliffs, Prentice-Hall.
2.	A. Chakrabarti, "Circuit Theory (Analysis & Synthesis)," 7th edition, Dhanpat Rai & Co.
3.	Mahmood Nahvi and Joseph Edminister, "Schaum's Outline of Electric Circuits," 7th ed. McGraw-Hill Education.
Online Resources:	
1.	Circuit Theory, Prof. S.C. Dutta Roy, IIT Delhi https://nptel.ac.in/courses/108102042

Course Code	Course Title					Type of Course
ELE205C	Signals and Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Professional Core

Course Objectives: Develop an understanding of the field of signals and systems and apply transform methods for their analysis with a focus on historical context and real-world applications.

Course Outcomes: After studying this course, students will be able to:

1. Understand the historical context and evolution of signals and systems and recognize the contributions of key pioneers in the field.
2. Classify signals based on their properties and parameters and analyze their characteristics in the time and frequency domains.
3. Apply Fourier series, Fourier transform, Laplace transform, and Z-transform for signal and system analysis.
4. Analyze the stability and causality of continuous-time and discrete-time systems using transform methods.
5. Evaluate real-world applications of signals and systems in various engineering disciplines and assess their societal impact and ethical considerations.

MODULE I

Introduction to Signals and their Characteristics: Historical context and evolution of the discipline of signals and systems, Contributions of key pioneers in the field, Evolution of signal processing techniques and their impact on modern technology. Nature of signals: Continuous-time and discrete-time signals. Classification of signals: Periodic and non-periodic, even and odd, power and energy, Invertible and Noninvertible, Deterministic and Random. Elementary signals - exponential, sine, step, impulse, ramp, rectangular, sine, triangular, signum. Signal parameters: Amplitude, frequency, phase, and bandwidth. Signal properties: Symmetry, causality, and linearity. Signal operations: Amplitude scaling, addition, multiplication, time shifting, and time scaling.

MODULE II

Fourier Series and Fourier Transform: Historical development of Fourier series and its applications, Fourier series representation of continuous time periodic signals and their properties, Fourier series representation of discrete-time periodic signals and their properties. Fourier transform and its significance in signal analysis, Continuous-time Fourier transform (CTFT) and its properties, Discrete-Time Fourier Transform (DTFT) and its properties.

MODULE III

Linear Continuous-Time Systems: Systems: definition, classification – Linear and Nonlinear, Time Variant and Time-Invariant, Causal and Non-causal, Stable and Unstable, Static and Dynamic. The Convolution Integral. Properties of Linear Time-Invariant (LTI) systems. Causal

LTI systems represented by linear constant-coefficient differential equations. Laplace transform, and its application in analyzing continuous-time LTI systems, Concept of Region of Convergence (ROC) for the Laplace transform.

MODULE IV

Linear Discrete-Time Systems: Introduction to discrete-time systems and their classification, Analysis of Causal Linear discrete-time systems described by Linear constant-coefficient difference equations, The z-Transform, Region of Convergence (ROC). Properties of z-Transform: linearity, time shift, scaling, time-reversal, differentiation, Initial value theorem. Inverse z-Transform. Analysis and characterization of LTI systems using z-transforms.

MODULE V

Real-World Applications of Signals and Systems: Applications of signals and systems in communication systems, audio processing, and image processing, Signal processing in control systems and automation, Impact of signals and systems in medical imaging and biomedical engineering, Emerging trends and applications in signals and systems.

Text Books:	
1.	Oppenheim, A. V., Willsky, A. S., and Nawab, S. H., "Signals and Systems," 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1996.
2.	Haykin, S., and Van Veen, B., "Signals and Systems," 2nd ed. Hoboken, NJ: Wiley, 2005.
Reference Books:	
1.	Hsu, H. P., "Schaum's Outline of Signals and Systems," 3rd ed. New York: McGraw-Hill Education, 2013.
2.	Mitra, S. K., "Digital Signal Processing: A Computer-Based Approach," 4th ed. Boston, MA: McGraw-Hill Education, 2010.
3.	Proakis, J. G., and Manolakis, D. G., "Digital Signal Processing: Principles, Algorithms, and Applications," 4th ed. Upper Saddle River, NJ: Prentice-Hall, 2006.
Online Resources:	
1.	Principles of Signals and Systems, Prof. Aditya K. Jagannatham, IIT Kanpur https://onlinecourses.nptel.ac.in/noc20_ee15/preview

Course Code	Course Title					Type of Course
PHY202C	Engineering Electromagnetics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Engineering Science

Course Objectives: The main objective of this course is to build mathematical and analytical abilities in electromagnetics and familiarize students with related concepts, including Maxwell's equations.

Course Outcomes: After studying this course, students will be able to:

1. Understand the basic mathematical concepts related to electromagnetic vector fields.
2. Apply the principles of electrostatics to the solutions of problems relating to electric field and electric potential, boundary conditions, and electric energy density.
3. Apply the principles of magnetostatics to the solutions of problems relating to magnetic field and magnetic potential, boundary conditions, and magnetic energy density.
4. Understand the concepts related to Faraday's law, induced emf, and Maxwell's equations.
5. Apply Maxwell's equations to solutions to problems relating to transmission lines and uniform plane wave propagation

MODULE I

Vector Analysis: Scalars and Vectors, Vector Algebra, Cartesian coordinate system, Vector Components, and unit vectors. Scalar field and Vector field. Dot product and Cross product, Gradient of a scalar field. Divergence and Curl of a vector field. Coordinate systems: cylindrical and spherical, relation between different coordinate systems. Expression for gradient, divergence, and curl in rectangular, cylindrical, and spherical coordinate systems. Divergence theorem, Stoke's Theorem.

MODULE II

Electrostatics I: Coulomb's law, Electric field intensity and its evaluation for (i) point charge (ii) line charge (iii) surface charge (iv) volume charge distributions. Electric flux density, Gauss law, and its applications. Electric field due to dipole. Energy density in the electrostatic field.

MODULE III

Electrostatics II: Energy expended in moving a point charge in an electric field. The line integral. Definition of potential difference and potential. The potential of a point charge and of a system of charges. Potential gradient. Poisson's equation, Laplace's equation, and Maxwell's first equation (Electrostatics). Energy associated with electrostatic fields, dielectrics in static electric fields. Boundary conditions for electrostatic fields.

MODULE IV

Magneto-static fields: Introduction, Biot-Savart's law (Ampere law for forces); Magnetic flux density, Magnetic field intensity, Ampere Circuital Law, magnetic scalar and vector potential, Inductor, magnetic induction, and Faraday's law. Time-varying fields: Review of Maxwell's equations, Boundary conditions, Time-varying field equations, Solution of wave equation in free space.

MODULE V

Electromagnetic waves: Introduction, wave equation for conducting media, uniform plane wave propagation, wave propagation in lossless and conducting mediums; wave propagation in good conductors, Skin depth penetration, wave propagation in good dielectrics, wave polarization, reflection and refraction of plane waves at plane Boundary (perfect conductor-normal incidence), Poynting vector and Poynting theorem.

Text Books:	
1.	Engineering Electromagnetics, William H Hayt et al. McGraw Hill 8th Edition, 2014.
2.	Introduction to Electrodynamics by Davis J. Griffiths, Pearson, 3rd Edition.
Reference Books:	
1.	Electromagnetic Field Theory, Rohit Khurana Vikas Publishing 1st Edition,2014
2.	Electromagnetics, J. A. Edminister McGraw Hill 3rd Edition, 2010
3.	Electromagnetic Field Theory, by L. Dutta and S. P. Ghosh, McGraw Hill, 2017.

Course Code	Course Title					Type of Course
ECE213C	Analog Electronics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Professional Core

Course Objectives: Upon completion of the course, students will possess a solid foundation in electronics, capable of designing and working with power supplies, amplifiers, feedback systems, oscillators, filters, comparators, and various waveform shaping circuits.

Course Outcomes: After studying this course, students will be able to:

1. Understand the linear and switch mode power supplies, basic rectifier circuits along with the filters and regulators
2. Learn about various power amplifier configurations and to analyze and design various power amplifier circuits for specific applications.
3. Understand the concept of feedback in electronic circuits and to design and analyze different oscillator circuits.
4. Learn and understand the OPAMP, its characteristics, and various applications.
5. Design and analyze various filter circuits using OPAMP, have a basic understanding of comparators, Schmitt triggers, and multi-vibrators.

MODULE I

Linear and Switch Mode Power Supplies: Constituents of a linear power supply, designing main transformer, Half wave and full wave rectifier circuits and their characteristic parameters, Filters: inductor filter, capacitive filter, LC filter, CLC filter, Regulators, Switch mode power supplies, Buck and boost regulators.

MODULE II

Power Amplifiers: Introduction- definitions and amplifier types, series fed class A amplifier. Transformer-coupled class A amplifier, Class B amplifiers, transformer-coupled push-pull amplifier circuit, class C and class D amplifiers.

MODULE III

Feedback and Oscillator Circuits: Feedback concept, advantages of negative feedback, feedback connection types, Oscillator theory, Barkhausen Criteria, RC phase shift Oscillator, LC Oscillator, Wien bridge Oscillator, Hartley Oscillator, Colpitts Oscillator.

MODULE IV

Operational Amplifiers and their Applications: Ideal OPAMP versus practical OPAMP, OPAMP characteristics, CMRR, Inverting & Non-Inverting Amplifier, Unity/Voltage follower, Summing & Subtracting Amplifier, Integrator & Differentiator Amplifier, Instrumentation Amplifier, voltage to current converter, current to voltage converter using OPAMP.

MODULE V

Filters, Comparators and Wave Shaping Circuits: Active filters: Low pass, High pass, Band pass, All Pass using OPAMP, Butterworth first & Second order filter, Comparators -Inverting & Non-Inverting Schmitt Trigger, Multi-vibrators: A-stable, Mono-stable & Bi-stable multi-vibrators.

Text Books:	
1.	Electronic Devices and Circuit Theory by Boylestead and Nashelsky, 4th Edition, Longman Higher Education.
2.	Electronic Devices and Circuit by Anil K. Maini and Varsha Agarwal, 2nd Edition, Wiley Publications.
3.	Integrated Electronics by Millman & Halkias, 2nd Edition, Tata McGraw Hill Publications.
Reference Books:	
1.	Electronic Circuits: Discrete and Integrated by D. Schelling and C. Belove, 3rd Edition, Tata McGraw Hill Publications.
2.	Electronic Circuits and Applications by Bernard. Grob, Tata McGraw Hill Publications.
3.	Microelectronic Circuits: Theory and Applications, Adel S. Sedra, Kenneth C. Smith, Arun N. Chandorkar, Oxford University Press.
4.	Electronic Circuits: Analysis and Design by Donald A Neamen, 3rd Edition, McGraw Hill Education.

Course Code	Course Title					Type of Course
PHY201C	Electrical Engineering Materials					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Professional Core
Course Objectives: To provide a basic understanding of the electric and magnetic properties of materials used in electrical engineering. This course also introduces the concepts of smart materials and superconductivity.						
Course Outcomes: Upon completion of this course, students will be able to: 1. Learn about the electrical materials used in electrical systems and machines. 2. Acquire knowledge of Dielectric Properties of Insulators 3. Apply concepts of Magnetization of matter, Magnetic Material Classification, Ferromagnetic Origin, Zero resistance and Meissner Effect, critical current density. 4. Acquire knowledge of the classification of semiconductors, semiconductor conductivity, temperature dependence, Carrier density, and energy gap, and trends in materials used in Electrical Equipment. 5. Acquire knowledge of superconductivity and design the electrical systems with proper materials for maximum efficiency.						

MODULE I

Conducting Materials: Review of metallic conduction based on free electron theory, Fermi-Dirac distribution – variation of conductivity with temperature and composition, materials for electric resistors- General Electric properties, material for brushes of electrical machines, lamp filaments, fuses, and solder.

MODULE II

Dielectric materials: Matter polarization and Relative permittivity: Relative permittivity, Dipole moment, Polarization vector, Local field, Types of Polarization: Electronic polarization, Ionic polarization, Orientational polarization, Interfacial polarization, Dielectric losses: Frequency dependence, Dielectric breakdown in solids, Ferroelectricity and Piezoelectricity.

MODULE III

Magnetic and Insulating materials: Magnetism, magnetic properties of materials, B-H curve, diamagnetic, paramagnetic, and ferromagnetic materials, CRGO and HRGO steel. Ferromagnetism and anti-ferromagnetism, ferrites, and other magnetic materials. Inorganic materials (mica, glass, porcelain, asbestos), organic materials (paper, rubber, cotton silk fiber, wood, plastics, and bakelite), resins and varnishes, liquid insulators (transformer oil), gaseous insulators (air, SF6, and nitrogen) and aging of insulators, mica-based materials, ceramic materials.

MODULE IV

Semiconductors: Conductivity of intrinsic semiconductors. Hall effect and carrier densities. Quantum Hall effect (Qualitative idea only). Drift currents and diffusion currents; Einstein relation. The continuity equation for minority carriers. Semi-quantitative discussion of the n-p junction rectifier, Quantitative treatment of the n-p junction rectifier. Thickness and capacitance of the junction barrier.

MODULE V

Materials For Special Applications: Introduction to smart materials, Materials for solar cells, fuel cells, and batteries. Materials for coatings for enhanced solar thermal energy collection and solar selective coatings, Cold mirror coatings, heat mirror coatings, anti-reflection coatings, sintered alloys for breaker and switch contacts, Superconductivity, properties of superconductors, critical field, Meissner effect, Type-I, and Type-II superconductors.

Text Books:	
1.	Electrical Engineering Materials by A. J. Dekker, Prentice-Hall, 1959.
2.	Solid State Physics by M. A. Wahab, Narosa Publications, 3rd Edition
Reference Books:	
1.	Principles of Electrical Engineering Materials and Devices by Kasap S. O., McGraw Hill, New York, 2000.
2.	Kittel's Introduction to Solid State Physics by Charles Kittel, Wiley India
3.	Solid State Physics by Adrianus J. Dekker, Red Globe Press London
4.	Solid State Physics by S. O. Pillai, 10th Edition, New Age Publications.

Course Code	Course Title					Type of Course
ELE208C	Introduction to Matrix Programming					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	0	0	2	2	1	Professional Core
Course Objectives: To provide the introduction and examples to students about the basic programming in MATLAB and develop their skillset in MATLAB programming						
Course Outcomes: Upon completion of this course, students will be able to: 1. Familiarization with the basic MATLAB environment and tools. 2. Learn different matrix operations and manipulation. 3. Understand the logic and syntax of programming with examples of different functions. 4. Applying the programming skills in designing new polymorphic functions. 5. Visualize various functions using plotting commands.						

MODULE I

Introduction to MATLAB: Layout, Command Window, Workspace, Current directory, functions of various windows, docking, and undocking of windows, Help in MATLAB. Simulink: Simulink Library and basic model design in Simulink.

MODULE II

Basics of programming: Rules for coding, syntax, variable types, initializing variables, editor programs, and operators. Matrices and Arrays: Arrays and matrices entries, manipulation of arrays and matrices, operations on matrices, transpose and inverse of a matrix, Displaying output data.

MODULE III

Building Codes with MATLAB: Control Flow/Branching Statements: If – else statements, switch – case construct, related examples. Loops: While and for loop, nested loops, break and continue statements, and related examples.

MODULE IV

Functions and Subfunctions: How to define a function, Simple examples to demonstrate the use of user-defined functions, Nested functions, and Polymorphic functions.

MODULE V

Errors and Plotting: Different types of errors and debugging of a program. Plotting: Simple 2D Plots (line color, line style, markers, legend, labeling axes, title, controlling axes), multiple plots on the same figure, multiple figures, subplots, Logarithmic and Polar plots, 3D Plots.

Text Books:	
1.	*Getting Started with MATLAB: A Quick Introduction for Scientists & Engineering* by Rudra Pratap, Oxford Press, 2010.
Reference Books:	
1.	*MATLAB Programming for Engineers*, Stephen J Chapman, Cengage Publishers.
2.	MATLAB For Dummies, Jim Sizemore and John Mueller

Course Code	Course Title					Type of Course
MTH204C	Advanced Engineering Mathematics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Basic Science

Course Objectives: Develop an ability to model, analyze and solve engineering problems using differential equations and transform methods for differential equations. Develop an understanding of complex analysis.

Course Outcomes: Upon completion of this course, students will be able to:

1. Understand the Laplace transform and its properties.
2. Apply the Laplace and inverse Laplace transformations to solve problems described by linear ODEs.
3. Understand partial differential equations (PDEs), the general and particular structure of solutions, and different methods for solutions.
4. Apply PDEs for modeling and analysis of real-world problems.
5. Evaluate integrals along a given path and compute the Taylor and Laurent expansions of complex functions.

MODULE I

Laplace transform and its properties: Definition and properties of Laplace transform - linearity, shifting. Laplace transform of standard signals - Unit step function, Dirac Delta function, periodic functions, Laplace transforms of derivatives and integrals. Second shifting theorem.

MODULE II

Inverse Laplace transform and applications: Inverse Laplace transforms- initial and final value theorems. Convolution theorem and its applications. Use of Laplace transforms in the solution of linear ordinary differential equations.

MODULE III

Partial differential equations and applications: Familiarities with different types of linear and nonlinear PDEs - Examples of PDEs arising in vibrating strings, heat transfer, conservation laws, and spread of epidemics.

MODULE IV

Solving Partial differential equations using analytical methods: Solutions of PDEs using separation of variables, D' Alembert's solution of the wave equation, Solution by Fourier series and Fourier transforms.

MODULE V

Complex analysis: Complex variables, analytic functions, Cauchy Riemann equations. Complex integration, Cauchy's fundamental theorem, Cauchy's integral formula, Cauchy's inequality, and Liouville's theorem. Expansions and Series in calculus: Taylor's & Laurent's expansions, Zeros & poles of analytic functions, Residues.

Text Books:	
1.	Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, John Wiley and Sons Inc.
Reference Books:	
1.	Saff E. B., Snider A. D., *Fundamentals of Complex Analysis for Mathematics, Science, and Engineering*, Prentice Hall India, New Delhi.
2.	Spiegel, Laplace Transforms, Schaum Series.
3.	Churchill R. V., *Complex variables and applications*, McGraw Hill Education (India).
4.	Snedden N., *The use of Integral Transforms*, McGraw Hill Education (India).
5.	*Linear Partial Differential Equation for Scientists and Engineers*, Tyn Myint-U and Lokenath Debnath, Springer, Indian reprint, 2006.

Course Code	Course Title					Type of Course
ECE214C	Analog Electronics Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	0	0	2	2	1	Professional Core

Course Objectives: By the end of the course, students should have gained a strong foundation in electronics, circuit analysis, and the practical use of various electronic components and instruments. They should be able to design, analyze, and construct basic electronic circuits using the concepts and skills learned throughout the course.

Course Outcomes: After studying this course, students will be able to:

1. Gain familiarity with essential electronic instruments like CRO (Cathode Ray Oscilloscope), Multi-meter, Function Generator, Regulated Power Supply, Active and Passive Components, and Breadboard.
2. To understand and analyze the Voltage-Current characteristics of diodes, half-wave, and full-wave rectifiers, particularly their behavior in forward and reverse bias.
3. To understand the concept of power amplification, explore the concept of negative feedback in electronic circuits and study oscillator circuits that generate continuous waveforms.
4. To learn about the operational amplifier (OPAMP) and understand its key characteristics, such as gain, bandwidth, input impedance, and output impedance, and to study various operational amplifier configurations, including inverting amplifier, non-inverting amplifier, summing amplifier, Subtractor, integrator, and differentiator.
5. Design and analyze different types of filters using operational amplifiers to Experimentsmanipulate signal frequencies and to study the construction and working principles of multi-vibrator circuits.

List of Experiments:

1. To get familiar with the working knowledge of the following instruments: CRO, multimeter, function generator, regulated power supply, active and passive components, and breadboard.
2. Study of V-I characteristics of the diode.
3. To study and obtain the characteristics of half-wave and full-wave rectifiers.
4. To study and obtain the characteristics of rectifier filter circuits.
5. To study the power amplification using power amplifiers
6. To study the negative feedback concept using Oscillator circuits
7. To study and determine OPAMP characteristics
8. Use of OPAMP as an inverting amplifier, non-inverting amplifier, summer, Subtractor, integrator, and differentiator
9. Design of low pass, high pass, band pass, and all pass filters using OPAMP.
10. To study the construction and working of A-stable, Mono-stable & Bi-stable multi-vibrators.

4th Semester

Course Code	Course Title					Type of Course
ELE256C	Electrical Machines-I					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	1	0	4	4	Professional Core

Course Objectives: Upon completion of the course, students will possess a deep and practical understanding of magnetic circuits, transformers, three-phase systems, DC generators, and DC motors. They will be equipped with both theoretical knowledge and hands-on skills to analyze, control, and operate these electrical machines effectively in various engineering applications.

Course Outcomes: After studying this course, students will be able to:

1. Get acquainted with magnetic circuits, constructional features of transformers, electromotive force (e.m.f.) equation, equivalent circuit model, phasor diagrams, losses, efficiency, and voltage regulation of transformers.
2. Learn how to carry out different tests on transformers and parallel operation of transformers. To get familiar with Autotransformers, distribution and power transformers, three-phase transformers, and their different types of connections.
3. Understand the principles of operation, construction, windings, types, power stages, efficiency, commutation and armature reaction in DC generators and DC motors, torque equation, and electric braking of DC motors.
4. Analyze different types of DC generators and DC motors, their characteristics, and their industrial applications.
5. Design the speed controlling techniques for various DC motors, the purpose of the starter in DC motors, and its design.

MODULE I

Single-phase Transformers: Fundamentals of magnetic circuits, magnetization curves, introduction to transformers, classification and construction of transformers, electromotive force (e. m. f.) equation, equivalent circuit model, phasor diagrams, KVA rating, losses and efficiency, voltage regulation.

MODULE II

Transformer tests and other types of Transformers: Transformer tests: polarity test, open circuit test, and short circuit test. Sumpner's back-to-back test, All day efficiency. Instrument transformers (Introduction), parallel operation of transformers, Autotransformers, saving of copper in autotransformers, distribution transformers, and power transformers.

MODULE III

Three-phase Transformers: Construction of three-phase transformers, different types of Connections: Star-Star, Star-Delta, Delta-Star, Delta-Delta, Vector group of transformers. Open delta connection, Scott connection, phase conversions: Three-phase to two-phase conversion and two-phase to three-phase conversion.

MODULE IV

DC Generators: Introduction & principle of operation of DC Generators, construction of DC Generators, types of DC Generators, EMF equation, types of windings, power stages and efficiency, commutation and armature reaction, characteristics of DC Generators, applications of DC Generators.

MODULE V

DC Motors: Principles of operation of DC Motors, construction of DC Motors, types of DC Motors, Back EMF and torque equation, torque and speed of DC Motors, characteristics of various types of DC motors, speed control of DC motors, starting and electric braking. Performing the different tests to determine the efficiency of DC motors.

Text Books:	
1.	*Electric Machinery Fundamentals* by Chapman, McGraw Hill Education.
2.	*Electrical Machinery* by P. S. Bhimbra, Khanna Publishers.
3.	*Electric Machines* by Nagrath and Kothari, McGraw Hill Education.
Reference Books:	
1.	*Electric Machinery and Transformer* by Guru, Hiziroglu, Oxford University Press.
2.	*Electric Machinery* by Fitzgerald, Kingslay, Umans, McGraw Hill Education.
3.	*Electrical Machines and Transformers* by Irving Kosov.
4.	*Electrical Machinery* by Charles S. Siskins
Online Resources:	
1.	Electrical Machines-I by Prof. Tapas Kumar Bhattacharya, IIT Kharagpur https://nptel.ac.in/courses/

Course Code	Course Title					Type of Course
ELE257C	Data Science with Statistical Foundations					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	2	0	2	3	3	Engineering Science

Course Objectives: This course would enable students to acquire a strong foundation in fundamental statistical concepts and train them to employ Python/MATLAB to propose data-driven solutions through techniques like regression analysis, model selection, and correlation assessment.

Course Outcomes:

1. Understand fundamental statistical concepts, including measures of central tendency (mean, median, mode), measures of variation (variance, standard deviation), statistical moments, skewness, and kurtosis.
2. Apply Python/MATLAB to explore data types, collect data from various sources, perform sampling techniques, and visualize datasets for effective analysis.
3. Analyze statistical distributions, probability theorems, and conditional probability.
4. Analyze moment-generating functions to calculate moments of random variables.
5. Develop a statistical mindset for problem-solving in real-world scenarios and propose data-driven solutions using Python/MATLAB for regression analysis, model selection, and correlation evaluation.

MODULE I

Basic statistical concepts and terminology: Measures of Central Tendency (mean, median, mode), Measures of variations (variance, standard deviation), Statistical moments for measuring shape and distribution of datasets, Skewness and Kurtosis to measure asymmetry and peakedness. Moment generating functions.

MODULE II

Introduction to Data Science and Statistical Thinking-I: Understanding different data types (numeric, categorical, textual) used in data science. Exploring various sources of data, such as databases, APIs, and web scraping. Data Collection and Sampling Techniques: Strategies for data collection, including surveys, experiments, and observational studies.

MODULE III

Introduction to Data Science and Statistical Thinking-II: Learning about sampling methods and their importance in obtaining representative data. Data Exploration and Visualization: Techniques for exploring and summarizing datasets using statistical and visual methods. Statistical Thinking and Problem Solving: Developing a statistical mindset to approach data-driven problem-solving. Applying statistical thinking in real-world scenarios to make informed decisions.

MODULE IV

Probability and Statistical Distributions: Fundamental concepts of probability theory, Statements and Proofs of theorems on addition and multiplication of probabilities, Conditional probability, and Bayes' theorem. Commonly used statistical distributions (e.g., normal, binomial).

MODULE V

Regression Analysis and Correlation: Understanding the concept of regression analysis. Simple linear regression and multiple linear regression. Least Squares Method: Fitting a regression line to data using the least squares method. Assessing the goodness of fit. Polynomial Regression: Extending regression analysis to polynomial models. Model selection and overfitting. Correlation Analysis: Understanding correlation and its significance.

Lab exercises:

1. Introduction to Python, Data types in Python, installing relevant libraries in Python. Load a real-world dataset (e.g., CSV file) using Python's Pandas or MATLAB's data import functions.
2. Write a Python/MATLAB function to calculate the mean, median, and mode of a given dataset. Apply the function to real datasets and analyze the differences between these central measures.
3. Computing Measures of Variations: Create a Python/MATLAB function to compute the variance and standard deviation of a dataset. Use the function to compare the variability of two datasets and visualize their spread.
4. Analyzing Skewness and Kurtosis: Implement Python/MATLAB code to calculate the skewness and kurtosis of a dataset. Identify and discuss the implications of positive/negative skewness and excess kurtosis.
5. Data Visualization: Create various plots, such as histograms, box plots, and scatter plots, to visualize data distributions and relationships. Analyze the visualizations to draw conclusions about the dataset's characteristics and identify potential outliers.
6. Simple linear regression: Load a dataset with two numerical variables, develop Python/MATLAB functions to perform simple linear regression and calculate the regression coefficients. Use the least squares method to fit the regression line to the data and visualize the results. Analyze the goodness of fit using measures like the coefficient of determination (R-squared) and residual plots.
7. Multiple Linear Regression: Prepare a dataset with multiple numerical predictors and a response variable, create Python/MATLAB scripts to perform multiple linear regression, and estimate the model coefficients.
8. Polynomial Regression and Overfitting: Implement Python/MATLAB code to fit polynomial regression models of different degrees to the data. Evaluate the performance of different polynomial models using metrics like mean squared error (MSE).
9. Correlation Analysis: Compute the Pearson correlation coefficient between two variables in a Python/MATLAB dataset. Create scatter plots to visualize the relationship between the variables. Interpret the correlation coefficient and its significance in terms of the strength and direction of the relationship.

Text Books:	
1.	J. VanderPlas, *Python Data Science Handbook: Essential Tools for Working with Data*, O'Reilly Media, 2016.
2.	D. C. Montgomery, G. C. Runger, *Applied Statistics and Probability for Engineers*, 7th ed., Wiley, 2017.

Course Code	Course Title					Type of Course
ELE258C	Control System Principles					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	1	0	4	4	Professional Core

Course Objectives: This course aims to impart a comprehensive understanding of control systems. It covers fundamental control concepts, system modeling in both frequency and time domains, time response analysis of Linear Time-Invariant (LTI) systems, reduction techniques for complex systems, and stability studies. By the end of the course, students will possess a strong foundation in control principles, modeling, analysis, and stability, equipping them to apply these skills in diverse engineering contexts.

Course Outcomes: After studying this course, students will be able to:

1. Define and explain control systems terminology, basic structure, and classification.
2. Develop mathematical models for physical systems using transfer functions and state-space representations.
3. Apply reduction techniques to simplify multiple subsystems.
4. Evaluate time-domain and frequency-domain characteristics of systems for standard input functions.
5. Evaluate the stability of control systems using different stability criteria, such as BIBO stability and asymptotic stability.

MODULE I

Introduction to the Control Problem: Control systems terminology and basic structure; History of control systems; Examples and classification; The control objectives; System configuration: open-loop and closed-loop systems; Genesis and essence of feedback control theory; Laplace transform review; Standard test signals; Linear time-invariant (LTI) systems; Impulse response; The transfer function; The general state-space representation; converting a transfer function to state-space and vice-versa; State-space for multiple-input multiple-output (MIMO) systems.

MODULE II

Modeling Strategies: Modeling in Frequency Domain: Models of electrical systems; Models of mechanical systems, models of thermal systems; Models of hydraulic systems; Transfer function for systems with gears; Electromechanical systems; DC Motor speed control, DC Motor position control; Modeling in Time Domain: The general state-space representation, Choice of state-variables; Minimum number of state-variables; Applying the state-space representation in electrical circuits with dependent sources; State-space representation of translations systems; Linearization of cart inverted pendulum using state-space.

MODULE III

Time response of LTI Systems: Introduction; Poles and zeros of transfer functions; pole-zero map and the complex plane; First-order systems and the time constant; Characteristics of first-order systems; Second-order systems; Characteristics of second-order systems; Steady state errors and

error constants; System with more poles and zeros; Effects of nonlinearities upon time response; Laplace transform solution of state equations; Time domain solution of state equations; Computation of matrix exponentials using Laplace transforms and Jordan Normal form; Cayley-Hamilton theorem; Solutions to homogeneous and non-homogenous cases; Eigen values and Eigen vectors.

MODULE IV

Reduction of Multiple Subsystems: Block diagram representation of systems; Signal flow graphs; Reduction using Mason's rule; Signal-Flow graphs of State-equations; Alternate representations in state-space; First and second companion forms of state-space models; Jordan's canonical form with state diagram; Similarity transformations; Diagonalizing a system in state-space.

MODULE V

Stability Studies: The concept of stability; BIBO stability; Relation between characteristic equation roots and BIBO stability; Asymptotic stability; Routh-Hurwitz stability criterion; Stability design with Routh-Hurwitz; Relative stability analysis; Stability in state-space; Controllability and Observability; Reachability and Sterilizability.

Text Books:	
1.	*Control Systems Engineering* by Norman S. Nise, John Wiley and Sons.
2.	*Control Systems–Principles and Design* by M. Gopal, Tata McGraw-Hill Ltd.
Reference Books:	
1.	*Feedback Control of Dynamic Systems*, Franklin and Powel, Prentice Hall.
2.	*Control Systems*, A. Anand Kumar, PHI Learning Private Limited.
3.	*Modern Control Engineering* by Katsuhiko Ogata, Prentice Hall of India Pvt. Ltd
Online Resources:	
1.	Control Engineering by Prof. M. Gopal, IIT Delhi https://nptel.ac.in/courses/108102043
2.	Systems & Control Lecture Notes, MIT Spring 2013 https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/

Course Code	Course Title					Type of Course
ELE259C	Electrical Measurements					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	1	0	4	4	Professional Core

Course Objectives: This course aims to develop a foundational understanding of measurement principles and error analysis. Students may further learn methods for measuring inductance, capacitance, resistance, and frequency using AC bridges. Students will be able to calculate power, power factor, and energy in AC circuits. Further, students may learn to use CRO to determine the frequency, time, phase, and amplitude of a signal.

Course Outcomes: After studying this course, students will be able to:

1. Learn about different standards of measurement and evaluate errors in measurement.
2. Study and understand the construction and principle of operation of various electromechanical indicating instruments and their mathematical analysis.
3. Evaluation of Inductance, Capacitance, and Frequency using AC bridges and analysis of small, medium, and large resistances using different methods.
4. Evaluation of power, energy, and power factor of single and three-phase circuits.
5. Learn how to use CRO for the measurement of frequency, time, and phase amplitude of a signal.

MODULE I

Introduction to Measurements & Unit System: Units & dimensions, Standards for measurement, Errors and their types, Error analysis, Accuracy & precision, Dead band & Dead zone, Resolution, Sensitivity, Classification of instruments- absolute, secondary, indicating, recording, integrating.

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MODULE II

Electro-mechanical Indicating Instruments: Basic principles and their classification, various methods of damping, galvanometers (D'Arsonal and Ballistic) Ammeters and Voltmeters (PMMC, Induction, Electrostatic and Dynamometer type), errors in voltmeters and ammeters, extension of instrument ranges. Current transformer (CT) and Potential transformer (PT) - theory, ratio and phase angle error, characteristics, effect of power factor, secondary burden.

MODULE III

Measurement of Resistance: Classification of Resistance, Measurement of Low resistance using potentiometer method and Kelvin double bridge, Measurement of medium resistance using ammeter voltmeter method, substitution method, Wheatstone bridge, Measurement of high resistance using loss of charge method, Meggar.

MODULE IV

Measurement of Capacitance, Inductance and Frequency: Measurement of Inductance, Capacitance, and Frequency using A.C bridges. CRO: Construction and working. Phase, time, frequency, and amplitude of a signal using CRO, DSO.

MODULE V

Measurement of Power & Energy: Power in AC circuits, construction, and operation of dynamometer and induction type of wattmeter, Measurement of power using wattmeter for single phase circuits and three phase circuits, Measurement of reactive power. Measurement of Energy: Single-phase induction type watt-hour meter, Poly-phase watt-hour meter.

Text Books:	
1.	Electrical Measurements and Measuring Instruments by E. W. Golding and F. C. Widdis, JOBS Publications.
2.	A Course in Electrical and Electronic Instruments and Measurements by A. K. Sawhney, Dhanpat Rai and Sons, Delhi.
Reference Books:	
1.	Electronic Instruments and Measurements by W. D. Cooper & A. D. Helfric, Prentice Hall of India, New Delhi.
2.	A Course in Electronics and Electrical Measurements and Instrumentation, J. B. Gupta, K. S. Kataria & Sons.

Course Code	Course Title					Type of Course
ECE263C	Digital Electronics and Logic Design					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	0	0	3	3	Professional Core

Course Objectives: This course is intended to introduce the students to the concepts and practical framework of the operation, application, and troubleshooting of electronic logic devices, combinatorial and sequential logic circuits, logic family interfaces, and digital-analog circuit interfaces.

Course Outcomes: Upon completion of this course students will be able to:

1. Identify analog and digital electrical signals and explain the operation of digital logic gates.
2. Convert numbers between decimal, binary, octal, and hexadecimal number systems.
3. Apply Boolean algebra to express logic operations as equations and Karnaugh maps to minimize (simplify) Boolean equations.
4. Identify and design combinatorial logic circuits and sequential logic circuits and explain their operation.
5. Identify, explain, and design various types of flip-flops, counter circuits, shift registers, and other logic circuits.

MODULE I

Introduction to Digital Electronics: Number Systems and Codes: Binary, octal, and hexadecimal number systems, binary arithmetic, binary code, excess-3 code, gray code, error detection and correction codes. Boolean algebra: Postulates and theorems, logic functions and logic gates (AND, OR, NOT, NAND, NOR).

MODULE II

Combinatorial Logic: Boolean Algebra and Reduction Techniques: Boolean Algebra, Karnaugh Mapping, De Morgan's Theorem. Exclusive OR and Exclusive-NOR Gates. Arithmetic Operations and Circuits: Half Adder, Full Adder. Data Control Structures: Code Converters, Multiplexers and Demultiplexers.

MODULE III

Sequential Logic: Logic Families and their characteristics, Flip-Flops: SR, JK, T, D, Master/Slave FF, triggering of FF, Analysis of clocked sequential circuits-their design, state minimization, state assignment, circuit implementation, Registers: shift registers, inter-conversion of shift registers. Practical considerations for digital design.

MODULE IV

Timers, Interfacing with the Real World: Counter Circuits: Asynchronous Counters, Synchronous Counters. Shift Registers: Serial/Parallel Data Conversions, Specialized Counter

Circuits. Multivibrators and Timers: Astable, Monostable, Schmitt Trigger. Interfacing with the Real World: Analog-to-Digital, Digital-to-Analog, Signals and Signal Conditioning

MODULE V

PLD and logic families: Programmable Logic Devices (PLD's): Programmable Array Logic, Programmable Logic Array – GAL, CPLD. Logic Families: RTL, DCTL, I2L, DTL, HTL, TTL, ECL, circuit diagram and analysis, characteristics and specifications, tri-state gates, totem-pole configuration.

Text Books:	
1.	Morris Mano, Digital Logic and Computer Design, Prentice-Hall of India.
Reference Books:	
1.	Floyd T.L., Digital Fundamentals, Charles E. Merrill Publishing Company.
2.	Jain R.P., Modern Digital Electronics, Tata McGraw Hill.
3.	Ronald J. Tocci, Digital Systems, Principles and Applications, Prentice-Hall of India.

Course Code	Course Title					Type of Course
ELE260C	Electrical Machines-I Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	0	0	2	2	1	Professional Core

Course Objectives: Upon completing the course, students will have acquired hands-on skills in transformer testing, DC machine experimentation, and motor control techniques. They will be equipped to understand, analyze, and operate transformers and DC machines in practical engineering applications.

Course Outcomes:

1. Identify the physical components of the transformer, DC generator, and DC motor.
2. Determine and interpret the efficiency and regulation of a single-phase transformer.
3. To study three-phase connections on a bank of three single-phase transformers.
4. To analyze and plot different characteristics of a separately excited DC generator, DC shunt, and DC series generator and to study the voltage build-up of a DC shunt generator.
5. Connect, start, and run DC motors using suitable starters and analyze the torque-speed characteristics and speed control of DC motors by flux or field control and armature voltage control.

Experiments on Transformers:

1. To perform open circuit and short circuit tests on a single-phase transformer.
2. To perform a polarity test on a single-phase transformer.
3. To determine the efficiency and voltage regulation of a single-phase transformer.
4. To perform Sumpner's test on two identical transformers.
5. To study three-phase connections on a bank of three single-phase transformers

Experiments on Direct Current Machines:

1. To study various parts of a DC machine and draw sketches of the same.
2. To plot the saturation curve of a DC machine.
3. To plot the external characteristics of a separately excited DC generator.
4. To study the voltage build-up of a DC shunt generator.
5. To plot the external characteristic of a DC shunt generator and compare the characteristics with that of a separately excited generator.
6. Starting of the DC motor by using a starter.
7. Speed control of DC series and shunt motor by armature voltage control.
8. Speed control of DC shunt motor by flux or field control.

Course Code	Course Title					Type of Course
ELE261C	Electrical Measurements Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	0	0	2	2	1	Professional Core

Course Objectives: This course aims to make students familiar with different measurement devices to measure inductance, capacitance, resistance, and frequency. Students can determine the phase difference and frequency of a sinusoidal AC voltage using the Lissajous pattern in C.R.O. Students learn the industrial practices of testing underground cables.

Course Outcomes: After studying this course, students will be able to:

1. Understand the concepts of measurement, error, and uncertainty.
2. Study the constructional details of an electromechanical indicating instrument with the help of a demonstration type of instrument.
3. Analyze and examine the bridges for the measurement of resistance, inductance, and capacitance measurement.
4. Evaluate the Power using wattmeters.
5. Understand the industrial practices of testing in underground cables.

List of Experiments:

1. Calibration of AC Voltmeter and AC Ammeter.
2. To study the constructional details of electromechanical indicating instrument with the help of a demonstration type of instrument.
3. Measurement of Resistance (high, medium, low).
4. To measure insulation resistance using Meggar.
5. Measurement of Inductance and Capacitance using A.C bridges.
6. To Determine the value of unknown frequency using Wein's bridge.
7. Measurement of power in single-phase and three-phase circuits using a single-phase and three-phase wattmeter.
8. Measurement of three-phase reactive power using a single-phase wattmeter.
9. Measurement of phase difference and frequency of a sinusoidal AC voltage using Lissajous patterns in C.R.O.

Course Code	Course Title					Type of Course
ELE262C	Control Systems Principles Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	0	0	2	2	1	Professional Core

Course Objectives: This lab course aims to cover the practical knowledge of control systems. The lab experiments are carefully designed to impart a comprehensive understanding of control systems theory and practices.

Course Outcomes: After studying the course, students will be able to:

1. Apply theoretical knowledge to study the time-domain characteristics of linear and nonlinear systems.
2. Analyze the performance characteristics of first and second-order systems.
3. Obtain the transfer functions of several systems from measurements.
4. Evaluate time-domain and frequency-domain characteristics of systems for standard input functions.
5. Evaluate the stability of control systems using different stability criteria, such as BIBO stability and asymptotic stability.

List of Experiments:

1. To study the time response characteristics of first and second-order systems.
2. To define a system's transfer function and state-space models in MATLAB.
3. To obtain the closed-loop performance of systems and compare it with the open-loop response.
4. To find a given system's absolute stability, controllability, and observability in MATLAB.
5. To study the performance characteristics of a DC motor angular position control system.
6. To study the performance characteristics of a DC motor speed control system.
7. To study a linear variable differential transformer (LVDT) performance characteristics.
8. To study the torque-speed characteristics of an AC servomotor, determine its parameters, and evaluate its transfer function.
9. To study and analyze the light intensity control system.
10. To study the control of the magnetic levitation system.

Course Code	Course Title					Type of Course
ECE264C	Digital Electronics and Logic Design Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	0	0	2	2	1	Professional Core

Course Objectives: The purpose of this course is to provide students with an introduction to the fundamental principles and practical implementation related to the functioning, application, and troubleshooting of electronic logic devices. Additionally, the course will enhance the practical capabilities of students to design combinational and sequential logic circuits, logic family interfaces, and digital-analog circuit interfaces.

Course Outcomes: At the end of this course, students will demonstrate the ability to:

1. Understand the basic logic operations and combinational logic elements.
2. Have the realization of basic combinational functions.
3. Solve similar problems using different methods (logic gates).
4. Design and analyze combinational circuits.
5. Design and analyze synchronous sequential logic circuits.

List of Experiments:

1. **Familiarization of ICs:**
   a) To study the testing of AND Gate
   b) To study the testing of NAND Gate
   c) To study the testing of OR Gate
   d) To study the testing of NOR gate
   e) To study the testing of XOR gate

2. **Combinational Circuits**
   a) To study the sum of Product
   b) To study the product of Sum
   c) To study the Half Adder Using Logic Gates
   d) To study the 1 Bit Full Adder Using Logic Gates
   e) To study the implementation of Boolean Functions using MUX
   f) To study the BCD-to-Seven Segment Display

3. **Sequential Circuits**
   a) To study the J-K Flip flop
   b) To study the Up Counter
   c) To study the Shift Register
   d) To study the State Machine Implementation
   e) To study a BCD to 7 Segment LED display
   f) To study of Binary to Grey Code Converter

Course Code	Course Title					Type of Course
ELE263A	Seminar					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	0	0	0	-	0	Professional Core

Course Objectives: To study research papers for understanding of a new field and to summarise and review them. To identify promising new directions of various cutting-edge technologies. To effectively communicate by making an oral presentation before an evaluation committee

Course Outcomes: After completing the seminar, students will be able to:

1. Identify and analyze the real time system problems
2. Acquire awareness on latest technology and current trends in the field of respective areas
3. Document and present technical reports
4. Participate in discussions for enhancement of knowledge
5. Adapt professional ethics

5th Semester

Course Code	Course Title					Type of Course
ELE302C	Electrical Machines-II					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	1	0	4	4	Professional Core

Course Objectives: Upon completion of the course, students will possess a deep and practical understanding of rotating machines, including three-phase induction motors, single-phase, fractional kilo-watt motors, synchronous generators, and synchronous motors. They will be equipped to analyze, design, and operate these machines effectively in various industrial and engineering contexts.

Course Outcomes: After studying this course, students will be able to:

1. Get acquainted with the basics concepts of rotating machines and learn about the three-phase induction motor construction, types, slip, equivalent circuit, torque/speed characteristics, losses, and efficiency, crawling and cogging.
2. Design various types of starters for three-phase induction motors and design the speed-controlling techniques for three-phase induction motors.
3. Analyze the starting and running performance of fractional Kilo-watt induction motors and double field revolving theory and develop the equivalent circuit of single phase induction motor based on double field revolving theory.
4. Learn and understand about the constructional features, types, and working principles of alternators and synchronous motors along with their equivalent circuits and phasor diagrams.
5. Evaluate and analyze the effect of load on the synchronous motor and able to obtain V and inverted V curves.

MODULE I

Basic Concepts of Rotating Machines: Rotating magnetic field produced by balanced three-phase and two-phase systems. Magneto-motive force and flux distribution, Induced voltage, Production of torque, Leakage fluxes. Introduction to three phase Induction motors. Principle of operation of an induction motor, Construction and Types of Induction motors.

MODULE II

Three-phase Induction Motors: Slip, slip speed, and synchronous speed of an induction motor. Similarities and dissimilarities of an induction motor with a transformer. Equivalent circuit, phasor diagrams on no load, full load, and at starting. Torque-speed characteristics, losses and efficiency, crawling and cogging, Induction motor tests, Starting of induction motors, and Speed control of induction motors.

MODULE III

Fractional Kilo-Watt Motors: Introduction to fractional Kilo-Watt motors, single phase induction motors. Double field revolving theory, Types of Single-phase induction motors,

Equivalent circuit of Single-phase induction motors, Shaded-pole Motor, Universal Motor. Application of single-phase fractional kilo-watt motors.

MODULE IV

Synchronous Generators (Alternators): Synchronous generators: Constructional features, types and working principle of alternators, EMF equation, types of windings, pitch factor, distribution factor and winding factor, leakage reactance, armature reaction, Equivalent circuit, phasor diagram, short circuit ratio (SCR), voltage regulation and its determination, Two-axis theory for salient type machines. Power angle equation and curve of cylindrical type and salient pole type synchronous machine.

MODULE V

Synchronous Motors: Introduction to synchronous motor. Principle of operation, starting, Equivalent circuit, Effect of load on the synchronous motor, Effect of varying excitation, Phasor diagram, different torques, V and inverted V curves, hunting, damper windings, Synchronous condenser/ synchronous phase Modifier.

Text Books:	
1.	Electric Machinery Fundamentals, S. J. Chapman, 4rth Edition, McGraw Hill Education.
2.	Electrical Machinery, P. S. Bhimbra, Khanna Publishers.
3.	Electric Machines, Nagrath and Kothari, 5th Edition, McGraw Hill Publishers.
Reference Books:	
1.	Electric Machinery and Transformer, Guru, Hiziroglu, Oxford University Press.
2.	Electric Machinery, Fitzgerald, Kingslay and S. Umans, McGraw Hill Education.
3.	Electrical Machines and Transformers by Irving Kosov.
4.	Electrical Machinery by S. K. Sen, Khanna Publishers.
Online Resources:	
1.	Electrical Machines-II by Prof. Tapas Kumar Bhattacharya, IIT Kharagpur https://nptel.ac.in/courses/

Course Code	Course Title					Type of Course
ELE304C	Elements of Power Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	1	0	4	4	Professional Core

Course Objectives: Introduce students to the basic concepts of electrical power systems, including generation, transmission, and distribution of electric power. Make them familiar with the general structure of the network for transferring power from generating stations to the consumers. To introduce the design aspects of power system transmission and distribution.

Course Outcomes: After studying this course, students will be able to:

1. Describe the components of a power system, including generators, transformers, transmission lines, and distribution networks.
2. Understand the fundamental concepts of electrical power systems, including voltage, current, power, and energy.
3. Apply mathematical formulas to calculate inductance, capacitance, voltage regulation, efficiency, and power in different power system elements.
4. Analyze and design the transmission and distribution network under various operating conditions.
5. Devise a comprehensive plan for integrating renewable energy sources into the existing power grid to improve its efficiency and stability.

MODULE I

Introduction to Power System: General Structure of Electrical Power System, Layout diagram of Power System, Overview of power generation and its significance, different voltage levels of power system, Advantages of high voltage transmission, Overhead and Underground Transmission System, Brief introduction to AC and DC transmission systems, Elements of AC distribution, Distribution Systems, Distributed generation, Smart grid, micro-grids.

MODULE II

Overhead Transmission System: Transmission line parameters, Types of overhead conductors- ACSR, Bundled and Stranded conductors, Calculation of inductance of single and double circuit line, Concept of GMR & GMD, Transposition of transmission conductors, Bundled conductors, Skin and Proximity effect, Calculation of capacitance of single and double circuit line, Effect of earth on capacitance of a transmission line.

MODULE III

Mathematical Modelling of Transmission Lines: Classification of transmission lines, Modelling and performance analysis of Short, Medium and Long transmission lines, ABCD parameters, Surge Impedance Loading (SIL)- Wavelengths and Velocity of propagation, Ferranti effect.

MODULE IV

Mechanical Design of Overhead Transmission Line: Calculation of sag and tension, Types of insulators and their applications, Voltage distribution over a string of insulators, String Efficiency & methods of its improvement. Corona, Critical disruptive voltage, Corona loss, Interference of power lines with communication lines.

MODULE V

Insulated Cables and Grounding: Classification of cables, Cable conductors, Insulating materials, Insulation Resistance, Electrostatic stress, Grading of cables, Capacitance calculation, Losses and current carrying capacity, Neutral grounding: Different types of grounding. Equipment Earthing.

Text Books:	
1.	Power System Analysis, J.J. Grainger and W.D Stevenson McGraw-Hill.
2.	Electric Power Systems, C.L. Wadhwa, New Age International.
Reference Books:	
1.	Power System Engineering, Nagrath and Kothari, Tata McGraw-Hill.
2.	Transmission and Distribution of Electrical Energy, H.Cotton, Hodder Arnold Publications.
3.	Power System Analysis, A. R. Bergen and V. Vittal, Pearson Education Inc.
4.	Electric Power Systems, B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, Wiley Publications.

Course Code	Course Title					Type of Course
ELE308C	Numerical Methods Using Scientific Computing					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	2	0	2	3	3	Engineering Science

Course Objectives: This course introduces fundamental numerical techniques and their practical applications through theory and lab practical. Students learn error analysis, numerical differentiation and integration, linear and nonlinear equation solving, and methods for ordinary and partial differential equations. Hands-on lab exercises using Python and MATLAB empower students with essential computational skills for real-world problem-solving.

Course Outcomes: After studying this course, students will be able to:

1. Understand the importance of MATLAB and Python in scientific computing.
2. Define and explain numerical approximation errors, including truncation and round-off errors, and their impact on numerical methods.
3. Apply Python packages, such as NumPy and SciPy, for numerical computations, data analysis, and plotting.
4. Apply and solve linear and nonlinear equations using iterative techniques.
5. Design and implement ODE solution methods, including explicit and implicit Euler's methods.

MODULE I

Introduction to Numerical Methods: What is numerical computing and why do we need it; Approximations Errors: defining errors and precision in numerical methods; truncation and round-odd errors; error propagation; global and local truncation errors.

Lab exercises: Introduction to Python packages for scientific computing; numerical computation in NumPy; Technical computing in SciPy; Getting started with MATLAB for numerical computation.

MODULE II

Numerical Differentiation and Integration: Numerical differentiation in single and multiple variables; numerical differentiation using Taylor Series expansion, Forward and backward difference schemes, central-difference scheme; Numerical Integration: Newton-Cotes integration formulae; Trapezoidal rule; Simpson's rule; Simpsons 3/8 rule.

Lab exercises: MATLAB functions for integrations; differential and integration using symbolic variables; Numerical derivative of noisy signals; SciPy package for numerical integration.

MODULE III

Numerical Methods for Linear and Nonlinear Equations: Linear algebra basics: Gauss elimination; LU decomposition and partial pivoting; direct solution methods of Ax=b; iterative

methods of Ax=b; eigenvalues and eigenvectors and solvability; Nonlinear equations: nonlinear equations in a single variable; Newton-Raphson method.

Lab exercises: MATLAB function *fzero* in a single variable; MATLAB function *fsolve* in single and multiple variables; Newton-Raphson in MATLAB and Python.

MODULE IV

Numerical Methods for Ordinary Differential Equations (ODE): Introduction to ODEs; linear and nonlinear ODEs; solution of homogeneous and non-homogeneous ODEs, implicit and explicit Euler's methods; second-order Runge-Kutta methods;

Lab exercises: MATLAB *ode45* algorithm in a single variable; Python's *odeint* algorithm in a single variable; higher-order Runge-Kutta methods; error analysis of Runge-Kutta methods.

MODULE V

Differential Equations – Practical aspects: Numerical stiffness in ODEs, System of ODEs, sources, and sinks, Matrix systems of differential equations; Higher order ODEs; Introduction to finite difference schemes for partial differential equations (PDEs).

Lab exercises: MATLAB *ode45* algorithm in multiple variables; MATLAB *ode15s* algorithm; a practical example of ODE-IVP; Getting started with PDE toolbox in MATLAB.

Text Books:	
1.	Robert Schilling and Sandra Harris, Applied Numerical Methods for Engineers using MATLAB and C-Thomson Learning, 2002.
2.	Fausett L.V. (2007) Applied Numerical Analysis Using MATLAB, 2nd Ed., Pearson Education
3.	Jaan Kiusalaas, Numerical Methods in Engineering with Python, Cambridge University Press, 2013.
Reference Books:	
1.	Sastry, S. S. "Introductory Methods for Numerical Analysis," Prentice Hall.
2.	Chapra S.C. and Canale R.P. (2006) Numerical Methods for Engineers, 5th Ed., McGraw Hill.
3.	Jain, M.K, R.K and Iyenger, S.R.K. "Numerical Methods for Scientific and Engineering Computations," New Age International Publication.
Online Resources:	
1.	Numerical methods by Prof. Sanjeev Kumar IIT Rookee https://archive.nptel.ac.in/courses/111/107/111107105/
2.	Numerical Methods for Engineers by Prof. Niket Kaisare IIT Madras https://archive.nptel.ac.in/courses/127/106/127106019/

Course Code	Course Title					Type of Course
ECE318C	Microprocessors and Microcontrollers					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	0	0	3	3	Professional Core

Course Objectives: To provide a solid foundation on the fundamentals of microprocessors and applications, interfacing the external devices to the processor according to the user requirements thus, enabling to create novel products and solutions for real-time problems.

Course Outcomes: After studying this course, students will be able to:

1. Assess and solve basic binary math operations using the microprocessor and explain the microprocessor's and Microcontroller's internal architecture and its operation within the area of manufacturing and performance.
2. Apply knowledge and demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor and microcontroller.
3. Compare accepted standards and guidelines to select the appropriate Microprocessor (8085 & 8086) and Microcontroller to meet specified performance requirements.
4. Analyze assembly language programs; select appropriate assemble into machine a cross assembler utility of a microprocessor and microcontroller.
5. Evaluate assembly language programs and download the machine code that will provide solutions real-world control problems.

MODULE I

Architecture of Microprocessors: General definitions of minicomputers, microprocessors, microcontrollers, Introduction to 8085 Microprocessor, 8086 Architecture-Functional diagram. Register Organization, Memory Segmentation. Programming Model, Physical memory organization, signal descriptions of 8086- common function signals. Minimum and Maximum mode signals. Timing diagrams. Interrupts of 8086.

MODULE II

Instruction Set and Assembly Language Programming of 8086: Instruction formats, addressing modes, instruction set, assembler directives, macros, simple programs involving logical, branch and call instructions, Looping, sorting, evaluating arithmetic expressions, string manipulations.

MODULE III

I/O Interface: 8255 PPI various modes of operation and interfacing to 8086. Interfacing keyboard, display, stepper motor interfacing, D/A and A/D converter, Memory interfacing to 8086, Interrupt structure of 8086, Vector interrupt table, Interrupt service routine, Interfacing Interrupt Controller 8259, DMA Controller 8257 to 8086, Serial data transfer schemes. 8251 USART architecture and interfacing, RS232.

MODULE IV

Architecture of Microcontrollers: 8051 Microcontroller hardware- I/O pins, ports and circuits-External memory – Counters and Timers-Serial Data I/O, Interrupts.

MODULE V

8051 Microcontroller Programming and Applications: 8051 instructions set – Addressing modes – Assembly language programming – I/O port programming -Timer and counter programming, 8051 interfacing: LCD, Stepper Motors, ADC - DAC and temperature sensor and Keyboard.

Text Books:	
1.	Ramesh S Gaonkar, Microprocessor Architecture, Programming and Application with 8085, 4th Edition, Penram International Publishing, New Delhi, 2000.
2.	John Uffenbeck, The 80x86 Family, Design, Programming and Interfacing, Third Edition. Pearson Education, 2002.
3.	Mohammed Ali Mazidi and Janice Gillispie Mazidi, The 8051 Microcontroller and Embedded Systems, Pearson Education Asia, New Delhi, 2003.
Reference Books:	
1.	A.K. Ray and K. M. Burchandi, Intel Microprocessors Architecture Programming and Interfacing, McGraw Hill International Edition, 2000.
2.	Kenneth J Ayala, The 8051 Microcontroller Architecture Programming and Application, 2nd Edition, Penram International Publishers (India), New Delhi, 1996.
3.	M. Rafi Quazzaman, Microprocessors Theory and Applications: Intel and Motorola Prentice Hall of India, Pvt. Ltd., New Delhi, 2003.
Web Resources	
1.	Nptel Web course on Microprocessor by Dr. Pramod Agarwal, IIT Roorkee. https://nptel.ac.in/courses/108/107/108107029/
2.	Nptel Web course on Microcontrollers and Applications by Dr. S. P. Das, IITKanpur. https://nptel.ac.in/courses/117/104/117104072/

Course Code	Course Title					Type of Course
ECO301C	Fundamentals of Economics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	0	0	3	3	Humanities & Social Science

Course Objectives: This course is intended to make students familiar with the basics of Economics. Accurately examine and analyze different economic concepts used in consumer behavior, producer behavior, and market structures. The students will be able to analyze and examine models through economic understanding.

Course Outcomes: After the completion of the course, the students will be able to

1. Understand the concepts of demand, supply, and its applications.
2. Understand and examine production and cost structure.
3. Analyze the behavior of firms under different market structures.
4. Grasp the core concepts of macroeconomics.
5. Be familiar with money and banking.

MODULE I

Introduction to Economics: Economics; Micro and Macroeconomics; Scarcity, choice, and Opportunity cost; Demand; Determinants and law of demand, Supply; Law of supply, Market equilibrium; Elasticity of demand; Price, Income, and Cross; Calculation of elasticities and their applications.

MODULE II

Production Function & Cost Structures: Production functions; short run vs long run; relation between Total, Marginal, and Average product; Isoquants; Meaning and properties; Cost and its types; Economies and Diseconomies of scale; Output maximization and cost minimization.

MODULE III

Market Structures: Market meaning and types; Price and output determination under perfectly competitive, Monopoly, and Monopolistic competitions; Oligopoly and its features; Decisions under uncertainty; Game theory and its applications.

MODULE IV

Macroeconomics: Concepts & Problems: Macroeconomics:- Nature and Meaning; Circular flow of income; National income; Concepts and measurements; GDP; Nominal vs. real; Unemployment and its Measurements, Inflation; Measuring inflation; Causes and consequences; The role of government in macroeconomic stability.

MODULE V

Money & Banking: Money-meaning and types; Demands for money- theories of demand for money; Supply of money and its measurements; Banking; Commercial banks; Central Bank and its functions.

Text Books:	
1.	*Principles of Economics*, Case K. E, Fair Ray C. and Oster S, Pearson Education.
2.	*Principles of Microeconomics,* N. Gregory Mankiw, South-Western Publication, 3rd Edition.
Reference Books:	
1.	*Principles of Engineering Economic Analysis*, White, Case, and Pratt. Wiley & Sons.
2.	*Engineering Economic Analysis*, Newnan, Eschenbach, Lavelle. Oxford.
3.	Samuelson P. A. & Nordhaus W. D., *Economics*, Tata McGraw-Hill 19th Edition, 2007
4.	Lipsey, R. G. & K. A. Chrystal, *Economics*, Oxford University Press, 11th Edition, 2007
5.	*Monetary Economics: Institutions, Theory & Policy*, Suraj B Gupta, S Chand & Company
6.	*Modern Microeconomics,* Anna Koutsoyiannis, Palgrave Macmillan.

Course Code	Course Title					Type of Course
ELE310C	Electrical Machines-II Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	0	0	2	2	1	Professional Core

Course Objectives: By the end of the course, students will possess a comprehensive understanding of induction motors, synchronous machines, and their operational characteristics. They will be equipped with both theoretical knowledge and practical skills to analyze and work with these machines effectively.

Course Outcomes: After studying this course, students will be able to:

1. Study different parts of a three-phase induction motor, single-phase induction motor, alternator, and synchronous motor.
2. Evaluate the equivalent–circuit parameters of three-phase and single-phase induction motors.
3. Analyze and determine the torque/speed characteristics of a three-phase induction motor and design various speed-controlling methods of induction motors.
4. Determine equivalent circuit parameters of an alternator and also its voltage regulation by different methods.
5. Analyze the behavior of synchronous motors at different loading conditions using V and inverted V curves.

List of Experiments:

1. To study the different parts of an Induction motor.
2. To determine the equivalent–circuit parameters of a 3-phase induction motor by no load and blocked rotor tests.
3. To determine the Torque-speed characteristics of a 3-phase Induction motor.
4. To determine the equivalent circuit parameters of a Single-phase Induction motor by no load and blocked rotor tests.
5. To study the construction of a synchronous machine.
6. To obtain the OCC and SCC of a synchronous machine.
7. To find the voltage regulation of an alternator by actual loading.
8. To obtain the V-curves and inverted V-curves of a synchronous motor.

Simulation-Based Experiments:

1. Production of RMF for the balanced two-phase and three-phase system in MATLAB.
2. To determine the torque-speed characteristics of an Induction machine in MATLAB.
3. To determine the voltage regulation and V-curves of a synchronous machine in MATLAB.

Course Code	Course Title					Type of Course
ELE311C	Elements of Power Systems Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	0	0	2	2	1	Professional Core
Course Objectives: To analyze the performance of power system networks by conducting various experiments through hardware and software.						
Course Outcomes: After studying this course, students will be able to: 1. Apply experimental values to calculate voltage drop, voltage regulation, efficiency, power, etc. 2. Analyze the performance of transmission and distribution lines and understand the ABCD parameters of a transmission line. 3. Acquire knowledge of substation, various electrical equipment, high voltage testing of electrical equipment, and flashover voltage testing of insulators. 4. Design and validate DC and AC distribution systems. 5. Apply the properties of insulated cables to evaluate the parameters and to design the 1-phase and 3-phase cables for underground system.						

List of Experiments:

1. To study different types of insulators.
2. Determine the potential distribution across different modules of a string of insulators with and without a guard ring.
3. To study different parts of an HT and LT cable.
4. To calculate the insulation resistance of a cable.
5. To determine the charging current of a cable.
6. To study different types of overhead conductors.
7. To determine the ABCD parameters of a transmission line.
8. To determine the voltage regulation and efficiency of a transmission line.
9. Demonstration of the Ferranti effect.
10. To design the AC distribution system
11. To determine the earth's resistance.

Simulation-based experiments:

1. To determine the transmission line parameters using MATLAB.
2. To determine the voltage regulation and efficiency of a transmission line using MATLAB.

Course Code	Course Title					Type of Course
ECE319C	Microprocessors and Microcontrollers Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	0	0	2	2	1	Professional Core

Course Objectives:
To Study the Architecture of 8085, 8086 microprocessor, and 8051 microcontroller and the design aspects of I/O and Memory Interfacing circuits.

Course Outcomes: After studying this course, students will be able to:

1. Demonstrate the programming concepts of 8085/8086/8051 for efficient coding.
2. Show the interfacing of different peripherals with 8086/8051.
3. Analyze the output of different peripherals when programmed in different modes using 8086/8051.
4. Develop the interfacing circuits for different applications with appropriate peripherals.
5. Design 8086/8051-based system for various real-time applications.

List of Experiments:

1. To study the architecture of 8085, 8086 & 8051 familiarization with its hardware, commands & operation of microprocessor
2. Programs for 16-bit arithmetic operations for 8086 (using Various Addressing Modes).
3. Program for sorting an array for 8086.
4. Program for string manipulations for 8086
5. Interfacing ADC and DAC to 8086
6. Interfacing to 8086 and programming to control stepper motor
7. Programming using arithmetic, logical and bit manipulation instructions of 8051.
8. Program and verify the Timer/Counter in 8051
9. Program and verify Interrupt handling in 8051
10. UART Operation in 8051
11. Interfacing LCD and keyboard to 8051
12. Develop any mini-project with processors.

6th Semester

Course Code	Course Title					Type of Course
ELE352C	Power Electronics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	1	0	4	4	Professional Core

Course Objectives: To introduce students to the basic theory of power semiconductor devices and passive components, their practical applications in power electronics. To familiarize students with the principles of operation, design, and synthesis of different power conversion circuits and their applications.

Course Outcomes: After studying this course, students will be able to:

1. Understand the characteristics of power electronic devices and the basic principle of operation of various power-electronic circuits.
2. Understand the fundamental principles involved in the operation of power electronic switches and the different methods to control them.
3. Design different types of phase-controlled single-phase and three-phase converters along with necessary protective circuits for application in different domains of engineering.
4. Design of DC-DC converter and inverter.
5. Analyze the single-phase and three-phase step-up/step-down AC voltage controller

MODULE I

Introduction to power electronics devices: Goals and objectives of power electronics, Characteristics and specifications of semiconductor power devices: Power Diode, Thyristors, Diac, Triac, GTO, MOSFET, IGBT, Characteristics of SCR, two-transistor analogy, triggering methods of SCR- R, RC and UJT firing circuits, di/dt and dv/dt protection of switches, Snubber circuits, SIC based switches and their drivers.

MODULE II

AC-DC Converters (Rectifiers): AC-DC Converters: Single-phase half-wave and full-wave uncontrolled rectifiers, Single-phase half-wave, and full-wave thyristor rectifiers with different types of loads, Three-phase full-bridge thyristor rectifier with different types of loads, Concept of freewheeling, Controlled rectifier performance calculations.

MODULE III

DC-DC Converters (Choppers): DC-DC converters: Fundamentals of DC-DC Converters, Buck Converter, Boost Converter and Buck-Boost Converter, Continuous and Discontinuous conduction mode of operations, DC-DC Converters design, Soft-Switched Converters.

MODULE IV

DC-AC Converters (Inverters): DC-AC converters: Introduction, Principle of operation of voltage source inverters, Single phase inverters, square wave operation of the inverter, Principle of operation of three-phase bridge inverter with R and R-L loads, 180^o conduction, 120^o conduction,

performance parameters of inverters, pulse width modulation (PWM), current source inverter (CSI).

MODULE V

AC-AC Converters: AC-AC converters: Principle of on-off and phase control, single phase and three phase controllers with R and R-L loads. Principle of operation of cycloconverters, single phase to single phase step-up and step-down cycloconverters.

Text Books:	
1.	M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2.	N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
3.	P. S. Bimbhra , "Power Electronics", 4th edition, Khanna Publisher, India, 2018.
Reference Books:	
1.	R W Erickson and D Makgimovic," Fundamental of Power Electronics" Springer, 2nd Edition, 2001.
2.	Philip T. Krein, "Elements of Power Electronics" Oxford University Press -2004
3.	M.S.J. Asghar, "Power Electronics", Prentice-Hall of India, 2004.

Course Code	Course Title					Type of Course
ECE364C	Communication Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Professional Core

Course Objectives: This course aims to equip students with the necessary knowledge and skills to understand various modulation techniques, digital communication systems, and the fundamentals of optical fiber communication.

Course Outcomes: After studying this course, students will be able to:

1. Study basic principles of communication systems.
2. Learn and analyze various analog modulation and demodulation schemes
3. Understand the random processes and different sources and classification of noise affecting the communication system.
4. Understand various reception techniques and the performance analysis of different radio receivers in the presence of noise.
5. Have knowledge of digital communication and digital modulation techniques.

MODULE I

Amplitude modulation (AM): Definition, AM modulation index, Spectrum of AM signal, Power analysis of AM signal, Standard AM generation and detection, Introduction to DSB/SC, SSB/SC and VSB AM signals, Frequency division multiplexing.

MODULE II

Angle modulation: Basic definition, Generation, and detection of FM waves, Bandwidth of FM signal, Narrow band and broad band FM signal.

MODULE III

Digital Communication Systems: Elements of digital communication systems, Advantages of digital communication systems, Elements of PCM: Sampling, Quantization and Coding, Differential PCM systems (DPCM), Delta modulation, adaptive delta modulation.

MODULE IV

Pulse Modulation (PM): Pulse modulation Techniques-Pulse Amplitude modulation (PAM), Pulse Position Modulation(PPM), Pulse Width Modulation (PWM), the definition of noise, Types, and Sources of noise, signal-to-noise ratio, Noise comparison of AM, FM, and digital communication systems.

MODULE V

Digital Modulation & Optical Fibre Communication: Introduction to basic digital modulation techniques (ASK, FSK, PSK, QAM), Introduction to Optical Fiber Communication: Block diagram of optical fiber communication system, Advantages of optical fiber communication, Principal components of an optical fiber communication system.

Text Books:	
1.	Modern Analog and Digital Communication System by B. P. Lathi, Oxford
2.	Communication System by Simon Hykin, 4th Edition, Wiley Publishers.
Reference Books:	
1.	Principles of Communication System, Taub and Schilling, McGraw Hill, 3rd Ed.
2.	Communication system; Analog and Digital, Sanjay Sharma.
3.	Data Communication by Stalling.

Course Code	Course Title					Type of Course
ELE357C	Power System Analysis					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	1	0	4	4	Professional Core

Course Objectives: To develop an understanding about the techniques used for calculation of various quantities under various faults. To train the students to analyze the power system under various disturbances and to have load flow calculations.

Course Outcomes: After studying this course, students will be able to:

1. Understand the representation of power system components and gain knowledge of symmetrical components.
2. Understand the categorization of faults and analyze the symmetrical and unsymmetrical faults in a power system.
3. Apply load flow techniques for the operation and planning of the power system.
4. Analysis of the behavior of the power system under transient and steady-state instability conditions and application of improvement techniques.
5. Gain knowledge of wave equation of transmission line and analyze the behavior of travelling waves under different line loadings for the protection of equipment.

MODULE I

Representation of Power System: Single line diagram, impedance and reactance diagram, per unit system, Advantages of per unit system, Changing the base of per unit quantities, Transients in simple circuits, Three-phase short circuit on an alternator, Re-striking Voltage after removal of short circuit.

MODULE II

Traveling Waves: Travelling waves on transmission lines: Open-end line, Short-circuited line, Line terminated through a resistance and characteristic impedance, Line connected to a cable, Bewley lattice diagrams. Faults, Types of faults: Symmetrical & Unsymmetrical faults, Analysis of Symmetrical faults, Short circuit capacity of a circuit breaker, Current limiting reactors.

MODULE III

Fault Analysis: Symmetrical components of a three-phase system, Three-phase power in terms of symmetrical components, Sequence impedances, Sequence network equations, Calculation of fault currents for unsymmetrical faults: Single Line to Ground, Line-to-Line, Double Line to Ground faults and for symmetrical 3-phase balanced faults, Open conductor faults.

MODULE IV

Load Flow Analysis: Introduction, Bus classifications, Nodal admittance matrix (Ybus), Development of load flow equations. Load flow solution using Gauss-Seidel and Newton-Raphson method, Approximation to N-R method, Fast decoupled solution for load flow equations, Calculation of line flows and line losses.

MODULE V

Power System Stability: Introduction, Transient, and Steady State stability, Power Angle Equation, Swing Equation, Equal Area Criterion of Stability, Critical clearing angle, Factors affecting transient stability, Introduction to various methods of voltage control, Introduction to Active and Reactive power control.

Text Books:	
1.	Power System Analysis, J. J. Grainger and W.D Stevenson McGraw-Hill.
2.	Electric Power Systems, C. L. Wadhwa, New Age International.
Reference Books:	
1.	Power System Engineering, Nagrath and Kothari, Tata McGraw-Hill.
2.	Transmission and Distribution of Electrical Energy, H.Cotton.
3.	Power System Analysis, A. R. Bergen and V. Vittal, Pearson Education Inc.
4.	Electric Power Systems, B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, Wiley.

Course Code	Course Title					Type of Course
ELE358C	Control Systems Design					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	2	0	2	4	3	Professional Core

Course Objectives: This course covers control design techniques such as root locus techniques, frequency response, state-space methods, and digital control design. Through practical lab exercises in MATLAB, students learn to design and analyze control systems effectively.

Course Outcomes: After studying this course, students will be able to:

1. Define the objectives of control system design for continuous-time and discrete-time systems.
2. Apply Root Locus techniques to design and analyze control system stability and performance.
3. Analyze and interpret Bode plots and Nyquist diagrams to assess system stability and frequency response characteristics.
4. Use frequency response techniques to Analyze and design compensators, such as cascade Lead, cascade Lag, Lead-Lag, and PID controllers.
5. Analyze and design control systems using state-space methods, including pole placement, state feedback, and observer-based control.

MODULE I

Introduction to Design via Root Locus Techniques: Design objectives; Introduction to design and compensation; The design process; Computer-aided design; Defining the Root Locus; Properties of Root locus; Sketching the Root Locus; Root locus for positive-feedback systems; Design using Root locus techniques; Lead-Lag compensation, Designing PID controllers using Root locus methods.

Lab exercises: Root Locus visualization in MATLAB, Pole-Zero plot, Effect of pole and zero on root locus; Designing compensator using MATLAB's Control System Toolbox.

MODULE II

Frequency Response Techniques and Stability: Frequency response of LTI systems; Stability and relative stability in frequency domain Asymptotic approximations; Bode plots and their use; Gain margin and Phase margin via Bode plots; Development of Nyquist Stability Criterion; Selected illustrative Nyquist plots; Stability via Nyquist Diagram.

Lab exercises: Sketching Bode and Nyquist plots in MATLAB; Frequency response measurement of LTI systems in MATLAB.

MODULE III

Design via Frequency Response: Performance specifications on system frequency response; Transient response via gain adjustment; Reshaping the Bode plot; Cascade Lead compensation, Cascade Lag compensation; Lead-Lag compensation; Cascade Proportional Integral Derivative

(PID) compensation in the frequency domain;

Lab exercises: PID tuning guides and automatic tuning in MATLAB; Compensation design using Bode plots in MATLAB; System identification from frequency domain data.

MODULE IV

Design via State Space: Control System Design using state variable methods; State variable feedback structure; Pole placement design using state feedback; Necessary and sufficient conditions for arbitrary pole placement; State regulator design; Servo design; Limitations of state feedback; State feedback with Integral control; Observers, open loop observer, and the Luenberger observer, Full order and reduced order observers.

Lab exercises: Defining state-space models in MATLAB; Pole placement in MATLAB; Designing full-order and reduced-order observers in MATLAB.

MODULE V

Introduction to Digital Control Design: State-space models of discrete systems, Controllability and Observability analysis of discrete systems, Design of Discrete PID Controller, Design of Discrete-time state feedback controllers.

Lab exercises: Defining discrete systems in MATLAB; finding observability and controllability of a discrete system in MATLAB.

Text Books:	
1.	Digital Control and State Variable Methods, M. Gopal, Tata McGraw-Hill Publishing Company Limited.
2.	Control Systems Engineering, Franklin & Power, Prentice Hall India.
3.	Computer-Aided Control Systems Design, Cheng Siong Chin, CRC Press, 2013.
Reference Books:	
1.	Linear Control System Analysis, John J. D'Azzo & Constantine H. Houpis, Marcel Dekker Inc. 5th edition.
Online Resources:	
1.	Control Engineering by Prof. M. Gopal, IIT Delhi https://nptel.ac.in/courses/108102043
2.	Creation and Analysis of State Space MATLAB, Part I https://in.mathworks.com/videos/state-space-models-part-1-creation-and-analysis-100815.html?s_eid=PSM_15028
3.	Control Design using State Space MATLAB, Part II https://in.mathworks.com/videos/state-space-models-part-2-control-design-100816.html?s_eid=PSM_15028

Course Code	Course Title					Type of Course
ELE359C	Power Electronics Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	0	0	2	2	1	Professional Core

Course Objectives: To expose students to operation and characteristics of power semiconductor devices and passive components, their practical application in power electronics. To provide practical exposure to operating principles, design and synthesis of different power electronic converters.

Course Outcomes: After studying this course, students will be able to:

1. Analyze the characteristics of thyristors along with their triggering and firing circuits.
2. Examine the full and half-bridge converters with R and R-L load.
3. Analyze the performance of step-up and step-down chopper with various switching circuits.
4. Analyze the performance of a PWM bridge inverter using IGBT as a switch with R and R-L load.
5. Analyze the performance of an AC voltage controller (with R and R-L load), and cycloconverter

List of Experiments:

1. To study V-I characteristics of Power MOSFET and IGBT.
2. To study V-I characteristics of SCR and measure latching and holding currents.
3. To study of R, RC half wave, and RC full wave triggering Methods of SCR.
4. To study UJT trigger circuit for half wave and full wave control.
5. Realization of single-phase half-wave and full-wave uncontrolled rectifiers with and without a filter at different loads.
6. To study SCR-based controlled rectifiers with different types of loads.
7. To study 3-phase fully controlled rectifiers with different types of loads.
8. To study step-up and step-down DC-DC converters.
9. To study the operation of single-phase full-bridge inverter.
10. To study the operation of 3-Phase Voltage Source Inverter (VSI).
11. To study the operation of single-phase AC voltage controller and waveform analysis.
12. To study the operation of step up and step down Cycloconverter for different types of loads.

Course Code	Course Title					Type of Course
ELE362C	Tinkering Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	0	0	2	2	1	Professional Core

Course Objectives: The Tinkering Lab course aims to provide students with hands-on experience in electronics and engineering. It covers design thinking, lab equipment use, and projects involving circuits, sensors, and embedded systems like Arduino. Through lab experiments, students design systems of their own interest and desire to enhance their problem-solving skills.

Course Outcomes: After studying this course, students will be able to:

1. Understand and demonstrate basic principles and concepts related to breadboard circuits, and embedded systems.
2. Understand and demonstrate basic principles related to simulation software.
3. Apply domain knowledge in implementing basic engineering designs.
4. Evaluate the feasibility, effectiveness, and efficiency of the design solution, considering factors such as cost, resources, and user requirements.
5. Create innovative solutions by implementing their unique design ideas individually and in team-based projects.

Theory for the lab

Overview of course objectives, expectations, and safety guidelines; Introduction to design thinking and the engineering design process; Familiarization with lab equipment, tools, and software platforms; Introduction to breadboard circuits and components; Guided projects involving basic electronic circuits, such as LED blinking, motor control, and sensor interfacing; Introduction to embedded systems: Arduino and its programming.

Sample Lab Experiments:

1. *Designing linear systems*: To design a prototype of second-order systems using active or passive components with adjustable time response characteristics.
2. *Designing a Weather Station*: To create a compact weather monitoring system using Arduino to measure temperature, humidity, and light intensity.
3. *Designing an overvoltage and under voltage trip circuit*: Design a trip circuit that protects sensitive loads against over and under voltage.
4. *Designing a Heart Rate Monitor:* Using a pulse sensor, create a heart rate monitor.
5. *Designing a Digital Spirit Level:* Objective: Build a digital level using an accelerometer.
6. *Designing Distance Measuring Device*: Develop a distance-measuring device using an ultrasonic sensor and display the results on an LCD. Compare the results with an actual measuring tape.
7. *Designing and realizing Digital Control:* To Design a digital PI controller using an Arduino Board and implement it in a temperature control system.
8. *Designing rectifier circuits*: To design half-wave and full-wave rectifiers on a breadboard and MATLAB and compare and comment on both results.
9. *Designing a four-quadrant operation circuit for a DC Motor*: To design a four-quadrant circuit for speed and direction control of a DC motor.
10. *Designing an ADC converter:* Convert an analog voltage into digital values using an ADC

on a microcontroller.

11. *Designing a wireless power transfer system:* Develop a device for wireless power transfer to charge batteries that cannot be connected electrically, such as pacemakers.

Course Code	Course Title					Type of Course
ELE360C	Power System Analysis Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	0	0	2	2	1	Professional Core

Course Objectives: Learn the techniques for calculating positive, negative, and zero sequence reactances of synchronous machines and transmission lines. Learn to perform symmetrical and unsymmetrical fault analysis in power systems using simulation tools.

Course Outcomes: After studying this course, students will be able to:

1. Determine the positive, negative, and zero sequence reactance of a synchronous machine and understand its role in unbalanced fault scenarios.
2. Measure and analyze positive, negative, and zero sequence impedances and currents in transmission lines to evaluate system performance during faults.
3. Perform a single line-to-ground fault on a transmission line, observe the effects, and interpret the fault analysis results.
4. Conduct a line-to-line fault on a transmission line and analyze the outcomes to comprehend fault behavior in different scenarios.
5. Simulate and calculate sub-transient, transient, and steady-state short circuit currents in an alternator to assess its dynamic response during faults.

List of Experiments:

1. To calculate the positive sequence reactance of the synchronous machine.
2. To calculate the negative sequence reactance of the synchronous machine.
3. To calculate the zero-sequence reactance of a synchronous machine.
4. Measurement of positive, negative, and zero sequence impedance and currents of the transmission line.
5. To perform the single line to ground fault on the transmission line.
6. To perform the line-to-line fault on the transmission line.

Simulation-based experiments:

1. To obtain the sub-transient, transient, and steady-state short circuit current on an alternator.
2. Ybus analysis.
3. To perform symmetrical fault analysis in a power system.
4. To perform un-symmetrical fault analysis in a power system.

Course Code	Course Title					Type of Course
ELE361A	Industrial Training (15 days)					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	0	0	0	-	0	Professional Core

Course Objectives: To understand use of advanced tools and techniques encountered during industrial training and visit. Interact with industrial personnel and follow engineering practices and discipline prescribed in industry. Develop awareness about general workplace behaviour and build interpersonal and team skills. Prepare professional work reports and presentations.

Course Outcomes: After completing the industrial training, students will be able to:

1. Relate, apply and adapt relevant knowledge, concepts and theories within an industrial organization, practice and ethics.
2. Understand how to work in actual industry environment
3. To identify promising new directions of various cutting-edge technologies
4. Evaluate the severity and consequences of the problems in the organisation and to take steps to address the problem.
5. Achieve skill to write technical documents and deliver oral presentation of the completed project, which in turn shall develop his communication skills.

7th Semester

Course Code	Course Title					Type of Course
ELE401C	Electrical Drives					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	1	0	4	4	Professional Core

Course Objectives:

The course aims to acquaint students with power conversion systems employing electric drives for industrial needs, covering electric motor operation, design, and applications. It establishes a foundation for assessing industrial drive performance, considering factors like energy efficiency, power quality, economic justification, environmental concerns, and practical viability.

Course Outcomes: After studying this course, students will be able to:

1. Understand the characteristics of power electronic devices, the basic principle of electric drives, and the fundamentals of drive dynamics.
2. Analyze the concepts of Rectifiers and Choppers fed to DC drives.
3. Design open-loop and close-loop control of DC drives.
4. Learn and analyze different steady-state speed control methods for Induction motors and understand the closed-loop block diagrams for different methods.
5. Get introduced to synchronous motors and special motor drives.

MODULE I

Introduction to Electric Drives: Definition of Electric Drive, Types of Loads, Components of load toques, Fundamental torque equations, Equivalent value of drive parameters for loads with rotational and translational motion. Determination of moment of inertia, Steady state stability, Transient stability, Multi-quadrant operation of drives, and Load equalization**.**

MODULE II

DC Motor Drives: Chopper fed DC motor for speed control, Motoring, and regeneration operation of chopper-fed separately-excited DC Motor Drive, Chopper-fed series motor drive, dynamic braking, regenerative braking, Composite braking, two quadrants and four quadrant operations of chopper-fed DC Motor Drives.

MODULE III

Controller Design for DC Motor Drives: Control structure of DC drive, inner current loop and outer speed loop, dynamic model of DC motor – dynamic equations and transfer functions, modeling of the chopper as gain with switching delay, the plant transfer function for controller design, speed controller specification and design.

MODULE IV

Induction Motor Drives: Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency, and (iii) applied voltage and frequency, static rotor resistance control of 3-phase slip ring Induction Motor, V/f control of induction motor, Analysis of VSI and CSI fed induction motor drive, Slip power recovery-Static Scherbius and Cramer drives.

MODULE V

Synchronous Motor and Special Motor Drives: Variable frequency control, self-control, Voltage source inverter fed synchronous motor drive, Brushless DC Motor, Switched Reduction Motor Drives, Introduction to Solar and Battery Powered Drive.

Textbooks:	
1.	G. K. Dubey, "Fundamentals of Electrical Drives," Narosa Publishing House, New Delhi, 2nd edition,2001.
2.	Vedam Subramanyam, Electric Drives Concepts and Applications, Tata McGraw Hill Education Private Limited, 2nd edition, 2011
3.	M. H. Rashid, "Power electronics: circuits, devices, and applications," Pearson Education India, 2009.
4.	P.S. Bimbhra, "Power Electronics", 4th edition, Khanna Publisher, India, 2018.
Reference Books:	
1.	Power Electronics and A.C Drives by B.K. Bose
2.	R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall, 2001
3.	W. Leonhard, "Control of Electric Drives," Springer Science & Business Media, 2001.
Web Resources:	
	Video course on "Fundamentals of Electrical Drives" by Prof. Shyama Prasad Das IITK, available on NPTEL at https://nptel.ac.in/courses/108/104/108104140/#

Course Code	Course Title					Type of Course
ELE407C	Introduction to Machine Learning					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	2	0	2	4	3	Professional Core

Course Objectives: This course provides a comprehensive introduction to machine learning fundamentals. It covers topics such as supervised and unsupervised learning algorithms, neural networks, and deep learning and their practical applications in electrical engineering, including load forecasting and fault detection. Through hands-on lab exercises utilizing Python libraries like scikit-learn and TensorFlow/Keras, students gain practical experience in implementing machine learning techniques for real-world electrical engineering problems, enhancing their data analysis and modeling skills.

Course Outcomes: After studying this course, students will be able to:

1. Describe the concepts and terminology related to machine learning.
2. Apply various learning algorithms, such as linear regression and stochastic gradient descent, to solve machine learning problems.
3. Evaluate the performance and limitations of supervised and unsupervised learning algorithms.
4. Design and build machine learning models, including recurrent neural networks.
5. Evaluate the application of machine learning in electrical engineering, such as solar and wind forecasting.

MODULE I

Foundations of Machine Learning

Introduction to Machine Learning; definition, motivation, role, and need of machine learning in Electrical Engineering; types of machine learning (supervised, unsupervised, reinforcement learning, historical perspective of machine learning and its implications; how machine learning differs from pure optimization.

Lab exercises:

- To define tensors in Python.
- To learn fundamental packages like NumPy, SciPy, Scikit-learn, Tensorflow/Keras, and Matplotlib.
- To import datasets and apply preprocessing in scikit-learn.
- To compare the effect of different scalers on data with outliers.

MODULE II

Supervised Learning Algorithms

Linear regression, feature selection, overfitting, and underfitting; hyperparameters and validation sets; estimators, bias and variance; maximum likelihood estimation, Bayesian statistics, stochastic gradient descent algorithm; backpropagation; k-Nearest neighbors, decision trees and random forest.

Lab exercises:

- Using scikit-learn to implement a simple linear regression model to predict the electricity demand for specific periods from historical data.
- Use scikit-learn to build a decision tree classifier to categorize data into multiple classes.
- To use k-nearest neighbors to group data into distinct clusters based on their similarities.

MODULE III

Unsupervised Learning Algorithms

Overview of unsupervised learning and its applications; clustering vs. dimensionality reduction; k-means clustering theory; introduction to principal component analysis (PCA), the intuition behind PCA and its applications; introduction to Gaussian mixture models (GMMs); autoencoders; introduction to anomaly detection;

Lab exercises:

- To implement PCA in scikit-learn to reduce the dimensionality of a dataset and visualize the results.
- To implement an anomaly detection algorithm using scikit-learn to identify outliers in a dataset.
- To define and implement an autoencoder model in TensorFlow to reconstruct input data.

MODULE IV

Neural Networks and Deep Learning

Introduction to Neural Networks; basic concepts; activation functions and feedforward networks; deep neural networks; Convolutional neural networks (CNNs); Recurrent neural networks (RNNs), bidirectional RNNs, deep recurrent networks, introduction to long short-term memory (LSTM) and other gated RNNs.

Lab exercises:

- To implement a simple feedforward neural network in TensorFlow to solve a classification problem.
- To build a CNN using TensorFlow to classify images from a dataset like CIFAR-10 or MNIST. Train the network on the dataset, visualize the learned filters, and evaluate the models' performance.
- Create an RNN using LSTM cells in TensorFlow to generate text character by character.

MODULE V

Machine Learning Applications in Electrical Engineering

How machine learning can be helpful in Electrical Engineering. Introduction to load forecasting problem; Fault detection in power systems; public datasets.

Lab exercises:

- Use LSTM with TensorFlow/Keras to predict solar and wind generation based on publicly

available datasets.

- Create a simple linear regression model using scikit-learn to predict the energy consumption in buildings based on publicly available energy consumption and relevant features in a dataset.
- To implement an autoencoder using TensorFlow/Keras to detect electrical equipment sensor data faults.

Text Books:	
1.	Deep learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016
2.	Deep learning with Python, Francois Chollet, Manning, 2017.
Online Resources:	
1.	Introduction to Machine Learning, MIT OCW 2023 http://introtodeeplearning.com/
2.	Machine Learning and Deep Learning: Fundamentals and Application by Prof. M. K. Bhuyan, IIT Guwahati https://onlinecourses.nptel.ac.in/noc23_ee87/preview

Course Code	Course Title					Type of Course
ELE410C	Switchgear and Protection					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	1	0	4	4	Professional Core

Course Objective: The main objective of this subject is to understand and know the construction and working of different relays and protection schemes for the protection of different components/Equipment's of the power system from different types of faults and abnormalities.

Course Outcomes (COs): After successfully finishing the course, students should possess the capability to:

1. Remember the purposes of protection in relation to major types of relays and protection principles.
2. Understand the different relay principles on the basis of their characteristics and constructions.
3. Apply the different protection schemes used for the protection of transmission lines, feeders, and bus bars.
4. Apply the various types of fault and protection schemes used for the protection of transformers, generators, and motors.
5. Understand the construction, working and rating capabilities of different types of circuit breakers for equipment and transmission line protection.

MODULE I

Introduction to Protection System: Introduction to protection system and its elements, functions of protective relaying, protective zones, primary and backup protection, desirable qualities of protective relaying, basic terminology, Difference between a metering CT and Protection CT, Potential Transformer. Electromagnetic Relays: Classification of Electromagnetic attracted and induction type overcurrent relays, induction cup type directional relay, Balanced beam type differential relay design considerations of electromagnetic relay.

MODULE II

Static and Numerical Relays: Introduction to static relays, Amplitude and phase comparators, Duality between Amplitude and Phase Comparator, realization of different time-current characteristics of an over-current static relays, Synthesis of impedance relays using static comparators, Development of an electronic circuit for implementing a Cosine phase comparator, Comparison with electromagnetic relay, Basics of Numerical Relays. Hardware Block Diagram, Advantages of Numerical Relays.

MODULE III

Protection of Transmission Line and Feeders: Over current protection of radial feeders, Protection of Parallel and ring mains feeders, Universal torque equation and characteristics of different distance relays, Comparison between distance relays, protection of three phase

transmission line for phase and ground fault, three stepped distance protection, carrier current protection, differential protection of bus-bar, High Impedance bus-bar protection, Lightening Arrester and surge diverter

MODULE IV

Electrical Equipment Protection: Overcurrent Protection, Percentage differential protection of transformer, Percentage differential relay with harmonic restrained (inrush phenomenon), High resistance ground faults in transformer, inter-turn faults, incipient faults in transformer (Buchholz Relay), Protection against over fluxing. Generator Protection and Motor: Failure of prime mover, Failure of field, over-current, over speed, over-voltage, Negative Phase Sequence Protection, stator winding faults (phase to ground, phase to phase, inter-turn fault between same phases). Motor abnormal operating condition due to failure of electrical supply and mechanical parts.

MODULE V

Circuit Breakers: Circuit Breaking: Properties of arc, arc extinction theories, re-striking voltage transient, current chopping, resistance switching, capacitive current interruption, short line interruption, circuit breaker ratings, constructional features and operation of Air Blast, SF6, Vacuum and D. C. circuit breakers.

Text Books:	
1.	Power System Protection and Switchgear by B. Ravindranath and M. Chander, New Age International Publishers.
2.	Fundamentals of Power System Protection by Bhidhe and Paithankar, PHI.
Reference Books:	
1.	Art and Science of Protective Relaying by Mason, Wiley Publishers.
2.	Protective relaying, Principles and Applications by J. L Black Burn
3.	Computer Relaying for Power Systems, by A.G. Phadke and J.S Thorp, Wiley India.

Course Code	Course Title					Type of Course
DMS4EEC	Project Management and Reporting					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Humanities & Social Sciences
Course Objectives: This course is aimed at introducing the primary concepts of project management & evaluation. The course will also equip students with the fundamentals of organizational behavior to effectively manage human resources in an organization.						
Course Outcomes: After studying this course, students will be able to: 1. Understand the fundamental concepts of project idea generation and screening. 2. Analyze the financial feasibility of a project using appropriate techniques. 3. Identify the behavioral dimension of project initiation, execution, and completion. 4. Apply network analysis for efficient scheduling of project activities. 5. Monitor project implementation, rectify deviations, and communicate reports.						

MODULE I

Project Management Foundation: Definition of a project; Production vs. Operations; Necessity of project management, Project life cycles; Overview of project idea generation and screening; Phases of project management; Market, technical, financial, economic & ecological analysis; Role of project management; Project management in various organization structures.

MODULE II

Capital Budgeting: Capital Budgeting- concepts, significance, and process; Project screening techniques; Discounting & Non-discounting techniques; Payback period, accounting rate of return, Profitability index, Discounted payback period, Net present value, Internal rate of return.

MODULE III

Organization Behavior: Effective project team; Stages of team building & growth (forming, storming, norming & performing); Team dynamics, Conflicts, and negotiations; Techniques of negotiation; Leadership- theories and styles.

MODULE IV

Network Analysis: Network analysis- concept & significance; Critical Path Method (CPM), Construction of network diagram; Forward & backward path (calculation of float); Resource loading and leveling; Program Evaluation & Review Technique (PERT).

MODULE V

Project Monitoring and Controlling: Project monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, communication and project meetings, ethics in projects, Multicultural and virtual projects.

Text Books:	
1.	Organizational Behaviour, Stephen P. Robbins, Pearson Publication.
2.	Project Management, Prasanna Chandra, McGraw Hill.
3.	Quantitative Techniques in Management, N.D. Vohra, McGraw Hill.
4.	Financial Management I. M. Pandey, Vikas Publications.

Course Code	Course Title					Type of Course
ELE409C	Electrical Drives Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	0	0	2	2	1	Professional Core

Course Objectives:

This course aims to provide students with hands-on experience and practical knowledge related to electrical drives and their applications. The course objective is to familiarize students with various types of electric motors, control techniques, and associated equipment used in modern industrial and commercial settings.

Course Outcomes: After studying this course, students will be able to:

1. Differentiate the testing of firing circuits in three phase-controlled bridge converters.
2. Examine the operation of three-phase fully and half-controlled converters for different types of loads experimentally.
3. Demonstrate the speed control methods of AC & DC motors.
4. Illustrate operation and analysis of different converters with reference to control strategy.
5. Analyze power quality aspects of three-phase controlled converters by calculating different parameters for different loads.

List of Experiments:

1. Control the speed of a DC motor using a Single-phase full-controlled bridge converter. Plot armature voltage versus speed characteristic.
2. Control the speed of a DC motor using a 3-phase full-controlled bridge converter. Plot armature voltage versus speed characteristic
3. To perform the speed control of the DC motor using Chopper.
4. Study of a four-quadrant separately excited DC motor drive
5. Control speed of a Single-phase induction motor in variable stator voltage mode using single-phase AC voltage regulator.
6. To perform the speed control test on the slip ring induction motor by rotor resistance control method.
7. Study of PWM Inverter fed three-phase Induction Motor Speed Control
8. Study of V/f control operation of three-phase induction motor drive.
9. Study of permanent magnet synchronous motor drive fed by PWM Inverter.
10. Open loop and closed loop control of BLDC motor.

Course Code	Course Title					Type of Course
ELE411C	Switchgear and Protection Lab					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	0	0	2	2	1	Professional Core

Course Objective: The main objective of this lab is to understand and to know the construction and working of different relays and protection schemes for the protection of different components/Equipment's of the power system from different types of faults and abnormalities.

Course Outcomes (COs): After successfully completing this lab course, students should possess the capability to:

1. Understand the various internal parts of the Electromagnetic relays used in the power system.
2. Analyse the different time-current characteristics of the over-current relays.
3. Understand the pickup or threshold value of the over and under-voltage relays.
4. Apply the primary and backup protection schemes along with the different protection schemes applied for feeder protection using static relays.
5. Apply differential protection schemes for various types of faults for the protection of transformers, generators, and motors with the help of numerical relays.

List of Experiments:

1. To analyze the different parts of armature attracted and induction disc type relay (electro-mechanical type).
2. To plot the time-current characteristics of induction disc-type overcurrent relays.
3. To observe the pickup value of an armature-attracted instantaneous type overvoltage relay.
4. To observe the pickup value of an armature attracted instantaneous type under voltage relay.
5. To note down the operating time of the primary and backup protection of the radial feeder using an over-current static relay.
6. To analyze the time-graded and current-graded overcurrent protection system of radial feeder using static over current relay.
7. To understand the working of gas actuated Buchholz relay for the protection of incipient faults of a transformer.
8. To understand the percentage differential relay using Numerical Relay.
9. To apply the percentage differential protection scheme for the protection of a single-phase transformer using a Numerical Relay.
10. To understand the working and operation of air circuit breakers.

Course Code	Course Title					Type of Course
ELE408C	Project (Minor)					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
7th	0	0	4	4	2	Professional Core

Course Objectives: To explore contemporary research issues and to perform literature survey on recent developments in a selected problem domain. Manage the work with team members and to workout with the strategies to find a solution addressing the problem.

Course Outcomes: After completing the minor project, students will be able to:

1. Perform literature survey to explore various methodologies.
2. Demonstrate a sound technical knowledge of their selected project topic.
3. Undertake problem identification, formulation and solution by considering ethical responsibility.
4. Design engineering solutions to complex problems utilizing as system approach.
5. Write technical report of the project apart from developing a presentation.

8th Semester

Course Code	Course Title					Type of Course
ELE451C	Project (Major)					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	0	0	16	16	8	Professional Core

Course Objectives: To inculcate the ability to synthesize the results of the detailed analytical studies conducted, lay down validity and design criteria, interpret the result for application to the problem, develop the concept and detailed design solution and to effectively communicate the project rationale.

Course Outcomes: After completing the major project, students will be able to:

1. Perform literature survey and identify the gaps to select an appropriate problem.
2. Analyze the design using modern tools for appropriate solutions.
3. Evaluate and critically assess the results for design specification.
4. Design and implement the solution with simulation and/or prototype model and develop further knowledge and competency.
5. Write technical report, journal/conference articles, patent filing and deliver oral presentations.

Course Code	Course Title					Type of Course
ELE452A	Internship (30 days/4 weeks)					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	0	0	0	-	0	Professional Core

Course Objectives: To comprehend the application of advanced tools and techniques prevalent in the industrial setting. Engaging with industrial personnel, adhering to established engineering practices, and maintaining discipline as dictated by industry standards. Awareness of general workplace behaviour while honing interpersonal and team skills. To compile professional work reports and deliver presentations, fostering the development of effective communication and presentation abilities crucial for success in the professional realm.

Course Outcomes: After completing the internship, students will be able to:

1. Demonstrate an enhanced level of technical proficiency in the specific field of their internship, showcasing a deep understanding of relevant tools, technologies, and methodologies.
2. Exposure to real-world industry practices, adapt to the dynamic nature of the professional environment, and effectively apply theoretical knowledge to practical scenarios.
3. Development of effective communication skills, enabling the student to articulate ideas, collaborate with team members, and convey technical information to both technical and non-technical audiences.
4. Ability to problem-solving and critical thinking abilities by actively participating in resolving challenges encountered during the internship, demonstrating an analytical approach to complex issues.
5. Develop a strong work ethic, understanding the importance of punctuality, accountability, and integrity in a professional setting.

Elective Courses (Discipline Centric)

Course Code	Course Title					Type of Course
ELE354E	Power Station Practice					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objectives: The objective is to gain a comprehensive understanding of power generation, distribution, economics, tariff design, safety, and various technical aspects related to power systems and infrastructure.

Course Outcomes: After studying this course, students will be able to:

1. Learn and understand the workings of different types of power stations.
2. Get acquainted with the terminologies that are important for the economic operation of power stations and understand the importance of the load curve in selecting the generation units.
3. Analyze how generation cost can be reduced and how tariffs can be designed for different categories of consumers.
4. Understand the single line diagram of a power plant, the placement of its components and their role, calculation of soil resistivity and resistance for site identification.
5. Design the different types of earthing systems for a substation.

MODULE I

Overview of Different Types of Power Stations, Working and Auxiliaries: Thermal power plants and their types, Hydroelectric stations and their types, Nuclear power stations and types, Diesel power stations, Gas turbine plants. Layout of a plant. Pollution Control schemes used in power plants, Selection of site, Calculation of water flow and capacity of the plant. Flow curve and flow duration curve. Non-conventional energy sources.

MODULE II

Power Generation Terms: Connected load, Maximum Demand, Demand Factor, Load factor, Capacity factor, Diversity factor, Load duration curve, and mass curve. Base load and peak load plants. Operating and spinning reserves. Effect of voltage and frequency on loads. Load forecasting. Load curve and selection of generating units. Key points in the selection of units.

MODULE III

Economics of Power Generation and Tariff Design: Cost of Power Generation: running cost and fixed cost. Method for providing for depreciation factor affecting the cost of generation. Effect of load factors and diversity factor on the generation cost. Reduction of costs by interconnection of stations, Advantages of coordinated operation of different types of power plants, Choice in size of plant and size of units. Tariffs in Electrical energy: Factors influencing the rate of tariff,

Designing tariff. Different types of tariffs: Flat rate tariff, Block rate tariff, Two-part tariff, Maximum demand tariff, Time of use tariff, Power factor tariff. Economics of Power Factor improvements.

MODULE IV

Substation Types and Auxiliaries: Classification of substations. Equipment for substations: Busbar, Lightening Arresters, Wave traps, C.T/P.T, Circuit breaker, Isolators etc. Selection and location of site for substation, Comparison between Outdoor and Indoor Sub-stations. Key diagram of the typical substation. Substation auxiliary supply.

MODULE V

Power System Earthing: Introduction: Definitions, Effects of electric currents on the human body, Soil resistivity, Grounding resistance, Potential gradient, Earthing mat, Touch and step potential, Size of the earthing conductor, Measurements of earth resistance and soil resistivity, Impulse behavior of grounding system, Introduction of neutral earthing, Isolated neutral or underground system, Grounded neutral system, Effectively grounded system, Solid or effective grounding, Resistance grounding, Resistance grounding, Arc suppression coil grounding, Voltage transformer grounding, Grounding transformer.

Text Books:	
1.	Elements of Electrical Power Station Design, M. V. Deshpandae, A. H. Wheeler and Co. Pvt. Ltd. Allahabad.
2.	Power Plant Engineering and Economics, B. G. A. Shrotzki and W. A. Vopal, McGraw Hill Book Co.
Reference Books:	
1.	Generation of Electrical Energy, B. R. Gupta, Eurasia Public House Pvt. Ltd. New Delhi
2.	Electric power system control, H.P. Young , Chapman and Hall.
Online Resources:	
1	IEEE Guide for Safety in AC Substation Grounding, IEEE Std 80-2000,30 Jan 20000

Course Code	Course Title					Type of Course
ELE355E	Special Electrical Machines					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objectives: By the end of the course, students will have gained a comprehensive understanding of Permanent Magnet Brushless DC Motors and a range of related motor types like synchronous, stepper and reluctance motors. They will be equipped with the knowledge and skills to analyze, design, and apply these motors for diverse industrial and technological applications.

Course Outcomes: After studying this course, students would have:

1. Developed a comprehensive understanding of permanent magnet Brushless DC motors and to analyze their magnetic circuit aspects.
2. Become well-versed with deep bar rotor and double cage rotor induction motors and study aspects related to the doubly fed induction generator.
3. Understood the operating principles, EMF and torque equations, phasor diagrams, and torque-speed characteristics of permanent magnet synchronous motors.
4. Understood the construction features, working, and types of reluctance motors and stepper motors and gain knowledge about reluctance torque and torque-speed characteristics.
5. Developed the capacity to analyze and draw the torque-speed characteristics of various types of synchronous motors and stepper motors.

MODULE I

Permanent Magnet Brushless DC Motors: Principle of operation, Magnetic circuit analysis, EMF and torque equations, torque-speed characteristics, Power controllers.

MODULE II

Special type of Induction Motors: Construction and working principle of deep bar rotor induction motor, double cage rotor induction motor, torque-speed characteristics, doubly-fed induction generator, reactive power compensation for induction generator.

MODULE III

Permanent Magnet Synchronous Motors: Principle of operation, EMF and torque equations, phasor diagram, torque-speed characteristics, Power controllers.

MODULE IV

Reluctance Motors: Synchronous Reluctance Motors: Constructional features, Types, axial and radial air gap motors: operating principle, reluctance torque, Phasor diagram, torque-speed characteristics, Switched Reluctance Motor.

MODULE V

Stepper Motors: Constructional features, principle of operation, variable reluctance motor, hybrid synchronous motors; Construction and working principle of Synchro's and Resolvers.

Text Books:	
1.	Electric Machinery Fundamentals by Chapman, McGraw Hill Education.
2.	Electrical Machinery by P. S. Bhimbra, Khanna Publishers.
3.	Electric Machines by Nagrath and Kothari, 5th Edition, McGraw Hill Education.
Reference Books:	
1.	Electric Machinery and Transformer by Guru, Hiziroglu
2.	Electric Machinery by Fitzgerald, Kingslay, Umans.
3.	Electrical Machines and Transformers by Irving Kosov.
4.	Electrical Machinery by Charles S. Siskins

Course Code	Course Title					Type of Course
ELE356E	Computational Electromagnetics					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objective: This course aims to equip students with analytical and computational skills to solve electromagnetics problems across diverse geometries and in the process obtain relevant design solutions as per user requirements.

Course Outcomes:

1. Remembering: Recall and classify fundamental electromagnetic theories, equations, and solution regions.
2. Understanding: Understand the use of analytical methods for solving electromagnetics problems in diverse geometries and understand the need and motivation for the use of numerical techniques in electromagnetics.
3. Analyzing: Solve problems in electrostatics and electromagnetics using analytical methods.
4. Applying: Apply numerical techniques like finite difference method (FDM) and finite element method (FEM) to solve electromagnetics problems.
5. Creating: Design solutions using FDM, FEM for microwave cavities, magnetostatics, and eddy current problems in various geometries using appropriate software.

MODULE I

Fundamental Concepts in Electromagnetics: Review of Electromagnetic Theory, Electrostatic Fields, Magnetostatic Fields, Time-Varying Fields, Boundary Conditions, Wave Equations, Time-Varying Potentials, Time Harmonic Fields, Classification of Electromagnetic Problems, Classification of Solution Regions, Differential Equations and Boundary Conditions.

MODULE II

Analytical Methods: Introduction, Separation of Variables, Separation of Variables in Rectangular Coordinates, Laplace's Equation, Wave Equation, Separation of Variables in Cylindrical Coordinates, Wave Equation, Separation of Variables in Spherical Coordinates, Laplace's Equation, Wave Equation, Some Useful Orthogonal Functions, Series Expansion, Poisson's Equation in different geometries, Strip Transmission Line, Practical Applications.

MODULE III

Finite Difference Method for Computational Electromagnetics: Introduction to Finite Difference Method (FD), FD Schemes for Different Partial Differential Equations (PDEs), Accuracy and Stability of FD Solutions, Finite-Difference Time-Domain (FDTD) Method, Practical Applications of FDTD.

MODULE IV

Method of Moments (MoM) for Electromagnetic Analysis: Integral Formulation of Electrostatics and Maxwell's Equations, Green's Functions and Numerical Integration, Application of MoM to Capacitance Calculation, Application of MoM to Electromagnetic Scattering from a Thin Wire.

MODULE V

Finite Element Method (FEM) in Electromagnetics: Introduction to Finite Element Method (FEM), FEM in One and Two Dimensions, Nodal and Edge Elements, Galerkin's Method and Variational Formulations, Application of FEM to Microwave Cavities, Application of FEM to Magnetostatics, Application of FEM to Eddy Current Problems

Text Books:	
1.	Sadiku, M. N. O.. "Numerical Techniques in Electromagnetics." CRC Press.
Reference Books:	
1.	Bondeson, A., Rylander, T., & Ingelstrom, P. "Computational Electromagnetics."
2.	Sadiku, M. N. O.. "Computational Electromagnetics with MATLAB, Fourth Edition." CRC Press.

Course Code	Course Title					Type of Course
ELE357E	Electrical Machine Design					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objectives: Upon completion of the course, students will have a solid foundation in electrical machine design, capable of analyzing, selecting dimensions, and designing various components for transformers, DC machines, and induction motors. They will be equipped to apply their knowledge in practical design scenarios and contribute effectively to the field of electrical machine engineering.

Course Outcomes: After studying this course, students will be able to:

1. Understand the basics of electrical machine design and to calculate the magnetic leakage and MMF for air gap.
2. Design and analyze the core, yoke, windings, and cooling system of a Transformer.
3. Design and analyze the armature windings used for various types of machines.
4. Design and analyze various parts of a DC machine to determine the main dimensions and the number of poles of a DC machine.
5. Design and analyze the stator and rotor core, number of stators and slots, and length of air gap for an induction motor.

MODULE I

Principles of Electrical Machine Design: Considerations in electrical machine design, design factors, fundamentals of magnetic circuits, Magnetization curves, Magnetic leakage, calculation of total MMF for the air gap, the effect of saliency, specific electrical and magnetic loading.

MODULE II

Design of Transformers: KVA output equation for 1-phase and 3-phase transformer, volt per turn, design for minimum cost, design for minimum loss or maximum efficiency, design of core, design of winding, the position of windings relative to the core, window dimensions, design of yoke

MODULE III

Armature Winding Design: Integrated approach for windings, relation between winding parameters, AC armature windings, phase spread, production of EMF in a conductor, production of EMF in a full pitch concentrated winding, production of EMF in a distributed winding, MMF distribution of armature windings, eddy current loss in conductors.

MODULE IV

Design of DC Machines: Output equation of DC machines, main dimensions of a DC machine, selection of the number of poles, the core length, armature diameter, length of the air gap, design of armature windings, design of field systems, design of commutator and brushes

MODULE V

Design of Induction Motors: Output equation of AC machines, main dimensions, Stator winding, stator conductors, shape of stator slots, number of stator slots, stator core, length of air gap, design of rotor (squirrel cage rotor and wound rotor).

Text Books:	
1.	Electric Machine Design by A.K. Sawhney, Dhanpat Rai & Co Pvt. Ltd.
2.	Electrical Machine Design by R.K. Agarwal, S. K. Kataria & Sons.
Reference Books:	
1.	Principles of Electrical Machine Design by S. K. Sen & S. C. Bhatia, Oxford Press.
2.	Electrical Machine Design by Rajiv Nagaranjan, Pearson Publications.
3.	Design of Electrical Machines by Mittle and Mittla, Standard Publishers Distribution.

Course Code	Course Title					Type of Course
ELE358E	Applied Linear Algebra for Electrical Engineering					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objectives: This course is intended to introduce the students to the concepts Matrices and properties matrices in problem-solving. Students will learn different matrix manipulations for effective ways of solving system equations.

Course Outcomes: Upon completion of this course, students will be able to:

1. Identify the importance of linear algebra and its applicability to practical problems, particularly in applications in machine learning/pattern recognition, data mining/search engines, and signal/image processing.
2. Learn important concepts of linear algebra, such as linear transformations, bases, projections, the least squares method, and various matrix decompositions such as LU, LDU, and eigenvalues.
3. Apply the principles of orthogonality in solving problems with no solutions.
4. Understand the significance of eigenvalues and eigenvectors in providing system information.
5. Learn the importance of diagonalization and orthonormality in problem-solving.

MODULE I

Vector Spaces and Basis: Fields, Vector spaces, Subspaces, Linear combinations and subspaces, Linear dependence and independence, Spanning Set and Basis, Finite dimensional spaces, Dimension.

MODULE II

Eliminations: Gaussian elimination, Solving Ax = b for square systems by elimination, pivots, multipliers, back substitution, invertibility of A, Elementary and Permutation matrices, Row Reduced Form, LU and LDU Factorization, Gauss-Jordan method to find the inverse of A, The Four Fundamental Subspaces associated with a matrix, Linear Transformations.

MODULE III

Orthogonality: Inner product, Euclidean Norm, Orthogonal Vectors, Orthogonal Subspaces, Projections, Projection onto a line, Projection onto a subspace, Projection Matrix, Orthogonal Bases and Orthonormalization by Gram-Schmidt, QR factorization. Properties of determinants, cofactor formula, applications to finding inv(A).

MODULE IV

Eigenvalues and Eigenvectors: Eigenvalues and Eigenvectors, Diagonalization of a Matrix, Characteristic equation, Cayley-Hamilton theorem, computing powers A^k and matrix exponentials to solve difference and differential equations.

MODULE V

Symmetric Matrices and SVD: Symmetric matrices, positive definite matrices, tests for positive definiteness, real Eigenvalues and orthogonal eigenvectors, Linear transformations and change of basis, Singular Value Decomposition, orthonormal bases for Diagonalization.

Text Books:	
1.	Introduction to Linear Algebra by Gilbert Strang, Wellesley Publishers
Reference Books:	
1.	Linear Algebra: Step by Step by Kuldeep Singh, OUP Oxford
2.	Schaum's Outline of Linear Algebra by Seymour Lipschutz and Marc Lipson, McGraw Hill Education
3.	Finite-Dimensional Vector Spaces by Halmos Paul, Ingram Short Title Publishers.
Online Resources:	
1.	Linear Algebra https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/

Course Code	Course Title					Type of Course
ELE359E	Power Generation Plants					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Discipline Centric

Course Objectives: To understand the fundamental concepts of power generation and the various types of power plants and to identify the components and working principles of different power generation systems.

Course Outcomes: After studying this course, students will be able to:

1. Remember the key concepts and major components of different types of power plants.
2. Explain the principles behind energy conversion in power generation processes.
3. Analyze and solve problems related to the performance and efficiency of power plants under varying operational conditions.
4. Understand the need for testing and procedures of the electrical devices.
5. Analyze the factors influencing the choice of fuel type and combustion technologies in power generation, considering economic, technical, and environmental aspects.

MODULE I

Hydroelectric Power Plant: Introduction, Advantages and limitations, selection of site, Hydrology-hydrological cycles and hydrographs, flow duration curve, mass curve, storage and pondage, essential elements of the hydroelectric power plant, classification, different types of turbines and their selection, governing of hydraulic turbines, Small hydroelectric power plants.

MODULE II

Thermal Power Plant-I: Introduction, Classification, General layout, Site Selection, Fuel handling and its methods, Fluidized Bed Combustion (FBC), Ash Handling, Accessories, Feed Water Heaters and Evaporators Advantages, disadvantages and limitations of Thermal power plant.

MODULE III

Thermal Power Station-II: Main parts of the thermal power station and their working, Steam turbines, Turbo-alternators, Different cycles, and Cogeneration.

MODULE IV

Nuclear Power Plants: Introduction, merits and demerits, selection of sites, main parts of the nuclear power station, plant layout and working of different types of reactors (pressurized water reactor (PWR), boiling water reactor, gas-cooled reactor, liquid metal tank feeder reactor, heavy water reactor), Pollution and Safety.

MODULE V

Diesel Engine & Gas Power Plant

Advantage and limitations, types of diesel plants, general layout, layout of diesel engine power plant and applications. Components of gas power plant, gas turbine fuels, turbine fuels, turbine materials, working, improvement of thermal efficiency of gas power plant and applications.

Text Books:	
1.	Gupta B. R. Power Plant Engineering, Eurasia publications.
2.	Nag P. K. Power Plant Engineering, Tata McGraw Hill Publications.
Reference Books:	
1.	Deshpande M. V. Elements of Electrical Power Station Design, Wheeler publications.
2.	Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Rai and Co.
3.	R. K. Rajput, Power Plant Engineering, Laxmi Publications.

Course Code	Course Title					Type of Course
ELE405E	Energy Conservation and Auditing					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Discipline Centric

Course Objective: This subject focuses on the study of energy conservation and audit. It also helps to understand the real-time energy conservation opportunities, energy management, and Energy Auditing in various sectors of the utilization of energy with the calculation of payback period of energy-efficient systems.

Course Outcomes (COs): After successfully finishing the course, students should possess the capability:

1. To remember an overview of energy conservation and efficiency
2. To understand the different policies, regulations setup by the national and international agencies to promote energy conservation along with the concept of net zero carbon buildings.
3. To apply the energy conservation concept in different sectors.
4. To understand the types of energy audits along with the roles and responsibilities of energy auditor and energy manager.
5. To apply the energy audit procedure in buildings along with the economic analysis reporting.

MODULE I

Introduction to Energy Conservation: Need for Energy Conservation, Energy Sources, Supply & Demand Overview of Electrical and Thermal Energy, the difference between energy conservation and efficiency.

MODULE II

Policy & Regulations for Energy Conservation: Institutional Structure, Energy Conservation Policies & Legislations, National and International Programs. ***Green Buildings:*** Net Zero Carbon Buildings a Framework Definition, World Green Building Trends, Smart Market Report, Steps towards Buildings Green

MODULE III

Energy Conservation Opportunities: Electrical, Buildings & Lighting Systems, Motors Pumps, Transformers, Power Transmission & Distribution System. ***Energy Conservation Opportunities:*** Thermal, Boilers Furnaces & Waste Heat Recovery Systems, Cogeneration Systems, HVAC.

MODULE IV

Energy Audit Basics: Definition and Objectives, Energy or process Flow diagram, Types of Energy Audit, major energy consuming equipment and systems, Duties of Energy Auditor & Manager, relevance of energy costs.

MODULE V

Energy Audit Procedure: Energy Audit Procedure, Energy Audit instruments, Energy Audit reporting formats, Energy audits for buildings, Energy audits for commercial buildings, Economic analysis.

Text Books:	
1.	Dr. Sanjeev S. R.Umesh, Energy Management, Katson.
2.	LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization, Hemisphere Publishing Corporation, Washington, 1998,.
Reference Books:	
1.	JL Threlkeld: Thermal Environmental Engineering, Second Edition, Prentice Hall, 1970.
2.	YP Abbi and Shashank Jain: Handbook on Energy Audit and Environment Management, TERI Press, 2006.
3.	WC Turner: Energy Management Handbook, Seventh Edition, Fairmont Press Inc., 2007.
4.	George Polimeros: Energy Cogeneration Handbook, Industrial Press, Inc., New York, 1981.
5.	B. R. Gupta, Generation of Electrical Energy, S. Chand.

Course Code	Course Title					Type of Course
ELE403E	Power System Operation and Control					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Discipline Centric

Course Objectives:
The objective of the course is to introduce the engineering and economic aspects of power system operation. The course focuses on the secure planning, operation, power generation and transmission control in electric utilities.

Course Outcomes: After studying this course, students will be able:

1. To understand the operating and controlling functions, as well as problems occurring in a power system with solutions.
2. To perform economic dispatch as well as unit commitment analysis of the thermal plant.
3. Design a frequency and voltage control scheme for single and multi-area power systems.
4. To learn and implement how security analysis is carried out in a power system under contingencies.
5. To understand the importance of SCADA in modern power systems and to learn the roles of EMS and LDC.

MODULE I

Introduction to Power System Structure, Problems and Solutions: General characteristics of modern power systems, evolution, structure, Operation and Control Functions and Hierarchies Design and Operating Criteria. Basic concerns of power system operation and control. Power quality, reasons for poor power quality, remedies.

MODULE II

Economic Power Dispatch and Unit Commitment: Economic dispatch of thermal units: Economic load dispatch of thermal units, including network losses, transmission line loss calculation, and use of optimization techniques to find economic dispatch. Unit commitment: Need for unit commitment, constraints in unit commitment problem, application of dynamic programming for solving unit commitment problem. Optimum power dispatches in hydrothermal power systems. Hydrothermal scheduling: short, medium, and long-range scheduling.

MODULE III

Load Frequency Control and Voltage Control: Concept of reactive power, control of active power and reactive power - active power and frequency control, reactive power flow analysis, real power balance and its effect on system frequency. Automatic generation control (AGC), generation control loops (AVR control, Governor Control, supplementary control, Q-V and P-f control loops,). Load frequency control. Single area and two area power system, tie-line power flows, Net interchange tie-line bias control.

MODULE IV

Power System Security: Introduction, factors affecting power system security, Security analysis, Contingency Selection, Techniques for contingency evaluation, contingency analysis using network sensitivity method and AC power flow method,

MODULE V

Optimal Power Flow and Data Acquisition System: Security constrained optimal power flow, Emergency control, Preventive control and Restorative Control. DC load flow. SCADA: SCADA systems, supervisory control, supervisory master stations, remote terminal units, communication links, and SCADA systems applications in power networks. Energy management center, Load dispatch center

Text Books:	
1.	Power System Stability and Control, Kundur, P., McGraw-Hill International, 1st Editions, 1994.
2.	Modern Power System Analysis, D. P. Kothari, I. J. Nagrath, McGraw Education, Fourth edition, 1996
Reference Books:	
1.	Power Generation Operation and Control, S. Sivanagaraju, G. Sreenivasan, Pearson, 1st edition, 2009.
2.	Power Generation Operation and Control, Allen J. Wood and Wollenberg B.F, John Wiley & Sons, 2nd Edition, 1996.

Course Code	Course Title					Type of Course
ELE404E	High Voltage Engineering					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Discipline Centric

Course Objectives: To introduce the basic concepts of fundamentals of insulating materials in electrical engineering, including breakdown phenomena in solids, liquids, and gases. It explores high D.C., A.C., and impulse voltages and currents measurement, overvoltage in power systems, insulation coordination, and high voltage testing techniques.

Course Outcomes: After studying this course, students will be able to:

1. Understand the basic physics related to various breakdown processes in solid, liquid, and gaseous insulating materials.
2. Understand the significance of high voltages and high currents.
3. Evaluate the form of discharges in Gaseous, Liquid and Solid dielectrics.
4. Analyze the magnitude of HVDC, HVAC (power frequency & high frequency), and impulse by different measurement schemes.
5. Design and development of high voltage equipment and utility establishment.

MODULE I

Overvoltage Phenomena and Insulation Coordination: Causes of overvoltages and their effects on power system - Lightning, Switching surges, System faults and other abnormal conditions, Protection against over-voltages, Surge diverters, Surge modifiers, and Insulation coordination.

MODULE II

Conduction and Breakdown in Dielectrics in Gases: Gases as insulating materials, Ionization and de-ionization processes, Townsend's theory, Types of Discharge, Breakdown in Uniform gap, non-uniform gaps, Streamer mechanism, Corona discharge.

MODULE III

Conduction and Breakdown in Dielectrics in Liquids: Liquids as insulators, Conduction and breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

MODULE IV

Generation and Measurement of High Voltage and Currents: Generation of high voltages, generation of high D.C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping, and control of impulse generators. Peak voltage, impulse voltage, and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, and partial discharge measurements.

MODULE V

Testing of High Voltage Equipment: Different tests on insulators-bushings-isolators-circuit breakers-cables, testing of transformers-surge diverters, radio interference measurement, use of I.S for testing.

Text Books:	
1.	High Voltage Engineering by M.S. Naidu and Kamaraju, Tata McGraw Hill.
2.	High Voltage Engineering by C.L. Wadhwa, Wiley Eastern Limited.
Reference Books:	
1.	High Voltage Engineering by E. Kuffel and M. Abdullah, Pergamon Press.
2.	An Introduction to High Voltage Experimental Technique by Dieter Kind, Wiley Eastern

Course Code	Course Title					Type of Course
ELE406E	Advanced Power Electronics					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Discipline Centric

Course Objectives: After conclusion of the course, the student will be able to: design power electronic converters that perform DC/DC and DC/AC electrical energy conversions. model and simulate the electrical, thermal, and electromagnetic performance of power electronic systems using advanced software tools.

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

1. Analyze and design the switched mode power converters.
2. Determine the power circuit configuration needed to fulfill the required power conversion with applicable constraints.
3. Analyze the improved power quality and Multi-pulse AC-DC converters.
4. Implement various PWM techniques applicable to three-phase Inverters for the reduction of harmonics at the Inverter output voltage.
5. Acquire in depth knowledge on the features of different topologies of Multilevel Inverters and methods to balance capacitor voltage.

Module I

Switched mode power supply (SMPS): Review of non-isolated DC-DC converters, Isolated DC-DC Converters; fly-back, forward, half bridge, full bridge and push-pull converters, Design aspects of Magnetics for DC-DC Converters.

Module II

Switching loss: hard switching, and basic principles of soft switching, Classification of resonant converters – Load resonant converters, Series and parallel; Resonant switch converters; Operation and analysis of ZVS, ZCS converters, comparison of ZCS/ZVS converters.

Module III

AC-DC converter: overview, power factor improvement techniques, PWM rectifiers, multi-pulse converters: 12,18 and 24 pulse converters, phase shifting transformers.

Module IV

Three phase VSI: PWM techniques of three phase VSI: Selective Harmonic Elimination (SHE), Sine PWM, Third harmonic injection, Space Vector Pulse Width Modulation.

Module V

Multi-level converters: Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel Converter's configurations, Pulse width modulation control in multi-level converters

Text Books	
1.	Mohan, Undeland, Robbins, “Power Electronics Converters, Applications, and Design” Wiley, Indian Edition.
2.	Bin Wu, “High Power Electronics Converters and ac drives” Wiley-IEEE Press, 2002
3.	DG Holmes and T Lipo, “Pulse width modulation for power converters” Wiley-IEEE Press, 2002.
4.	M. H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
Reference Books:	
1.	Bimal K. Bose, “Power Electronics and Motor Drives: Advances and Trends”, Academic Press

Course Code	Course Title					Type of Course
ELE407E	Nonlinear Control Systems					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Discipline Centric

Course Objective: This course aims to equip students with a comprehensive understanding of nonlinear systems, enabling them to identify various nonlinearities, interpret phase portraits, analyze stability using methods like Lyapunov's direct approach, and design effective nonlinear control systems through techniques such as feedback linearization and sliding mode control.

Course Outcomes: After the end of the course, students will be able to:

1. Understand Nonlinear Systems: Describe different types of nonlinearities and recognize unique characteristics of nonlinear systems.
2. Analyze Phase Portraits: Construct and interpret phase portraits and analyze both linear and nonlinear systems using phase plane analysis.
3. Apply Describing Function Method: Utilize the describing function method to analyze common nonlinearities.
4. Assess Stability of Nonlinear Systems: Define equilibrium points, differentiate between stable and unstable systems, apply linearization and Lyapunov's direct method for local stability analysis, and apply Lyapunov's analysis to linear time-invariant systems.
5. Design Nonlinear Control Systems: Create control designs based on Lyapunov's direct method, implement feedback linearization techniques, and grasp the fundamental concepts of sliding mode control for nonlinear systems.

MODULE I

Introduction to Nonlinear Systems: Types of non-linearities, peculiar properties of nonlinear systems, motivations for studying nonlinear control systems.

MODULE II

Phase Plane Analysis: Concept and construction of phase portraits, Phase plane analysis of linear and nonlinear systems, Existence of limit cycles.

MODULE III

Describing Function Method and Applications: Describing functions of common nonlinearities, describing function analysis of nonlinear systems.

MODULE IV

Stability of Nonlinear Systems: Equilibrium points, Concept of stability of nonlinear systems, Linearization and Local stability, Lyapunov's direct method, Lyapunov’s analysis of LTI systems

MODULE V

Nonlinear Control System design: Control design based on Lyapunov's direct method, Feedback Linearization, Basic concepts of sliding mode control.

Text Books:	
1.	Applied Nonlinear Control, J. J. Slotine, Prentice Hall, 1991.
Reference Books:	
1.	Nonlinear System Analysis, M. Vidyasagar, Society for Industrial and Applied Mathematics, 2002.
2.	Nonlinear Systems, H. K. Khalil, 3rd Edition, Prentice Hall, 2001.

Course Code	Course Title					Type of Course
ELE455E	Utilization of Electrical Energy					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objective: To comprehend the various uses of Electrical Energy consumption and fundamental principles of various categories of energy consuming sectors like electric heating, electric welding, lighting schemes, electric traction system and electric drives.

Course Outcomes (COs): After successfully finishing the course, students should possess the capability to:

1. Understand various methods of employing electrical energy for heating in both commercial and residential settings.
2. Understand several methods of using electrical energy for welding purposes.
3. Apply an appropriate lighting system in practical scenarios.
4. Analyze suitable traction systems based on specific applications.
5. Develop the capacity to distinguish between traditional and alternative energy vehicles.

MODULE I

Illumination: Nature of light, definitions, Laws of illumination, requirements of good lighting, Types of lighting schemes, Design of indoor lighting and outdoor lighting systems, street lighting, flood lighting, introduction to various types of lamps: incandescent, fluorescent, CFL and LED

MODULE II

Electric Welding: Introduction to electric welding, Importance of welding, welding equipment's, Resistance welding, Electric arc welding.

MODULE III

Electric Heating: Advantages of electric heating, Modes of transfer of heat, Classification of electric heating methods: Resistance heating (Direct and Indirect), Arc Furnaces, Induction Heating-Types and Advantages, Dielectric Heating-Advantages and applications.

MODULE IV

Electric Traction: Types of electric traction, systems of track electrification Traction mechanics-types of services, speed time curve and its simplification, average and schedule speeds, Tractive effort, specific energy consumption, mechanics of train movement, coefficient of adhesion and its influence.

MODULE V

Electric & Hybrid Electric Vehicles: Need for Electric vehicle- Comparative study of diesel, petrol, hybrid and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles,

Design requirement for electric vehicles, Main components and working principles of hybrid and electric vehicles, Different configurations of hybrid and electric vehicles.

Text Books:	
1.	Utilization of Electric Energy, E Openshaw Taylor 12th Impression, 2009, Universities Press.
2.	Modern Electric, Hybrid Electric and Fuel Cell Vehicles, E. Gay, Mehrdad, Ehsani, YiminGao, Sabastien. Ali Emadi, CRC Press.
3.	Art & utilization of Electric Energy, H. Partab.
4.	Utilization of Electric Power & Electric Traction J.B Gupta].
Reference Books:	
1.	H. Partab, " Modern Electric Traction" Dhanpat Rai & Sons.
2.	C.L. Wadhwa, " Generation, Distribution and Utilization of Electrical Energy" New Age International Publications.
3.	James Larminie and John Lowry, "Electric Vehicle Technology Explained " John Wiley & Sons,2003

Course Code	Course Title					Type of Course
ELE452E	Flexible AC Transmission Systems (FACTS)					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: The course is aimed to provide exposure the commonly used power electronics based compensating devices (FACTS). Also, the use of power electronics devices for reactive power compensation has increased immensely and thus demanding the thorough analysis of FACTS devices for their proper implementation.

Course Outcomes: Upon completion of this course students will be able to:

1. Learn about the necessity of using FACTS devices over conventional compensators.
2. Understand the proper controller for the specific application based on system requirements.
3. Analyze reactive power requirement and management. Assess and evaluate various compensators.
4. Understand use of SVC for Reactive Power Control and Coordination, Control Signals for System Transient Stability
5. Analyze the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping.

MODULE I

Facts Concept and General System Considerations: Concepts and general system consideration: Power Transmission Networks, Control of Power Flow in AC Transmission Line, Opportunities for FACTS devices, Types of FACTS Controllers: Shunt connected controllers, Series Connected controllers, Combined Shunt and Series connected controllers.

MODULE II

Shunt Compensators: Introduction to Shunt Compensation – Ideal Shunt Compensation, Advantages of Shunt compensation: Transient Stability, Power transfer capability, Voltage Stability. Objectives of Shunt compensation –Voltage control by SVC – VI characteristics – advantages of slope in dynamic characteristics – Influence of SVC on system voltage, Working of TCR, Operation of TSC.

MODULE III

Series Compensators: Introduction to series compensation – Ideal Series compensation, Advantages of series compensation: Transient Stability, Power transfer capability, Voltage Stability, Objectives of series compensation –Principle and operation of TCSC, VI characteristics, GCSC, TSSC, TSSR.

MODULE IV

Modern Compensators: STATCOM – principle of operation –VI characteristics – Applications, advantages. SSSC – principle of operation – Applications, advantages; UPFC: - Modes of operation – Applications, advantages. Introduction to IPFC.

MODULE V

Other Compensators: Objectives of voltage and phase angle regulators — Approaches to thyristor-controlled voltage and phase angle regulators – Industrial applications of FACTS devices- Case studies.

Text Books:	
1.	Understanding FACTS–Concept &technology of flexible AC transmission systems by Narain G. Hingorani and Laszl Gyugyi, Wiley, IEEE Press.
Reference Books:	
1.	FACTS Controllers in Power Transmission and Distribution by K.R. Padiyar, New Age International (P) Limited New Delhi.
2.	Thyristor-Based FACTS controllers for Electrical Transmission Systems by R. Mohan Mathur and Rajiv K. Verma,

Course Code	Course Title					Type of Course
ELE453E	Extra High Voltage (EHV) AC & DC Transmission					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: The objective of this course is to provide students with a comprehensive understanding of Extra High Voltage (EHV) AC & DC Transmission systems, including their principles, design, operation, and relevant technologies.

Course Outcomes: After studying this course, students will be able to:

1. Memorize key terms and definitions related to EHV transmission, such as corona discharge, insulation coordination, and voltage conversion.
2. Summarize the factors affecting the selection of insulation materials and design considerations for EHV transmission lines.
3. Apply knowledge of transmission line parameters to determine voltage drop and power losses in EHV systems.
4. Compare and contrast EHV AC and DC transmission systems in terms of their suitability for specific applications, considering factors like efficiency, cost, and reliability.
5. Design an EHV AC or DC transmission system for a given scenario, considering technical, economic, and environmental factors.

MODULE I

Introduction: Introduction-Necessity for EHV Transmission, Problems and disadvantages of EHV-AC transmission systems, Operational aspects of EHV power transmission, Compensation in EHV transmission system- series, shunt and mixed compensation, Environmental and biological effects.

MODULE II

EHV levels: Standard voltage levels for transmission lines, Selection of suitable voltage levels for transmission lines, Hierarchical levels of Transmission network, Average values of line parameters, Power handling capacity and line losses in EHV Transmission line, Number of circuits required for an EHV Transmission line, Cost of transmission line and equipment, Mechanical consideration in line performance.

MODULE III

Power flow: Power flow through an EHV line and transmission efficiency, Corona – factors effecting corona, Audible noise, Measurement formula for audible noise, Reduction of switching surges on EHV line, Towers, Clearance and Creepage distances.

MODULE IV

Comparison: Comparison of EHV AC and DC transmission: Economics of DC power Transmission, Technical performance and reliability, Choice of HVDC Transmission system,

Description of HVDC converter station, Types of HVDC links, Merits and limitations of HVDC system, Modern trends in HVDC Transmission.

MODULE V

Power electronics in EHV: Line commutated converter, Voltage source converter, Principle of HVDC link control, DC breaker, Harmonic filters, Converter faults, over current and over voltage protection scheme in HVDC substation.

Text Books:	
1.	Begamudre. R.D, "Extra voltage AC Transmission Engineering", Third Edition, New Age International (P) Limited, Publisher.
2.	Padiyar. K. R," HVDC Power Transmission System", New Age International (P) Limited, Publisher.
Reference Books:	
1.	Chakrabarti. A. M. L.Soni, P. V. Gupta, U. S. Bhatnagar," Power System Engineering", Dhanpat Rai and Co.
2.	High Voltage Engineering Fundamentals by E. Kuffel, W.S. Zaengl and J. Kuffel Newnes Publisher.

Course Code	Course Title					Type of Course
ELE456E	Electric Vehicle Technology					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: Explain electric, hybrid electric, and plug-in hybrid electric vehicle (PHEV), their architecture, technologies and fundamentals. Explain the design, component sizing of the power electronics converters and various electric drives suitable for hybrid electric vehicles. Demonstrate different configurations of electric vehicles and charging techniques.

Course Outcomes: After studying this course, students will be able to:

1. Identify EV concepts, EV configurations and various EV parameters for a better understanding of the EV technology
2. Analyze the EV propulsion system and electric motors for vehicular applications
3. Elaborate various hybrid electric vehicle configurations and explain the power flow control in all HEV configurations
4. Development of the Charging Infrastructure for EV
5. Design battery charger for an EV

MODULE I

Introduction: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the-Art EVs & HEVs, Comparison of EV Vs IC Engine. EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters.

MODULE II

EV Propulsion: Electric Motor: Choice of the electric propulsion system, a block diagram of EV propulsion system, the concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, in-wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications, Electric vehicle retrofitting in conventional vehicle.

MODULE III

HEV (Hybrid Electric Vehicle): Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow control in all HEV configurations, Examples of HEV system performance.

MODULE IV

EV Chargers: Conductive, Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods.

MODULE V

Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move and-charge zone, V2G and G2V.

Text Books:	
1.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2.	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
Reference Books:	
1.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
Web Resources	
1.	https://onlinecourses.nptel.ac.in/noc21_ee112/preview
2.	https://onlinecourses.nptel.ac.in/noc22_ee53/preview

Course Code	Course Title					Type of Course
ELE457E	Power System Dynamics and Stability					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives:

After completing the course, students will get acquitted with the detailed understanding power system stability, modeling of synchronous machines, transient and small signal stability analysis, as well as methods to enhance stability and manage voltage stability in power systems.

Course Outcomes: After studying this course, students will be able to:

1. Learn the basic concept and classifications of stability and understand its importance in the power system.
2. Design the models of synchronous machines, Excitation systems, Governors, etc., and to perform the steady state analysis.
3. Carry out the transient stability analysis of a single and multi-machine system.
4. Examine the small signal stability of a single and multi-machine system.
5. Design the PSS, High speed excitation system and reactive power control for transient and voltage stability enhancement of power system.

MODULE I

Introduction to Power System Stability: Definitions-classification of stability - Rotor angle and voltage stability. Stability problems in Power System and its impact on Power System Operations and Control.

MODULE II

Modeling of Synchronous Machine: Physical Characteristics. Rotor position dependent model. D-Q Transformation. Steady State Analysis of Synchronous Machines. Short Circuit Transient Analysis of a Synchronous Machine. Modeling of Excitation and Prime Mover Systems. Excitation System Control- Automatic Voltage Regulator. Prime Mover Control Systems-Speed Governors.

MODULE III

Transient Stability: Swing equation. Solution of swing equation. Numerical methods. Euler method. Runge-Kutte method. Critical clearing time and angle. Effect of excitation system and governors. Multi-machine stability. Extended equal area criterion. Transient energy function approach.

MODULE IV

Small Signal Stability: Small signal stability: State space representation. Eigenvalues. Modal

matrices. Small signal stability of signal machine infinite bus system. Effect of field circuit dynamics. Small signal stability of multi-machine system.

MODULE V

Frequency and Voltage stability: Centre of Inertia Motion. Load Sharing: Governor droop. Single Machine Voltage stability: Generation aspects. Transmission system aspects. Load aspects. PV curve. QV curve. PQ curve. Analysis with static loads.

Text Books:	
1.	Power System Dynamics and Stability, P. Sauer and M. A. Pai, Prentice Hall, 1997.
2.	Voltage Stability of Electric Power Systems, Van Cutsem, T., and Vournas, C., Kluwer Academic Publishers, 1998.
3	An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems, Abhijit Chakrabarti, D. P. Kothari, A. K. Mukhopadhyay and Abhinandan De, PHI Learning Private Ltd., 2010.
Reference Books:	
1.	Power System Stability and Control, Kundur, P., McGraw-Hill International, 1st Editions, 1994. (Text Book)
2.	Power System Dynamics, Stability and Control, K.R. Padiyar, B. S. Publications, 2002.

Course Code	Course Title					Type of Course
ELE458E	Power Quality					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: To study the various issues affecting Power Quality, their production, monitoring and Mitigation.

Course Outcomes: After studying this course, students will be able to:

1. Explain Various Power Quality terms of Electrical Power System.
2. Evaluate the performance of power systems (in regard to Power Quality Issues) under various power quality polluting devices using appropriate power quality monitoring tools and techniques.
3. Explore transient overvoltage sources (e.g., atmospheric and switching transients, motor starting, capacitor switching, UPS switching) and study protective devices.
4. Analyze the causes of Harmonics, its effect on various equipment and its mitigation techniques.
5. Design harmonics mitigation techniques and tools to meet the desired standards

MODULE I

Introduction to Power Quality: Importance of Power Quality, Common Disturbances in Power Systems, Short-Duration Voltage Variation, Long-Duration Voltage Variations, Transients, Impulsive Transients, Oscillatory Transients, Voltage Imbalance, Sag, Swell, Harmonics, DC Offset, Notching, Noise, Voltage Fluctuations, Power Frequency Variations, Ambiguous Terms CBEMA and ITI Curves, Standards.

MODULE II

Voltage Sag: Sources of voltage sag: motor starting, arc furnace, fault clearing, etc; estimating voltage sag performance and principle of its protection; solutions at end-user level- Isolation Transformer, Voltage Regulator, Static UPS, Rotary UPS, and Active Series Compensator.

MODULE III

Electrical Transients: Sources of Transient Over voltages- Atmospheric and switching transients- motor starting transients, pf correction capacitor switching transients, ups switching transients, neutral voltage swing, etc., devices for over-voltage protection.

MODULE IV

Harmonics: Causes of harmonics; current and voltage harmonics: measurement of harmonics; effects of harmonics on – Transformers, AC Motors, Capacitor Banks, Cables, and Protection Devices, Energy Metering, Communication Lines, etc.

MODULE V

Harmonic Mitigation Techniques: Design and analysis of filters to reduce harmonic distortion – Power conditioners, passive filter, active filter - shunt, series, hybrid filters, UPQC.

Text Books:	
1.	Roger C Dugan, McGrahan, Santoso&Beaty, "Electrical Power System Quality" McGraw Hill
2.	Arindam Ghosh,"Power Quality Enhancement Using Custom Power Devices Power Quality Enhancement Using Custom Power Devices", Springer, 2002.
3.	C. Sankaran, "Power Quality" CRC Press
Reference Books:	
1.	Angelo Baggini (Ed.) Handbook of Power Quality, Wiley, 2008
2.	G. T. Heydt, 'Power Quality', Stars in circle publication, Indiana, 1991
3.	Math H. Bollen, 'Understanding Power Quality Problems' Wiley-IEEE Press, 1999

Course Code	Course Title					Type of Course
ELE459E	Fundaments of Smart Grids					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: To understand the evolution of electric grids and the concept of smart grids. Gain knowledge of smart sensors and automation technologies for real-time pricing and home automation.

Course Outcomes: After studying this course, students will be able to:

1. Remember the key concepts related to smart grids and differentiate them from conventional grids.
2. Explain the need for and benefits of implementing smart grids and identify various sensing, measurement, control, and automation technologies used in smart grids.
3. Apply knowledge of smart sensors and automation technologies to real-time pricing and home automation.
4. Analyze the implications of wide-area measurement systems (WAMS) and phase measurement units (PMUs) in power system monitoring and control.
5. Create a proposal for a smart grid implementation, considering the integration of smart technologies and distributed energy resources.

MODULE I

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid.

MODULE II

Sensing, Measurement, Control and Automation Technologies: Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug-in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.

MODULE III

Smart Grid Technologies: Smart Substations, Substation Automation, Feeder Automation, Geographic Information Systems (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU), PMUs application to monitoring & control of power system.

MODULE IV

Micro Grids and Distributed Energy Resources: Introduction to distributed generation, Concept of microgrid, need & applications of microgrid, formation of microgrid, issues of interconnection, Integration of renewable energy sources, protection & control of micro grid. Islanding, need and

benefits, different methods of islanding detection.

MODULE V

Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid-connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web-based Power Quality Monitoring, Power Quality Audit.

Text Books:	
1.	A. Keyhani, "Design of Smart power grid renewable energy systems", Wiley IEEE.
2.	W.G.Clark, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
Reference Books:	
1.	J.N. Green, R.G. Wilson "Control and Automation of Electric Power Distribution Systems (Power Engineering)", CRC Press.
2.	R.C. Dugan, M.F. McGranghan, S. Santoso, H.W. Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.
3.	Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley

Course Code	Course Title					Type of Course
ELE460E	Principles of System Identification					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: The main goal of the course is to give a self-contained mathematical treatment of System Identification theory and methods. Throughout the course both off-line and on-line system ID methods will be presented. Effectiveness of the design methodology will be demonstrated using static maps and dynamic systems, in continuous and discrete time domains. Students will be asked to run a course project (system ID related) using models of their choice.

Course Outcomes: After studying this course, students will be able to:

1. State and describe the system identification problem.
2. Understand what class of models are suited for a given process and be equipped to handle uncertainties in data.
3. Identify parametric and non-parametric dynamical models from data.
4. Apply various system identification methods; prediction error method, instrumental variable method or recursive identification to estimation problems in engineering.
5. Analyze system-identification tasks for obtaining state-space models.

MODULE I

Introduction: Motivation; historical developments; system identification basics; quantitative and qualitative model; deterministic vs. stochastic models; non-parametric vs. parametric models; data generation and acquisition; data pre-processing; data visualization; model assessment and validation; prior process knowledge; identifiability; overfitting; goodness of the model; developing the state-space model.

MODULE II

Mathematical Descriptions of Processes: Definition of mode; classification of models; models for identification; convolutional model; finite impulse response (FIR) model; step response model; frequency response model; difference equation form; state-space models; Illustrative example in MATLAB: estimation of FIR model; estimation of step-response model; estimation of difference equation model; estimation of state-space model.

MODULE III

Identification of Dynamic Models: Introduction; non-parametric descriptions; parametric descriptions; equation-error models: ARX family, ARMAX family, ARIMAX models; output-error family; Box-Jenkins family; selecting an appropriate model structure; Predictions: conditional expectation and linear predictors; one-step ahead prediction and innovations; multi-step and infinite-step ahead predictions; model identifiability; system identifiability.

MODULE IV

Identification of Parametric and Non-parametric input-output Models: Parametric time-series models: Estimation of AR models; Y-W models; least squares; modified covariance methods; Bug's methods; ML estimator; estimation of MA models; Non-parametric input-output models: direct impulse response estimation; regularization and including prior knowledge; indirect estimation for parametric models.

MODULE V

Identification of State-Space Models: Mathematical essentials: observability and controllability; Kalman filter; extended Kalman filter, extended observability matrix; realization methods; subspace identification methods: MOESP method and N4SID method.

Text Books:	
1.	*Arun K. Tangirala, Principles of System Identification: Theory and Practice, CRC Press 2014.*
2.	*Karel J. Kessman, System Identification: An Introduction, Springer 2011.*
Online Resources:	
1.	*Principles of System Identification by Prof. Arun K. Tangirala, IIT Madras. https://archive.nptel.ac.in/courses/103/106/103106149/*

Course Code	Course Title					Type of Course
ELE461E	Optimal Control Methods					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Discipline Centric

Course Objectives: The main objective of this course is to determine control signals that will cause a process (plant) to satisfy some physical constraints and at the same time extremize (maximize or minimize) a chosen performance criterion (performance index or cost function).

Course Outcomes: After studying this course, students will be able to:

1. Define the optimal control problem from specifications on dynamic constraints and objective formulation.
2. Explain the basic concepts of calculus of variations, such as function, function, variation, and increment.
3. Analyze and solve optimal control problems using Pontryagin's principle and Hamiltonian formalism.
4. Apply linear quadratic regulator techniques to design control systems for different performance indices and constraints.
5. Analyze and solve variational problems by deriving and solving Euler-Lagrange equations for different constraints and boundary conditions.

MODULE I

Introduction to Optimal Control: Classical and modern control; concept of optimization; statement of the optimal control problem; performance index; constraints; types of constraints.

MODULE II

Calculus of Variations and Optimal Control: Basic Concepts: Function and functional, increment; differential and variation; optimum of a function and a functional; basic variational problem; fixed-end time and fixed-end state system; discussion of Euler-Lagrange equation; different cases for Euler-Lagrange equation; the second variation, extrema of functions and functionals with conditions; Variational approach to optimal control systems; optimal control systems with Hamiltonian formalism (Pontryagin principle), application to minimum time; Energy and control effort problem.

MODULE III

Linear Optimal Control Systems: Finite time linear quadratic regulator; LQR system for general performance index; analytical solution to the matrix differential Ricatti equation; infinite time linear quadratic regulator; finite-time linear quadratic tracking problem

MODULE IV

Dynamic Programming: Bellman’s principle of optimality, multistage decision processes, Optimal control using Dynamic Programming, the Hamilton Jacobi Bellman (HJB) equation

MODULE V

Optimization-based feedback for discrete systems: Least-square estimation; Minimum energy control; Model predictive control (MPC)

Text Books:	
1.	D.S. Naidu, "Optimal Control Systems," CRC Press, 2003.
2.	D. E. Kirk, "Optimal Control Theory: An Introduction" Dover, 2004Fausett L.V. (2007) Applied Numerical Analysis Using MATLAB, 2nd Ed., Pearson Education
Reference Books:	
1.	B. D. O. Anderson and J. B. Moore, "Optimal Control: Linear Quadratic Methods," Dover Publications, 2014
2.	F.L. Lewis, D. Vrabie and V.L. Syrmos, "Optimal Control," 3rd edition, Wiley & Sons, 2012
Online Resources:	
1.	Optimal Control by Prof. G. D. Ray, IIT Kharagpur https://archive.nptel.ac.in/courses/108/105/108105019/

Elective Courses (Generic)

Course Code	Course Title					Type of Course
ELE 354G	Renewable Energy Systems					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Generic

Course Objectives: This course aims to reflect a comprehensive learning experience covering fundamental energy concepts, various renewable energy technologies, their practical applications, and the broader implications of energy choices on the environment and future energy security

Course Outcomes: After studying this course, students will be able to:

1. To Assess different energy resources, understand energy, environment and need for renewables.
2. To apply and analyze the concepts of solar energy: solar thermal & solar PV technology.
3. To learn and implement the concept of wind energy extraction and its uses.
4. To evaluate the scope and potential of other renewable energy resources.
5. To create awareness of energy conservation and to search for future energy sources.

MODULE I

Introduction to Energy Scenarios: Introduction to energy demand and supply systems, Classification and types of energy sources, Advantages and disadvantages of renewable and non-renewable energy sources, Global and National energy status.

MODULE II

Solar Energy: Introduction**,** Factors affecting solar energy: Solar irradiance, different solar angles, Measurement of solar radiation, Solar energy variation curves, **Solar PV Systems:** Solar cell, principle, operation, and characteristics, Formation solar cell/module/array, Block diagram and components of Solar PV system for residential applications, **Solar Thermal Systems:** Solar collectors and its classification, Solar water heating system, Solar space heating/cooling system, Other technologies.

MODULE III

Wind Energy: Introduction, Origin of winds, Nature and characteristics of wind with time and height, Measurement of wind data, Wind rose, Estimation of wind energy, Components and working principle of wind energy conversion system (WCES), Types of wind turbines

MODULE IV

Other Renewable Energy Sources: Biomass Energy: Introduction, Biomass resources, Energy conversion techniques, Urban waste to energy conversion, **Small Hydro:** Introduction and classification of small hydro plant (SHP), Advantages and Disadvantages of SHP, Layout of SHP,

Classification of hydro turbines, Estimation of hydro power generation, **Geothermal Energy:** Introduction, origin and distribution of geothermal energy, Types of geothermal resources, **Ocean Energy:** Introduction to tide, wave and ocean thermal energy, Origin of tidal energy, Power conversion from tidal energy, Power generation from wave energy, Ocean thermal energy conversion system

MODULE V

Emerging Technologies and Energy Storage: Introduction, classification and application of fuel cells, Introduction, types and applications of hydrogen energy, Different methods of hydrogen production, Various energy storage technologies.

Text Books:	
1.	B. H. Khan, "Non-Conventional Energy Resources", Tata McGraw-Hill, 2006.
2.	John F. Walker & Jenkins. N, "Wind Energy Technology", John Wiley and Sons, 1997.
3.	M. R. Patel, "Wind and Solar Power Systems: Design, analysis and Operation", Taylor and Francis,
Reference Books:	
1.	G.D. Rai, "Non-Conventional Energy Sources", First Edition, Khanna Publishers, Delhi,1999.
2.	Van Overstraeton and Mertens R.P., "Physics, Technology and Use of Photovoltaics",Adam Hilger, Bristol, 1996.
3.	Agarwal M.P., "Future Sources of Electrical Power", S. Chand Co. Ltd., New Delhi, 1999.

Course Code	Course Title					Type of Course
ELE355G	Sensors, Transducers, & Instrumentation Systems					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Generic

Course Objectives: Successful completion of this course will equip students with a comprehensive understanding of mechanical and electromechanical sensors, transducers, telemetry, data acquisition, display devices, and emerging sensor technologies for real-life applications.

Course Outcomes: After studying this course, students would have:

1. Understand and remember the terminologies of Transducers and various Sensors.
2. Learn to choose the proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, and acceleration.
3. Apply signal conditioning for measurements and analyze telemetric applications.
4. Evaluate various measurement techniques for industrial applications based on display devices, recorders, smart transmitters, and sensors.
5. Set up testing strategies to evaluate the performance characteristics of different types of sensors and transducers.

MODULE I

Mechanical and Electromechanical Sensor: Definition, principle of sensing & transduction, classification. Thermal sensors: Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Resistance thermometer, Thermistors, Thermocouples. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature. Inductive sensors: Reluctance change type, Mutual inductance change type, transformer action type, Magnetostrictive type, Ferromagnetic plunger type. LVDT & RVDT: Construction, material, output input relationship. Proximity sensor.

MODULE II

Transducers: Capacitive, Piezoelectric, Hall effect, and optoelectronics transducers. Measurement of Motion, Force, Pressure, and temperature. Measurement of flow of liquid and liquid levels using differential pressure transducers, venturi meters and electromagnetic flow meters, etc.

MODULE III

Display Devices and Recorders: Display devices, storage oscilloscope, spectrum analyzer, strip chart & x-y recorders, flux meters, magnetic tape & digital tape recorders.

MODULE IV

Telemetry: General telemetry system, landline & radio frequency telemetering system, transmission channels, and media, receiver & transmitter. Data Acquisition System: Analog & digital data acquisition system, Digital measuring techniques, Sample and Hold Circuits, Comparator, Buffers, D/A Conversion and A/D Conversion, Weighted Resistor DAC, R-2R ladder DAC, Dual Slope, Parallel-comparator, Successive Approximation ADC techniques, Single channel and multi-channel Data Acquisition System (DAS).

MODULE V

Recent Developments and Real-life Applications: Computer-aided measurements, fiber-optic transducers, microsensors, radiation sensors, smart sensors, smart transmitters.

Text Books:	
1.	A. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons.
2.	B.C. Nakra & K. Chaudhary, "Instrumentation, Measurement and Analysis", Tata McGraw Hill 2nd Edition.
Reference Books:	
1.	Rajendra Prasad, Electronic Measurement and Instrumentation Khanna Publisher.
2.	E.O. Decblin, "Measurement System – Application & design", McGraw Hill.
3.	W.D. Cooper and A.P. Beltried, "Electronics Instrumentation and Measurement Techniques" Prentice Hall International.

Course Code	Course Title					Type of Course
ELE404G	Electrical Installations					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Generic

Course Objectives: The course aims to provide students with a foundational understanding of electrical installations, focusing on safety practices, codes and standards, wiring methods, and practical skills needed to effectively plan, execute, and troubleshoot basic electrical installations in residential and small commercial settings. By the end of the course, students should be able to perform safe and accurate electrical installations while adhering to industry regulations and best practices.

Course Outcomes: After studying this course, students will be able to:

1. Understand & interpret electrical wiring drawings, its preparation, types of wiring, test & measurement of various electrical parameters as per IS, and Selection of electrical accessories.
2. Know fundamental considerations for electrification of commercial complexes & public buildings, illumination requirements & use of D.G. set in case of emergency.
3. Understand different methods of service connections, metering systems, and cable laying in buildings.
4. Know Safety rules for the electrical installation of buildings, various protection devices & IE rules for installation & testing.
5. Design electrical installation systems for commercial & public buildings, calculation of total electrical load, specifications of materials & accessories, estimating & costing of materials, different mounting arrangements & locations for electrical components.

MODULE I

Elements of Electrification: Wiring layout, Type of wiring- Concealed /Surface conduit etc. Calculation of total electrical load, Specification of wiring material and accessories, selecting appropriate mounting arrangements and positioning of Switchboards, distribution boards, main switch, Selection of electrical accessories such as main cable, bus bars, and main switches

MODULE II

Electrical Measurement Instruments: Multimeter: analog multi-meter, digital multi-meter; tester: tong tester, energy-meter, megger, earth resistance meter, power factor meter; extension of range of measurement instruments: voltmeter, ammeter, loading effect of voltmeter, voltage drops effect of an ammeter; high voltage testing and measurements; calibration.

MODULE III

Fundamental Consideration for Electrical Installation for Commercial Complexes and Public Buildings: concept of commercial installation, comparison of residential and commercial installation, illumination requirements in commercial and public building, power conditioning and its importance; different power conditioning appliances: battery, inverter, diesel generator set,

stabilizer, ups; change over switch. Use of national building code for safety, ie rules related to electrical installation and testing.

MODULE IV

Earthing: Earthing and its importance: Basic considerations of earthing, earthing resistance, Measurement of soil resistivity; Types of ground connections, Pipe Earthing, Plate Earthing; Ground Testing.

MODULE V

Estimating and Costing Fundamentals: Introduction to electrical drawings, Estimation of Single and Three Phase Wiring: Steps for Estimation and Costing of Electrical Installations, costing calculations and Schedule of Rates; Estimation and Costing of House Wiring and Electrical Installations

Text Books:	
1.	Electrical Design, Estimation and Costing by Raina K.B. Bhattacharya S.K., Wiley Estern Ltd.
2.	A course in Electrical Installation, Estimating & Costing by Gupta J.B., S.K. Kataria and Sons.
Reference Books:	
1.	Bureau of Energy Efficiency Reference book: No.1, 2, 3, 4. Energy Conservation Guidebook, Dale R Patrick, Stephen W Fardo, 2nd Edition, CRC Press
2.	Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience publication.
3.	Handbook of Energy Audits, Albert Thumann, 6th Edition, The Fairmont Press.

Course Code	Course Title					Type of Course
ELE405G	Design of Solar PV Systems					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Generic

Course Objective: The objective of the course is to develop a comprehensive technological understanding of solar PV parameters, system components and also provide in-depth understanding of design parameters to help in designing the different applications based solar PV power plant

Course Outcomes (COs): After successfully finishing the course, students should possess the capability to:

1. Understand the energy scenario and forecast of the environment along with the state policies for combating the climate change.
2. Understand the working of solar cells along with the impact of different parameters on the output power.
3. Analyse the effect of different solar angles and the estimation of solar energy generation.
4. Understand the different components of the solar power plants along with different solar configurations of solar plant
5. Design the solar photovoltaic power rating along with the backup for different applications.

MODULE I

Introduction to Solar Photovoltaic Energy: General aspects of energy system Global and Indian Energy Scenario, Solar PV forecast 2040, net-zero CO_2 emissions in 2050, India's rooftop solar market, State Energy Policy, Working of Solar Cell, solar materials for photovoltaic system, physics of photovoltaic system Semiconductor, Silicon Semiconductor, Phosphorus, Boron, N-type Silicon, P-type Silicon, Formation of Solar Cell, p-n junctions, Solar Cell, Solar PV module, Solar PV, Module Arrays, PV and IV characteristics of solar cells, types of solar cells.

Lab Exercises:

1. To plot the different characteristics of Solar PV panels.
2. Series and parallel connection of solar panels for enhancing the voltage and current rating of the PV array.

MODULE II

Solar Resource Assessment: Solar Resource: Solar Irradiance, Insolation, Solar Radiation, PSI, Sun Path, Tilt Angle, Solar Angle, Calculate Altitude Angle, Azimuth Angle, Calculate Optimum Tilt Angle, Solar Radiation Energy, estimating solar energy generation on flat and tilted surfaces, Solar Photovoltaic conversion,

Lab Exercises:

1. To estimate the solar radiation on the horizontal and tilted plain and also estimate the seasonal effects.

2. To estimate the solar energy generation on the horizontal and tilted plain and also estimate the seasonal effects.

MODULE III

Technical Specification and data sheets: Electrical Specification of different PV modules, understanding of Datasheet, Effects of parameters, Effects of temperature and irradiance on output voltage, current, and power, Effect of connecting different voltage and current rated panels on power output. Effects of shadings, Voltage and current mismatch in Solar PV systems.

Lab Exercises:

1. To measure the effects of temperature and irradiance on the Solar PV panel output parameters like current voltage and power.
2. To measure the effects of shading on the Solar PV panel output parameters like current voltage and power.

MODULE IV

Solar PV plant components: Overview and selection criteria for types of photovoltaic system, solar inverters, battery and charge controller, solar PV balance of system: AC Cables, AC Distribution Boards, AC Isolator, Array Junction Boxes(AJB), Batteries (optional, usually found only in small rooftop plants), Connectors, DC Cables, DC Distribution Boards, switches, Earthling Kit, Fuses, Lightning Protection, Meters, Surge Protection Devices, Transformers Electrical installation design Wires & Cables, Mechanical structure Design, Types of Solar PV System, Off Grid, On-Grid, Hybrid System, Design methodology for SPV system.

Lab Exercises:

1. To understand the main components and balance of the system of a solar plant.
2. To understand the different configurations and types of solar plants

MODULE V

Solar PV Application Design and Calculation: Solar PV system installation and its application design and calculation, Street light design and calculation, Solar water pump design and calculation, EV charging station design and calculation, cold storage design and calculation.

Lab Exercises:

1. To design the solar plant for domestic consumers using homer software
2. To design the solar plant for industrial consumers using Homer software along with the economic analysis

Text Books:	
1.	Solar Photovoltaics – Fundamentals, Technologies and Applications, C. S. Solanki, 2nd ed. (PHI Learning, 2011)

2.	Non-Conventional Energy Resources, B.H Khan, 3rd Edition, McGraw Hill Education India Private Limited, 1 July 2017
Reference Books:	
1.	Handbook of photovoltaic science and engineering, ed. A. Luque and S. Hegedus (John Wiley and Sons,2010)
2.	Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. V.V.N. Kishore(TERI Press, 2008).
3.	Photovoltaic system engineering, R. A. Messenger and A. Abtahi, 3rd ed. (CRC Press, 2010)
4.	Grid-connected PV systems design and installation, GSES (GSES India Sustainable Energy, 2013)

Course Code	Course Title					Type of Course
ELE450G	Small Hydro Plants					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Generic

Course Objectives: This course is designed to equip students with a comprehensive overview of small hydroelectric power plants, including their design, operation, and environmental considerations. By the end of the course, students should have a solid understanding of the principles, components, and processes involved in small hydroelectric power generation.

Course Outcomes: After studying this course, students will be able to:

1. Understand the types of hydro plants and the suitability of different hydropower plants.
2. Understand the different components of the small hydropower plant and design the small hydropower plants.
3. Evaluate the power potential of a SHP site.
4. Select and analyze the suitable hydraulic turbine for a SHP site.
5. Evaluate the economic viability and socio-economic benefits of a SHP site.

MODULE I

Introduction of small hydropower plants (SHPs): Classification of hydropower plants, Advantages and disadvantages of small hydropower plants (SHPs), Types of Small hydropower plants, Potential of SHPs, Development of SHPs in India and worldwide, process of SHP site development, Barriers to small hydropower development, Problems being faced in execution of SHPs.

MODULE II

Hydrology: Classification of fluids, characteristics of water, units of pressure, pascal's law, applications of pascal's law, hydraulic press, pressure measurement types of fluid flow, streamline and turbulent flow, velocity equation, Bernoulli's equation, power equation, continuity equation, cavitation, venturi meter, orifice meter, pitot tube.

MODULE III

Civil work of small hydropower plants (SHP): Site selection, environmental aspect, run-of-the-river, and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, surge chamber, spillways, tailrace, penstock, and powerhouse.

MODULE IV

Components of Small Hydropower Plants (SHP): Hydraulic turbines: types and operational aspects classification of hydraulic turbines; Francis, Pelton, Kaplan and propeller, differences between impulse and reaction turbines; operational aspects of turbines, efficiency and selection of turbines, types of generators, synchronous and induction generators, transformers.

MODULE V

Financial aspects and Environmental issues of SHP: Cost structure, Initial and operation cost. Environmental issues related to small and large hydropower plants, Potential of small hydropower in Northeast India.

Text Books:	
1.	Small hydroelectric Engineering Practice- Bryan Leyland, CRC Press
2.	Hydropower Engineering- C.C. Warnik, Prentice Hall.
3.	A Textbook of Water Power Engineering: R.K.Sharma, T.K.Sharma
Reference Books:	
1.	Hydroelectric Handbook: Creagar, W.P. and Justin, J.D., John Wiley & Sons, New York.
2.	Davis' Handbook of Applied Hydraulics, Zipparro, V. J. and Hasen H., Mc-Graw Hill, Inc., New York
3.	Hydropower Structures :R.S.Varshiray, Nem Chand and Bros. Roorkee

Course Code	Course Title					Type of Course
ELE451G	Wind Energy Technology					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Generic

Course Objectives: The objective of the course is to impart understanding related to wind power generation, its future scope, technologies, environmental benefits, site selection and mechanism.

Course Outcomes: After studying this course, students will be able to:

1. Learn about the traditional use of wind power, how wind power is calculated, and terms used in the wind industry.
2. Understand the construction and design of different types of wind turbines as well as different controlling mechanisms used in Wind Energy Conversion Systems (WECS).
3. Select a particular type of generator for a specific WECS site.
4. Learn about the geography of the wind farm site and then design the layout of the wind farm.
5. Learn about the applications of power electronics in wind energy conversion systems.

MODULE I

Basic Fundamentals: Traditional use of wind power, origin of wind and its applications, apparatus used for measurement of wind speed, wind energy dynamics, lift and drag forces, power extracted from wind, axial thrust on turbines, torque, maximum power and Betz criteria, power coefficient, wind turbine operational characteristic, assessment of wind energy.

MODULE II

Wind Turbines Types: Horizontal axis wind turbine (HAWT) and Vertical axis wind turbines (VAWT) constructions, applications, relative merits, and operational difficulties, lift and drag turbines, upwind and downwind machines, wind energy input controlling mechanisms and strategies: Pitch control, Stall control, etc., Types of Turbine blades, Aerophile dynamics.

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MODULE III

Wind Energy Conversion Systems (WECS): Basic components, fixed speed and variable speeds WECS, their advantages and disadvantages. Type of generators used in WECS (Synchronous, Induction, D.C, etc.), Mode of operation of WECS. Application of power electronics in WECS control.

MODULE IV

Wind Farm and Location: Typical layouts, site selection of wind farms, power evacuation, and operational problems with grid interface. Offshore and onshore wind farms, merits and challenges.

MODULE V

World Scenario and Environmental Effects: Growth in the wind industry and challenges, Comparison of growth in developed, developing, and underdeveloped nations: Wind potential, installed capacity (Both grid-tied and stand-alone). Developments in turbine materials, Ecological impact on wildlife, birds, marine life (offshore wind farms), noise problem and its solutions.

Text Books:	
1.	Non-Conventional Energy Sources, B. H. Khan, McGraw Hill, 3rd Edition, 2017.
2.	Wind Energy: Theory and Practice, Siraj Ahmed, 2ed Edition, PHI Publications.
3.	Wind Energy Conversion System, L.L. Freris, Prentice Hall,(U.K.), 1990.

Course Code	Course Title					Type of Course
ELE452G	Optimization for Engineering Design					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	2	0	2	4	3	Generic

Course Objectives: This course introduces fundamental optimization principles. It covers single and multivariable unconstrained optimization, constrained optimization, and evolutionary optimization techniques such as Genetic Algorithms and Simulated Annealing. Through hands-on MATLAB lab exercises, students gain practical experience in applying these techniques to real-world engineering problems, enhancing their problem-solving abilities.

Course Outcomes: After studying this course, students will be able to:

1. State and describe the optimization problem formulation relating to engineering application.
2. Analyze and evaluate single variable unconstrained optimization techniques.
3. Apply multivariable unconstrained optimization techniques based on optimality criteria and gradient-based methods.
4. Evaluate and solve constrained optimization problems using Penalty function techniques.
5. Synthesize knowledge of evolutionary optimization techniques, including metaheuristic techniques.

MODULE I

Overview of Optimization: Introduction, Historical development, Engineering applications of optimization, Optimization problem formulation, Classification of Optimization Problems.

Lab Exercises:

1. To define linear and nonlinear functions in MATLAB.
2. To define single and multi-variable functions in MATLAB.
3. To visualize contour plots using MATLAB's *fcontour* command of famous unimodal functions.

MODULE II

Single Variable Unconstrained Optimization Techniques: Single Variable unconstrained optimization - Optimization criteria, bracketing methods – Exhaustive search method, Bounding phase method; Region Elimination methods – Fibonacci search method, Golden section search method; Gradient-based methods – Newton Raphson method, Bisection method; Root finding using optimization technique.

Lab Exercises:

4. To implement Bracketing methods: Bounding Phase, Exhaustive Search, and tabulating the results in MATLAB.

5. To implement Fibonacci and Golden Section methods for region elimination in MATLAB.
6. To implement Newton Raphson for a single variable in MATLAB and tabulate the results.

MODULE III

Multivariable Unconstrained Optimization Techniques: Multivariable unconstrained optimization- Optimality criteria; Unidirectional search, Direct search methods, Box's evolutionary optimization method, Coordinate Descent method, Powell's conjugate direction method; Gradient-based methods, Cauchy's steepest descent method, Newton's method, Conjugate gradient method.

Lab Exercises:

7. To calculate the gradient vector and Hessian matrix of functions in MATLAB.
8. To implement unidirectional search methods in MATLAB and tabulate the results.
9. To visualize the descent and ascent directions of a function in MATLAB.
10. To analyze and implement Descent algorithms in MATLAB.

MODULE IV

Constrained Optimization Techniques: Constrained optimization, problem formulation, local and global minima in constrained problems, Kuhn tucker Conditions; Transformation to unconstrained problems using Penalty functions; Specialized Methods- Integer programming, Solving integer programming problems using Penalty function method; Introduction to Geometric programming.

Lab Exercises:

11. To get familiarized with MATLAB’s optimization toolbox.
12. To solve constrained optimization problems in MATLAB and tabulate the results.

MODULE V

Evolutionary Optimization Techniques: Introduction to Genetic Algorithm (GA), Differences and similarities between Genetic Algorithms and Traditional methods, GAs for Constrained Optimization; Introduction to Simulated Annealing.

Lab Exercises:

13. To generate random numbers from standard distributions in MATLAB.
14. To find global optima using GA in MATLAB.
15. To compute a few iterations of the simulated annealing method in MATLAB.

Text Books:	
1.	Kalyanmoy Deb, Optimization for Engineering Design 2nd Edition, Prentice Hall, India 2021.
2.	Kalyanmoy Deb, Multi-objective optimization using Evolutionary algorithms, John Wiley
Reference Books:	
1.	S. Rao, Optimization Techniques.
Online Resources:	
1.	Introduction to Optimization by Prof. A. Goswami and Prof. Debjani Chakraborty, IIT Kharagpur https://nptel.ac.in/courses/111105039

Course Code	Course Title					Type of Course
ELE454G	Carbon Audit and Net Zero Energy Buildings					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Generic

Course Objective: This course will give an in-depth understanding of the effects of carbon emissions on the environment and consequent challenges skills to conduct carbon audits, different definitions of Net Zero-Energy building (NZEBs) and the different steps involved in achieving NZEB goals.

Course Outcomes (COs): After successfully completion of course, students should possess the capability to:

1. Identify the effects of carbon emissions on the environment and consequent challenges,
2. Acquire necessary knowledge and skills to conduct carbon audits and life cycle analysis to identify carbon management opportunities,
3. Understand the concept of Zero Energy Building definitions, solar energy utilization in buildings and other Renewable sources of power generation for buildings
4. Analyze the transient building heat transfer and its impact on thermal comfort and Energy conservation studies in building perspective
5. Get familiar with novel materials and designs for NZEB construction, Tangible strategies for reducing energy demands in different climatic zones.

MODULE I

Energy and society, Climate change and the greenhouse gases, Relative contribution of various sectors to global anthropogenic greenhouse gas emissions, mitigation, adaptation and other potential strategies, Energy as a measure source of carbon emissions, Estimation of carbon emissions from extraction, conversion, storage, transport and utilization of various energy carriers

MODULE II

Carbon management in new buildings and cities, Carbon implications of waste reduction and recycling, Strategies for carbon storage in soil and in oceans, Energy generation for a low carbon society, Carbon credits, trading schemes, Carbon economics, Low carbon investments, Carbon labeling, Challenges and opportunities in carbon management in energy sector and energy intensive industries and applications

MODULE III

Introduction to net zero energy buildings (nzebs) and its concepts; different definitions of nzebs; relevance of such systems; steps to achieve nzebs; challenges involved in the design of such systems, sources of renewable power for nzebs; thermal loads and energy use in buildings.

MODULE IV

Design Considerations in NZEBs: Building fabric/ envelope, HVAC and Lighting Systems, Integration with Solar/ Renewable Energy Systems, Comfort considerations in NZEBs: Thermal Comfort, Visual Comfort, Acoustic Comfort, Indoor Air Quality; Carbon Footprint Mitigation; NZEB Case Studies, Future Directions

MODULE V

Building Management Systems; Optimal resource dispatch (thermal and electrical), demand side management with NZEB operation including HVAC, lighting control Operation of building microgrids in grid connected/islanded modes, provision of ancillary services or peer to peer sharing among the various buildings

Text Books:	
1.	Subramanian S. M., The Carbon Footprint Handbook, CRC Press (2015).
2.	Emmanuel R., Keith B., Carbon Management in the Built Environment, Routledge (2012).
3.	Athienitis A. and O'Brien W., Modeling, Design, and Optimization of Net-Zero Energy Buildings, Ernst &Sohn, (2015).
4.	Goswami, D. Y., Principles of Solar Engineering, CRC Press Taylor & Francis Group (2015).
5.	Chwieduk, D., Solar Energy in Buildings, Elsevier (2014).
6.	Arora, C. P., Refrigeration and Air Conditioning, McGraw Hill Education (2017).
Reference Books:	
1.	UNDP, Carbon Handbook, United Nations Development Programme (2014).
2.	Holman, J. P., Heat Transfer, McGraw Hill Education (2010).
3.	Duffie, J. A., Beckman, W. A., Solar Engineering of Thermal Processes, John Wiley & Sons, 2006

Audit Courses

Course Code	Course Title					Type of Course
MTH210B	Bridge Course in Mathematics-I					Audit
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	2	0	0	2	0	Engineering Science

Course Objectives: Bridge learning gaps that students have in their knowledge and understanding of key mathematical concepts like Sets, Matrices, Trigonometry, Complex numbers, and Coordinate geometry to make them well-equipped to grasp mathematical concepts in more advanced courses.

Course Outcomes: After studying this course, students will be able to:

1. Understand the fundamental concepts of sets, including set notation, operations, and set theory principles.
2. Perform operations on matrices, including addition, subtraction, and multiplication, and use matrices to solve systems of linear equations.
3. Calculate determinants of square matrices and apply them to determine the invertibility of a matrix and to solve systems of linear equations using Cramer's rule.
4. Apply trigonometric functions, identities, and the unit circle to solve problems involving angles, triangles, and periodic phenomena.
5. Utilize coordinate geometry principles to analyze geometric figures, including lines, planes, and conic sections.

MODULE I

Sets, Relations and Functions: Definition and Representation of Sets, Types of Sets, Operation on Sets. Definition and Types of Relations, Partial Order and Equivalence Relations. Definition, classification, and types of functions, Composition, and Inverse of functions, Basic single variable functions (exponential, log, etc.) and their properties.

MODULE II

Matrices and Determinants: Types of Matrices, Operations on Matrices, Determinants and Cofactors, Inverse of a Square Matrix, Rank of Matrix, Elementary row/column operations, System of Linear Equations

MODULE III

Trigonometry: Ratios in right triangles, Introduction to the trigonometric ratios, Reciprocal trigonometric ratios. Unit circle, Trigonometric values on the unit circle, Graphing sinusoidal functions, Amplitude, midline, and period. Non-right triangles & trigonometry. Trigonometric equations and identities.

MODULE IV

Complex numbers: Imaginary numbers, Complex numbers. The complex plane. Adding & subtracting complex numbers. Multiplying complex numbers. Complex conjugates & dividing complex numbers. Absolute value & angle of complex numbers. Distance & midpoint of complex numbers. Introduction to Complex Functions.

MODULE V

Basic Coordinate Geometry: Straight Line: Equations, direction ratios, and direction cosines, angle between two lines, distance of a point from a line. Plane: General form, intercept and normal form, Condition of co-planarity of two lines, equation of a plane passing through the intersection of two planes, angle between two intersecting planes, bisectors of angles between two intersecting planes, parallelism, and perpendicularity of two planes. Equations of skew lines, shortest distance between two skew lines. Introduction to conic sections.

Text Books:	
1.	Higher Algebra by Hall and Knight, published by S. Chand & Co. Ltd.
2.	Schaum's Outline of Precalculus by Fred Safier and Agnes A. Herzberg, McGraw-Hill Education.
Reference Books:	
1.	Coordinate Geometry by S.L. Loney, Arihant Publications.

Course Code	Course Title					Type of Course
MTH260B	Bridge Course in Mathematics-II					Audit
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	2	0	0	2	0	Engineering Science

Course Objectives: Bridge learning gaps that students have in their knowledge and understanding of key mathematical concepts like differential and integral Calculus, differential equations and applications of calculus in a real-world context to make them well equipped to grasp mathematical concepts in more advanced courses.

Course Outcomes:

1. Understand the fundamental concepts of differential and integral calculus, including limits, derivatives, and definite and indefinite integrals.
2. Solve first-order ordinary differential equations using various methods, such as separation of variables, integrating factors, and exact equations.
3. Analyze and solve higher-order ordinary differential equations, including homogeneous and nonhomogeneous equations, using techniques like undetermined coefficients and variation of parameters.
4. Apply calculus to vector quantities and analyze vector-valued functions, including derivatives and integrals of vector functions.
5. Understand and apply fundamental theorems of calculus, including the Fundamental Theorem of Calculus, to evaluate integrals and solve problems involving areas, volumes, and physical applications.

MODULE I

Limits and continuity: Estimating limits from graphs, Estimating limits from tables, Formal definition of limits (epsilon-delta): Limits and continuity, Properties of limits, Limits by direct substitution, Limits using algebraic manipulation, Strategy in finding limits, Squeeze theorem, Types of discontinuities, Continuity at a point, Continuity over an interval: Limits and continuity, Removing discontinuities, Infinite limits, Limits at infinity: Limits and continuity, Intermediate value theorem.

MODULE II

Differential Calculus: Derivatives: definition and basic rules: Average vs. instantaneous rate of change, Secant lines, estimating derivatives, Differentiability, Power rule, Derivatives of trigonometric functions, Product and Quotient rules, chain rule Implicit differentiation, Differentiating inverse functions, Second derivatives, Logarithmic differentiation.

MODULE III

Applications of Differential Calculus: Straight-line motion, non-motion applications of derivatives, Approximation with local linearity, L'Hospital's rule. Analyzing functions. Mean value theorem, Extreme value theorem and critical points Intervals on which a function is increasing or decreasing, Relative (local) extrema, Absolute (global) extrema, Concavity and

inflection points, second derivative test, sketching curves, Connecting f, f', and f". Introduction to Taylor series and its applications.

MODULE IV

Integration: Integrals as accumulations of change, Approximation with Riemann sums, Summation notation review, Riemann sums in summation notation, defining integrals with Riemann sums, Fundamental theorem of calculus and accumulation functions, Definite integral, Properties of definite integrals, Reverse power rule, Indefinite integrals of common functions, Definite integrals of common functions, Integrating using different methods.

MODULE V

Differential Equations: First order differential equations - Variable separable, homogeneous, linear, exact differential equation - Integrating factors - Existence and uniqueness of solution, General solutions of second order differential equation - Homogeneous and non-homogeneous differential equations with constant coefficients - Method of variation of parameters - Method of undetermined coefficients, higher order differential equations with constant coefficients

Text Books:	
1.	*Essential Calculus: Early Transcendentals*, James Stewart, Cengage Learning.
2.	*Calculus: An Intuitive and Physical Approach*, Morris Kline, Dover Publications.
Reference Books:	
1.	*A First Course in Differential Equations with Modeling Applications*, Dennis G. Zill, published by Cengage Learning.

Elective Courses (Open)

Course Code	Course Title					Type of Course
ELE001	Technology: What, Why and Why not?					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	2	0	0	2	2	Open

Course Objective: To provide students with a comprehensive understanding of the historical development of technology, introducing key philosophical concepts related to technology and science, exploring the relationship between the two, and delving into various aspects of technological artifacts, knowledge, processes, and their ethical, aesthetic, and social implications.

Course outcomes: After the completion of the course:

1. Students will be able to identify and describe significant technological advancements throughout history, understanding their impact on societal development.
2. Students will comprehend foundational principles of philosophy of technology and philosophy of science, articulating the interconnectedness of these disciplines and their relevance to contemporary issues.
3. Students will critically analyze the dynamic relationship between technology and science, evaluating how advancements in one field contribute to the progress of the other.
4. Students will investigate the nature of technological artifacts, the knowledge involved in their creation, and the processes that drive technological advancements.
5. Students will engage in philosophical discussions about how technology shapes and reflects human nature, considering the reciprocal influence between humans and their technological creations.

Brief history of technology; Introduction to Philosophy of technology and philosophy of science, the relationship between technology and science; Technological artifacts; Technological knowledge; Technological processes; Technology and the nature of humans; Ethics and aesthetics of technology; Design and technology; Ethical and Social Aspects of Technology.

Text Books:	
1.	Teaching about Technology, Marc J. De Vries.
2.	Philosophy of Technology, Val Dusek.
3.	A Companion to the Philosophy of Technology Edited by Jan Kyrre Berg Olsen.

Course Code	Course Title					Type of Course
ELE002	Green Buildings: An introduction					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	2	0	0	2	2	Open

Course Objective: Student will learn the basics of green design and sustainable development concepts, will learn to identify various implementing strategies for green design in projects and will learn about institutional guidelines for the development and certification of green designs

Course Outcomes (COs): After successfully finishing the course, students should possess the capability:

1. To define sustainability and a green building, along with its features and benefits.
2. To carry out Green Building rating using different rating agencies guidelines.
3. To understand the energy efficiency terms and methods used in green building practices.
4. To apply different alternate effective use water requirements.
5. To apply different alternate sources of renewable energy and effective use of solar energy.

MODULE I

Introduction to Green Buildings: Definition of green buildings, definition of sustainability, typical features of green buildings, benefits of green buildings towards sustainable development.

MODULE II

Green Building Rating Systems- Building Research Establishment Environmental Assessment Method **(**BREEAM) – Leadership in Energy and Environmental Design (LEED) - GREEN STAR -GRIHA (Green Rating for Integrated Habitat Assessment) for new buildings – Purpose - Key highlights - Point System with Differential weightage.

MODULE III

Methods to reduce operational energy: Energy efficient building envelopes, Solar Heat Gain Coefficient, U-Values for facade materials, efficient lighting technologies, energy-efficient and BEE-rated appliances for heating and air-conditioning systems in buildings,

MODULE IV

Water conservation and efficiency: Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, water-efficient plumbing systems, water metering, wastewater treatment, recycle and reuse systems.

MODULE V

Utility of Solar Energy in Buildings: Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings, energy metering and monitoring, the concept of NET ZERO buildings.

Text Books:	
1.	HarharaIyer G, Green Building Fundamentals, Notion Press
2.	Dr. Adv. HarshulSavla, Green Building: Principles & Practices
Reference Books:	
1.	Sam Kubba, "Handbook of Green Building Design and construction", Elsevier Architecture Press.
2.	Abe Kruger and Carl Seville, "Green building: principals and practice in residential construction", Cengage Learning.
3.	IGBC Green New building rating system (Version 3.0), March 2015.
4.	GRIHA Manual Volume-1: Introduction to National Rating System by Ministry of New and Renewable Energy, Government of India and the energy and resource institute, New Delhi.
5.	Kibert, C. "Sustainable Construction: Green Building Design and Delivery", John Wiley & Sons, 2005
Online Resources:	
1.	https://www.youtube.com/watch?v=THgQF8zHBW8
2.	https://www.youtube.com/watch?v=DRO_rIkywxQ

Course Code	Course Title					Type of Course
ELE003	Electricity in Daily Use					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	2	0	0	2	2	Open

Course Objective: The main objective of this subject is to have the basics and fundamental understanding of electrical engineering, domestic appliance features, electrical energy tariff along the concept of energy conservation.

Course Outcomes (COs): After the completion of the course the students will be able to

1. Remember the Basic of electrical engineering
2. Understand the electrical wiring concept along with the ratings and specifications.
3. Understand the various features of different electrical appliances used for domestic purposes.
4. Analyze the electricity tariffs and able to calculate the monthly electricity bills.
5. Apply the energy conservation techniques at their home.

MODULE I

Fundamental concepts: What is electricity, how is electricity produced, how is current produced, how is current and voltage measured, the concept of resistance, basic DC circuits, Power in DC circuits, Series and Parallel connections, what is Alternating current, Alternating current circuits, Power in AC circuits.

MODULE II

Safety, Wiring and Earthing: Features of power supplied to domestic consumers, Symbols and sign conventions as in Electricity rules, safety measures in electrical circuits, Earthing and its utility, Typical wiring layout in a home, specifications of wires, plugs and sockets of different current ratings. Safety equipment

MODULE III

Features of various electrical equipment used by domestic consumers: Power rating and other features of Incandescent, CFL lamps and LED lighting, Domestic water pumps, Mixers and Grinders, Single phase transformers and Automatic voltage stabilizers, Inverters, Refrigerators, Televisions, Iron, Water heaters, Induction heaters, Infrared Heaters, Rice cookers, Micro-wave ovens.

MODULE IV

Electricity Tariff: Various Electrical Utility companies supply power to consumers in the state, Measurement of power consumption by the consumer by the Utility, Significance of power usage agreement signed with the Utility, Tariff calculation, and understanding the electricity bill. Introduction to smart meters, the concept of net metering.

MODULE V

Electrical energy conservation at home: Steps that can be taken to minimize electrical energy consumption in homes, e.g., for lighting, cooking, Space heating, water heating, choosing appliances that are energy efficient, star rating of appliances.

Text Books:	
1.	Basic Electricity by Van Valkenburg
2.	Basic Electricity – A self-teaching guide by Charles W Ryan
Reference Books:	
1.	Salomon, T., Bedel, S. (2007). The Energy Saving House. United Kingdom: Centre for Alternative Technology Publications.
2.	S C Bhargava. Household Electricity and Appliances. (2020). (n.p.): BSP Books . ISBN:9789390211432, 9390211433

Course Code	Course Title					Type of Course
ELE004	Solar Photovoltaic Installation and Maintenance					Elective
Prerequisite	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	2	0	0	0	2	Open (Skill)

Course Objective: The objective of the course is to develop a comprehensive technological understanding in solar PV parameters, system components and provide in-depth understanding of design parameters to help in designing and installation of the different applications based solar PV power plant

Course Outcomes (COs): After successfully finishing the course, students should possess the capability:

1. To understand the solar radiation and basics definitions
2. To understand the different configuration of the solar power plants along with the different parameters of data sheets
3. To design the solar photovoltaic sizing and rating along with the backup for different application.
4. To understand the design of electrical wiring of different configuration.
5. To able to do the basic maintenance of solar plant

MODULE I

Solar Radiation: Irradiation and Peak Sun Hours, Solar Radiation Data, Sun path Diagram, Defining the Position of the Sun, Solar Altitude, Geometric Effects, Tilting Solar Modules,

MODULE II

PV System Configurations and Technical Specification: Grid Connected PV Systems, Standalone PV Systems, Grid Tied with Battery Backup Systems, Comparison of deferent configuration. Electrical Specification of different PV Module, understanding of Datasheet, Pmax, Vmp, Voc, Imp, Isc, Module Fill Factor, Efficiency.

MODULE III

Sizing of different Components: Sizing of solar panel, inverters and batteries, Solar PV system installation and its application design and calculation,

MODULE IV

Installation of rooftop Solar Plant: Design and understanding of single line diagram of Electrical wiring of different configuration of PV plants along with its installation

MODULE V

Maintenance & Troubleshooting

Maintenance: Panel Dry and wet cleaning, batteries and charge controller maintenance, Precautions and Preventive Steps, Troubleshooting, fault tracing etc.

Text Books:	
1.	Solar Photovoltaics – Fundamentals, Technologies and Applications, C. S. Solanki, 2nd ed. (PHI Learning, 2011)
2.	Non-Conventional Energy Resources, B.H Khan, 3rd Edition, McGraw Hill Education India Private Limited, 1 July 2017
Reference Books:	
1.	Handbook of photovoltaic science and engineering, ed. A. Luque and S. Hegedus (John Wiley and Sons,2010)
2.	Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. V.V.N. Kishore(TERI Press, 2008).
3.	Photovoltaic system engineering, R. A. Messenger and A. Abtahi, 3rd ed. (CRC Press, 2010)
4.	Grid connected PV systems design and installation, GSES (GSES India Sustainable Energy, 2013)

Course Code	Course Title					Type of Course
ELE005	Electrical System Installations and Maintenance					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	2	0	0	2	2	Open (Skill)

Course Objective: Empower students with skills to plan, install, and test wiring for diverse projects. Develop expertise in estimating costs, tendering, and contracting, emphasizing IE rules and enhancing capabilities for project planning and execution. Focus on skill development in relevant areas.

Course Outcomes (COs): After the completion of the course the students will be able to

1. Understand the types of wiring and accessories required for conduiting and wiring.
2. Identify the symbols and sign conventions used in electrical wiring installations.
3. Take safety measures along with the installation of safety equipment in residential, commercial, and industrial units.
4. Perform detailed load calculations and determine the appropriate wire sizes for them.
5. Perform the maintenance of small electrical appliances.

MODULE I

Electrical Wiring: Types of wires, wiring system, Specifications of different types of wiring materials, Accessories, wiring tools, Wiring circuits, Domestic wiring

MODULE II

Electrical Safety Guidelines: Features of power supplied to domestic consumers, Symbols and sign conventions as in electricity rules, Specifications of wires, Plugs and sockets of different current ratings, Earthing and its utility, Safety measures in electrical circuits, Safety equipment.

MODULE III

Domestic Wiring: Layout for domestic wiring, Load calculation, conductor selection, Parts of switchgear, Use of megger and earth tester.

MODULE IV

Distribution System: Transmission lines, Line supports, cross arms, pole brackets and clamps, guys and stays, conductors spacing and clearances, span lengths, overhead line insulators, insulator materials lightning arrestors, Earthing of lines, Guarding of overhead lines.

MODULE V

Repairs and Maintenance of Electrical Appliances: Materials and cost required for maintenance work, Tools used for repairs & maintenance work, Maintenance of electric fan,

electric iron, electric geyser, rice cooker, toaster, single phase transformer, single phase motor, etc.

Text Books:	
1.	Electrical Design, estimating & Costing, Raina, K. B. and Bhattacharya,S.K. New Age International (p) Limited, New Delhi
2.	Electrical Estimating & costing, Uppal, S L, New Age International (p) Limited, New Delhi
Reference Books:	
1.	Electrical Installation Estimating & Costing, Gupta, J.B., S. K. Kataria & Sons, New Delhi
2.	I.E. rules for wiring, Electricity supply act-1948., Bureau of Indian Standards, Electricity supply act-1948.

Course Code	Course Title					Type of Course
ELE006	Energy: Environmental Impact and Conservations					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
-	3	0	0	3	3	Multidisciplinary (FYUGP)

Course Objective: To provide students with a comprehensive understanding of energy, its various forms, sources, and the impact of energy consumption on the environment, society, and economy. Additionally, the course aims to equip students with knowledge and skills for promoting energy conservation and reducing personal carbon footprints through sustainable practices.

Course Outcomes: After the completion of the course the students will be able to:

1. Recall and list the various forms of energy, including conventional and unconventional sources.
2. Explain the impact of energy consumption on the environment, citing specific examples of air and water pollution, ozone layer depletion, and global warming.
3. Apply energy conservation principles in different sectors such as household, transportation, agriculture, service, and industry to demonstrate an understanding of energy-efficient practices.
4. Analyze the global energy scenario, evaluating energy demands in urban and rural sectors and examining the political impacts of energy consumption on a societal level.
5. Develop a plan for reducing personal carbon footprint, integrating renewable energy sources, solar rooftops, and electric vehicles, and justify the choices made for sustainable living practices.

MODULE I

Introduction to Energy and Energy Demand: Definition and units of energy, energy flow diagram to the earth, origin and time scale of fossil fuels, Conventional and unconventional energy sources, energy conversion and storage. Global energy scenario, urban and rural demand in sectors like agriculture, industry, transport, domestic etc.

MODULE II

Impact of Energy: Role of energy in economic development and social transformations, Impact of energy consumption and production on environment, air and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation, Concept of Carbon footprint and Carbon trading, Political impact of energy, WHOs data on human health affected by unclean energy.

MODULE III

Energy Convservation: Concept of energy conservation, energy conservation in various sectors, household, transportation, agricultural, service and industrial sectors. Introduction to Energy Tariff, Energy Demand Side management, energy efficient practices and technologies, start ratings.

MODULE IV

Methods for reducing personal carbon footprint: Motivation for using renewable energy, installation of solar rooftops, solar water geysers, electric vehicles, green building overview, planning for green from the start to design, site selection and development, house design and orientation, passive heating/ cooling and day-lighting.

Text Books:	
1.	Non-conventional Energy Resources, B. H. Khan, McGraw Hill.
2.	Energy Management and Conservation, K. V. Sharma, P. Venkateshaiah, Wiley
Reference Books:	
1.	Green Building: Principles and Practices in Residencial Construction, Abe Kruger, CArl Seville, Delmar Cengage Learning.

Course Structure and Subject-Wise Course Contents For B. Tech Honors/ Minor Specialisation in

Energy Systems Engineering

Applicable for 2023 batch onwards

Course Structure

S. No	Semester	Course Code	Course Title	Hours Per Week			Credits
				L	T	P	
1.	III	ELE201S	Fundamentals of Solar Technologies	3	0	0	3
2.	IV	ELE250S	Wind and Small Hydro Systems	3	0	0	3
3.	V	ELE301S	Power Electronics for Renewables	3	0	0	3
4.	VI	ELE350S	Energy Storage Systems	3	0	0	3
5.	VII	ELE401S	Modelling of Energy Systems	3	0	0	3
6.	VIII	--	Energy Audit and Management (ELE450S) OR *Any approved relevant course from the NPTEL/ SWAYAM Platform	3	0	0	3
Total Credits							**18**

* *The students will be given the flexibility of choosing the course in the 8th Semester.*

Course Code	Course Title					Type of Course
ELE201S	Fundamentals of Solar Technologies					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Specialisation

Course Objectives: The objective of this course is to provide students with a comprehensive understanding of solar energy, encompassing both photovoltaic (PV) and solar thermal technologies. At the end of this course, students will acquire knowledge about solar resource assessments, various PV technologies and their parameters, balance of system considerations, as well as gain in-depth insights into the theory, design, and practical aspects of solar thermal collectors and energy storage mechanisms.

Course Outcomes: After successfully completing the course, students will be able to:

1. Assess and understand solar thermal principles, including collector designs and energy storage mechanisms.
2. Analyze solar PV technologies and balance of system factors, while also comprehending solar thermal collector theory and applications.
3. Design efficient solar PV systems integrating insights from solar thermal energy storage mechanisms.
4. Estimate costs for solar PV installations and grasp the economics of grid-connected systems, integrating solar thermal energy assessment principles.
5. Understand both solar PV and solar thermal domains, prepared for diverse roles in renewable energy sectors

Module I

Solar Resource Assessment and Thermal Energy: Basics of solar radiation, solar angles, measurements and estimation of solar radiation, Measurement and recording of solar irradiance with Pyranometer and irradiance meter. Classifications of solar collectors, flat plate and evacuated tube solar collectors, concentrating solar collectors, design considerations, design of receivers for heat collection, Tracking systems for solar concentrators, Emerging technologies in solar concentrators.

Module II

Solar Thermal Application: Solar thermal energy systems for various industrial process heating, water heating, water distillation, drying, solar cooker, solar building heating and cooling, and solar refrigeration, thermal energy storage systems: sensible, latent and thermochemical energy storage system, materials for energy storage.

Module III

Solar Photovoltaic: Design of solar photovoltaic cell and its working principle, types of solar cell, characteristics of solar cell, data sheet and parameter understanding, Efficiency of solar cell, factor affects the performance of solar cell, solar photovoltaic module/panel and array, estimation and measurement of PV module power, selection of PV module. overview and selection criteria for

different types of photovoltaic system, solar inverters, battery and charge controller, AC cables, AC distribution boards, AC isolator, array junction boxes (AJB), connectors, DC cables, DC distribution boards, Disconnects/switches, Earthling Kit, fuses, lightning protection.

Module IV

Solar PV Application Design and Calculation: Design and calculation of streetlight, Solar water pump, EV charging station and cold storage, Introduction to MPPT and its types, Introduction to power tracker, Types of solar PV System, Off Grid, On-Grid, Hybrid system.

Module V

Design of Solar Thermal Technologies: Design considerations, challenges and possible solutions in integrating solar thermal energy systems for various applications, Solar thermal power generation: Stand-alone and Grid-connected.

Books Recommended:

Text Books:	
1.	Solar Photovoltaics – Fundamentals, Technologies and Applications, C. S. Solanki, 2nd ed., PHI Learning, 2011.
2.	Non-Conventional Energy Resources, B.H Khan, 3rd Edition, McGraw Hill Education India Private Limited, 1 July 2017
Reference Books:	
1.	Handbook of photovoltaic science and engineering, ed. A. Luque and S. Hegedus, John Wiley and Sons, 2010.
2.	Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. V.V.N. Kishore, TERI Press, 2008.
3.	Photovoltaic system engineering, R. A. Messenger and A. Abtahi, 3rd ed., CRC Press, 2010.
4.	Grid connected PV systems design and installation, GSES India Sustainable Energy, 2013.

Course Code	Course Title					Type of Course
ELE250S	Wind & Small Hydro Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	0	0	3	3	Specialisation

Course Objectives: This course is designed to equip students with a comprehensive overview of small hydroelectric power plants and wind energy including their design, operation, and environmental considerations. By the end of the course, students should have a solid understanding of the principles, components, processes as well as problems involved in small hydroelectric power generation and wind energy.

Course Outcomes: After studying this course, students will be able to:

1. Acquire a comprehensive understanding about the aerodynamics, control strategies, and grid integration of horizontal axis wind turbines.
2. Acquire skills relevant to wind energy professionals, including modeling, analysis, and decision-making in wind turbine design and operation.
3. Understand the different types of small hydro plants and suitability.
4. Understand the different components and evaluate the power potential of various SHP's.
5. Apply theoretical knowledge to practical scenarios through case studies and real-world examples.

Module I

Regulation Strategies for Wind Turbines: Control Strategies: Constant Speed Wind Turbines, Variable Speed Wind Turbines, Passive Stall Control, Variable Pitch Control, Active Stall Control, Control System: Sensors, Controller, Actuators, Safety System, Main Control Loops: Torque, Pitch, Yaw Angle, External Grid, SCADA. Wind Turbine Modelling.

Module II

Grid Integration of Offshore Wind Farms: Connection requirements: fault ride through, frequency range and frequency control, Reactive range capability and voltage control. Grid connection methods: HVAC connections, LCC HVDC connection, VSC HVDC connection, Alternative solutions, Case studies, comparison of connection methods.

Module III

Aerodynamics of Horizontal Axis Wind Turbines (HAWT): Basic aerodynamic issues, wind-speed variation from ground, capacity factor, Flow models and analysis, Torque and power coefficients, maximum wind energy conversion efficiency, optimum HAWT: Ideal blade twist and taper, non-ideal effects and Tip loss, aerofoils for HAWT, Unsteady aerodynamic effects of HAWTs, Velocity -Power response of turbine, energy model

Module IV

Introduction to Small Hydro Power Plants (SHPs): Classification of SHPs, Advantages and disadvantages of SHP's, Types of SHP's, Potential of SHP's, Power Equation, Site selection.Run-of-the-river and storage schemes, diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, surge chamber, spillways, tail race, penstock and power house. SWOT analysis.

Module V

Components of Small Hydro Power Plants (SHPs): Hydraulic Turbines: Types and Operational Aspects, Classification of Hydraulic Turbines; Francis, Pelton, Kaplan and Propeller, differences between impulse and reaction turbines; Operational Aspects of Turbines, Efficiency and selection of turbines, types of generators, synchronous and induction generators, transformers.

Books Recommended:

Text Books:	
1.	Small hydroelectric engineering practice- Bryan Leyland, CRC Press, 2014.
2.	Advances in Wind Energy Conversion Technology, Satyajith Mathaw, Geeta Susan Philip, Springer Heidelberg Dordrecht London New York, 2011.
Reference Books:	
1.	A Textbook Of Water Power Engineering: R.K.Sharma, T.K.Sharma
2.	Wind Energy Handbook T. Burton, D. Sharpa, N. Jenkins and E. Bossenyi, by John Wiley & Sons, Ltd Baffins Lane, Chichester West Sussex, PO19 1UD, England

Course Code	Course Title					Type of Course
ELE301S	Power Electronics for Renewables					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	0	0	3	3	Specialisation

Course Objectives: The objective of this course is to acquaint students with the principle of operation, design and synthesis of different power conversion circuits for their application in renewable energy systems.

Course Outcomes: After studying this course, students will be able to:

1. Understand the role of various power electronic components in renewable energy technologies.
2. Design DC to DC and DC to AC converters.
3. Describe various charge controllers and inverters used in solar energy technologies.
4. Understand various solar DC efficient products available in the market.
5. Understand the power converters for wind energy conversion systems.

Module I

Power Electronics Components: Components of power electronic circuits used in renewable energy like diode, MOSFETs, IGBTs, etc. their functionalities and I-V characteristics.

Module II

DC – DC Converters: Need of DC-DC conversion in renewable energy technologies, basics of DC-DC conversion, design of circuits, input and output parameters.

Module III

Application of DC-DC Controllers to Solar Energy: Solar based DC products for domestic and industrial appliances, functionality and design of simple charge controller, input and output parameters, design of MPPT charge controller

Module IV

DC – AC Conversion: Need of DC-AC conversion in renewable energy technologies, basics of DC-AC conversion, design of circuits, input and output parameters: functionality and design of off-grid inverter and hybrid inverters.

Module V

Controlled Rectifier: Half bridge and full-bridge ac-dc converters, power circuit and steady state analysis, DC-AC-DC, AC-DC-AC converters for wind energy system.

Books Recommended:

Text Books:	
1.	M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2.	P.S. Bimbhra , "Power Electronics", 4th edition, Khanna Publisher, India, 2018.
3.	Remus Teodorescu, Marco Liserre, Pedro Rodriguez, "Grid Converters for Photovoltaic and Wind Power Systems" Wiley-IEEE Press, January 2011.
4.	Sudipta Chakraborty, Marcelo G. Simões, William E. Kramer, "Power Electronics for Renewable and Distributed Energy Systems" Springer 2013.USA
Reference Books:	
1.	Fang Lin Luo, Hong Ye, "Advanced DC/AC Inverters: Applications in Renewable Energy" CRC Press, 2013.
2.	Philip T. Krein, "Elements of Power Electronics" Oxford University Press -2004
3.	Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, "Power Electronic Converters for Microgrids" Wiley-IEEE Press, April 2014.

Course Code	Course Title					Type of Course
ELE350S	Energy Storage Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Specialisation
Course Objectives: After completing the course, students shall know about the role and application of various energy storage technologies in modern power systems. The students will get acquainted with the knowledge of energy storage techniques, battery chemistry, battery management systems, and the development cycle for batteries.						
Course Outcomes: After studying this course, students will be able to: 1. Understand the role and applications of different energy storage devices. 2. Get acquainted with the working principles of modern energy storage techniques. 3. Learn about the different components and chemical processes of a battery. 4. Understand the charging/discharging control of the battery for enhanced life. 5. Design the development cycle for the battery.						

Module I

Introduction to Different Types of Storage Techniques: What is energy storage and why is it used, Components of basic ESS, Role of ESS in power system, Possible applications of ESS in power system, Classification of various energy storage technologies used in electrical industry: Pumped Hydro, Compressed air, Flow batteries, Battery storage, Fuel cell, Flywheel energy storage, Superconducting magnetic energy storage system, Supercapacitor energy storage system etc. Performance parameters of ESS

Module II

Energy Storage Used in Modern Power Systems: Lead-acid battery, lithium-ion battery, sodium-ion battery, Nickel-cadmium battery, Nickel metal hydride battery, Supercapacitor, Superconducting magnetic energy storage system, Flywheel energy storage system, their features and comparison, High-temperature batteries.

Module III

Working of Batteries (Battery Chemistry): Electrode, Electrolytes, Collectors, Chemical reactions in batteries, Lithium-ion Batteries: Lithium Manganese Oxide, Lithium iron phosphate, Lithium nickel manganese cobalt oxide, Lithium nickel cobalt aluminum oxide batteries, Saltwater batteries, and Potassium ion batteries.

Module IV

Battery Management System for Batteries (Power Conditioning System): Objective of battery management system: Charging and discharging control, determination of state of charge (SOC) and state of health (SOH), distributed, modular and centralized BMS topologies, impact on battery life

Module V

Development Cycle for Batteries: Battery size and design (electrical, mechanical, thermal), Development of EMS software and hardware, Prototype development, Lab testing (energy density, energy efficiency, Ampere Hour density, number of charge and discharge cycles, operating temperature, self-discharge etc.) and validation, Safety tests, Certification.

Books Recommended:

Text Books:	
1.	Energy Storage for electricity grid: Benefits and Market potential Assessment guide, Jim Eyer, Garth Corey, Scandia Report, Scandia National Laboratories, Feb 2010.
2.	Energy storage: Fundamentals, Materials and Applications, Robert A Huggins, Springer, 2016.
3.	Energy Storage Systems, David Elliot, IOP Science, 2017.
Reference Books:	
1.	Energy storage technologies and applications, C. Michael Hoff, Artech House, 2022.

Course Code	Course Title					Type of Course
ELE401S	Modelling of Energy Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Specialisation

Course Objectives: Through this course, the students will learn about modeling of energy systems and associated phenomena and apply these models for analysis of thermal and electrical energy systems.

Course Outcomes: At the end of the course, the students would be able to:

1. Understand various energy system models, including continuum, stochastic and network models.
2. Develop models of thermal systems, including heat exchangers, refrigeration systems and air-conditioners.
3. Design models of chemical energy systems, analyze reactor behavior and perform thermogravimetric analysis.
4. Develop an understanding of electrical systems modeling techniques, including transfer functions, state space models, and model order reduction techniques.
5. Model synchronous and induction machines, including the application of various transformation techniques used in modeling.

Module I

Fundamentals of Energy Systems: Introduction; Types of Energy Systems Models- Continuum, Stochastic and Network Models, Continuum Model Equations of Energy Stochastic Models, Overview of Molecular Dynamics and Population Balance Models, Process Optimization

Module II

Thermal Systems Modelling: Overview of design and simulation, Methodology for heat exchangers, refrigerators and air conditioners, Parametric Estimation, Optimization Methods: Lagrange Multiplier, Search Techniques, Geometric Programming

Module III

Chemical Energy Systems Modelling: Heating and Cooling of Reactors, Ignition and Extinction Temperatures, Multiplicity and Hotspot Formation in Reactors, Fossil Fuel Pyrolysis and Combustion Models, Adiabatic Combustion Temperature, Thermogravimetric Analysis, Modelling of fuel cells and batteries.

Module IV

Electrical Energy Systems Modelling: Introduction to electrical systems modelling, Transfer function and State space models, Lumped and Distributed parameter models, Nonlinear models, Linearization, Model Order Reduction, Modelling of PV systems.

Module V

Modelling of Synchronous Machine and Excitation System: Modeling of Excitation and Prime Mover Systems. Excitation System Control- Automatic Voltage Regulator. Prime Mover Control Systems-Speed Governors, equivalent circuit, Modelling of wind energy system.

Books Recommended:

Text Books:	
1.	Numerical Heat Transfer and Fluid Flow, Taylor and Francis, S.V. Patankar, 2018.
2.	Mathematical Modeling: A Chemical Engineer's Perspective. Academic Press. Fogler, H. Scott, 1999.
3.	P. Kundur, " Power System Stability and Control", Mc Graw-Hill Publications, 2006.
Reference Books:	
1.	Heat Transfer, J.P. Holman and Souvik Bhattacharya, McGraw Hill, 2017.

Course Code	Course Title					Type of Course
ELE450S	Energy Audit and Management					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Specialisation

Course Objectives: This course provides the engineering students with the knowledge and skills necessary to conduct energy audits, analyze energy consumption patterns, and implement energy management strategies. Students will explore various aspects of energy efficiency, renewable energy integration, and energy policy.

Course Outcomes: Upon successful completion of this course, students will be able to:

1. Explain the importance of energy efficiency and the role of energy audits.
2. Conduct energy audits and analyze energy consumption data.
3. Identify energy efficiency opportunities in various systems.
4. Understand the basics of energy management systems and policies.
5. Present findings and recommendations from energy audits effectively.

Module I

Introduction to Energy Audit: Overview of Energy Audit, Importance of energy efficiency, Types of energy audits, Energy consumption metrics, Role of energy auditors

Module II

Energy Audit Process: Pre-Audit Preparation, Data Collection and Analysis, Energy Audit Tools and Techniques, Identifying energy efficiency opportunities, Case studies and Field Visits.

Module III

Energy Conservation: Energy-Efficient Technologies, Lighting and HVAC Systems Efficiency, Motors and drives optimization, Building envelope improvements, Industrial process optimization.

Module IV

Demand Side Management (DSM): Concept and Scope of Demand Side Management, Difference between Energy Efficiency and DSM, Evolution of Demand Side Management, DSM Strategy, Planning, Implementation and its application, Customer Acceptance & its implementation issues, National and International Experiences with DSM, UDAY scheme and other government initiatives for DISCOMs.

Module V

Energy Management and Policies: Energy management systems (EMS), Energy monitoring and control, Energy policy and regulations, Energy conservation programs, laws and regulations, present state of implementation and standardization, labeling in India, energy efficiency rating for buildings and appliances

Books Recommended:

Text Books:	
1.	Energy Management and Conservation by P. Venkataseshaiah K.V. Sharma, Wiley India, 2011.
2.	Energy Conservation Guidebook, Third Edition, By Dale R. Patrick, Stephen W. Fardo, River Publishers, 2015.
3.	Handbook of Energy Auditby Sonal Desai, McGraw Hill Education, 2017.
4.	Wayne C Turner, Energy Management Handbook, The Fairmount Press., 2000.
5.	D Patrick and S W Fardo, Energy Management and Conservation, Prentice Hall Inc, 2006.
6.	Hamies, Energy Auditing and Conservation; Methods, Measurements, Management Case Study, Hemisphere, Washington, 1980.
Reference Books:	
1.	Gellingn, Chamberli, Demand Side Management: Concepts and methods, Penwell, 1993.
2.	Charles M Cotlschalk, Industrial Energy Conservation, John Wiley & Sons, 1996.

Course Structure and Contents

B. Tech Honors/ Minor Specialisation

In

Electric Vehicle Technology

Course Structure

S. No	Semester	Course Code	Course Title	Hours Per Week			Credits
				L	T	P	
1.	III	ELE202S	Introduction to Electric Vehicles	3	0	0	3
2.	IV	ELE251S	Vehicle Dynamics	3	0	0	3
3.	V	ELE302S	Safety and Regulations of EVs	3	0	0	3
4.	VI	ELE350S	Energy Storage Systems	3	0	0	3
5.	VII	ELE402S	EV Charging Infrastructure	3	0	0	3
6.	VIII	---	EV Motor Drives (ELE451S) OR * Any approved relevant course from the NPTEL/ SWAYAM Platform	3	0	0	3
Total Credits							**18**

* *The students will be given the flexibility of choosing the course*

Course Code	Course Title					Type of Course
ELE202S	Introduction to Electric Vehicles					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
III	3	0	0	3	3	Specialisation

Course Objectives: Understand the basics of electric and hybrid electric vehicles and their architecture. Develop the ability to design and determine component sizing and the power electronics devices used in electric and hybrid electric vehicles. Analyze various electric drives suitable for electric and hybrid electric vehicles.

Course Outcomes: After studying this course, students will be able to:

1. Understand basics of Electric Vehicles.
2. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
3. Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration and performance analysis.
4. Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.
5. Design the electric propulsion unit and its control for hybrid electric vehicles.

Module I

Electric Vehicles (EV) and Hybrid Electric Vehicle (HEV): Electric vehicles (EV) development, past, present and future, comparison with IC engine driven vehicles, Basic concept of electric traction, introduction to various electric drive-train topologies - power flow control in electric drive-train topologies, fuel efficiency analysis, Hybrid Electric Vehicle: Fuel cell Vehicles, Hybrid Electric Vehicles (HEV), series, parallel and series-parallel (split) systems.

Module II

Electric Vehicle Architecture: Introduction, Configurations, Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Power Flow Control in Electric Drive train, Positioning of Motors, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption, Single and Multi-Motor drives.

Module III

Transmission system for Hybrid and Electric Powertrain: Need for transmission system in EV and HEV, Torque and Speed Matching, Design consideration of transmission system, Types and Procedure, Power Transmission, Power flow and management, Powertrain components for series, parallel, series-parallel hybrid, Power and Torque distribution, Types of transmission, Single Speed, Multi-speed transmission in EV Planetary Gearbox in HEV- Drive shaft in EV and HEV.

Module IV

Powertrain components of Hybrid and Electric Vehicles: Traction Motor Types, Configuration and Control, Motor Drives: DC Motor, Brushless DC Motor, Switched Reluctance Motor, AC

Induction Motor. Introduction to Power electronic components, Electronic Control Unit of Motors, Various Control Modes, Drive system Efficiency.

Module V

Sizing of Powertrain Systems: Fundamentals of Vehicle Propulsion, Vehicle Resistance, Basics, sizing and rating of powertrain components, Introduction to tractive force, torque and power, Basics and factors influenced on tractive force, torque and power (2w, 3w & 4w), Calculation of battery pack- motor torque and power requirements for EV-Case study – Operating fuel economy, Electric vehicle retrofitting in conventional vehicle.

Books Recommended:

Text Books:	
1.	Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. M, Modern electric, hybrid electric, and fuel cell vehicles. CRC press, 2018.
2.	Denton, T. Electric and hybrid vehicles. Routledge, 2020.
3.	K.T.Chau, Zheng Wang, Chaos in Electrical Drive Systems: Analysis, Control & Applications, 1st Edition, John Wiley and Sons, 2011.
Reference Books:	
1.	Chung Chow Chan, K.T.Chau, Modern Electric Vehicle Technology, 1st Edition, Oxford University Press, 2001.
2.	John Lowry, John Wiley and Sons, Electrical Vehicle Technology Explained-James Larminie, 1st Edition, 2003.

Course Code	Course Title					Type of Course
ELE251S	Vehicle Dynamics					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
IV	3	0	0	3	3	Specialisation

Course Objectives: To understand the dynamics of a vehicle, especially under different riding conditions. Understand various dynamic loads acting on a vehicle and calculate the loads and forces associated with the vehicles.

Course Outcomes: After studying this course, students will be able to:

1. Describe the various static and dynamic forces acting on a vehicle.
2. Evaluate the effect of various vehicle parameters on the ride and handling of the vehicle.
3. Articulate road loads and Tire dynamics in electric vehicles.
4. Interpret riding comfort & vibrations, cornering and roll over in electric vehicles to understand the vehicular dynamics.
5. Infer on the suspension kinematics and controllable suspension elements used in electric vehicles.

Module I

Vehicle Dynamics Fundamentals: Fundamental approaches to vehicle dynamics, Vehicle axis system, Forces & moments affecting a vehicle, Earth Fixed coordinate system, dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, Brake proportioning, braking efficiency.

Module II

Acceleration and Braking: Front wheel drive vs rear wheel drive vs. all-wheel drive, vehicles Braking Performance: Braking force analysis, brake design and analysis, antilock braking system; wheel lock-up, tire/road friction, safety and maintenance issues in braking.

Module III

Road Loads: Wind drag and car body design, rolling resistance, breakdowns of total road loads, Aerodynamics Tire and Tire Dynamics, Tire specifications and constructions: tire motion analysis, tire force analysis, tire contact stress analysis, tire vibration analysis, tire models.

Module IV

Ride & Cornering/steering: Riding comfort; perception of vibration; vibration sources; vibration transmission to the passengers, Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover.

Module V

Chassis and Suspension Systems: Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Suspension Geometry, Anti-Dive Suspension Geometry, Suspension Dynamics, Multi-body vibration, Choice of suspension spring rate, Calculation of effective spring rate.

Books Recommended:

Text Books:	
1.	T. D. Gillespie, Fundamentals of Vehicle Dynamics. Society of Automotive Engineers, 1992.
2.	H. Pacejka, Tyre and Vehicle Dynamics, 3rd ed. Butterworth-Heinemann, 2012.
3.	M. Blundell and D. Harty, The Multi body Systems Approach to Vehicle Dynamics, 1st ed. Butterworth-Heinemann, 2004.
Reference Books:	
1.	J. Y. Wong, Theory of Ground Vehicles, 4th ed. John Wiley and Sons, 2008
2.	Vittore Cossalter, Motor Cycle Dynamics, Lulu.Com; 2nd ed. Edition, 2006

Course Code	Course Title					Type of Course
ELE302S	Safety and Regulations of EVs					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
V	3	0	0	3	3	Specialisation

Course Objectives: Upon completion of the course, students will have a deep understanding of safety systems in automobiles, covering both conventional vehicles and the evolving landscape of Electric Vehicles, ensuring students are equipped to design, implement, and comply with safety standards in the automotive industry.

Course Outcomes: After studying this course, students will be able to:

1. Recognize the distinction between active and passive safety in automobiles and comprehend the significance of driver assistance systems and associated terminology.
2. Understand the balance between stiffness, toughness, and energy absorption in vehicle structures. Identify and analyze restraint systems, safety belts, head restraints, and airbag implementations in automobiles.
3. Design steering controls to mitigate impact-related injuries, design of seats for safety.
4. Understand the processes and types of homologations required for compliance with various regulations and their impact on vehicle design and production.
5. Explore safety regulations specific to Electric Vehicles (EVs), understanding their impact on design and operation.

Module I

Introduction to Automotive Safety: Automotive Safety - Active and passive safety, Driver assistance systems in automobiles, definitions and terminology.

Module II

Automotive Safety: Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Ergonomics and human response to impact, Vehicle safety systems: Restraints systems used in automobiles, Types of safety belts, Head restraints, Air bags used in automobiles.

Module III

Design of Automotive Safety: Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles, Importance of Bumpers in automobiles.

Module IV

Classification of Vehicles, Homologation and Regulations: Specification & Classification of Vehicles including M, N and O layout, Homologation & its Types, Regulations overview: EEC, ECE, FMVSS, AIS, CMVR, Type approval Scheme, homologation for export, Conformity of Production.

Module V

EV Safety Regulations: EV Regulatory aspects, Electric system safety: Protection against electric shocks: Voltage levels on board, Protection against direct contact and indirect contact, Battery safety: Electrical, mechanical and chemical aspects, Explosion hazards

Books Recommended:

Text Books:	
1.	Watts, A. J., et al "Low-speed Automobile Accidents" Lawyers and Judges 1996
2.	Jullian Happian-Smith 'An Introduction to Modern Vehicle Design' SAE, 2002
3.	Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles, MEP, London, 1995
4.	Olson L. P, Forensic aspects of driver perception and response, Lawyers and Judges 1996.
Reference Books:	
1.	Matthew Huang, "Vehicle Crash Mechanics", CRC Press, 2002.
2.	David C. Viano, "Role of the Seat in Rear Crash Safety", SAE International, 2002.
3.	Ching-Yao Chan, "Fundamentals of Crash Sensing in Automotive Air Bag Systems", SAE International, 2000.
4.	Rollover Prevention, Crash Avoidance, Crashworthiness, Ergonomics and Human Factors", SAE Special Publication, November 2003.

Course Code	Course Title					Type of Course
ELE350S	Energy Storage Systems					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VI	3	0	0	3	3	Specialisation

Course Objectives: After completing the course, students shall know about the role and application of various energy storage technologies in modern power systems. The students will get acquainted with the knowledge of energy storage techniques, battery chemistry, battery management systems, and the development cycle for batteries.

Course Outcomes: After studying this course, students will be able to:

1. Understand the role and applications of different energy storage devices.
2. Get acquainted with the working principles of modern energy storage techniques.
3. Learn about the different components and chemical processes of a battery.
4. Understand the charging/discharging control of the battery for enhanced life.
5. Design the development cycle for the battery.

Module I

Introduction to Different Types of Storage Techniques: What is energy storage and why is it used, Components of basic ESS, Role of ESS in power system, Possible applications of ESS in power system, Classification of various energy storage technologies used in electrical industry: Pumped Hydro, Compressed air, Flow batteries, Battery storage, Fuel cell, Flywheel energy storage, Superconducting magnetic energy storage system, Supercapacitor energy storage system etc. Performance parameters of ESS

Module II

Energy Storage Used in Modern Power Systems: Lead-acid battery, lithium-ion battery, sodium-ion battery, Nickel-cadmium battery, Nickel metal hydride battery, Supercapacitor, Superconducting magnetic energy storage system, Flywheel energy storage system, their features and comparison, High-temperature batteries.

Module III

Working of Batteries (Battery Chemistry): Electrode, Electrolytes, Collectors, Chemical reactions in batteries, Lithium-ion Batteries: Lithium Manganese Oxide, Lithium iron phosphate, Lithium nickel manganese cobalt oxide, Lithium nickel cobalt aluminum oxide batteries, Saltwater batteries, and Potassium ion batteries.

Module IV

Battery Management System for Batteries (Power Conditioning System): Objective of battery management system: Charging and discharging control, how SOC and health are determined, Distributed, modular and Centralized BMS topologies, Impact on battery life.

Module V

Development Cycle for Batteries: Battery size and design (electrical, mechanical, thermal), Development of EMS software and hardware, Prototype development, Lab testing (energy density, energy efficiency, Ampere Hour density, number of charge and discharge cycles, operating temperature, self-discharge etc.) and validation, Safety tests, Certification.

Books Recommended:

Text Books:	
1.	Energy Storage for electricity grid: Benefits and Market potential Assessment guide, Jim Eyer, Garth Corey, Scandia Report, Scandia National Laboratories, Feb 2010.
2.	Energy storage: Fundamentals, Materials and Applications, Robert A Huggins, Springer, 2016.
3.	Energy Storage Systems, David Elliot, IOP Science, 2017.
Reference Books:	
1.	Energy storage technologies and applications, C. Michael Hoff, Artech House, 2022.

Course Code	Course Title					Type of Course
ELE402S	EV Charging Infrastructure					Core
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VII	3	0	0	3	3	Specialization

Course Objectives: To develop an understanding of electrical vehicle battery charging methods including fast charging and discharging behavior. Analyze renewable energy-based Electric Vehicle charging stations and understand electric vehicle charger specifications.

Course Outcomes: After studying this course, students will be able to:

1. Analyze the impact of EV charging on the power grid.
2. Design and analyze the various charging infrastructures and their selection and sizing.
3. Design of Renewable Energy-based Electric Vehicle Charging Station
4. Evaluate the various charging methodologies and analyze their performances.
5. Design the charger specifications along with study and selection of communication protocol.

Module I

Introduction to EV charging System: Introduction, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid-distribution system, effect of EV charging on generation and load profile, Smart charging technologies, Identification of EV demand, EV penetration level for different scenarios.

Module II

Electric Vehicle Battery Fast Charging: On-board & off-board charging, Fast Charging Process, Fast Charging Strategies, Fast Charger Configuration, Using Equalizing/Leveling Chargers, Inductive Charging—Making Recharging Easier, Range Testing of Electric Vehicles Using Fast Charging, Wireless Charging

Module III

Types of charging stations and Charging Infrastructure: Battery Swapping Station, Move-and-charge zone, AC charging and DC charging, Onboard and offboard charger specification, EVSE technical specification and charging time calculation, Selection and sizing of the fast and slow charger.

Module IV

Renewable Energy based Electric Vehicle Charging Station: Renewable Energy based Electric Vehicle Charging Station, calculation and selection, components of charging station, Earth protection system for charging stations, fire & safety aspects of charging stations, different case studies of charging approach.

Module V

Advancements in Charging: Recent advancements in Vehicle to Grid (V2G) and Grid to Vehicle (G2V) technologies, Case Studies on EV charging, Reliability of charging stations, predictive approach and analyzing for long-term maintenance free operation, Significance of bathtub curve, reliability prediction based on working condition.

Books Recommended:

Text Books:	
1.	Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002
2.	Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003
3.	Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013.
4.	Alam, M. S., Pillai, R. K., &Murugesan, N. (Eds.). Developing Charging Infrastructure and Technologies for Electric Vehicles. IGI Global, 2022.
Reference Books:	
1.	Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", Mc Graw- Hil, 1998..
2.	Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.
3.	Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
4.	Tariq Muneer and Irene IllescasGarcía, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017.

Course Code	Course Title					Type of Course
ELE451S	EV Motor Drives					Elective
Semester	**L**	**T**	**P**	**Contact Hours/Week**	**Credits**	**Course Category**
VIII	3	0	0	3	3	Specialisation

Course Objectives: The course aims to equip students with a deep understanding of electric motor technologies and their control systems, enabling them to design, analyze and implement control mechanisms for a variety of electric motors used in Electric Vehicle powertrains and beyond.

Course Outcomes: After studying this course, students will be able to:

1. Understand the basics of DC motors, their torque-speed characteristics, and dynamics.
2. Understand the design, selection, and practical implementation of PI controllers for speed control.
3. Explore and analyze different control methods, including rotor field-oriented, stator field-oriented, and variable voltage-variable frequency control in induction motors.
4. Analyze the application and operational characteristics of PMSM and SRM in EV powertrains.
5. Understand the practical implementation and benefits of closed-loop observers for sensor less control in PMSM and Direct Torque Control (DTC) systems.

Module I

Fundamentals of Power Converters: Power semiconductor switches: ratings, characteristics, power loss, temperature rise calculations, and control, Introduction to Wide Band Gap devices (SiC and GaN) and their applications, Phase controlled converters, DC-DC Converters, Voltage source inverters: single phase and three phase inverters.

Module II

EV Motors Characteristics: Requirement of EV motors, Comparison of EV motors, Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field weakening control, Four quadrant operation, DC Motor Dynamics & Control

Module III

Dynamical System Control: Gain & Phase Margins, PD Controller, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI controller with reference model, comparison of conventional PI Controller with PI controller with Reference Model.

Module IV

Induction Motor Speed Control: Dynamic modelling of Induction motor, Rotor Field oriented control, Stator Field Oriented Control, Field Weakening Control, Variable Voltage Variable

Frequency Control, PWM Techniques- Space Vector PWM- Hysteresis Control, Comparison of PWM techniques and closed loop control of drives, Variable voltage variable frequency control.

Module V

Permanent Magnet AC Motor Drives: Permanent magnet synchronous machine for EV powertrain, Non-Salient & Salient Drives, Generic Model, Steady State Analysis, Field Oriented Control, Switched Reluctance Machine for EV powertrain. Operating principles, Analysis of SRM drives and speed control, Multi-input EV drives concepts and their operation.

Books Recommended:

Text Books:	
1.	Electric Motors and Drives: Fundamentals, Types and Applications by Austin Hughes and Bill Drury, 5th edition, Newnes publications, 2019.
2.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
3.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
Reference Books:	
1.	K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019
2.	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York, 2001.
3.	Electrical Machines, Drives and Power Systems by Theodore Wildi, Pearson publications, 2013.

Annexure I

Evaluation Mechanism for Practical Courses, Projects (Minor and Major) and Industrial Training

a) Practical Courses

1. Continuous assessment throughout the semester consisting preferably of a viva and report evaluation after each experiment is performed – 50 marks
2. End term Exam – 50 marks, consisting of:
    1. Viva-voce - 20 marks.
    2. Performing a particular practical/simulation during the exam along with report writing for the same – 30 marks

b) Projects (Minor)

1. Marks to be given by concerned Project supervisor(s) – 20 marks.
2. The following would be evaluated by a duly constituted departmental committee.
    1. Preliminary presentation (preferably at the beginning of the semester) – 20 marks.
    2. Final Presentation which would include demonstration of model/simulation (if any) – 30 marks.
    3. Final Viva-voce – 20 marks
    4. Project Report – 10 marks (Soft Bound)

c) Projects (Major)

1. Marks to be given by concerned Project supervisor(s) – 20 marks.
2. Preliminary presentation to be evaluated by a duly constituted departmental committee and held preferably at the beginning of the semester – 20 marks.
3. The following would be evaluated by the External examiner.
    - Final Presentation which would include demonstration of model/simulation (if any) – 30 marks.
    - Final Viva-voce – 20 marks
    - Project Report – 10 marks (Hard Bound)

d) Industrial Training and Seminar

The evaluation would be done by a duly constituted departmental committee and would preferably be spaced throughout the semester. The distribution of marks would be as follows:

1. Presentation – 50 marks
2. Report – 20 marks (Soft Bound)
3. Viva-voce – 30 marks.

e) Courses with non-zero contact hours in more than 1 component within the L-T-P-S framework would be evaluated as follows:

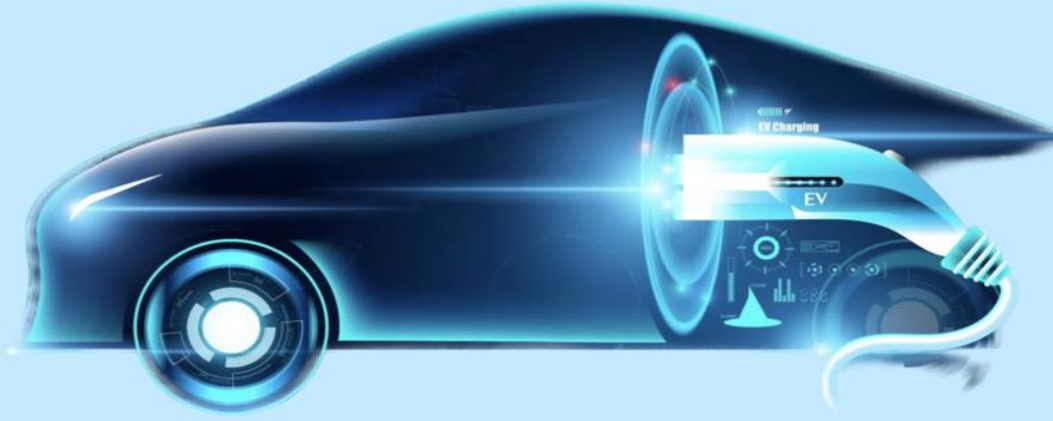
P and S components would be treated as part of continuous internal assessment (CIA) and evaluated as such in proportions to the credits assigned.
L and T components would be evaluated primarily as part of the end-term assessment with the marks given in proportion to the credits assigned. Since the end-term is of 50 marks, any evaluation marks beyond 50 would be evaluated as CIA.

Example: L-T-P-S = 2-1-2-0 with total credits = 4.

Credits for L and T component = 3, thus proportion of marks = 75 Marks.
Break-up of Marks for L and T components: Major = 50 Marks and CIA = 25 Marks.

Credits for P component = 1, thus proportion of marks = 25 Marks.
Break-up of Marks for P component: only CIA = 25 Marks.

The CIA component of this course would consequently be of 50 Marks, out of which 25 marks are for Mid-Term assessment of theory part and 25 marks are for performance in the practical as assessed by the teacher concerned.



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